LAW- PLANT AND MACHINERY

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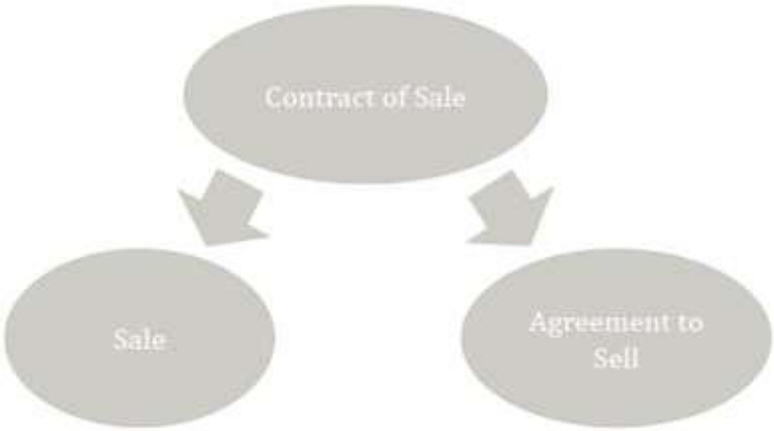
1.Preamble – Sales of Goods Act, 1930

- The law relating to sale and purchase of goods, prior to 1930 were dealt by the Indian Contract Act, 1872.
- In 1930, Sections 76 to 123 of the Contract Act was repealed and a separate Act known as the Sale of Goods Act, 1930 was passed
- This act lays down special provisions governing the contract of sales of goods .The general law of contract is also applicable to the contracts for the sale of goods unless they are inconsistent with the express provisions of the Sale of Goods Act

2.Definition of Contract of Sale

According to Section 4 of the Act, a Contract of sale means *"a contract where the **seller transfers** or **agrees to transfer/"ownership" the property** in **goods** to the **buyer** for **price**". Includes both Sale and Agreement to sell. Will be between two parties and will be express (oral) or in written.*



Contract of Sale is of two types : Sale and Agreement to Sell
(As Mentioned Above)

3.Sale of Goods and Agreement to Sell

Sale : It is a contract where the ownership in the goods is transferred by seller to the buyer **IMMEDIATELY** at the conclusion of Contract.

Agreement to Sale: It is a contract of Sale where the transfer of property in goods is to take place at a future date or subject to fulfillment of certain conditions. Here the seller **agrees** to transfer the property in goods to the buyer for a price.

Key Difference between Sale and Agreement to Sale : Where under a contract of sale the property in the goods in transferred from the seller to the buyer, the contract is called a sale, but where the transfer of the property in the goods is to take place at a future time or subject to some condition thereafter to be fulfilled, the contract is called an agreement to sell.

An agreement to sell becomes a sale when the time elapses or the conditions are fulfilled subject to which the property in the goods is to be transferred. ***(So, Ultimately the agreement to sale will become sale as time lapses subject to fulfillment of conditions)***

4.Distinction between Sale and Agreement to Sale

Basis	Sale	Agreement to Sale
Transfer of Property	Ownership if transferred immediately. It is executed Contract	Ownership if transferred at a future date subject to conditions. It is executory Contract.
Type of Goods	Existing and Specific Goods	Future and Contingent Goods
Risk of Loss	Buyer even if the goods are in possession of the seller.	Seller even if the goods are in possession of seller
Consequences of Breach	If buyer fails to pay the seller, seller can sue for the price of goods.	If there is any breach, then buyer can sue seller only for damages and not for price (e.g Liquidated damages)
Right to resell (from Seller)	No	Yes

5.Defination of Goods

Defination of Goods: Goods is the subject matter—Goods means every kind of movable property other than ACTIONABLE CLAIMS AND MONEY and includes stocks and shares, growing crops, grass and things attached to or forming part of the land which are agreed to be severed before sale or under the contract of sale. Trade marks, copyrights, patent rights, goodwill, electricity, water, gas are all goods.

Category of Goods – Specific Goods, Ascertained Goods (Sale) Future Goods, Contingent Goods (Fishing Example, Agreement to Sale)

Actionable claim means a claim to a debt or any beneficial interest in movable property not in possession (which can be enforced by action in a court. A debt from one person to another is an actionable claim and cannot be bought or sold as goods but they can only be assigned. **(An unsecured debt)**

A disputed claim which can be enforced through court of law and is excluded from the definition of good.

Definition of Goods – Existing Goods (Sale) and Future Goods (Agreement to Sell)

Specific Goods: Those Goods which are identified and agreed upon at the time of contract of sale.

Ascertained Goods: Though similar to specific goods are those goods which become ascertained subsequent to the formation of a contract of sale

Unascertained Goods: Goods which are not identified and agreed upon at the time of contract of sale. These good are called generic goods and are defined by description only and may form part of big lots of goods.

Future Goods: Goods not in existence at the time of contract of sale, Goods are to be manufactured or produced or acquired by the seller after making the contract of sale.

E.G I Phone for Existing Goods.
(Ownership = Title + Possession)

6.Unpaid Seller- Section 45 of the Sale of Goods Act, 1930

Rights of unpaid seller:
An unpaid seller is one

- who has not been paid/tendered the price
- A bill of exchange or other negotiable instrument received but dishonoured or otherwise irregular
- Who has got a court decree but not yet satisfied (or executed)
- Any person who is in the position of the seller (agent or a consignee who had paid for the goods and responsible for the price

A unpaid seller has an immediate right of action for the price.

Unpaid seller has two kinds of rights:

- Against the goods
- Against the buyer personally

Right against the goods

- when the property in goods has passed: Lien, Stoppage in Transit and Re-sale
- when the property in goods has not passed: Withholding delivery and Stoppage in Transit

Right against the buyer personally

- Suit for the price
- Suit for damages
- Repudiation of the contract **(Cancellation of Contract)**
- Suit for interest **(If late payment, need to compensate with Interest)**

Examples of Unpaid Seller

- X Sells goods of Rs. 5 lacs to Y on a credit of one month, but after expiry of one month he does not pay the price, here X is said to be unpaid seller
- X Sells goods of Rs 5 lacs to Y on a credit period of 1 month but Y pays only 1 lac after 1 month, x is termed as unpaid seller.

7. Rights of Unpaid Seller- Section 46 of the Sale of Goods Act, 1930

Right of Lien: (Ownership Transferred, however possession of Goods with Seller)

A lien is a right to retain the possession of the goods until the price is paid. This right is immediate in case of cash sales. In case of credit sales it is after the expiry of the credit period. The right is also available when the buyer becomes insolvent at any time.

Lien depends on actual possession and not on title whether as seller or as his agent or as bailee for the buyer

Possession of the goods by the seller must not expressly exclude the right of lien Lien can be exercised only for the price and not for other charges (like taxes, duties)

Seller having made part delivery of the goods may exercise lien on the remainder (unless there is a condition to waive the lien)

(Eg : Seller had to supply 100 Kgs of wheat of which 40 Kgs were supplied, can Lien be exercised on remaining 60 Kgs) – "Yes", Since 60 Kgs is in Seller's Possession

A sold certain goods to B for a price 500 and allowed him to pay the price within 1 month. B becomes insolvent during the period of credit.A unpaid seller can exercise his right of lien.

Right of stoppage in transit: (Ownership Transferred)
This right is available: a) when the buyer becomes insolvent and b) when the goods are in transit.
Insolvency means failure to pay them on the due date whether he has committed an act of insolvency or not

This right is an extension of the right of lien

The carrier may hold goods as an agent of the seller

If the carrier is holding goods as an agent of the buyer, seller cannot exercise the right of stoppage in transit

If the carrier is holding goods in an independent capacity, the seller has the right of stoppage. Stoppage can be effected by taking possession or by giving notice of stopping.

Right of lien or stoppage in transit is not affected by any sale or pledge which the buyer would have made unless the seller has assented to the same.

Right to Stoppage in Transit : Essence is to regain possession and Right of Lien : Essence is to retain possession.

Right of Resale: (Ownership Transferred)

When the goods are perishable

When the notice of resale is given to the buyer but buyer does not respond by payment /tender of price within a reasonable time

In case of loss in a resale, seller can claim it from the buyer as damages for breach of contract

In case of surplus the seller is not bound to hand it over to the buyer (buyer cannot benefit from his own wrongs)

Notice is a must or there should be clause in the sale contract expressly reserving the seller's right of re-sale

Right of withholding delivery: (Ownership Not Transferred)

Where the property in goods has not passed to the buyer, the unpaid seller has a right of withholding delivery This right is co-existent with the right of lien and stoppage in transit

Rights of the Unpaid seller against the buyer personally: **(Ownership Not Transferred)**

a) Suit for the Price; b) Suit for damages for non-acceptance; c) Repudiation of the contract before due date and d) Suit for interest

8.Remedies of Buyer Against the Seller (From Buyer Perspective)

Damages for Non Delivery: Where the seller wrongfully neglects or refuses to deliver the goods to the buyer the buyer may sue the seller for damages for non delivery.

Suit for Specific Performance: where the seller commits of breach of the contract of sale, the buyer can appeal to the court for specific performance.

Suit for breach of warranty: If there is a breach of warranty on the part of seller, or where the buyer elects to treat breach of condition as breach of warranty in such circumstances the buyer is not entitled to reject the goods.

Suit for damages for repudiation of contract by the seller before the due date

Suit for Interest.

9.Warranty and Condition – Express and Implied

A Condition is a stipulation – Which is ESSENTIAL to the main purpose of contract and the breach of which gives the aggrieved party a RIGHT TO TERMINATE THE CONTRACT.

A warranty is a stipulation which is COLLATERAL to the main purpose of the contract and the breach of which gives the aggrieved party a RIGHT TO CLAIM DAMAGES and not right to terminate the contract or reject goods.

Condition and warranty may be express or implied.

Express means which are agreed upon between the parties at the time of contract and implied means which are presumed by law to be present in the contract.

9.Implied Conditions (Presumed by law)

Condition as to title Section 14(a)

Condition as to description

Sale by Sample (Covered)

Sale by Sample as well as by description (Covered)
Condition as to merchantable quality

Sale as quality and fitness

Condition as to wholesomeness.

10.Implied Condition – Sale as to Sample (Section 17)

Condition as to Sample (Section 17) in a contract of sale of sample there is an implied contract:

- The bulk shall correspond with the sample in quality
- The buyer shall have a reasonable opportunity of comparing the bulk with the sample
- The goods shall be free from any defect rendering them un- merchnatile.

Eg: A Company sold certain shoes made of special sole by sample for French army. The shoes were found to contain paper not discoverable by ordinary inspection. Held, the buyer was entited to the refund of the price plus damages**.**

A agreed with B to sell certain oil described as refined sunflower oil, warranted only equal to sample. The goods tendered were equal to sampls, but contained a mixture of hemp oil. B can reject the goods.

11.Rule of Caveat Emptor – Let the Buyer be aware (Section 16)

When sellers display their goods in the open market, it is for the buyers to make a proper selection or choice of the goods. If the goods turn out to be defective, he cannot hold the seller liable.

It is duty of buyer to satisfy himself before buying the goods on his own skill and judgement.

A sold pigs to B. These pigs being infected caused infection to other pigs as well. It was held that the seller was not bound to disclose that the pigs are unhealthy.

Exceptions:

- When purpose of buying is in seller notice (Buyer relies on sellers skills – described Goods)
- When goods are sold under BRAND name
- When good are bought by sample
- When goods are sold under description
- When seller commits fraud.

12.Passing of Property in "Goods" (Section 18-24)

Passing or tranfer of property constitutes the most important element and factor to decide the legal rights and liabilities of seller and buyer. Passing of property implies passing of ownership. If the property has passed to the buyer the risk in the goods sold is that of buyer and not of seller, though the goods may still be in seller possession.

Transfer of ownership in different stages of SPECIFIED Goods (Sale)

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13.Passing of Property in "Goods" in case of Specific Goods

Goods in a deliverable state:

Example: *X goes into a shop and buys a television and asks the shopkeeper for its home delivery. The shopkeeper agrees to do it. The Television immediately becomes the property of X.*

Goods to be put into a deliverable State:

Example: *A stock of wheat was sold at an agreed price per quintal. The wheat was to be weighed by the seller for ascertainment of the price. A part of the wheat was weighed and carried by the buyer but the remaining was swept away by the flood. Held, the loss of the remainder should be borne by the seller since the property in the remainder has not passed because the required weighing was not done.*

Example: *A sold carpets to the Company which were required to be laid. The carpet was delivered to the company's premises but was stolen before it could be laid. It was held that the carpet was not in deliverable state as it was not laid, which was part of the contract and hence, the property had not passed to the buyer company*

14.Passing of Property in “Goods” (Section 18-24) – Future Goods i.e unascertained Goods

In case of a contract for the sale of unascertained or future goods, ownership will not pass to the buyer, unless and until the goods are ascertained.

Goods by description:

Example: A agrees to purchase 1000 quintals of cotton from warehouseman, out of which he took delivery of 500 quintals and remaining to take later on. The warehouseman weighed the cotton and kept the remaining separately and informed A to take them and agreed to do so. Before he takes delivery of the remaining goods the warehouse caught fire and destroyed the cotton. A, is liable for the price to the warehouseman since he has appropriated the goods, and the ownership is transferred to him.

(Appropriation of goods involves selection of goods with the intention of using them in performance of the contract and with the mutual consent of the seller and the buyer)

Delivery to the carrier:

Example: A bill of lading of railway parcel is made out in the name of the buyer and is sent to him, the ownership in the goods passes from the seller to the buyer. In case the goods are subjected to accidental loss or by theft, the seller will not be liable.

Goods sent on approval or "on sale or return"

Example :- *A, sends to B a water motor on approval or return in March 2012. B to return it after trial in August, 2012. The water motor has not been returned within a reasonable time, and therefore, A is not bound to accept it and B must pay the price.*

Risk passes with property: The owner of goods must bear the loss or damage of the goods unless otherwise agreed to. Under Section 26 of the sale of goods act, unless otherwise agreed the goods remain at the sellers risk until property therein has passed to the buyer. After the event they are at the buyer's risk, whether the delivery has been made or not.

15.Sale by Non – Owners (Transfer of Title by Non-Owners) Covered under Tranfer of Title i.e Section 27 – 30

"Nemo Dat Qui Non Habet"—No one can give that which one has not got.(latin)

A thief cannot pass a better title to his buyers than what he himself has. It is only the owner

In general, the seller sells only such goods of which he is an absolute owner.

Sometimes, persons other than owners can pass on good title: a) Title by estoppel (where the owner by his conduct or silence leads the buyer to believe that the seller has authorised); b) Sale by mercantile agent (agency in the ordinary course of business); c) Sale by one of the joint owners; d) Sale by a person in possession under a voidable contract; e) Sale by seller in possession after sale (buyer has to buy in good faith); f) Sale by buyer in possession after having bought or agreed to buy; g) Sale by unpaid seller; and h) Sale by finder of lost goods; Sale by pawnee or pledgee; Sale by Official receiver or Assignee; Sale in Market by enforcement

Please Note Sale / Agreement to sale is different from Hire Purchase.

16.Exceptions – Non owners can pass bonafide title.

Sale by Mercantile AGENT : He is in possession of goods with consent of owner, ordinary course of business as agent

E.G Authorized Car Seller agent sells at a price less than market. Owner is not happy. Buyer is not obliged to compensate.

Sale by Co-joint owners – A, B and C are three brothers.

Sale by one who has already sold the goods but continues to be in possession thereof:

Example: During ICL matches, P buys a TV set from R. R agrees to deliver the same to P after some days. In meanwhile R sells the same to S, at a higher price, who buys in good faith and without knowledge about the previous sale. S gets a good title.

Sale by buyer obtaining possession before the property in the goods has vested in him :

Example: A took a car from B on this condition that A would pay a monthly instalment of `500 as hire charges with an option to purchase it by payment of ` 10,000 in 24 instalments .After the payment of few instalments. A sold the car to C. B can recover the car from C since A had neither bought the car, nor had agreed to buy the car. He had only an option to buy the car.

Salient Features of Factory Act, 1948

Objectives of Factories Act; Working Hours (Holidays, Extra time), Health, Safety, Welfare & Penalties

Section 2(m) defines factory as whereon ten or more workers or were working on any day of the preceding twelve months and in any part of
which a manufacturing process is being carried on with the aid of power OR

whereon twenty or more workers are working, or were working on any day of the preceding twelve months, and in any part of which a manufacturing process is being carried on without the aid of power, or is ordinarily so carried on.

Health Section 11 to 20 deals with the health of workers in the work place defining the various parameters in maintaining the cleanliness, disposal of effluent, standard of lightening, noise levels, latrines, etc.,

Safety Section 21 to 41 deals with the safety provisions. Fencing of machineries, restriction of women and children in certain type of process, testing of pressure plants, hoists and lifts, lifting machineries, chains, ropes and lifting tackles by competent persons, appointment of safety officers etc., are explained.

Welfare Section 42 to 50 specifies the necessity for welfare of workers such as washing facilities, first aid appliances, rest room, crèches, canteen,
appointment of welfare officers, etc.,

Provision relating to Hazardous Process Section 41(A) to 41(H) deals various special provisions for factories wherein hazardous process are carried on. Here compulsory disclosure of information by the occupier to the workers as well as to the public, permissible limit of exposure of
chemicals and toxic substance, workers participation in safety management etc, are prescribed.

Working Hours Section 51 to 66 handles the restriction of working hours such as weekly hours, weekly holidays, compensatory holidays, night
shifts, over time, etc.,

Employment of Young Persons Section 67 to 77 explains the working conditions of young persons, regarding the certificate of fitness reduced
working hours etc.
Annual Leave with wages Section 78 to 84 deals with the leave eligibility for a worker

Penalty and Procedure Section 92 to 106A deals with the penalty provisions. For any contravention of the provisions of this act, or of any rules
made there under, the occupier and the manager of the factory shall each be guilty of an offence and punishable with imprisonment for a term
which may extend to 2 Years of with fine which may extend to 1 lakh rupees or with both.

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Salient Features of Electricity Act, 2003

Sr No.	Category	Key Features of Indian Electricity Act 2003
1	**Objectives**	▸ Encouraging autonomous regulation with the separation of policy regulation and operational aspects ▸ Rationalizing tariff and lowering the cross-subsidization levels ▸ Creating competition in the industry ▸ Ensuring supply of electricity to all areas ▸ Protecting consumer interests
2	**Policy**	▸ A National electricity plan shall be prepared in accordance with National Electricity Policy every 5 years National policy on stands alone systems for rural areas and Non-conventional energy systems National policy on electrification and local distribution in rural areas
3	**Restructuring**	▸ Vertical integration instead of horizontal unbundling of State Electricity Boards (SEBs) to make them financially strong ▸ State governments will have the freedom to decide the sequence and phases of restructuring, and also retain the integrated structure of the SEB for a limited period ▸ Introduction of the concept of power trading as a distinct activity, and the introduction of a spot market for bulk electricity
4	**Generation**	▸ Removal of captive power plants from the ambit of licensing and other permissions ▸ Generators can contract directly with DISCOMs ▸ DISCOMs can have embedded generation ▸ Captive generation allowed freely—can supply to associates ▸ Elimination of Licensing requirement and techno-economic clearances for generation projects except hydel projects
5	**T & D**	▸ Provision for Private participation in distribution ▸ Surcharge for open access to meet current cross-subsidy burden (except for CPP's) ▸ Dedicated transmission lines allowed (not regulated) ▸ Central and State transmission Utilities (CTU and STUs) not permitted to trade ▸ Transmission licensees allowed ▸ Multi Year Tariff (MYT) recommended ▸ Bidding allowed

PRINCIPLES OF INSURANCE AND LOSS ASSESSMENT

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UNIT – 1
INTRODUCTION TO INSURANCE

1.1 What is Insurance?

There is normally expected lifetime for the asset, during which time it is expected to perform. However, if the asset gets lost earlier, being destroyed or made non-functional, through an accident or other unfortunate event, the owner and those deriving benefits there from suffer. Insurance is a mechanism that helps to reduce such adverse consequences.

1.2 Purpose and Need of Insurance

Assets are insured, because they are likely to be destroyed or made non-functional, through an accidental occurrence. Such possible occurrences are called perils, like fire, earthquake, flood, break down, accident etc.

The damage that these perils may cause to the asset, is the risk that the asset is exposed to.

The risk only means that there is a possibility of loss or damage, it may, or it may not happen. There has to be an uncertainty about the risk. If there is no uncertainty about the occurrence of an event, it cannot be insured against.

The risk may sometime be referred to as subject matter of insurance.

There are other meanings of the term ‘risk’. To the ordinary man in the street ‘risk’ means exposure to danger. In Insurance practice, ‘risk’ is also used to refer to the peril or loss producing event. For examples, it is said that fire insurance covers the risks of fire, explosion, cyclone, flood etc. Again, it is used to refer to the property covered by insurance, for example, a timber construction is considered to be a bad ‘risk’ for fire insurance purpose.

Conceptually, the mechanism of insurance is very simple. People who are exposed to the same risk come together and agree that, if any one of member suffers the loss, the others will share the loss and make good to the person who lost. By this method the risk is spread among the community and the likely big impact on one is reduced to smaller manageable impacts on all Insurance does not protect the asset. It does not prevent its loss due to the peril. The peril cannot be avoided through insurance.

Insurance only tries to reduce the impact of the risk on the owner of the asset and those who depend on that asset. It compensates, may not be fully, the losses. Only economic or financial losses can be compensated

The purpose of insurance is to safe guard against misfortunes by making good the losses of the unfortunate few, through the help of fortunate many, who are exposed to the same, risk but saved from the misfortune. Thus, the essence of insurance is to share losses and substitute certainty with uncertainty.

1.3 How Insurance Works?

People facing common risks come together and make their small contributions to a common fund. The contribution to be made by each person is determined on the assumption that while it may not be possible to say beforehand, which person will suffer, it is possible to say, on the basis of past experiences, how many persons, on an average, may suffer losses. The following examples explain the above concept.

- In a village, there are 400 houses, each valued at Rs.20,000/-. Every year, on an average, 4 houses got burnt, resulting into a total loss of Rs.80,000/- If all 400 owners come together and contribute Rs.200/- each, the common fund would be Rs.80,000/-. This is enough to pay Rs.20,000/-, to each of the 4 owners whose houses got burnt thus the risk of 4 no. house owners is spread over 400 no. house owners of the village. Rs.200/- paid by house owner is called premium payable. Rs.20,000/- is the sum insured of the risk.

- Similar risk is houses in a village, claim of few Rs.20,000/- each, total Rs.80,000/- , loss suffered by the 4 house owners and shared by 400 house owners insurer is in the position of trustee as it is managing the common fund.

- It has to ensure that that nobody is allowed to take undue advantage of the arrangements. The decision to allow the entry is the process of underwriting of risk. Both underwriting and claim settlement have to be done with great care.

The Business of INSURANCE – POOLING OF RISK & RESOURCES

The business of insurance done by insurance companies, called insurers, is to bring together persons with common insurance interests (sharing the same risks), collecting the share of contribution (called premium) from all of them, and paying out compensations (called claims) to those who suffer. The premium is determined on the same lines as indicated in the example above with some additions made for the expenses of administration.

Thus, insurance may be described as a method or a technique which provides for collection of small amounts of premium form many individuals and firms out of which losses suffered by the few are paid.

ROLE OF INSURANCE IN ECONOMIC DEVELOPMENT.

An insurance company's strength lies in the fact that huge amounts are collected and pooled together, these amounts come by way of premiums. Every premium represents a risk that is covered by that premium. In effect, therefore, these vast amounts represent pooling of risk. The funds are collected and held in trust for the benefit of the policyholders. The management of insurance companies is required to keep this aspect in mind and make all its decisions in ways that benefit the community. This applies also to its investments. That is why successful insurance companies would not be found investing in speculative ventures. Their investments benefit the society at large.

The system of insurance provides numerous direct and indirect benefits to the individual and his family as well as to industry and commerce and to the community and the nation as a whole. Those who insure, both individuals and corporates, are directly benefited because they are protected from the consequences of the loss that may be caused by the accident or fortuitous event. Insurance, thus, in a sense protects the capital in industry and releases the capital for further expansion and development of business and industry.

Insurance removes the fear, worry and anxiety associated with this future uncertainty and thus encourages free investment of capital in business enterprises and promotes efficient use of existing resources. Thus, insurance encourages commercial and industrial development and thereby contributes to a vigorous economy and increased national productivity. No bank or financial institution would advance loans on property unless it is insured against loss or damage by insurable perils.

Insurers are closely associated with several agencies and institutions engaged in fire loss prevention, cargo loss prevention, industrial safety and road safety.

Before acceptance of a risk, insurers arrange survey and inspection of the property to be insured, by qualified engineers and other experts. The object of these surveys is not only to assess the risk for rating purposes but also to suggest and recommend to the insured, various improvements in the irks, which will attract lower rates of premium.

Insurance ranks with export trade, shipping and banking services as earner of foreign exchange to the country. Indian insurers operate in more than 30 countries. These operations earn foreign exchange and represent invisible exports.

UNIT – 2

FUNDAMENTALS/PRINCIPLES OF GENERAL INSURANCE

CONTRACT OF INSURANCE

When the insured pays the premium and the insurer accepts the risk, the contract of insurance is concluded. The policy issued by the insurer is the evidence of the contract.

2.1 Conditions Necessary for a Contract

1. There should be consideration, i.e. there should be offer and acceptance of both parties, and one party will give offer the other party will accept.
2. There should be consent of both parties, (agreement). – Both parties should be of the same mind with a common intention. For example, if the proposer desired fire insurance, and the insurers issue a burglary policy, there is no consent arising out of common intention.
3. The parties to contract must be competent, minors and person of unsound mind are not competent to sign contracts.
4. The object of contract must be legal and not against public policy. For example, stolen goods cannot be insured.

2.2 Principles of General Insurance

Insurance contracts are subject to certain special principles evolved under common law in the U.K. and are generally followed by Indian courts. The principles are known as fundamental or basic principles of law of insurance.

2.2.1 Utmost good faith

The parties to a commercial contract, according to law, are required to observe good faith. The seller cannot mislead the buyer in respect of the transaction, but he has no obligation to disclose all information about the subject of the contract. It is the buyer's duty to be careful while entering into the contract. 'Let the buyer beware.' Is the legal rule?

In insurance contract there is duty of utmost good faith and giving material facts information. The proposer has duty to disclose all material information/facts about the subject matter of insurance to the insurer. The material fact is that, enables insurer to decide whether to accept the risk and the rate of premium and terms and conditions of acceptance. The duty applies not only to the material facts which the proposer knows, but also extends to the material facts which he ought to know.

The following are some examples of material facts
Fire Insurance (a) Construction of the building; (b) Occupancy (e.g. office, residence, shop, godown, manufacturing unit, etc.) (c) The nature of goods, i.e. non-hazardous, hazardous extra-hazardous etc.

Marine Insurance (a) Method of packing i.e. whether in single gunny bags or double gunny bags, whether in new drums or second hand drums' etc. (b) the nature of goods (e.g. whether the machinery is new or second hand);

Motor Insurance (a) Cubic capacity of engine (private car); (b) the year of manufacture; (c) carrying capacity of a truck (tonnage); (d) the purpose for which the vehicle is used; (e) the geographical area in which it is used; etc

Personal accident Insurance (a) the exact nature of occupation; (b) age, height and weight; (c) physical disabilities etc.

General (a) The fact that previous insurers had rejected the proposal, or charged extra premium, or cancelled, or refused to renew the policy (b) Previous losses suffered by the proposer.

Note: If the insurance is placed through an agent, the latter has similar duty to disclose all material facts known to him or communicated to him by the proposer.

Facts which are common knowledge or matters of law need not be disclosed by the proposer. For example, if a proposer seeks riot cover, he need not disclose the fact of prevalence of riot conditions. Insurance are expected to know about it in the normal course.

The duty of disclosing material facts ceases when the contract is concluded by the issue of a cover note or a policy. The duty arises again at the time of renewal of the policy. However, a policy condition provides the duty also arises during the period of the policy, if there is any change in the risk.

The breach of duty of utmost good faith may arise unintentionally through an oversight or because the proposer thought that it was not a material fact, if there is non-disclosure or mis-representation with fraudulent intention, the insurance contract will become void; it will not be contract at all. If duty of utmost good faith is breached in any other way, the contract becomes voidable, which will mean, the insurers have the option to avoid the contract and reject the claim.
Unenforceable contracts are those which cannot be produced as an evidence in court of law, If an insurance policy is not stamped as per the Indian stamp act, the contract becomes unenforceable.

Contractual duty
Proposal forms are designed to obtain all material information about the subject matter of insurance. Each form contains a declaration to the effect that all the questions have been answered truly and correctly, and that the proposal and declaration shall be the basis of the contract.

The legal effect of the above declaration is that insurers can avoid the contract if any answer is inaccurate or incorrect, even if the answer is not material to the risk. This is called the contractual duty of utmost good faith, which is far stricter than the common law duty.

The duty of disclosure of "material information" regarding a proposal or policy also applies to insurers, agents or insurance intermediaries, as provided in IRDA Regulations (Protection of Policyholders' Interests) 2002.

2.2.2 Insurable Interest

The owner of property has a right under law to effect insurance on the property, if he is likely to suffer financially, when property is lost or damaged. This legal right to insure is called insurable interest. Without insurable interest, the contract of insurance will be void. Because of this legal requirement of insurable interest, insurance contracts are not gambling transactions.

Examples of insurable interest

(a) Ownership of property (and joint ownership) is a clear example of insurable interest.

(b) A bank has insurable interest in the property on the mortgage of which loans have been given. The interest is limited to the amount of the loan. Usually, under such circumstances, the policies are issued in the joint names of the insured and the bank.

(c) A ship owner has insurable interest in the ship owned by him. Cargo owners, both sellers and buyers, have insurable interest in the goods owned by the owner.

(d) The owner of a motor vehicle has insurable interest in the vehicle; he also has insurable interest in potential third party liability. If a third party is injured in the accident, the damages payable to the third party would be financial loss to the insured, Hence, he can insure his third party liability.

(e) A person has insurable interest on his own life.

Insurable interest can arise in a variety of ways but the above examples are sufficient to explain the concept.

Time When Insurable Interest should be Present

In fire and miscellaneous insurance, insurable interest must be present both at the time of taking the policy and at the time of loss. For example, if the property insured under a fire insurance policy is sold and there is a loss after the sale, the insured cannot recover the loss as he has no insurable interest at the time of loss.

In marine cargo insurance, insurable interest is required at the time of loss. It may not be present at the time of effecting insurance. An importer of goods may insure the goods under a marine policy, although at the time, he may not be the owner of the goods. Ownership of the goods passes from the exporter to the importer when the payment is made. If goods arrive damaged at destination, and if the importer had paid for the goods, he can recover the loss as he has insurable interest at the time of loss and also has a policy. In marine hull insurance, insurable interest must be present both at the time of taking the policy and at the time of loss.

Assignment

Assignment means transfer of rights and liabilities of an insured to another person who has acquired insurable interest in the property insured. Generally fire and miscellaneous insurance policies are assigned only with the consent of the insurers. Marine cargo policies are, however, freely assignable without the previous knowledge or consent of the insurer. The reason is that the ownership of goods insured under a marine cargo policy frequently changes when the goods are still in transit, and it is necessary that the benefit of the policy should pass to the new owner, A marine hull policy cannot be assigned without the consent of the insurers.

1.2.3 Indemnity

The principle of indemnity arises under common law and requires that an insurance contract should be governed by principle of indemnity. The object of the principles is to place the insured in the same financial position as far as possible, as he occupied immediately before the loss. The effect of this principle is to prevent the insured from making any profit out of his loss or gaining any benefit or advantage.

The measure of indemnity applied to some types of property is explained below:

Building

In these cases, the cost of reinstating the building or repairing the damage portion, is assessed and from that an appropriate allowance is made toward depreciation, depending upon the age and condition of the building.

Machinery

In practice, the measure of indemnity is the replacement value at the place and date of loss or damage. Less an appropriate allowance towards depreciation.

If the damaged machinery is repairable, the measure of indemnity is the cost of repairing the damage. If however, during repairs, any part is replaced, an appropriate allowance is to be made towards depreciation on the total cost of repairs including labour cost.

Stocks

In respect of the stocks of wholesalers and retailers, the measure of indemnity is not the selling price of the wholesaler or the retailer, but it is the price at which he can replace the goods, the element of expected profit does not pay any part in computing the measure of indemnity.

Fire insurance policies may be issued on Reinstatement Value basis. Under these polices, generally issued for covering building or machinery, the basis of indemnity is the cost of repairs or cost of reinstatement or replacement of damaged or destroyed property by new property of the same type. In as much as the insured gets new property in the place of old, the principle of indemnity is modified, (this is explained in Unit – 6 : Fire and Special Peril Insurance).

Motor Insurance

The indemnity shall not exceed.

(a) For total/constructive total loss of the vehicle the insured's Declared Value of the vehicle (including accessories thereon) as per Schedule of the policy less the value of the wreck.

(b) For partial losses, costs of repair / replacement as per depreciation limits specified in the policy.

Claims for third party liability are indemnified as per law, subject to limits, if any, under the policy.

Marine Insurance

The values of cargo are subject to constant fluctuations during transit from one country to another, Besides, the market values of ships fluctuate widely, but the market value may not reflect the true value of the ship to its owner, Therefore, almost all the marine ship/hull insurance policies are issued as valued policies or agreed valued policies, where under the sum insured is agreed between the insurers and the insured as the value of the insured property. The agreed amount is payable in the event of total loss, irrespective of considerations of depreciation, etc.

Personal Accident Insurance

Personal accident insurances are not contracts of strict indemnity. After an accident in which the insured person is disabled, it is not practicable to place him in the same financial position in which he was before the accident, since no monetary value can be placed on human life. So, these are fixed benefit policies.

CVSRTA

Limitation of Liability of Insurer

i. The sum insured is the maximum limit of liability under the policy and is always defined in policy.
ii. If sum insured is less than required the condition of average will be applicable. In such case only that proportion of loss is payable, which the sum insured bears to the market value of the insured property at the time of loss.
iii. Some policies are subject to “excess” or “franchises”.
iv. The difference between ‘excess’ and ‘franchise’ should be clearly understood. In either case, if the loss does not reach the limit, it is not payable at all. If it exceeds the limit, the excess only is payable under the ‘excess’ clause and the entire loss is payable under the ‘franchise’ clause
v. For example, if there are two insurance policies ‘A’ and ‘B’ policy ‘A’ subject to an excess of Rs.1,000/- and policy ‘B’ subject to a franchise of Rs.1,000/-, and if a loss of Rs.500/- is reported under each policy, nothing will be payable under both the policies.
vi. If however, the loss under each policy was Rs.1,100/-, policy “A’ will pay Rs.100/- only but policy ‘B’ will pay Rs.1,100/-.
vii. Salvage is property, which is partially damaged, by fire for example, and if the full loss is paid, the insurers may take over the salvage and dispose it off.

2.2.3.1 Subrogation under Policy Conditions

The right of subrogation is implied in all contracts of indemnity and is automatic and without any express condition in contract.

Subrogation may be defined as the transfer of rights and remedies of the insured to the insurer who has indemnified the insured in respect of the loss. If the insured has any rights of action to recover the loss from any third party, who is primarily responsible for the loss, the insurer, having paid the loss, is entitled to avail himself of these rights to recover the loss from the third party. The effect is that the insured does not receive more than the actual amount of his loss and any recovery effected from the third party goes to the benefit of the insurer to reduce the amount of his loss.

The principle may be illustrated by the following example:

If cargo is damaged due to the negligence of a carrier (e.g. railways, truck operators, shipping companies etc.) who has an obligation to make good the loss of the insured, the benefit of this obligation passes to the insurer.

The right of subrogation is implied in all contracts of indemnity, In other words its application to contracts of indemnity is automatic without any express condition in the contract. It arises, however, only after payment of a loss.

Fire and miscellaneous policies contain an express condition to the effect that the right of subrogation can be exercised by the insurer even before payment of a claim. In certain circumstances, it becomes necessary to take action immediately against a third party in order to ensure that the rights of recovery are not prejudiced by any delay.

Marine insurance policies are subject to the doctrine of subrogation, but the policies do not contain any conditions, and the insurers are subrogated to the rights of the insured only after payment of claim.

The IRDA Regulations make specific provisions that the policyholders shall assist the insurer in recovery of claims from other parties.

2.2.3.2 Contribution under Policy Conditions

If an insured takes out more than one policy, say two policies, he can not recover the claim two times, it would amount to making profit, he can recover only one claim from any one of insurance companies, or each company is liable for ratable proportion of claim.

Sum Insured Rs.3,00,000/- Claim Rs.1,80,000/-

		Claim	
Sum insured with insurer A	Rs. 50,000/-	A pays	Rs.30,000/-
Sum insured with insurer B	Rs.1,00,000/-	B pays	Rs.60,000/-
Sum insured with insurer C	Rs.1,50,000/-	C pays	Rs.90,000/-
	Total Rs.3,00,000/-		Total Rs.1,80,000/-

The application of the principle of contribution is subject to the following pre-requisites.

1. The subject matter must be common to all policies.
2. The peril, which is causing loss, must be common.
3. The interest covered must be the same in all policies, must be in favour of same insured.
4. The policies must be in force at the time of loss.
5. The policies must be legally enforceable.

2.2.4 Proximate Cause

In an insurance contract the claim/loss to the property is payable if it is caused by a peril insured in the policy, similarly if it is caused by uninsured peril it is not payable. If the loss is caused by one peril only it is easy to decide if claim is payable or not. In actual situation the loss may be the result of two or more causes acting simultaneously, or one after the other. It becomes then, necessary to choose the most important, the most effective, and the most powerful cause which has brought about the loss. This cause is termed as the Proximate Cause all other causes being considered as remote.

2.4.1.1 Example

A person insured under a personal accident insurance policy went out hunting and met with an accident. Due to shock and weakness, he was not able to walk, while lying on the wet ground he contacted cold, which developed into pneumonia, which caused his death.

The court held that the proximate cause was accident covered in the policy and the remote cause was pneumonia, hence claim was payable.

2.4.1.2 Example

A person was covered under personal accident insurance policy. He suffered accidental injuries and was taken to hospital. While undergoing treatment he contracted an infectious disease, which caused his death. The court held that the proximate cause of death was infectious disease and the remote cause was accident. Hence the claim was not payable under personal accident policy.

The proximate cause or theory of cause proxima enables one to decide which one is remote cause and which one is proximate cause. If there are more than one cause or concurrent causes theory of cause proxima must be used.

UNIT – 3
FIRE AND SPECIAL PERILS INSURANCE

INTRODUCTION

Fire insurance offers financial protection against property damage due to fire or specified special perils.

3.1 Subject Matter Insured – Examples of Insurable Property

- Building.
- Electrical installation.
- Contents of building (plant & machinery, equipment, accessories)
- Goods in open/storage in building, Raw material, in process, semi finished, finished, packing materials,
- Utility, boiler, water treatment plant, sub-station, pump-house
- Furniture, fixtures, fittings,
- Pipelines (including content), inside/outside premises.
- Contents in dwelling, shops, hotels etc.

The standard fire and special perils policy covers the following perils:

The perils specified in the policy are -

1. Fire

Excluding destruction or damage caused to the property insured by -

(a) (i) its own fermentation, natural heating or spontaneous combustion.

(ii) its undergoing any heating or drying process.

(b) Burning of property insured by order of any Public Authority:

Note: Spontaneous Combustion can be covered at extra premium

2. Lightning

3. **Explosion / Implosion**

Explosion / Implosion cover excludes loss, destruction of or damage.

(a) To boilers (other than domestic boilers) or their contents resulting form their own explosion / implosion.

(b) Caused by centrifugal forces.

Note: This risk be covered by Boiler Explosion policy in Engineering Insurance

4. **Aircraft Damage**

Destruction or damage caused by Aircraft, other aerial or space devices and articles dropped there from excluding those caused by pressure waves.

5. **Riot, Strike and Malicious Damage**

Loss of or visible physical damage or destruction by external violent means directly caused to the property insured by riot, strike, and malicious damage.

Terrorism damage exclusion warranty:

Notwithstanding any provision to the contrary within this insurance it is agreed that this insurance excludes loss. Damage cost or expense directly or indirectly caused by, any act of terrorism.

For the purpose of this endorsement an act of terrorism means an act, including but not limited to the use of force or violence and / or the threat thereof, of any person or group(s) of persons whether acting along or on behalf of or in connection with any organization(s) or government(s), committed for political, religious, ideological or similar purpose including the intention to influence any government and / or to put the public, or any section of the public in fear.

Terrorism cover

When the insured opts for Terrorism Damage cover by paying additional premium as provided, cover will be granted by attaching an endorsement:

Terrorism cover will be a separate cover which can be granted only in conjunction with Riot, Strike and Malicious Damage cover (RSMD), Terrorism cover will not be given in isolation without RSMD cover.

Deductibles

Every claim under terrorism cover will be subject to a deductible as under:

Industrial Risks:	0.5% of Total Sum Insured subject to a minimum of Rs.1 Lakh.
Non-industrial Risks:	0.5% of Total Sum Insured subject to a minimum of Rs.25,000/-

6. **Storm, Cyclone, Typhoon, Tempest, Hurricane, Tornado, Flood and Inundation**

The natural perils cover is defined as :

Loss, destruction or damage directly caused by Storm, Cyclone, Typhoon, Tempest, Hurricane, Tornado, Flood or Inundation excluding those resulting from earthquake, volcanic eruption or other convulsions of nature (wherever earthquake cover is given as an "add cover" the words " excluding those resulting form earthquake, volcanic eruption or other convulsions of nature" shall stand deleted.)

7. **Impact Damage**

Loss or visible physical damage or destruction caused to the property insured due to impact by any Rail / Road vehicle or animal by direct contact not belonging to or owned by –

(a) The insured or any occupier of the premises or

(b) Their employees while acting in the course of their employment.

8. **Subsidence and Landslide including Rockslide**

"Loss, destruction or damage directly caused by subsidence of part of the site on which the property stands or Landslide/Rockslide excluding…."

(a) The normal cracking, settlement or bedding down of new structures

(b) Demolition, construction, structural alterations or repair of property or ground works or excavations.

9. **Bursting and/or Overflowing of Water Tanks, Apparatus and Pipes**

10. **Missile Testing Operations**

11. **Accidental Leakage from Automatic Sprinkler Installations**

12. Bush Fire

Excluding destruction or damage caused by forest Fire.

3.2 General Exclusions

This policy does not cover –

(a) The first 5% of each and every claim subject to a minimum of Rs.10,000/- in respect of each and every loss arising out of "Act of God" perils such as Lightning, STFI, Subsidence, Land slide and Rockslide.

(b) The first Rs.10,000/- for each and every loss arising out of other perils (the excess is not applicable to dwellings).

(c) Loss, destruction or damage caused by war, and kindred perils.

(d) Loss, destruction or damage directly or indirectly caused to the property insured by nuclear peril.

(e) Loss destruction or damage caused to the insured property by pollution or contamination excluding -

  (i) Pollution or contamination which itself results form a peril hereby insured against.

  (ii) Any peril hereby insured against which itself results from pollution or contamination.

(f) Loss, destruction or damage to bullion or unset precious stones, curios or works of art for an amount exceeding Rs.10,000/- manuscripts, plans, drawings, stamps, coins or paper money, cheques, books of accounts or other business books, computer systems records, explosives etc. Unless otherwise expressly stated in the policy.

(g) Loss, destruction or damage to the stock in cold storage premises caused by change of temperature.

(h) Loss, destruction, or damage to any electrical machine, apparatus, fixture or fitting arising from or occasioned by over-running, excessive pressure, short circuiting, arcing, self-heating or leakage of electricity from whatever cause (lightning included) provided that this exclusion shall apply only to the particular electrical machine, apparatus, fixture or fitting so affected an not to other machines, apparatus, fixture of fitting which may be destroyed or damaged by fire so set up.

This is known as "electrical Risks" exclusion. These risks can be covered under Machinery Insurance policy (Engineering Insurance).

It is to be noted that only damage to the particular electric machine, etc by specified electrical risks is excluded; but resulting fire damage to other machines, etc is covered.

(i) Expenses incurred on

(a) Architects, Surveyors and Consulting Engineer's Fees; and

(b) Debris Removal necessarily incurred by the insured following a loss destruction or damage to the property insured by an insured perils in excess of 3% and 1% of the clam amount respectively.

Note: Cover for expenses in excess of 3% and 1% can be arranged by endorsement

The other exclusions under the policy are –

(a) Loss or damage by spoilage from the interruption of any process caused by any of the perils covered.

(b) Loss or damage by earthquake.

(c) Loss or damage to insured property if removed to any building or place other than the insured premises (except machinery temporarily removed for repairs etc for a period not exceeding 60 days)

(d) Theft during or after the occurrence of any insured perils.

Note: Add-on cover is available for (a), (b), and (c)

3.3 Sum Insured

3.3.1 Market value basis/depreciated value basis which is arrived at by deducting, depreciation from its present day replacement value.

3.3.2 Reinstatement value basis, which is arrived at by reinstating the property with same kind or type by new property.

3.4 Period of Insurance

3.4.1 Usually 12 months, expires at mid-night on last day.

3.4.2 The policy can be taken for short period by paying short period rate.

3.5 Premium Rate

Premium rate depends on following:

1. Nature of industry
2. Nature of storage in open/inside building etc.
3. Nature of property
4. Nature of operation/construction/processing etc.
5. Nature of segregation of property etc.

3.6 Policy Conditions

3.8.1 Refers to misrepresentation, misdescription or non-disclosure of material facts. In such event the policy becomes voidable.

3.8.2 Refers policy ceases after 7days from the date of fall or displacement of any building or part thereof. Insurer can continue on revised terms.

3.8.3 Refers to discontinuing risk, if there is any change in risk insured must inform insurer.

3.8.4 If there is concurrent marine policy claim will be preferred in marine and then under fire.

3.8.5 Cancellation of policy by insured on short period basis of premium rates, cancellation of policy by insurer on pro rata basis of premium rates.

3.8.6 Refers to duty of insured after happening of claim, notice of claim, 15days to file claim details, of other insurances going to court, arbitration, etc.

3.8.7 Refers to rights of insurers after the happening of claim, this does mean that insured cannot abandon damaged property, whether the insurers takes possession or not.

3.8.8 Refers to fraudulent false, claim willful negligence, etc all benefits will be forfeited.

3.8.9 Refers to option available to the Insurance Company to reinstate or replace instead of paying claim, i.e. when insured prefers highly exaggerated claim.

3.8.10 Refers to condition of average, when sum insured selected in policy is lower than its value. This is the condition of average. An insured is expected to insure his property for its full value. In the event of claim if it is found that he has not covered the property for its full value, then he has to bear a portion of the claim on his own account.

Example

Value of property = Rs.2,00,000/-

Sum insured = Rs.1,50,000/-

Loss = Rs.80,000/-

The amount payable = $\frac{1,50,000}{2,00,000} \; x \;\; 80,000 \;\; = \;\; Rs.60,000/-$

3.8.11 Refers to condition of contribution, i.e. risk covered in more than one policy.

3.8.12 Refers to condition of subrogation, i.e. if third party is responsible for causing damage.

3.8.13 Refers to provision for arbitration.

3.8.14 Refers to all communication to insurers in writing or printed.

3.8.15 Refers to re-instatement of sum insured i.e. after the claim is Settled the sum insured is required to be reinstated by paying premium.

3.7 Extensions (Add on covers)

1. Architects fees in excess of 3.0%
2. Debris removal expenses in excess of 1.0% of claim amount
3. Deterioration of stocks in cold storage premises due to temperature rise
4. Spontaneous combustion
5. Forest fire
6. Impact damage
7. Omission to insure, additions alterations or extensions
8. Earthquake (shock and fire)
9. Spoilage material damage cover under a separate item in the policy
10. Temporary removal
11. Loss of rent
12. Start up expenses
13. Escalation clause

Escalation clause:

This clause, applicable to policies on buildings, machinery and accessories only, can be incorporated in policies on payment of additional premium.

The clause allows automatic regular increase, not exceeding 25% in the Sum Insured throughout the period of the policy. The automatic increase operates from the date of inception up to the date of occurrence of any of the insured perils. Pro rata condition of average will apply as usual.

3.8 Special Policies

1. **Floater Policy**

   These policies cover stock at various specific locations under one sum insured. The insured may have stocks in two or more godowns, He is able to declare for insurance the total value of goods in all godowns but not separate values for each godown.

   Unspecified locations are not allowed. Similarly, in a manufacturing risk, the stocks in the process blocks, godowns and /or in the open can be covered under one sum insured

2. **Declaration Policies**

   To take care of frequent fluctuations in stocks / stock values, Declaration policy(ies) can be granted subject to the following conditions.

The policy is issued for a sum insured selected by the insured (Insurers stipulate a minimum Sum Insured).

a. Monthly declarations based on the average of the value at risk on each day or highest value on any day of the month shall be submitted by the insured. If declarations are not received within the specified period, the full Sum Insured under the policy shall be deemed to have been declared.

b. Refund of premium on adjustment based on the declaration / cancellation shall not exceed 50% of the total premium.

Illustration

Sum Insured	Rs.1,00,00,000 (1 crore)
Rate	Re.1/- per mille
Premium	Rs.10,000/-

Monthly declaration:

January	52,00,000
February	56,00,000
March	46,00,000
April	46,00,000
May	30,00,000
June	30,00,000
July	30,00,000

August	30,00,000
September	40,00,000
October	40,00,000
November	40,00,000
December	40,00,000

Total Declaration	-------------	Rs.4,80,00,000/-
Average Sum Insured	Rs.40,00,000/-	
Premium		Rs.10,000/-
Premium on average S.I.		Rs.4,000
		Rs.6,000

According to rules above refund cannot exceed 50% of the total premium. Therefore, refund is Rs.5,000/- and not Rs.6,000/-

2. Reinstatement Value Policy

This is the fire policy with the reinstatement value clause attached to it. The clause provides that in the event of loss, the amount payable is the cost of reinstating property of the same kind or type, by new property.

This basis of settlement differs from the basis under the fire policy where the losses are settled on the basis of market value i.e. making deductions for depreciation, etc.

The reinstatement value clause incorporates the following special provisions:

(a) Reinstatement must be carried out by the insured and completed within 12 months after the destruction of damage, failing which the loss will be settled on the normal indemnity basis i.e. according to the fire policy.

(b) The reinstatement basis of settlement will not apply.
  - If the insured fails to intimate to the insurer within 6 months or any extended time his intention to replace the damaged property.
  - If the insured is unable or unwilling to replace the damaged property. In such cases the loss will be settled on the normal basis of indemnity.

(c) The work of reinstatement may be carried out upon another site and in any manner required by the insured provided the liability under the policy is not thereby increased.

These insurances are granted to insured whose bonafide are satisfactory and, are generally issued only in respect of building, plant and machinery in a comparatively new condition.

These insurances are not granted on stocks.

3. Industrial All Risks Policy

This is package cover designed for industrial risks (both manufacturing and storage facilities) with an overall sum assured of Rs.100 crores and above. The policy provides cover for the following:

- Fire and special perils
- Burglary
- Machinery Breakdown / Boiler Explosion / electronic equipment (Material Damage)
- Business Interruption (Fire & allied perils)
- Business Interruption (machinery Breakdown). This is an optional cover.

Discounts in rates are provided. Under insurance of up to 15% is permitted. Apart from the reduced costs of premium, there is administrative convenience both for the insured and the insurer.

3.9 Consequential Loss (Fire) Insurance

Fire insurance is designed to provide protection in respect of loss of or damage to buildings, machinery, furniture and fittings, goods and merchandise, etc. by fire and allied perils. The insurance affords cover for "material damage". However an indemnity for the "material damage" does not provide complete protection to the insured who may also suffer trading losses due to total or partial stoppage of the business.

The purpose of consequential loss or loss of profit insurance (also known as Business Interruption Insurance) is therefore, to make good these losses, namely net profit, standing charges and increased cost of working.

Turnover of a business consists of the following elements:

(a) Variable Charges:

These are expenses incurred in producing the goods (e.g. purchase of raw materials, wages, etc.)

(b) Standing Charges:

These expenses are fixed in amount irrespective of the volume of the business transacted (e.g. taxes, bank interest, salaries to permanent staff, etc.)

(c) Net Profit:

This is turnover minus variable and standing charges.

(d) Gross Profit:

Standing charges, and net profit together constitute the gross profit of the business.

Indemnity Period

The profits policy provides indemnity in respect of loss of gross profits during the indemnity period which is selected by the insured. The indemnity period chosen by the insured may vary from 3 months to 3 years.

The indemnity period is to be distinguished from the period of insurance which is usually a year; the insured peril must occur during the period of insurance and the indemnity period commences on the date of loss and terminates when the business returns to normal level or on the completion of selected period whichever is earlier.

The Sum Insured

The sum insured is to be fixed by the insured. As the indemnity provided by the consequential loss policy is in respect of loss of gross profits for the indemnity period naturally the sum insured should represent the gross profits of the indemnity period selected. Where the indemnity period is 12 months or lees, the sum insured should be the annual amount of the gross profit i.e. the annual amount of the net profit and the insured standing charges. Where the indemnity period is 24 months, the sum insured should represent twice the annual gross profit and so on.

The sum insured is to be computed form the insured's accounts. The standing charges have to be computed from the insured's accounts. The standing charges have to be specified by the insured. Some examples of the standing charges are :-

- Interest on loans, bank overdrafts and debentures, including brokerage on deposits;
- Rent;
- Directors fees and remuneration;
- Legal, auditing and other professional fees and expenses;
- Insurance premiums;
- Advertising and publicity expenses;
- Conveyance, Stationery, Postage, Telephone, Telex, Telegram, Telephone expenses;
- Office and General Establishment expenses;
- Salaries to permanent staff including Employees State Insurance contributions;
- Wages including Employees State Insurance contributions etc.

When Loss becomes Payable

(a) Fire or other insured peril must occur at the insured premises
(b) Property used for the business of the insured at the insured premises must be destroyed or damaged and the loss must be admissible in material damage policy.
(c) The business must be interrupted or interfered with as a consequence.
(d) The resulting loss is paid in accordance with the provisions of the policy.

Note: A formula is incorporated in the policy to calculate the loss. (This is known as "specification").

Payment of loss under the L.O. P. policy is subject to payment or admission of liability for the loss under the material damage insurance i.e. fire and special perils policy. (This is the material damage clause)

UNIT – 4

CLAIM

4.1 The processing and settlement of claims is one of the important functions in an insurance organization. Indeed, the payment of claims may be regarded as the primary service of insurers to the public.

For proper settlement of claims, it is necessary to have a sound basic knowledge of General Law of Contract as applicable to insurance and the special principles of law governing in Insurance contracts. In addition it is necessary to have a thorough knowledge of the terms, conditions and warranties incorporated in the policies as also the loss assessment procedures.

The settlement of claims has to be prompt as well as fair. It is also necessary that the personnel handling claims must have the personal qualities of patience, tact, diplomacy and courtesy.

The settlement of claims involves examination of the loss in relation to the coverage under the policy and compliance with policy conditions and warranties;

The first aspect to be dealt with is whether the loss is within the scope of the policy. The legal doctrine of proximate cause provides guidelines to decide whether the loss is caused by an insured peril or an excepted peril.

The burden of proof, or to use the legal expression, the onus of proof that the loss is within the scope of the policy is upon the insured. However, if the loss is caused by an excepted peril the onus of proof is on the insurer. However, this onus of proof under some policies is shifted back to the insured so that he has also to prove that the loss was not caused by an excepted peril.

The second aspect to be decided is whether the insured has complied with policy conditions, especially conditions which are precedent to liability. These conditions relate to immediate notification of loss to the insurers, submission of proof of cause and extent of loss, providing assistance and cooperation to the insurers in recovering losses from third parties, or others responsible for the loss.

If a breach of condition is alleged, the onus of proving it is on the insurers. If the insurers, after having learnt of breach of conditions, have ignored the breach then they are deemed to have waived their rights and cannot rely upon the breach of condition to repudiate liability.

The third aspect is in respect of compliance with warranties. The survey report would indicate whether or not warranties have been complied with. Insurers, however, take a liberal view when the breach of warranty is purely of a technical nature and is not in any way connected with the cause of loss or the extent of loss.

The fourth aspect relates to the examination of the observance of utmost good faith by the proposer before the conclusion of the contract, and if provided by policy conditions, during the currency of the policy. Especially on the occurrence of a loss the insured is expected to act as if he is uninsured. In other words, he has a duty to take measures to minimize the loss.

The fifth aspect concerns the determination of the amount payable. The amount of loss payable is subject to the sum insured. However, the amount payable will also depend upon the following:

(i) The extent of the insured's insurable interest in the property affected
(ii) The value of salvage
(iii) Application of pro-rata average
(iv) Deduction for any excess or franchise
(v) Application of contribution and subrogation conditions

The sixth aspect relates to resolution of disagreement between the insurers and the insured. The majority of property and liability policies incorporate an Arbitration condition to resolve disputes regarding the amount of loss, the liability being admitted under the policy. If question of liability is involved, the matter has to be settled through a court of law. In marine policies there is no arbitration condition.

The final aspect deals with recovery from the third parties under subrogation proceeding and requisite contributions from co-insurers, facultative and treaty reinsures, etc.

4.2 The claims which are dealt with under insurance policies fall into the following categories:

(a) Standard claims:
These are claims which are clearly within the terms and conditions of the policy. Settlement of these claims present no difficulty.

(b) Non-Standard claims:
These are claims where the insured has committed a breach of condition or warranty. The settlement of these claims is considered subject to certain rules and regulations framed by the insurers.

(c) Ex-gratia payments:
These are losses which fall outside the scope of cover under the policy and hence are not payable. However, in very special cases, to avoid hardship to the insured, settlement of these losses is considered as a matter of grace. For example, due to genuine oversight a certain item of property is not included in the insurance although it was the intention of the insured to include it.
Ex-gratia settlements are never made on the basis of the full amount of the loss. A certain percentage only is paid.

Also, such claims are paid “without precedent” so that the insurers do not have an obligation to meet similar claims in future. Although, there is no legal liability to pay for such losses yet the courts have approved of such settlements. In the English case Taunton vs. Royal Insurance Co., the court held that the directors were authorized, for the benefit of the business, under the discretionary powers vested in the managers of a trading concern to pay such losses, the payment being akin to an expenditure upon an advertisement. Thus ex-gratia payments can be justified on grounds of good business policy.

Since the payments are made without admission of legal liability, subrogation rights do not arise under these payments. Where co-insurance is involved the leading office has to consult the co-insurers before deciding on ex-gratia settlement. In any case, ex-gratia payments require the approval of the Boards of Directors of the companies.

4.3 Claim Settlement – Preliminary Procedure

4.3.1 Notice of loss

1. Policy conditions usually provide that the loss be intimated to the insurer immediately. The purpose of an immediate notice is to allow the insurer to investigate a loss at its early stages.
2. Under certain types of policies (e.g. Burglary) notice is also to be given to police authorities. Under Rail transit cargo policies, notice has to be served on the Railway also.

4.3.2 On receipt of intimation of loss or damage insurers check that:

- The policy is in force on the date of occurrence of the loss or damage;
- The loss or damage is by a peril insured by the policy;
- The subject matter affected by the loss is the same as is insured under the policy; and
- Notice of loss has been received without undue delay.

4.3.3 Investigation and assessment of loss

Surveyor will carry out investigation for following Property damaged. What is the most probable cause of damage?

If property will be repaired/ replaced or combined, no temporary repairs will be permitted; Photographs will be taken as evidence. Surveyor will assess the cost of repairs/replacements and give final assessment.

4.3.4 Survey report

Surveyor may give preliminary/ interim /final report considering status of claim progress. Surveyor may give adjustment of loss in terms of policy conditions. It will include salvage, under insurance, deductibles, parts not payable etc. He must give clear opinion regarding cause of damage and if that is covered in terms of insurance contract. He must give opinion about sum insured of damaged item and its replacement value as on the date of damage.

Insured will submit claim form, photographs and estimate/bills of repairs to surveyors to facilitate the procedure of claim.

4.3.5 Insurer will offer claim settlement along with claim discharge voucher.

4.3.6 Arbitration

If the claim is payable and there is difference of opinion regarding quantum of loss, insured can go for arbitration. If there is difference of opinion regarding cause of damage, the insured can go to court of law within 12 months from date of disclaimer.

4.3.7 Salvage

The parts, which require repairs/replacements will become property of insurer, Surveyors must assign / assess salvage value, which must be deducted from claim amount.

4.3.8 Recoveries

After the claim settlement, the insurers under the law of subrogation are entitled to the rights and remedies of the insured and to recover the paid loss from third party who may be responsible for loss under respective law applicable.

4.3.9 Loss minimization

Surveyors are finding out the cause of damage/accident and therefore they have to suggest the measures of loss minimization in their survey report for avoiding the loss in future.

4.3.10 Reinsurance

If a policy is having reinsurance, then the loss can be recovered from reinsurers. Details may be submitted to reinsurers.

UNIT – 5

EXAMPLES – PRINCIPLES OF CLAIM SETTLEMENT

5.1 Example on Reinstatement Basis

M/s. Adarsh Chemicals had taken a Fire and Special Perils Insurance Policy for their Chemical Plant at Karamsad for the period 01/01/03 to 31/12/03 on Reinstatement value basis as under:

Item	Sum Insured
a. Building	Rs.1,00,00,000/-
b. Plant and Machinery	Rs.3,50,00,000/-
c. Electrical Installation including sub-station	Rs.75,00,000/-
d. Furniture Fixtures and Fittings	Rs.40,00,000/-
e. Stocks and Stocks in Process	Rs.3,00,00,000/-

On 25th February 2003 there was a fire in the plant and they reported the loss to their insurance company. The insurance Company appointed M/s. Arun Dasgupta & Co. as surveyor, who surveyed the loss and submitted their final Survey Report on April 15th, 2003. Following is an extract from the survey report.

1. Fire affected building was partly repaired and replaced and the cost incurred was Rs.12,00,000/- The reinstatement value of the building was found to be Rs.1,20,00,000/- on the date of repair completion/reinstatement.
2. The cost of repairs and replacement of Plant and Machinery affected by the fire was Rs.57,00,000/- net of salvage. The re-instatement value of the plant and machinery was found to be Rs.5,25,00,000/- at the time of reinstatement.
3. Electrical installation was affected by fire to the extent of Rs.8,00,000/- its present re-instatement cost was Rs.1,00,00,000/-
4. Furniture Fixtures and Fittings were affected to the extent of Rs.9,00,000/- by fire and were re-instated by them. The re-instatement value of Furniture Fixtures and Fittings was Rs.60,00,000/- on the date of the loss.

5. Cost of stocks and stocks in process was affected by fire to the extent of Rs.30,00,000/- (market value). The sum insured was adequate.

Insured had incurred a cost of removal of debris of Rs.1,25,000/-
What is amount of claim M/s. Adarsh Chemicals will get from the insurance company?
Compute the loss on reinstatement basis.

SOLUTION
(Assessment on Reinstatement value basis)

A. <u>Building</u>

Repairs to building	Rs.12,00,000/-
Insured value	Rs.1,00,00,000/-
Reinstatement value	Rs.1,20,00,000/-

They are found under insured in the proportion of

$$\frac{1,00,00,000}{1,20,00,000}$$

Therefore claim payable on building will be

$$12,00,000 \times \frac{1,00,00,000}{1,20,00,000} = \text{Rs.}10,00,000/- \qquad \text{(A)}$$

B. **Plant & Machinery**

Repairs and replacement of Plant & Machinery	Rs. 57,00,000/-
Insured value of Plant & Machinery	Rs. 3,50,00,000/-
Reinstatement value of Plant & Machinery	Rs. 5,25,00,000/-

They are found under insured in the proportion of

$$\frac{3,50,00,000}{5,25,00,000}$$

Therefore claim payable on plant & machinery will be

$$57,00,000 \times \frac{3,50,00,000}{5,25,00,000} = \text{Rs.}38,00,000/- \qquad \text{(B)}$$

C. **Electrical Installations**

Repairs/replacements	Rs. 8,00,000/-
Insured value	Rs. 75,00,000/-
Reinstatement value	Rs.1,00,00,000/-

They are found under insured in the proportion of

$$\frac{75,00,000}{1,00,00,000}$$

Therefore claim payable on electrical installations will be

$$8,00,000 \times \frac{75,00,000}{1,00,00,000} = \text{Rs.}6,00,000/- \qquad \text{(C)}$$

D. **Furniture, Fixtures and Fittings**

Cost of Repairs/replacement	Rs.9,00,000/-
Insured value	Rs.40,00,000/-
Reinstatement value	Rs.60,00,000/-

They are found under insured in the proportion of

$$\frac{40,00,000}{60,00,000}$$

Therefore claim payable on furniture, fixtures and fittings will be

$$9,00,000 \times \frac{40,00,000}{60,00,000} = \text{Rs.}6,00,000/- \qquad \text{(D)}$$

E. **Stocks and Stocks in Process**

Stocks value affected (market value) Rs. 30,00,000/-
Insured value (market value basis) Rs.3,00,00,000/-
(No under insurance)

Therefore claim payable on stocks will be Rs.30,00,000/- (E)

Therefore total claim will be Rs. A + B + C + D + E

= Rs.10,00,000 + Rs.38,00,000 + Rs.6,00,000 + Rs.6,00,000 + Rs.30,00,000
= Rs.90,00,000/-
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Removal of debris claim

As the insured has not covered the ADD ON cover for removal of debris, insured is covered for removal of debris only up to 1.0% of claim amount i.e. Rs.90,000/- and therefore insured will get claim only up to Rs.90,000/- out of their claim for Rs1,25,000/-.

Final claim of insured will be Rs.90,00,000 + Rs.90,000 = Rs.90,90,000/-
An excess of Rs.10,000/- will be further applicable

5.2 Example on Market Value Basis

M/s. Indian Chemicals had taken a Fire and Special Perils Insurance Policy for their Chemical Plant at Vadodara for the period 01/01/05 to 31/12/05 on market value basis as under

Item	Sum Insured
a. Building	Rs.1,00,00,000/-
b. Plant and Machinery	Rs.3,50,00,000/-
c. Electrical Installation including sub-station	Rs.75,00,000/-
d. Furniture Fixtures and Fittings	Rs.40,00,000/-
e. Stocks and Stocks in Process	Rs.3,00,00,000/-

On 25th February 2005 there was a fire in the plant and they reported the loss to their insurance company. The insurance Company appointed M/s. Arun Dasgupta and Co. as surveyor, who surveyed the loss and submitted their final Survey Report on April 15th, 2005.

Following is an extract from the survey report:

1. Fire affected building was partly repaired and replaced and the cost incurred was Rs.12,00,000/-. The reinstatement value of the building was found to be Rs.1,20,00,000/- on the date of repair. Market value was Rs.1,08,00,000/-arrived at by deducting 10% depreciation from RIV on date of damage.
2. The cost of repairs and replacement of Plant and Machinery affected by the fire was Rs.57,00,000/-. The re-instatement value of the plant and machinery was found to be Rs.5,25,00,000/- on the date of damage. Market value was Rs.3,94,00,000/- arrived at by deducting 25% depreciation from RIV on the date of damage.
3. Electrical installation was affected by fire to the extent of Rs.8,00,000/- its present re-instatement cost was Rs.1,00,00,000/- on the date of damage. Market value was Rs.80,00,000/- arrived at by deducting 20% depreciation from RIV on the date of damage.
4. Furniture Fixtures and Fittings were affected to the extent of Rs.9,00,000/- by fire and were re-instated by them. The re-instatement value of Furniture Fixtures and Fittings was Rs.60,00,000/- on the date of the loss, market value was Rs.48,00,000/- arrived at by deducting depreciation of 20% from RIV on the date of damage.

5. Cost of stocks and stocks in process was affected by fire to the extent of Rs.30,00,000/-(market value).

Insured had incurred a cost of removal of debris of Rs.1,25,000/-

What is amount of claim M/s. Indian Chemicals will get from the insurance company? Compute the loss on the market value basis. Assume that fire has taken place after 5 years of operation.

SOLUTION

(Assessment on Market value basis)

A. <u>Building</u>

Repairs to building	Rs.12,00,000/-
Insured value	Rs.1,00,00,000/-
Reinstatement value	Rs.1,20,00,000/-

Less depreciation 10% = Rs.12,00,000/- (at 2% per year or part thereof)

Therefore market value = Rs.1,08,00,000/-

The insured were found under insured on market value basis and under insurance is applicable as under:

$$10,80,000 \times \frac{1,00,00,000}{1,08,00,000} = \text{Rs.}10,00,000/- \qquad \text{(A)}$$

B. <u>Plant & Machinery</u>

Cost of Replacements net of salvage	Rs. 57,00,000/-
Insured value	Rs.3,50,00,000/-
Reinstatement value	Rs.5,25,00,000/-

Less depreciation 25% = Rs.1,31,25,000/- (at 5% per year or part thereof for 5 years)

Therefore market value = Rs.3,94,00,000/-

The insured were found under insured on market value basis and under insurance is applicable as under:

$$42,75,000 \times \frac{3,50,00,000}{3,94,00,000} = \text{Rs.}37,97,589/-$$

Say Rs.38,00,000/- (B)

C. <u>Electrical Installations</u>

Cost of Reinstatement by repairs/replacements	Rs. 8,00,000/-
Insured value	Rs. 75,00,000/-
Reinstatement value	Rs.1,00,00,000/-

Less depreciation 20% = Rs.20,00,000/- (at 4% per year or part thereof for 5 years)

Therefore market value = Rs.80,00,000/-

The insured were found under insured on market value basis and under insurance is applicable as under:

$$6,40,000 \times \frac{75,00,000}{80,00,000} = \text{Rs.}6,00,000/- \qquad (C)$$

D. <u>Furniture, Fixtures and Fittings</u>

Cost of Reinstatement by repairs/replacement	Rs.9,00,000/-
Insured value	Rs.40,00,000/-
Reinstatement value	Rs.60,00,000/-

Less depreciation 20% = Rs.20,00,000/-

Therefore market value = Rs.80,00,000/-

The insured were found under insured on market value basis and under insurance is applicable as under:

$$7,20,000 \times \frac{40,00,000}{48,00,000} = \text{Rs.}6,00,000/- \qquad \text{(D)}$$

E. <u>Stocks and Stocks in Process</u>

Stocks value affected (market value)	Rs. 30,00,000/-
Insured value (market value basis)	Rs.3,00,00,000/-
Total market value - fully insured	Rs.3,00,00,000/-

The insured were adequately covered and they get their claim in full for

Rs.30,00,000/- (E)

Therefore total claim will be Rs. A + B + C + D + E

= Rs.10,00,000 + Rs.38,00,000 + Rs.6,00,000 + Rs.6,00,000 + Rs.30,00,000

= Rs.90,00,000/-

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Removal of debris claim

As the insured has not covered the ADD ON cover for removal of debris, their claim is covered in the policy to the extent of 1% of claim amount = Rs.90,000/- out of Rs.1,25,000/-.

<u>Final claim on Market Value</u>

<u>Insured will get total claim of Rs.90,00,000 + Rs.90,000 = Rs.90,90,000/-</u>

An excess of Rs.10,000/- will be further applicable

5.3 Guiding Principles of Claim Settlement

1. Insured must have insurable interest in property damage at the time of claim.
2. There must be insurance contract and property should be damaged by perils covered in the policy, (claim is admissible) if damage is caused by more than one peril use principle of proximate cause and arrive at efficient, powerful, effective cause.
3. Surveyor must assess the claim after physical inspection of damaged property, observe the principle of indemnity and observe the basis of claim settlement provided in the policy.
4. Surveyor must list out the damaged parts and assess the salvage value of damaged parts, if insured wants to retain damaged parts as emergency spares, surveyor should give proper comment on the same.
5. If the damage is caused, for which third party is responsible the subrogation rights must be reserved for insurer.
6. If the property insured is covered with more then one insurance company the condition of contribution must be observed.
7. If the cause of damage is not clear, surveyor must resort to laboratory testing and try to find the most probable cause of damage.
8. If there is breach of any warranty surveyor must bring it to the notice of insurer and insured.
9. If there is any difference of opinion, surveyor must consult insurer and appoint technical expert.

UNIT – 6

OBLIGATIONS AND RIGHTS OF INSURER AND INSURED

6.0 OBLIGATIONS AND RIGHTS OF INSURER & INSURED, DUTIES OF THE INSURER AND THE INSURED

All insurance policies impose certain duties on the insured. Some of the duties are supplemented by the common law, state statutes and regulations. Similarly the duties of the insurer are implied by insurance contracts and it is strengthen by Protection of Policyholders' Interest Regulations framed by Insurance Regulatory and Development Authority of India.

6.1 The rights, duties and obligations of the Insured are briefed below.

1. Obligation to pay the premium to purchase the insurance policy, to examine the policy and to decide the exercise of free look period as allowed by the policy.
2. Duty to observe utmost good faith while purchasing the policy and throughout the policy period. The misrepresentation can void a policy. This is the application of honesty.
3. To act/behave as if uninsured and take all reasonable steps to protect the subject matter. If it is discovered that the insured is behaving recklessly or in a way that could invite the loss or increase the loss or liability, the claim will be prejudice.
4. Duty to notify the loss or claim to the insurer. The policy condition provides the time limit (normally forthwith) for claim intimation and also for other compliance.
5. To notify all material facts concerning to the incident and the loss or underlying claim.
6. To provide proof of loss and required documents.
7. The duty to cooperate with the insurer and the surveyor.
8. The duty requiring the insurer's consent for incurring the defence cost.
9. In case of property damage claim, the duty to take all reasonable and necessary steps to prevent further damage after the loss.
10. Duty and obligation to protect the rights of subrogation. When the Insured has a right of recovery from the third party who is responsible for the loss, the insured has to take all steps to protect the right of recovery and to subrogate his right to the insurance company as per the policy condition and common law.
11. Right of indemnification i.e. right to receive the claim as per the terms, coverage, limitations and compliance of the policy.

6.2 The rights, duties and obligations of the Insurer are briefed below.

1. It is the duty of the insurer to ensure that
   a. Interest of the insurance policy holders (insured) is protected.
   b. Insurer, distribution channels and other regulated entities fulfil their obligations towards policyholders and have in place standard procedures and best practices in sale and services of insurance policies.
   c. Policy holders-centric governance by insurer with emphasis on grievance redressal.
2. Duty to defend the Insured. It is insurer's obligation to provide an insured with defense to claim made under a liability insurance policy.
3. Duty to gain the insured's cooperation. It is the duty of the insurer to maintain good relationship with the insured. Each party must be able to rely on one another and abide by the guidelines of their end.
4. The duty of good faith and fair dealing. The insurer owes a duty to deal fairly and in good faith with its insured. The duty at the time of entering contract is to provide all details of coverage. The timely issuance of policy. Fair dealing and supporting at the time of claim.
5. The duty to settle the claims/pay benefits. Insurer should be careful to make settlement offers based on a realistic evaluation of the covered exposure. Once the insured contingency/accident happens and the damages have been reviewed, if it is found that the claim qualifies based on the benefits, time periods and exclusions given in the policy, it is the duty of the insurer to pay for it.
6. In case the claim is not admissible, it is the duty of the insurer to inform the insured giving reasons.
7. Privacy protection. It is the duty of the insured to protect the privacy of the insured.
8. It is the duty of insurer to adopt all required measures for the assessment of the risk and fixing the premium. The premium should be as per the associated risk.
9. Reserve for policy. It is the duty of the insurance company to set a side certain amount of income/premium for policy reserve. This will ensure the obedience of their commitment to pay the claim.

FOR DETAIL STUDY REFERANCE-
INSURANCE POLICY
COMMON LAWS AND PRINCIPLES OF INSURANCE
IRDAI NOTIFICATION. PROTECTION OF POLICYHOLDERS' INTEREST.

SUPPLEMENTARY READING (from PME guidelines 2015)

(A) **Fire Insurance Policy** is a contract of indemnity with a view to place the Insured in same or similar pre-damage position. Thus, at the time of loss or destruction of any used asset, the insured is able to obtain a depreciated value by way of a claim from the Insurers which is value as new at the time of damage less depreciation for the use made over the years of usage. The quantum of depreciation provided in the books of account is not of any consequence; as such depreciation is charged on the original cost (purchase price) and moreover repairs and maintenance carried out by the owner is not reflected in the depreciation calculation. The value as new at the time of damage, due to price rise and inflation is much higher than the original cost.

Further, the amount of depreciation charged in the account books is never kept aside in cash form or separately funded and is used up in the industrial operation or expansion, i.e., either in working funds or in capital assets. As a result, the insured had to find a fresh flow of funds to reinstate the destroyed assets to the extent of the depreciation deducted in the claim. If there is any under-insurance, the proportionate loss is borne by the insured and the amount of depreciation together in aggregate would be the fresh funds requirement. In the absence of such funds availability, the insured would normally be forced to give up the rehabilitation or replacement of the destroyed asset. This is the drawback of market value policy.

Keeping the above factors in mind and to meet the varying needs of different types of industries and trade, special types of policies have been designed with certain changes in the basis of indemnity under fire insurance policy by providing **variations to Principle of Indemnity**. The **Reinstatement Value (RIV)** is one of such variations. RIV policy is discussed in detail later.

(B) **Insurance valuation under Indian context**

(i) **Contract of insurance**

All insurance contracts are inter alia contracts of indemnity except personal accident, i.e. the Insurer undertakes to place the Insured in the same position before the damage subject to adequate sum insured and subject to policy conditions, clauses, warranties.

(ii) Fire insurance covers

The standard fire and special perils policy covers fire and allied perils like:-

- Fire
- Lightning
- Explosion / Implosion
- Aircraft damage
- Riot, strike, malicious damage
- Storm, cyclone, typhoon, tempest, hurricane, tornado, flood and inundation
- Impact damage
- Subsidence and landslide including rock slide
- Bursting and/or overflowing of water tanks, apparatus and pipes
- Missile testing operations
- Leakage from automatic sprinkler installations
- Bush fire

The above policy also covers following costs:-

- Architects' consultants' and surveyors' fee up to 3% of admissible claim amount
- Debris removal up to 1% of admissible claim amount

The cost for Architects' fee (above 3%) and debris removal (above 1%) can be insured at additional premium.

Earthquake and terrorism damage are not included in the standard policy referred above. However, an add-on cover for these can be taken separately as add on covers at extra premium.

(iii) In case of sum insured for building, machinery and stock exceeds ` 100 crores **Industrial All Risk Policy (IAR)** can be availed. Now in de-tariffed scenario the limit of ` 100 crores is relaxed and many insurers are giving IAR cover for sum insured of ` 50 crores. This policy covers fire and all special perils including flood, earthquake, burglary, machinery break-down, boiler explosion and electronic equipment insurance. The policy covers business interruption (fire & special perils) i.e. fire loss of profit cover. The policy provides option to cover business interruption due to machinery break-down i.e. machinery break-down loss of profit. The amount of ` 50 crores or any limit for IAR fixed by the insurer is not limited to one location but for any number of locations in India under single ownership.

The advantages of this policy are:-

- It includes covers for earthquake, burglary, machinery break-down, boiler explosion & electronic equipment.
- Lower rate of premium
- Machinery break-down risk is covered on single sum insured i.e. total value of plant and machinery in a plant and it is not required to specify each & every machinery with its value/sum insured.

(C) Indemnity

(i) Principle of indemnity:

Indemnity is compensation for actual material loss or damage sustained due to an insured peril. The indemnity is to secure against loss or damage and make good the loss as per policy terms and conditions. It is imperative to bear in mind that fire insurance contract is a contract of indemnity.

Insurers undertake to place the insured after the loss due to an insured peril in the same financial position as he was before the loss, neither better nor worse; profit of any kind out of insurance taken is not permissible under a fire policy. If it was possible to derive profit, abuse and malpractices would result.

Lord Mansfield states in a judgement as under:

"Fire Insurance was considered as an indemnity only, in case of a loss; and therefore the satisfaction ought not to exceed the loss. The rule of indemnity was calculated to prevent fraud, lest the temptation of gain should occasion unfair and willful losses".

That a contract of fire insurance is one of indemnity cannot be too strongly emphasized. A contract of fire insurance is fundamentally one of indemnity, since its object is to make good, within the limits of the amount of insurance, and subject to terms and conditions of the policy, the actual loss sustained and nothing more.

(ii) Insurable interest

It is necessary for the insured to have insurable interest in the insured property at time of loss in order to observe the principle of indemnity. Policy does not only insure property itself, but also the insured's interest in the property and measurement of loss is the extent of such interest in property damaged or destroyed by an insured peril.

The following items constitute insurable interest –

* Existence of a property capable of being damaged or destroyed by fire or an insured peril.
* Such property should be the subject matter of insurance.
* The proposer must stand in some legal relationship with this object, whereby he benefits by its safety or be prejudiced by its loss.
  Mere expectancy of interest is not sufficient.

(D) Utmost Good Faith

In addition to the general law of contract, the insurance contract is also subject to certain special principles under common law like utmost good faith.

In insurance contracts, the legal doctrine of "utmost good faith" applies. This casts on the insured, the positive duty to disclose all material facts which have bearing on the insurance. A breach of this duty may make the contract void or voidable depending upon the nature of the breach.

Material facts are those which would influence a prudent insurer in his decision as to acceptance of insurance or in fixing premium, and terms and conditions of acceptance.

Duty of disclosures continues throughout preliminary negotiations leading up to the contract, but ceases when contract is complete. It applies again at renewal which is tantamount to making a fresh contract and the insured should make necessary disclosure of any new material fact.

Over and above utmost good faith Insurable Interest and Indemnity also apply in insurance contracts.

(E) **Various add on covers/clauses are available and for each such cover there are applicable clauses. However, for valuer's and insured's point of view the following add on covers/clauses are important:**

(i) Add on cover for omission to insure additions, alterations or extensions

(ii) Add on cover for start-up expenses

(iii) Designation of property clause

(iv) Reinstatement Value clause

(i) Local authorities' clause

(vi) Escalation clause

(vii) Architects', Surveyors' and Consulting Engineers' fees (up to 3% of the admissible claim amount) clause

(viii) Removal of debris clause (up to 1% of the admissible claim amount)

Explanation to above add on covers/clauses

(i) Add on cover for omission to insure additions, alterations or extensions clause (this is to be incorporated if opted at additional premium)

"The Insurance by this policy extends to cover buildings and / or machinery, plant and other contents as defined in columns ... hereof which the insured may erect or acquire or for which they may become responsible -

(a) at the within described premises,

(b) for use as factories.

* The liability under this extension shall not exceed in respect of (a) above, 5% of the sum insured by each item, in respect of (b) above, 5% of the sum insured by item No.(---).
* The insured shall notify the insurer of each additional insurance as soon as it shall come to their knowledge and shall pay the appropriate additional premium thereon from the date of inception.
* Following the advice of any additional insurance as aforesaid, cover by this extension shall be fully reinstated.
* No liability shall attach to the insurers in respect of any building, machinery, plant or other contents while such property is otherwise insured."

N.B.

* All new additions to building and/or machinery and plant not specifically insured/included during the currency of the policy should be declared at the end of the year and suitable additional premium paid on *pro rata* basis from the date of completion of the construction/erection of additions subject to adjust-ment against the advance premium collected.
* If the insured fails to declare the values of such additions within 30 days after the expiry of the policy, there shall be no refund of the advance premium collected.
* "Other contents" in the above clause shall mean 'furniture and fittings' and does not include stocks.

(ii) Add on cover for Start-up expenses (this is to be incorporated if opted at additional premium)

"It is hereby agreed and declared that this policy extends to cover start-up costs necessarily and reasonably incurred by the insured consequent upon a loss or damage covered by this policy."

A separate sum insured may be mentioned for this clause if included.

(iii) Designation of property clause

"For the purpose of determining, where necessary, the item under which any property is insured, the insurers agree to accept the designation under which the property has been entered in the insured's books."

(iv) Reinstatement Value Clause/Policy (if reinstatement basis is opted):

This extension of cover is usually granted on buildings, machinery, furniture, fixtures and fittings only. It is not granted for stocks in trade or merchandise.

To safeguard and uphold the principle of indemnity, it is provided that Reinstatement Value Clause shall have no effect, if the insured fails to replace or reinstate the property damaged or destroyed, or the insured is unwilling to replace or reinstate the property destroyed or damaged on the same or another site.

Reinstatement Value Clause reads as under:

" It is hereby declared and agreed that in the event of the property insured under (Item Nos.____) of the within policy being destroyed or damaged, the basis upon which the amount payable under (each of the said items of) the policy is to be calculated, shall be the cost of replacing or reinstating on the same site or any other site with property of the same kind or type but not superior to or more extensive than the insured property when new as on date of the loss, subject to the following Special Provisions and subject also to the terms and conditions of the policy except in so far as the same may be varied hereby."

Special Provisions

* The work of the replacement or reinstatement (which may be carried out upon another site and in any manner suitable to the requirements of the insured subject to the liability of the Company not being thereby increased) must be commenced and carried out with reasonable dispatch and in any case must be completed within 12 months after the destruction or damage or within such further time as the company may (during the said 12 months) in writing allow, otherwise no payment beyond the amount which would have been payable under the policy if this memorandum had not been incorporated therein shall be made.

* Until expenditure has been incurred by the insured in replacing or reinstating the property destroyed or damaged, the company shall not be liable for any payment in excess of the amount which would have been payable under the policy if this memorandum had not been incorporated therein.

* If at the time of replacement or reinstatement the sum insured representing the cost which would have been incurred in replacement or reinstatement if the whole of the property covered had been destroyed, exceeds the sum insured thereon at the operation of any of the insured perils or at the commencement of any destruction of or damage to such property by any other peril insured against by this policy, then the insured shall be considered as being his own insurer for the excess and shall bear a rateable proportion of the loss accordingly. Each item of the policy (if more than one) to which this Memorandum applies shall be separately subject to the foregoing provision.

This Memorandum shall be without force or effect if -

*"the insured fails to intimate to the company within 6 months from the date of destruction or damage or such further time at the Company may in writing allow, his intention to replace or reinstate the property destroyed or damaged.

*the insured is unable or unwilling to replace or reinstate the property destroyed or damaged on the same or another site".

(v) Important considerations / variations etc.

(a) Valuation of plant for fire insurance purpose is the estimation of possible financial loss by reference to machinery of comparable output, productivity and quality at a given point of time, seen in the background of policy terms and conditions. Valuation is carried out to decide the "Value at Risk" of plant.

This is the maximum possible loss of value of a physical asset measured against policy terms and conditions. Reinstatement Value is the amount payable under the policy to be calculated and shall be the cost of replacing or reinstating on the same site or any other site with property of the same kind or type but not superior to or more extensive than the insured property when new as on date of loss. It is a standard provision of insurance policies that in the event of the loss the insured will take all reasonable steps to minimize his loss. It is common for the insured to attempt to replace the plant as quickly as may be prudent in order to minimize any loss of turnover to the business and goodwill of his added advantage of minimizing any loss-of-profit claim on insurers if such insurance is there.

Reinstatement Value is inclusive of machinery foundation. So, while instructing insurer it should be made clear in writing that the plant and machinery are insured inclusive of their foundations.

(b) The important variations which flow from the Insurer's Reinstatement Value clause compared to the Market Value (Depreciated Value) policy are set out hereafter.

(i) Damaged / destroyed / irreparable property to be replaced by new property of "the same kind or type but not superior to or more extensive than the insured property" and the monetary claim to be **allowed on value as new basis without deducting depreciation.**

For damage to repairable property, the full cost of repairs including replacement of parts would be payable without deduction of any depreciation, subject to the repairs / replacement of parts are of the "same kind or type."

(ii) Such monetary claim is to be paid only after actual repairs / replacement of parts / reinstatement has been completed and then payment shall be made for claims made by the insurer, as per terms and conditions of relevant policy.

(iii) The important aspects to be borne in mind by the insured are set out hereafter.

a. The insured has the option to reinstate or not and the said option has to be exercised within 6 months of the damage or any further time limit which may be allowed by the insurer in writing.
b. The reinstatement may be done at the same site or at any other site.
c. The reinstatement has to be completed within 12 months of the date of damage. Extension of time, may be allowed by the insurer.
d. To obtain full coverage and claims, the sum insured has to be adequate to cover the value of insured property **at the time of reinstatement of the damage.**

(iv) To get full advantage of maintaining an undisturbed cash flow and of getting a new asset against the old asset destroyed, it is abundantly clear that full insurance on RIV basis is absolutely essential.

Example on reinstatement value and condition of average:

A machine was purchased in 2004 for ` 50,000/-. If it is to be replaced today, it will cost say ` 5,00,000/- (a). The physical depreciation for 10 years is say ` 2,25,000/- (b). In this example,

Actual cost (historical cost) = ` 50,000/-

Reinstatement value
(replacement cost) on date of loss or damage
= ` 5,00,000/- (a)
Depreciated replacement cost
(a) – (b) = ` 2,75,000/-

Thus, if the machinery is totally damaged due to an insured peril and is insured for reinstatement, the insured will get a sum of ` 5,00,000/- even if the machine is worth only ` 2,75,000/- in the market at the time of total loss, provided the actual reinstatement of the damaged machinery is accomplished, as per Reinstatement Value Clause.

If it is desired to take benefit of the escalation clause, with 25% escalation, the insurable value will work out to:

$$5,00,000 + \frac{25}{100} \times 5,00,000 = \text{` } 6,25,000/-$$

If there is a total loss during the year, the maximum amount payable to the insured for the reinstatement of the machinery will be ` 6,25,000/- provided reinstatement cost incurred is ` 6,25,000/- and provided the loss has taken place on the last day of the period of insurance. (Please see Escalation clause under paragraph (vi) later). In all such cases, salvage, if any, of the damaged property will always belong to the Insurance Company.

Condition of Average

If the amount of insurance is less than the value of the machinery damaged or destroyed, on the date of damage, due to an insured peril, the condition of average will operate, and the insured will proportionately receive less than the actual loss suffered.

A loss payable as per condition of average is worked out as under:

$$\frac{\text{Sum insured}}{\text{Value of machinery at the time of loss}} \times \text{Loss} = \text{Claim amount payable}$$

(c) However, the manner in which the **condition of average** is applied with particular reference to the sum insured at the time of damage being required to be equivalent to value as new of the insured property item-wise at the time of reinstatement / reconstruction, to ensure full insurance is a very difficult task. The changing factors of prices, local taxes, excise duty, sales tax, customs duty, and fluctuations in the rate of foreign exchange, makes the task almost impossible. Even if the sum insured is fixed adequately at the time of inception or renewal of the insurance policy, no insured can forecast when the damage will take place during the 12 months period of the policy or the type of loss that will take place or the time or period required for reinstatement. In case of a major catastrophic loss involving special purpose imported machinery, such period of reinstatement could exceed two or three years. Alternatively, in small loss or if required spares are available in stock, the period of repairs / reinstatement may be a week or two or even less. The various factors which build up the cost or value may fluctuate after the loss also leading to more difficulty. Unfortunately there is no provision for adjustment of the Sum Insured after the loss. Escalation takes care of inflation up to policy period. If reinstatement extends beyond expiry of policy there is no remedy available for increase in price from the date of expiry of policy to the completion of reinstatement except to over insure.

How much to over insure will depend on the facts and in the circumstances of each individual case.

In view of the above, it is evident that there is no tailor-made exact solution to the problem of how to determine the Reinstatement Value in advance and this is known and recognized by the insurers world-wide.

(v) Local authority's clause:

Reinstatement value policy can be extended to cover additional cost of re-instatement solely by reason of the necessity to comply with the regulations of local authority by incorporating the following clause in the policy.

"The insurance by this policy extends to include such additional cost of reinstatement of the destroyed or damaged property hereby insured as may be incurred solely by reason of the necessity to comply with the Building (or other) Regulations under or framed in pursuance of any Act of Parliament or with bye-laws of any municipal or local authority provided that :

The amount recoverable under this extension shall not include:

● The cost incurred in complying with any of the aforesaid Regulations or bye-laws,

in respect of destruction or damage occurring prior to the granting of this extension,

* in respect of destruction or damage not insured by the policy,
* under which notice has been served upon the insured prior to the happening of the destruction or damage,
* in respect of undamaged property or undamaged portions of property other than foundations (unless foundations are specifically excluded from the insurance by this policy) of that portion of the property destroyed or damaged.
* The additional cost that would have been required to make good the property damaged or destroyed to a condition equal to its condition when new had the necessity to comply with any of the aforesaid Regulations or bye-laws not arisen.
* The amount of any rate, tax, duty, development or other charge or assessment arising out of capital appreciation which may be payable in respect of the property or by the owner thereof by reason of compliance with any of the aforesaid Regulations or bye-laws.
* The work of reinstatement must be commenced and carried out with reasonable dispatch and in any case must be completed within twelve months after the destruction or damage or within such further time as the insurers may (during the said twelve months) in writing allow and may be carried out wholly or partially upon another site (if the aforesaid Regulations or bye-laws so necessitate) subject to the liability of the insurer under this extension not being thereby increased.

* If the liability of the insurer under (any item of) the policy apart from this extension shall be reduced by the application of any of the terms and conditions of the policy then the liability of the insurers under this extension (in respect of any such item) shall be reduced in like proportion.
* The total amount recoverable under any item of the policy shall not exceed the sum insured thereby.
* All the conditions of the policy except in so far as they may be hereby expressly varied shall apply as if they had been incorporated herein."

No additional premium is charged for inclusion of this clause in the policy.

(vi) Escalation clause (if opted at additional premium)

"In consideration of the payment of an additional premium amounting to 50% of the premium produced by applying the specified percentage to the first or the annual premium as appropriate on the under noted item(s) the sum(s) insured thereby shall, during the period of insurance, be increased each day by an amount representing 1/365th of the specified percentage increase per annum.

Unless specifically agreed to the contrary the provisions of this clause shall only apply to the sums insured in force at the commencement of each period of insurance.

At each renewal date the insured shall notify the insurers:-

* The sums to be insured under each item above, but in the absence of such instruction the sums insured by the above items shall be those stated on the policy (as amended by any endorsement effective prior to the aforesaid renewal date) to which shall be added the increases which have accrued under this clause during the period of insurance up to that renewal date.

* The specified percentage increase(s) required for the forthcoming period of insurance, but in the absence of instructions to the contrary prior to renewal date the existing percentage increase shall apply for the period of insurance from renewal.

All the conditions of the policy in so far as they may be hereby expressly varied shall apply as if they had been incorporated herein."

It will be in order for insurers to allow automatic regular increase in the Sum Insured throughout the period of the policy in return for an additional premium to be paid in advance. The terms and conditions for this extension are as follows:

- The selected percentage shall not exceed 25% of the sum insured.
- The additional premium, payable in advance, will be at 50% of the final rate, to be charged on the selected percentage increase.
- The sum insured at any point of time would be assessed after application of the Escalation Clause.
- Escalation Clause will apply to policies covering building, machinery and accessories only and will not apply to policies covering stock.
- Escalation Clause will apply to all policies and is not restricted to policies issued on reinstatement value basis.
- Pro rata Condition of Average will continue to apply as usual.
- The automatic increase operates from the date of inception up to the date of operation of any of the insured perils.

(vii) Architects', Surveyors' and Consulting Engineers' fees (up to 3% of the admissible claim amount) clause

"It is hereby declared and understood that the expenses incurred towards Architects', Surveyors' and Consulting Engineers' fees for plans, specifications, tenders, quantities and services in connection with the superintendence of the reinstatement for the building, machinery, accessories and equipment insured under this policy is covered up to 3% of the adjusted loss, but it is understood that this does not include any costs in connection with the preparation of the insured's claim or estimate of loss in the event of damage by insured perils."

The insurers may cover Architects' fees up to further 4.5% in addition to 3% which is already covered under the policy as per above clause subject to appropriate additional premium payable.

(viii) Removal of debris clause (up to 1% of the admissible claim amount)

"It is hereby declared and agreed that the expenses incurred up to 1% of the admissible claim amount is included in the sum insured on:

(a) removal of debris from the premises of the insured;
(b) dismantling or demolishing;
(c) shoring up or propping."

Note: (b) and (c) above should be deleted when neither building nor machinery are covered.

The insurers may cover removal of debris charges for higher amount, over and above 1% up to 10% of sum insured subject to additional premium payable.

(F) Other types of insurance policies

1. Machinery break-down policy:

a) The Insurance Policy covers "Unforeseen and sudden physical damage" subject to certain exclusions. The insured has the choice to select specific machinery for insurance. While a deductible of 1% of the Sum Insured is common, this can be increased at the insured's option with a reduction in premium.

b) The Sum Insured "shall be equal to the cost of reinstatement of the insured property by a new property of the same kind and capacity." If the item-wise Sum Insured "is less than the amount required to be insured as per above provision, the Company will pay only in such proportion as the Sum Insured bears to the amount required to be insured.

c) The provisions for settlement of claims are briefly stated hereafter.

(i) If the damage can be repaired, then full cost of repairs to restore the machine to pre-damage condition is payable. No depreciation will be deducted on the value of parts replaced unless such parts are of limited life. However, if the cost of repairs exceeds the actual pre-damage value of the property, i.e., depreciated value, settlement of claim will be limited to actual pre-damage value after taking account of salvage.

(ii) If the insured property is destroyed, the Insurance Company will settle the claim for actual pre-damage value, i.e., depreciated value, after taking into account value of salvage.

(iii) In both the above situations, the Insurance Company will make payments only after being satisfied that the repairs have been effected or replacements have taken place.

(a) It is evident from the above provisions that the Sum Insured has to be equal to the replacement cost while the maximum settlement of any claim for repairs or replacement would be on the basis of actual value net of depreciation and salvage. Further payment of any claim will be made only after repairs or replacements are carried out.

(b) The problems of determining the reinstatement value and the Sum Insured are identical to what has been narrated earlier.

(i) Boiler and pressure plant insurance policy:

This policy covers explosion/implosion (including flue gas explosion) and collapse damage to boiler and pressure plants wherein steam is being generated.

G. Illustration on computation of Insurable Value (Hypothetical Case)

Insurable value is based on market value or reinstatement value. Both these values are discussed earlier and out of two, reinstatement value is desirable though premium payable is high but the benefits derived are more in the event of loss.

Computation of reinstatement value of a machine installed in a plant.

The plant manufactures seafood products by cooking / blanching or raw. The raw materials used are sea caught shrimps, cephalopods (Squids, Octopuses and Cuttlefish) and fishes. The aquaculture shrimps are also used as raw material. The product is either individually quick frozen in IQF freezer or block frozen in plate freezer. The product is also semi IQF in the air blast freezer. Ammonia gases are used as refrigerant. The product is stored in the frozen store below -18^0C temperature. The finished product is transported in refrigerated container for shipment.

The machine to be insured is located in a plant in Kerala where the company produces IQF and other frozen products in the unit. The capacity of the IQF plant is 3500 TPA with 3 shift operation, Block plant is 3500 TPA and Blast is also 3500 TPA. Current capacity utilization is around 60 to 70% for IQF and Block. The total manpower of the plant is 300 which includes managers, officers, staff and workmen. Pre-processing, cold store and packaging material facilities are created for facilitating better consumer safety.

The product profile of the plant is given below:

- Raw / blanched / cooked IQF shrimps
- Block / blast frozen shrimps
- Raw / blanched / cooked IQF cephalopods
- Block / blast frozen cephalopods
- IQF raw / blanched / cooked sea food mix
- Blast frozen fishes / fish fillet

The process employed by the plant:

- IQF freezing (ammonia refrigeration)
- Plate freezing (ammonia refrigeration)
- Blast freezing (ammonia refrigeration)
- Cooking / blanching through steam generation from non IBR boiler
- Cold storage (ammonia refrigeration)

Valuation procedure

First step is to inspect the machine and collect the data so that the current cost of brand new machine can be estimated and supplier of machine can quote current price without any further query.

The details collected for machine under consideration are as under:

Plant, machinery and equipment to be valued: IQF Hardening – Tunnel

Single belt tunnel for individual quick freezing (hardening) of products.

On a plastic modular belt the product is led past the high velocity airflow called Arctic Flow®, which blows the air across the belt and past the product and then continuously blows through the evaporator.

The rapid horizontal Arctic Flow® and the ultra-low temperature ensure a quick and homogenous freezing within a minimum of time. Thus, ensuring a good quality finished product, with an equalized core temperature of minimum -18^0 C within a minimum of time.

Features

- Plastic modular belt, suitable for small and large products.
- Belt frame and support, in-feed/outlet and guiding plates are in stainless steel in an open design, to ensure easy cleaning and a long life without corrosion.
- In-and-Out – feed openings are fully covered by 2 x double layer silicon strip curtains to minimize air/moisture entering the cabinet, which prevents frosting built-up on the evaporator and prolongs the time in between defrosting periods.
- Self-adjusting mechanically operated belt tension system to slacken or tighten belt.
- Long durable UHMW polyethylene wears rails on frame and belt support, to ensure long belt life.
- Electrically operated ventilators to ensure optimal air circulation from evaporator to product for quick and uniform freezing.
- Evaporator.
- Fully insulated cabinet made of 125 mm sandwich panels, insulated with polyurethane and plated with 0.6 mm galvanized steel plate, coated with 150 µm white PVC.
- Fully welded stainless steel floor with center mounted gully and hatch for water outlet when defrosting and cleaning.
- The cabinet is equipped with access door mounted with electrical door heaters to prevent ice bounding of panel.
- Additional emergency breakers mounted next to in-feed conveyor and inside cabinet for full personnel security.
- Internal electrical neon lights mounted in ceiling for clear view when freezing, cleaning or maintenance.

Technical data

Cabinet dimension (L x W x H) (external)	:	3,900 x 2,300 x 2,700 mm
Belt type	:	Plastic modular
Belt width effective/overall	:	850 mm effective, 900 mm
Conveyor length	:	3,600 mm
Belt speed - minutes per cycle	:	Adjustable from 2 to 10
No. of belt	:	1
Maximum product height	:	750 mm
Product in-feed height	:	1,100 mm
Product outlet height	:	750 mm
Refrigeration duty to product	:	10 kW
Coolant supply to evaporator	:	15 kW
Suction temperature	:	Minus 40^{0} C, at evaporator
Air temperature	:	Minus 35^{0} C
Cooling medium system	:	R-717 or R-22 pump
Cooling pump flow rate	:	4-5 times evaporated liquid
Installed fan power	:	3.3 kW
Power supply	:	6 kW
Voltage	:	3 x 380 V 50 Hz
Year of installation	:	January, 2013
Date as on which valuation is made	:	31^{st} December, 2014
Gross Book Value	=	` 1,25,00,000/-
Depreciation	=	` 14,25,000/-
Net Book Value	=	` 1,10,75,000/-

The figures indicated in this case are hypothetical.

The identical machine is available from the same manufacturer.

The computation of RIV based on the quotation received is as under:

Particulars	Amount in `	
Ex-works price at manufacturer's site.	1,05,00,000	(a)
C I F (custom duty, insurance and freight)	35,00,000	(b)
Landed cost at Indian port	1,40,00,000	(a) + (b) = (c)
Clearing, forwarding and transit insurance from port to the plant	3,00,000	(d)
Handling charges at plant	50,000	(e)
Costs of foundation, erection and installation	6,50,000	(f)
Total	**1,50,00,000**	(c) + (d) + (e) + (f)

(a) The insurance policy is for the period of one year.
(b) ` 1,50,00,000/- is value on first day of policy.
(c) Suppose something happens on last day of policy – what about increase in the price from day one to last day. Let us assume that increase in the price is likely to be 10%.

Therefore, insurable value after considering escalation will work out to ` 1,65,00,000/-.

Note: (i) The question of computation of depreciation does not arise as policy recommended is not market value policy but reinstatement value policy (RIV).

(ii) Even if the policy is taken at ` 1,65,00,000/- based on scientific valuation carried out by the valuer, the insurance company will issue RIV policy and collect premium on the basis of ` 1,65,00,000/- but shall not commit to pay ` 1,65,00,000/- in the event of total loss because the question of adequacy of insurable value shall be considered at the time of reinstatement.

H The approach to valuation for computation of insurable value is dependent on the type of the policy, i.e. whether policy is on RIV basis or market value basis. However, in both the cases the first step is to estimate current cost of brand new similar item. These costs include following:

A. For indigenous machine

(i) Ex-works price of machine
(ii) Packing and forwarding charges
(iii) Excise duty
(iv) VAT (Value added tax)
(v) Handling charges
(vi) Transportation charges
(vii) Transit insurance cost
(viii) Foundation, erection and installation costs

B. Imported machine

As per Illustration for valuation for insurable value given earlier.

Note: Taxes and duties mentioned above are non-recoverable tax i.e. effective taxes.

If the policy is with the escalation clause then amount worked out by considering above factors would be increased depending upon the escalation amount.

Let us consider the case of a process plant established 5 years back to manufacture a particular product. It has an installed capacity of X unit. The unit has 100 machines. All the machines are to be insured on RIV basis without escalation.

The RIV of each individual machine as on date of taking new policy is say ` 1.00 Crore giving a total of ` 100.00 Crores.

The latest plant to manufacture same product with an installed capacity of X unit can be established with 75 machines, RIV of such entire plant is ` 80 Crores. The latest plant is economical to operate also.

Let us consider the following two situations due to any insured peril:

(a) One of the machines is damaged in such a way that it cannot be repaired.
In this case insurance company will approve the claim for ` 1.0 Crore because RIV of damaged machine is ` 1.0 Crore.

(b) All the machines of plant are damaged and all the machines are beyond repair.
In this case insurance company will not approve the claim for ` 100 Crores as RIV for all the machines as per current technology is ` 80 Crores.

There are differences between the valuation of PME for reinstatement insurance value and replacement cost new for financial reporting. The lack of provision for interest charges in valuation for insurance is one of these. For computation of replacement cost new the finance charges are to be considered. In the case of some large plants, this may represent a significant percentage of the overall cost. In insurance valuation, provisions for the finance charges is incorrect and will lead to the statement of inflated values.

INDUSTRIAL PROCESSES

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The study material for the subject of Industrial Processes is divided into two parts: Industrial Processes – I and Industrial Processes – II.

This section covers Industrial Processes- I

INDUSTRIAL PROCESSES - I

INDEX

BRIEF INTRODUCTION

It is very important for students of plant and machinery valuation to study the various industrial processes.

Industrial Processes is a very wide subject covering large number of industries; they are custom-built as per the specific requirement of a client with in a class of industries; it is well nigh impossible to cover the subject in toto for the present study material.

In order to get how things work in the plants it is essential for the students to visit large number of plants of diverse varieties.

Plant and machinery in any Industrial Process can be broadly classified in following categories:-

(a) Process equipment depending on process involved.
(b) Utility equipment

The study material for this subject is divided in following parts:
- Industrial Processes–I and
- Industrial Processes–II.

Industrial Processes – I covers :

1. Factory Planning and Layout:
    - Plant location
    - Plant layout
    - Types of Plant Layout
    - Process Layout
    - Product layout
    - Group Layout

2. Production system and automation
    - Types of production
    - Types of automation

3. Material flow, process, sequences, and automation & control and following Industrial Processes:
    - Textile spinning mill
    - Dairy
        - Ice cream
        - Industrial Milk Processing
    - Solvent Extraction and Vegetable Oil Plants

Industrial Processes – II covers :

- Iron, Steel and Nosn-Ferrous Metal Production
- Chemical (Dye)
- Pharmaceutical
- Plastic
- Rubber
- Paper and paper products
- Printing, binding and publishing
- Food (Bread making)
- Soft drink

Note : Utility is covered in Industrial Processes – I.

CVSRTA

UNIT-1

FACTORY PLANNING AND LAYOUT

<u>Plant Location:</u>

“A plant is a place where men, materials, machines and equipment are brought together for manufacturing a product”.

Three major consideration in the plant location are;

- The need to produce close to the customer
- The need to locate near the appropriate labour force
- Availability of raw material

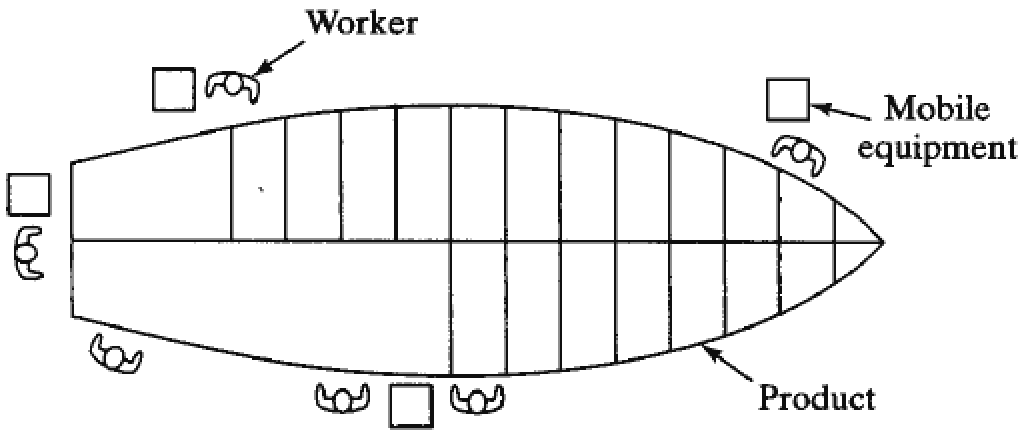
A Valuer has to examine the plant site and its layout while assessing the value of the plant.

<u>Plant Layout:</u>

A plant layout is a systematic arrangement of various departments, machines, equipment and services of men for economical, effective and efficient functioning of an organization for production of any goods. It includes;

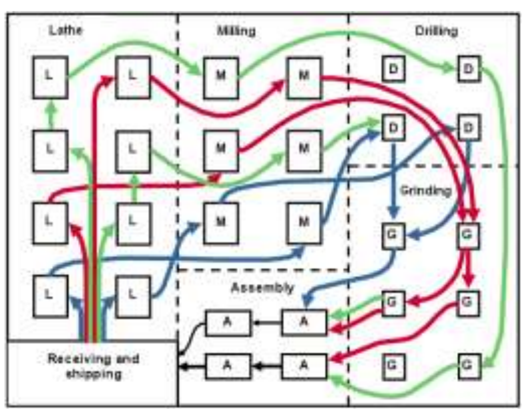
- Space needed for material movement
- Storage
- Hazardous materials storage
- Emergency escape
- Product size

<u>Types of Plant Layout:</u>
Fixed Position Layout: Materials stays at fixed place and Machines are moving. Aircraft and Ship buildings are examples of fixed position layout.



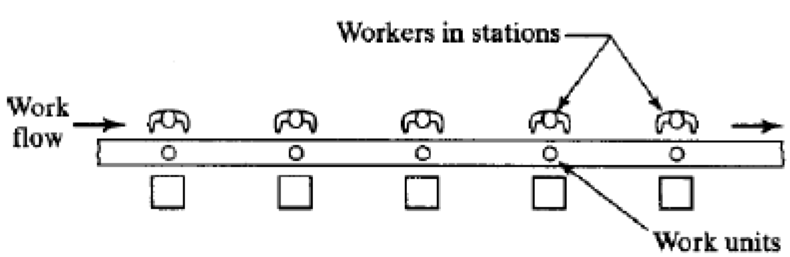
Process Layout :

Machines are fixed and Materials are moving. Small scale production units, repair and maintenance shops are examples of process layout.



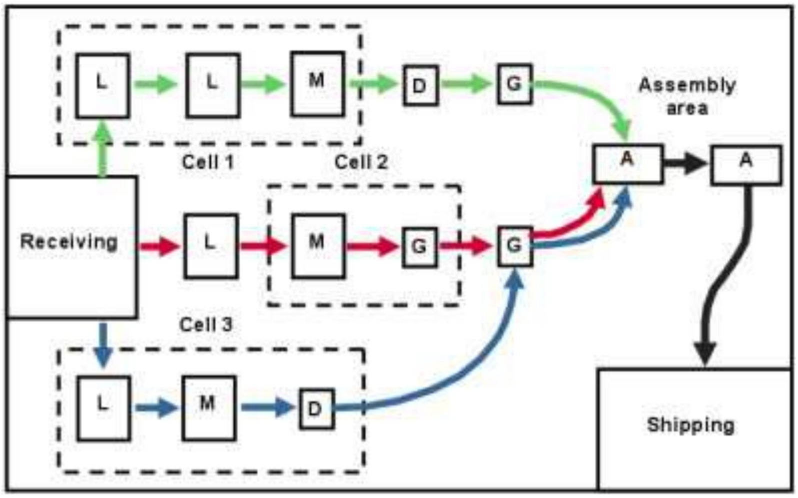
Product Layout:

The volume of production is high where separate production line is justified like Automobile Industries, TV, Refrigerator, Air conditioner, Washing machine.



Group Layout:

Groups of different equipment performs a sequence of operation like Automotive component manufacturing.



UNIT-2

PRODUCTION SYSTEM AND AUTOMATION

Production system means manpower, materials, machines and methods in order to accomplish the manufacturing operation of the company and part of the production systems are automated.

Type of Production:
Job Shop Production (One-off Production) : Low volume production of customized products such as aircraft, power plants, submarine, ships.

Batch Production: Product is prepared stage by stage over a series of workstations and different batches of products are made. Bakery products, pharmaceuticals ingredients etc. are examples of such production.

Mass Production: Large volume to satisfy high demand and it is a continuous process to manufacture identical parts.

- Quantity production: manufacturing of single parts on standard machines with the use of special dies, moulds. Screws, nuts, nails are examples of such production
- Flow line production (Continuous): To manufacture high volumes of products with high production rates and low costs. Separate dedicated flow line is created for each product. Dedicated machines are used to manufacture the products at high production rates. Assembly lines of cars, bulbs, razors, chemical plants, refineries are examples of such production.

Automation can be defined as the process of following a predetermined sequence of operations with little or no human labour, specialized equipment and devices that perform and control manufacturing process.

Programmable Logic Controller (PLC) system is the most advance version of automation used in the industries which is reducing space, saves energy, easy maintenance, economical, greater life & reliability, flexibility, less project time.
Automation in manufacturing plants can be implemented in manufacturing process, material handling, inspection, assembly and packaging.

Type of Automation::

Fixed Automation or Hard Automation: Sequence of processing operations are fixed by the equipment configuration. Many operations are integrated into a single piece of equipment. Production lines are designed to produce a standardized product such as engine blocks, valves, gears and spindle. It has high production rates hence used for mass production of parts. Examples of fixed automation include machining transfer lines foundin the automotive industry, automatic assembly machines.

<u>Programmable Automation:</u> Sequence of operations are controlled by a program so the same equipment is used to produce different products. CNC, industrial robots and PLCs are examples of programmable automation.

<u>Flexible Automation:</u> It is an extension of programmable automation as there is no time lost for changeover from one part type to another while programming the system. It has low production rates.

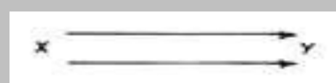
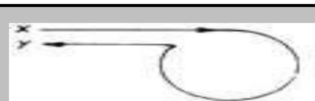
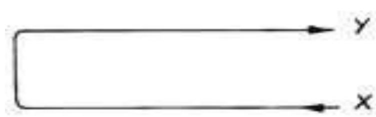
UNIT-3

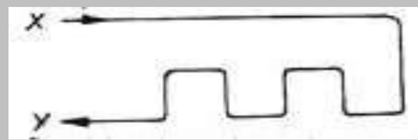
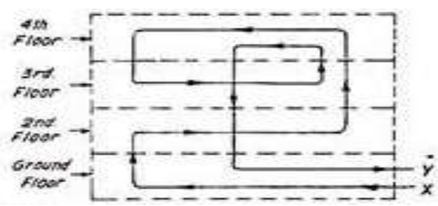
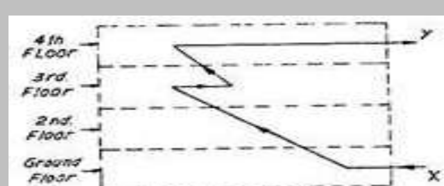
MATERIAL FLOW, PROCESS SEQUENCES AND AUTOMATION & CONTROL

Material Flow:

One of the most important phase of the plant layout is to achieve an optimum effective flow of material through the plant.

While designing a new plant layout, generally the flow patterns are decided earlier and then system facilities is designed.

Flow Pattern	**Flow Pattern**	**Characteristics and Place of Use**
Line Flow		Straight, materials enters at one end and leave at other end. It is preferred in buildings having long length and less widths. Paper Plant
L Type flow		Resembles line flow and used where buildings are more wide but less long. Asphalt Mixing Plant
Circular Flow		Preferred for rotary handling systems. Electric Bulb Industry
U type flow		Supervision is simpler and preferred in square shaped buildings Electric Motor Industry
S or inverted S		Preferred in production lines are longer than U type. The system is compact, space has better utilized and supervision efficient. Automotive Assembly Line
Combination of U and Line Flow		

Combination of Line Flow and S type flow		
Combination of Line and Circular		This system needs smaller building length as compared to line flow.
Processing Upwards		The material may be processed while moving upwards or downwards in multi-storey buildings. In processing downwards, gravity helps to bring the material down but all the material has to be taken to the top storey.
Retraction type of flow in multi-storey buildings		It involves more material handling cost as compared to (i) but finds better space and equipment utilization.
Inclined Flow		Such system may be adopted depending upon the process characteristics.

Process Sequence:
Process is a sequence of operations and processes designed to create a specific product. It is nothing but the turning materials into product. At every stage it covers one or more resources. These outputs then serve as an inputs for the next stage until a known goal or end result is achieved.

Activities:
Production Planning: Required level of production in a specific time horizon. Production Scheduling: Allocation of finite resources to meet the demand requirements such as capacity, precedence, start and due dates.
Production sequence: Resource level ordering of jobs on a shared workstations.

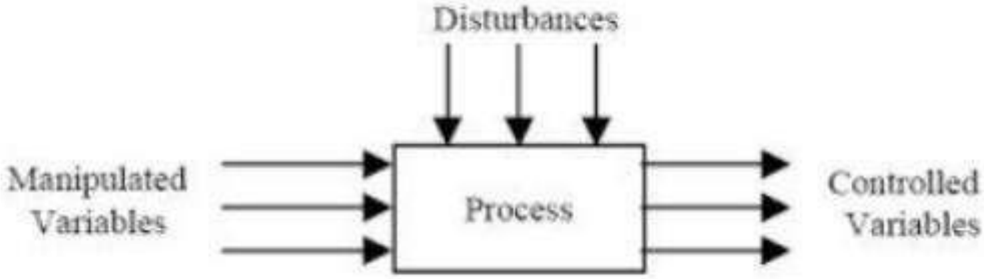
Priority Rules for sequencing Jobs on shared machines:
First come, First served (FCFS): Jobs are assigned to a shared resource in the order in which they are placed Shortest Processing Time (SPT): Jobs are ordered based on the length of the processing time means jobs with shortest processing time are ordered first.

Longest Processing Time (LPT): Jobs with the longest processing time are order first.

Earliest Due Date (EDD): Jobs are ordered based on their required delivery dates means jobs with earliest due dates are order first.

Automation & Process control:

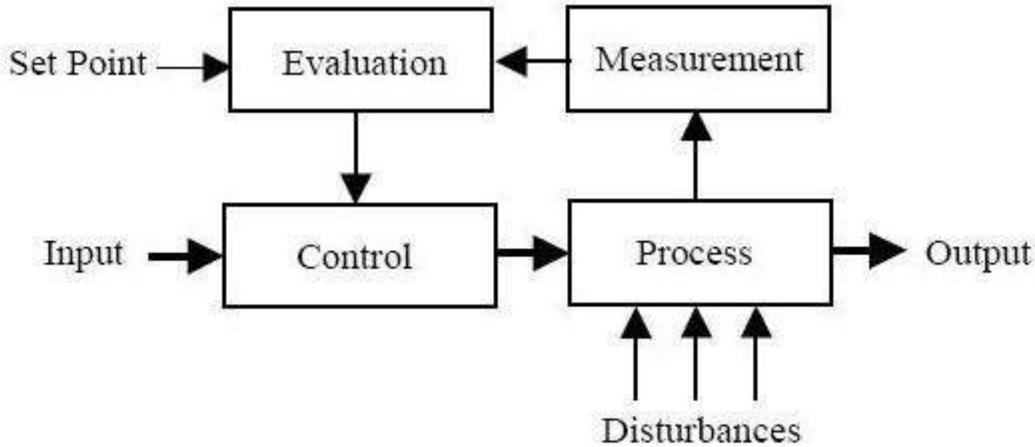
Control in process industries refers to the regulation of all aspects of process.
All process systems consists of three main factors or terms:



Manipulated Variables: Valve Position, motor speed, damper position etc.

Controlled Variables: Temperature, Level, Position, Pressure, pH, density, moisture content, weight and speed

The control system must adjust the manipulated variables so the desired value or set point of the controlled variables is maintained despite of any disturbances.
Process control system consists of four elements:

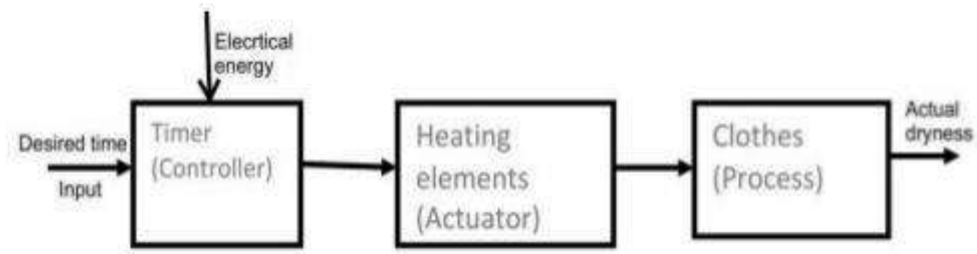


Process: It consists of an assembly of equipment and material related to manufacturing operation. Ex. Liquid level is placed under control includes components as a tank, liquid, flow of liquid into and out of from the tank, inlet and outlet piping.

Measurement: It is conversion of the process variable into an analog or digital signal that can be used by the control system and that device called a sensor or instrument. Typical measurements are pressure, level, temperature, flow, position and speed.

Evaluation: The measurement value is examined, compared with the desired value or set point and the corrective action needed to maintain proper control is determined and device called controller. The controller can be pneumatic, electronic or mechanical.
Control: The control element in a control loops is the device which direct influence on the process or manufacturing sequence. In given example it will be a control valve that adjust the flow of liquid in a process.

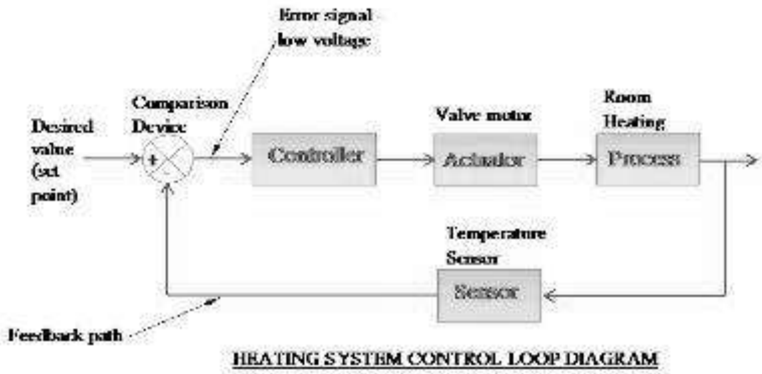
Type of Process Control System:
Open Loop Control System: A control action is applied on the output of the system. It does not receive any feedback signal to control or alter the output status.
Set point, Controller, Actuators, Process, Disturbances



❖ An operator would set a timer (controller) to say 30 minutes and at the end of the 30 minutes the drier will automatically stop and turn-off even if the clothes are still wet .

❖In this case, the control action is the manual operator assessing the wetness of the clothes and setting the process accordingly

Closed Loop Control System:
The output of the process affects the input control signal. The system measures the actual output of the process and compares it to the desired output.
Comparator, Error Amplifier, Controller, Output Attenuator, Sensor Feedback

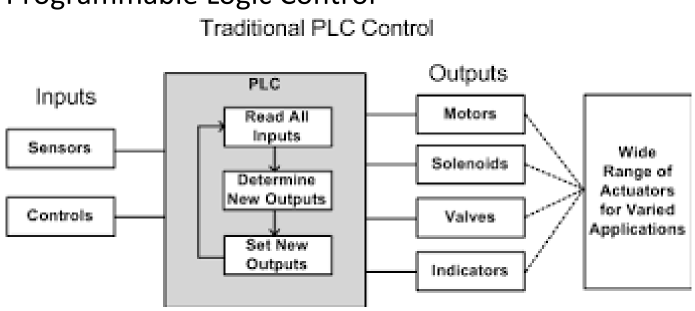


❖The temperature sensor is installed in the room to be controlled and sends a signal back along the feedback path to the comparison device incorporated in the controller.

❖The comparison device compares the value of temperature at the sensor to that of the desired value or set point on the controller.

Primary Devices of Process Control System:

Programmable Logic Control



Distributed Control System

UNIT - 4

EQUIPMENT EMPLOYED IN INDUSTRIAL PROCESSES

Plant and machinery in any Industrial Process can be broadly classified in following categories:-

(a) Process equipment depending on process involved.

(b) Utility equipment

Type of utility services		**Broad category of equipment required**
• Electricity	:	Electrical Installations such as transformers, control panels, circuit breakers, DG set, etc.
• Steam	:	Boilers, economizers, superheaters, etc.
• Water	:	Humidification plant, water reservoir, water supply distribution, ejector system, etc.
• Air	:	Air compressors, air dryers, etc.
• Cooling:		Refrigeration compressors, air conditioners, condensers, receivers, etc.
• Fire protection	:	Diesel engine pump, jockey pump, water reservoir, fire extinguishers, etc.
• Instrumentation	:	Level controllers, flow meters, chemical analyzer, etc.
• Effluent Treatment	:	Aerators, tanks, clarifiers, flocculators, pumps, etc.

It is worth while to mention that though utility services fall broadly under above categories for all the industrial processes; but equipment required within a service differ from plant to plant or say process to process as these are custom built as per client's requirement.

The subject of Industrial Processes is divided into two parts:

- Industrial Processes-I and
- Industrial Processes- II.

Industrial Processes - I covers following :

(a) Topics covered in Unit 1 to 3 (above).

(b) Equipment used for each of above utility services in an industrial plant with technical specifications to give an idea about type of equipment.

(c) The same utility services in different industrial processes employ equipment with quite different technical specifications used in utility services; in order to show this a comparison is made for two industries employing Boilers and ETP and same is covered in Industrial processes - I.

(d) Flow-diagram with brief description of process involved and technical specifications of equipment of following industrial processes :
- Textile spinning mill
- Dairy
  - Ice cream
  - Industrial Milk Processing
- Solvent Extraction and Vegetable Oil Plants

(**Note:** **<u>Utility equipment are covered only under Industrial Processes – I)</u>**

UNIT - 5

UTILITY EQUIPMENT

INTRODUCTION

Every industrial process have utility services depending upon process involved out of following :-

- Electricity
- Steam
- Water
- Air
- Cooling
- Fire Protection
- Instrumentation
- Effluent Treatment

The study of utility services is essential for student of plant and machinery valuation.

Note : The information on technical specifications and other details of utility equipment given herein after pertains to a specific industry. This is to be taken as guidance; because the technical specifications of same equipment vary from industry to industry.

CVSRTA

I. ELECTRICAL INSTALLATIONS

1. 2 pole structure

Consisting of

- 11 kV Four Pole structure made out of ISMB pole 250 x 150 mm, M.S. channel 150 x 75 mm, M.S. angles, Red oxide primer and two coats of aluminium painting of the structural members, Concrete foundations (1:2:4) with muffling of 600 x 600 mm and 300 mm h, with clamps 50 x 50 M.S. flat with 11 kV pin insulators – 6 nos. and ACSR conductor (DOG).

- 11 kV GOD with earth switch combination, 200 A suitable for vertical, single break mounting with operating handle and mechanical interlock and 11 kV DO unit with DO fuse.

- 11 kV distribution class lightening arrestors.

- Switchyard gate made out of 40 mm dia. G.I. pipe 1 ½" square 8 SWG GI wire mesh and two leaves gate with clear width of 2500 mm

- 8 SWG GI wire 1 ½" mesh chain link fencing of 2.4 mtr. height with 50 x 50 x 6 M.S. angle at every 2 mtr in interval and 50 x 50 x 6 angle at top. The fencing duly painted 2 coat of red oxide primer with aluminium paint.

- Supply and spreading of gravel 40 mm size, 100 mm thick with due leveling of the switchyard – 8.5 CM

- Stay wire with porcelain, clamps and foundation – 2 nos.

- 3 x 150 sq. mm. XLPE, 11 kV (E) Al conductor armoured cable – 50 mtr

- Outdoor heat shrinkable joint termination for 3 x 150 sq. mm. XLPE, 11 kV Al conductor armoured cable – 1 no.

- Indoor heat shrinkable joint termination for 3 x 150 sq. mm. XLPE, 11 kV Al conductor armoured cable – 5 nos.

2. Transformer

Rating	:	1500 kVA
Voltage	:	11 / 0.415 kV
Type	:	Oil cooled copper wound
Winding connection	:	Delta / Star
Vector group	:	Dyn 11
Tap changer	:	On load tap changer + 10% to – 15% in steps of 1.56%
Cooling	:	ONAN

3. Switchgear

a. HT Switchgear

11 kV, 630 A, Vacuum Circuit Breaker panel

Vacuum circuit breaker

11 kV indoor, 350 m VA, 630 A, Crompton make single panel.

Totally enclosed; single bus-bar; floor-mounting; metal-clad; indoor; extensible type; flush-fronted; horizontal draw-out; horizontal/vertical isolation type. Suitable for voltage (in kV), fault level (in mVA) and rating (in Amps), all three mentioned above, for use on above voltage, 3 phase, 3 wire, 50 Hz, effectively earthed system.

b. LT Switchgear

LT panels :

- **Main power distribution board** – 1 no.

- **(Motor Control Centre -1) M.C.C. – 1** - 1 no.

  Comprising of

  - **Incomer of 630 A FSU**
    Control transformer – 1 kVA for 110 V AC control supply

  - **Outgoing feeders:**
    Star/Delta – 45 kW KC-31 1, 2 and 3
    FSUs 63 A – Compressor and Bock compressor 1 and 2
    DOL starter – 5.5 kW CT pump, 2 kW CT condenser fan 1 and 2
    1.5 kW CT pumps 1, 2 and 3, - evaporators 1, 2, 3 and 4 – CT fan 1 and 2 – Fn 1 and 2
    1 kW evaporator 1 and 2
    0.18 kW – CT fan 1 and 2
- **M.C.C. – 2 - 1 no.**

  Comprising of -

  - **Incomer of 630 A FSU**
    Control transformer – 1 kVA for 110 V AC control supply

  - **Outgoing feeders:**
    Star/Delta – 55 kW KC-51 1, 2 and 3
    DOL starter – 5.5 kW condenser pump 1 and 2
    3.7 kW Frick condenser 1 and 2 and condenser pump
    1.5 kW Frick condenser fan
    1.0 kW Frick condenser fan 1 and 2
    0.75 kW condenser fan No.2 /1 and 2
    0.41 kW Condenser fan No.1 / 1, 2, 3 and 4
    1.2 kW – 22 nos. axial / condenser fans and evaporators

- **M.C.C. – 3 - 1 no.**

  Comprising of –

  - **Incomer of 630 A FSU**

    Control transformer – 1 kVA for 110 V AC control supply

  - **Outgoing feeders:**

    Star/Delta – 75 kW – Compressor KC-06/2, KC 51
    Star/Delta – 55 kW KC-06/1
    DOL starter – 5.5 kW CW circular pump 1 and 2
    3.7 kW Brine circular pump, agitator
    3 kW – CW agitator 1 and 2
    2.3 and 2 kW – Chilling pump, CT pump and CW air pump – 1, 2 and 3
    1.5 kW – Frick condenser pump / fan 3 nos., CT mono and fan
    1.2 kW – Frick condenser fan
    0.75 kW – Condenser fan no.2 / 1 and 2
    0.41 kW – Frick condenser fan no. 2, 3 and 4
    1.2 kW – 22 nos. axial / condenser fans and evaporators
    FSUs 200 A / 100 A – CS 2, 3, Pallet cooling

- **Production M.C.C. – 1 no.**

  Comprising of -

  - **Incomer of 630 A FSU**

    Control transformer – 0.5 kVA for 110 V AC control supply

  - **Outgoing feeders:**

    FSUs 125 A – Straight line and power sockets
    FSUs 100 A – HT Fut and 2 spare
    FSUs 63 A – 14 nos. Cre Frez, cata, RT machine etc.
    FSUs 32 A – 8 nos. cut ext, bkm filling and spare

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- **Utility M.C.C. – 1 no.**

  Comprising of –

  - **Incomer of 630 A FSU**
    Control transformer – 1 kVA for 110 V AC control supply

  - **Outgoing feeders:**
    FSUs 250 A – ETP
    FSUs 100 A – 2 spare
    FSUs 63 A – 3 nos. boilers
    DOL starter – 21 kW – Air compressor 1, 2 and 3
    15 kW – 2 nos. spare
    5.5 kW – 2 nos. DB blowers
    3.7 kW – 6 nos. RW / Chlo. Water pump and spare
    2.2 kW – 3 nos. water soft pups
    1.5 kW – HSD transfer pump
    0.75 kW – HSD transfer pump

- **Mix Plant M.C.C. – 1 no.**

  Comprising of –

  - **Incomer of 400 A FSU**
    Control transformer – 1 kVA for 110 V AC control supply
  - **Outgoing feeders:**
    Star/Delta – 22.5 kW - homgn
    Star/Delta – 15 kW – 2 nos. spare
    Star/Delta – 12.5 kW - homgn
    DOL starter – up to 5.6 kW – 5 nos. HS mixing and spare
    5.5 kW – 1 no. PHE cooling
    3.7 kW (up to) – 5 nos. Sauce RW, PHE cool and spare
    2.3 kW – 2 nos. hist pumps
    2.2 kW – 10 nos. phe transfer, mix transfer etc.
    1.5 kW – 17 nos. Aging VATS
    1.2 / 1.1 kW – 4 nos. CT blo, mix room and HW pump
    0.8 / 0.75 kW – 5 nos. Kulfi, CaCl etc.

- **M.L.D.B. – 1 no.**

  Comprising of –

  - **Incomer of 250 A FSU**

  - **Outgoing feeders:**
    FSUs 63 A – 12 nos. for different lighting DBs.

- **2500 A L.T. Busduct – 10 mtr complete with**

Straight run	:	9.6 mtr
Right angle bend	:	4 nos.
Wall frame assembly	:	1 no.
TPN Al. Flex	:	1 no.
TPN Cu. Flex	:	1 no.

  Transformer panel with copper bus bars 0.6 m length.

4. Cables

Supply, installation, testing and commissioning of the following :

L.T. Cables
PVC insulated, PVC sheathed, armoured, 1100 V grade power and control cables laid in trays, trenches, buried in ground.

Consisting of -

- 3.5 x 300 sq. mm. AYFY : 250 mtr
- 3.5 x 185 sq. mm. AYFY : 400 mtr
- 3.5 x 150 sq. mm. AYFY : 800 mtr
- 3.5 x 50 sq. mm. AYFY : 250 mtr
- 3 x 35 sq. mm. AYFY : 450 mtr
- 4 x 16 sq. mm. AYFY : 1300 mtr
- 4 x 4 sq. mm. YWY Copper : 450 mtr
- 4 x 6 sq. mm. YWY Copper : 250 mtr
- 3 x 6 sq. mm. YWY Copper : 350 mtr
- 3 x 4 sq. mm. YWY Copper : 650 mtr
- 4 x 2.5 sq. mm. YWY Copper : 350 mtr
- 3 x 2.5 sq. mm. YWY Copper : 3,600 mtr
- 4 x 1.5 sq. mm. YWY Copper : 3,700 mtr

5. Cable terminations

LT cable termination

Termination of PVC insulated, PVC sheathed, 650 / 1100 V grade, armoured cable including stripping of cable insulation.

Consisting of -

- 3.5 x 300 sq. mm. AYFY : 9 nos.
- 3.5 x 185 sq. mm. AYFY : 16 nos.
- 3.5 x 150 sq. mm. AYFY : 36 nos.
- 3.5 x 50 sq. mm. AYFY : 5 nos.
- 3 x 35 sq. mm. AYFY : 9 nos.
- 4 x 16 sq. mm. AYFY : 48 nos.
- 4 x 4 sq. mm. YWY Copper : 28 nos.
- 4 x 6 sq. mm. YWY Copper : 7 nos.
- 3 x 6 sq. mm. YWY Copper : 17 nos.
- 3 x 4 sq. mm. YWY Copper : 54 nos.
- 4 x 2.5 sq. mm. YWY Copper : 12 nos.
- 3 x 2.5 sq. mm. YWY Copper : 270 nos.
- 4 x 1.5 sq. mm. YWY Copper : 274 nos.

6. Lighting

Industrial dust proof type lighting panels (Degree of protection IP 42)

Plant – 1

Consisting of -

- Lighting panel with 63 A TPN.MCB and 3 nos. DP 63 A, 30 mA ELCB shall be incomer and 24 nos. 20A SP MCB's as outgoing. The board is suitable for incoming cable of 4 x 16 sq. mm. AYFY conduit 2 x 2.5 sq. mm. YWY cables on outgoing side – 12 nos.

- Street lighting panel with 63 A TPN-MCB as incomer, 70A contactor, auto manual switch, ON/OFF P.B., indicating lamp, 24 hour timer and 4 nos. 32A 4P30mA – ELMCB as outgoing

- 3/4" dia. M.S. black stove enameled conduit with 3 runs of 2.5 sq. mm. stranded copper conductor PVC wires from MCB DB to Lighting control switch box – 300 mtr

- Light points by using ¾” dia. M.S. black stove enameled conduit and 3 runs of 2.5 sq. mm. Stranded copper conductor PVC wires –260 nos.

- 1” dia. M.S. black stove enameled conduit and 2 runs of 4 sq. mm. + 1 run of 2.5 stranded – 250 mtr

- 5 / 15A socket outlet with surface type switchbox – 30 nos.

- 1 phase – 3 pin – 20-A-metal clad plug socket with 25 Amp, 30mA, DP ELCB in metal enclosure – 50 nos.

- 3 phase, 440 volts, 30 Amp – 5 pin plug sockets with 32 Amp – 30mA, 4P-EL MCB – 6 nos.

7. Street lights

Steel tubular pole IS 2713, class B, M.S. pole duly painted with 2 coats of red oxide primer and 2 coats of aluminium paint. 50 mm dia. GI pipes for cable entry, weatherproof type cast iron junction box with 2 nos. earthing terminal receiving 4 x 16 sq. mm. AYFY cable (2 nos.) and 3 nos. 2.5 sq. mm. stranded copper flexible wires (minimum size 200 mm x 115 mm x 115 mm) with necessary MCB protection, Elmex terminals. Type SP 30 height above ground. 7.5 M size 139.7 x 5.4, 114.3 x 4.5, 88.9 x 3.25 mm dia. (Single bracket) – 10 nos.

8. Earthing

- Earth pit 40 m dia., 3 m long, class B GI pipe buried in earth pit with charcoal and salt each in alternative layers including excavation re-filling etc. with CI legend identification marker – 25 nos.

- GI earth conductor of following sizes to be laid in cable trays in ground including jointing by welding, connecting to equipment, painting to welded portion by black bitumen paint.

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a. 50 x 6 mm GI strip : 850 mtr
b. 25 x 6 mm GI strip : 350 mtr
c. 25 x 3 mm GI strip : 350 mtr
d. 8 SWG GI : 150 mtr
e. 12 SWG GI : 200 mtr
f. 14 SWG GI wire : 250 mtr
g. Test link box : 10 nos.

9. Cable tray

2 mm thick perforated / ladder type GI cable tray with coupler plate and hardware of following sizes:

- 50 mm wide x 25 mm height x 2 mm thick perforated – 15 mtr
- 100 mm wide x 25 mm height x 2 mm thick perforated – 15 mtr
- 150 mm wide x 25 mm height x 2 mm thick perforated – 160 mtr
- 300 mm wide ladder type with 75 x 20 mm side channel and 50 x 20 mm rungs tx 2 mm thick – 250 mtr
- 450 mm wide ladder type with 75 x 20 mm side channel and 50 x 20 mm rungs tx 2 mm thick – 150 mtr
- 600 mm wide ladder type with 75 x 20 mm side channel and 50 x 20 mm rungs tx 2.5 mm thick – 250 mtr

10. Lighting fixtures

Installation of following lighting fixtures:

- 2 x 36 W mirror opting lighting fixtures – 200 nos.
- 150 W HPSV – street light type lighting fixtures – 12 nos.
- Post stop Lantern – 125 – W – HPMV – 3 nos.
- 11 W – CFL – Fittings – 12 nos.
- 1200 mm sweep ceiling fans - 12 nos.

11. Light fittings

- 46 nos.
  Luminaire : WSS24071
  LP : 2600

  46 nos.
  Luminaire : WLS 701

- 143 nos.
  Luminaire : WIF 42236 SGW
  276 nos.
  Luminaire : L 36/11

- 113 nos.
  Luminaire : WIF 52236 SGW

  209 nos.
  Luminaire : L 36/11

- 78 nos.
  Luminaire : WCF 81236 SGW
  LP : 2475

  172 nos.
  Luminaire : L 36/11

- 3 nos.
  Luminaire : WRF 25118
  LP : 450

  3 nos.
  Luminaire : L 18/11

- 91 nos.

  Luminaire : WCF 26236 SGW

  LP : 1875

  188 nos.

  Luminaire : L 36/11

- 43 nos.

  Luminaire : WHM 91125 NISL

  43 nos.

  Luminaire : WLM 125

  43 nos.

  Luminaire : WGM 16125

  LP : 1650

II. <u>WATER</u>

(a) Purified water plant

NaOCI dosing system

- Raw water storage tank
  No. of units : One
  Capacity : 1000 litres
  M.O.C. : HDPE

- Raw water pump
  No. of unit : One
  Type : Centrifugal monobloc
  Capacity : 1.25 m^3/hr
  Head : 30 m WC
  M.O.C. : S.S. 304
  Make : Grundfos, Denmark

- Multigrade filter

  No. of unit : One

  Type of unit : Vertical down flow

  Mode of operation : Manual

  Maximum flow rate : 1.25 m^3/hr

  Filter media : Graded sand

  Time required for backwash : 5 – 7 minutes

  Pressure vessel diameter: 257 mm

  Height on straight : 928 mm

  Material of construction : FRP

  Valve type : Manual Diaphragm valve

  M.O.C. of valve : U-PVC

Ultrafiltration system

- Ultrafiltration membranes with housing
  No. of units : One
  Mode of operation : Automatic
  Type : Hollow fiber
  Permeate flow rate : 1.12 m^3/hr
  M.O.C. : Poly sulphone
  Make : Koch, U.S.A.

- UF fast flush pump
  No. of unit : One
  Type : Horizontal centrifugal
  Capacity : 5.5 m^3/hr
  Head : 15 m
  M.O.C. : S.S. 316 – Wettable parts
  Make : Grundfos

- UF backflush pump
  No. of unit : One
  Type : Horizontal centrifugal
  Capacity : 1.8 m^3/hr
  Head : 15 m
  M.O.C. : S.S. 304 – Wettable parts
  Make : Grundfos

- UF Premate / DM feed water storage tank
  No. of units : One
  Capacity : 500 litres
  M.O.C. : HDPE

Demineralisation plant

- DM water feed pump
  No. of unit : One
  Type : Horizontal centrifugal
  Capacity : 1.12 m^3/hr
  Head : 30 m WC
  M.O.C. : S.S. 316
  Make : Grundfos, Denmark

- SMBS dosing system
  No. of dosing pump : One
  Type : Positive displacement pump
  Body : Polypropylene
  Flow range : 1.2 – 6 lph
  Power supply : 1 φ, 230 V, 50 Hz

  Dosing tank
  No. of unit : One
  Capacity : 50 litres
  M.O.C. : HDPE

- ORP analyzer
  No. of units : One
  Type : On-line
  Make : Fisher Rosemount

- Strong Acidic Cation exchanger
  No. of unit : One
  Type of unit : Up flow packed bed
  Mode of operation : Manual
  Maximum flow rate : 1.12 m^3/hr
  Vessel diameter : 305 mm
  Height on straight : 990 mm
  Material of construction : FRP

Valve type : Diaphragm
M.O.C. of valve : U-PVC
Type of resin : Strong Acidic Cation
Make of resin : LANXESS, Germany
Resin quantity : 75 litres
Regenerant (HCl) : 4.12 kgs (100%)

- Regenerant tank for SAC
  Capacity : 50 litres
  M.O.C. : HDPE

- Strong base anion exchanger
  No. of unit : One
  Type of operation : Up flow packed bed
  Mode of operation : Manual
  Maximum flow rate : 1.12 m^3/hr
  Vessel dia. : 335 mm
  Height on straight : 1111 mm
  M.O.C. : FRP
  Valve type : U-PVC
  Make of valve : George Fischer
  Make of resin : LANXESS, Germany
  Resin quantity : 100 litres
  Regenerant (NaOH) : 4 kgs (100%)

- Regenerant tank for SBA
  Capacity : 50 litres
  M.O.C. : HDPE

- Conductivity meter
  No. of unit : One
  Type : On-line
  Location : Outlet of SBA unit
  Range : 0 – 100 μs/cm
  Make : Megh

- Mixed bed unit
  No. of unit : One
  Mode of operation : Manual
  Type : Vertical down flow
  Maximum flow rate : 1.12 m^3/hr
  Vessel diameter : 200 mm
  Height on straight : 2000 mm
  M.O.C. : MSRL
  Valve type : Diaphragm
  M.O.C. : U-PVC
  Resin quantity
  Cation : 25 litres
  Anion : 25 litres
  Make of resin : LANXESS, Germany
  Internal coating of vessel : Internally rubber lined
  Rubber lining thickness : 3 mm
  External painting : Two coats of red oxide primer
  Regenerant (HCl) : 2.5 kgs (100%)
  Regenerant (NaOH) : 2.5 kgs (100%)

- Regenerant tank for Cation unit of MB
  No. of units : One
  Capacity : 50 litres
  M.O.C. : HDPE

- Regenerant tank for Anion unit of MB
  No. of units : One
  Capacity : 50 litres
  M.O.C. : HDPE

- Aquatech ultra-violet disinfection unit
  No. of unit : One
  Location : Outlet of MB
  Maximum flow rate : 1 m^3/hr
  Maximum operating pressure : 3.5 kg/cm^2
  Operating temperature : 30^0C
  Make of UV source elements : Philips, Holland / Light Source, USA
  Inlet /Outlet pipe size : 1”
  Power requirement: 230 V, 39 W, 1 phase
  M.O.C.
    UV chambers : S.S. 316
    Control panel : Made of 16 gauge CRCA Epoxy Powder coated sheet

- Conductivity meter
  No. of units : One
  Range : 0 – 10 μs / cm
  Location : At outlet of MB units
  Make : Fischer Rosemount

- Flow Indicator-cum-Totalizer
  No. of unit : One
  Type : On-line
  Location : Outlet of mixed unit
  Make : Techtrol

- DM water storage tank
  No. of units : One
  Capacity : 500 litres
  M.O.C. : S.S. 316

- RO feed pump
  Type : Horizontal centrifugal
  Capacity : 1.12 m^3/hr
  Head : 20 m
  M.O.C. : S.S. 316 Wettable parts
  Power supply : 3 phase, 440 V, 50 Hz
  Make : Grundfos

- Micron porosity cartridge filter
  No. of unit : One
  Capacity : 1 m^3/hr
  Type : Cartridge filter
  Filter elements : 1 lot of spun bonded PP filter elements
  Housing : PP
  Make : Pall

Reverse Osmosis System

- R.O. high pressure pump
  Quantity : One
  Type : Vertical multistage
  Capacity : 2.37 m^3/hr
  Head : 8.06 bar
  M.O.C. : S.S. 316 wetted parts
  Make : Grundfos, Denmark

- Reverse osmosis membranes
  No. of elements : 1 lot
  Type : Hot water sanitizable membranes
  Membrane diameter : 4”

- Reverse osmosis pressure tube
  No. of units : 1 lot
  M.O.C. : S.S. 316

- Conductivity meter
  No. of units : One
  Make : Fischer Rosemount
  Range : 0 – 10 μs / cm
  Location : Outlet of RO

Cleaning system for RO membranes (CIP system)

- CIP pump
  No. of unit : One
  Type : Centrifugal Monobloc
  Capacity : 2.5 m^3/hr
  Head : 30 m
  M.O.C. : S.S. 316, Wettable parts
  Make : Grundfos, Denmark

- Cartridge filter
  No. of unit : One
  Capacity : 2.5 m^3/hr
  Type : Cartridge
  Filter elements : 1 lot of spun bonded PP elements
  Housing : S.S. 316

- CIP tank (steam jacket heating)
  Capacity : 50 litres
  M.O.C. : S.S. 316

Purified water distribution system

- Jacketed and insulated purified water storage tank
  No. of units : One
  Type : Vertical cylindrical with dish ends
  Make : Aquatech
  Capacity : 1 KL
  Diameter of vessel : 1000 mm
  Height of vessel: 1250 mm
  M.O.C. of vessel : S.S. 316 L
  M.O.C. of jacket : S.S. 304
  Cladding : S.S. 304 seal welded

- Hydrophobic vent filter
  Housing : S.S. 316 L electro-polished to 240 grit internally and externally 180 grit
  Cartridge : Jacketed with hydro-phobic cartridge
  Location : Above USP water tank

- Sanitary pressure transmitter for level monitoring
  Type : Sanitary DP transmitter
  Location : Bottom of USP water tank
  Make : Fisher Rosemount
  Tank nozzle M.O.C. : S.S. 316 L
  Measurement range : 0 – 2 bar
  Temperature range : 12 – 85^{0}C

- Product loop pump for recirculation
  Quantity : One
  Type : Sanitary type, centrifugal
  Flow rate : 3 m^3/hr
  Head : 40 meters
  Make : Alfa Laval

- Conductivity meter with auto dumping system
  No. of units : One
  Range : 0 – 10 μs / cm

  Make : Fisher Rosemount
  Location : At return line of loop

Manufactured by : Aquatech Industries (India) Private Ltd.

(b) Ejector system complete with

(i) Water jet ejector system

Capacity : 40 torr

- **Water tank**
  Type : Rectangular
  Capacity : 5000 litres
  M.O.C. : M.S.
  Dimensions :
  Length : 3500 mm
  Width : 1250 mm
  Height : 1260 mm

- **Centrifugal pump**
  Type : MEGA – G – 50 - 125
  Capacity : 60 m^3/hr
  Head : 20 m
  Serial no. : 0532915
  Drive : 7.5 hp, 2900 rpm, FLP motor of Crompton Greaves make
  Manufactured by : K.S.B. Pumps Ltd.

- **Centrifugal pump**
  Type : MEGA – G – 50 - 160
  Capacity : 55 m^3/hr
  Head : 30 m
  Serial no. : 0532916
  Drive : 10 hp, 2900 rpm, FLP motor of Crompton Greaves make
  Manufactured by : K.S.B. Pumps Ltd.

- **Centrifugal pump**
  Type : MEGA – G – 50 - 160
  Capacity : 55 m^3/hr
  Head : 30 m
  Serial no. : 0532911
  Drive : 10 hp, 2900 rpm, FLP motor of Crompton Greaves make
  Manufactured by : K.S.B. Pumps Ltd.

- **Centrifugal pump**
  Type : MEGA – G – 50 - 160
  Capacity : 70 m^3/hr
  Head : 32 m
  Serial no. : 0532926
  Drive : 12.5 hp, 2920 rpm, FLP motor of Crompton Greaves make
  Manufactured by : K.S.B. Pumps Ltd.

- **Centrifugal pump**
  Type : MEGA – G – 50 - 160
  Capacity : 55 m^3/hr
  Head : 32 m
  Serial no. : 0532917
  Drive : 10 hp, 2900 rpm, FLP motor of Crompton Greaves make
  Manufactured by : K.S.B. Pumps Ltd.

- **Water ring vacuum pump**
  Type : WR 28100 x 100
  Capacity : 250 m^3/hr
  Ultimate vacuum : 40 torr
  Eq. No. : 7-05-1700
  Drive : 15 hp, 1475 rpm, FLP motor of Crompton Greaves make
  Manufactured by : H.K. Industries.

- **Vacuum trap tanks – 6 nos.**
  Type : Vertical cylindrical with welded top and bottom torispherical ends.
  Capacity : 500 litres
  M.O.C. : M.S.
  Dimensions
  Dia. : 800 mm
  Height : 1350 mm

(ii) Steam jet ejector system
Capacity : 1 torr

- **Water tank**
  Type : Rectangular
  Capacity : 5000 litres
  M.O.C. : PP/FRP
  Dimensions :
  Length : 2850 mm
  Width : 1280 mm
  Height : 1280 mm
- **Centrifugal pump**
  Model : PPCL – 100 - CT
  Capacity : 30 m^3/hr
  Head : 35 m
  Serial no. : 0508 PP75 0942
  Drive : 15 hp, 2930 rpm, FLP motor of Crompton Greaves make
  Manufactured by : Antico

- **Centrifugal pump**
  Model : PPCL – 75 - CT
  Capacity : 30 m^3/hr
  Head : 35 m
  Serial no. : 0508 PP75 0943
  Drive : 15 hp, 2930 rpm, FLP motor of Crompton Greaves make
  Manufactured by : Antico

- **Centrifugal pump**
  Model : PPCL – 100 - CT
  Capacity : 80 m^3/hr
  Head : 25 m
  Serial no. : 0508 PP100 945
  Drive : 15 hp, 1475 rpm, FLP motor of Crompton Greaves make
  Manufactured by : Antico

- **Vacuum trap tanks – 2 nos.**
  Type : Vertical cylindrical with welded top and bottom torispherical ends.
  Capacity : 500 litres
  M.O.C. : F.R.P.
  Dimensions
  Dia. : 800 mm
  Height : 1350 mm
  Supplier : H.K. Industries

III. BOILERS

(1) Steam Boiler

Type	:	Horizontal smoke tube-cum-water wall multi fuel boiler.
Model	:	Agroman-20
Capacity	:	2500 kg/hr (F & A 100^0 C)
Operating pressure	:	10.54 kg/cm^{2}g
Steam dryness fraction	:	98%
Safety valve set pressure	:	10.91 kg/cm^{2}g
Steam condition	:	98% dryness fraction minimum
Fuel	:	Coal
Thermal efficiency	:	75% $\pm$ 2 with HRU on NCV of fuel as per BS 845 Part-I
Flue gas temp.	:	Exit gas from III-pass 210-240^0 C Exit gas from HRU 150-170^0 C
Fuel consumption	:	Coal @ 4500 Kcal/hr : 415 Kg/hr

<u>Mechanical Data</u>

Boiler Tube size	:	
Water wall tubes	:	63.5 mm OD
Water wall tube thickness	:	3.66 mm
Smoke tube	:	63.5 mm OD
Smoke tube thickness	:	3.66 mm
Heat transfer area	:	91 m^2

<u>M.O.C.</u>

Shell/tube plates	:	ASTM 515 / 516 Gr. 70
Water wall tubes / smoke tubes	:	BS 3059
Down corner, riser pipe / header	:	ASTM 106
Stand pipe	:	ASTM 106
Non-pressure part	:	IS 2062

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<u>Rotating Equipment</u>

F.D. Fan

Type	:	Centrifugal direct drive
Quantity	:	One
Flow	:	3500 m^3 per hour
Head	:	100 mm wg
Speed	:	2900 rpm
Motor	:	3 HP (1.7 kW)

I.D. Fan

Type	:	Centrifugal ‘V’ belt drive
Quantity	:	One
Flow	:	8750 m^3 per hour
Head	:	200 mm wg
Speed	:	2900 rpm
Motor	:	10 HP (7.5 kW)

Feed Pumps

Type	:	Centrifugal multistage
Quantity	:	Two
Capacity	:	2500 litres per hour
Head (pressure for wp of 10.54 kg/cm^2g)	:	120 m
Speed	:	2900 rpm
Motor	:	5 HP (3.73 kW)

Temperature Profile & Velocity Profile

Boiler		
Inlet gas temperature of II pass tubes	:	800 – 950^0 C
Velocity of gases in the II pass tubes	:	16 to 18 m/s
Inlet gas temperature of III pass tubes	:	300 – 350^0 C
Exit flue gas temperature of III pass tubes	:	210 – 240^0 C
Velocity of gases in the III pass tubes	:	16 to 18 m/s
Heat Recovery Unit		
Inlet flue gas temperature of HRU	:	210 – 240^0 C
Velocity of gases in the tubes	:	16 to 18 m/s
Exit flue gas temperature of HRU	:	150 – 170^0 C
Draft Losses		
Furnace	:	60 mm WGC

2. Water Softening Plant

Softner

M.O.C.	:	M.S.R.L.
Diameter / thickness	:	500 mm
Height	:	800 mm
Average treated flow	:	3 m^3 per hour
Maximum treated flow	:	4 m^3 per hour
Maximum working pressure	:	4 kg / cm^2

Minimum working pressure : 2.5 kg / cm^2

Average operating pressure : 3.0 kg / cm^2

Resin quantity	:	150 litres
Inlet hardness	:	125 ppm
Outlet hardness	:	5 ppm

Pressure drop across the system	:	0.7 kg / cm^2
Salt quantity for regeneration	:	23 kg
Inlet / Outlet size	:	25 / 25

<u>Salt / Saturator</u>

Diameter	:	450 mm
M.O.C.	:	H.D.P.E.
Depth	:	700 mm

<u>Output between two regeneration</u> : 72 hours

<u>Regeneration cycle Time</u> : 2 hours

<u>Instrumentation</u>

Rotameter

No. of unit	:	One
Type	:	On line
Range	:	500 – 5000 LPH
Location	:	Before inlet of filter unit

Water meter

No. of unit	:	One
Type	:	On line
Location	:	Before inlet of filter unit

Resin trap		
No. of unit	:	One
Location	:	Outlet of softner unit
M.O.C.	:	S.S. 316

3. Feed Tank

Capacity	:	10,000 litres
M.O.C.	:	M.S.

4. Chimney

Type	:	Cylindrical, vertical with conical flare at bottom
Overall size	:	450 mm ID x 30000 mm long
Thickness	:	8 mm to 14 mm

<u>Top end</u>

Type	:	Cylindrical shell
Size	:	450 mm ID x 10000 mm long
M.O.C.	:	M.S.

<u>Bottom end</u>

Type	:	Flare
Size	:	2000 mm ID x 20000 mm ht.
M.O.C.	:	M.S.

IV. HUMIDIFICATION PLANTS

In many industrial process (like textile) it is essential to maintain humidity in the room to a certain pre-requisite level. The humidity in the atmosphere varies with season. During & pre-monsoon season have maximum humidity (It can be even 100% when it is raining). Winter will have minimum humidity. For maintaining the Relative Humidity (RH) and temperature of air in some of the processes, the humidification plants are installed. The humidification plants senses the humidity in the room, and then either adds or removes humidity from the air and then this controlled air is blown in to the room. The humidity can be increased by spraying fine particles of water and can be reduced by either heating the air OR by lowering the temperature of the air. By reducing the temperature, the water vapour gets condensed and can be removed easily. The air with controlled humidy is blown it to the process area and the air from the room is sucked back through return air duct.

Given under is the technical details of the humidification plants deployed in one of the textile unit. The quantity of the plant is also mentioned, so that the students can visualize as to how many units can be used in a single textile mill. It is once again to remind that the details given under is for a typical plant. Size, quantity and specification may differ from plant to plant depending on the nature of use. :

Sr. No.	Number of Plants	Details of Humidification Plant
1.	5	Marshall Plant each 27000 CFM capacity with one supply air fan and supply air return Air ducts, Fan Motor 10 HP Crompton Parkinson. Motor for water spray – 7.5 HP Kirloskar make. Location of fan – side.
2.	1	Vertical Marshall Plant Fan & Motor same as above. Motor for Water spray – 5 HP. Location of fan Building top.
3.	2	C. Doctor make. Capacity : 1,00,000 CFM each comprising two supply air fans (20 HP), two return air fans (40,000 CFM, 12.5 HP), one Kirloskar make water pump (35 liters/sec. 20 HP) and ducting per plant.
4.	2	C. Doctor make. Capacity : 75,000 CFM each comprising of two supply air fans (15 HP), one return air fan (60,000 CFM, 20 HP) and one water pump (20 HP) and ducting per plant.
5.	2	C. Doctor make. Capacity : 1,05,000 CFM each comprising of two supply air fans (20 HP), two return air fans (84,000 CFM, 15 HP) and one water Pump (35 liters/sec., 20 HP) and ducting per plant.
6.	78	Bahnson Humidifiers – C. Docotor make, L type unit 3/4 HP, 2200 CFM, 9 Gal/hr. water evaporation per fan.
7	2	Crompton Water Pumps for all above fans. Kirloskar make. Type PSM-1 63 GPM at 180’, 10 HP Motor.

Given under is the details of another textile unit . This is given to visualize as to how the machinery can differ from one unit to another.

1	2	HD-4 fan. Capacity – 1200 RFM Motor – 5.75 HP. No separate water pump.
2	2	Bahnson Fan. 2200 CFM Capacity. Motor – ¾ HP
3.	4	Marshalling Plant each 2700 CFM capacity with one supply air fan (10 HP) and no return air fan and one water pump (60 GPH, 5HP) per plant with one stand by pump motor (20 HP) common for all four plants.
4	4	SF humidification plant each 5800 M3/hr capacity with two supply air fans (10 HP) and no return air fan and two water pumps (650 liters/min., 7.5 HP) per unit.
5	30	Bahnson fans – 2200 CFM capacity Motor ¾ HP.
6	2	(a) Fan capacity 4200 CFM each with one supply air fan (10 HP) and no return air fan and one water pump (12.5 HP) per unit.
7		(b) HD-4 fan. Capacity – 1200 CFM each. Moor HP – 5.75, No water pump and no return air fan.
8	1	(a) Fan Motor HP – 35. Fan Motor HP – 15. Water Pump – 2 Nos. (12.5 HP)
9	12	(b) Bahnson fans. 2200 CFM Capacity. Motor – ¾ HP.
10	145	Bahnson fans same capacity as above with Beacon 2 nos. of water pump (12.5 HP) and one water pump (10 HP).
11	6	(a) Bahnson fans.
12	1	(b) Fan capacity – 4200 CFM. Fan Motor HP – 10. Water Pump – 12.5 HP.

V. WATER SUPPLY, DISTRIBUTION AND PURIFICATION PLANTS

Water is essential for life. It can be human life or industry's life. There are many industrial processes, like chemicals or textiles, which need lots of water. The water can be obtained from various sources like Municipal authority, from river or canals or from bore well.

The raw water taken from the source can be used fro some purpose like in humidification plant etc., but for industrial and drinking use, the same is processed first. The processing of water includes filtration to remove solid / suspended impurities. The water after filtration can be used fro drinking purpose. (Some times Chlorine may be added to this water). When water is to be used for generating steam in boilers, the same is treated by softening plant. The water softening plants are used to remove dissolved impurities (like salts) from the water. If we use untreated water in the boiler, the tubes can get choked.

Entire water distribution system consists of raw water pumps, intermediate storage tanks (or sumps), filters, softening plants, pumps at various stages for pumping water from one place to another, final storage tank and of course the piping network for supply of water.

Given under is the details of water supply distribution system of a processing house.

1.0 Source of water supply is as under :

(A) From Municipal authority through 6” pipe line.

(B) Canal water from water irrigation department through two pumps located in the factory area, details of which are as under:

Make – Mather & Platt
Motor – 30 HP/27 HP
Size – 10” x 8”/11” x 9”.

(C) From Tube well/bore well installed in the mill area.

Water is collected and stored in a tank of 65,100 cu. ft. area. From this tank water is also supplied to caustic recovery plant installed in one of the Unit through two pumps. The details of which are as under:

Make – Everest/Worthington Simpson
HP – 20/12.5
Size – 5” x 4”/4” x 4”
Water is fed from this water tank to the overhead tank for drinking through Mather & Platt make, 30 HP, Size 5” x4” pump.

Water is also supplied from this tank for humidification plants, fire protection and other services where water equipment exists.

Raw water is fed to reaction tank (23’x23’x17’-6”) from Factory tank no.1 through pump (HP 12.5 size 4” x 3” capacity – 7000 GPH) Outlet of this reaction tank is connected to two gravity filters (each 7’-6” dia and 10’ height). Soft water is collected from these gravity filters in the underground water tank from where it is fed to the boiler feed water tank (10’-6’ x 8’ – 3000 Gallons) and overhead MS tank (25’ x 21’ x 9’ – 2955 Gallons) through two pumps details of which are as under:-

Make – Kirloskar
Size – 3” x 2½” / 4” x 3”
Motor – 10 HP / 7.5 HP
Capacity – 100 GPM / & 45 GPM

WATER PURIFICATION PLANTS

(WATER SOFTNERS)

Water purification plants consists of three water softening plants which are installed in Unit for supply of soft water to all the boilers. This soft water is supplied to feed water tank located in boilers house for further supply to boiler drum. Details of three softening plants are as under:

(a) Water Softener
Make – Candy Filters
Type – Base exchange
Capacity – 69 M3/Hr (15180 GPH)

Raw water is fed from Mill tank No.1 and tube well through pumps to water softener and soft water is collected from the outlet of the softener in the underground softened water well of 50' dia. and 30' deep. From this softened water well, soft water is pumped to overhead MS tank of capacity 24000 Gallons. The details of these pumps are as under:

Make – Kirloskar
Type – Centrifugal
Size – 6" – 4"
Capacity – 10000 GPH
Motor – 50 HP

(b) Water Softener
Make – Permutit Co. England
Type – Base exchange
Capacity – 2000 GPH

(c) Water Softener
Make – Candy Filters
Type – Lime Soda – Sodium Aluminate
Capacity – 14000 GPH

VI. AIR COMPRESSORS

1. Air dryer

Type	:	Heatless
Model	:	ECHL 10
Capacity	:	170 Nm^3 per hour
Working pressure	:	150 psig
Test pressure	:	250 psig

2. Air Compressor

Type	:	Reciprocating
Model	:	7 x 5 ESV 1 NL2 Package
Size	:	7” x 5”
Speed	:	750 rpm
Discharge pressure	:	100 psig
Displacement	:	165 cfm

Motor

Capacity	:	22 kw
Speed	:	1440 rpm
Make	:	Siemens

After cooler

Type	:	Vertical after cooler with moisture separator

Air receiver tank

Capacity	:	0.54 m^3
Serial no.	:	PE 1942

3. Process Air Tank

Type	:	Cylindrical, vertical with top and bottom dished ends
Capacity	:	5,200 litres

<u>Shell</u>

Size	:	1600 mm ID x 2200 mm long
M.O.C.	:	M.S.
Thickness	:	10 mm

<u>Dished ends</u>

Type	:	10% Torispherical
M.O.C.	:	M.S.
Thickness	:	12 mm

4. Instrument Air Tank

Type	:	Cylindrical, vertical with top and bottom dished ends
Capacity	:	2,000 litres

<u>Shell</u>

Size	:	1200 mm ID x 1400 mm long
M.O.C.	:	M.S.
Thickness	:	8 mm

<u>Dished ends</u>

Type	:	10% Torispherical
M.O.C.	:	M.S.
Thickness	:	10 mm

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VII. REFRIGERATION

1. Brine Chilling Plant

Capacity	:	75 TR
Make	:	Kirloskar Pneumatic

<u>Compressor</u>

Model	:	KC-6
Refrigerant	:	R717
RPM	:	750
TR at selected RPM	:	76.5 TR
Power consumed	:	88.3 kw
Motor	:	150 hp, 1488 rpm, Crompton Greaves make

<u>Condenser</u>

Type	:	Shell and tube
M.O.C.	:	Shell : M.S.
		Tube : BS 3059 ERW Steel
Condensing temp.	:	40^0 C
Cooling water inlet temperature	:	32^0 C
Cooling water outlet temperature	:	36^0 C
Cooling water pressure drop	:	0.8 kg/cm^2
Cooling water flow rate	:	77 m^3 / hr (for condenser)
Area of heat transfer	:	a. Water side : 58.4 m^2
		b. Refrigerant side : 73 m^2
Heat transfer (heat rejection) rate	:	244333 kcal per hour
Shell	:	760 mm OD x 3048 mm long
No. of tubes	:	240
Tube	:	31.75 mm OD x 3048 mm long
Tube thickness	:	3.25 mm (10 gauge)
No. of passes	:	8
Make	:	Aircon

Chiller

Medium	:	30% w/w MEG
Chilled brine flow rate	:	48 m^3 per hour
Chilled brine pressure drop	:	0.6 kg/cm^2
Area of heat transfer	:	1. Chilled brine side: 49.80 m^2 2. Refrigerant side : 63.25 m^2
M.O.C.	:	1. Tube : BS 3059 ERW Steel 2. Baffles : M.S. 3. Shell : M.S.
Evaporating temp.	:	(-) 13^o C
L.M.T.D.	:	7.2^o C
Chilled brine inlet temp.	:	(-) 3^0 C
Chilled brine outlet temperature	:	(-) 8^0 C
No. of passes	:	8
Shell	:	710 mm OD x 3048 mm long
Tube	:	31.75 mm OD x 3048 mm long
Shell thickness	:	10 mm
Tube thickness	:	3.25 mm (10 gauge)
No. of tubes	:	208
Make	:	Aircon

Receiver

M.O.C.	:	M.S.
Size	:	610 mm dia. x 3000 mm long
Shell thickness	:	10 mm
Dish thickness	:	10 mm
Mounting	:	Horizontal
Make	:	Aircon

Surge drum

M.O.C.	:	M.S.
Size	:	406 mm dia. x 1800 mm long
Shell thickness	:	8 mm
Dish thickness	:	8 mm
Mounting	:	Horizontal
Make	:	Aircon

2. Brine Chilling Plant

Capacity	:	75 TR
Make	:	Kirloskar Pneumatic

Compressor

Model	:	KC-6
Refrigerant	:	R717
RPM	:	750
TR at selected RPM	:	76.5 TR
Power consumed	:	88.3 kw
Motor	:	150 hp, 1488 rpm, Crompton Greaves make

Condenser

Type	:	Shell and tube
M.O.C.	:	Shell : M.S.
		Tube : BS 3059 ERW Steel
Condensing temp.	:	40^0 C
Cooling water inlet temperature	:	32^0 C
Cooling water outlet temperature	:	36^0 C
Cooling water pressure drop	:	0.8 kg/cm^2
Cooling water flow rate	:	77 m^3 / hr (for condenser)
Area of heat transfer	:	a. Water side : 58.4 m^2
		b. Refrigerant side : 73 m^2

Heat transfer (heat rejection) rate	:	244333 kcal per hour
Shell	:	760 mm OD x 3048 mm long
No. of tubes	:	240
Tube	:	31.75 mm OD x 3048 mm long
Tube thickness	:	3.25 mm (10 gauge)
No. of passes	:	8
Make	:	Aircon

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L.M.T.D.	:	7.2^0 C
Chilled brine inlet temp.	:	(-) 3^0 C
Chilled brine outlet temperature	:	(-) 8^0 C
No. of passes	:	8
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Size	:	610 mm dia. x 3000 mm long
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Surge drum

M.O.C.	:	M.S.
Size	:	406 mm dia. x 1800 mm long
Shell thickness	:	8 mm
Dish thickness	:	8 mm
Mounting	:	Horizontal
Make	:	Aircon

3. Brine Circulation Pump

Type	:	Centrifugal
Model	:	CC 125 x 100 – 200
Flow rate	:	130 m^3 per hour
Head	:	40 m
Size	:	125 x 100
Serial no.	:	105266 – 02
Make	:	Sulzer Pumps India Ltd.

Motor

Capacity	:	40 hp
Speed	:	2940 rpm
Motor make	:	Hindustan

4. Brine Circulation Pump

Type	:	Centrifugal
Model	:	CC 125 x 100 – 200
Flow rate	:	130 m^3 per hour
Head	:	40 m
Size	:	125 x 100
Serial no.	:	105266 – 01
Make	:	Sulzer Pumps India Ltd.

<u>Motor</u>

Capacity	:	40 hp
Speed	:	2940 rpm
Motor make	:	Hindustan

5. Brine Circulation Pump

Type	:	Centrifugal
Model	:	CC 100 x 80 – 160
Flow rate	:	60 m^3 per hour
Head	:	25 m
Size	:	100 x 80
Make	:	Sulzer Pumps India Ltd.

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<u>Motor</u>

Capacity	:	10 hp
Speed	:	2910 rpm
Motor make	:	Hindustan

6. Brine Circulation Pump

Type	:	Centrifugal
Model	:	CC 100 x 80 – 160
Flow rate	:	60 m^3 per hour
Head	:	25 m
Size	:	100 x 80
Serial no.	:	105265 – 02
Make	:	Sulzer Pumps India Ltd.

<u>Motor</u>

Capacity	:	10 hp
Speed	:	2910 rpm
Motor make	:	Hindustan

7. Brine Circulation Pump

Type	:	Centrifugal
Model	:	CC 100 x 80 – 160
Flow rate	:	60 m^3 per hour
Head	:	25 m
Size	:	100 x 80
Serial no.	:	105265 – 01
Make	:	Sulzer Pumps India Ltd.

<u>Motor</u>

Capacity	:	10 hp
Speed	:	2910 rpm
Motor make	:	Hindustan

CVSRTA

8. Brine Storage Tank

Type	:	Cylindrical, vertical with conical top and flat bottom
Capacity	:	40,000 litres

<u>Top end</u>

Type	:	Conical
Size	:	3550 mm OD
M.O.C.	:	M.S.
Thickness	:	5 mm

<u>Bottom end</u>

Type	:	Flat
Size	:	3650 mm OD
M.O.C.	:	M.S.
Thickness	:	10 mm

<u>Shell</u>

Size	:	3500 mm ID x 4500 mm HT
M.O.C.	:	M.S.
Thickness	:	8 mm

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VIII. COOLING TOWER

1. Cooling Tower

Model	:	D8-8002
Flow rate	:	425 m^3/hr
Draft / Flow rate	:	Induced / Cross
Hot water temp.	:	37^0 C
Cold water temp.	:	32^0 C
Wet bulb temp.	:	28^0 C
Packing type/depth	:	Splash/1525 mm
Average heat load per 24 hours	:	710 TR
Make	:	Techno

<u>Mechanical equipment data</u>

Fan type	:	FRP
Quantity	:	2 nos.
Model	:	P6-1900
Capacity	:	125000 m^3 per hour
Diameter	:	1900 mm
Blades	:	6

<u>Motor</u>

Capacity	:	10 hp
Speed	:	960 rpm
Make	:	Techno

<u>M.O.C.</u>

Frame	:	Wooden (treated)
Casing and Louvers	:	Asbestos cement sheet
Drift eliminators	:	Treated timber
Fill	:	Treated timer
Make	:	Techniq

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2. Cooling Water Transfer Pump

Type	:	Centrifugal
Model	:	UP 80/30
Flow rate	:	75 m^3 per hour
Head	:	25 m
Size	:	80 x 125
Make	:	Kirloskar Bros. Ltd.

<u>Motor</u>

Capacity	:	15 hp
Speed	:	1455 rpm
Motor make	:	ABB

3. Cooling Water Transfer Pump

Type	:	Centrifugal
Model	:	UP 80/30
Flow rate	:	75 m^3 per hour
Head	:	25 m
Size	:	80 x 125
Serial no.	:	1745204091
Make	:	Kirloskar Bros. Ltd.

<u>Motor</u>

Capacity	:	15 hp
Speed	:	1455 rpm
Motor make	:	ABB

4. Cooling Water Transfer Pump

Type	:	Centrifugal
Model	:	UP 80/30
Flow rate	:	75 m^3 per hour
Head	:	25 m
Size	:	80 x 125
Serial no.	:	1745204090
Make	:	Kirloskar Bros. Ltd.

Motor

Capacity	:	15 hp
Speed	:	1455 rpm
Motor make	:	ABB

5. Cooling Water Circulation Pump

Type	:	Centrifugal
Model	:	UP 150/38 A
Flow rate	:	225 m^3 per hour
Head	:	40 m
Size	:	150 x 200
Serial no.	:	1746004103
Make	:	Kirloskar Bros. Ltd.

Motor

Capacity	:	75 hp
Speed	:	1475 rpm
Motor make	:	Crompton Greaves

6. Cooling Water Circulation Pump

Type	:	Centrifugal
Model	:	UP 150/38 A
Flow rate	:	225 m^3 per hour
Head	:	40 m
Size	:	150 x 200
Make	:	Kirloskar Bros. Ltd.

Motor

Capacity	:	75 hp
Speed	:	1475 rpm
Motor make	:	Crompton Greaves

7. Sand Filter

Supplied by	:	Seion International

IX. PIPING INSTALLATIONS

1. Ammonia valves and fittings for ammonia refrigeration system
   Consisting of -

- Expansion valves of required size and quantity
  Type : Expansion, flanged with set
  Temperature applications : Low temperature, - 50^0 C

- Non-return valve of required size and quantity
  Type : Liquid, flanged with set
  Temperature applications : Low temperature, - 50^0 C

- Ammonia line valves of required size and quantity
  Type : Globe
  Temperature applications : Low temperature, - 50^0 C

- Solenoid valve with filter set (Castle) of required size and quantity
  Type : Flanged with set
  Temperature applications : High temperature

- Thermostatic expansion valve (Danfoss) of required size and quantity
  Type : Flanged with set
  Temperature applications : Range $–5^0$ to $–20^0$ C

- Back pressure regulating valve with CVP (Danfoss) of required size and quantity
  Type : Flanged with set
  Temperature applications : Range $–5^0$ to $–20^0$ C
  Make : Danfoss

2. Ammonia valves and fittings for ammonia refrigeration system

Consisting of -

- Electronic float switch of required size and quantity

Type	:	Threaded
Temperature applications	:	Low temperature, - 50^0 C
Make	:	Sigma

- Dual safety valve manifold of required size and quantity

Type	:	Threaded
Temperature applications	:	High temperature
Make	:	Superfreez

Safety relief valve of required size and quantity

Type	:	Threaded
Temperature applications	:	Low temperature, - 50^0 C
Make	:	Superfreez

- Expansion valve of required size and quantity

Type	:	Expansion, flanged with set
Temperature applications	:	Low temperature, - 50^0 C
Make	:	Super

- Non-return valve of required size and quantity

Type	:	Gas, flanged with set and Liquid, flanged with set
Temperature applications	:	High temperature
Make	:	Super

- Ammonia filter required size and quantity

Type	:	Flanged with set
Temperature applications	:	Low temperature, - 50^0 C
	:	High temperature
Make	:	Superfreez

- Ammonia flow indicator of required size and quantity

Type	:	Flanged with set
Temperature applications	:	High temperature
Make	:	Superfreez

- Oil drain valve of required size and quantity

Type	:	Needle
Temperature applications	:	Range $–5^0$ to $–20^0$ C
		High temperature
Make	:	Super

- Solenoid valve with filter set (Castle) of required size and quantity

Type	:	Flanged with set
Temperature applications	:	High temperature
Make	:	Manik's

3. Compressed air piping (S.S. 304 schedule 10 pipe) of required size and quantity
4. Compressed air piping (GI 'B' class pipe) of required size and quantity
5. Raw water piping (GI 'B' class pipe) of required size and quantity
6. Chlorinated water piping (GI 'B' class pipe) of required size and quantity
7. De-chlorinated water piping (GI 'B' class pipe) of required size and quantity
8. Soft water piping (GI 'B' class pipe) of required size and quantity
9. Chilled water piping (GI 'B' class pipe) of required size and quantity
10. Glycol piping (GI 'B' class pipe) of required size and quantity

11. Steam supply and distribution piping (M.S. seamless IBR A-106 pipe) of required size and quantity
12. Ammonia high temperature piping (M.S. seamless,106, Grade ‘B’ pipe) of required size and quantity
13. Ammonia low temperature piping (M.S. seamless, A-333, Grade 6LT pipe)
14. S.S. conduit pipe
15. S.S. square pipe
16. PUF insulation
17. Hot insulation
18. Insulation
19. M.S., G.I. and Steel (Low and High temperature) pipeline fittings
20. S.S. Dairy pipes – (1.6 mm thick)
21. S.S. Sch 5 pipe
22. S.S. Unions
23. S.S. Bend
24. S.S. – 2 way plug valve with SMS unions
25. S.S. – 3 way plug valve with SMS unions
26. S.S. – NRV with SMS unions
27. S.S. – B/F valve with SMS unions
28. S.S. 304 rectangular pipe –

    Type : High polished
29. S.S. 304 square pipe –

    Type : High polished
30. PUF pipe section – 50 mm thickness

    Temperature : High quantity – 30

    Low quantity – 60

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X. FIRE FIGHTING EQUIPMENT

The system comprises of 9 ground hydrants, 3 monitors and 3 fire escape hydrants equivalent to 21 hydrants. (One monitor is considered equivalent to three hydrants). The mains have been laid underground and above ground over pedestals and over pipe racks carrying utility piping. The mains are M.S. heavy confirming to IS 1239 and have been provided wrapping and coating for the underground portion.

The system is fed by one no. 171 m^3 per hour diesel engine driven fire service pump. A jockey pump of 10.8 m^3 per hour has been provided to maintain the pressure in the system. Details of the pumps are as follows :

1. Main Pump with Engine with Control Panel

<u>Pump</u>

Type	:	CE 80/32
Size	:	80 x 125
Capacity	:	171 m^3 per hour
Head	:	70 m
Pump no.	:	18823040010
Make	:	Kirloskar Brothers Ltd.

<u>Engine</u>

Type	:	4 RI 3467
Rated hp	:	94
Speed	:	2150 rpm
Make	:	Kirloskar Oil Engines Ltd.

2. Jockey Pump

Type	:	Centrifugal
Model	:	CPHM – 25 – 26 A
Size	:	25 x 50
Capacity	:	10.8 m^3 per hour
Head	:	70 m
Serial no.	:	1789304162
Make	:	Kirloskar Brothers Ltd.

Motor

Capacity	:	2 hp
Speed	:	2900 rpm

The pressure switch of the Jockey pump has been set in such a way that the pump will come into operation when the system pressure drops to 5.5 kg/cm^2 and will cut out when the pressure reaches 7 kg/cm^2. The pressure of the main pump has been set to operate the pump at 4.5 kg/cm^2. The stopping of the main pump is manual.

Pressure gauges have been provided on the delivery of the pump sets before non-return valves to indicate the pressure developed by the pump. One more pressure gauge has been provided near the pressure switches to indicate the system pressure. An air vessel has been provided to dampen the water hammers.

The pumps draw water from an above ground reservoir of 375 m^3 and the pumps work under flooded suction condition.

Operation of the System

The pressure in the system will be generally maintained at 7 kg/cm^2. In case of minor leakages if the pressure drops to 5.5 kg/cm^2 the Jockey pump will come into the operation. When the pressure in the system reaches 7 kg/cm^2 the pump will stop automatically.

In case any hydrant or monitor is opened the pressure will drop rapidly and the Jockey pump will not be able to maintain the pressure. When the pressure drops down to 4.5 kg/cm^2 the Diesel Engine driven pump will come into operation. This pump, however will have to be stopped manually after closing the hydrants or monitors opened.

<u>Fire extinguishers</u>

1.	Quantity	:	36 nos.
	Type	:	CO_2
	Capacity	:	4.5 kgs.
2.	Quantity	:	29 nos.
	Type	:	D.C.P.
	Capacity	:	5 kgs.
3.	Quantity	:	3 nos.
	Type	:	Mechanical foam
	Capacity	:	9 litres
4.	Quantity	:	1 no.
	Type	:	Mechanical foam
	Capacity	:	50 litres

<u>Piping</u>

Underground hydrant system

Size	:	200 NB
Under ground	:	117.49 m
Size	:	150 NB
Under ground	:	489.21 m
Above ground	:	36.53 m
Size	:	125 NB
Under ground	:	728.25 m
Above ground	:	40.00 m

Size	:	100 NB
Under ground	:	268.73 m
Above ground	:	76.28 m

Size	:	80 NB
Under ground	:	252.94 m
Above ground	:	57.66 m

XI. INSTRUMETNATION

Fundamentals of Process instrumentation

In a process industry, out of the other engineering fields, Instrumentation is one which contributes very high in the cost. Instrumentation is very costly and are of very divergent in nature. The technology in instrumentation changes very rapidly. An instrument procured today may become obsolete within couple of years.

Due to this reason, it is very important for a valuer to know little in-depth about instrumentation.

At the end of the chapter, an effort is made to track the changing technology in the instrumentation. This will help to decide the replacement cost.

What is Instrumentation ?

- Instrumentation is art & science of measurement & control.
- It makes available the necessary process information (Indication/ Trending/ Status) at a predetermined destination in a pre determined form.
- It also controls the parameter within a specified limits / at specified value.
- Instrumentation provides a means to the plant operator to operate the plant safely, continuously & consistently with optimum productivity.
- It minimizes the human element in the plant operation.

Instrumentation provides Handle for Monitoring

- Health of the Process
- Health & Performance of Equipments
- Draws attention to the exceptional conditions

In fact Instrumentation acts as eyes & ears for engineers of all the disciplines in general and chemical engineers in particular.

Parameters Measured

The Parameters encountered in the Process Industry are:

Basic parameters-

- Pressure
- Level
- Flow
- Temperature

Other parameters that are also important in process industry and which are controlled are –

- Quality of Intermediates & Finished Products
  - Physical
  - Chemical

- Speed / Vibration/ Displacements for rotary machines

Basic Instrument Terminology

Now before learning something about instrumentation, let us see some of the basic terminology :

Process:-

This is the series of Continuous or regularly Recurring steps or actions, intended to achieve a predetermined result, as in refining oil, heat treating metal, or manufacturing paper.

Primary Element:-

The element or device which generates conditions in the measured variable that may be detected by a sensing element. e.g. Orifice Plate
(**Note:** A primary element may also be a sensing element)

Transmitter:-

A transducer which responds to a measured variable & converts it to the standardized transmission signal which is a function only of the measurement.

Controller:-

A device or program which regulates automatically to regulate variable.

Converter:-

A transducer which responds to a instrument signal & changes its form e.g. I/P Converter.

Actuating Element:-

That part which adjusts the Correcting element in response to a signal e.g. Valve Actuator

Correcting Element:-

The part of the correcting unit which directly adjusts the value of the operating conditions e.g. Valve

Signal :-

It is the event or phenomena that conveys data from one point to another.

- Pneumatic air Pr. 0.2 to 1.0 Kg/cm2 g through tubes
- Electrical 4 to 20 mA through copper conductor
- Digital signal through twisted / shielded pairs.

Typical Instrument Characteristic

As a valuer one has to differentiate between different variants of same function instrument. One must compare following specifications to know this difference -

Accuracy:-

In Process Instrumentation, degree of conformity of an indicated value to a recognized accepted Standard value, or Ideal value.

TERMINOLOGIES

Range:-

The region between the limits within which a Quantity is measured, received or transmitted.

Upper Range Limit (URL):-

The highest quantity that a device can be adjust to measure.

Lower Range Limit (LRL):-

The Lowest quantity that a device can be adjusted to measure

Upper Range Value (URV):-

The highest quantity that a device is adjust to measure.

Lower Range Value (LRV):-

The Lowest quantity that a device is adjusted to measure

Reading the Specification:-

x %age of Calibrated Span

x %age of URL

x %age of Reading

Error:-

Zero Error

Span Error

'Zero & Span Error are sometimes expressed together as a Total Error'

Other Important Characteristics:

Precision, Sensitivity, Dead Zone & Rangeability

Accuracy & Calibration:-

ISO Standard states that the calibration instrumentation. Must have ≥5 times the accuracy of the instrumentation to be calibrated.

EXAMPLE OF SPECIFICATION SUPPLIED BY MANUFACTURER:

Functional Specification:-

Environment within which the instrument can operate & still meet its performance specification.

Most Common are: Service, Output, Power Supply, Load Limitation Indication, Hazardous Location

Performance Specification:

Temperature effect, Over pressure effect, Static pressure effect & Vibration effect.

MTBF (Mean Time Between Failure)

BASIC MEASUREMENTS IN INSTRUMENTATION

Having understood the basics of instrumentations, let us see the various types of instruments widely found in the industry –

- Pressure
- Temperature
- Flow
- Level

Pressure Measurement

Pressure measurement and control is necessary because in all process many reactions are function of the pressure (positive or vacuum) as well as temperature. In addition to it's control, to obtain desired condition for the process it is also necessary for delivery of material through equipment piping. The other variables such as level and flow can be inferred from Pressure Measurements.

The principles used for pressure sensors are :

- U tube manometer
- Bourdon tubes
- Bellows
- Diaphragm
- Strain gauges
- Variable Capacitance
- Piezo Resistor
- Piezo electric
- Resonant wire sensor
- Silicon resonant sensor

The principle of working of each is not covered under this scope of study.

Temperature Measurement

Energy in form of heat is most important variable & vital parameter in process control for quality control of product & safe operation of plant.

This parameter is very sluggish in measurement for changes in temperature.

Temperature form high no. of control loop in the most of the process & hence one will find many instruments for this parameter.

Temperature is the degree of Hotness or Coldness measured on Definite scales.

1. Fahrenheit Scale : ^{o}F
2. Celsius Scale : ^{o}C

Temperature Measurement Method

There are two basic methods of instruments to measure temperature i.e Non Electric method and Electric method.

Non Electrical Method

- Change in volume of liquid when it’s temperature is changing.
- Change in pressure of when it’s gas temperature is changing.
- Change in vapour pressure when it’s temperature is changing.
- Change in dimension of solid when it’s temperature is changing.

These method based Temperature Measuring instruments are generally used for local field indication only.

Some of the examples are - Liquid filled thermometer, Vapor pressure filled thermometer , Gas filled thermometer, Mercury filled thermometer, Bimetallic thermometer

Electrical Method

- Electromotive force generated by Thermocouple.
- Change in Resistance of material.
- By asserting the energy received by Radiation.
- By comparing colours of the controlled filament and object whose temperature is sought.

Some of the examples are :-

- Thermocouple : -

  J Type : Iron- Constantan

  T Type : Copper- Constantan

  K Type : Chromel – Alumel

  E Type : Chromel - Constantan

  R Type : Plat 13% Rhod-Plat

  S Type : Plat 10% Rhod-Plat

  B Type : Plat 30% Rhod-Plat

- Resistance Detector Thermometer (RTD)

  When a material changes resistance, with a change in temperature, the change is called the 'temperature coefficient of resistance', for a material. This coefficient is expressed, as ohms per degree of temperature is positive for most metals.

  Metals chosen for resistance thermometer have a high degree of linearity over the resistance temperature range for which the thermometer designed.

- Semiconductor Resistance Thermometer
- Optical Pyromeer
- Radiation Pyrometers

Level Measurement

Types of Level Measurement

a. Bubbler type

Usually local indicator on open tanks containing corrosive, slurry or viscous process liquids. Can also be used on pressurized tanks, but only up to the pressure of air supply.

b. Capacitance type

Point and continuous level measurement of solids and liquids (both conductive and non conductive) utilizing the wetted probe.

c. Buoyancy type

d. Differential pressure type

e. Ultrasonic type

f. Radar type

High accuracy, non contact measurement of liquids in larger tanks. Interference can be caused by agitators and other metallic surfaces, thick foam or window coating. Suitable where material is flammable or dirty.

g. Nucleonic type

h. Level gauges

i. Level switches

Flow Measurement

Types of Flow Meters

a. Orifices
b. Pitot Tubes, Averaging and Duct Section Units
c. Turbine Flow meters
d. Magnetic Flow meters
e. Ultrasonic Flow meters
f. Variable Area Flow meters
g. Mass Flow meters – Coriolis

Changing Technology

Instrument is a field which is changing very rapidly. Given under is the evolution history of a particular type of instrument. It indicates as to what technology was used earlier and how gradually it changed to the today's technology.

(A) Indication

Indication Local
Indication Remote

- Pneumatic
- Analog Electronics
- Digital Electronics
- Microprocessor (Configurable)
- DCS & PLC (Programmable)

(B) Recording

- Paper – Pen
- Thermal Charts
- Trending

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(C) **Control**

- Local Instruments
- Local Panels
- Plant Wise Control Room
- Centralized Control Room for numbers of Plants

(D) **Transmission Media**

- Pneumatic air pressure 0.2 to 1.0 Kg/cm^{2}g through tubes
- Electrical 4 to 20 mA through copper conductor
- Digital signals through twisted/ Shielded pairs
- Light signals through Fiber cables
- Air waves – wireless

XII. EFFLUENT TREATMENT PLANT

1. Centrifuge

Type	:	Three point suspension
Size	:	60”

Motor

Capacity	:	15 hp
Speed	:	1440 rpm
Motor make	:	Hindustan

2. Storage Tank

Type	:	Vertical, cylindrical
Capacity	:	25,000 litres
M.O.C.	:	H.D.P.E.

3. Transfer Pump

Type	:	HRZ
Model	:	1 – 6
Size	:	40 x 25
Capacity	:	20 m^3 per hour
Head	:	20 m
Serial no.	:	119
Make	:	Global Engineering

Motor

Capacity	:	5 hp
Speed	:	2880 rpm
Motor make	:	Hindustan

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4. Transfer Pump

Type	:	H R C
Model	:	1 – 6
Size	:	40 x 25
Capacity	:	6 m^3 per hour
Head	:	17 m
Serial no.	:	117
Make	:	Global Engineering

<u>Motor</u>

Capacity	:	3 hp
Speed	:	2860 rpm
Motor make	:	Hindustan

5. Transfer Pump

Type	:	H R Z
Model	:	1 – 6
Size	:	40 x 25
Capacity	:	20 m^3 per hour
Head	:	22 m
Serial no.	:	118
Make	:	Global Engineering

<u>Motor</u>

Capacity	:	5 hp
Speed	:	2860 rpm
Motor make	:	Hindustan

6. Controlled Volume Pump

Model	:	WDML – 1750 / 300
Flow rate	:	250 litres per hour
Strokes per minute	:	100
Discharge pressure	:	2 kg/cm^2
Make	:	Swelore Engineering Pvt. Ltd.

Motor

Capacity	:	1 hp
Speed	:	1440 rpm
Type	:	F L P
Motor make	:	S.P.M.

7. Rotary Gear Pump

Size	:	½” x ½”

Motor

Capacity	:	0.5 hp
Speed	:	1380 rpm
Motor make	:	Hindustan

8. Reactor

Type	:	Cylindrical, vertical with flat bottom, open top with flat cover
Capacity	:	15,750 litres

Shell

Size	:	2800 mm ID x 3200 mm height
M.O.C.	:	F.R.P.

Dished ends

Type	:	Flat
M.O.C.	:	F.R.P.

Agitator

Type	:	45^0 pitched blade turbine type – 2 sets
Size	:	900 mm (sweep dia.) x 125 mm width ‘T’ sect. – 4 blades per set

M.O.C.	:	F.R.P.
Thickness	:	16 mm

<u>Shaft</u>

Size	:	130 mm dia. X 3750 mm long
M.O.C.	:	EN-8 with FRP lining

<u>Reduction Gear Box</u>

Type	:	V – 400
Ratio	:	20:1

<u>Motor</u>

Type	:	F L P
Capacity	:	10 hp
Speed	:	1440 rpm
Motor make	:	Hindustan

9. Reactor

Type	:	Cylindrical, vertical with flat bottom, open top with flat cover
Capacity	:	15,750 litres

<u>Shell</u>

Size	:	2800 mm ID x 3200 mm height
M.O.C.	:	F.R.P.

<u>Dished ends</u>

Type	:	Flat
M.O.C.	:	F.R.P.

<u>Agitator</u>

Type	:	45^0 pitched blade turbine type – 2 sets

Size	:	900 mm (sweep dia.) x 125 mm width 'T' sect. – 4 blades per set
M.O.C.	:	F.R.P.
Thickness	:	16 mm

Shaft

Size	:	130 mm dia. X 3750 mm long
M.O.C.	:	EN-8 with FRP lining

Reduction Gear Box

Type	:	V – 400
Ratio	:	20:1

Motor

Capacity	:	10 hp
Speed	:	1440 rpm
Motor make	:	Hindustan

10. H_2O_2 Day Tank

Type	:	Cylindrical, vertical with conical top and flat bottom
Capacity	:	2 m^3

Top end

Type	:	Conical
M.O.C.	:	F.R.P. with 3 mm thick PP lining

Bottom end

Type	:	Flat
Size	:	1550 mm dia.
M.O.C.	:	F.R.P. with 3 mm thick PP lining

Shell

Size	:	1400 mm ID x 1600 mm HT
M.O.C.	:	F.R.P. with 3 mm thick PP lining

<u>It will be interesting to study how the equipment in the same category of utility has altogether a different sets of equipment which is evident from equipment in Boiler and ETP depts. mentioned below for another industry</u>

<u>Name of the department : Boilers</u>

(1) Coal/oil fired boiler - no.1

Type	:	Two drum integral type natural circulation water tube boiler equipped with spreader stroker and oil burners for multi fuel firing.
Capacity	:	25 t/hr
Steam pressure (pr.) at super heater outlet	:	63 bar g.
Steam temperature	:	$400^{o}C \pm 10^{o}C$

Accessories :-

-	Oil burners	:	4 nos.
	Type	:	steam assisted pressure jet fuel burners.
	Capacity	:	450 kg/hr of oil
	Make	:	Wesman Hamworthy (LU-300)
-	Stroker	:	5.5m long x 3.25m wide chain grate
-	Coal spreaders	:	3 nos.
-	ID fans	:	2 nos.
	Capacity	:	20,000 m^3
	Motor	:	100 HP

- FD fan

Capacity	:	39,200 m^3/hr
Motor	:	40 HP

- CA fan

Capacity	:	2,900 m^3/hr
Motor	:	40 HP

- SA fan

Capacity	:	7,840 m^3/hr
Motor	:	20 hp

- Mechanical dust collector

Make	:	Andrew Yale

- R.F. multi cyclone type collector

- Grit Interceptor

- Boiler Feed water pumps :

1. Pump

Model	:	HDA 65/13
Capacity	:	32 m^3/hr
Motor		
KW	:	125
R.P.M.	:	2970
Make	:	K.S.B.

2. Pump – 2 nos.

Type	:	450 DOH
Model	:	HDAF 65/13
Make	:	K.S.B.

- Soot blowers – 5 nos.

  Type : Electrically operated retractable multinozzle manually operated rotary.
- Instrumentation and controls
- Water level control having indications and alarm system
- Economizer

  Make : ISGEC John Thompson

(2) Steam turbine generator

Model	:	Simple cylinder axial flow impulse reaction
Capacity	:	1440 kW
Speed	:	10,000 r.p.m.
Inlet steam pressure	:	64.24 kg/cm^2
Exhaust pressure	:	16.32 kg/cm^2
Initial steam temp.	:	400^{o}C
Max. steam flow rate	:	22.5 t/hr.
No. of nozzle control		
Valves	:	2 + 1
Rate of oil circulation	:	17.5 m^3/hr
Oil cooler	:	shell and tube type
Generator	:	SGK 210201/4 air cooled three phase synchronous generator.
Rating	:	1800 kVA, 1440 kW, 3 ph, 1500 rpm, 2504 A, 0.8 pf lag, 50 c/s, 415 v $\pm$ 5% with 4 terminals.
Make	:	BHEL
Excitation unit	:	50 volt, 220 amp, static (tyristor type) 11 kW unit.
Air cooler	:	Quantity of air - 11520 m^3/hr Quantity of water - 20m^3/hr
Make	:	BHEL

(3) D.M. Plant

Type	:	2 stream continuous operation
Capacity	:	(a) 50t/hr
		(b) 300 m^3/regeneration
Normal output	:	25m^3/hr

Raw water specifications :

ph - 8.0 silica - 20 ppm

Total dissolved solids – 145 ppm as $caco_3$

The plant consists of following major equipment :-

- Alum. dosing system - 2 nos.

  Capacity : 40 litres

- Upflow filters - 2 nos.

  Maximum flow outlet : 50 m^3/hr

  Water turbidity : < 2 ppm

- Activated carbon - 2 nos.

  Flow : 50 m^3/hr

  Filter : M.S. vessel

- Strong acid cation - 2 nos.

  Flow : 50 m^3/hr

  Each filled with 1130 litres INDON 225 RESIN

- Degasser Tower - 1 no.

  Flow : 50 m^3/hr

  M.O.C. : M.S. lined with rubber and polypropynopylene rings.

- Strong base anion units - 2 nos.

  Flow : 50 m^3/hr

  Capacity : 1700 litres

  M.O.C. : M.S. lined with 3 mm rubber

- Regeneration equipment
  Bulk acid and alkaline tanks, dilution tanks, acid and alkali transfer pumps.

- DM water transfer pumps (with s.s. parts) - 2 nos.

Capacity	:	60 m^3/hr
Model	:	CHPM
Head	:	115 m
Make	:	Akay

- DM storage tanks - 2 nos

Capacity	:	90 T and 120 T
M.O.C.	:	M.S. lined with epoxy each

- Chemical dosing metering pumps – 2 nos.

Type	:	Duplex plunger
Model	:	DP/30/DVP
Capacity	:	3 litres/hr and 2 litres/hr

2 nos. mixing tanks, 1 ton cap. each with M.S. circular tank for sulphite and phosphate solutions.

Make	:	ION exchange

(4) Coal handling plant

Capacity : 40 t/hr. single stream operation

(One crusher and one bucket elevator standby)

Coal size at feed hopper	:	250mm max.
Product of crushed coal	:	+20mm - 2%
		20 to 20mm - 32%
Lifting capacity	:	20 kg

- Coal crushers - 2 nos

Type	:	hammer
Capacity	:	40 tph
Make	:	Motkal

- Bucket elevators - 2 nos.

  Positive discharge spaced buckets with double strand ROL-LON make chain and 40 tph capacity.

- Conveyor no.2

  Type : reversible

- Belt conveyor no.: 3

  (for conveying coal from bucket elevator to coal bunker)

  Capacity : 40 t/hr

  Size : 400 mm width x 41.5 m length

- Conveyor No.4A

  (for feeding coal to bunker no.1)

  Capacity : 40t/hr

  Size : 400 mm width x 41.5 m length

- Conveyor 4B

  (for feeding coal to bunker no.2)

  Capacity : 40t/hr

  Size : 400 mm width x 8 m length

- Vibrating feeder

  Type : Spring mounted electrically operated

  Capacity : 0 to 40t/hr

- Magnetic separator

  Cross bolt self cleaning magnetic separator with lifting capacity of 20 kg.

- Electronic belt weigher

  PA make 40 t/hr capacity continuous weigher with totalizing counter.

- LNG coal bunkers

160 t coal capacity fully welded M.S. bunkers feeding to anti separation chutes of boiler

Supplied by : Inter Roll Pvt. Ltd., New Delhi.

(5) Ash handling plant

Type	:	Submerged belt, conveyor belt, screw conveyors etc.
Capacity	:	2 t/hr of ash per boiler

The plant consists of following major equipment :-

- Conveyor no.1A

Capacity	:	2 t/hr
Length of conveyor	:	10.10 m
Width of belt	:	600 mm
Speed	:	1.2 m/minute
Material of belt	:	nylon 4 ply
M.O.C.	:	4 ply nylon

- Conveyor no.1B

Capacity	:	2 t/hr
Length of conveyor	:	13.77 m
Width of belt	:	600 mm
Speed	:	1.2 m/minute
Material of belt	:	Nylon duck 4 ply
M.O.C.	:	4 ply nylon

- Conveyor no.2

Capacity	:	14 t/hr
Length of conveyor	:	50.80 m
Width of belt	:	500 mm
Speed	:	20 m/minute
Material of belt	:	Nylon 5 ply 3002

- Screw conveyors - 4 nos.

M.S. screw conveyors complete with drive units to remove ash from economizer and dust collector hoppers of both boilers of capacity 26 t/hr and 4 t/hr respectively.

- Riddling hopper ash removal
  6" dia CI pipe system below riddling
  hopper with water jet

- Ash silo
  Concrete ash silo of 120 t capacity (1.3 t/m^3 wet ash capacity) 3.35 m above ground level having two outlets for loading with truck.

Supplied by : Simplicity Projects Pvt. Ltd.

(6) Deaerator

Type	:	Tray type
Capacity	:	60 t/hr
M.O.C.	:	A 285 Gr. 'C' for shell and dished ends.
M.O.C. (tray)	:	SS 304
Spray nozzles	:	4 nos.
M.O.C. (spray nozzles)	:	S.S.
Deaerator water capacity	:	60 t/hr.
Water pump	:	140^{o}C saturated
Storage tank capacity	:	30m^3
Design pressure	:	4.0 kg/cm^2
Temperature	:	225^{o}C
Make	:	WATCO

(7) Pressure reducing desuperheat station from installed in parallel to turbine generating set

Capacity	:	63 kg/cm^2
Temperature	:	250^{0}C
M.O.C.	:	Hardened S.S./Vulcanised ASTM A216 - WCB
Make	:	Copes Vulcan Ltd., U.K.

(8) Air compressors – 2 nos.

Type	:	Horizontal balanced opposed, double acting two stage reciprocating electrical driven, oil less.
Model	:	2HY, 2TERT
Capacity	:	225 c.f.m.
Working pressure	:	8 kg/cm^2
Air temperature after last stage	:	148^{o}C to 150^{o}C
Air Temperature after cooler	:	- 40^{o}C to 41^{o}C,
Speed	:	825 r.p.m.
Motor	:	75 hp, 1440 rpm
Air dryer	:	200 c.f.m.
Make	:	Lamda
Make	:	K.G. Khosla

(9) L.S.H.S. storage tanks - 2 nos

Type	:	Vertical cylindrical insulated
Capacity	:	180 m^3
Thickness	:	10 mm
M.O.C.	:	M.S.

(10) Boiler chimney - 1 no.

Type	:	Self supported
Size	:	1372 mm ID x 45.7 m height
M.O.C.	:	M.S.

(11) D.G. set complete with accessories

Details of engine :-

Capacity	:	840 hp at 428 r.p.m.

Details of generator :-

Capacity	:	730 kVA, 415 V, 428 rpm

Diesel storage tank with unloading and transfer pumps

Capacity	:	75 m^3
M.O.C.	:	M.S.
Make	:	SKL

(12) Cooling tower

Type	:	Series 10
Model	:	A365-101
Capacity	:	540 US GPM (100m^3/hr)
Hot water	:	380^oC
Cold water	:	31^oC
Fan	:	One 72" dia. 6 blades driven by 15 hp motor
Gear box	:	20 T series spiral bevel gear

(13) Boiler with super heater and other accessories

Type	:	Oil fired
Capacity	:	16 t/hr at 16 kg/cm^2
Super heater temperature	:	300^oC

Feed water pumps – 2 nos.

Capacity	:	25 t/hr.

Steam driven feed

Water pumps	:	25 t/hr

Induced draft fan

Accessories :

- Water softening plant

Capacity	:	400 m3/regeneration
Flow rate	:	25 m3/hr

Pumps - 2 nos.

HP	:	20

- Insulated raw water tank

Capacity	:	50 m^3
M.O.C.	:	M.S.

- Insulated soft water tank

Capacity	:	70 m^3
M.O.C.	:	M.S.

- Insulated feed water tank

Capacity	:	60 m^3
M.O.C.	:	M.S.

- Furnace oil tank with transfer pumps – 2 nos.

Capacity	:	45 m^3

- M.S. chimney

Height	:	30 m

Make : Sieinmuler, Germany

(14) Boiler with super heater, deaerator and accessories.

Type	:	Package
Model	:	Stemax - ST/35/F/75/P/1
Capacity	:	3500 kg/hr
Working pressure	:	73.6 kg/cm^2
Fuel	:	Furnace oil
Make	:	Thermax

(15) Boiler with super heater, deaerator and accessories

Type	:	Package
Model	:	Stemax - ST/35/F/75/P/1
Capacity	:	3000 kg/hr
Fuel	:	Furnace oil
Accessories	:	Furnace oil service tank and D.M. water feed tank
Make	:	Thermax

(16) Boiler with accessories

Type	:	Package
Capacity	:	10 t/hr saturated steam
Make	:	Wester Works

(17) Common equipments for boilers near MOR

- M.S. furnace oil storage tank with transfer pumps.

- D.M. plant

  S.S. D.M. water storage tanks - 2 nos.

  Capacity : 3.0 m^3 each

- M.S. chimney

Bottom dia.	:	1450 mm
Top dia.	:	750 mm
Height	:	51 m

Name of the department : Effluent Treatment Plant (E.T.P.)

E.T.P.

Capacity	:	1200 T/day

The plant consists of :-

- Raw effluent tank

Type	:	R.C.C. with acid proof tiling
Capacity	:	50 T

It consists

(a) Agitator driven by 15 hp/1440 r.p.m. motor.

(b) Raw effluent pumps driven by 15 hp/1440 r.p.m. motor.

Make	:	Chem flow

- Initial sumps – 2 nos.

Type	:	Fat trap R.C.C. with acid proof tiling
Capacity	:	20 T each

- Equalising tank with agitator

Type	:	R.C.C. with acid proof tiling
Capacity	:	50 T
Drive	:	Reduction gear box driven by 15 hp motor.

Pumps – 2 nos.

HP	:	2.5

- Neutralizers – 2 nos.

Type	:	R.C.C. with acid proof tiling
Capacity	:	150 T
Drive	:	Reduction gear box driven by 5 hp motor.

Pumps – 2 nos.

Type	:	3 NK10
HP	:	15
R.P.M.	:	1440

- Primary clarrifier

Capacity	:	150 T

Primary sludge pumps

Type	:	3 NK10

- Acidification tank – 2 nos.

Capacity	:	7 tons each

High speed pumps – 2 nos.

Drive	:	20 hp/2900 r.p.m. motor
Make	:	Chem Flow

- Line slurry tank with agitators

Capacity	:	40 t

Agitator driven by 7.5 hp motor – 4 nos.

- Dissolved oxygen tank with agitator

Type	:	R.C.C.
Capacity	:	7 / 10 T

- Filter press

Capacity	:	45 plates x 25 frames

Screw type conveyor driven by 37.5 hp/1440 r.p.m. motor.

- Aeration tanks – 2 nos.

Type	:	R.C.C.
Capacity	:	750 T

It consists

(a) Surface aerators driven by 25 hp motor with reduction gear box – 2 nos.

(b) Sludge pumps for circulation.

- Secondary clarrifier

Type	:	Cylindrical
Capacity	:	80 T

It consists R.C.C. tank with an arm driven by 5 hp double geared motor.

- Thickner

Capacity	:	90 T

- Acid storage tanks – 2 nos.

Capacity	:	15 T each

The above comparison makes it amply clear that each industry has its specific type of utility equipment

EXERCISE

1. Enumerate types of utility services.
2. Write short note on equipment required in utility services.

UNIT - 6

INDUSTRIAL PROCESSES

A. MANUFACTURING PROCESS IN A TEXTILE SPINNING MILL

In a textile mill a series of manufacturing process is undertaken for converting cotton and other fibres into yarn and for converting the yarn into fabrics. The raw material for a textile mill continues to be cotton. However, other fibres are also being used as raw material either with or without cotton.

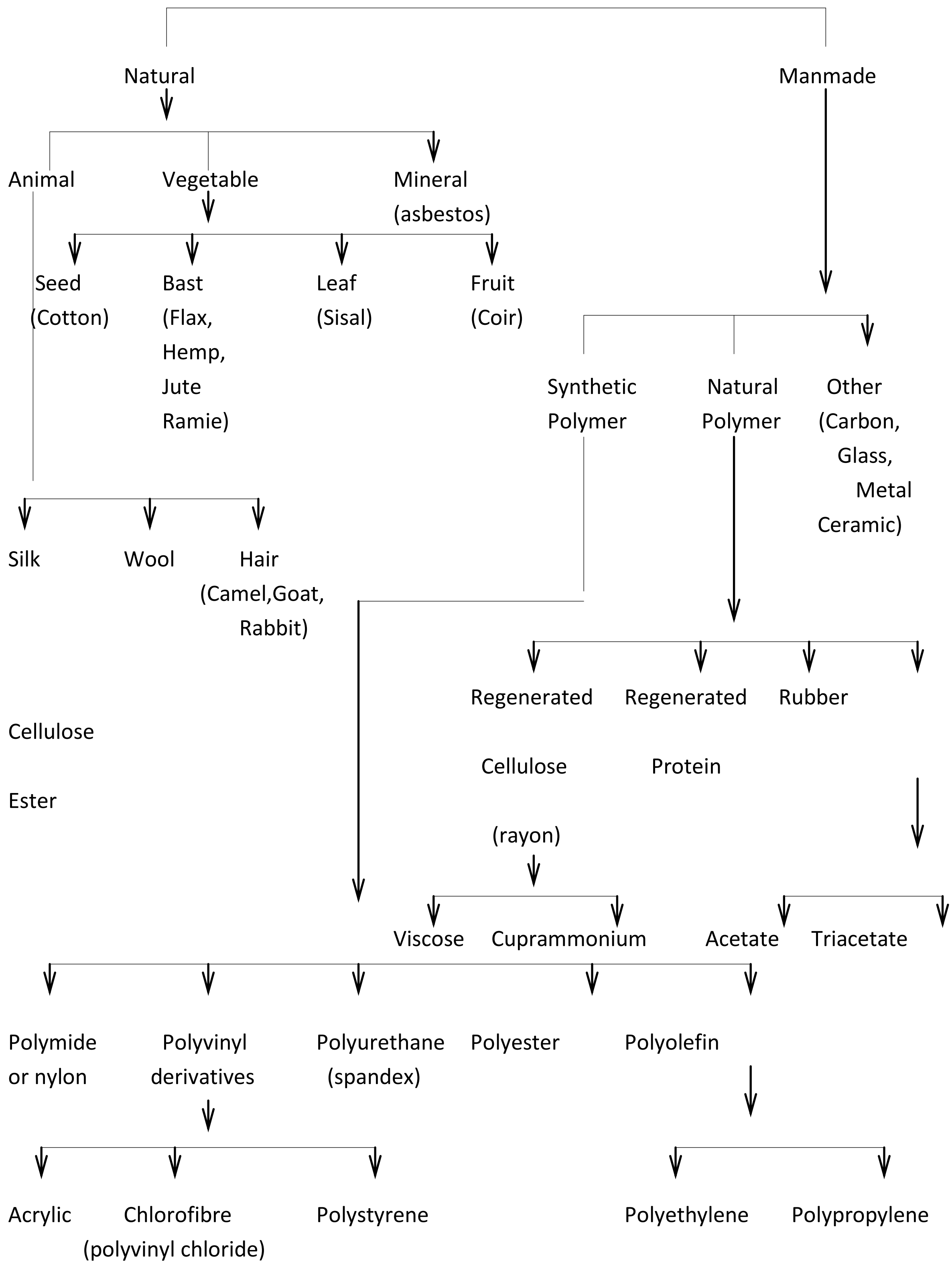
<u>Classification of textile fibres:</u>

The textile fibres may be divided into major groups, namely, (a) natural fibres and man-made fibres. **Table on next page describes the different fibre** types classified under each major group.

Any textile spinning mill has following departments:

- Mixing and blow room
- Carding
- Combing
- Draw frame
- Speed frame
- Ring frame
- Open-end spinning
- Air-jet spinning

Textile Fibres



TEXTILE MILL

PROCESS FLOW DIAGRAM

(SPINNING)

COTTON FIBRE IN BALES

↓

MIXING AND BLOW ROOM
(LAP)

↓

CARDING
(SLIVER)

↓

COMBING
(SLIVER)

↓

DRAW FRAME
(SLIVER)

↓

SPEED FRAME
(ROVING)

↓

RING SPINNING

↓

YARN

- **Mixing and blow room :**

The functions of a blow room line are –

* To open the cotton from matted condition to the loose open state in which it was before bailing.
* To remove all the impurities and make the cotton look as clean as possible.
* To mix thoroughly the different component fibres of a mixing so as to give a homogeneous blending.
* To prepare the cotton into a convenient package from being transported to subsequent machines.

Each machine in the blow room line is known as an opening or as a beating point. The points are in reality doing the function of teasing and opening the lumps and, thus, reducing them in size, so as to prepare the materials ready for the beater that follows.

The types and number of machines required in a blow room line are governed by the class-condition of the cotton. American and Egyptian varieties of cotton are cleaner and, for opening and cleaning such cottons milder treatment with very less number of cleaning points are required. Whereas, most Indian cottons being very dirty can only be cleaned with a harsher treatment with more number of cleaning points.

- **Carding :**

The object of carding is to open out thoroughly the tine lumps, locks or tufts to a state where fibre becomes individualized and the cotton is no more in an entangled state. Equally important function is the removal of all impurities, neps, short fibres etc, which have escaped the blow room action and finally it has to prepare the well cleaned material into a compact silver form and lay into containers for subsequent processes.

Next to blow room, carding is the only major stage for cleaning cotton. The two major regions of a card where this cleaning takes place are taker-in and flats. The variations in the cleaning efficiencies of the card may arise from the nature of trash present in the lap cotton and the condition of carding.

The sheet of cotton in the form of a roll or lap is fed to the carding engine at a very slow rate. The first to start the action is a saw tooth covered licker-in roller, next in action comes the cylinder which has its surface covered with tiny wire points. The surface speed of this is almost twice that of the licker-in. Due to the difference of surface speeds the fibre bunches are stripped off the licker-in by the cylinder wire. The bunches now receive the real seathing, teasing or carding action, when they come between the two sets of wire points, namely flat wire and cylinder wire. Next to the cylinder(a) is small cylinder which moves at a very slow speed than cylinder (a) and it is known as doffer. The centrifugal force of the cylinder throw off the fibres to the doffer.

- **Combing :**

Combing is a process which is introduced in spinning of finer yarns and high quality yarns from cotton. Carded material is short of several important properties which a combed quality normally possesses. The carded material still contains short fibres, neps, fine kitty and leaf particles; short fibres are a hindrance to spinning of finer counts where the number of fibres in the cross section of the yarn is very less. In case of quality yarns, the short fibres cause thick and uneven places in the yarn length and the yarn looks hairy. Besides, very short fibres do not contribute any thing to yarn strength. Comber is a machine where short fibres below a certain pre-determined length can be easily separated out.

After combing the fibres are more or less uniform, well straightened or parallelised and free from neps and particles of trash that escaped carding.

There are different grades of combing based on amount of waste extracted. The percentage of waste extracted depends entirely on the end use of the product.

Up to 9% waste	:	Half combed yarn quality
10 to 18% waste	:	Ordinary combing quality
Over 18% waste	:	Fully combing quality

- **Draw frame :**

By carding, the tangled mass of fibres is well opened so that every fibre becomes quite free. These individual free fibres lie haphazardly criss cross in the web. These haphazard fibres require to be straightened and parallelised to the possible extent. The function of draw frame :

* To straighten the fibres in the silvers
* To make them lie in a manner parallel to their neighbours and to the sliver axis
* To improve the uniformity or evenness of the slivers

Straightening of the fibres is accomplished by drafting them with pairs of rollers which are made to revolve at different surface speed. Doubling, that is feeding more slivers together into drafting zone improves the uniformity, but if not properly manipulated tends to produce unevenness.

- **Speed frame :**

Speed frame forms the final stage in spinning preparatory sequence of operations. The main object of a speed frame process is to reduce the sliver bulkiness to a diameter suitable enough for the ring spinning frame to spin yarn. The diameter reduction is done by drafting system without disturbing the regularity. The desired degree of fineness or hank of material is known as roving.

As the drafting takes place, the fibres per cross section of roving reduces, and the roving is too loose and weak with insufficient cohesive power to keep up the continuous strand form. For this purpose minimum twist is imparted to the roving as it comes out of the front roller nip after drafting. After twist the roving is would on to a bobbin, that is doffed when full. This package or bobbin can be conveniently transported to the next machine, i.e. ring frame.

- **Ring frame :**

Ring spinning is the most conventional way of producing spun yarns. In this system yarn is twisted by using a revolving traveler. As the rotational speed of the package is greater than that of the traveler, winding of yarn takes place. Helically twisted structure of free yarn gives a smoother feel of the fabric.

This is the final stage where actual yarn is manufactured. All the earlier processes are considered under "spinning preparatory".

The object of spinning preparatory is three fold, namely :

* to draw out the roving being fed to the ring frame to the desired degree of fineness;
* to impart sufficient twist to the emerging strand of fibres and form continuous yarn; and
* to wind up the spun yarn into same convenient package form.

Twist is the only physical means known to keep the fibres together in a continuous strand form. The fibres take a helical form and entwine with the neighbouring fibres as twist is imparted. For a given type of cotton, there is an optimum twist per inch for the optimum strength. Beyond this the downward trends in strength is noticed owing to the fibres suffering a crushing effect rather than closer clinging.

- **Open-end spinning :**

  A spinning system in which, sliver feed stock is highly drafted, ideally to individual fibre state and thus creates an open end or break in the fibre flow. The fibres are subsequently assembled on the end of a rotating yarn twisted in rotor spinning. A method of open-end spinning uses a rotor (a high speed centrifuge) to collect and twist individual fibres in to yarn. The fibres on entering a rapidly rotating rotor are distributed around its circumference and temporarily held there by centrifugal force. The yarn is withdrawn from the rotor wall and because of the rotation of the rotor, twist is generated.

  Rotor spun yarns are more regular, bulkier and weaker as compared to ring spun yarn.

- **Air-jet spinning :**

  It is a system of stable fibre spinning, which utilizes air to apply the twisting to the yarn during its formation. The air is blown through small holes arranged tangentially to the yarn surface and this causes the yarn to rotate. By using two air jets operating in opposite twist direction, yarns with controlled properties but of complex structure are produced. The yarns are comparatively weaker than ring spun yarn and there is also a tendency for fabric handle to be harsh.

CVSRTA

TECHNICAL SPECIFICATIONS OF PLANT AND MACHINERY IN A TEXTILE SPINNING MILL

1. Bale Opener

Model	:	1000 mm
Upright lattice		
Working surface	:	1.5 sq. m.
Speed	:	0.8/1.2/2.4 m/sec
Opening cylinder		
Diameter	:	400 mm
Speed	:	800 to 850 rpm
Output per machine		
Normal	:	60 to 120 kg/h
Special cases	:	Up to 150 kg/h
Percentage of waste extraction in relation to weight of raw cotton	:	Up to 1.8%
Percentage of trash in total waste	:	60% to 80%
Cleaning effect, i.e. quantity of trash removed in relation to trash content of the raw cotton	:	Up to 25%
Nominal rating of the three motors		
Opening cylinder motor	:	4 hp at 960 rpm
Upright lattice motor with gear unit	:	1.1 hp/105 rpm
Feed lattice motor	:	0.5 hp at 17 rpm

Space requirements

Length of machine without feed belt	:	3275 mm
Width of machine across doors	:	1286 mm
Height of machine	:	2325 mm

Weight

Net	:	2450 kg
Gross	:	3300 kg

2. **Double Scutcher**

Working width	:	1020 mm
Lap width	:	900 to 1016 mm
Lap length	:	Up to 65 m
Lap weight	:	Up to 26 kg
Roller pressure per side	:	Up to 2000 kg
Delivery speed	:	5 to 8 m/min
Output	:	Up to 180 kg/hr

Nominal rating motors

Exhaust and delivery apparatus	:	6 hp at 1440 rpm
Hopper feeder	:	1 hp at 1440 rpm
1^{st} beater (two-bladed)	:	4 hp at 1440 rpm
2^{nd} beater (Kirschner)	:	4 hp at 1440 rpm
Material feeding	:	4 hp at 960 rpm
Lap doffing	:	0.125 hp at 960 rpm

Space requirements

Overall length of machine	:	8708 mm
Overall width of machine	:	1920 mm
Height of scutcher	:	1560 mm
Height of hopper feeder	:	2325 mm
Height of filling trunk	:	2000 mm

Overall height (with 2 m filling trunk height) with pipe connecting piece	:	3825 mm

3. <u>ERM Cleaner</u>

Working width	:	1000 mm
Beater diameter	:	400 mm
Speed	:	1000 rpm, 850 rpm, 650 rpm
Output	:	Maximum 500 kg/hr

Nominal rating of motors

Beater	:	5.5 hp at 1450 rpm
Feed rollers via gearing	:	0.75 hp at 5-18 rpm
Blow fan	:	5.0 hp at 2850 rpm

Miscellaneous

Pressure head	:	120 mm WC
Net weight	:	2300 kg

Space requirements

Width	:	1500 mm
Length	:	1000 mm
Height	:	3960 mm

4. <u>Mono Cylinder Cleaner</u>

Pin cylinder

Diameter over pins	:	700 mm
Length	:	1200 mm
Speed	:	700 rpm

Under-pressure in machine

Water column	:	10 mm
Air requirements	:	0.7 to 1.0 cu.m./sec.

Motor		
Nominal rating	:	3 hp
Speed	:	1450 rpm
Production	:	Up to 500 kg/h
Space requirements		
Width without motor	:	1500 mm
Depth	:	1095 mm
Height	:	1900 mm
Net weight	:	850 kg

5. <u>Aeromix</u>

Range of utilization	:	Cotton and man-made fibres up to 60 mm
Holding capacity	:	Effective volume of mixing 350 kg
Production	:	Normally 500 kg/hr
Power consumption		
Opening rollers	:	1 motor 7.5 kw at 1440 rpm
Conveying elements	:	1 gear motor 0.55 kw at 9 to 45 rpm
Conveyor belt	:	1 gear motor 0.55 kw at 9 to 45 rpm
Ventilator A5/7	:	1 motor 3 kw/2890 rpm
Air requirements		
Air at inlet for conveyance of material (maximum permissible volume)	:	1.6 cu.m./sec
Air at outlet for conveyance of material	:	0.5 cu.m./sec
Air for conveyance of dust to filter installation	:	1.6 cu.m./sec (maximum)

Space requirements

Width	:	1600 mm
Length	:	5000 mm
Height	:	3430 mm

6. <u>Aerofeed</u>

Duty range

Cotton	:	Up to 50 mm cut length
Man-made fibres	:	Ascertain suitability by trial in each case
Operating conditions	:	Continuous three shift operation if possible, without frequent style changes.

Performance

Output per flock feeder	:	Up to 300 kg/hr
Number of cards per flock feeder	:	5 to 10 high production cards C1/2
Feed weight per card	:	600-750 g/m

Feed chute

Above C1/2 card height	:	2815 mm
Total weight	:	2000 k

Condenser

Motor rating	:	6.0 hp
Motor speed	:	1440 rpm

Beater

Motor rating	:	3.0 hp
Motor speed	:	960 rpm
Beater speed	:	500, 600, 811 rpm

Feed rollers

Motor rating	:	0.4 hp
Motor speed	:	0 – 2800 rpm
Feed rollers reduction speed ratio	:	41:1

Return feed roller

Motor rating	:	0.25 hp
Motor speed	:	1440 rpm
Roller speed	:	16-23 rpm

Ventilation fan

Motor rating	:	5.5 hp
Motor speed	:	1440 rpm
Fan speed	:	1200 – 1800 rpm

7. <u>High Production Card</u>

Can coiler	:	PA 600
Can diameter	:	600 mm
Can changer	:	For can diameter 600 mm height 1220 mm including castors
Levelling	:	Footplates with screw leveling
Working width	:	1000 mm

Diameters over clothing

Licker-in	:	253 mm
Cylinder	:	1290 mm
Doffer	:	680 mm
Feed roll	:	80 mm
Detaching roll	:	120 mm

Speeds depending on material

Licker-in	:	590-1150 rpm
Cylinder	:	250, 360, 450 rpm

Fats	:	110 per set, 43 of them in the working position, running forward
Flat speed	:	Adjustable to 95, 137, 171 mm/min.
Drive	:	By squirrel-cage motor via flat belts

Main motor

Rating	:	5.5 kw
Speed	:	1440 rpm at 50 Hz
Regulating motor	:	0.37 kw
Brush motor	:	0.2 kw
Fan motor	:	1.85 kw
Speed	:	2800 rpm at 50 Hz

8. <u>Draw Frame</u>

Number of deliveries per machine	:	2
Ends up per delivery	:	4-6-8 cans up to 600 mm x 1200 mm

Delivery speeds

For combed material	:	Up to 220 m/min
For carded material	:	Up to 300 m/min

Production per machine at 100% efficiency

Combed	:	Up to 150 kg/hr
Carded	:	Up to 200 kg/hr
Draft in drafting arrangement	:	3.5 to 13
Silver count at delivery (normal) range	:	0.17 to 0.42 metric
Range of staple lengths	:	22 to 75 mm

Can dimensions at delivery		
Diameter	:	350 to 500 mm
Height	:	1050 o 1200 mm
Compressed air requirements per machine	:	0.2 cu. m./hr at 2 to 7 at gauge pressure
Nominal rating of motor		
Main motor	:	5 hp at 1440 rpm
Blower motor	:	2.5 hp at 2880 rpm
Space requirements		
Width of machine (constant)	:	1700 mm
Depth of machine with 8 feed cans per delivery and with cans up to 450 mm delivery		
Long creel	:	4860 mm
Short creel	:	3135 mm
Super long creel	:	6360 mm
Depth of machine with 8 feed cans per delivery and with cans for 500 mm delivery		
Long creel	:	4990 mm
Short creel	:	3265 mm
Super long creel	:	6490 mm
Diameter of can at feed	:	350 mm, 400 mm, 450 mm 500 mm, 600 mm
Maximum height of machine	:	1698 mm, 1773 mm, 1848 mm
Height of can at delivery	:	1050 mm, 1125 mm, 1200 mm
Height of can at feed	:	1050 mm, 1125 mm, 1200 mm

Height from floor to under edge of feed table		
When using –		
Super long creel	:	1600 mm 1675 mm 1750 mm
Long and short creel	:	1410 mm 1485 mm 1560 mm
Operating height = height of delivery roller above floor	:	1436 mm 1511 mm 1586 mm
Distance from front edge of frame to front roller	:	415 mm operating depth
Depth of headstock	:	960 mm up to 450 mm can delivery 960 mm + 130 mm = 1090 mm for 500 mm can delivery
Net weight	:	2000 kg

9. Sliver Lap Machine with Auto Lap

Ends up	:	Normally up to 24 ends up possible
Count of sliver fed	:	Ne 0.12-0.18 (for 36 ends up sliver count up to Ne 0.22)
Can dimensions	:	400 – 600 mm up to 1250 mm high
Weight of feed	:	75 to 120 grams/m
Draft	:	1.5 – 2.0
Lap weight	:	50 to 75 grams/m
Lap width	:	250 mm in case of feeding ribbon lap 300 mm in case of feeding comber direct
Total weight		
Total weight of laps 250 mm	:	Up to 13 kg
Total weight of laps 300 mm	:	Up to 15 kg
Working speed	:	Up to 65 m/min
Compressor air	:	1.2 N. cu. m./hr at 7-9 at gauge
Nominal motor rating	:	4 hp, 1440 rpm at 50 Hz

10. Ribbon Lap Machine with Auto Lap

Number of heads	:	6
Staff	:	500 mm
Doubling	:	6
Width of lap feed	:	250 mm
Weight of feed	:	50 – 75 g/m
Draft	:	5 – 8
Working speed	:	Up to 65 m/min
Width of lap delivered	:	300 mm
Weight of lap delivered	:	50 – 75 g/m
Maximum dia. of lap	:	450 mm
Total weight of lap	:	Up to 15 kg
Compressed air required	:	12 N.cu.m./hr at 7-9 at gauge
Nominal motor rating	:	4 hp, 1440 rpm at 50 Hz

11. High Speed Comber

Number of heads per machine/ gauge	:	8/430 mm
Feed lap		
Weight	:	55-70 g/m, normally 60 g/m
Maximum diameter	:	500 mm
Maximum or normal width	:	300 mm
Waste percentage	:	5 – 25
Nips per minute	:	140 – 240
Production per machine	:	16-40 kg/hr at 90% efficiency
Slivers per machine/doublings per sliver	:	2/4
Draft range of drafting arrangement	:	5 – 10
Count of sliver delivered	:	0.20 – 0.34 metric
Range of fibre lengths	:	24.6 to 50 mm

Cad dimensions

Diameters	:	400, 450 and 500 mm
Heights	:	1050, 1125, 1250 mm
Compressed air required per machine	:	0.2 N. cu. m./hr at 7-10 at gauge
Nominal motor rating	:	Normal/slow gear
Main drive	:	2.2 hp at 1350 rpm/0.16 hp at 81 rpm
Fan	:	4.0 hp at 2860 rpm

Weight

Net	:	4800 kg
Gross	:	5100 kg

Space requirements

Length	:	5,619 m
Width	:	1,506 m

12. Speed Frame

Box length	:	487.32 mm
Distance between spindles	:	121.83 mm
Number of spindles per system	:	4
Bobbin size	:	300 mm x 160 mm
Number of spindles per machine	:	24 to 96, 108, 120
Roving count range Ne	:	0.5 – 3.5
Break draft	:	1 – 3
Total draft	:	3.5 – 13 for 3 roller drafting 9 – 25 for 4 roller drafting
Maximum flyer speed mechanically possible	:	1400 rpm
Maximum delivery rate	:	30 m/min for cotton 40 m/min for synthetic

Total power requirement depending on the number of spindles (including suction device 2.0 hp)	:	9.5 – 14.5 hp
Machine length for 120 spindles	:	17000 mm
Machine width with cans of 500 mm dia.	:	3910 mm
Compressed air requirements	:	1.0 N. cu. m./hr
Air exhaust from suction system	:	26 cu. m./min

13. Ring Spinning Frame

Spindle gauge	:	70 mm
Ring diameter	:	42 mm
Tube length	:	200 mm
Yarn counts	:	100 – 4.2 tex 10 – 235 Nm 6 – 140 Ne
Range of twist	:	140 – 2550 turns/m (3.6 – 64.7 t.p.i)
Spindle speed	:	Up to 20000 rpm mechanically possible
No. of spindles	:	Up to 864

Dimensions

Width over spindle centers	:	620 mm
Width of machine without doffer	:	780 mm
Width of machine with doffer	:	1020 mm

Length of machine for 864 spindles	:	32500 mm

14. Automatic Pirn Winding Machine

Total number of spindles	:	24 (two sided machine)
Length of machine	:	4.2 mete
Width of machine	:	1.8 metre
Spindle speed	:	5000 – 10000 rpm
Power requirement of machine	:	4 kw
Weight of machine	:	2000 kg

15. Open-end Spinning Machine

Gauge	:	200 mm
No. of rotors per machine	:	168
Rotor speed	:	31000 – 60000 rpm
Rotor dia.	:	54/66 mm
Delivery speed	:	Up to 150 m/min
Speed of opening roller	:	5000 – 9000 rpm
Size of feed can	:	350 mm dia. x 900 mm
Take up tube	:	54/60 mm dia. x 145 mm
Size of take up package	:	300 mm dia. maximum
Weight of package	:	Up to 4 kg
Installed power	:	35 kw
Motor for rotor drive	:	2 x 11 kw
Motors for opening roller drive	:	2 x 3 kw
Motor for trash suction	:	2.2 kw
Motor for third hand	:	2 x 2.2 kw
Motor for headstock cooling fan	:	0.1 kw
Conveyor motor	:	0.3 kw
Total air discharged from the machine	:	0.85 cu.m./sec

B. DAIRY

ICE – CREAM

Ice Cream is a frozen dairy food made by suitable blending and processing of milk cream and other milk product, together with sugar, dextrose, corn syrup in dry or liquid form, with or without stabilizer, emulsifier and colour, and with incorporation of air during the freezing process.

Among milk products, ice cream is an excellent source of food energy, vitamins, calcium, phosphorus and other important minerals. The digestibility and palatability of ice cream is also high. The ice cream can satisfy the satiety level of all people from children to aged people.

Ice Cream can be divided into four main categories according to the ingredient used :

1. Ice cream made exclusively from milk product.
2. Ice cream containing vegetable fat.
3. Sherbet Ice cream made of fruit juice with added milk fat and milk solids not fat.
4. Water ice made of water, sugar and fruit concentrate.

Ice Cream composition varies a lot in different localities and market with the consideration of legal requirement, quality of product desired, raw material available, plant procedure, trade demands, competition, cost etc. A satisfactory composition produces an ice cream which has the desired combination of cost, food value, flavour, body and texture, cooling effect, colour scheme, viscosity, whipping ability and freezing point.

Composition and properties of Ice-Cream Mix

- Composition of Ice-cream is expressed as % of its constituent, i.e. as % of milk fat, SNF, sugar, stabilizer/emulsifier, total solid, etc.
- Generally a good Ice-cream contains 12% fat, 11% milk solid not fat, 15% sugar, 0.3-0.5% of stabilizer and emulsifier, and 38.3% of total solids
- In Ice-cream, the percentage of milk fat varies more than any other constituent
- After considering legal requirement, quality of product, raw material available, plant procedure, trade demands, competition and cost, there is a choice of a product minimum, average or high fat/solids composition.

➢ **Role of Ice Cream Mix Constituents**

1. Milk fat

- Milk fat provides flavour, richness, smoothness, and aids in decreasing the size of ice crystals.
- Produces a characteristic smooth texture by lubricating the palate.
- Helps to give body to the ice cream.
- Aids in good melting properties.
- Aids in lubricating the freezer barrel during manufacturing (non-fat mixes are extremely hard on the freezing equipment).
- Milk fat is usually the most expensive ingredient.

Legal requirements for milk fat in ice cream are at least 10% and not more than 20%. If milk fat is increased above 15%, milk solids-non-fat (MSNF) may be decreased to the same extent to as low as 6%. Too much milk fat decreases whipping ability and consumption due to high price, excessive richness, and high calorific value.

2. **<u>Milk Solids Non-Fat (MSNF)</u>**

The serum solids or MSNF contain lactose, caseins, whey proteins, minerals and ash. Protein helps make ice cream more compact, smooth, and resistant to melting. If over used, a salty taste, or sandy defect may result because of the excess lactose. MSNF should be no more than 15.6-18.5% of total solids.

MSNF plays the following role :

1. It is a cheap source of total solids.
2. Improves texture.
3. Gives body and melt resistance.
4. Allows higher overrun without snowy or flaky textures.
5. Protein provides emulsification and whipping properties.
6. Protein increases water holding capacity, enhances viscosity and reduces iciness.

3. **<u>Sweeteners</u>**

Sweeteners provide sweetness and increase viscosity and total solids of the mix. They also improve body, texture, and palatability of ice cream. Sucrose is the main sweetener. Approximately, 45% of the sucrose can be replaced with corn syrup. Corn syrup costs less but isn’t as sweet as sucrose. Legally, sweeteners are used at level of 13 to 20% of total solids.

4. **<u>Stabilizers</u>**

Stabilizers are usually polysaccharides such as gelatin, gums, seaweed, carrageenan, and may come from vegetable sources. Stabilizers are responsible for increasing the viscosity of milk and ice cream. Increasing the viscosity decreases water migration, producing a firmer ice cream and reducing ice crystal size. Ice crystals can cause ice cream to be coarse, thus stabilizers increase smoothness and resistance to melting. Too much stabilizer can make the mix too viscous, making the ice cream heavy and soggy.

- Specific functions of stabilizers :
  1. Provides smoothness in body and texture
  2. Retards ice crystal growth
  3. Provide uniformity and resistance to melting
  4. Aids in suspension of flavouring particles
  5. Stabilizes foam
  6. Prevent shrinkage in frozen product
  7. Slow water migration

5. Emulsifiers

Emulsifiers contain a hydrophilic portion, and a lipophilic portion letting them act as an interface between fat and water. This allows them to reduce interfacial tension between the two phases creating an emulsion. Emulsifiers aid in developing the appropriate fat structure and air distribution in ice cream. They provide smoothness and a stiffer body, enabling production of smaller and more evenly distributed air cells.

Emulsifiers can be mono- or di-glycerides. Glycerides are derived from partially hydrolysed fats or oils from vegetables or animals. Polysorbate 80 is also an emulsifier. The legal requirements for emulsifiers and stabilizers together is maximum 0.5%

6. Flavours and Colours

- Flavour increases the acceptability of Ice-cream. Flavour is considered as the most important characteristics of Ice cream. Natural and synthetic flavour substances are available for flavouring of ice cream.

- Ice cream should have a delicate, attractive colour which can be readily associated with the flavour. Most colours are of chemical origin. Colours are available in liquid or powdered form. Most ice cream manufacture prefer dry colour since these are more economical and can be dissolved in boiling water as and when needed

Properties of Ice Cream Mix

1. ***Viscosity:*** This is defined simply as the resistance offered by liquid to flow. It is the important property of ice cream mix. Whipping quality and air retention quality of mix is very much dependent on mix viscosity. There are two types of viscosity (a) Apparent viscosity, which is thickening condition that disappear on agitation; (b) Basic viscosity, which remain after apparent viscosity disappear.

   The viscosity of ice cream depends on

   1. Composition of mix
   2. Kind and Quality of Ingredients
   3. Processing and Handling of mix.
   4. Temperature of assessment

2. ***Mix Stability:*** This refers to stability or resistance to separation by the milk protein in an ice cream mix. This defect is caused by various factors which affect the colloidal stability of the milk protein, such as high mix acidity, low citrates and phosphate, high calcium and magnesium content, high homogenizing pressure, high heat treatment, low ageing time etc.

3. ***Specific Gravity:*** Specific gravity or density of an ice cream mix varies with its composition and may range from 1.05 -1.12.

4. ***Surface Tension:*** This pertains to the attraction between the molecules of a liquid at its surface. The normal surface tension values of ice cream mix may range from 48 – 53 dyne/ sq.cm.

5. ***Freezing point:*** It depends on the soluble constituents and varies with the composition. Mix constituents which affect the freezing point directly are sugar, milk sugar, milk salt and any other substance in true solution. An average mix has a freezing point of about 27.5 ^{0}F.

6. ***Whipping rate:*** High whipping rate means the ability to whip rapidly to a high over run. Whipping ability is improved by high processing temperature, proper homogenization and ageing of mix.

➢ Ice-Cream Ingredients and its Source

- ***Sources of Fat:*** Sweet Cream, Frozen Cream, Plastic Cream, Unsalted Butter, Butter oil.

- ***Sources of Milk Solid Not Fat:*** Skim Milk, Skim Milk Powder, Condensed Skim Milk (plain/sweetened), and Sweet Cream Butter Milk, Whey Solids.

- ***Sources of Fat and MSNF:*** Whole Milk and its Powder, Condensed Whole Milk (Plain/Sweetened), Evaporated Milk.

- ***Sweetening Agents:*** Cane or Beet Sugar (Sucrose), Dextrose, Corn Syrup (Dextrose + Maltose), Invert Sugar (Glucose + Fructose), Saccharin.

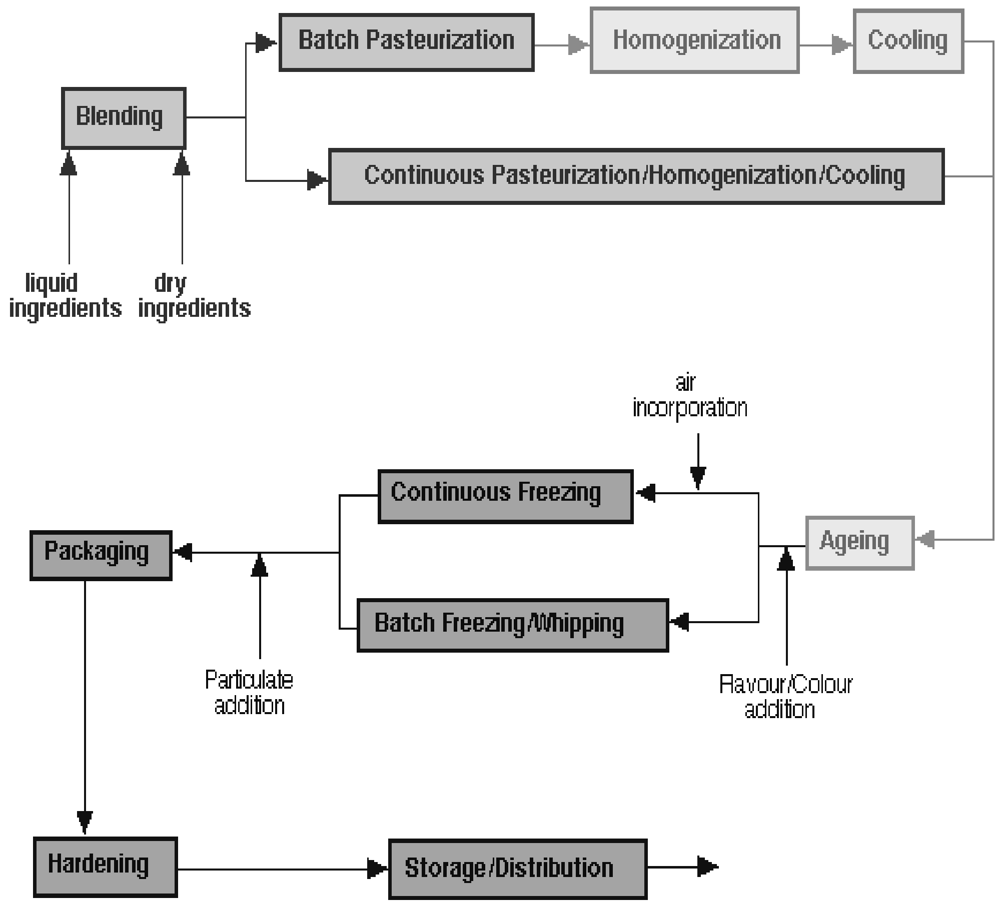
- ***Stabilizers:*** Sodium Alginate, Guar Gum, Carrageenan, Carboxy Methyl Cellulose, Pectin and other Gums.

- ***Emulsifiers:*** Mono- or di-glycerides of fat forming fatty acids.

➢ Preparation of Ice-Cream

The basic steps in the manufacturing of ice cream are generally as follows:

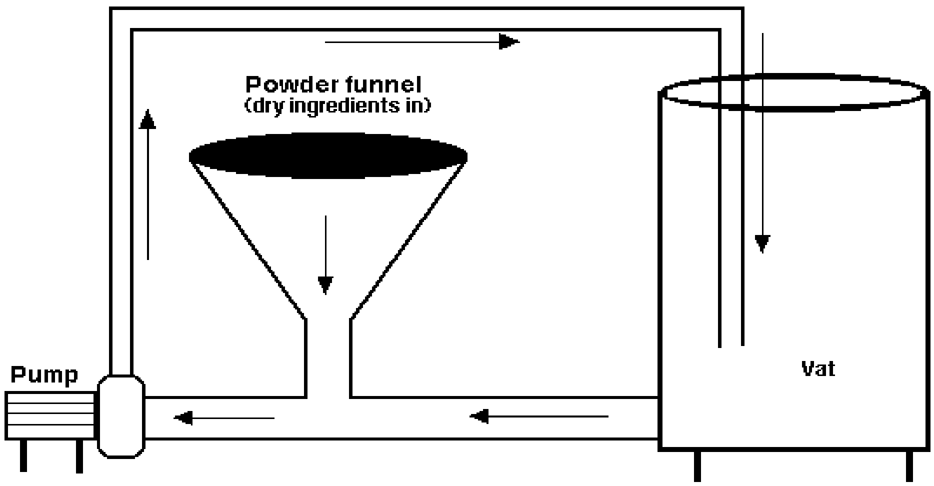
- blending of the mix ingredients
- pasteurization
- homogenization
- ageing the mix
- freezing
- packaging
- hardening



<u>Process flow diagram for ice cream manufacture:</u> the red section represents the operations involving raw, unpasteurized mix, the pale blue section represents the operations involving pasteurized mix, and the dark blue section represents the operations involving frozen ice cream.

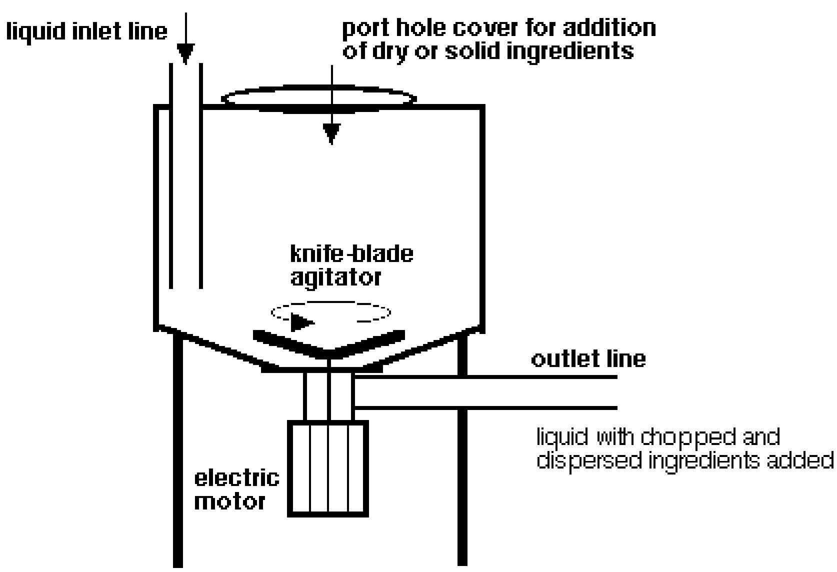
❖ <u>Blending</u>

- First the ingredients are selected based on the desired formulation and the calculation of the recipes from the formulation and the ingredients chosen, and then the ingredients are weighed and blended together to produce what is known as the "ice cream mix". Blending requires rapid agitation to incorporate powders, and often high speed blenders are used.



Simple hopper device for incorporating dry ingredients into recirculating liquids

High shear blender for incorporating dry ingredients into ice cream mix.



❖ Pasteurization

- The mix is then pasteurized. Pasteurization is designed for the destruction of pathogenic bacteria. Pasteurization also reduces the number of spoilage organisms such as psychrotrophs, and helps to hydrate some of the components (proteins, stabilizers).

- Both batch pasteurizers and continuous (HTST) methods are used, which depends on quantity of ice cream mix to be prepared. Generally for preparing small quantity of ice cream mix i.e. less than 2000 liters batch pasteurizers is used and for the mix quantity more than that continuous high temperature short time pasteurization method is used.

Batch pasteurizers : Batch pasteurizer lead to more whey protein denaturation which some people feel gives a better body to the ice cream. In a batch pasteurization system, blending of the proper ingredient amounts is done in large jacketed vats equipped with some means of heating, usually steam or hot water. The product is then heated in the vat to at least 69 C (155 F) and held for 30 minutes.
The heat treatment must be severe enough to ensure destruction of pathogens and to reduce the bacterial count to a maximum of 100,000 per gram.

Continuous pasteurization: Continuous pasteurization is usually performed in a high temperature short time (HTST) heat exchanger following blending of ingredients in a large, insulated feed tank. Some preheating, to 30 to 40 ^{0} C, is necessary for solubilization of the components. The HTST system is equipped with a heating section, a cooling section, and a regeneration section.

Following pasteurization, the mix is homogenized by means of high pressures and then is passed across some type of heat exchanger (plate or double or triple tube) for the purpose of cooling the mix to refrigerated temperatures 4 ^{0}C.

❖ Homogenization

- Homogenization of the mix should take place at the pasteurizing temperature. The high temperature produces more efficient breaking up of the fat globules at any given pressure and also reduces fat clumping and the tendency to thick, heavy bodied mixes. The higher the fat and total solids in the mix, the lower the pressure should be. If a two stage homogenizer is used, a pressure of 2000 - 2500 psi on the first stage and 500 - 1000 psi on the second stage is quite satisfactory. Two stage homogenization is usually preferred for ice cream mix. Clumping or clustering of the fat is reduced thereby producing a thinner, more rapidly whipped mix. Melt-down is also improved.

- Homogenization helps to forms the fat emulsion by breaking down or reducing the size of the fat globules found in milk or cream to less than 1 μ m. Homogenization provides the following functions in ice cream manufacture:
    - Reduces size of fat globules
    - Increases surface area
    - Forms membrane
    - Makes possible the use of butter, frozen cream, etc.

Two Stage Homogenizer

❖ **Ageing**

The mix is then aged for at least four hours or usually overnight. This allows time for the fat to cool down and crystallize, and for the proteins and polysaccharides to fully hydrate.

Ageing provides the following functions:

- Aging is performed in insulated or refrigerated storage tanks, silos, etc. It has a cooling jacket, agitator, spray balls for cleaning, inlet and out let valve and temperature indicator. Mix temperature should be maintained as low as possible without freezing, at or below 5 C. An aging time of overnight is likely to give best results under average plant conditions.
- Improves whipping qualities of mix and body and texture of ice cream
- Provides time for fat crystallization, so the fat can partially coalesce;
- Allows time for full protein and stabilizer hydration and a resulting slight viscosity increase;
- Allows time for membrane rearrangement and protein/emulsifier interaction, as emulsifiers displace proteins from the fat globule surface. This favours partial coalescence of fat during freezing.

Aging Tank

❖ **Freezing**

- Following mix processing, the mix is drawn into a flavour tank where any liquid flavors, fruit purees, and/or colour is added. The mix then enters the dynamic freezing process which both freezes a portion of the water and whips air into the frozen mix. The "barrel" freezer is a scraped-surface, tubular heat exchanger, which is jacketed with a boiling refrigerant such as ammonia or Freon. Mix is pumped through this freezer and is drawn off at the other end in a matter of 30 seconds, (10 to 15 minutes in the case of batch freezers) with about 50% of its water frozen. There are rotating blades inside the barrel that keep the ice scraped off the surface of the freezer and the dashers inside the machine help to whip the mix and incorporate air.

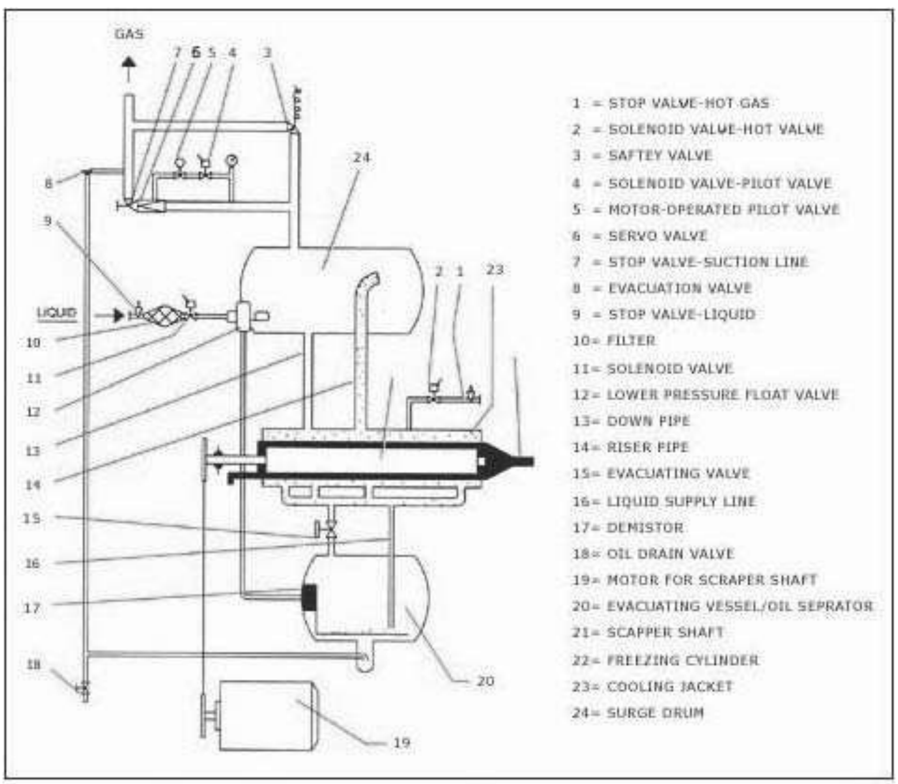
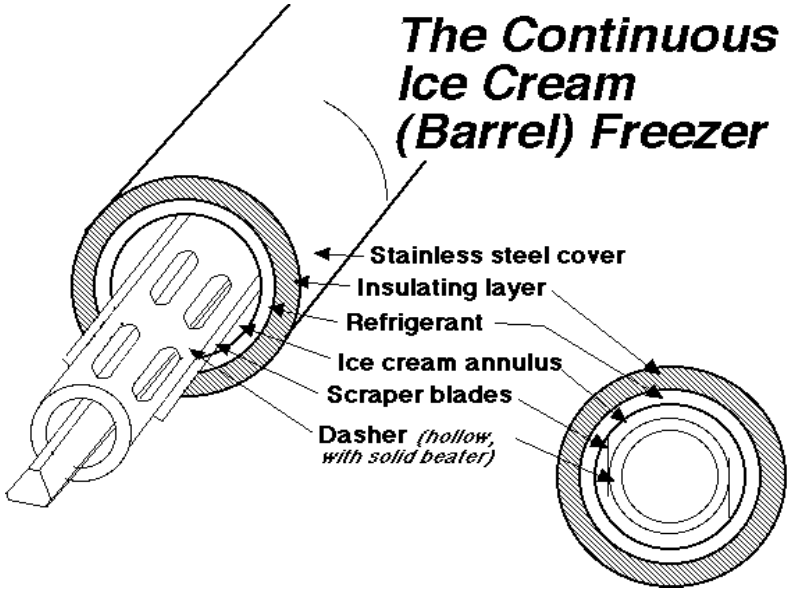


Fig. 2- Flooded arrangement for ice cream freezer
Courtesy of Gram Equipments, Denmark



- As the ice cream is drawn with about half of its water frozen, particulate matter such as fruits, nuts, candy, cookies etc, is added to the semi-frozen slurry which has a consistency similar to soft-serve ice cream. In fact, almost the only thing which differentiates hard frozen ice cream from soft-serve, is the fact that soft serve is drawn into cones at this point in the process rather than into packages for subsequent hardening.

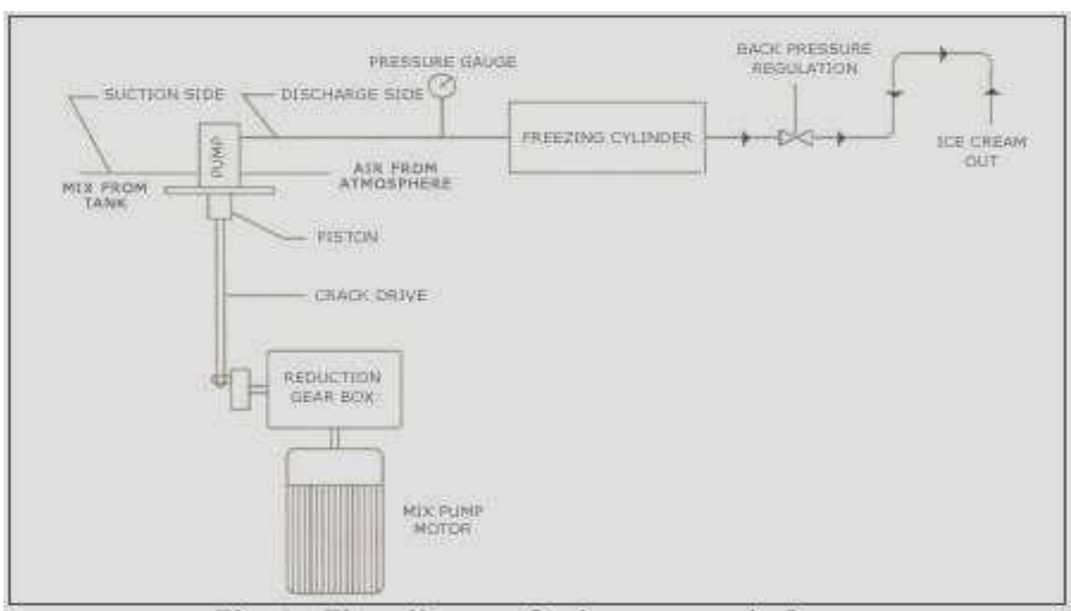


Fig. 4 - Flow diagram for ice cream mix freezer

Packaging of Ice Cream

- When ice cream is drawn from the freezer, it is usually collected in containers which give it the desired shape or size for convenient handling during the hardening and marketing processes.
- The major and basic requirements for packages of ice cream is to give protection against contamination, attractive appearance, ease of opening and reclosure, ease of disposal, protection against moisture loss and temperature fluctuations.
- Most bulk ice cream is packaged in fiber board cartons coated with wax or polythene-wax blends for protection against moisture and oxygen. The most recent trend is plastic cylindrical container with a recloseable lid.
- Retail ice cream is packaged in cups, stick or bars. Cups may be of paper or cardboard specially made to avoid moisture loss.

Hardening

After the particulates have been added, the ice cream is packaged and is placed into a blast freezer at -30° to -40° C where most of the remainder water is frozen. Below about -25° C, ice cream is stable for indefinite periods without danger of ice crystal growth; however, above this temperature, ice crystal growth is possible. This limits the shelf life of ice cream.

Over Run in Ice Cream

- Ice cream contains a considerable quantity of air, up to half of its volume. This gives the product its characteristic lightness. Without air, ice cream would be similar to a frozen ice cube. The air content is termed its overrun, which can be calculated mathematically.
- Over run is usually defined as the volume of ice cream obtained in excess of the volume of the mix. I t is usually expressed in percentage.
- This increased volume is composed mainly of the air incorporated during the freezing process.

- The amount of air which is incorporated depends upon the composition of the mix and the way it is processed and is regulated so as to give that percentage of overrun or yield which will give the proper body, texture and palatability necessary to a good quality product.
- Too much air will produced a snowy, fluffy, unpalatable ice cream while too little over run results in to a soggy, heavy product.
- The control of overrun is very important and should be as nearly constant as possible from batch to batch and from day to day.

There are two basic or fundamental methods for calculating percentage overrun i.e. by volume land by weight:

$$\text{(i) \% Overrun} = \frac{\text{(Volume of ice cream)} - \text{(Volume of mix)}}{\text{Volume of mix}} \times 100$$

$$\text{(ii) \%Overrun} = \frac{\text{(Weight of unit volume of mix)} - \text{(Weight of unit volume of ice cream)}}{\text{Weight of unit volume of ice Cream}} \times 100$$

- **Cold Room Storage and Dispatch**

Cold Room Storage: After hardening ice cream goes to cold room where it gets stored at -18 ^{0}C till it is dispatched.

Dispatch: It involves great sense of responsibility, efficiency, commitment and accuracy.

It involves various activities like :

- To load the refrigerated vans for transport of ice cream.
- To send the order at committed time and place.
- To check and avoid any sort of damage during loading, transportation and unloading.
- To take care about sending bills to distributors as well as collecting DD, checks and cash regarding payment of bills from distributors.

- To take care about the start route i.e. clearing demands of all distributors, which are coming in that route, so that additional transportation cost, is avoided.

FORMS OF DISPATCH

- **REFRIGERATED TRUCKS / VANS:** The truck is refrigerated first to attain the required temperature, for a particular period of time. Then it is loaded with hardened ice cream from cold storage.

- **FROZEN PADS OF BRINE:** A Eutectic pad which is jacketed flat metal container containing calcium chloride solution. Temperature around –21°C is attained by putting this pad in the same brine solution at the temperature around -32°C and having specific gravity of 1.26. This pad is kept around the packed ice cream in a big metal box. This type of arrangement is generally used for small routes and for small quantities of ice cream.

- **PLASTIC AND METAL CONTAINERS HAVING DRY ICE :** It is extensively used for transportation of ice cream for short as well as for long distance. It is very old procedure of retailing and transportation of ice cream. Dry ice is broken down in small pieces and wrapped in paper to avoid rapid evaporation, and placed around packages of ice cream in metal or plastic containers by keeping air tight arrangement.

A FLOW CHART FOR COMMERCIAL PREPARATION OF ICE CREAM

Skimmed Milk powder // Cream // Milk // Sugar // Emulsifiers & Stabilizers

Making the Mix

↓

Pasteurizing the mix

↓

Batch Process
(68°C for 30 min)

Continuous Process
(83-85°C for 25 second)

↓

Homogenizing the mix
(1st Stage – 2500psi, 2nd Stage- 500psi)

↓

Cooling to (0 to 6°C)

↓

Ageing the mix in ageing tank (<10°C)

↓

Freezing the mix [-4 to –5°C]
[Batch or Continuous Freezer]

↓

Packaging of ice cream (-4 to -5°C)

↓

Hardening Tunnel (-35°C)

↓

Cold Storage of ice cream (-23 to -29°C)

↓

Dispatch of ice cream (-18 to -25°C)

CVSRTA

PROCESS FLOWCHART FOR ICE CREAM CUP VARIETIES

Continuous freezer

↓

Ice cream at –4 to –6°C

↓

Toppings (opt.) of sauces, choco mix → Automatic cup filling machine ← Nut or fruit feeder (opt.)

Pneumatically operated by adjusting strokes of piston

Suckers are there to lift cups and lids from cup and lid loader

↓

Product is lifted from bottom

↓

Fall-out on horizontal surface

↓

Packing manually in corrugated fiber boxes

↓

Hardening tunnel

↓

Cold storage

PROCESS FLOW CHART FOR CONE VARIETIES:

Continuous freezer

↓

Ice cream at –4 to -6°C

↓

Granule distribution →

Topping (pneumatically operated) →

Ice cream from freezer doser →

Suction of lid from lid loader →

Wafer chocolate spray →

Lifting of cone from its edge →

Manual loading of cone wafer →

Automatic filling machine

↓

Ejecting out horizontally

↓

Hardening tunnel (-35°C)

↓

Packaging in CFB

↓

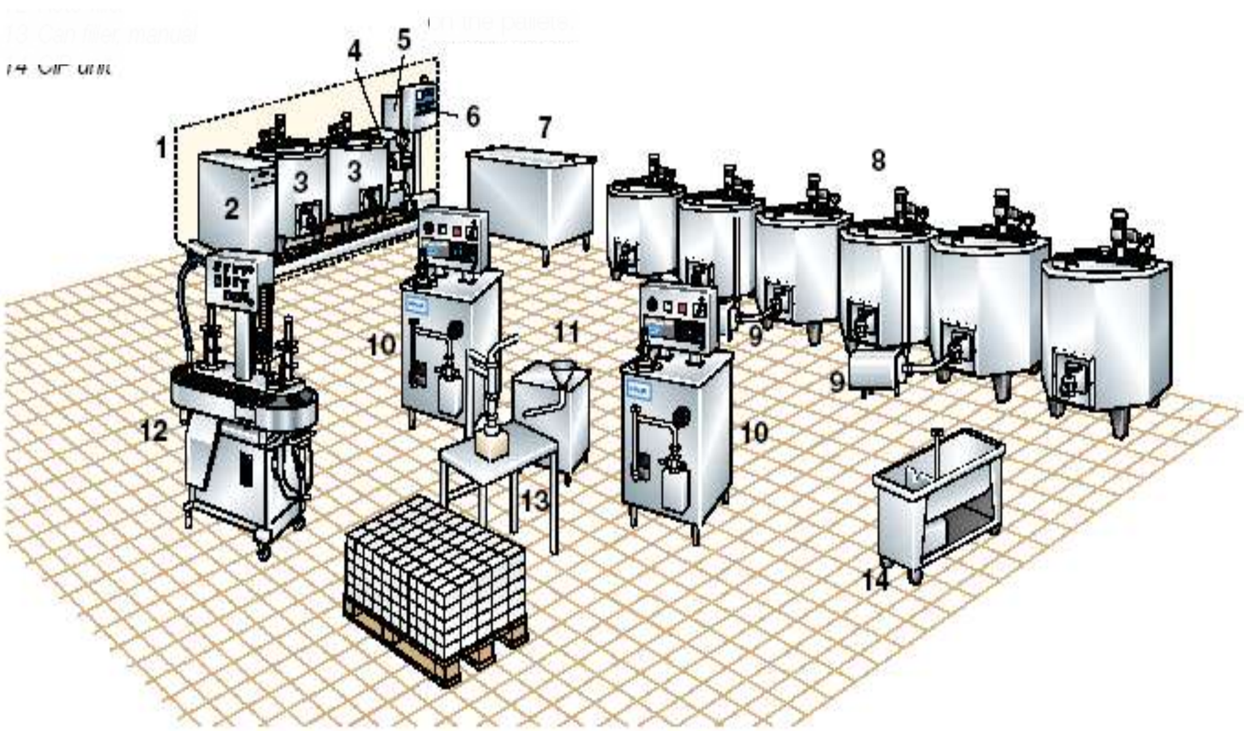
Cold-storage

- **<u>Ice Cream Defects</u>**

  The type of defects that can manifest in ice cream includes

  - Flavor Defects
  - Body and Texture Defects
  - Melting Quality Defects
  - Colour and Appearance Defects
  - Shrinkage Defect

- The below figure shows the production plant for 500 liters per hour of ice cream products.



MAJOR ASPECT CONCERNING ICE CREAM MANUFACTURING

- **NEED AND IMPORTANCE OF QUALITY CONTROL IN ICE CREAM**

It is very much important to control and maintain quality of ice cream in all aspect i.e. right from quality of raw material to final product. As ice cream is consumed by children to aged people, from healthy to sick person, so it is much more essential to maintain quality in case of ice cream.

Various kinds of defects can occur in commercial ice cream because of use of low quality ingredients, improper handling, misleading the set process and methods of production, improper storage, unhygienic environment, and improper transport.

Any Good ice cream can remain edible for almost 1 year if it is made with proper ingredient, standard procedure, proper storing, good handling, accurate storage temperature, proper transport and by keeping under hygienic condition.

The quality of ice cream can be judged and analyzed with the help of different chemical, physical and biological tests. For this purpose quality control laboratories and section is established and the purpose of achieving set quality standards gets fulfilled.

Various tests and observations which are done for controlling the quality of ice cream are as follows:

- Checking the temperature of butter cold storage and raw material cold storage.
- Checking Adulteration in milk and cream.
- Performing all kind of various bench tests for milk and cream, i.e. checking fat, SNF, acidity, temperature, organoleptic test, etc.
- Analysis of ice cream mix temperature regularly and periodically.
- Checking the same for final finished ice cream.
- For nut Variety: checking its nut weight, organoleptic test, overrun, temperature, acidity, weight of ice cream, fat%, protein%.

- For pain variety: checking its weight, overrun, temperature, acidity, fat%, protein%, organoleptic test.
- For Cone variety: checking its cone toppings, sogginess, volume of chocolate at bottom, organoleptic test, nut contents and its weight, top breakage, ice dream acidity, final weight, volume of total ice cream in it.
- For Stick variety: Checking its overrun.
- Checking the CIP practices followed in plant.
- Checking and maintaining required specific gravity of brine solution of each and every candy tank.
- Taking care of hygienic aspect during handling and processing of ice cream.
- Checking the COD (Chemical Oxygen Demand) and BOD (Biological Oxygen Demand) of incoming effluent water and treated effluent water

❖ **Testing for Raw-Material**

- Dry fruits length, colour, shape and quality.
- Check for adulteration.
- Check for bacterial contamination.
- Quality of fruits.
- Weight of cone wafers, pastry and other commodities.
- Organoleptic test of various commodities.
- Manufacturing and expiry date in case of essence and colour.
- Finding ^{0} Brix and total solids and also organoleptic test in case of squashes.

❖ **Testing for Packaging Material**

- Breaking Strength
- Gram per Square Meter
- Printing Quality
- Locking of Folders and Packs
- Cup and Lid Diameter
- Volume
- Number of Corrugated fiber layers, etc.

QUALITY ASSURANCE FOR ICE CREAM

In addition to Quality Control another tool known as Quality Assurance Department is established to achieve Total Quality Management (TQM) approach is to implement quality factor in the entire company. TQM covers business plan and strategies, manufacturing, production technology, marketing and sales, customer satisfaction, personnel administration and finance. It is organizational approach towards quality.

- Line inspection of entire company
- Laboratory control.
- Product development (Research & Development).
- Factory sanitation and microbiological aspect.
- Customer Relation and Satisfaction by undertaking consumer complaints.
- Inspection, checking and passing of in coming raw-material and packaging material.

Other major functions of Quality Assurance and Quality Control are as follows:

- In process testing
- Microbiological Testing to check Total Viable Count, Coliform Count, Yeast and Mould count and pathogen testing
- Taking care of consumer complaints
- Random Testing of finished product
- Record Keeping and updating of standards of quality

CLEANING IN PLACE (CIP)

For safety and quality of final product proper cleaning and sanitization of equipment is must. Cleaning implies the removal of dust and foreign matter from the surface of each machine and connecting and supply pipe lines. While sanitization implies the destruction of all pathogenic and almost all non-pathogenic micro-organism from equipment surface and inside the pipe lines. It is also called Sterilization. Cleaning in Place refers to that system of cleaning and sanitization, which does not require any dismantling of equipments and lines.

In any ice cream manufacturing unit high level of CIP system in followed. It includes cleaning and sanitization of all vats, kettles, storing and ageing tanks, circulating pipe lines, continuous freezers, all handling and processing equipments.

➢ **STEPS FOLLOWED FOR CLEANING IN PLACE(CIP)**

- **For Ageing Tank:**

First it is rinsed with clean water to drain of all sticking mix inside it and it is also washed from outside to clean dust or any foreign matter sticking to it. Then wash with washing solution. Then with the help of spray balls caustic solution at 80^0C is sprayed. Then again rinsing it with water at 80^0C. Finally steaming is done inside the tank for 15 minutes.

- **Mix Circulating Pipe Lines:**

After the end of production, firstly hot water at 80^0C is passed through these lines. Then caustic solution is passed through these pipe lines at 80^0C. Then finally circulation of hot water is done.

- **Vats and Kettles:**

Water is heated in the vat and kettle with the help of steam around 80 to 90^0C. Then caustic solution is added in that heated water. After sometime it is drained out and again it is thoroughly rinsed with hot water properly. Final treatment is done with steam.

- **Continuous Freezers:**

After completion of ice cream production, the flavour tank is rinsed properly by clean water. Then water is passed inside continuous freezer so that ice-cream remaining inside is taken out. Then the specified solution as per freezer manufacturer specification is passed inside it for proper cleaning. Then again water is passed through it.

- **<u>Crates:</u>**

Lots of plastic crates are used for handling, transport and carrying ice-cream. As it in direct contact with ice-cream it is essential to clean and sanitize it. Automatic Crates Washer machine is available or manually it can be cleaned by hot water and steam, which cleans and sanitize all kinds of plastic crates.

PROCESS OF CIP

Circulation of Well Water

↓

Circulation of (1 %) lye solution at 80^{0}C for 30min.

↓

Circulation of hot water at 80^{0}C for 10min.

↓

Circulation of nitric acid solution 0.5% at 80^0 C for 20min

↓

Circulation of hot water at 80^{0}C for 10min.

↓

Circulation of well water

RAW- MATERIAL STORING & PURCHASING

Introduction

Proper buying of materials and merchandise and control of stock are of great importance in any industry. The material must be bought of proper quality and size, at appropriate quantities and at appropriate time.

PURCHASING DEPARTMENT

The purchase department takes care of each and every requirement needed in the company. The company has its own two stores namely Packaging material store and Raw material store.

IMPORTANCE OF PURCHASE DEPARTMENT

Purchase department has to make available the needed stock at the required time so that the manufacturing operation is not interrupted. There has to be co-ordination between finance and purchasing department and has to function in close association with other departments.

The quantities in which purchases are to be made should be so decided as to be of greatest economic advantage to the company. The quantity to be ordered for each item will be decided after considering its rate of sales or consumption, the time required from order to delivery, the savings resulting from transportation rates or quantity discounts, safety margin to ensure against unexpected delays, and the prediction of the future business cycle.

There are many ways followed by the purchase department for buying materials like -

- Requirement purchasing
- Hand to mouth purchasing
- Group purchasing
- Forward purchasing
- Schedule purchasing
- Market purchasing
- Speculative purchasing

The packaging material store should be well designed so that no damage due to moisture, water, rain, sun or wind occurs. Particular amount of each and every packaging material is stocked so that no stock out situation occurs.

RAW MATERIAL SECTION

This section is the life line of any company. It is the section from where requirements of each and every department are fulfilled. Raw material department of any industry or a food processing industry has a vital role to play in it. The final product quality is mainly dependent on the quality of raw material used.

Raw material section of any food industry requires suitable hygienic conditions, proper floor and storage place, proper cold storage section for perishable items, proper temperature and humidity that depends on kind of goods to be stored.

'**FIRST IN FIRST OUT**' principle should be adopted.

➢ PLANT MAINTENANCE

It is one of the important sections of any company. It takes care about all utility, which are used to perform all the activities in company. It takes care about the maintenance and proper working of each and every machine used for Ice cream manufacturing like continuous freezers, homogenizers, pumps, motors, compressors etc.

- It provides maintenance facility to all other departments.
- Operating and taking care of whole Refrigeration system, by which proper temperature in hardening, cold storage, candy tank, candy tunnel and raw materials cold store is achieved.
- It provides compressed air for the pneumatically operated automatic packaging machine.
- It takes cares of all pumps, control panel, instruments, electric supply of whole company.
- Boiler plant which supplies steam wherever required in the entire plant is taken care by this section.
- It provides chilled water for ice cream mix ageing and storing tank.
- It makes necessary arrangement for any civil, mechanical and electrical work.
- Takes care of each and every electrical and electronics devices.

Maintenance section is equipped with

- Refrigeration plant
- Boiler plant
- Water softening plant
- Air compression system
- Electrical supply
- Workshop
- Effluent Treatment Plant

Maintenance staff should be highly skilled and experience one. Stocks of various required equipment and spare parts should be also kept. Classification of the people working in maintenance should have combination of all different engineering and technical field e.g. electrician, fitter, welder, refrigerant plant operator, helper, and there respective section engineer.

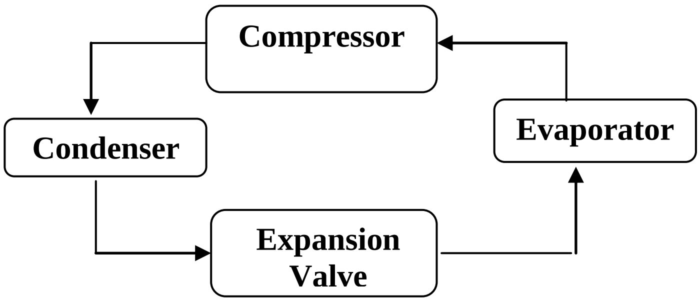
- REFRIGERATION PLANT

Mostly refrigeration system used in any commercial ice cream company is Vapor Compression System utilizing ammonia as a refrigerant. The refrigeration plant installed should meet the entire refrigeration requirement of the ice cream plant. It includes :

- Raw Material Cold Store
- Cold Room
- Butter Cold Store Room
- Hardening Room and Tunnel
- Ice cream Storage Room

REFRIGERATION

Refrigeration Cycle



High Side	Low Side
High Pressure	Low Pressure
High Temperature	Low Temperature

Flow Chart for Refrigeration Cycle

Liquid Ammonia Receiver

↓

Gas Liquid Cooler

↓

Liquid Accumulator (-40°C)

↓

Pressure Reducing Valve

Ammonia Liquid Header

liquid goes to the evaporating coil

Candy Tank & Candy Tunnel | Hardening Tunnels | Cold Rooms | Raw Material & Butter Cold Store

↓

Liquid Accumulator (-40°C)

↓

Ammonia vapor goes to low stage Booster Compressor

↓

High Pressure

↓

Gas Liquid Cooler

↓

High stage suction of compressor

↓

Compressed ammonia vapor goes to oil separator

↓

Shell & Tube Condenser

↓

Liquid Ammonia Receiver

DIFFERENT EQUIPMENT AND THEIR FUNCTION

- Receiver: **This is the tubular shell which stores the refrigerant.**

- **Liquid Accumulator:** Refrigerant through expansion valve accumulates here and from here, it goes to the evaporator coil

- **Water Chiller:** Chilling of water , used to cool mix in ageing and storing tank

- **Compressor:** Low temperature and low pressure compressed to high temperature and high pressure gas.

- **Oil Separator:** To separate oil from high pressure ammonia gas.

- **Economizer:** It is used in liquid line solenoid valve, suction line check valve, thermo-static expansion valve.

- **Condenser:** Shell and Tube Condenser is used to condense the high-pressure gas to high pressure liquid.

- **Cooling Tower:** To supply cool water to condenser.

- **Booster Compressor:** Make the low temperature vapor to high temperature.

Nearly all commercial ice cream plants and particularly the larger plants, use ammonia as a refrigerant. However, refrigerant R-22 is used in smaller plants. Freezing equipment such as batch freezer, small size continuous ice cream freezer, refrigeration aging vat, surface cooler for cooling ice cream mix, ice cream storage cabinets etc. Use R-22, R-12 and R-134a refrigerants.

For economy and safe operation it is recommended to use a multistage ammonia compression system. It is an acceptable practice to select a evaporator temperature of - 40^0C, - 30^0C and - 10^0 C for hardening room, continuous freezer and cold store and ice bank systems respectively. Hence one or more booster compressors are used for different suction pressures and discharge into a second stage.

Multi Stage Compressor System

Many plants use an in - built two-stage compressor and select the number of cylinders for low stage and high stage on the basis of application. A separate compressor is used for high temperature refrigeration (for cooling of mix and ingredients cold store).

SOME IMPORTANT POINT ABOUT REFRIGERATION PLANT:

- Sulfur Candle Test detects ammonia leakage. In which a dense white fume shall indicate the leakage of ammonia.
- While entering a room with ammonia leakage, put the mask approved for ammonia use or spray water to the plant, which absorbs ammonia
- Oil level should be determined at mid way in the top sight glass provided on the oil separator.

SAFETY MEASURES TO AVOID AMMONIA LEAKAGE:

- The ammonia bottle should be stored separately where no other gas bottle is stored.
- Full or empty bottle should be stored horizontally; if vertically then tight fastened so that no falling over takes place.
- It should not be exposed to direct sun light and temperature exceeding 59°C or lower than -10°C.
- It should not in contact with water or alcohol.
- Servicing of each and every valve tapings should be periodically done.

If some leakage is found proper action should be taken immediately. Nearby water valve is kept in case any big ammonia leakage as water absorbs ammonia. First aid kit should also be kept in case of any accident.

DAILY CHECKLIST: (every one hour interval)

- Ammonia level in the receiver.
- Cold water forward temperature.
- Cold storage temperature.
- Hardening room temperature.
- Candy tank and candy tunnel temperature.
- Butter cold storage temperature.
- Raw material cold storage temperature.
- Cooling tower water level.
- Water level in condenser and cooling tower pump is also check.
- Temperature of ageing tank and storing tank of mix section.
- Total operational hours of compressor.
- Defrosting start and stop time.
- Ice thickness.
- Cooling tower pump start and stop time.
- Total bore water consumption.
- Electric current supply available in refrigeration control panel.
- Volt consumed.

BOILER SECTION

Boiler is one of the essential equipment in any food industry, which generates steam. Boiler is a pressure vessel in which heat is produce by combustion of fuel to transform water into steam at desired temperature and pressure. It is a high-pressure device so appropriate safety measures are exercised.

WORKSHOP:

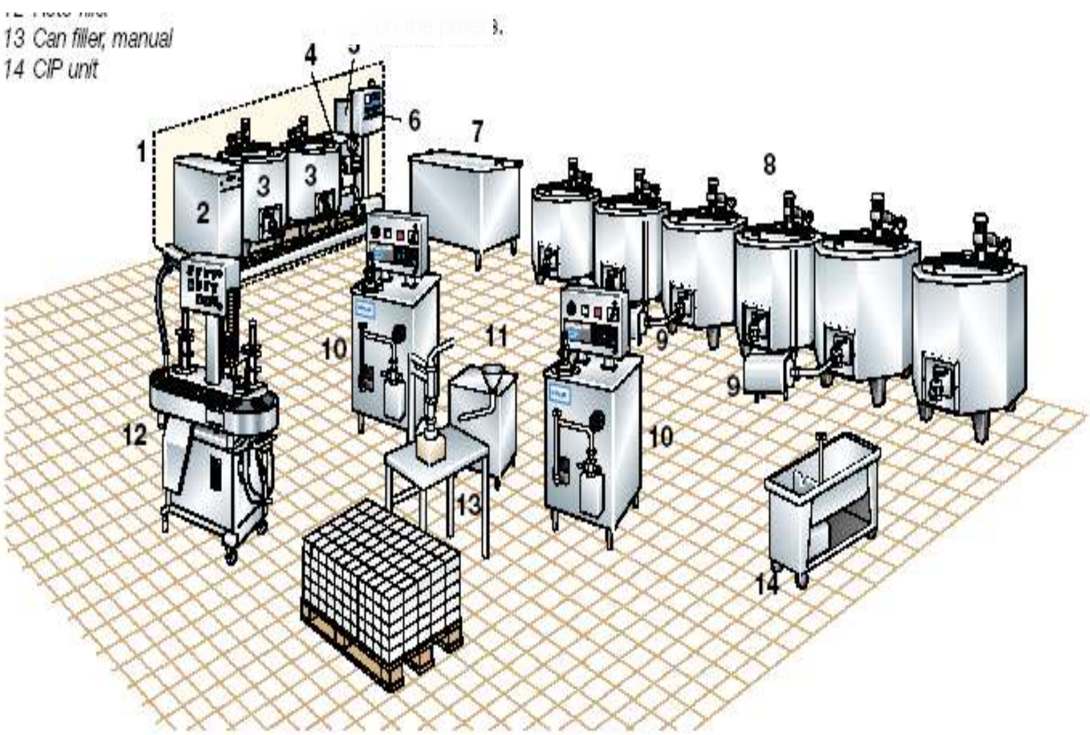
Maintenance and repairing of each and every machine and equipment are taken care of here. Various operations like wielding, replacing of spare parts, servicing, painting and lubricating etc. is done here. A professional approach should be followed to solve each and every problem. In rare cases external assistance is also taken

CVSRTA

EFFLUENT TREATMENT PLANT

- All kind of effluent water from the dairy plant enters into this plant for treatment purpose. Different drain lines collect effluent water in a common drain line.
- The first unit after common drain line is collection tank. From this collection tank plastic pieces, different floating matters, candy sticks and various other solid matters is taken out manually with the help of coarse screens.
- The effluent water is allowed to sediment in this tank for certain period of time and regularly the flocculated solid is taken out from it.
- Next the effluent is sent to equalization tank with the help of pump. At equalization tank, effluent is homogenized flow wise through circulation. Here mixing and homogenization is achieved by coarse bubble aeration by provision of air blower. Here flocculants so formed is separated
- In aeration tank aerobic biodegradation of organic content take place due to development of microorganisms. Necessary oxygen required to maintain aerobic condition is supplied by suitable aeration system. Recycling of effluent water is done at aeration tank
- The sludge so obtained is sent to sludge drying beds. After checking BOD & COD of the final treated water it is collected into a treated waste water sump. If the value of BOD & COD of treated effluent is within the permissible limit then from here it is pumped and passed through pressure sand filters and disposed into disposal pipeline.

- Figure shows the production plant for 500 liters per hour of ice cream products.



1. Ice Cream mix preparation module containing
2. Water heater
3. Mixing and processing tank
4. Homogenizer
5. Plate heat exchanger
6. Control Panel
7. Cooling water Unit
8. Ageing Tank
9. Discharge Pump
10. Continuous freezer
11. Ripple pump
12. Roto-filler
13. Can filler, manual
14. CIP Unit

TECHNICAL SPECIFICATIONS OF PLANT AND MACHINERY IN AN ICE CREAM PLANT :

A. PRODUCTION

1. Mixing/Ageing Tanks

Capacity	:	1,000 litres
Type	:	S.S. conical bottom cylindrical vessel
Dimensions:		
Diameter	:	1,140 mm
Straight height	:	1,085 mm
Leg height	:	600 mm up to outlet V/V
Agitator:		
Type	:	Hygienic paddle type fitted with geared motor
Speed	:	30 rpm
Power	:	1 hp
M.O.C.	:	S.S. 316
Construction:		
Inner shell and all product contact surfaces	:	S.S. 316, 4 mm thick
Intermediate	:	S.S. 304, 2.5 mm thick
Insulation (thermocol, high density)	:	100 mm thick
Outer cladding	:	S.S. 304, 1.6 mm thick
Pressure:		
Vessel	:	1 bar
Jacket	:	2 bar

Others:

- Complete with top conical disc and manhole

Fitted with

- sight glass in manhole cover
- adjustable ball feet
- proper spray ball for effective cleaning
- thermowell for gauge and probe
- pressure release vent / valve (for releasing jacket pressure)
- adequate supports and stiffeners
- S.S. geared motor cover

Connection:

- Mix outlet (at bottom center) (50 mm dia.) with S.S. 304 Butterfly valve
- Chilled water inlet (at side bottom) (25 mm) fitted with S.S. ball valve
- Chilled water outlet (at side top) (40 mm) fitted with NRV
- Drain (at bottom) (50 mm) fitted with brass gate valve
- Mix inlet (at top) (50 mm dia.) with S.S. 304 Butterfly valve

2. Homogenizer

Model	:	MC7 – 3TIBS
Capacity	:	2,000 litre per hour
Design Pressure	:	210 bar
Driving Power	:	16 kw

Maximum Product Temp. 90^0 C

Homogenizing valve assembly

Type	:	2 stage
Valve Material	:	Special wear resistant alloy

Valve Type:

First stage	:	Gaulin “Dyna Jet”
Second stage	:	Piloted Type
Adjustment	:	Hand wheel operated

Cylinder assembly including flat diaphragm type pressure gauge

Pump valves	:	Ball type
Pump valve seats	:	Tapered replaceable
Lungers	:	Special stainless steel
Cylinder block	:	Special stainless steel
Packing adjustment	:	Automatically, spring loaded

Cast iron drive frame, designed to accommodate motor on adjustable motor rail underneath driving mechanism which includes integrated gear reduction, force feed oil lub system with independent electrically driven oil pump with 0.37 kw motor, oil cooler low oil pressure (LOP) safety switch and pulley drive.

Exterior finish	:	Stainless steel clad
Base type	:	Adjustable feet with rubber dampening pads
LOP switch type	:	Standard
Drive motor	:	18.5 kw, 400V, 3 ph, 50 c/s,1500 rpm, type IP-54
Make	:	APV Gaulins

3. Pump

Capacity	:	2,500 litres per hour
M.O.C.	:	S.S. 304

4. Pasteuriser

Capacity	:	5,000 litres per hour
M.O.C	:	S.S. 304
Type	:	HX
Make	:	APV

5. Ice –cream Freezer

Type	:	Hoyer Frigus
Capacity	:	600 litres per hour
Model	:	SF 600 N1
Continuous ice-ream freezer capacity	:	300 litres per hour
Mix inflow temperature	:	+ 4^0 C
I/C out feed temperature	:	- 6^0 C
Solid content	:	8 – 12%
Power of dasher	:	5.5 kw

Power of compressor:		10.5 kw
Pump motor	:	0.75 kw
Auxiliary	:	0.85 kw
Total installed power:		34.2 kw

Water consumption:

5^0 C	:	600 litres per hour
15^0 C	:	1300 litres per hour
28^0 C	:	3600 litres per hour
at minimum pressure:		2 kg per sq. cm.

Refrigerant	:	R404
Total quantity	:	2.8 kg

Air operating pressure	:	4 to 8 bar

6. Cone Filler

Model	:	ICE PACK 5000
Capacity	:	Minimum 2500 pieces per hour Maximum 5000 pieces per hour
Power supply	:	220-380 V/3phase/50c/s.
Electrical Power	:	1 kw
Heating System		
Power	:	0.5 kw
Drive motor	:	0.48 kw
Vibrating system power:		0.02 kw
Working pressure	:	6-7 bar
Make	:	Cattabrigga, Italy

7. Cup Filler

Capacity	:	3000 cups per hour
Cup size	:	100 to 125 ml

8. Lolly machine along with

Rollo machine

Model	:	Rollo – 32
Maximum speed	:	32 strokes per minute
No. of lanes	:	14
Main motor power	:	3 kw
Warm brine pump	:	1.1 kw
Cold brine pump	:	11 kw
Chocolate pump	:	0.37 kw
Booster pump	:	7.5 kw
Brine quantity	:	5,000 litres
Weight of brine	:	6,500 kgs
Total weight including brine	:	22,000 kgs
Overall dimension:		
Total height	:	2,750 mm
Table height	:	1,450 mm
Width	:	3,550 mm
Length	:	5,260 mm

Rollo wrapper

Model	:	Hoywrap ML 32-7
Serial no.	:	Z415, 3768
Main motor	:	3 kw
No. of lanes	:	7
Air pressure	:	4 to 8 bar

R.T. machine

Speed	:	25 strokes per minute
No. of lanes	:	4
Motor	:	2 hp
Air pressure	:	4 to 8 bar
Make	:	Rollatainer

9. Fruit/nut feeder

Capacity	:	3000 litres per hour
Drive	:	1hp

10. Ice-cream Hardening Tunnel

Model	:	10TR
Capacity	:	1200 litres per hour

Suitable for 90 trays of 5' x 2' 15 gauge ss 316

11. Chilled store room/cold storage with refrigeration unit

Room size	:	6 x 5 x 6 m
Skin materials	:	Pre-painted G.I. sheet
Temperature to be maintained	:	2^0 C to 4^0 C
Product to stored	:	Raw material for ice cream
Refrigeration load	:	7 kw
Pull down time	:	18 hours

Design parameters:
The refrigeration units are designed 4^0 to 45^0 C condensing and -28^0C evaporation temperature and suit to ambient temperature 40 to 50^0C.

Compressor with suitable air-cooled condensing unit to withstand Indian tropical condition and evaporator coil with stainless steel hauling with inner grooved coils.

The evaporator and condenser fans are designed to suit for the both winter and summer session to maintain the required condition in all parameters.

Technical specification for refrigeration unit

Type of refrigeration unit	:	Split type

Condensing unit:

The condensing unit is made up self-supporting steel frame with sealed compressor and Air-cooled condenser coil, fan motor, electrical control and it can be mounted on the floor within 7 mts. radius from the evaporator unit.

Evaporator:

The housing of the evaporator unit is made up of high quality 304a stainless steel, specially designed copper coil, self lubricated axial fans and consisting with all safety controls with defrost circuit with heaters and power saving flow controls. The indoor and outdoor unit is interconnected with copper refrigerant pipeline.

Model	:	ERCS 3000 x 2
Condensing unit	:	Danfoss make
No. of unit	:	2 nos. room size (6 x 5 x 6 m)
Compressor	:	Danfoss / Kirloskar
Cooling capacity	:	7 kw
Power required	:	4.3 kw x 2
Power supply	:	440 volts (+ 5 volts) 50 cycles
Condenser and evaporator fans	:	0.75 kw
Thermostat-cum-Temperature display	:	Digital electronic control
Refrigerant	:	R404a
Condenser fans	:	G.E.C.
Evaporator unit	:	Eakcon make

No. of unit	:	2 nos.
Evaporator fans	:	EBM Nadi (imported)
No. of fans	:	2 nos.
Condenser fans	:	GEC
Expansion valve	:	Danfoss / Alco (imported)
Solenoid valve	:	Danfoss (imported)
Drier	:	Danfoss / Sporian (imported)

Electric control box
with all arrangement: 2 nos.

12 CIP unit consists of S.S.jacketted tanks, pumps and filter

13 Piping installations

1. Ammonia valves and fittings for ammonia refrigeration system.

   Consisting of -

   - Expansion valves of required size and quantity
     Type : Expansion, flanged with set
     Temperature
     applications : Low temperature, - 50^0 C

   - Non-return valve of required size and quantity
     Type : Liquid, flanged with set
     Temperature
     applications : Low temperature, - 50^0 C

   - Ammonia line valves of required size and quantity
     Type : Globe
     Temperature
     applications : Low temperature, - 50^0 C

   - Solenoid valve with filter set (Castle) of required size and quantity
     Type : Flanged with set

Temperature
applications : High temperature

- Thermostatic expansion valve (Danfoss) of required size and quantity

  Type : Flanged with set

  Temperature
  applications : Range -5^0 to -20^0 C

- Back pressure regulating valve with CVP (Danfoss) of required size and quantity

  Type : Flanged with set

  Temperature
  applications : Range -5^0 to -20^0 C

  Make : Danfoss

2. Ammonia valves and fittings for ammonia refrigeration system
Consisting of -

- Electronic float switch of required size and quantity

  Type : Threaded

  Temperature
  applications : Low temperature, - 50^0 C

  Make : Sigma

- Dual safety valve manifold of required size and quantity

  Type : Threaded

  Temperature
  applications : High temperature

  Make : Superfreez

- Safety relief valve of required size and quantity

  Type : Threaded

  Temperature
  applications : Low temperature, - 50^o C

  Make : Superfreez

- Expansion valve of required size and quantity

  Type : Expansion, flanged with set

  Temperature applications : Low temperature, - 50^{o} C

  Make : Super

- Non-return valve of required size and quantity

  Type : Gas, flanged with set and Liquid, flanged with set

  Temperature applications : High temperature

  Make : Super

- Ammonia filter required size and quantity

  Type : Flanged with set

  Temperature applications : Low temperature, - 50^{o}C

  : High temperature

  Make : Superfreez

- Ammonia flow indicator of required size and quantity

  Type : Flanged with set

  Temperature applications : High temperature

  Make : Superfreez

- Oil drain valve of required size and quantity

  Type : Needle

  Temperature applications : Range -5^{0} to -20^{0} C

  High temperature

  Make : Super

- Solenoid valve with filter set (Castle) of required size and quantity

  Type : Flanged with set

  Temperature applications : High temperature

  Make : Manik's

3. Compressed air piping (S.S. 304 schedule 10 pipe) of required size and quantity

4. Compressed air piping (GI 'B' class pipe) of required size and quantity

5. Raw water piping (GI 'B' class pipe) of required size and quantity

6. Chlorinated water piping (GI 'B' class pipe) of required size and quantity

7. De-chlorinated water piping (GI 'B' class pipe) of required size and quantity

8. Soft water piping (GI 'B' class pipe) of required size and quantity

9. Chilled water piping (GI 'B' class pipe) of required size and quantity

10. Glycol piping (GI 'B' class pipe) of required size and quantity

11. Steam supply and distribution piping (M.S. seamless IBR A-106 pipe) of required size and quantity
12. Ammonia high temperature piping (M.S. seamless,106, Grade 'B' pipe) of required size and quantity

13. Ammonia low temperature piping (M.S. seamless, A-333, Grade 6LT pipe)

14. S.S. conduit pipe

15. S.S. square pipe

16. PUF insulation

17. Hot insulation

18. Insulation

19. M.S., G.I. and Steel (Low and High temperature) pipeline fittings

20. S.S. Dairy pipes – (1.6 mm thick)

21. S.S. Sch 5 pipe

22. S.S. Unions
23. S.S. Bend

24. S.S. – 2 way plug valve with SMS unions

25. S.S. – 3 way plug valve with SMS unions

26. S.S. – NRV with SMS unions

27. S.S. – B/F valve with SMS unions

28. S.S. 304 rectangular pipe –
    Type : High polished

29. S.S. 304 square pipe –
    Type : High polished

30. PUF pipe section – 50 mm thickness
    Temperature : High quantity – 30
    Low quantity – 60

INDUSTRIAL MILK PROCESSING :

Flow chart for Industrial milk processing

Raw milk

↓

Chilling using surface cooler or Plate chiller

↓

Refrigerated storage in bulk cooler

↓

Preheat to 40^0C

↓

Filtration of milk

↓

Clarification of milk
(removal of dust, dirt, leucocytes, etc.)

↓

Standardization of milk
(for specific fat and SNF contents)

↓

Pasteurization
Batch/Holder method, Minimum 63^0C/30 minutes
HTST method, Minimum 72^0C/15 seconds
UHT method, Minimum 138^0C/1-2 seconds

↓

Immediate cooling to < 6^0C

↓

Packaging
HTST method : Form-fill-seal machine in low density polyethylene sachets
UHT method: Aseptic packing in Tetrapaks

↓

Storage
LTLT/HTST – Refrigeration temperature (< 7^0C)
UHT sterilised – at ambient temperature

Flow chart for pathway of milk in HTST pasteurizer

Sediment

Raw chilled milk → Regeneration-I (40^{0}C) → Filtration/clarification → Regeneration-II (50^{0}C)

Balance tank ← (if less heated)

Cream → Cream pasteurizer → Cream storage (5^{0}C)

Cream separator Skim milk → Regeneration-III (65^{0}C) → Heating section (73^{0}C) → FDV →

Holding section (15 sec) → Regeneration-III(60^{0}C) → Regeneration-II (35^{0}C)

Regeneration-I (20^{0}C) → Chilling section (5^{0}C) → Pasteurized chilled milk storage tank

Processing

The processing operations for fluid or manufactured milk products include cooling, centrifugal sediment removal and cream separation, standardization, homogenization, pasteurization or sterilization, and packaging, handling, and storing.

Cooling

After removal from the cow by a mechanical milking machine, (at – 34^{0}C), the milk is rapidly cooled to $\leq$ 4.4^{0}C to maintain quality. At this low temperature, enzyme activity and microorganism growth are minimized. Commercial dairy production operations usually consist of a mi8lking machine, a pipeline to convey the milk directly to the tank, and a refrigerated bulk milk tank in which the milk is cooled and stored for later pickup. The pipelines, made of stainless steel, are usually cleaned by a cleaning-in-place (CIP) process. Bulk milk is pumped from the refrigerated bulk milk tank to a tanker and transported to a processing plant.

Centrifugation

Centrifugal devices include clarifiers for removal of sediment and extraneous particulates, and separators for removal of fat (cream) from milk.

Clarification

A standardizing clarifier removes fat to provide a certain fat content while removing sediment. Clarifiers have replaced filters in the dairy plant for removing sediment, although the milk may have been previously strained or filtered while on the farm. A clarifier has a rotating bowl with conical disks between which the product is forced. The sediment is forced to the outside of the rotating bowl where the sludge or sediment remains. Some clarifiers have dislodging devices to flush out the accumulated material. The clarified milk leaves through a spout or outlet.

Clarification is usually performed at 4.4^0C, although a wide range of temperatures is used. The clarifier may be between the bulk milk tanker and raw milk storage tank, the raw milk receiving tanks and raw milks storage tank, the storage tank and standardizing tank, the standardizing tank and high temperature – short time (HTST) pasteurizer, the preheater or regenerative heater for raw milk and the heating sections of the HTST pasteurizer.

Bactofugation

The process is not used for ordinary fluid milk, but for sterile milk or cheese. Bactofugation is a specialized process of clarification in which two high velocity centrifugal bactofuges operate at 20,000 rpm in series. The first device removes 90% of the bacteria, and the second removes 90% of the remaining bacterial, providing a 99% bacteria-free product. The milk is heated to 77^0C to reduce viscosity. From the centrifugal bowl there is a continuous discharge of bacteria and a high density nonfat portion of the milk (1-1.5%).

Separation

The original gravity-fed units incorporated air to produce foam and separators developed 5,000 – 10,000 times the force of gravity to separate the fat (cream) from the milk. Skimmed milk is used for standardization and the cream was used for butter and other fat-based dairy products. Separators in the 1990s are pressure or forced-fed sealed airtight units. The separator removes all or a portion of the fat, and the skimmed milk or reduced fat milk is sold as a beverage or ingredient in other formulated foods.

Separation is done between 32 and 38^{0}C, although temperature as high as 71^{0}C are acceptable. Cold milk separators, which have less capacity at lower temperatures, may be used in processing systems in which the milk is not heated.

Separating fat globules from milk serum is proportional to difference in densities, the square of the radius of the fat globule, and centrifugal force; and inversely proportional to flow resistance of the fat globule in serum, viscosity of the product through which the fat globule must pass, and speed of flow through the separator.

The ease with which the separated products leave the bowl determines the richness of the fat. Fluid whole milk enters the separator under pressure from a positive displacement pump or centrifugal pump with flow control (**Figure 1**). The fat (cream) is separated and moves toward the center of the bowl, while the skimmed milk passes to the outer space. There are two spouts or outlets, one for cream and one for skimmed milk. Cream leaves the center of the bowl with the percentage of fat (~ 30-40%) controlled by the adjustment of a value, called a cream or skim milk screw, that controls the flow of the product leaving the field of centrifugal force and thus affects the separation.

STANDARDIZATION

Standardization is the process of adjusting the ratio of butterfat and solids-not-fat (SNF) to meet legal or industry standards. Adding cream of high butterfat milk into serum of low butterfat milk might result in a product with low SNF.

A standardizing clarifier and separator are equipped with two discharge spouts. The higher fat product is removed at the center and the lower fat product at the outside of the centrifugal bowl. Accurate standardization is performed by sampling a storage tank of milk and adding appropriate fat or solids, or by putting the product through a standardizing clarifier and them into a tank for adjustment of fat and SNF.

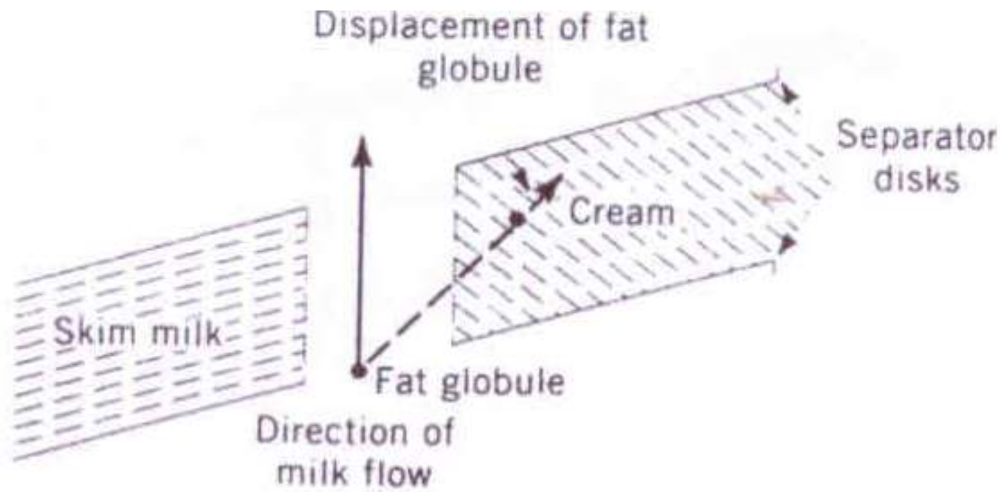


Figure – 1 : Diagrammatic representation of fat globule separation in a centrifugal separator

Homogenization

Homogenization is an integral part of a continuous HTST pasteurization. It is the process by which a mixture of components is treated mechanically to give a uniform product that does not separate. In milk, the fat globules are broken up into small particles that form a more stable emulsion in the milk. In homogenized milk, the fat globules do not rise by gravity to form a cream line as with untreated whole milk. The fat globules in raw milk are 1-15 μ m in diameter, they are reduced to 1-2 μ m by homogenization.

Milk is homogenized in a homogenizer. It is forced at high pressure through the small openings of a homogenizing valve by a simple valve or a seat, or a disposable compressed stainless steel conical valve in the flow stream (**Figure – 2**). The globules are broken up as a result of shearing, impingement on the wall adjacent to the valve, and to some extent by the effects of cavitation and explosion after the product passes through the valve. In a two-stage homogenizer, the first valve is at a pressure of 10.3-17.2 Mpa (1500-2500 psi) and the second valve at ~ 3.5 Mpa (500 psi). The latter functions primarily to break up clumps of homogenized fat particles, and is particularly applicable for cream and products with more than 6-8% fat.

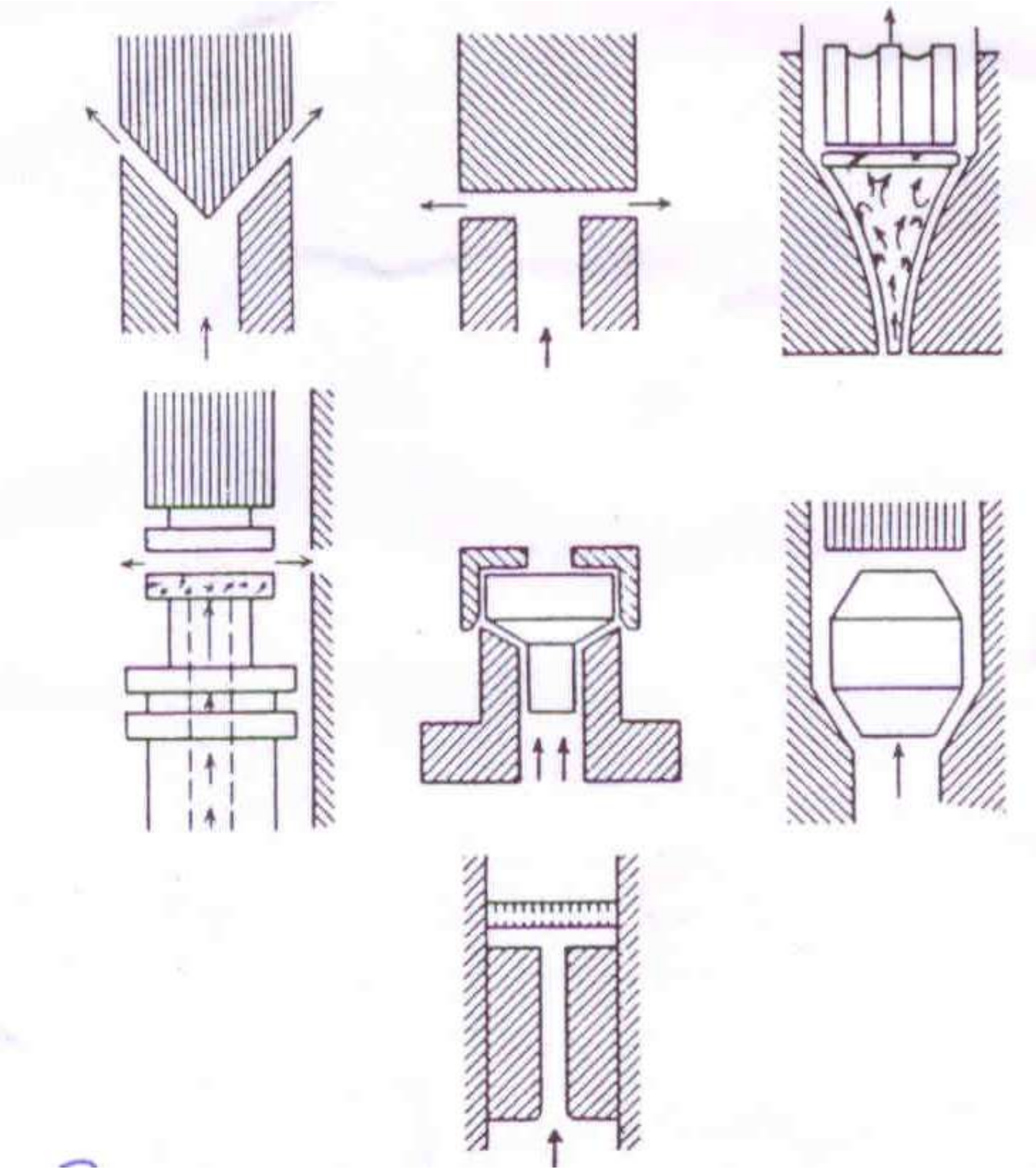


Figure – 2 : Types of homogenizer valves based on velocity and impact

A homogenizer is a high pressure positive pump with three, five, or seven pistons, that is driven by a motor and equipped with an adjustable homogenization valve. At 17.2 Mpa (2500 psi) and a volume of 0.91 t/h a 56 kW (75 hp) motor is required.
Several operating factors should be considered:

(1) before homogenization milk is heated to break up fat globules and prevent undesirable lipase activity;
(2) as the temperature of the milk is increased, the size of the globules decreases;
(3) viscosity of fluid milk is not greatly influenced by homogenization, whereas viscosity of cream is increased;
(4) clarification before or after homogenization prevents the formation of sediment which otherwise adheres to the fat.

Pasteurization

Pasteurization is the process of heating milk to kill pathogenic bacteria, and most other bacteria, without greatly altering the flavour. It also inactivates certain enzymes, e.g., phosphates.

Pasteurization may be carried out by batch or continuous-flow processes. In the batch process, each particle of milk must be heated to at least 63^0C and held continuously at this temperature for at least 30 min. In the continuous process, milk is heated to at least 72^0C for at least 15 s in what is known as high temperature-short time (HTST) pasteurization. For milk products having a fat content above that of milk or that contain added sweeteners, 66^0C is required for the batch process and 75^0C for the HTST process. For either method, following pasteurization the product should be cooled quickly to $\leq$ 7.2^0C. Time-temperature relationships have been established for other products including ice cram mix, which is heated to 78^0C for 15 s.

Another continuous pasteurization process, known as ultrahigh temperature (UHT), employs a shorter time (2 s) and a higher temperature (minimum 138^0C). The UHT process approaches aseptic processing.

Batch Holding

The milk in the batch holding tanks is heated in a flooded tank around which hot water or steam is circulated, or by coils surrounding the liner through which the heating medium is pumped at a high velocity. Two other methods include spraying hot water on the tank liner holding the milk, and pumping hot water through a large-diameter coil that circulates in the milk. A self-acting regulator closely controls the temperature of the water, usually heated with steam.

An airspace heater ejects steam into the airspace above the product and into the foam, maintaining a temperature at least 5^0C above the minimum holding temperature of 63^0C. The time-temperature exposure is recorded on a chart which must be kept for proof of treatment.

Valves are mounted so that the plug of the valve is flush with the tank to avoid a pocket of unpasteurized milk, and a leak detector valve permits drainage of the milk trapped in the plug of the valve.

Agitators provide adequate mixing without churning, assist in heat transfer by sweeping the milk over the heated surface, and assure that all particles are properly pasteurized.

High Temperature – Short Time Pasteurizers

The principal continuous-flow process is the high temperature-short time (HTST) method. The product is heated to at least 72^0C and held at that temperature for not less than 15 s.

The equipment needed includes a balance tank, regenerative heating unit, positive pump, plates for heating to pasteurization temperature, tube or plates for holding the product for the specified time, a flow-diversion valve (FDV), and a cooling unit (**Figure – 3**). Often the homogenizer and booster pump also are incorporated into the HTST circuit.

The balance or float tank collects raw milk entering the unit, receives milk returned from the flow-diversion valve that has not been adequately heated, and maintains a uniform product elevation on the pasteurizer intake.

The heat-regeneration system partially heats the incoming cold product and partially cools the outgoing pasteurized product. The regenerator is a stainless steel plate heat exchanger, usually of the product-to-product type. The configuration is so arranged that the outgoing pasteurized product is at a higher pressure to avoid contamination. A pump in the circuit moves the milk from the raw milk side and the discharge to the final heater. Heat regenerators are usually 80-90% efficient. The regeneration efficiency may be improved by increasing the number of regenerator plates, and although this increases the energy for pumping, it also increases the cost for additional heat-exchanger plates.

The final heater increases the regeneration temperature (~ 60^{0}C) to pasteurization temperature (at least 72^{0}C) with hot water. The hot water is ~ 1-2^{0}C above the highest product temperature (73^{0}C). Four to six times as much hot water is circulated compared to the amount of product circulated on the opposite side of the plates.

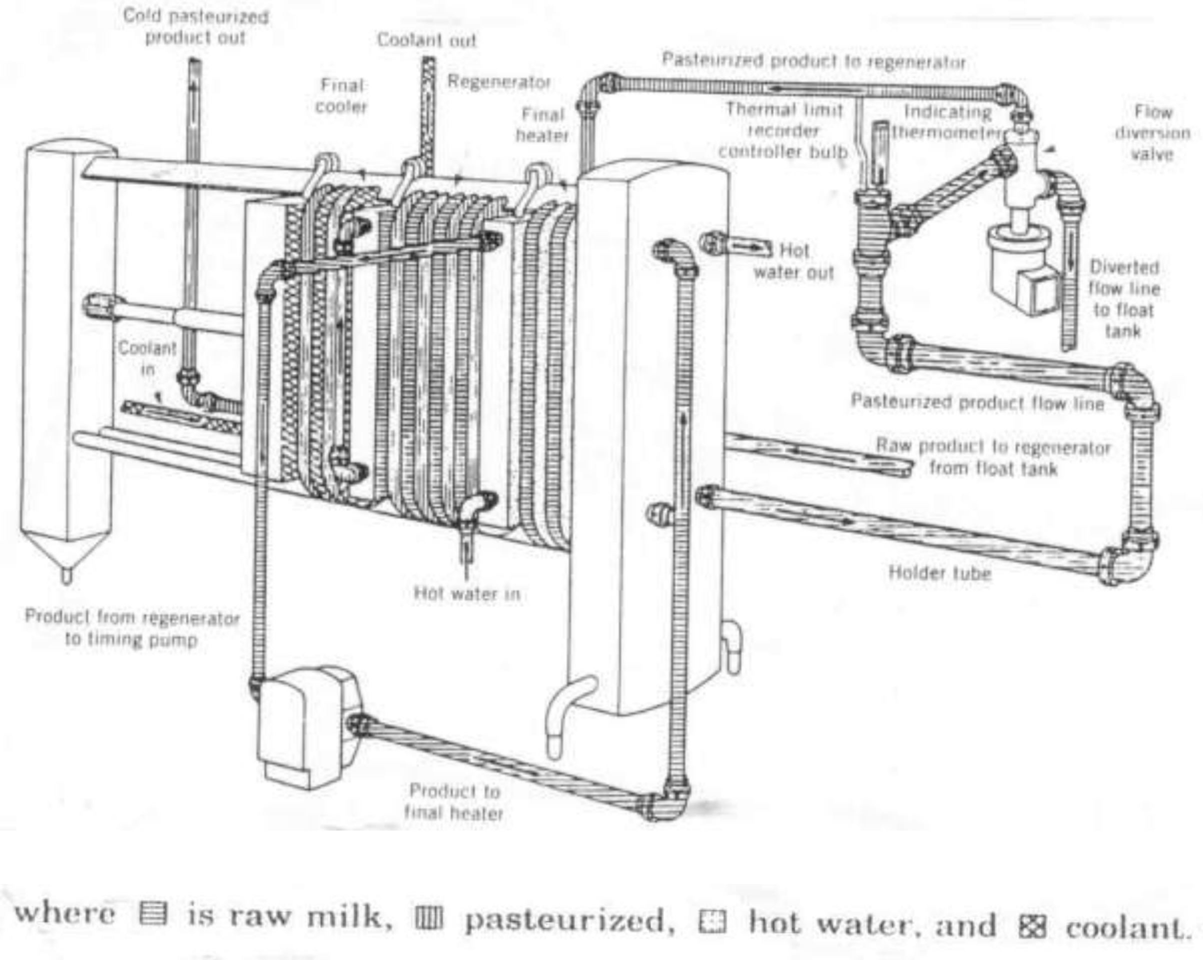


Figure – 3 : Flow through a typical HTST plate pasteurizer,

The holder or holding tube is at the discharge of the heater. Its length and diameter assure that fluid milk is exposed to the minimum time-temperature (72^{0}C for 15 s). Glass or stainless steel tubing, or plate heat exchangers, may be used for holders. Holding tubes must be designed for continuous uphill flow 0.64 cm/m) from the start of the tube to the FDV.

On the outlet of the holder tube, the FDV directs the pasteurized product to the regenerator and then to the final cooling section (forward flow) Alternatively, if the product is below the temperature of pasteurization, it is diverted back to the balance tank (diverted flow). The FDV is controlled by the safety thermal-limit recorder.

The final cooling section is usually a plate heat exchanger cooled by water chilled through refrigeration. Milk leaves the regenerator and enters the cooling section at ~ 18-24^{0}C and is cooled to 4.4^{0}C by glycol, or water circulating at 1^{0}C. The relationships of regenerator, heater, and cooler for flow, number of plates, and pressure drop are given in **Table – 1**.

Capacity, L/h	3,800	7,600	11,360	15,140	18,930
regenerator, 84%[b]					
plates, number	31	51	71	91	111
pressure drop milk, kPa[c]	62	90	103	103	117
heater[d]					
plates, number					
water, L/min	9	15	21	29	33
pressure drop milk, kPa[c]	261	522	587	787	492
pressure drop water, kPa[c]	55	76	76	69	96
	83	117	76	69	165
cooler[e]					
plates, number					
water, L/min					
pressure drop milk, kPa[c]	9	17	31	41	49

pressure drop water,	326	662	462	643	772
kPa[c]	55	55	117	117	145
total, 84% regeneration	131	131	165	165	179
plates, number					
pressure drop, milk, kPa[c]					
size of frame, m	49	83	123	161	193
	122	221	296	289	358
total, 90% regeneration					
plates, number	1.22	1.2	1.83	2.13	2.13
pressure drop, milk, kPa[c]					
size of frame, m	73	109	147	189	239
	131	200	214	221	207
	1.52	1.83	1.83	2.13	2.44

Table – 1 : Representative Capacities of HTST Plate Pasteurizers

The heat transfer sections of the HTST pasteurizer, i.e., regenerator, heater, and cooler, are usually stainless steel plates ~ 0.635 – 0.91 mm thick. Plates for different sections are separated by a terminal that includes piping connections to direct product into and out of the spaces between plates. The plates are mounted and connected in such a manner that the product can flow through ports connecting alternate plates. The heat-transfer medium flows between every other set of plates.

The stainless steel plates are separated (ca 3 μ m between) by nonabsorbent vulcanized gaskets. Various profiles and configurations, including raised knobs, crescents, channels, or diamonds, provide a rapid, uniform heat-transfer plate surface. During operation the plates must be pressed together to provide a seal, and mounted and connected in such a manner that air is eliminated.

For regeneration, the milk-to-milk regenerator is most common. A heat transfer medium, usually water, provides a milk-water-milk system. Both sides may be closed (**Figure – 4**) or the raw milk supply may be open.

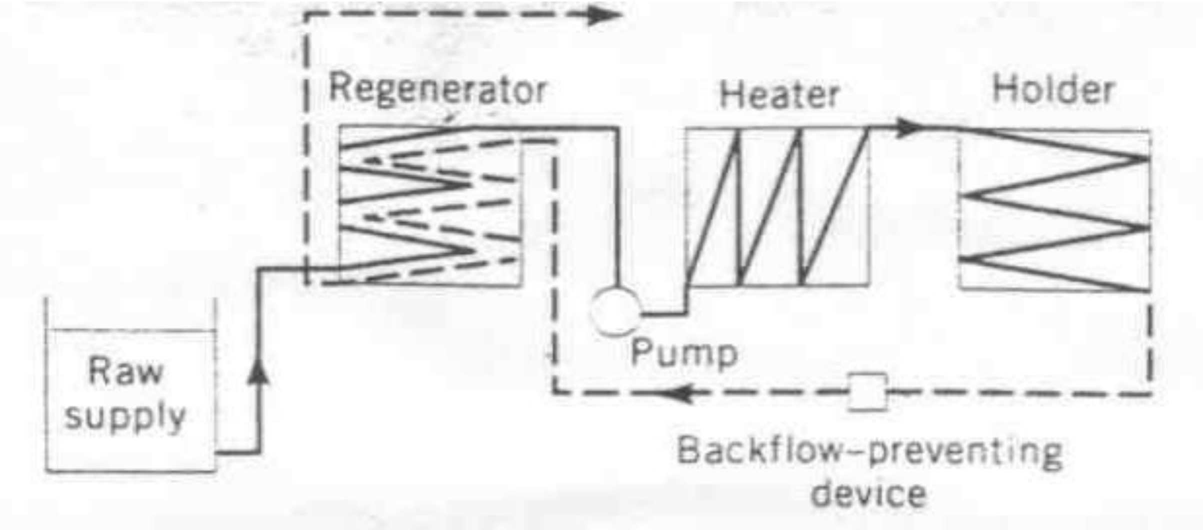


Figure – 4 : Milk-to-milk regenerator with both sides closed to atmosphere

A homogenizer or rotary positive pump my be used as a timing or metering pump to provide a positive, fixed flow through the pasteurization system (**Figure – 5**). The pump is placed ahead of the heater and the holding section. Various control drives assure that the pasteurized side of the heat exchanger is at a higher (7 kPa (1 psi)) pressure than the opposite side.

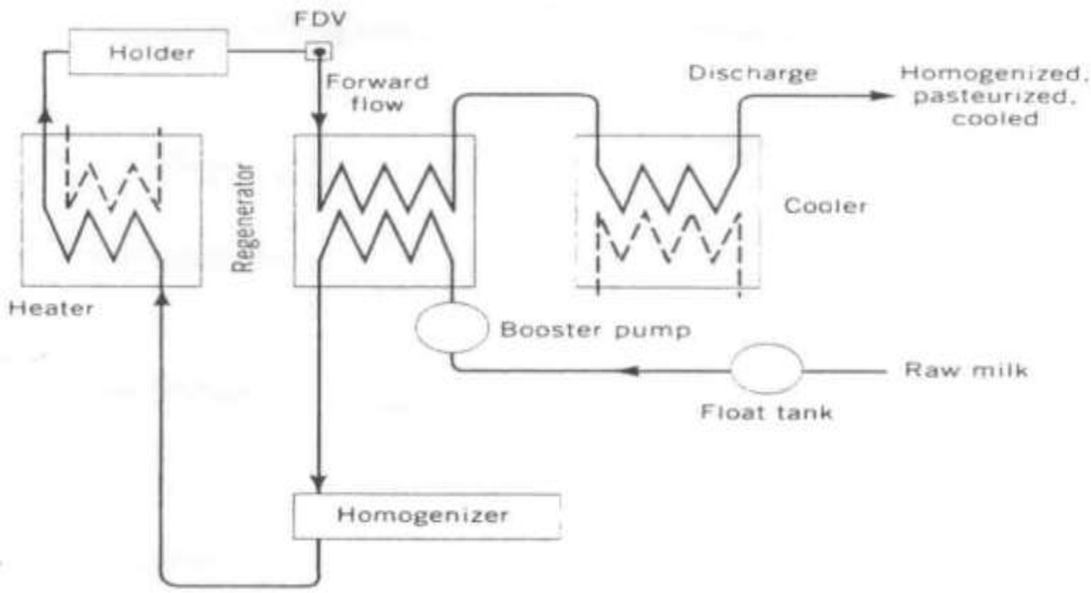


Figure – 5 : Homogenizer used as a timing pump for HTST pasteurization. Details of bypass, relief lines, equalizer, and check valves are not included

The homogenizer can be used as a timing pump as it is homogenizing the product (**Figure – 6**) or both the timing pump and homogenizer can be used in the same system.

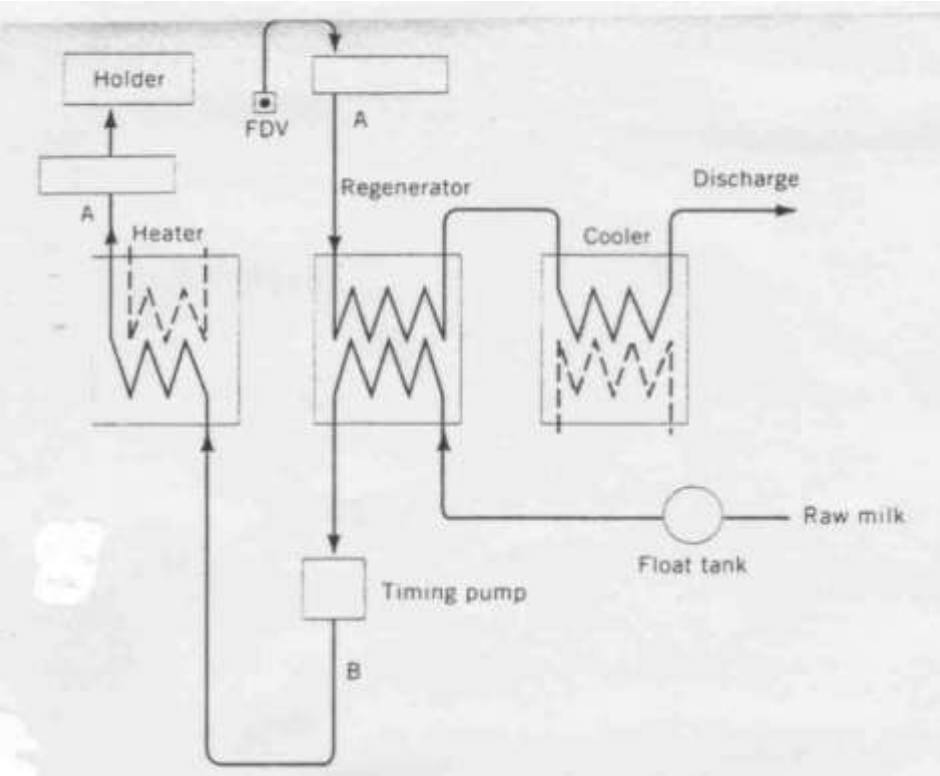


Figure – 6 : Homogenization of regenerated milk, A, after HTST heat treatment, and B, before HTST pasteurization. Details of bypass, relief lines, equalizer, and check valves are not included

<u>*Booster Pump*</u>

Use of a centrifugal booster pump avoids a low intake pressure, particularly for large, high volume units. A low pressure (> 26.6 kPa (200 mm Hg)) on the intake of a timing pump can cause vaporization of the product. The booster pump is in the circuit ahead of the timing pump and operates only when the FDV is in forward flow, the metering pump is in operation, and the pasteurized product is at least 7 kPa (1 psi) above the maximum pressure developed by the booster pump (**Figure – 7**).

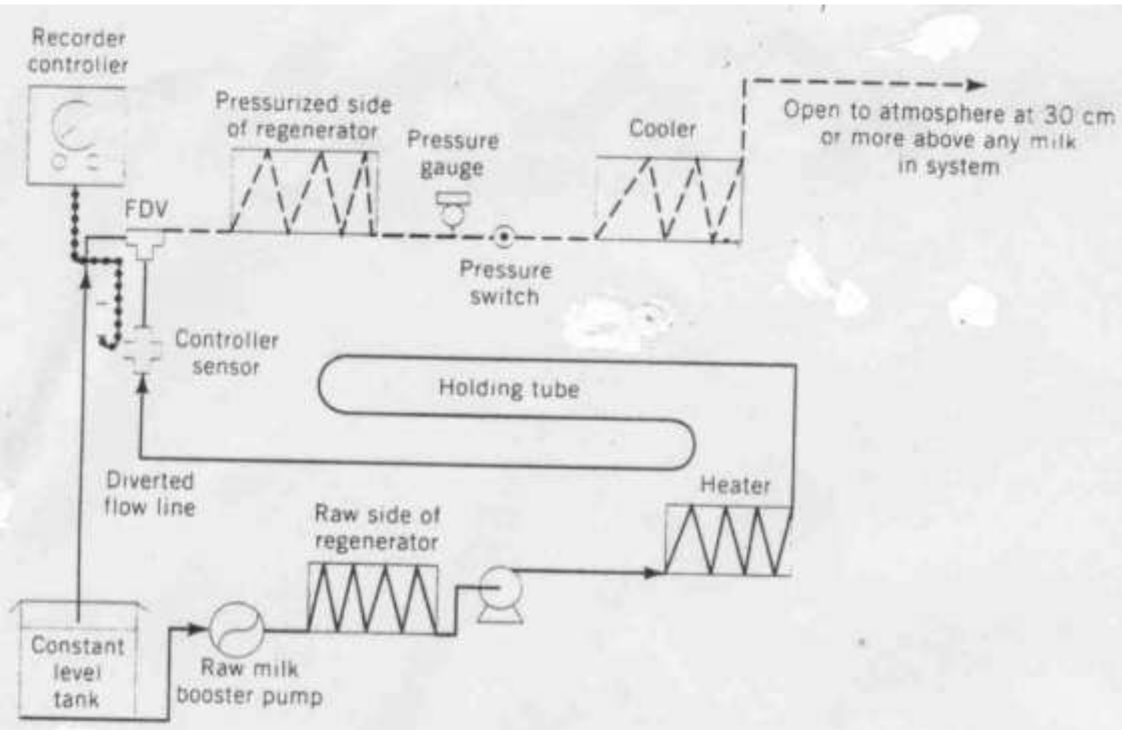


Figure – 7 : Booster pump for milk-to-milk regeneration, where (---) is pasteurized milk, (--) is raw milk, and (-•-) is capillary tubing

Separator

Fat is normally separated from the milk before the HTST; however, in one system the airtight separator is placed after the FDV, following pasteurization. A restricting device and several control combinations are placed in the line after the FDV to ensure that constant flow is maintained, that vacuum does not develop in the line, that the timing pump stops if the separator stops, and that the legal holding time is met.

Control System

For quality control, a complete record of the control and operation of the HTST is kept with a safety thermal-limit recorder-controller (**Figure – 8**). The temperature of product leaving the holder tube, ahead of the FDV, is recorded and the forward or diverted flow of the FDV is determined. Various visual indicators, operator temperature calibration records, and thermometers also are provided.

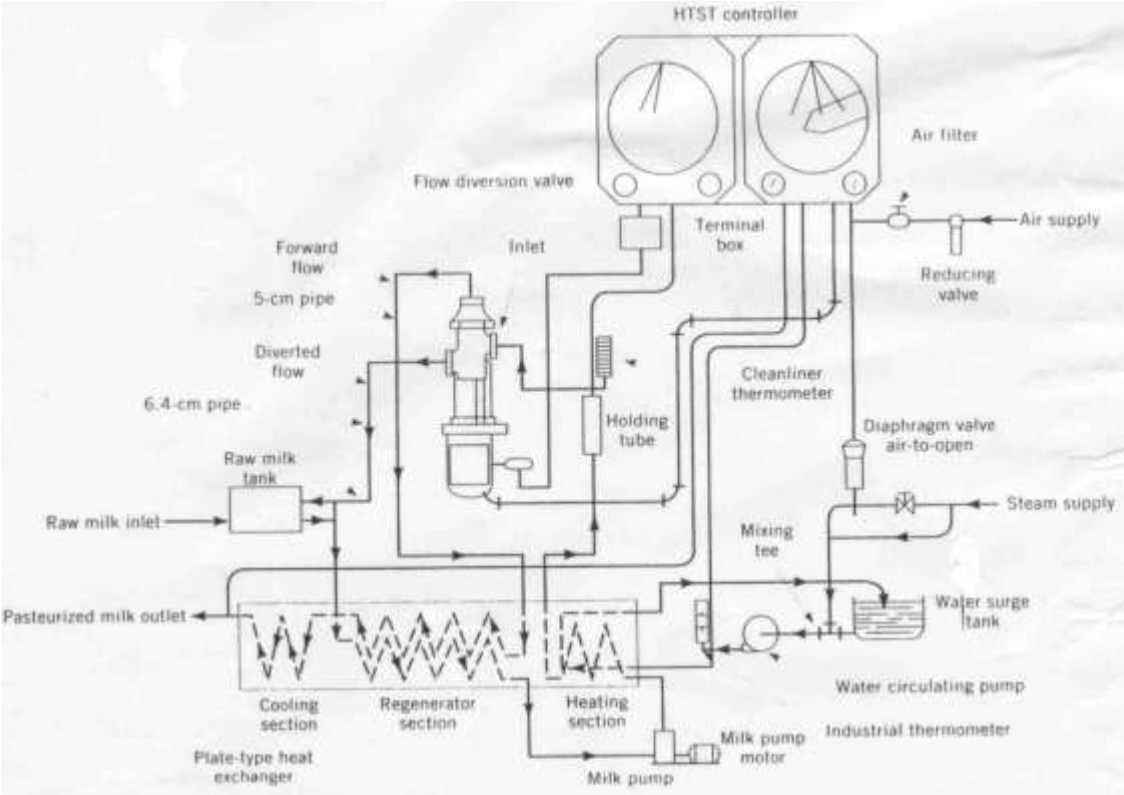


Figure – 8 : HTST control system

Utilities

Electricity, water, steam refrigeration, and compressed air must be provided to the pasteurizer for heating, cooling, and cleaning of water. The water is heated by steam injection or an enclosed heating and circulating unit. The controller, sensing the hot water temperature, permits heating until the preset temperature is reached, usually 1-2^{0}C above the pasteurization temperature. A diaphragm valve, directed by the controller, maintains the maximum temperature of the hot water by control of the steam. Water is cooled with a direct expansion refrigeration system and may be cooled directly or over an ice bank formed by direct expansion refrigeration. The compressed air should be clean, relatively dry, and supplied at ~ 138 kPa (20 psi) to operate valves and controls.

Other Continuous Processes

Various pasteurization heat treatments are identified by names such as quick time, vacuum treatment (vacreator), modified tubular (Roswell), small-diameter tube (Mallorizer), and steam injection. The last three methods are ultrahigh temperature (UHT) processes. Higher treatment temperatures with shorter times, approaching two seconds, are preferred because the product has to be cooled quickly to prevent deleterious heat effects.

Vacuum Treatment

Milk can be exposed to a vacuum to remove low boiling substances, e.g., onions, garlic, and some silage, which may impart off-flavours to the milk, particularly the fat portion. A three-stage vacuum unit, known as a vacreator, produces pressures of 17, 51-68, and 88-95 kPa (127, 381-508, and 660-711 mm Hg). A continuous vacuum unit in the HTST system may consist of one or two chambers and be heated by live steam, with an equivalent release of water by evaporation, or flash steam to carry off the volatiles. If live steam is used, it must be culinary steam which is produced by heating potable water with an indirect heat exchanger. Dry saturated steam is desired for food processing operations.

Product Heat Treatment

Equivalent heat treatment for destruction of microorganisms or inactivation of enzymes can be represented by plotting the logarithm of time versus temperature. These relationships were originally developed for sterilization of food at 121.1^{0}C, therefore the time to destroy the microorganism is the F_0 value at 121.1^{0}C (250^{0}F). The slope of the curve is z, and the temperature span is one log cycle. The heat treatment at 131^{0}C for one minute is equivalent to 121.1^{0}C for 10 minutes (**Figure – 9**).

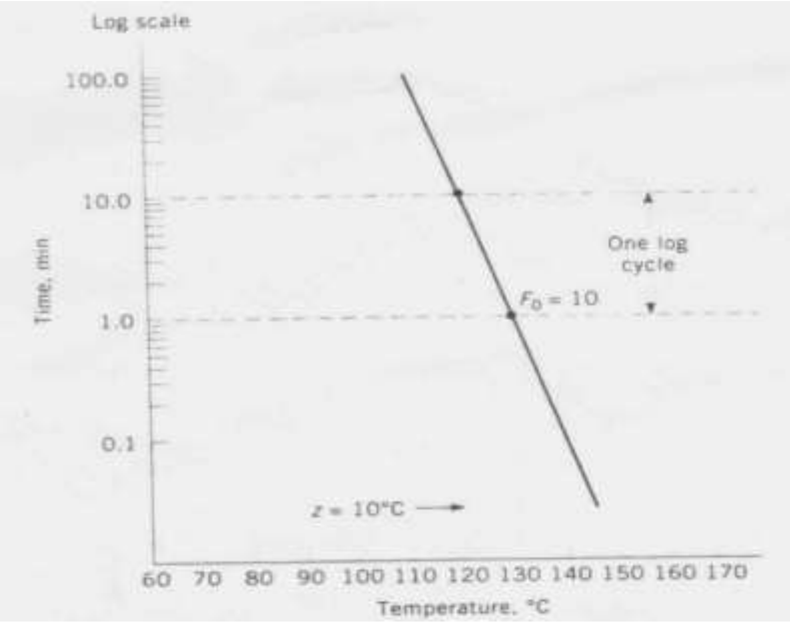


Figure – 9 : Representation of z and *F* values. F_0 is the zero point for identifying the sterilization value at 121.1^{0}C (250^{0}F) : $F_0 / t = e^{2.3/z(T - 121.1)} = 10^{(T - 121.1)/z}$

Equipment

Equipment is designed according to 3A Sanitary Standards established by a committee of users, manufacturers, and sanitarians in the food industry. The objective of the committee is to provide interchangeable parts and equipment, establish standards for inspection, and provide knowledge of acceptable design and materials, primarily, to fulfill sanitary requirements. Sanitary equipment design requires that the material of construction is 18-8 stainless steel, with a carbon content of not more than 0.12%, although equally corrosion-resistant material is acceptable; the metal gauge for various applications is specified; surfaces fabricated from sheets have a No.4 finish or equivalent; weld areas are substantially as corrosion resistant at the parent material; minimum radii are often specified, e.g. for a storage tank, 0.62 cm for inside corners of permanent attachments; no threads are in contact with food; and threads are Acme threads (flat-headed instead of V-shaped).

Materials of Construction. Stainless Steel

The use of stainless steel (qv) for flat surfaces, tubing coils, and castings in milk and dairy equipment has advanced since the 1950s. The contact surfaces of milk and dairy equipment are primarily stainless steel, which permits cleaning-in-place (CIP), automation, continuous operations, and aseptic processing and packaging.

Many types of stainless steels are available. The type most widely used in the dairy industry is 18-8 (18% chromium, 8% nickel plus iron). Small amounts of silicon, molybdenum, manganese, carbon, sulfur, and phosphorus may be included to obtain characteristics desired for specific applications.

The most important stainless steel series are 200-, 300-, and 400-series. The 300-series, primarily 302, 304, and 316, is used in the dairy industry, whereas the 400-series is used for special applications, such as pump impellers, plungers, cutting blades, scrapers, and bearings. Surface finishes are specified from No.1 to No.8 (highly polished); the No.4 finish is most commonly used.

Stainless steel develops a passive protective layer ($\leq$ 5-nm thick) of chromium oxide (1118-57-3) which must be maintained or permitted to rebuild after it is removed by product flow or cleaning.

Cleaning

Equipment is cleaned to prevent contamination of subsequent dairy processing operations and damage to the surface. In cleaning stainless steel, surface contaminants are removed that would otherwise destroy the protective passive layer. The surface is dried and exposed to air to rebuild the protective passive chromium oxide layer. Metal adhering to the stainless steel surface should be removed with the least abrasive material, and after cleaning, the surface should be washed with hot water and left to dry. Equipment should be sanitized with 200-ppm chlorine solution within 30 minutes before use, not necessarily after cleaning, to avoid corrosion resulting from chlorine on the surface for an extended period of time. For cleaning-in-place (CIP), the velocity of the cleaning solution over the surfaces should be $\leq$ 1.5 m/s.

Excessive velocities can cause erosion of the surface and reduction of the protective layer. Excessive time of contact of the cleaning solution may cause corrosion, depending on the strength of the cleaning solution.

Piping and Tubing

Piping size is designated by a nominal rather than an exact inside diameter i.e. a pipe of 2.5-cm diameter can have an inside diameter slightly more or less than 2.5 cm, depending on the wall thickness. Tubing size is designated by the outside diameter, i.e., a tube of 2.5-cm diameter has an outside diameter of 2.5 cm, and as the thickness of the tubing increases the inside diameter decreases and is always less than 2.5 cm. Both piping and tubing have fixed but different outside diameters for a particular size, and standard fittings can be used with different wall thicknesses.

The food industry uses stainless steel tubing or piping extensively for moving food products, conventional steel, cast iron, copper, plastic, glass (qv), aluminum, and other alloys are used for utilities.

Most piping and tubing systems are designed for in-place cleaning. Classification is based on the type of connections for assembly: welded joints for permanent connections; ground joints with Acme threads and hexagonal units having gaskets for connections that are opened daily or periodically, and clamp-type joints.

Corrosion between the support device and the pipeline must be avoided. Drainage is provided by the pipeline slope, normally 0.48-0.96 cm/m of length, and gaskets must be nonabsorbent and of a type that does not affect the food product.

Fittings

Fittings connect pipes and provide for the attachment of equipment to change flow direction. They must be easily cleaned inside and out, have no exposed pipe threads, and, if of the detachable type, have an appropriate gasket. The fittings are constructed of the same or similar materials as the pipeline and are installed on tubing.

An air valve, sometimes called the air-activated valve, is widely used for automated food handling operations. Although electronic or electric control boxes may be a part of the system, the valve itself generally is air-activated, and is more reliable than other types. Air-operated valves are used for in-place cleaning systems, and for the transfer and flow control of various products.

Pumps

The flow of fluids through a dairy processing plant is maintained by a centrifugal (non-positive) or a displacement (positive) pump. Positive displacement pumps are either of the piston or plunger type, which are usually equipped with multiple pistons, or of the rotary positive type. The pump is selected on the basis of the quantity of product to be moved against a specified head. Generally, a hardenable 400-series stainless steel is used for the moving parts which chip easily and must be handled carefully during disassembly, cleaning, and assembly.

Centrifugal Pump

The centrifugal pump consists of a directly connected impeller which operates in a casing at high speed. Fluid enters the center and is discharged at the outer edge of the casing. The centrifugal pump is used with for moving products against low discharge heads or where it is necessary to regulate the flow of product through a throttling valve or restriction. Pumps for a CIP system include a self-cleaning diaphragm.

Positive Pumps

Positive pumps employed by the food industry have a rotating cavity between two lobes, two gears that rotate in opposite directions, or a crescent or stationary cavity and a rotor. Rotary positive pumps operate at relatively low speed. Fluid enters the cavity by gravity flow or from a centrifugal pump. The positive pump also may use a reciprocating cavity, and may be a plunger or piston pump. These pumps are not truly positive with respect to displacement, but are used for metering product flow.

Cleaning Systems

Both manual and automatic methods are used for cleaning food processing (qv) equipment.

Cleaning-In-Place

In diary plants, the equipment surfaces and pipelines are cleaned in place at least once every 24 hours. Cleaning-in-place (CIP) systems evolved from recirculating cleaning solutions in pipelines and equipment to a highly automatic system with valves, controls, and timers. The results of cleaning in place are influenced by equipment surfaces, time of exposure, and the temperature and concentration of the solution being circulated.

In the CIP procedure, a cold or tempered aqueous prerinse is followed by circulation of a cleaning solution for 10 minutes to one hour at 54-82^{0}C. The temperature of the cleaning solution should be as low as possible, because hot water rinses may harden the food product on the surface being cleaned, but high enough to avoid excess cleaning chemicals. A wide variety of cleaning solutions may be used, depending on the food product, hardness of water, and equipment.

A CIP system includes pipelines interconnected with valves to direct fluid to appropriate locations, and the control circuit, which consists of interlines to control the valves that direct the cleaning solutions and water through the lines, and air lines which control and move the valves. A programmer controls the timing and the air flow to the valves on a set schedule. A simple CIP system circuit is shown in **Figure – 10**.

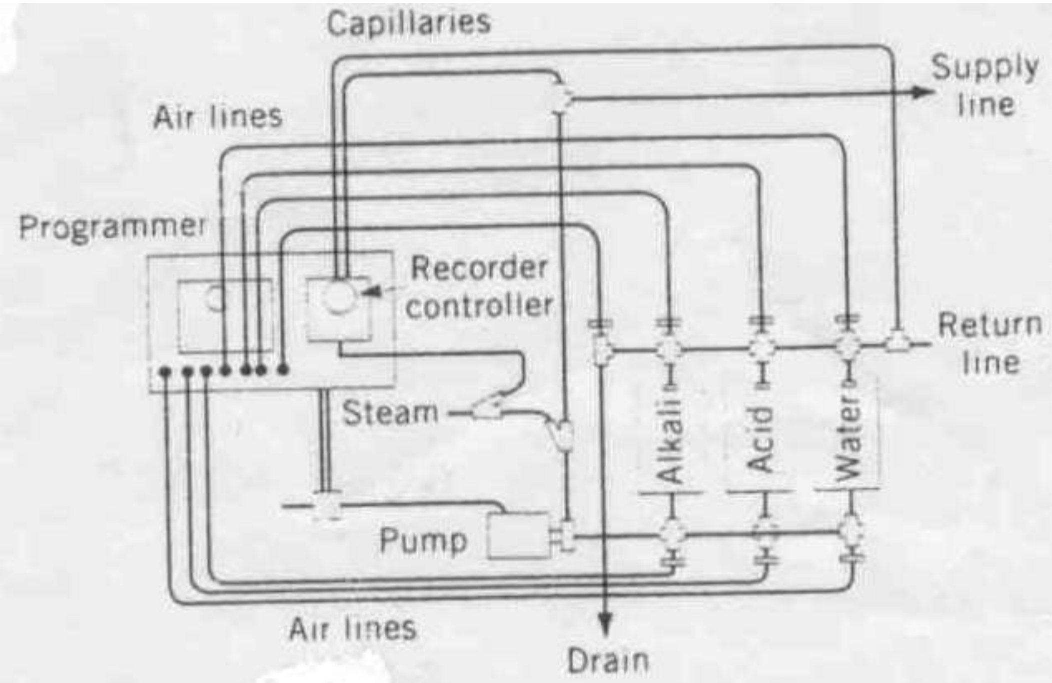


Figure – 10 : Simple circuit for CIP system

Storage, Cooling, Shipping and Packaging

Bulk Milk Tanks

Commercial dairy production enterprises generally employ tanks in which the milk is cooled and stored. In some operations, the warm milk is first cooled and then stored in a tank; 3A Standards have been established for their design and operation. Among other requirements, the milk must be cooled to 4.4^0C within two hours after milking. The temperature must not be permitted to increase above 10^0C when warm milk from the following milking is placed in the tank. Bulk milk tanks are classified according to method of refrigeration, i.e., direct expansion (DX) or ice bank (IB); pressure in tank, i.e., atmospheric or vacuum; regularity of pickup, i.e., every day or every other day; capacity, in liters, when full or at amount which can be received per milking; shape, i.e., cylindrical, half-cylindrical, or rectangular; position, i.e., vertical or horizontal; and method of cooling refrigeration condenser, i.e., by water, air, or both.

Cooling

A compression refrigeration system, driven by an electric motor, supplies cooling for either direct expansion or ice bank systems (**Figure – 11**). In the former, the milk is cooled by the evaporator (cooling coils) on the bulk tank liner opposite the milk side of the liner. The compressor must have the capacity to cool the milk as rapidly as it enters the tank.

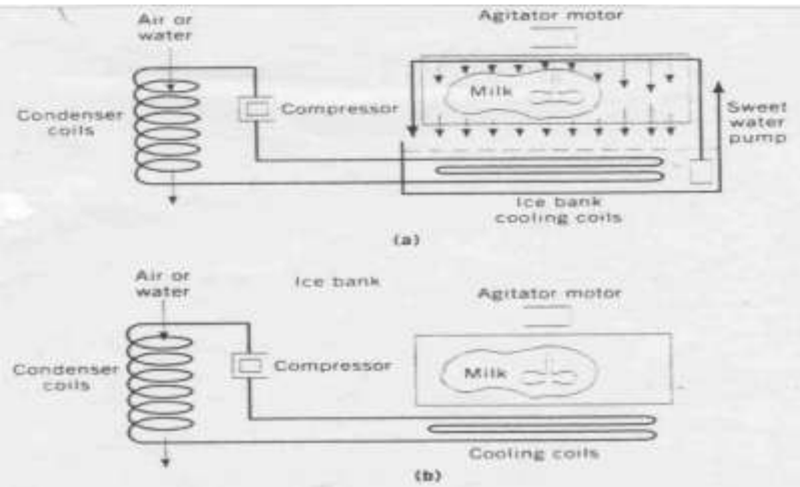


Figure – 11 : Compression refrigeration supplying cooling for (a) the ice bank, where (↓) represents the flow of sweet water and (---), the water level, or (b) the direct expansion systems

In the ice bank system, ice is formed over the evaporator coils. Water is pumped over the ice bank and circulated over the inner liner of the tank to cool the milk. The water is returned to the ice bank compartment. This system provides a means of building refrigeration capacity for later cooling; therefore a smaller compressor and motor can be used, although the unit operates two to three times as long as a direct expansion system for the same cooling capacity. Off-peak electricity might be used for the ice bank system, thus reducing operating costs.

Important features of bulk milk tanks include a measuring device, generally a calibrated rod or meter; cleaning and sanitizing facilities; and stirring with an appropriate agitator to cool and maintain cool milk temperatures.

Surface Coolers

Milk coming from cows may be rapidly cooled over a stainless steel surface cooler before entering a bulk tank. The cooler may either use compression refrigeration or have two sections, one using cold water followed by a section using compression refrigeration.

Shipping

Bulk milk is hauled to the processing plant in insulated tanks using truck tanks or trailer tankers. The milk is transferred from the bulk tank to the tanker with a positive or centrifugal-type pump. For routes of some distance, pick-up every other day reduces handling costs.

Receiving Operations

Bulk milk-receiving operations consist primarily of transferring milk from the tanker to a storage tank in the plant. Practically all Grade A milk is handled in bulk.

Packaging

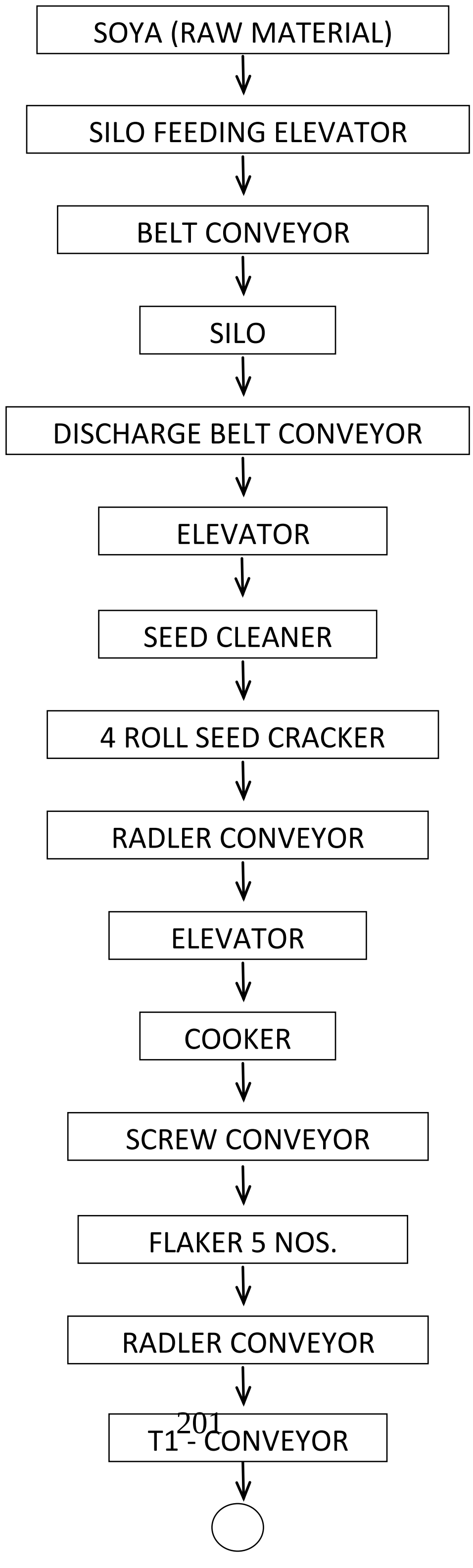
Aseptic packaging was developed in conjunction with high temperature processing and has contributed to make sterilized milk and milk products a commercial reality.

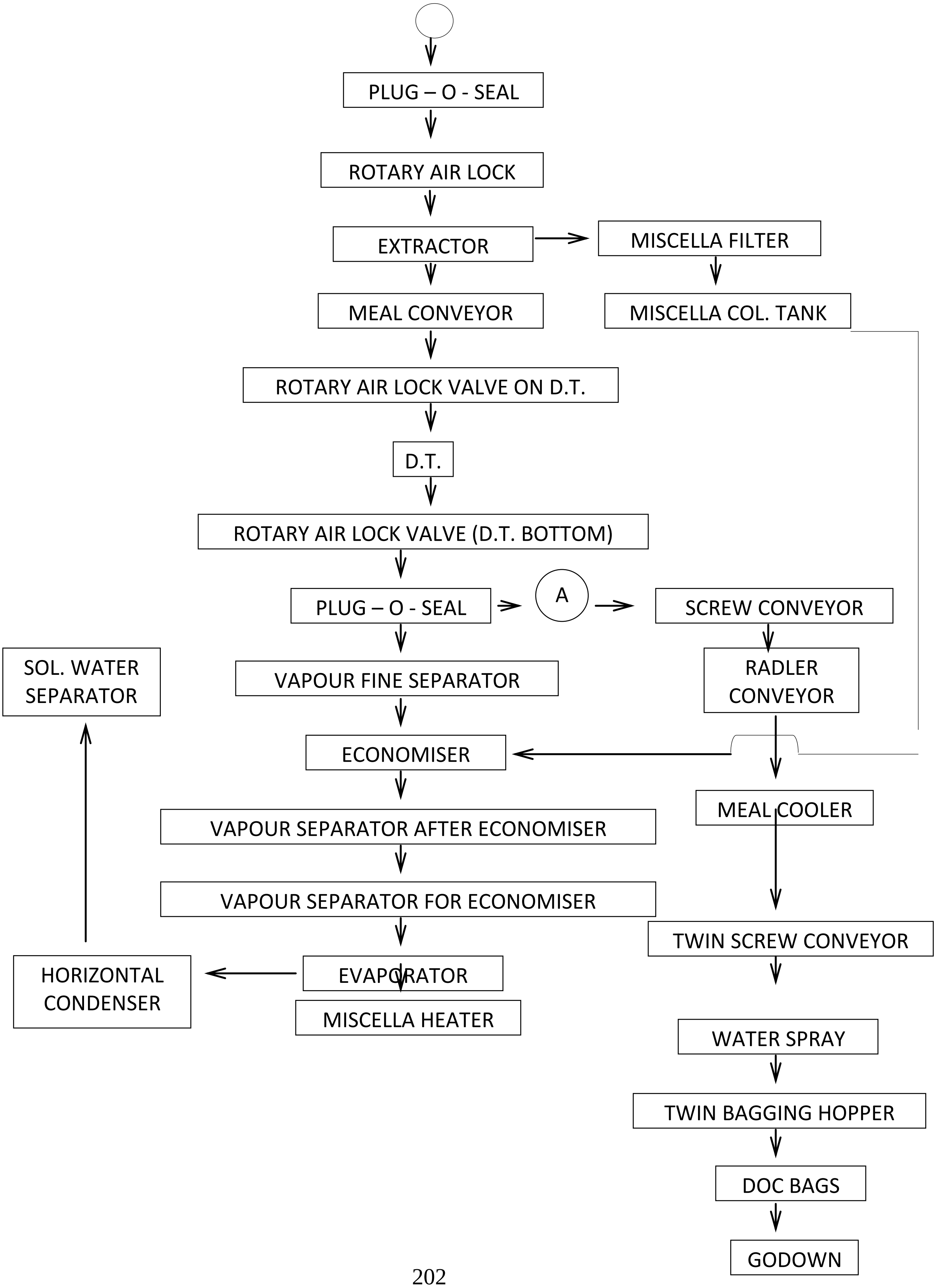
The objects in packaging cool sterilized products is to maintain the product under aseptic conditions, to sterilize the container and its lid, and to place the product into the container and seal it without contamination. Contamination of the head space between the product and closure is avoided by the use of superheated steam, maintaining a high internal pressure, spraying the container surface with a bactericide such as chlorine, irradiation with a bactericidal lamp or filling the space with an inert sterile gas such as nitrogen.

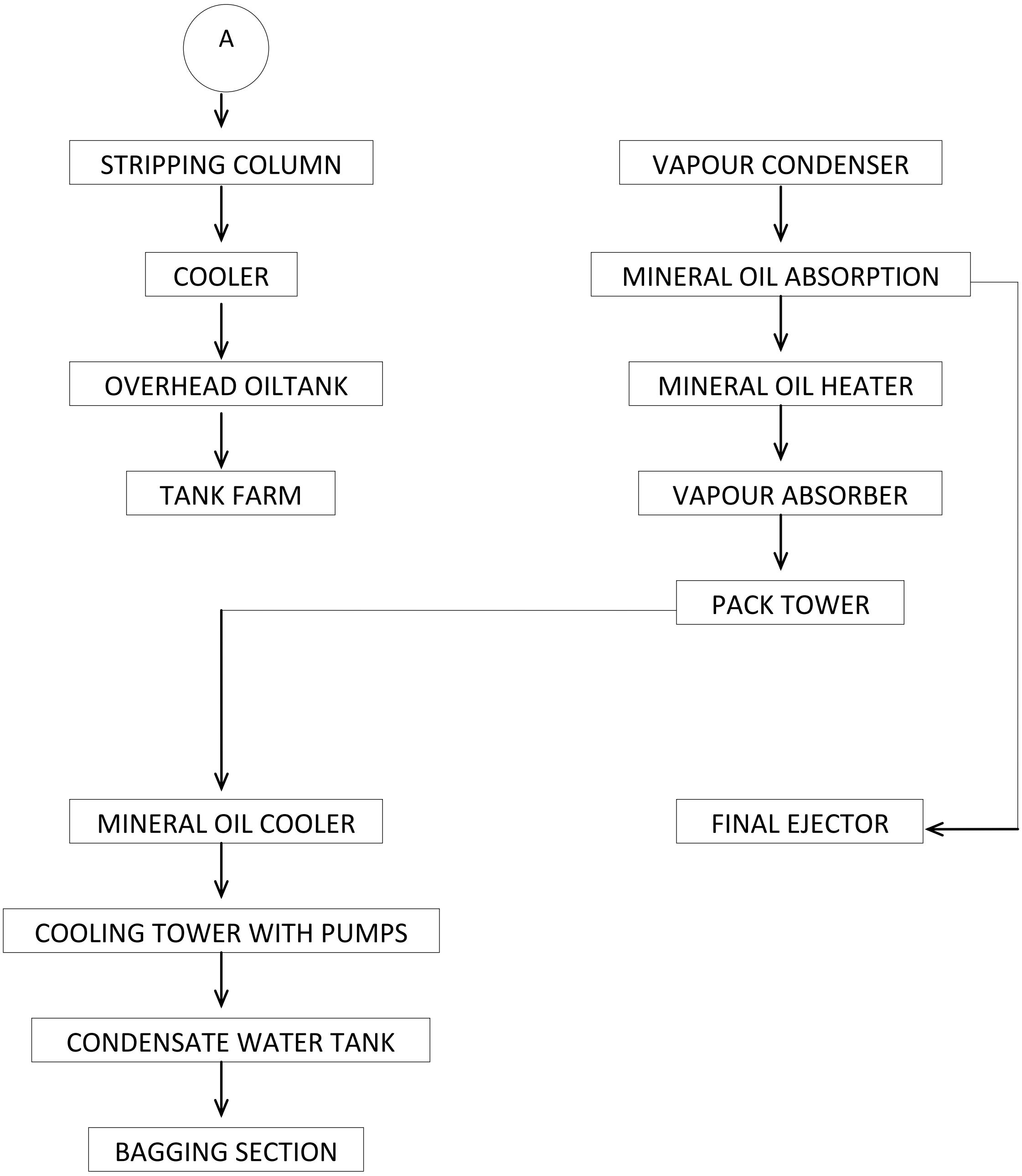
C. SOLVENT EXTRACTION AND VANASPATI PLANTS

1. Solvent Extraction

PROCESS FLOW DIAGRAM
(SOLVENT EXTRACTION PLANT)




PLUG – O - SEAL
ROTARY AIR LOCK
EXTRACTOR
MISCELLA FILTER
MEAL CONVEYOR
MISCELLA COL. TANK
ROTARY AIR LOCK VALVE ON D.T.
D.T.
ROTARY AIR LOCK VALVE (D.T. BOTTOM)
PLUG – O - SEAL
A
SCREW CONVEYOR
SOL. WATER SEPARATOR
VAPOUR FINE SEPARATOR
RADLER CONVEYOR
ECONOMISER
MEAL COOLER
VAPOUR SEPARATOR AFTER ECONOMISER
VAPOUR SEPARATOR FOR ECONOMISER
TWIN SCREW CONVEYOR
HORIZONTAL CONDENSER
EVAPORATOR
MISCELLA HEATER
WATER SPRAY
TWIN BAGGING HOPPER
DOC BAGS
GODOWN


A
STRIPPING COLUMN
COOLER
OVERHEAD OILTANK
TANK FARM
VAPOUR CONDENSER
MINERAL OIL ABSORPTION
MINERAL OIL HEATER
VAPOUR ABSORBER
PACK TOWER
MINERAL OIL COOLER
COOLING TOWER WITH PUMPS
CONDENSATE WATER TANK
BAGGING SECTION
FINAL EJECTOR

(1) **Solvent extraction plant :**

Solvent extraction is a process to extract oil from oil-bearing materials by treatment with a low boiling point solvent in contrast to methods of extraction by mechanical pressing (such as expellers, hydraulic presses, ghanis etc.). By solvent extraction almost all the oil is recovered leaving only 0.8 to 1.2% residual oil in raw material. In the case of mechanical pressing the residual oil left in the oilcake may be anywhere from 6% to 14%. The solvent extraction method can be applied directly to any low oil content raw materials. It can also be used to extract pre-pressed oil cakes obtained from high oil content materials. Because of high percentage of recovery of oil, solvent extraction has become the most popular method of extraction of oils and fats.

The process :

Solvent extraction is basically a process of diffusion of a solvent into oil-bearing cells of the raw material, resulting in a solution of the oil in solvent. Various solvents can be used for extraction. However, after extensive research and consideration of various factors such as commercial, economics, edibility of the various products obtained from extraction, physical properties of the solvent especially its low boiling point etc., hexane is considered to be the best and it is exclusively used for the purpose.

In a nutshell, the extraction process consists of treating the raw material with hexane and recovering the oil by distillation of the resulting solution of oil in hexane called miscella. The hexane absorbed in the material is recovered by evaporation and condensation as also from the distillation of miscella. The hexane thus recovered is reused for extraction. The low boiling point of hexane (67^0 C) and the high solubility of oils and fasts in it are the properties exploited in the solvent extraction process. The entire extraction process can be divided into the following stages :-

- Preparation of raw material
- Process of extraction
- Desolventisation of extracted material
- Distillation of miscella
- Solvent recovery by absorption
- Mean finishing and bagging

Because of the highly inflammable character of the normal hexane, those stages of process which involve high speed machinery, such as, material preparation, finishing and begging are carried out at least 50 feet away from the main extraction plant wherein the remaining processing stages involving handling of the solvent are carried out. The typical flow chart illustrates the various processing steps.

Preparation of raw material :

For thorough and efficient extraction, it is necessary that each and every oil bearing cell of the material is brought in contact with the solvent. Therefore, proper preparation of materials prior to extraction is very important to ensure this contact. The smaller the material size, the better is the penetration of the solvent into the oil-bearing cells; but too fine a size will prevent the solvent from percolating through the mass. Therefore, an optimum size is to be maintained for best extraction. Hence material preparation methods vary from material to material depending on its oil content, size and physical properties.

For high oil content materials (oil content 15% or more), the following steps of preparation are recommended to make the material suitable for penetration of the solvent into the oil cells as well as for best percolation.

* Passage of the seed through corrugated roller mills with 3 mm flutes to reduce the size to about 3 mm.
* Heating the broken material to about 80^0 C with open steam in a temperor and humidifying the material to raise the moisture content to about 11 to 12%.
* Flaking of the humidified material between a pair of plain rolls to 0.25 mm thickness or below.
* Conveying the flakes to the extraction system after crisping them firm.

Rice bran is a fine floury material and therefore bound to obstruct the percolation. The best preparation of rice bran for extraction is to pelletise the same after tempering with open steam. The pelletised bran is then crisped in a current of air while conveying to the extractor.

Some oil-seeds can be directly extracted e.g. cotton-seed, soyabean, etc. But they are to be decorticated by special equipment to separate the oil-bearing meats from the hulls. The decorticating equipment vary from seed to seed. The decorticated meats are tempered, flaked and the flakes are sent to extractor after crisping.

The prepared material enters the extractor through the rotary air seal. The extractor consists mainly of a very slow moving articulated band conveyor inside a totally enclosed chamber. The band is lined with perforated sheets and porous stainless steel cloth. The mass of the material moving on this band forms a slow moving bed. During the movement of the bed through the extractor it is washed continuously at various points with miscella of decreasing concentrations and finally with a fresh solvent in a counter current manner by means of sprayers kept in a line over the meal bed. The miscella percolates through the perforated bottom and collects in various hoppers kept below the bed. The miscella from the lat hopper which is concentrated is taken off for distillation.

Desolventisation of extracted material :

After the fresh solvent wash the material is discharged from the band conveyor into an air-tight chain conveyor which conveys it to the desolventiser. In the desolventiser the material is heated to about 100^0 C by jacketed steam, and thus the absorbed solvent is evaporated into vapours (Boiling point of hexane is $67^0 – 70^0$ C). Finally, the material which is now completely desolventised is continuously discharged through air-tight seal into a pneumatic conveyor, which carries it into the bagging section. The vapours evolved in the desolvemtisers are led through a dust catcher wherein they are washed with hot water, to a condenser.

Some materials, such as cotton-seed and soyabean extractions, are toasted after desolventisation. In these cases both the steps of desolventisation and toasting can be combined into one operation by the use of Desolventiser – Toaster (D.T.) instead of the tubular jacketed desolventiser.

The D.T. consists of a vertical cylindrical vessel with horizontal jacketed compartments and a central rotating vertical shaft on which are mounted sweeps in each compartment. The material to be desolventised and toasted is fed into the top compartment of D.T. and heated with open steam. Open steam condenses a lot of moisture in the material at the same time evaporating the solvent. The moisture up to 14 to 15% is condensed. The material then flows to lower compartment. In lower compartments the material is gradually heated to 115 to 120^0 C thus evaporating all the solvent, cooking the material and driving away extra moisture. The cooking in presence of moisture destroys undesirable enzymes. High temperature attained toasts the material. The solvent and water vapours from various compartments are led first to a dust catcher wherein they are scrubbed with hot water spray to remove fine dust and then led to a condenser to condense the vapours. The desolventised and toasted meal from bottom most compartment discharges into a radler conveyor.

Distillation of miscella :

The final miscella (solution of oil in hexane) obtained from the extractor is collected in a tank from where it is pumped to the distillation column kept under vacuum by means of a series to steam ejectors. The miscella is heated by jacket steam in the distillation column and thus the hexane is turned into vapour immediately. The vapors are led to another condenser through an entrainment separator.

The concentrated miscella from the evaporator is pumped into a similar secondary distillation unit to raise the temperature to about 100 – 110^0 C and then taken into the final stripper kept under high vacuum. Open steam is injected in the latter to strip the last traces of hexane from the oil. The vapour both from the secondary still and the stripper are condensed in a third condenser. The oil freed from solvent is pumped from the stripper to the storage.

Solvent recovery by condensation :

All the condensers are of floating head type with tube-bundles to carry the cooling water. The cooled water at 30^0 C or below is circulated inside the tubes in all the condensers and the vapours are passed outside the tubes. Thus the vapours are cooled and condensed into liquid.

The uncondensed vapours from each condenser are sucked by the services of ejectors and pushed through the last condenser to a contact cooler where they are washed with cold water spray. All the condensate liquid hexane water from these condensers and contact cooler is led to a solvent water separator wherein the pure solvent is separated from water by settling the difference in densities of water and the solvent and their immiscibility accomplishes complete separation. The fresh pure solvent from this tank is pumped to the extractor continuously for the final washing of the meal bed.

TECHNICAL SPECIFICATIONS OF PLANT AND MACHINERY FOR SOLVENT EXTRACTION PLANT

Solvent Extraction Plant is a custom built plant. Solvent extraction capacity is expressed in terms of tones per day of oil extracted.

Plant and machinery is installed in following sections:

A. Raw Material Storage
B. Preparatory
C. Solvent Extraction
D. Meal Finishing

RAW MATERIAL STORAGE

1. M.S. Seed Storage Silo made out of M.S. Plate of 6 mm, 8 mm and 10 mm thickness

Size	:	Dia. 11.8 m Height : 14.0 m

2. Seed Feeding M.S. Hopper

Capacity	:	10 tonnes
Size	:	Length – 2 m Width – 5 m Depth – 2 m

3. M.S. Silo Feeding bucket Elevator

Number of buckets	:	118
Size of bucket	:	220 mm x 200 mm x 400 mm
Type of belt	:	Nylon
Width of belt	:	500 mm
Thickness of belt	:	12 mm
Length of belt	:	54 m

Details of drive

HP	:	30
Speed	:	1500 rpm

Gearbox

Type	:	V – 800
Ratio	:	20:1

4. **M.S. Silo Feeding Belt Conveyer**

Capacity	:	60 tonnes per hour
Type of belt	:	Nylon
Width of belt	:	750 mm
Thickness of belt	:	8 mm
Length of belt	:	13.9 m
Details of drive		
HP	:	10
Speed	:	1500 rpm
Gearbox		
Type	:	V – 600
Ratio	:	20:1

PREPARATORY

1. **M.S. Bucket Elevator Feeding to Seed Cleaner**

Capacity	:	30 tonnes per hour
Size of bucket	:	150 x 150 x 300 mm
Number of buckets	:	40
Type of belt	:	Canvas
Width of belt	:	300 mm
Thickness of belt	:	8 mm
Total length of belt	:	14 m
Details of drive		
HP	:	10
Speed	:	1500 rpm
Gearbox		
Type	:	V – 600
Ratio	:	20:1

2. **M.S. Vibrating Seed Cleaner**

Capacity	:	30 tonnes per hour
Details of drive		
HP	:	3
Speed	:	1500 rpm

3. **M.S. Screw Conveyor Carrying Cleaned Beans to Seed Cracker**

Capacity	:	25 tonnes per hour
Pitch of screw	:	250 mm
Casing dia.	:	320 mm
Length of conveyor	:	5.0 m
Details of drive		
HP	:	3
Speed	:	1500 rpm
Gearbox		
Type	:	U – 400
Ratio	:	25:1

4. **Seed Cracker**

Capacity	:	50 tonnes per hour
Number of rolls	:	4
Type of rolls	:	Chilled cast iron
Details of motor		
HP	:	60
Speed	:	1000 rpm

5. M.S. Radler Conveyor for Cracked Bean Discharge

Capacity	:	30 tonnes per hour
Length of conveyor	:	10.9 m
Width of chain	:	484 mm
Total length of chain	:	20 m
Pitch of chain	:	125 mm

Details of drive

HP	:	5
Speed	:	1500 rpm

Gearbox

Type	:	U – 400
Ratio	:	25:1

6. M.S. Bucket Elevator Feeding to Seed Cooker

Capacity	:	30 tonnes per hour
Size of bucket	:	150 x 150 x 300 mm
No. of buckets	:	40
Type of belt	:	Canvas
Width of belt	:	300 mm
Thickness of belt	:	8 mm
Length of belt	:	14 m

Details of drive

HP	:	10
Speed	:	1500 rpm

Gearbox

Type	:	U – 600
Ratio	:	20:1

7. **M.S. Seed Cooker having 5 Stages with Steam Heating Jacket at each stage**

Storage capacity	:	2.5 tonnes
Overall size	:	2.5 m dia. x 5.25 m height

Seed cooker is provided with IBR 8 mm thick, 65 mm dia., 27 nos. star pipes in each jacket.

Details of drive		
HP	:	20
Speed	:	1500 rpm
Gearbox		
Type	:	Helical VB3 – 200
Ratio	:	52:1

8. **M.S. Bucket Elevator Feeding to Screw Conveyor**

Capacity	:	30 tonnes per hour
Size of bucket	:	150 x 150 x 300 mm
Number of buckets	:	40
Chain pitch	:	75 mm
Chain width	:	100 mm
Chain length	:	14 m
Details of drive		
HP	:	10
Speed	:	1500 rpm
Gearbox		
Type	:	U – 600
Ratio	:	20:1

9. M.S. Screw Conveyor for Distributing Cracked Beans to all the Flakers

Capacity	:	30 tonnes per hour
Pitch screw	:	300 mm
Length of screw	:	18 m
Size of casing	:	320 mm
Details of drive		
HP	:	10
Speed	:	1500 rpm
Gearbox		
Type	:	U – 400
Ratio	:	25:1

10. M.S. Hydraulic Flaker with Chilled Cast Iron Rolls

Capacity	:	125 tonnes per day
Size of roll	:	500 mm dia. x 1300 mm long
Details of drive		
HP of motor	:	30
Speed of motor	:	1000 rpm
HP of geared motor	:	2
Speed of geared motor	:	30 rpm

11. M.S. Radler Conveyor for Flake Discharge

Capacity	:	25 tonnes per hour
Length of conveyor	:	59 m
Width of chain	:	485 mm
Length of chain	:	120 mm
Pitch	:	125 mm

SOLVENT EXTRACTION

1. Extractor Feeding Radler Conveyor

Body of conveyor		
Capacity	:	20 tonnes per hour
Overall dimensions	:	500 mm width x 300 mm height x 65 m long made out of 5 mm and 3 mm thick M.S. plate.
Radler chain		
Type	:	Pin roller
Overall width	:	485 mm
Pitch	:	125 mm
Details of drive		
HP	:	10
Speed	:	1440 rpm
Gearbox		
Type	:	U – 600
Ratio	:	20:1
Chain drive		
Type	:	Duplex
Pitch	:	1”
Length of chain	:	5 m
Sprocket teeth		
Pinion	:	19 teeth duplex
Wheel	:	57 teeth duplex

CVSRTA

2. Plug-O-Seal Screw Conveyor with Mechanical Seal

Capacity	:	25 tonnes per hour
Type	:	Double sealing (Outer body made out of 6 mm)
Size	:	300 mm dia. x 2 m long.
Details of screw conveyor		
Pitch	:	250 mm
Length	:	2 m
Details of shaft		
Material of construction	:	M.S.
Dia.	:	50 mm
Length	:	2850 mm

3. Rotary Airlock Valve for Extractor Sealing

Dia.	:	300 mm
Length	:	500 mm
Details of drive		
HP	:	3
Speed	:	1440 rpm
Gearbox		
Type	:	U – 400
Ratio	:	20:1

4. Extractor

Complete with

- Main body
- Belt conveyor assembly
- Inside sprocket and shaft
- Drum shaft
- Brush shaft
- Pumps

Details of each of the above items:

Main body

Extractor body is fabricated out of M.S. plate of 10 mm and 5 mm thick.

Overall dimensions:

Width	:	2300 mm
Length	:	23000 mm
Height	:	4500 mm

The body is fabricated to house the chain conveyor with woven wire carrier. The welded joints are subjected to hydraulic tests for any leakage as the same are subject to the use of inflammable quality of material.

The extractor is in the fire section with one inlet and one outlet. Each section is provided with two 600 mm dia. glass windows.

Details of drive:

Type of motor	:	Flame-proof
HP	:	3
Speed	:	960 rpm

Gearbox

Type	:	U – 1200
Radio	:	1000:1

Pinion	:	14 teeth – 35 mm pitch – 2 nos.
Wheel	:	98 teeth – 35 mm pitch

Belt conveyor assembly

Craddle frame

Number of cradle frame: 120

Size of cradle frame	:	400 mm x 1800 mm

Perforated sheet	:	400 mm x 1800 mm – 120 nos. with S.S. net 25 g x 28 mesh

Inside sprocket and shaft

Inside sprocket	:	4 nos.
Dia.	:	1100 mm
Number of teeth	:	8
Pitch	:	400 mm
Shaft	:	2 nos.
Dia.	:	200 mm
Length	:	3200 mm
Material of construction	:	EN8

Drum shaft

Drum shaft with 136 nos. of M.S. strips and mechanical seal

Dia	:	400 mm
Length	:	2200 mm
Material of construction	:	M.S.
Size of strips	:	350 x 50 x 8 mm thick

Brush shaft

Type of brush	:	Nylon wire
No. of brushes	:	6
Size of pipe	:	150 mm dia. x 2200 mm long
Material of construction	:	M.S.
Size of shaft	:	80 mm dia. x 2650 mm long with mechanical seal

Pumps

Pumps with flame proof motors

Type	:	KPD 65/20	- 12 nos.
Type	:	15 PCH 75	- 3 nos.
Type	:	1 PCH 63	- 2 nos.

5. De-oiled Meal Sealed Conveyor

Size of box :		500 mm x 350 mm x 14 m
Material of construction	:	M.S.
Chain		
Size of chain	:	485 mm
Pitch	:	125 mm
Length of chain	:	32 m
Inside sprocket	:	9 teeth
Drive and driven shaft made out of EN8		
Size	:	80 mm dia. x 1000 mm – 1 no. 80 mm dia. x 600 mm – 1 no.
Details of drive		
Type of motor	:	Flameproof
HP	:	10
Speed	:	1440 rpm
Gearbox		
Type	:	U – 400
Ratio	:	20:1
Sprocket	:	19 teeth, 1” pitch 57 teeth, 1” pitch
Length of duplex chain	:	4 m

CVSRTA

6. Rotary Airlock Valve on D.T.

Size	:	400 mm dia. x 500 mm long
Sprocket	:	38 teeth, 1” pitch
Length of simplex chain	:	6 m

7. Dissolventiser Toaster (D.T.)

No. of compartments	:	7
Material of construction	:	M.S. plate 10 mm thick
Overall size	:	3250 mm dia. x 8250 mm long
Type and thickness of insulation	:	100 mm glasswool
Details of inner jacket	:	3000 mm dia. x 100 mm height with 37 nos. of stay pipe of 75 mm dia. (IBR)

Details of drive		
Type of motor	:	Flameproof
HP	:	75
Speed	:	1440 rpm

Gearbox		
Type	:	VB2 – 350
Ratio	:	57:1

8. Rotary Airlock Valve for D.T. Bottom

Material of construction	:	M.S.
Size	:	250 mm dia. x 400 mm long
Sprocket	:	19 teeth, 1” pitch Simplex
Chain length	:	1000 mm

9. Plug-O-Seal Screw Conveyor

Details of body	:	300 mm M.S. pipe x 2500 mm long
Pitch of screw	:	250 mm
Length	:	2500 mm
Screw plate thickness	:	5 mm
Details of drive		
Type of motor	:	Flameproof
HP	:	3
Speed	:	1440 rpm
Gearbox		
Type	:	U – 400
Ratio	:	20:1
Chain		
Length	:	1 m
Pitch	:	1”
Sprocket	:	Simplex type

(a) 25 teeth, 1” pitch

(b) 38 teeth, 1” pitch

10. Vapour Separator with Water Spray arrangement

Materials of construction	:	M.S. plate 6 mm thick with 75 mm glasswool insulation.
Size	:	1500 mm dia. x 1500 mm long
Conical height	:	950 mm
Outlet dia. :	65 mm	
Number of spray	:	10
Ducting inlet/outlet	:	700 mm

11. Economiser

Material of construction	:	M.S. plate 8 mm thick
Overall size	:	1080 mm dia. x 8000 mm long

There are **three** sections as under:

Section – 1
Cone having length of 1000 mm

Section – 2
Central part of 4500 mm long
650 nos. of S.S. 304 tubes of 22 mm dia. x 4500 mm long are housed inside.

Section – 3
2500 mm long with 6 nos. of 3 mm thick M.S. baffle at top.

12. Vapour Separator after Economiser

Material of construction	:	M.S. plate 8 mm with 75 mm thick glasswool insulation.
Size	:	1200 x 1200 x 750 mm Cone
Outlet dia.	:	50 mm
Central pipe	:	500 mm dia.

13. Separator for Economiser with Internal Cone

Material of construction	:	M.S. 6 mm plate with 75 mm glasswool insulation.
Size	:	1350 x 1350 x 750 mm Cone
Outlet dia.	:	1080 mm
Size of baffle plate	:	1340 mm dia. x 3 mm thick
Internal cone	:	1080 x 550 x 75 mm

14. Miscella Filter

Material of construction	:	M.S. 5 mm thick plate
Overall size	:	1350 mm dia. x 1500 mm long
Size of cone	:	950 mm long x 65 mm dia. at outlet

Inner buckets

Material of construction	:	S.S. 304 Net of 150 mesh 1 m x 1 m
Size	:	300 mm dia. x 1000 mm long

15. Flasher Heater

Material of construction	:	M.S. 8 mm thick plate with 75 mm glasswool insulation.
Overall size	:	950 mm dia. x 3000 mm long.

Details of tubes

Material of construction	:	S.S. 304
Size	:	22 mm dia. x 3000 mm long
Number of tubes	:	450

16. Flasher Separator

Materials of construction	:	M.S. 6 mm plate with 75 mm glasswool insulation.
Overall size	:	1200 mm dia. x 1200 mm long
Size of cone	:	Dia. at bottom 150 mm x 750 mm long.
Size of baffle plate	:	1150 mm dia. x 1150 mm long x 3 mm thick

CVSRTA

17. Final Heater

Materials of construction	:	M.S. plate 8 mm thick with 75 mm glasswool insulation.
Overall size	:	860 mm dia. x 3000 mm long
Details of tubes	:	S.S. 304, 22 mm dia. x 3000 mm long

18. Final Heater Separator

Materials of construction	:	M.S. plate 6 mm thick with 75 mm glasswool insulation.
Overall size	:	1200 mm dia. x 1200 mm long
Size of cone	:	Dia. at bottom 150 mm x 750 mm long.
Size of baffle plate	:	1150 mm dia. x 1150 mm long x 3 mm thick

19. Stripping Column

Materials of construction	:	M.S. plate 8 mm thick with 75 mm glasswool insulation
Overall size	:	1200 mm dia. x 5000 mm long

15 NB, 'C' class M.S. tube is spiraled on outer side of stripper. 400 mm dia. tube fabricated from 22 SWG, S.S. 304 sheets with 65 numbers of 22 SWG, S.S. 304 strips in 300 mm width are provided inside the body along the length. End plates are provided with drilled holes for fixing strippers at both ends.

20. Miscella Tank and Waste Water Heater

Material of construction	:	M.S. plate 8 mm thick
Insulation	:	100 mm glasswool
Overall size including waste water heater.	:	2000 mm dia. x 7700 mm long
Size of waste water heater including waste water heater.	:	2000 mm dia. x 7700 mm long
Size of waste water heater	:	2000 mm dia. x 1000 mm long
Total number of chambers	:	5
Total number of partitions	:	4
Material of construction of partitions	:	M.S. plate 6 mm thick
Details of each chamber	:	**Chamber – 1** It consists of coil made out of 15 NB 'C' class pipe of 32 m long. **Chamber – 2 and 3** Divider of the tank **Chamber – 4** Housing inlet pipe of S.S. 304 construction (65 NB, 3 mm thick) in total length of 12 mm with 6 bends. **Chamber – 5** Includes float made of 22 SWG, S.S. 304 sheet.
Size of float	:	300 mm x 300 mm

21. Separator for Vacuum Pump

Material of construction	:	M.S. plate 6 mm thick
Overall dimensions	:	750 mm dia. x 750 mm long
Length of cone	:	500 mm
Dia. of outlet	:	50 mm

22. Vacuum Breaker

Material of construction	:	M.S. 6 mm thick plate
Overall size	:	500 mm dia. x 750 mm long
Size of M.S. pipe	:	75 mm dia. x 1000 mm long

23. Condenser

Capacity	:	350 sq. metre
Type	:	Shell and tube

Materials of construction

Shell	:	Made out of 10 mm and 8 mm thick M.S. plate
Tubes	:	19 mm dia. x 1 mm thick S.S. 304 tube 1250 mm dia. x 6000 mm long
Overall dimensions	:	1250 mm dia. x 6000 mm long.

24. Pressure Breaker

Material of construction	:	M.S. plate 6 mm thick
Overall size	:	500 mm dia. x 750 mm long
Size of M.S. pipe	:	75 mm dia. x 1000 mm long.

25. Pack Tower

Material of construction	:	M.S. plate 5 mm thick
Overall dimensions	:	450 mm dia. x 4500 mm long
Number of raising ring provided	:	5000
Dia. of atomizer	:	25 mm

26. Mineral Oil Cooler

Material of construction	:	M.S. plate 8 mm thick
Overall size	:	1000 mm dia. x 2500 mm long

The oil cooler is made out of 1000 mm dia. x 2500 mm long fabricated out of 8 mm thick M.S. plate with 32 mm thick flange plate. The spiral coil made out of 25 NB, 'C' class, tube is housed inside the cooler. There are three spiral wound coils as:

400 mm dia., 600 mm dia. and 800 mm dia. totaling to 350 metres long.

27. Cooling Tower with Pumps

Type	:	Double flow, induced draft cross flow cooling tower. Fibre glass with aluminium blade.
Capacity	:	300 cu. m./hr
Hot water	:	42^0 C
Cold water	:	32^0 C
Design wet bulb	:	28^0 C
Overall dimensions	:	7500 x 6300 x 3750 mm
Inside basin	:	7000 x 4500 mm
Static pumping head above basin curb	:	3000 mm
Fan diameter/number of blades	:	2400 mm/6

Fans and cells

Input BHP	:	10
Gear reducer series	:	20 T
Type of gears	:	Spiral bevel
Motor HP	:	12.5

CVSRTA

28. Preheater Exchanger

Capacity	:	30 sq. m.
Materials of construction	:	Shell – M.S.
		Tube – S.S. 304

MEAL FINISHING

1. M.S. Radler Conveyor for Carrying DOC from SEP to DOC Section

Capacity	:	25 tonnes per hour
Total length	:	37 m
Width of chain	:	485 mm
Length of chain	:	75 m
Pitch of chain	:	105 mm
Details of drive		
HP	:	10
Speed	:	1500 rpm
Gearbox		
Type	:	U – 600
Ratio	:	25:1

2. M.S. DOC Cooler Two Stage

Capacity	:	25 tonnes per hour
Details of drive		
HP	:	20
Speed	:	1500 rpm
Gearbox		
Type	:	U – 1000
Ratio	:	50:1

3. M.S. Radler Conveyor for Carrying Cooled DOC to Bagging Chute

Capacity	:	25 tonner per hour
Total length	:	13.65 m
Width of chain	:	485
Length of chain	:	28 m
Pitch	:	105 mm
Details of drive		
HP	:	5
Speed	:	1500 rpm
Gearbox		
Type	:	U – 400
Ratio	:	25:1

4. Pulverizer

Size	:	750 mm dia. x 200 mm width
Details of drive		
HP	:	30
Speed	:	2900 rpm

Final solvent recovery by absorption :

The vapour and gases from the contact cooler are led to absorber where they come into intimate contact with an absorbing oil (vegetable oil or mineral oil). The solvent vapours, if any, are absorbed in this oil and non-condensable gases are let out into the atmosphere. While theoretically these gases leaving the plant are expected to be free from hexane, in practice, a small amount of the solvent is lost with these gases.

The oil containing the absorbed solvent is led into an evaporator kept under vacuum and heated to 100^0 C. The solvent is vapourized and these vapours are led into one of condensers and recovered. The hot oil from the evaporator is passed through a cooler to cool to room temperature, and having been freed from hexane it is sprayed back into the absorber.

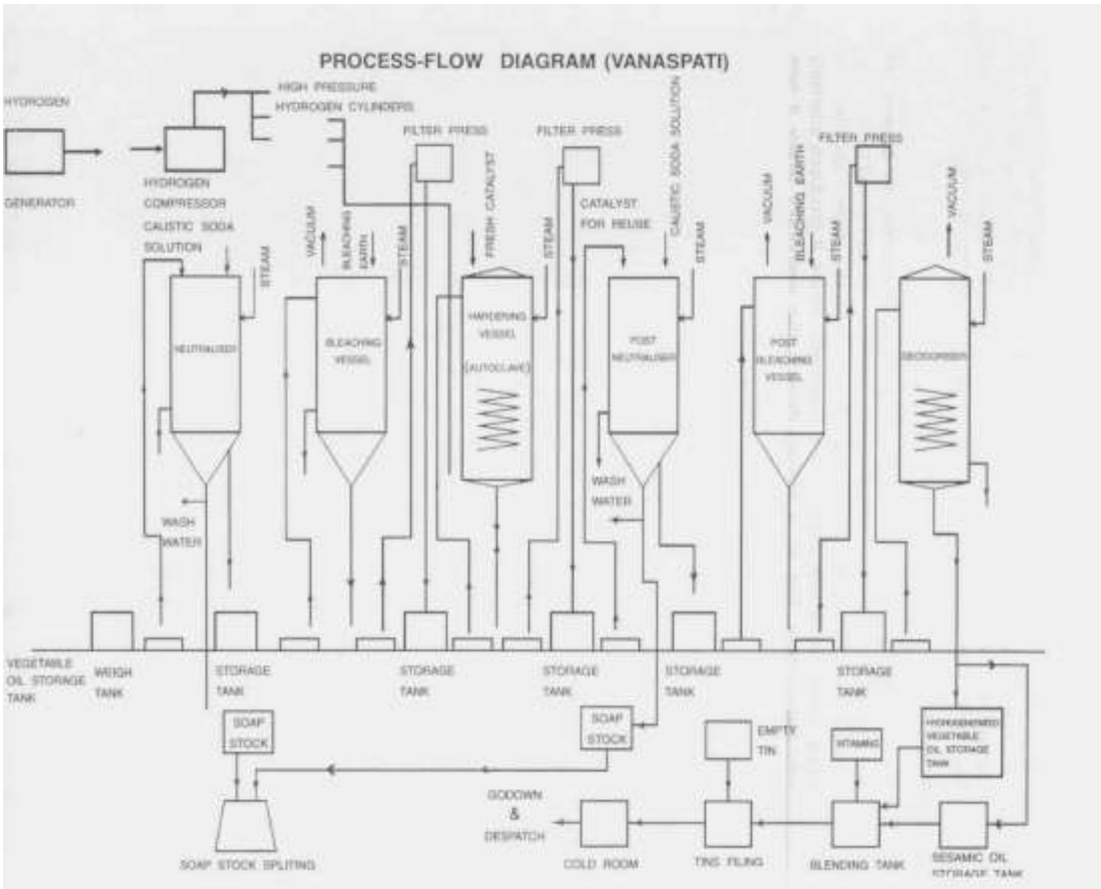
Meal finishing and bagging :

The radler conveyor carries the desolventised meal form the DT to bagging section.

The meal is not only conveyed but also cooled to about 45-50^0 C by means of cold air draft induced in the conveyor by a blower. The meal drops to a humidifier from the radler. In the humidifier the meal is mixed with enough moisture to bring up the moisture content, thus replacing the amount of water lost during the extraction and desolventisation steps. The humidified meal is then bagged at the discharge of the humidifier.

(2) Vanaspati plant :

Process flow diagram



Chemistry of vanaspati

Everyone know oils and fats as an ingredient of daily food or perhaps as a raw material for soap making. But only a few people know them as a group of organic compounds called 'fatty acids'. Fatty acids, in their turn, are formed by union of several carbon atoms in a straight chain with hydrogen and oxygen atoms. A single chain may contain anywhere from 6 to 24 carbon atoms, but the common one are 12, 14, 16, 18 and 20 carbon chains. A fatty acid is said to be saturated when all the carbon atoms are combined with hydrogen to their full capacity. They are said to be unsaturated when combination with hydrogen is incomplete and there is a possibility of further addition of hydrogen. Higher the unsaturation, lower is the melting point of fatty acid. As such, many oils containing unsaturationremain as liquids at normal temperature. Those which contain lesser amount of unsaturated acids exist as solid or semi-solid fats at normal temperature. A liquid oil can be converted to a required degree of hardness by reducing its unsaturation by controlled reaction with hydrogen.

Vanaspati is a product obtained by such controlled hydrogenation of edible liquid oils (called 'soft oils' in the industry), so that its hardness, consistency and grainy appearance resemble natural Ghee. The addition of hydrogen to an oil occurs when the hydrogen gas is brought into contact with the oil at higher temperatures in the presence of metallic nickel catalyst prepared under controlled conditions. In practice, however, the process is not so simple. Several steps are involved in the process as described in succeeding paragraphs.

Processing of vanaspati

Pre-neutralising :

Crude vegetable oils, as they are obtained from oil mills or ghanis or solvent extraction plants, contain a small amount of free fatty acids (without combination with glycerin) and traces of mucilage. These, if not eliminated, impede the hydrogenation reaction. Also the presence of these effects the stability of final product in respect of its wholesomeness and life. These are removed by treatment of the oil with a calculated quantity of solution of caustic soda. When so treated, the caustic soda reacts with fatty acids which results into soap forming. When allowed to settle, the soap stock constitutes a valuable by-product. A small portion of oil is thus lost in this operation, the loss depend on the free fatty acid content of oil.

The neutralized oil is then given a series of hot water washes to free it completely from soap and caustic soda, each washing being settled and separated.

Pre-bleaching :

The neutralized and washed oil is then heated under vacuum when the moisture from the oil is evaporated and oil becomes dry. The dried oil is mixed with bleaching earth and carbon, stirred and filtered free from earth and carbon. The earth and carbon absorb the colouring matter from the oil thus producing a light coloured oil. Bleaching is essential to produce a snow-white coloured Vanaspati. Improper bleaching may result in darkish colour to the final product.

Hydrogenation :

The pre-bleached oil is treated with hydrogen gas in the presence of nickel catalyst for hardening. The extent of hydrogenation is checked by periodic determination of melting point of the oil. When the required melting point has been reached the reaction is stopped, and oil is filtered free from nickel.

Post-neutralising and bleaching :

The high temperature of hydrogenation and sometimes the presence of trace of moisture in the hydrogen gas, results in the slight splitting of neutral oil into free fatty acids. Therefore, neutralizing operation is repeated after hydrogenation. Also the drying and bleaching operations are repeated as a necessary sequel to neutralizing. Post-bleaching also helps to remove any traces of nickel left out in the oil after hydrogenation operation.

Deodorisation :

The oil is now hardened but still has the original taste and odour. These are removed by the process of steam distillation of oil at high temperature under vacuum. Under these conditions the steam passed through the oil carries with it all the odoriferous matter from the oil as well as any traces of fatty acids still left. When the oil is free from taste and odour it is cooled and filtered to sparkling appearance.

Blending and packing :

The oil is then blended with vitamins A and D and filled in clean tins which are then weighed and sealed.

Chilling :

This is the operation when the hardened oil takes its final form to Vanaspati with grainy appearance similar to Ghee. The sealed tins are kept in cold room (cooled by refrigeration plants, with regulated temperature and cold air draft, so that chilling is slow and gradual).

This way the oil solidifies with large crystal formation. This form of Vanaspati is very popular in India where people are used to Ghee. Western countries where Ghee is unknown and butter is commonly used, the artificial butter called 'Margarine' is made by chilling the hardened oil quickly with continuous agitation. This way, the oil solidifies to soft and uniform buffer consistency. Also perhaps, the hardening of oil is carried out to a lesser degree in the case of Margarine. Margarine is packed in small packets after being chilled.

Refrigeration :

The cold air for circulation in the chilling rooms is obtained by blowing air through a refrigeration unit operating with ammonia gas as the refrigerant. The ammonia gas is compressed and cooled in a condenser where it liquefies. The liquid ammonia is evaporated in an evaporator where it produces intensely cold temperature. The air is passed through this evaporator where it gets chilled.

Hydrogen gas production :

Hydrogen gas required for the hydrogenation reaction is obtained by the electrolysis of water. When high electric current is passed through water it splits into hydrogen and oxygen. Special cells are used for electrolysis, so that hydrogen and oxygen produced do not mix. The hydrogen gas is washed free from impurities and collected in a low pressure gas holder. It is compressed into high pressure storage cylinders from where it is drawn for use in the processing plant.

The major process equipment consists of :

1. Neutralizers
2. Bleachers
3. Hyrdogenation
4. Deodorization
5. Blending and packing
6. Hydrogen gas production

The bulk of the equipment consists of tanks made out of plates of varying thickness as high as 25 mm in case of autoclaves. Depending upon the requirement the tanks are with heating coils of required sizes. Some of the tanks are insulated, fitted with paddle type stirrers, anchor type stirrer, etc.

The specifications of remaining equipment :

1. Electrolysers

Capacity	:	70 m^3/hr of hydrogen gas and 35 m^3/hr of oxygen gas
Model	:	150 E 60
Sr. No.	:	1
Make	:	Bamag

2. Low Pressure Holder for Hydrogen Gas

Capacity	:	80 m^3
Dimensions	:	5.18 m dia. x 4.57 m ht.
Plate Thickness	:	
Cell Plate	:	6 mm
Bell Plate	:	4 mm
Bottom Plate	:	8 mm
Material of Construction	:	Mild Steel

3. Oxygen Gas Low Pressure Holder

Capacity	:	50 m^3

4. Hydrogen Gas Compressor

Horizontal type, 2 Stage Air Compressor

Type	:	ESH-2 Lub
Size	:	9” – 4 ¾” x 7”
Drive	:	47 KW, 1475 rpm flame proof motor

5. Neutralizers

Insulated with paddle type stirrer, heating coil inside, dilute, caustic soda sprinkling ring on top.

Capacity : 29 T total, 27 T working

Make : Sancer, U.S.A.

6. Autoclave

Capacity : 15.5 T

Dimension : 2.7 m dia. x 5.40 m ht.

Plate Thickness :

Shell : 22 mm

Top and Bottom : 25 mm

Material of Construction : Mild Steel

Working Pressure : 125 lb/sq.inch

7. De odoriser with condenser, catch all, insulated with panel board, steam coil, vacuum system comprising of steam flow chart, vacuum gauge, temperature gauge but without stirrer.

Working Capacity : 12 T

Make : Luster & Samcer Inc., Chemical Engineers, U.S.A.

8. Form Filling and Sealing Machine with Conveyor Belt and Heat Sealing Control

Capacity : 1 kg

Material of Construction : Stainless Steel

9. Volumetric Filling Machine for 2 kg Poly Jar

Type : 2 Head

10. Poly Jar Sealing Machine for 1 Kg

Type : 2 Head

11. Filter Press

Material to be filtered (ltrs.)
Operating temperature (^{0}C)
Operating pressure (kg / cm^2)
Flammable / Non flammable / others

Type of plate : Chamber / plate & frame

Plate size (mm) :

Cake Thickness (mm) :
No. of chambers :

Material of filter press plate : C.I. / P.P. / Wood

Filter press body : C.I. commercial/ C.I. graded / M.S.

Material of flanges : M.S.R.L. / C.S. / S.S. / P.P.

Type of closing devices: Ratchet closing.
Manually operated hydraulic closing mechanism with hand pump.
Electrically operated hydraulic closing mechanism.

Filtrate discharge : Closed / open

Washing : Simple / thorough

Drip collection tray : M.S. / S.S. / P.P. / F.R.P. / other

Auto shifter : Plate shifting device

INDUSTRIAL PROCESSES - II

INDEX

UNIT - 1

IRON, STEEL & NON-FERROUS METAL PRODUCTION

INTRODUCTION

The role of materials has been sufficiently important in progress of civilization and advancement of societies. Advanced technologies involve sophisticated materials, as they utilize products, devices and system, which consist of materials. Metals have played a key role in transforming life of human beings. Tremendous developments have taken place in production and ferrous and non-ferrous metals and their respective innumerable alloys, which have made important significant and contributions to the up gradation of technology. In fact early civilization has been also designated by the level of material developments such as Stone Age, Bronze Age and the Iron Age. In present scenario metals are still most versatile material and have largest share in engineering and other applications.

Pure metals, because of their poor physical and mechanical properties, they are rarely used for engineering applications. This has led to the development of alloys like binary, ternary alloys etc. The material, which is a mixture of two or more metallic elements and possesses metallic properties, is called Alloy.

Metals and their alloys used in engineering industry and construction, by virtue of their composition are broadly classified into two groups as (1) Ferrous metals and (2) Non-ferrous metals.

1. Ferrous metals

   These include those materials having iron as their main constituent or base metal. These include wrought iron, cast iron and steels of all kinds. It may be noted that Carbon in Iron is considered as metal.

2. Non-ferrous metals

   Those metals or their alloys, which do not possess iron as their main constituent popularly, known as non-ferrous metals. Examples are aluminium, copper, tin, lead, zinc and their alloys like Brass, Gun Metal, Bronze.

It may be noted that whenever any metal is produced it always contains impurities and their content is generally lower than 1%. They are not intentionally added but are present due to limitation of manufacturing process, viz. Pig Iron contains 3-6% carbon, 1-3% Silicon by virtue of use of coke as a fuel and reducing agent and silica in the Iron Ore.

Objective :

By the end of this chapter students will learn about:-

- Ferrous metals
- Non – Ferrous metals
- Non-Ferrous Alloys
- Pig iron
- Wrought iron
- Cast iron
- Steel making

Ferrous Metals and Alloys

Ferrous alloys are produced in very large quantities as compared to any other type of metals. They are very important as fabricating and construction materials. The reason for their widespread use are –

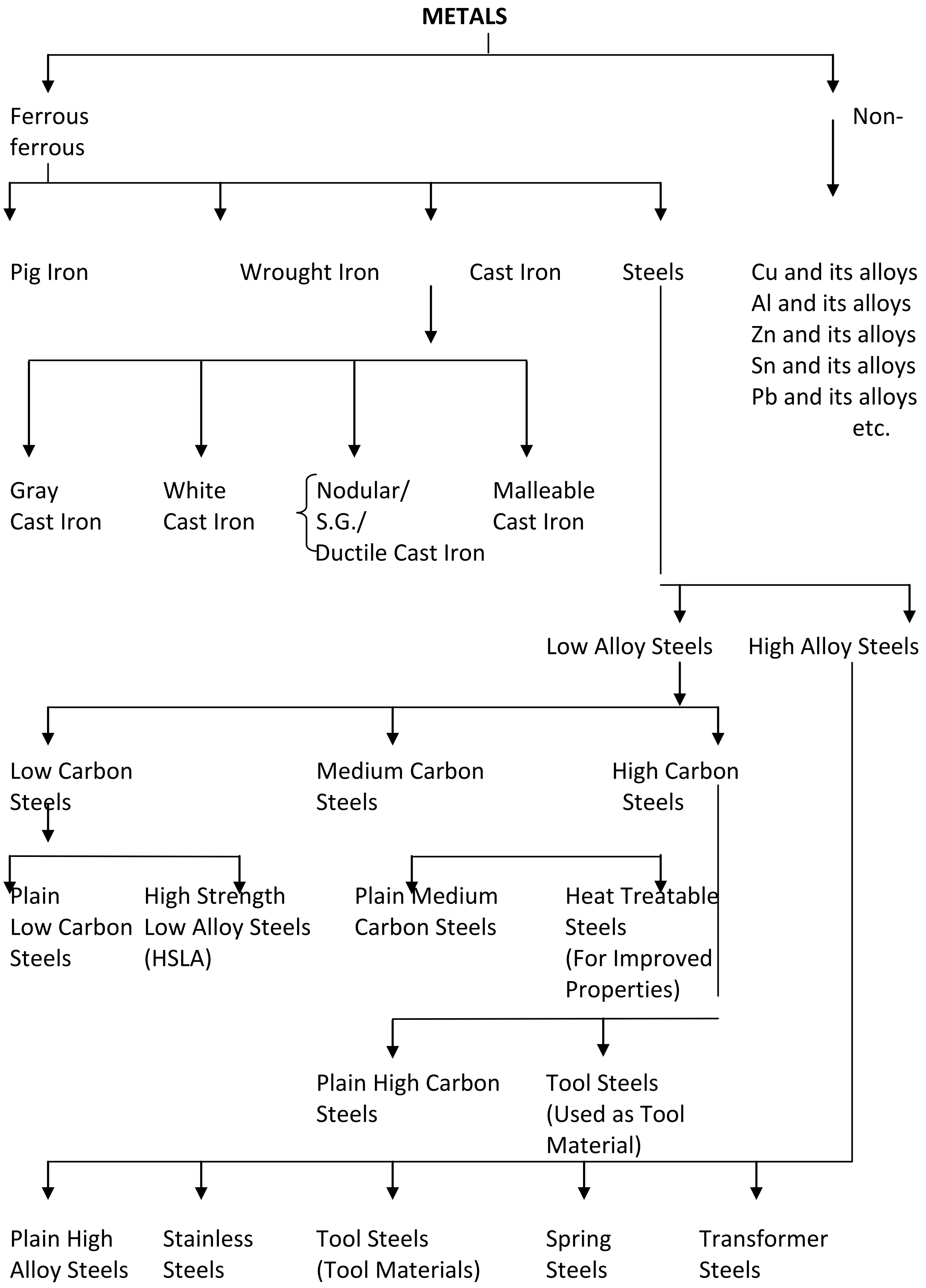
(a) Their ore (raw materials) are abundantly available in several states of India.

(b) Iron and steels production can be economical on basis of cost per unit length.

(c) They are extremely versatile and by giving proper treatment wide range of physical and mechanical properties can be developed.

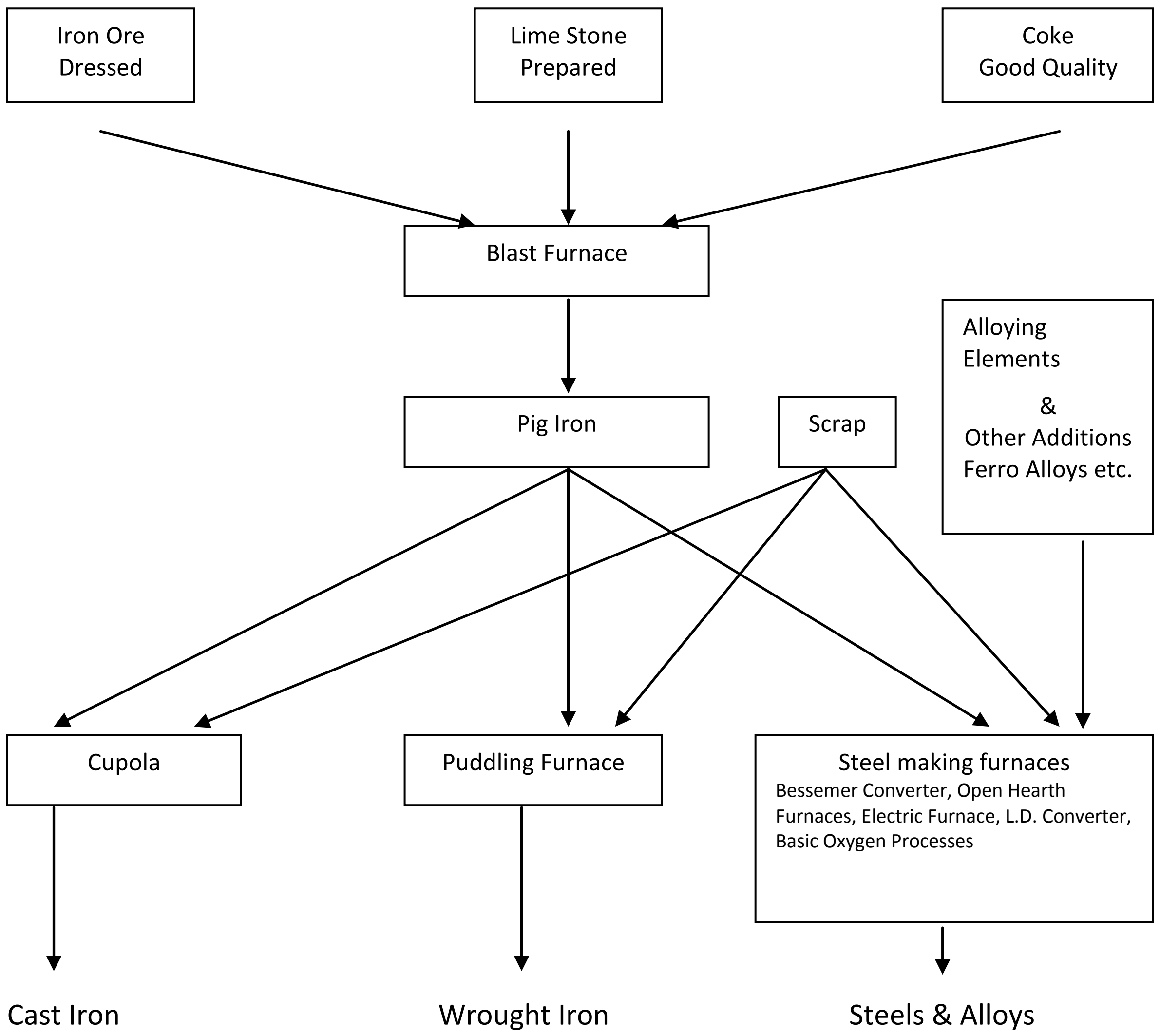
The only principal disadvantage of many ferrous alloys is they are susceptible to corrosion.

The following flow diagram shows the classification of various ferrous alloys.



The flow chart for production of ferrous metals is shown below:

The schematic flow diagram showing the process steps in brief for conversion of raw materials into major groups of ferrous products.



Manufacture of Pig Iron

Pig Iron is the basic raw material for all ferrous products like iron and steel. It is manufactured by smelting iron ore in blast furnace using –

(1) A hard porous fuel such as coke which supply intense amount of heat to melt iron ore and also serves as reducing agent.

(2) Lime stone as a fluxing agent to lower down the melting point of iron-ore and to promote removal of gangue material (silica, alumina in the ore, sulphur, ash and other residues of fuel) by forming a fusible slag.

(3) A blast of air which supplies required oxygen for combustion of the fuel.

The Process

The process is one in which iron ore, coke and flux are charged in alternate layers from the top of the furnace. The charge is taken to the top of furnace by a specially designed bucket called 'SKIP', running along an incline. The charge is then introduced into the throat by a special arrangement known as "double bell and hopper arrangement." This arrangement prevents hot blast from being released from top of furnace. A hot blast of air under pressure is introduced in near the bottom through a number of nozzles called "Tuyers" spread along the periphery of blast furnace at about 1 m from bottom. These tuyers are water cooled to prevent from getting melted due to immense heat in the zone they are located. The air blast is pre-heated to economize fuel consumption by passing cold air and hot air discharged from furnace, alternately through heated checker work of "hot blast stoves". This heat recovery system is an essential part of blast furnace plant.

The carbon in the coke is burned into carbon dioxide at the tuyers level and the resulting gases rich in carbon dioxide, rise through descending stock. The carbon dioxide disintegrates in to carbon monoxide and free elemental Carbon which reduces iron oxide in to Iron. The temperature in the melting zone is of the order of 1,400 to $1{,}700^{0}$ C. The residue from ore, ash from fuel react with lime stone to form 'slag'. The molten iron collects in the bottom of hearth covered by a layer of molten slag which acts as a cover preventing molten iron from getting oxidized. Two tap holes are provided in the wall of the hearth, one at the bottom for tapping out molten iron and other near the top of the hearth for discharging 'Slag'. The iron is tapped at intervals from six to twelve hours. The furnace is kept in operation till its refractory get worn-out.

The modern blast furnace plant for smelting iron is shown in the following figures (1 to 3) and consists of –

1. Blast furnace.
2. The appliance for sending charge (ore, fuel and flux) to top of furnace and charging them into furnace.
3. The blowing engines for sending blast of air.
4. The stoves for heating the air blast.
5. The pumping plant for supplying water for cooling furnace walls and tuyers and for steam raising etc.
6. 'Dust – catchers' for cleaning blast furnace gas.
7. Plant for generating power from blast furnace gas.
8. The appliances for disposal of slag and pig iron.

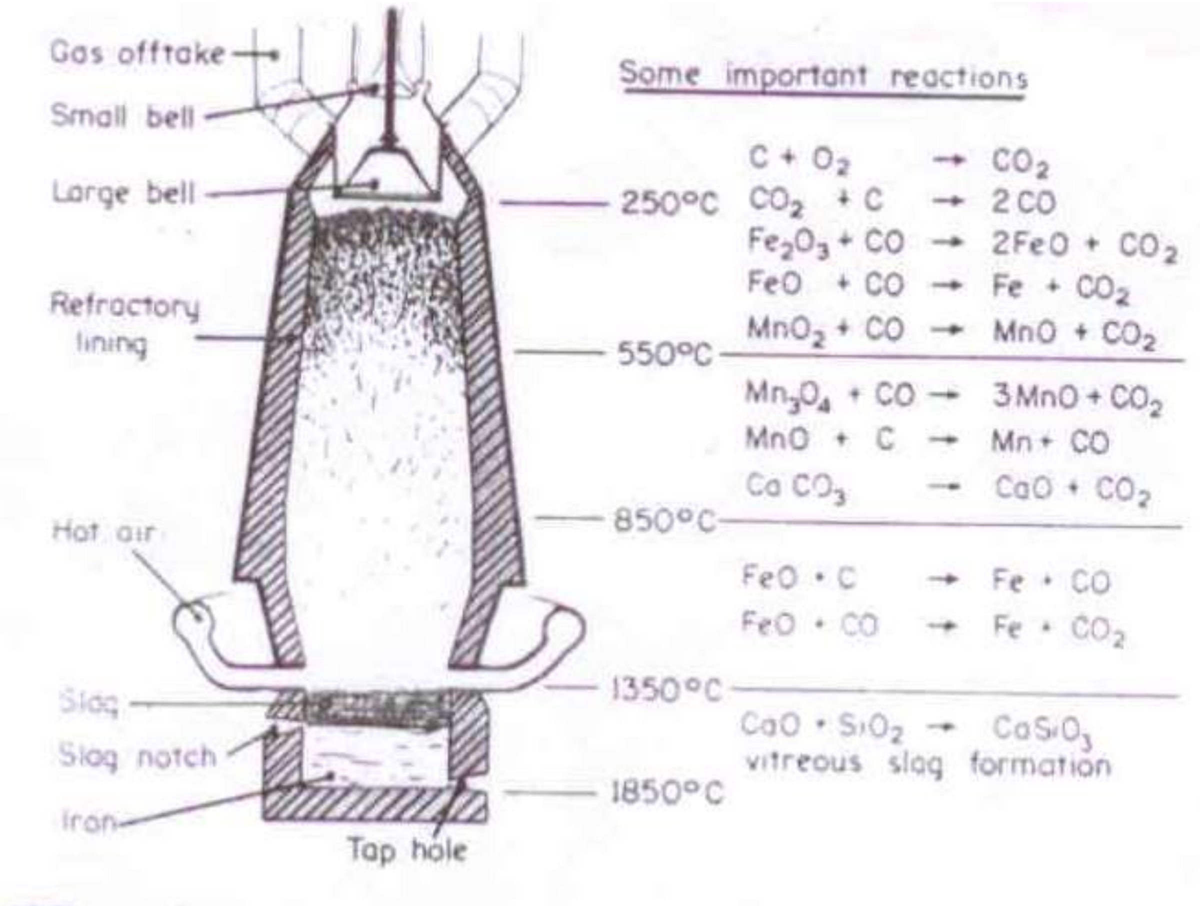


Figure – 1 : A schematic section through a blast furnace. The important reactions occurring in the various heating zones of the furnace are shown

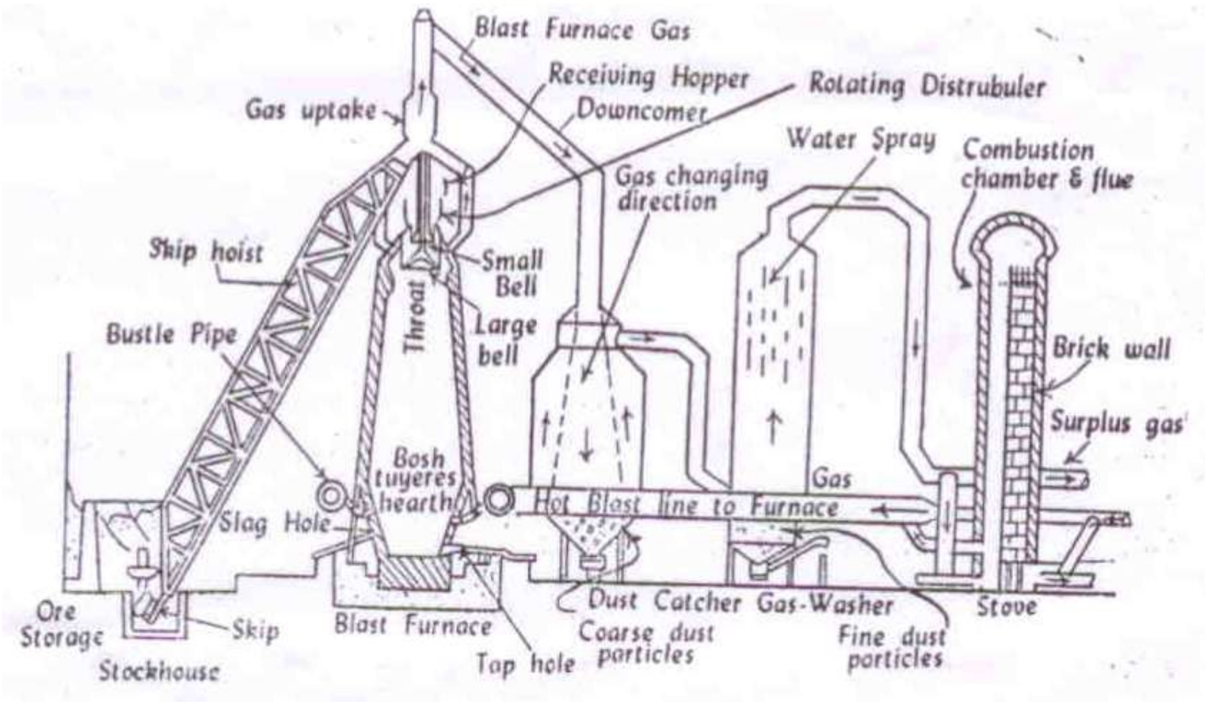


Figure -2 : Layout of a modern blast furnace plant

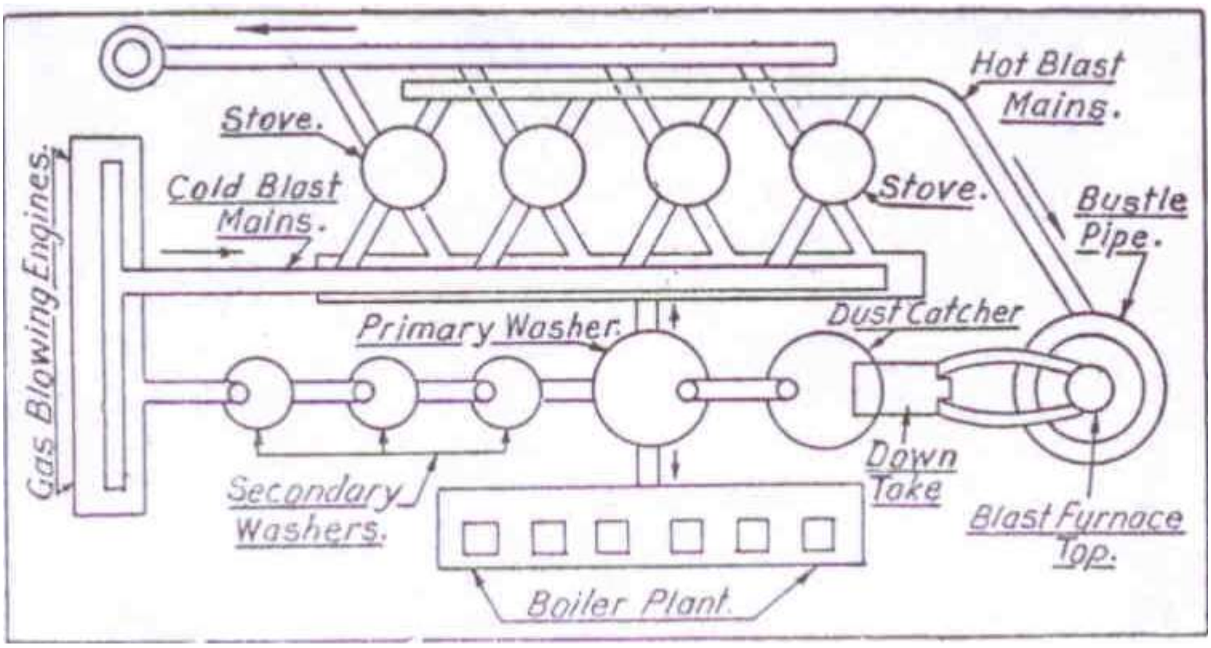


Figure - 3 : Blast furnace layout plan

Disposal of Pig Iron and Slag

The pig iron tapped from the blast furnace is disposed off in one of the three ways:

1. Cast in stand-beds (pig bed)
2. Cast in cast iron moulds in pig – casting machine
3. Directly transferred to steel making process (steel works) in hot metal ladles in molten condition.

1. Casting in sand is the older method and still in use. In this method, sand-beds are prepared in front of furnace and moulds are made into them to receive the liquid pig iron. When the iron is cooled, the pigs are broken away and loaded into wagons for transportation.

2. Casting in cast iron moulds carried out in "Pig Casting Machine", consisting of a long series of moulds carried on an endless chain. When the metal is poured in each mould from a ladle through a spout, the mould moves forward and its place is taken by the next one. The pig iron chills quickly into metal mould and by the time it reaches the other end it is solid and drops automatically into wagon. These empty moulds are given a coating of lime or clay to avoid sticking of pig iron.

3. If blast furnace plant is working in conjunction with a steel works, the pig iron is tapped into a ladle mounted on a carriage and directly transported to steel works where it can be directly charged to steel making furnace or stored in a 'Mixer' which is a vessel of 600 – 1200 tons capacity.

For tapping out of furnace from tap hole is cleaned with chisel rod and clay plug is removed till hot skull in front is visible, then it is opened out by an oxygen jet. After tapping of furnace the tap hole is closed by special mud by 'MUDGUN'. The clay becomes hard and tap is closed effectively.

Disposal of Slag

The slag made in an iron blast furnace amounts form ½ - 1 ton per ton of pig iron. Being light weight occupies a large volume and therefore to be removed more frequently than iron. In some plants slag is directly granulated by stream of crater jet and obtained in granule form which can be used as ballast for railways or as raw material for slag cement or for making slag bricks, or floor tiles. In plants where slag is not granulated it is poured in tilting slag ladles and dumped away in molten condition in slag yard. The general composition of blast furnace slag consists of SiO_2, CaO and Al_2O_3 with smaller amount of MgO, MnO, FeO and CaS.

Types of Pig Iron

The product of blast furnace is classified by chemical composition into three grades:

1. Basic pig iron

   It is mainly used for steel making and is low in silicon. Composition is as follows:

Carbon-	3.5 to 4.4%	Silicon	-	1.5% maximum
Manganese-	1.0 to 2.0 %	Sulphur	-	0.04%
Phosphorous-	Up to 1%	Iron	-	Balance

2. Foundry pig iron

   It is mainly used for the production of cast iron castings. Depending on amount of carbon, it is classified in to various grades. The general composition is as follows:

Carbon-	3.0 to 4.5%	Silicon -	0.5 to 3.5%
Manganese-	0.4 to 1.25 %	Sulphur -	0.05% maximum
Phosphorous-	0.04 to 1.0%	Iron -	Balance

3. Ferro alloys

These are alloys of pig iron and use various metals such as manganese, chromium, silicon, tungsten. They are used as as additives in iron and steel industries to control the properties of iron and steel. viz.

(a) Ferro – Manganese - Pig iron contains 75 to 82% Manganese

(b) Ferro – Silicon - Pig iron contains 5 to 17% Silicon

(c) Ferro-Chrome - Pig Iron contains 5- 60% chromius

<u>Other methods of pig iron production</u>

The manufacturing process described above is most standard one. But in modern age, attempts are being made to modify it or adopt new methods because of two reasons:

I. Height of modern blast furnace has increased and it requires more capital and labour for its working.

II. The coke which is used as fuel is becoming short in supply and inaccessible.

The following are the alternative methods for pig iron manufacture:

1. Electric reduction furnace
2. Low shaft blast furnace
3. Sponge iron process

Modern trends in blast furnace practice:

In view of acute shortage of good quality metallurgical coal, it will be worthwhile to enumerate some of the present trends to reduce coke consumption in blast furnace:

1. Use of pre-heated blast

2. Fuel injection in blast – With blast, fuel oil or pulverized coke can be used. Where natural gas is available, it reduces consumption of coke. Naphtha can also replace natural gas.

3. Oxygen enrichment of blast to increase productivity.

4. Humidification of blast.

5. High top pressure operation of blast furnace - By increasing pressure at the top of furnace, the speed of gases moving upwards through furnace decreases substantially by introducing a choke valve in outlet gas pipe of furnace. These results in higher pig iron production and decrease in dust losses.

WROUGHT IRON

Wrought iron is probably highly refined form of iron with a small amount of slag forged out in form of slag fibers. A typical representative analysis range of wrought iron is –

Carbon	-	0.02 to 0.03%	Silicon	-	0.10% maximum
Manganese	-	0.02% maximum	Sulphur	-	0.01 – 0.02%
Phosphorous	-	0.05 to 0.25%	Slag	-	0.05 – 15%
Iron (Fe)	-	Balance (Remainder)			

In olden days, wrought iron, the purest form of iron, was produced commercially by a process known as 'PUDDLING PROCESS'. In the year 1925 James ASTON developed a new process which is wholly mechanical and wrought iron can be manufactured quickly and economically. The process is known as ASTON or BYERS PROCESS.

The processes are described in brief as follows:

1. Puddling Process

   In this process the pig iron is first subjected to a preliminary refining to remove silicon as completely as possible by using iron ore as refining agent. It is then cast into moulds. The refined pig iron is melted in a coal fired reverberatory type of furnace (Figure - 4). The oxidizing agent like iron ore are added with passing of a strong current of air. Thus, during the process of puddling most of carbon and other impurities are oxidized. The slag formed is removed and purified iron becomes thick and assumes the form of white spongy mass as balls. These balls are known as puddle balls.

The slag contained in puddle ball is removed by a process of “SHINGLING” using power hammers or passing the balls through squeezing machine to convert them into “blooms” having a cross section of 15 to 100 mm approximately. These bars are cut into short length, fastened together in piles, reheated to welding temperature and again “rolled” into bars to obtain wrought iron of desired quality.

2. Aston or Byers Process

In this process, pig iron is first melted in a cupola furnace and refining of molten metal is done in a Bessemer converter. The refined iron so made is poured into cooler ladle containing liquid slag prepared in an open hearth furnace at a predetermined rate.

The molten steel temperature drops and it results in a spongy mass. This Spongy mass is then given the treatment of shingling and rolling as described before. The hot bloom thus obtained is immediately passed through rolling mills to produce the products of wrought iron of different shapes and sizes.

The wrought iron is available in form of plates, sheets, bars, structural shapes, forging blooms and billets.

The melting point of wrought iron is 1510^{0}C. On heating at white heat it becomes soft enough to take any shape by hammer or press (forged). It cannot be heat-treated like steel but can be easily welded. During rolling slag particles elongate in direction of rolling. The presence of slag fibers improves strength, fatigue resistance and corrosion resistance of iron. It is tough, ductile and malleable. The presence of slag fibers in rolling direction work as reinforcing elements to improve tensile strength in longitudinal direction. Thus, it is like a composite material.

It is used for hooks, rivets, chains, railway couplings, water and steam pipes, bolts, nuts, horse shoe bats, boiler tubes, roofing sheets, armatures, electro-magnets, etc.

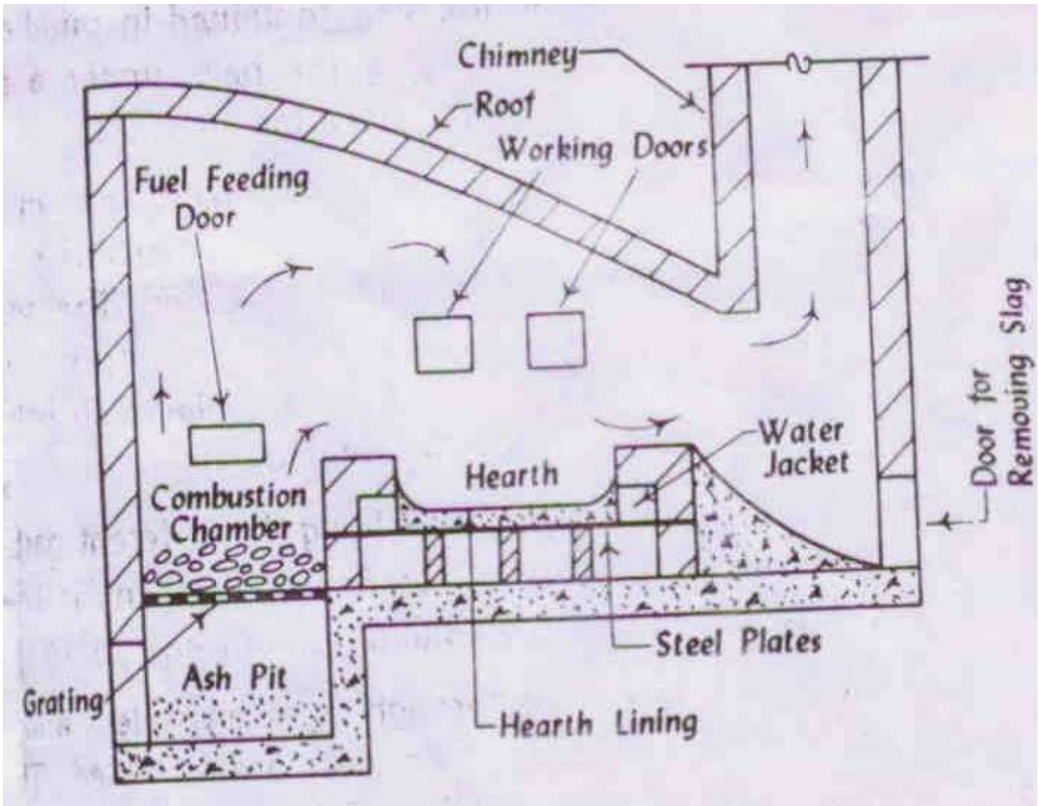


Figure – 4 : Reverberatory furnace

CAST IRON

Cast iron may be defined as an alloy of iron and carbon containing more than two percent carbon. In practice, most cast irons contain 2 to 4% of carbon and 1 to 3% silicon. In addition to carbon and silicon other elements such as sulphur (S), phosphorus (P) and manganese (Mn) are also present in cast iron.

Casting is the most convenient fabrication method to obtain metals and alloys in to the desired shape. There are several metals and alloys which cannot be mechanically worked. Cast iron being brittle material and because of its poor ductility and malleability it cannot be forged, rolled, extruded, drawn or pressed into desired shapes. However, because of its relatively lower melting point, it can be easily melted and cast with or without machining into required shape and size.

The most common furnace for melting of cast iron is cupola furnace which is the basic melting unit of cast iron foundry. It produces molten iron very inexpensively and yet allows for good compositional control. The furnace consist of a cylindrical steel shell, lined with high grade refractory and standing upright on four supporting pillars. The bottom of the furnace is closed with drop doors which support the entire charge during firing and allow easy removal of residues left after firing is complete. The section of cupola is shown in Figure – 5. The cycle of operation of cupola is as follows:

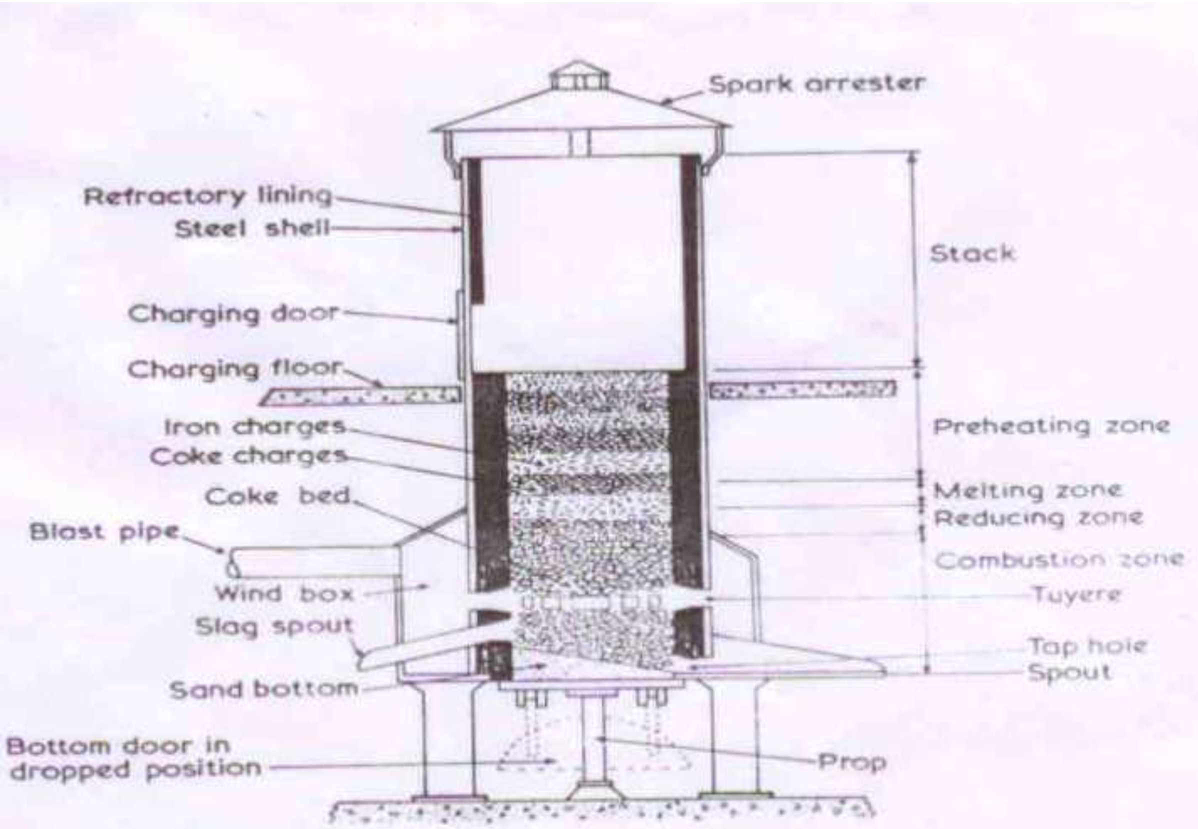


Figure - 5 : Section through a cupola furnace

1. The lower portion of the furnace is covered with Kindling wood and some coke which is charged to a height of about 75 cm above the tuyers. Then it is lit.

2. Alternate charges of pig iron, scrap (foundry returns) and coke are now added with a little lime stone to flux with ash of the coke to form slag.

3. The blast of air is turned on and charging of pig iron, coke and lime stone is repeated in successive layers.

4. The slag formed which float on molten metal is tapped off periodically when necessary.

5. The molten metal is also tapped off periodically every 10 – 15 minutes. The air blast is being turned off during this operation.

The inside diameter of cupola varies between 45 to 250 cm and melting capacity ranges between 1 to 10 tons per hour.

In "hot blast cupolas" the blast is preheated by hot outgoing products of combustion and this makes possible to achieve high temperature for melting steel scrap in larger proportions.

The composition of molten metal tapped in the ladle is checked prior to pouring into the moulds. For adjustment of final composition of the melt the special alloying elements are added into the ladle before pouring.

Finally bottom of the cupola is dropped and whatever is left out in cupola falls down. Next day cupola is cleaned and inside refractory work is checked, inside surface is given a clay wash, bottom is prepared and cupola is ready for a fresh charge.

Recent Trends in Cupola Practice

1.	Hot blast cupola	-	Explained above.
2.	Balanced blast cupola	-	Ensures complete combustion and economy in coke rate combustion and uniform temperature.
3.	Oxygen enrichment of blast	-	Enrich the blast with oxygen to achieve higher combustion rate and high temperature. This results in lower coke rate and high productivity.

4.	Basic line cupola	-	Cast iron low in S and P produced.
5.	Calcium carbide addition in cupola	-	Reduces amount of S in cast iron.

The Rotary Furnace

In rotary furnace, temperature and composition of cast iron can be more closely controlled. A mixture of known compositions of pig iron and scrap can be charged. Rotary furnace designed for primarily for production of black heart malleable castings. Then later on, because of many advantages over cupola, it is used for wide range of gray irons and also for steel. In places like Gujarat and South India, where there is shortage of metallurgical coke, the Rotary furnaces are an advantage.

The furnace consists of a cylindrical drum of strong steel plates, with cone shaped ends closed by two circular plates, lined with refractory material. At one conical end is the oil burner and the opposite end is placed with exhaust pipe for removal of products of combustion, including ash. The drum is mounted on four rollers and slowly rotated by an electric motor through a suitable reduction gearbox at a speed of 1 rpm. The temperatures of 1500^0C – 1550^0C can readily be obtained. The rotary furnaces have capacity between 1/2 to 10 tons. The following figure - 6 shows the construction of Brackelsberg Rotary Furnace.

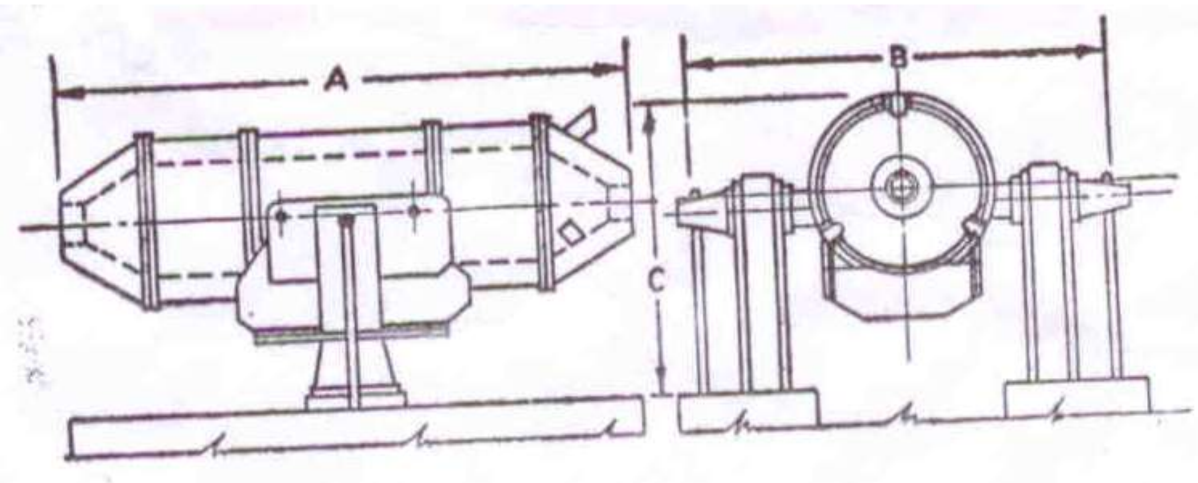


Figure - 6 : Diagram showing construction of Brackelsberg furnace

Steel castings are usually made in electric arc furnace and also in high frequency induction furnace.

Types of Cast Iron

The mechanical properties of cast iron depends not upon the absolute amount of carbon but upon the form of carbon and other elements present. The appearance of fractured surface gives a rough idea of mechanical properties. They are classified into following varieties:

1. White cast iron
2. Gray cast iron
3. Malleable cast iron
4. Nodular cast iron
5. Chilled cast iron
6. Mottled cast iron
7. Alloy cast iron
8. Mehanite cast iron

1. White cast iron

The fractured surface of white cast iron is white in colour and is a result of fast cooling, all the carbon is in the combined form (cementite). The iron is extremely hard and unmachinable. It is important raw material for production of malleable cast iron. It is not suitable for structural parts because of high brittleness. Common uses of white cast irons are in road roller surfaces, wearing plates, grinding balls, pump liners, dies, extrusion nozzles and rollers of rolling mills.

2. Grey cast iron

The fractured surface exhibits grey colour. Carbon is present in free form as graphite flakes. Grey cast iron is very important engineering material because of its low cost and versatile engineering properties. The mechanical properties depend upon the amount, size and distribution of graphite flakes. Grey cast iron is typically weak in tension, fairly soft, brittle strong in compression and possesses excellent casting properties. It has excellent vibration damping capacity.

The common applications of cast iron are - as machine basis, engine frames, clutch plates, brake drums, pump housing, cylinder and pistons of I.C. engines, fly wheels, gear housings, elevator counter weights, drainage pipes, man-holes etc.

3. Malleable cast iron

Malleable cast irons, combines excellent casting qualities with a measure of strength and ductility and are produced by suitable annealing of white iron castings. The process is known as "Malleabilization", on the basis of the appearance of fractured surface there are two types of malleable cast iron namely White heart and Black hearth malleable cast iron. Typical applications of Malleable Cast Irons are connecting rods, transmission gears, crank shafts axles, differential housing in automobiles, flanges, farm equipments, rail road, marine and machine parts, fittings for power transmission and distribution system, switch gear parts, railway electrification system etc.

4. Nodular cast iron

Also known as Ductile or spheroidal cast iron: - Nodular cast iron is produced by inoculating medium carbon cast iron melts with small amount of such materials as nickel – magnesium (2%), ferro-silicon or calcium silicide just prior to pouring. These additions cause graphite flakes to attain nodule or spheroidal shapes during solidification. This cast iron possesses high strength, ductility toughness, good fluidity, good castability with excellent machinability and good wear resistance. The sulphur and phosphorous content should be 0.02% maximum.

Typical applications includes railway couplings, friction blocks, impellers, valves, pumps, compressor bodies, crankshafts, suspension parts, gears and other automotive and machine components.

5. <u>Chilled cast iron</u>

Chilled cast iron is produced when the casting gets solidified by rapid cooling producing white cast iron at surface and grey cast iron at the core. Chilled cast iron possesses high hardness and wear resistance at surface and low hardness and strength at the core. It is used where high wear resistance is required. Typical application include grinding balls, extrusion nozzles, jaws for crushing ores, rolls, rail-road – freight – car wheels etc.

6. <u>Mottled cast iron</u>

It is an intermediate variety between grey and white cast iron. The fracture is mixed type known as mottled. This cast iron is used for small castings.

7. <u>Alloy cast iron</u>

Additions of alloying elements results in improvement in properties. Most common alloying elements are nickel, chromium, molybdenum and copper. Alloying additions improve corrosion resistance and other properties. Ni-hard, Ni-resist and Nomag are examples of some alloy cast iron.

8. <u>Meehanite cast iron</u>

It is special grade of cast iron and possesses excellent mechanical properties due to size, shape and distribution of graphite flakes. Calcium silicide is added to liquid melt before casting. It can be heat treated. It is used where high strength in grey cast iron is required.

In modern practice it is possible to obtain castings with comparable properties with those components manufactured by other manufacturing methods. Nearly ten percent of production of engineering metals and alloys is processed in foundries (ferrous and non-ferrous both).

The foundry plant is comprised of the following sections:

(a) Melting shop
(b) Raw material yard
(c) Pattern shop
(d) Moulding shop
(e) Core making bay
(f) Sand mixing and preparation section
(g) Finishing section - For cleaning, shot blasting, fettling and grinding of castings
(h) The heat treatment section - with furnaces, quenching media
(i) The inspection, painting and dispatch section
(j) Chemical and mechanical laboratory for testing sands, and finished castings.

Steel Making

Steel occupies the most important place among metals. The main reason for this is, it offers wide range of physical and mechanical properties. It is available cheaply and abundantly. It has specific property of magnetism. Indian annual production of steel is still very small compared to other advanced countries of the world in spite of abundant raw material available.

The pig iron is unsuitable for most industrial applications and needs further refining either to steel or cast iron. Steel is essentially an alloy of iron and carbon which varies from 0.008 to 2% maximum. The commercial steels, in addition to carbon contain some amount of manganese, silicon, sulphur and phosphorous. Sulphur and phosphorous are treated as undesirable impurities and are highly detrimental. Many other elements such as Nickel, Chromium, Vanadium, Tungsten, Molybdenum, Titanium etc. may be present in certain amounts depending upon their grades. These are known as alloy steels and special steels. They are used in space research and atomic energy programmes, defence, electronics, automobiles, petrochemicals and many other engineering applications.

The mechanical properties of steels and alloy steels can be improved by heat-treatment and surface hardening methods.

There are numerous steel making processes used for producing commercial and special steels. Ancient methods of steel making by crucible and cementation processes have now become extinct.

The commercial processes for making steels are –

(i) Bessemer process

(ii) Open-hearth furnace process

(iii) Oxygen processes

(iv) Electric arc furnace process

(v) Electric induction furnace process

Out of above processes open-hearth furnace and basic oxygen processes are most widely used practice for steel production. Bessemer process is now-a-days used to lesser extent. The electric furnace methods are used for production of special steels like stainless steels, tool steels, high quality low alloy steels.

Steel and its properties:

Suitable building material due to

- Steel
  - Higher strength to weight ratio
  - Higher modules of elasticity
  - Higher ductility
  - Higher toughness
  - Better uniformity

- Equally strong in
  - Tension
  - Compression
  - Shear

Description of the processes in brief :

(i) Open hearth (furnace) process

This is the oldest process of steel making and there are people, even today, who believe that Open-hearth steel has better mechanical properties than all new processes.

The major tonnage of steel produced is mainly by basic open hearth route. It is capable of producing steels of different varieties for major applications. The capacity of furnace ranges from 50 to 500 tonnes. Each batch of production is called HEAT and its duration may be up to 15 hours. The furnace consists of a shallow pan or hearth. The dimension of a 150 tonnes furnace may be as follows:

Length – 15 meters Width – 5 meters and Depth – 1 meter

Dead burnt magnesite refractory is used for hearth. Fuel may be pulverized fuel, blast furnace gas and coke oven gas mixture or petroleum oil. The air for combustion is preheated in the heat exchangers (Regenerators) which are below the furnace. They operate on regenerative cycle. Sometimes to facilitate the process oxygen is blown through pipe introduced through the roof of furnace (oxygen lancing).

Raw material for open hearth process :

(i) Liquid Pig iron and steel scrap or
(ii) Hot metal from blast furnace or Bessemer converter and
(iii) Lime stone as flux and slag former.

At the end of heat when C, Si, S, P, and Mn are reduced to desired level deoxidizers are added to reduce oxygen level in metal. After tapping the metal alloying is done by ferrochrome ferromolybdenum in the ladle.

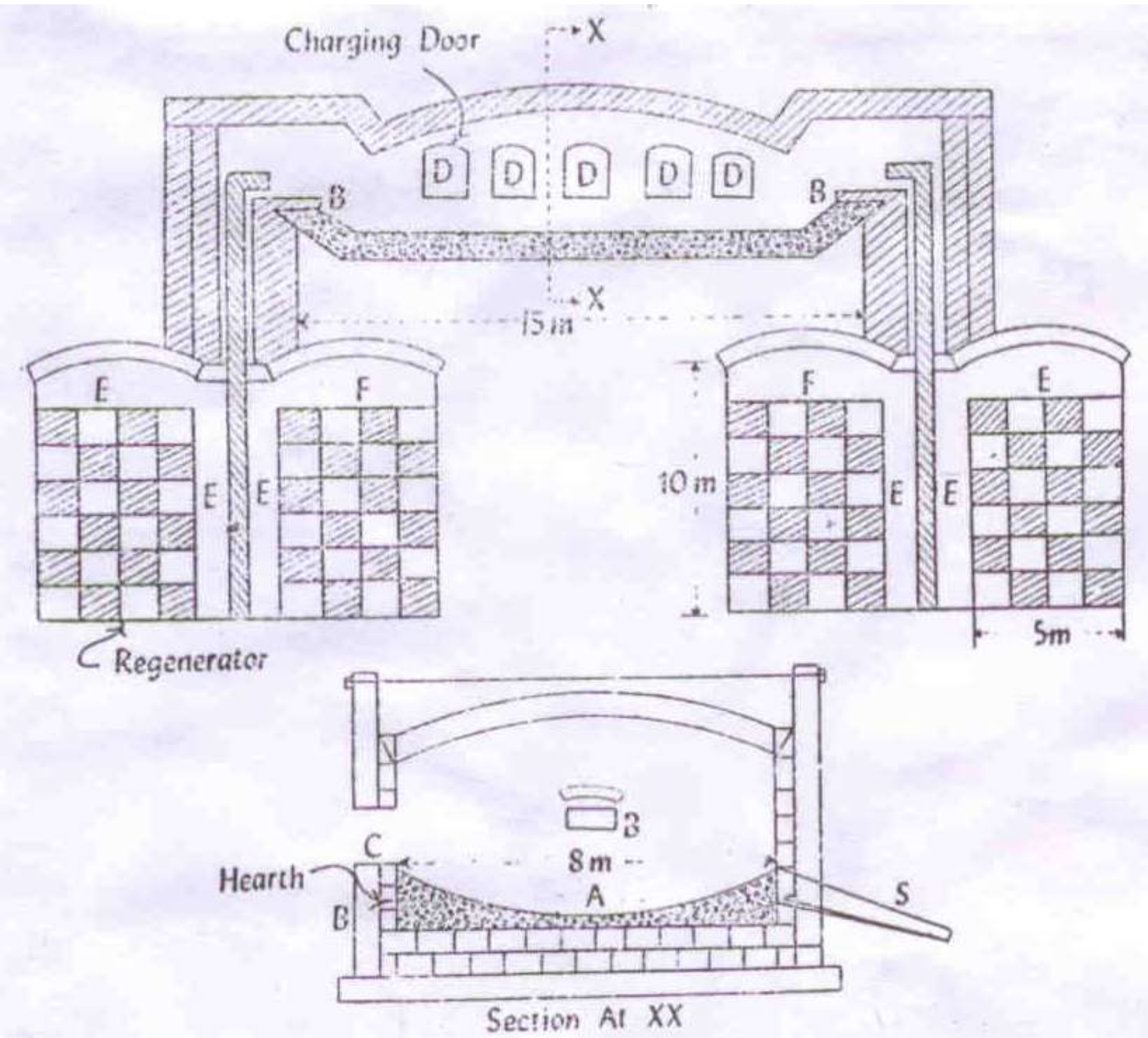


Figure - 7 : Section of an open-hearth furnace

(ii). <u>Bessemer process</u>

This is earliest modern device for production of steel by blasting air through molten pig iron for 15 – 20 minutes, patented in the year 1857 by Sir Henery Bessemer of England. This process is known after the inventor and was the first major step for mass production of steel. The figure – 8 shows a Bessemer converter which consists of the bottom and a pear shaped steel shell. From bottom, air (not preheated) is blown into the molten metal. The combustion of Silicon (Si), C and other elements oxidize and liberate sufficient amount of heat.

The carbon monoxide produced burns with a long blue flame at mouth of converter, when flame dies converter is emptied. The capacity of converter may range from 5 to 100 tonnes. The air blast pressure is 2.1 kg per sq. cm of converter area. The final composition of steel is made up by addition of deoxidizers, Ferro alloys and carbon in form of petroleum coke. The converter may be of acid or basic type depending on its refractory and final composition of steel to be produced. The high contents of P, S and Nitrogen in steel make the acid Bessemer steel a low grade material. Usually all Bessemer steels are plain carbon steels used for pipes, welding rods, tubes, tin plates etc.

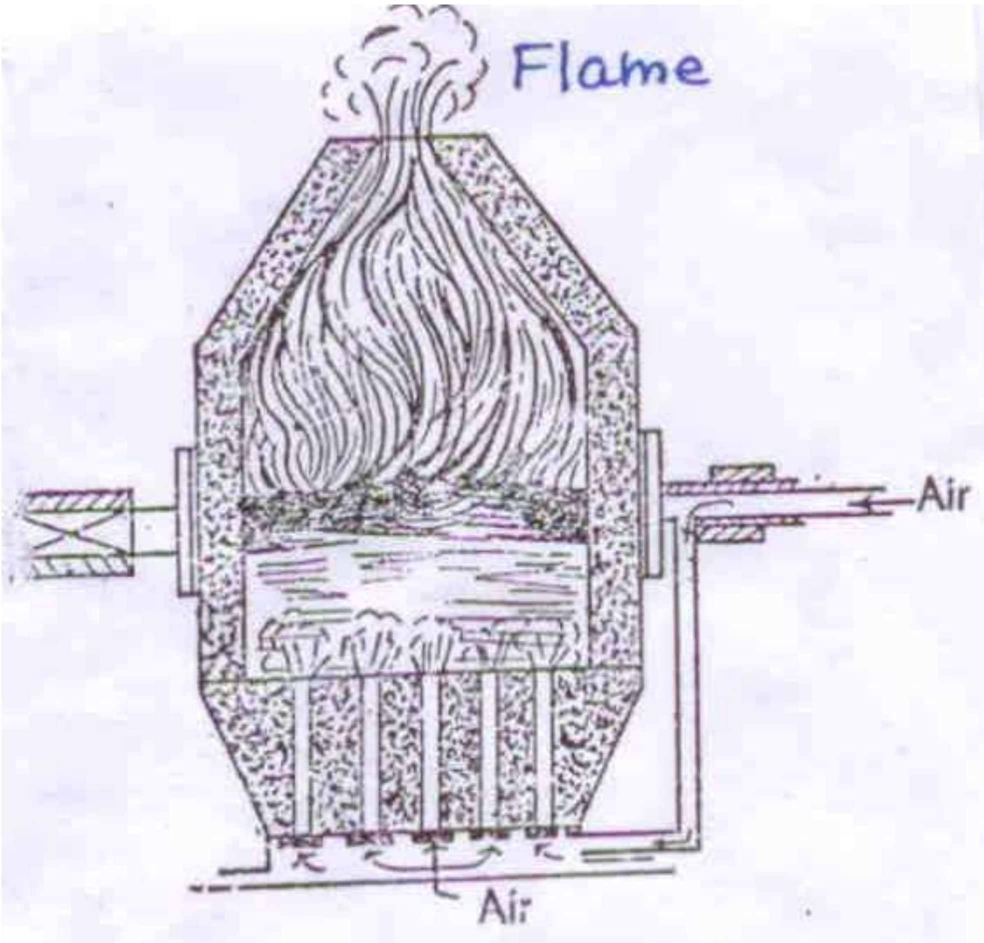


Figure - 8 : Bessemer converter in operation

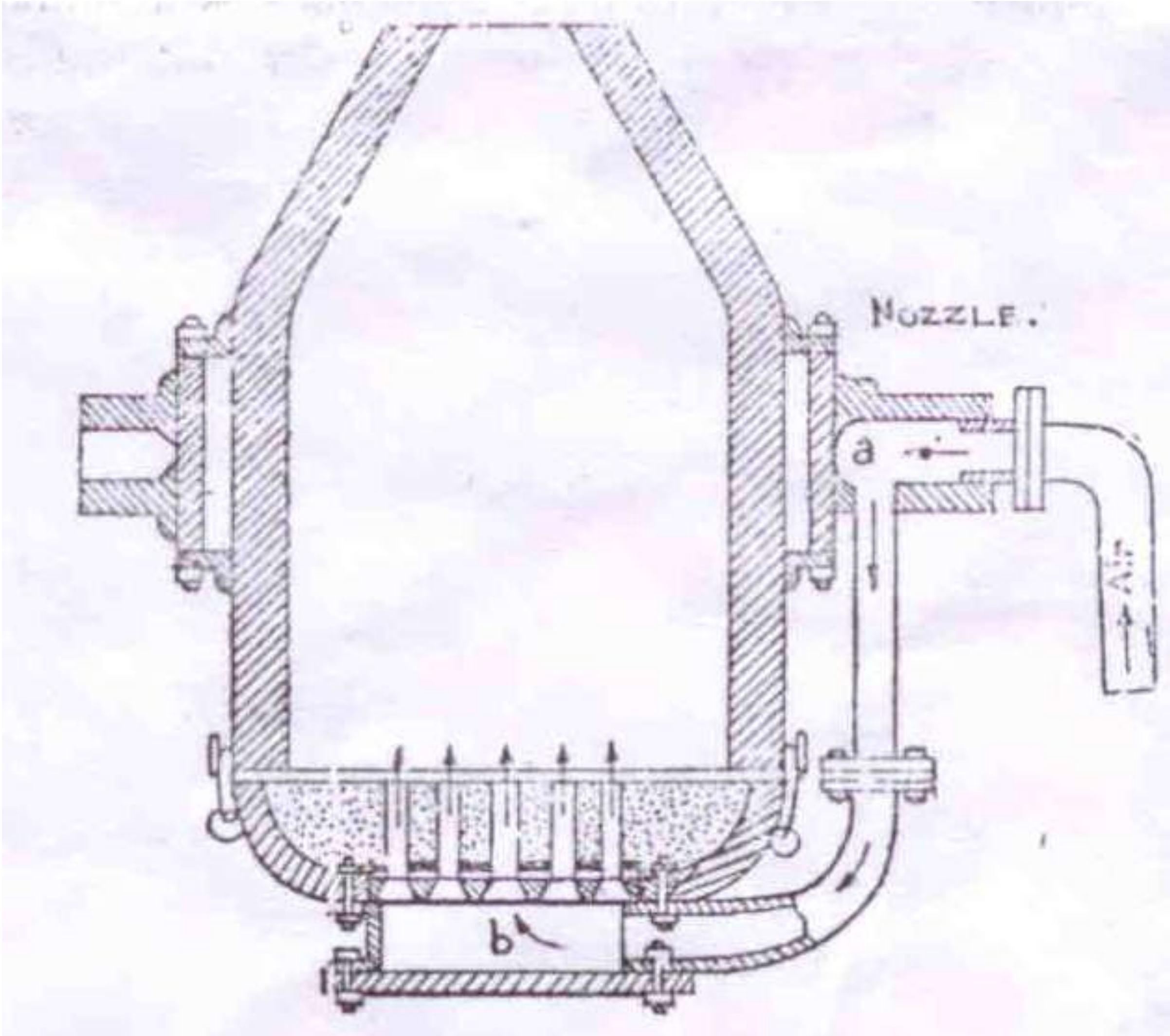


Figure -9 : Section through Bessemer converter showing hollow Trunnion at 'a' for conducting air blast to wind-box 'b'

(iii). <u>Oxygen process</u>

This process is in a fact modification of Bessemer process – Oxygen is blown through the molten metal instead of air. Few important oxygen processes are:–

1. L.D. process (Linz – Donawitz process)
2. O.L.P. process (Oxygen – Lime Powder process)
3. Kaldo – process

L.D. process

This process was originated in 1953 in Austria and has already been adopted in many countries of the world. The productivity and high quality of steel are essential features for flat and plate products. The process consists of introducing very pure oxygen at a pressure of 7 to 10.5 kg per sq. cm. through a water cooled lance lowered through the mouth of vessel to within one meter from metal bath. The blowing time is about 20 minutes. The modern L.D. converters are of capacities ranging from 100 – 300 tonnes. The L.D. steel is low in hydrogen, oxygen and nitrogen. It is also low in phosphorous and sulphur. In this respect, it is much superior to Bessemer steel and basic open hearth steel. Such converters are now popular and major producer of steel. The L.D. process is cheap and economical.

The following figure - 10 shows two types of basic oxygen converters.

A. Rotory Converter **B. L.D. Converter**

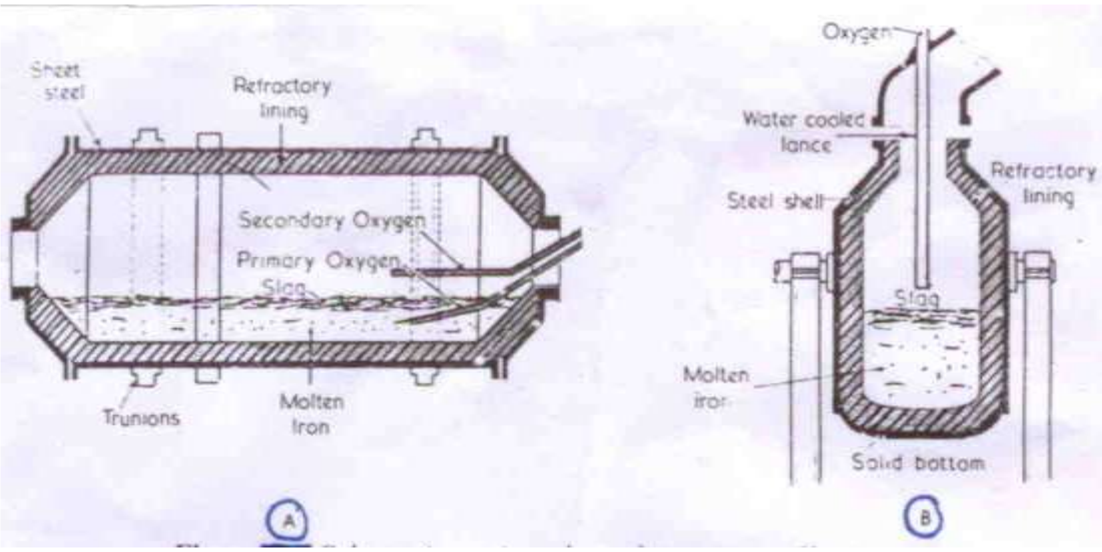


Figure - 10 : Schematic sections through two types of basic oxygen Converters : (A) the rotor converter : (B) the L.D. converter

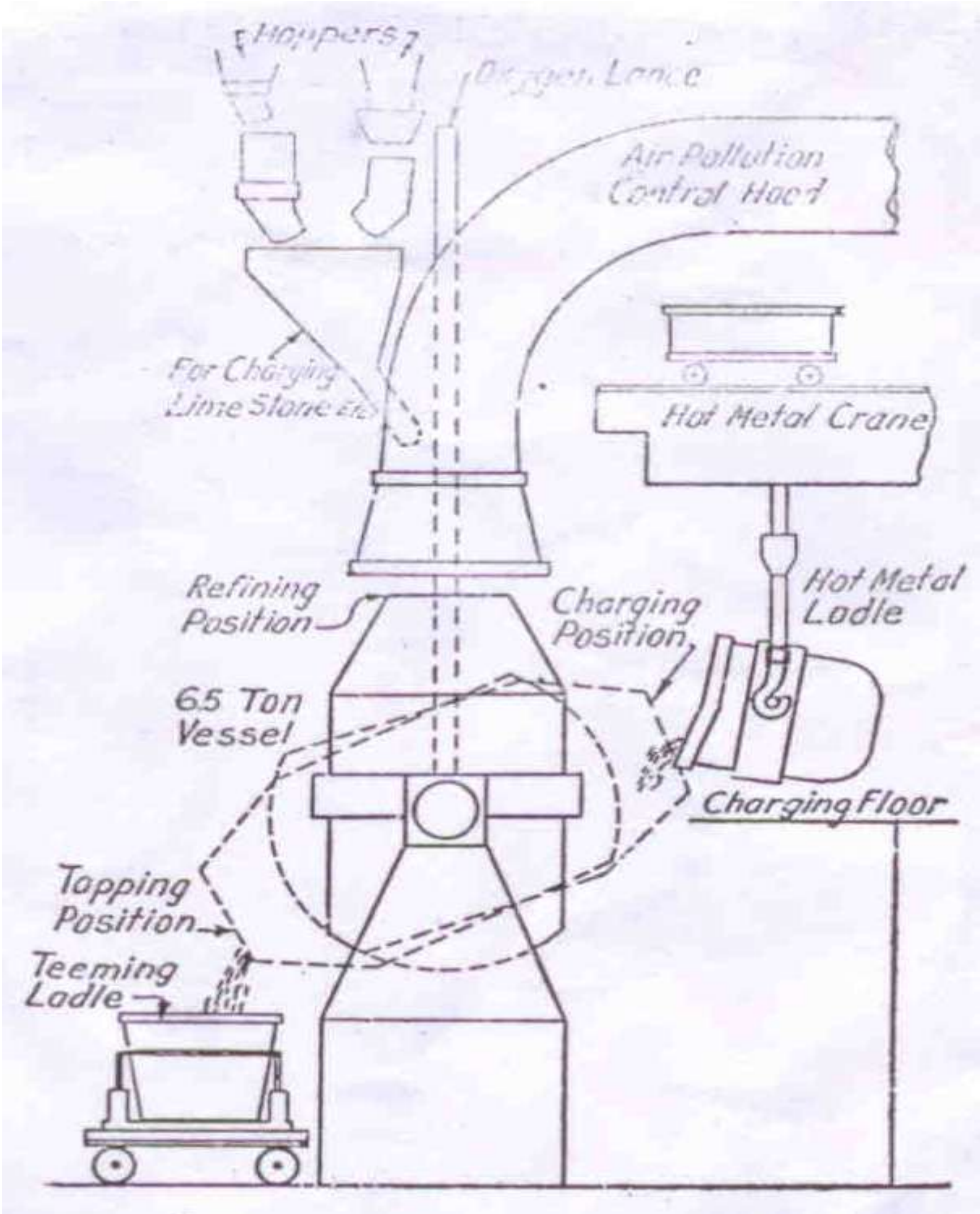


Figure - 11 : L.D. process

Kaldo process

The process is modification of L.D. process, developed in Sweden, now being employed in many parts of world. The main advantage of process is, high phosphorous pig iron can be treated to produce steel containing as low as 0.02% P.

The converter is inclined at 15 – 20^0C with horizontal and is rotated at a speed of 20 – 30 revolutions per minute. The oxygen lance is introduced through open end of vessel. It also acts as outlet for exhaust gas. The rotation of vessel ensures better slag-metal mixing and reaction. Initial capacity was about 30-50 tonnes but higher capacity converters of about 130 tonnes are in operations now-a-days. Blowing-time is 40 minutes. Tap to tap time is 80 minutes. Production rate is about 100 tonnes per hour.

The steel produced is low in S, N_2 and Oxygen. The investment and operational cost is low. The following figure - 12 shows Kaldo furnace.

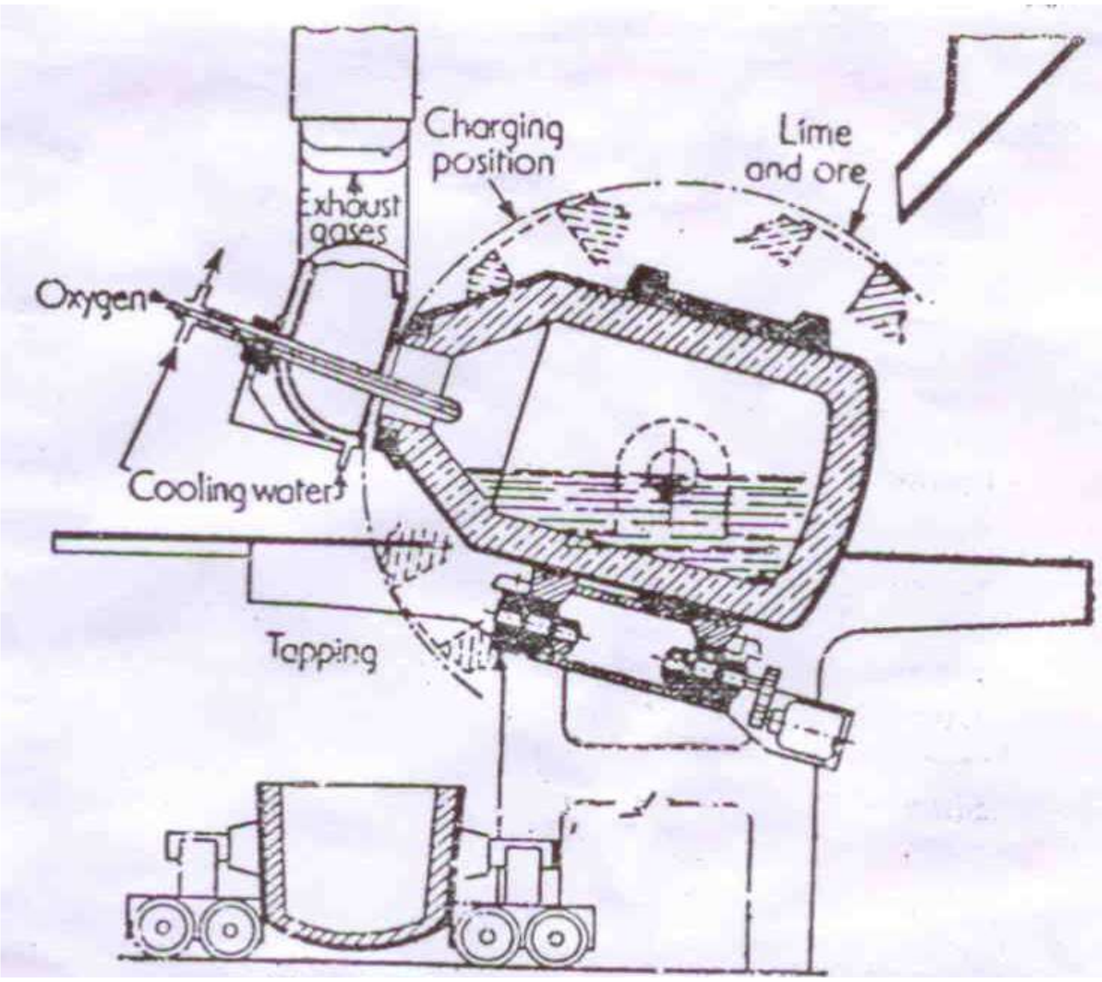


Figure - 12 : The Kaldo furnace

(iv) <u>Electric arc melting furnace</u>

This is basically a refining furnace where electricity is used for heating and melting the metal. The main advantages of process are:

1. It permits greater flexibility with neat and clean operation
2. Temperature can be controlled easily
3. Amount of slag formed is small
4. High quality of steel produced
5. 100% steel scrap can be used.

The only disadvantage is steel produced is more expensive. Electrical furnaces are of two types - 'Arc type' or 'Induction type'.

The arc furnaces are of circular dished bottom with suitable lining of refractory. The carbon or graphite electrodes are introduced through the roof of the furnace. Special controls are incorporated to adjust the gap between electrodes and the metal for arc stability. The arc furnaces can be employed for 100% steel scrap charge. Sometimes oxygen lancing is also practiced to reduce power consumption, reduce carbon and such impurities. The Heroult arc furnace is used to produce most tonnage of steel in the world (Figure – 14). It varies in size from 1/2 to 100 tonnes. But sizes from 5 to 25 tonnes are common.

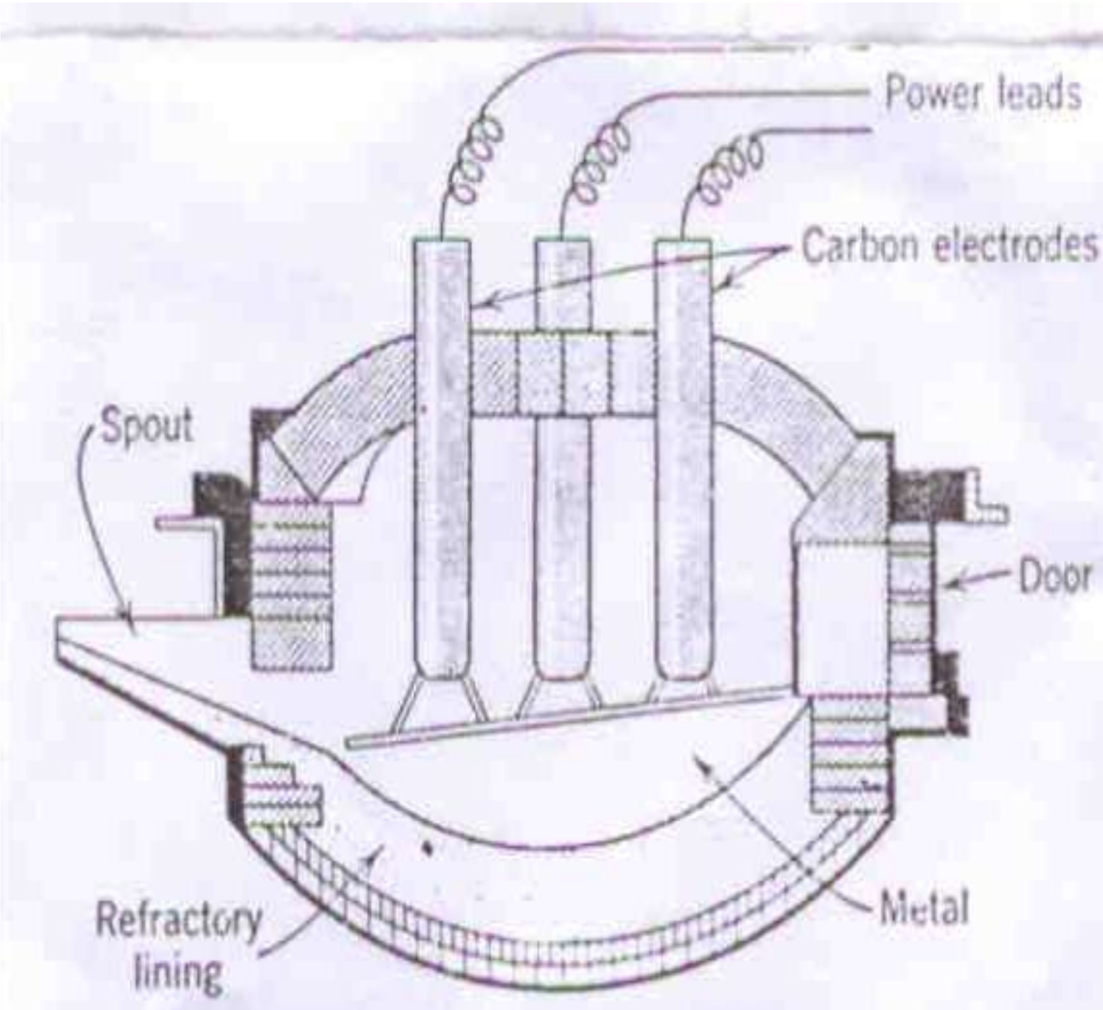


Figure – 13 : Direct electric arc furnace

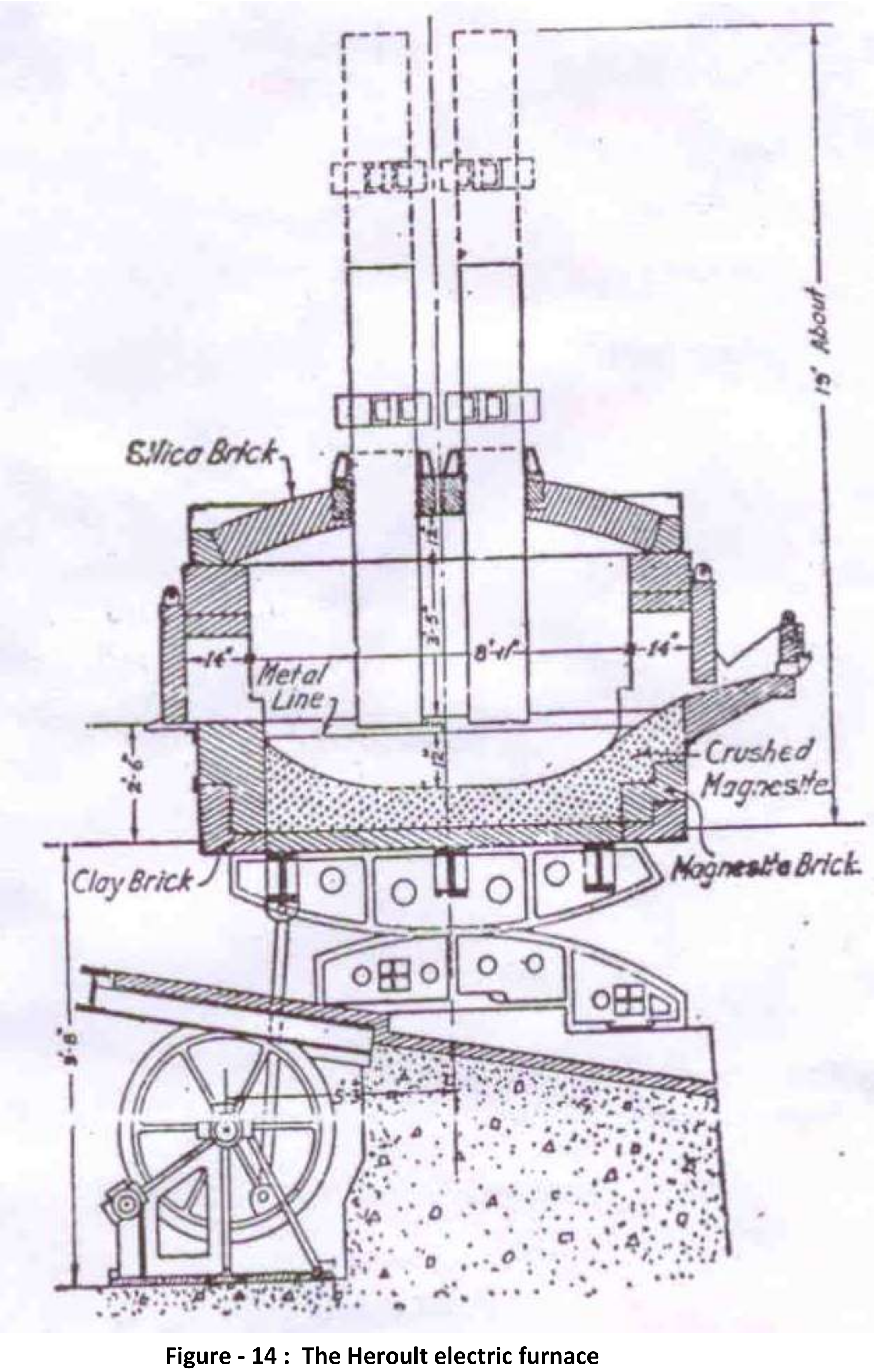


Figure - 14 : The Heroult electric furnace

(v) Manufacture of steel by electric Induction Furnace

The induction furnace consists of a hollow coil of water cooled copper tubing which acts as primary of transformer. The secondary is the metal to be melted which is kept in a refractory crucible inside the copper coil. A high frequency alternating current of frequency of about 1000 to 3000 cycles per second is passed through the coil which induces high frequency current in the metallic charge. The charge may melt in an hour or so. Because of strong stirring action created by high frequency current the refining process is complete in few minutes. The diagram of furnace is shown below.

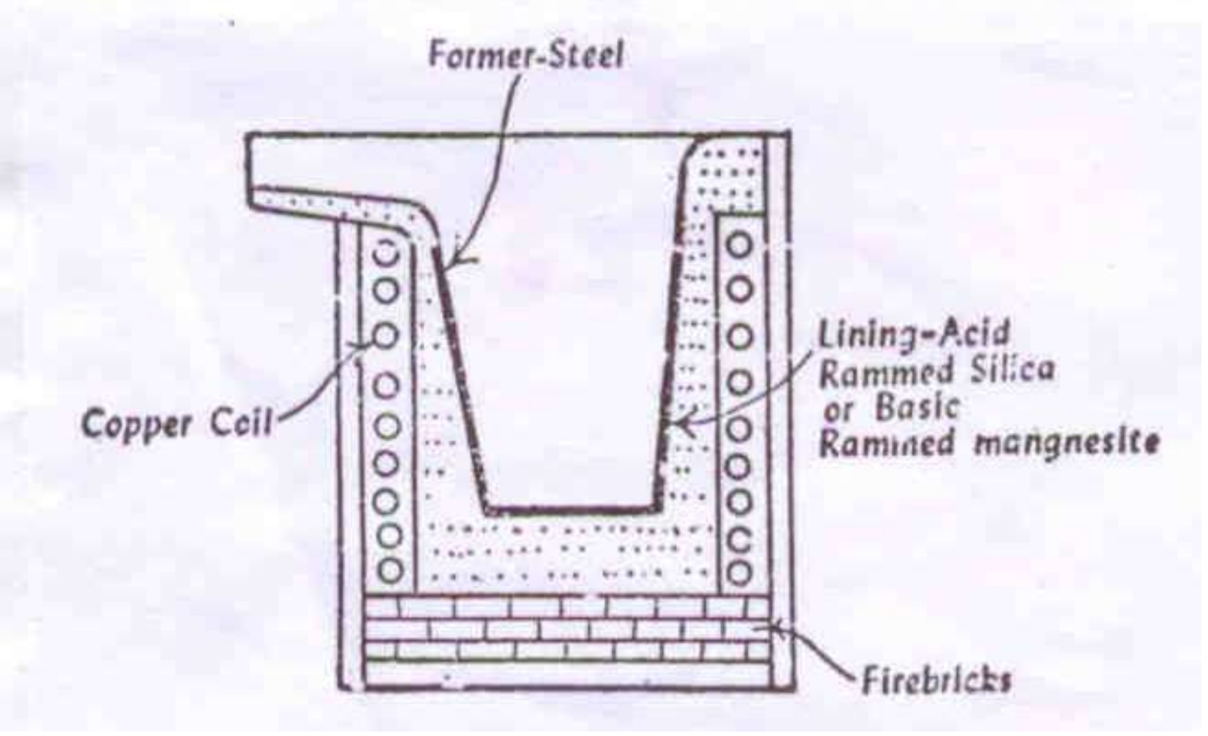


Figure - 15 : Section of high frequency furnace

The quick melting high frequency furnaces are adopted for manufacture of high alloy and special purpose steel, permanent magnet steels, stainless steels, die steels and tool steels.

Other process of making steels are as follows

(a) Duplex process - This process of steel making is combination of

1. Acid Bessemer process
2. Basic open hearth process

The pig iron is treated in acid lined Bessemer converter in which impurities like Si, Mn and C are eliminated. Then this steel is treated in Basic Lined open hearth in which S & P are eliminated.

Thus, a good quality of steel is produced economically and time is also saved.

(b) To improve the quality steel further Duplex process is extended to Triplex Process. The melt obtained from basic open hearth is further treated in Electric furnace to produce steel of High Quality.

(vi) There are other processes of steel manufacturing which are called refining processes which help produce very high grade ultra low impurity steels like maraging steels. They are:

(i) Vacuum Refining process
(ii) Electro-slag reefing process

Vacuum Refining Process : Here an induction furnace encased in vacuum chamber is used to remove impurities like production of non-magnetic steel used in motor/generator lamination strapping, pure iron used in magnetic applications.

Electro-Slag Refining Process : The equipment consists of an electric arc furnace of cylindrical shape with a water cooled starter plate, of same composition as final product, at bottom. The slag of precisely controlled composition is placed above starter plate. A solid bar of 150-300 dia steel acts as an electrode. With highly controlled mechanism, an arc is struck with the starter plate which melts the electrode as also the granulated slag, the refining and removal of undesired impurities take place.

The purified metal solidifies on the water cooled starter plate. The electrode is continuously raised. The refining speeds are around 5-10 mm/ min. The typical bar of 2500 mm takes about 4-6 hours.

NON-FERROUS METALS AND ALLOYS

Non-ferrous metals and alloys are not produced in large tonnage as ferrous metals but they are very important for industrial growth as they possess combination of properties not found in iron and steels. They have some important properties as follows:

Good formability
Low density
High thermal and electrical conductivities
Good corrosion resistance
Attractive colours

Non-ferrous metals are poor in weldability and strength and stiffness as compared to steel. Some non-ferrous alloys like Nimonic, Inconel are very popular due to their high strength at high temperature characteristics and hence used for automobile and aircraft industries. Basically non-ferrous alloys are those which do not contain iron as a base. The main non-ferrous group consists of Aluminium, Copper, Nickel, Titaniun, Lead, Tin and zinc etc.

Manufacture of aluminium

Aluminium occurs in abundance on earth surface in various forms like oxides, sulphates, silicates, phosphates etc. but commercially it is produced mainly from Bauxite (Al_2O_3, $2H_2O$) which is hard rated oxide of aluminium. Steps are as follows:

1. Bauxite is ground and then it is purified.

2. It is then dissolved in fused cryolite which is double fluoride of aluminium and sodium $AlF_3.3NAF$.

3. The above solution is transferred to electrical furnace known as aluminium reduction cell and then aluminium is separated out by electrolysis in Hoopes' cell.

Purification of bauxite is essential. Several methods are available for purification. The BAYER'S PROCESS is most common. The precipitated aluminium hydroxide obtained is washed, filtered and ready for calcinations. The calcination is carried out in tubular rotary Kiln which yields 99.5% Al_2O_3 with little impurities.

The calcined Al_2O_3 is converted to aluminium by electrolysis in electrolytic furnace as shown in Figure – 16. The furnace serves two important functions - keeps electrolyte in liquid form and causes electrolytic dissociation of alumina.

The furnace consists of rectangular open shell of 8 – 10 feet long and 4 – 5 feet wide and 22 feet deep made of 2/3" thick steel plate lined with fire brick. The coke lining of bottom serves as cathode and anodes etc. carbon electrode made of petroleum coke known as Soderberg type of electrodes. The metal accumulated at bottom is siphoned off at regular interval. For favourable conditions the bath composition should be maintained as AlF_3 – 59%, NaF – 21%, CaF_2 – 20%.

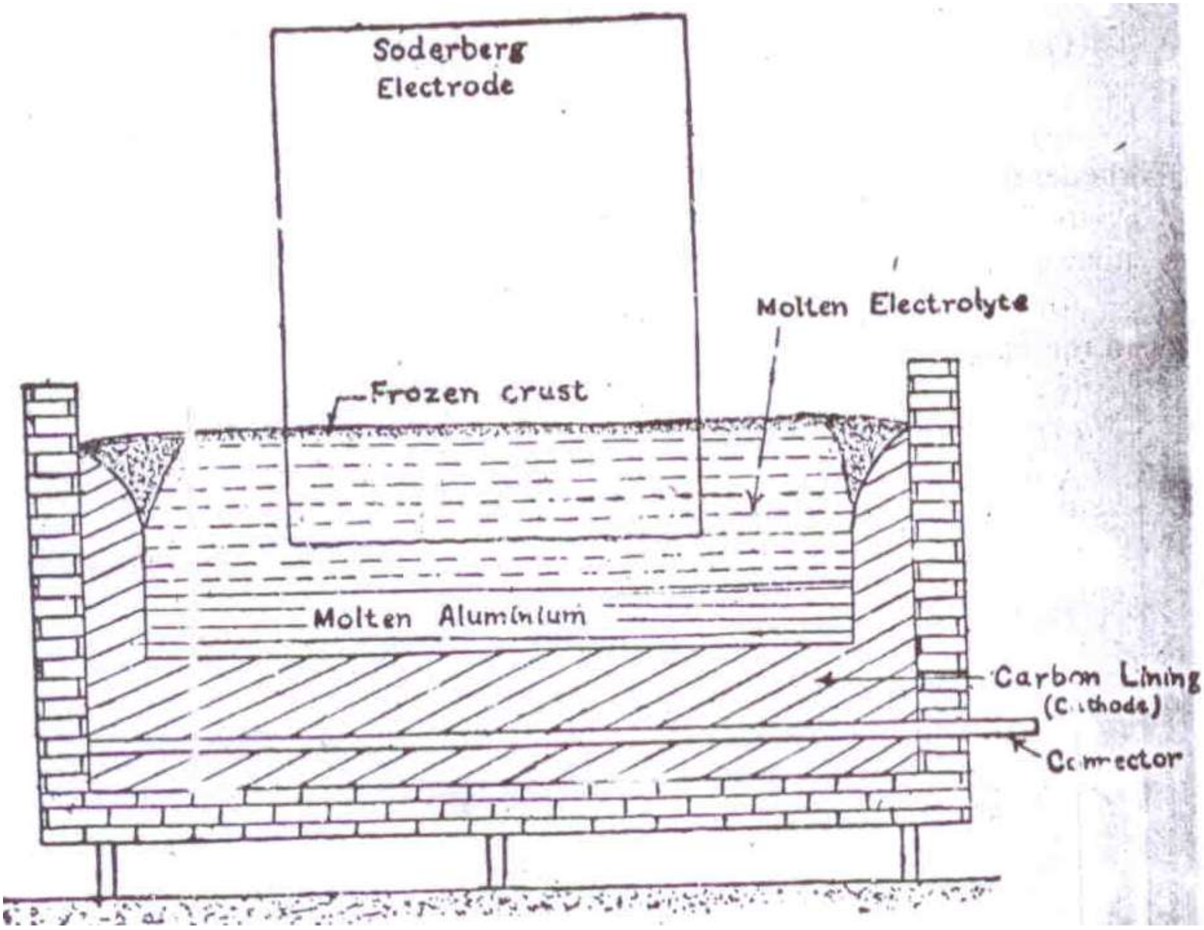


Figure – 16 : Aluminium reduction cell

Refining of Aluminium

Commonly used process of refining is by '<u>Hoopes' Cell'</u> which is shown in Figure – 17 with different parts. The bath is operated at 900^0 – 1100^0C with a current of about 30000 amps at a voltage of 5 – 7 volts. The purity of product is 98 – 99%. The main feature of cell is electrolyte which consists of three layers of different material. The bottom most is fused anode and impure metal. Then layer of cryolite aluminium fluoride and barium fluoride. Al_2O_3 is added to have requisite specific gravity and fluidity on Top Pure Aluminium layer acting as cathode. Because of high temperature in Hoop's Cell refractory wear and tear is more. In recent Gadau process the operating temperature is about 700^0C resulting better operation and separation of refined aluminium.

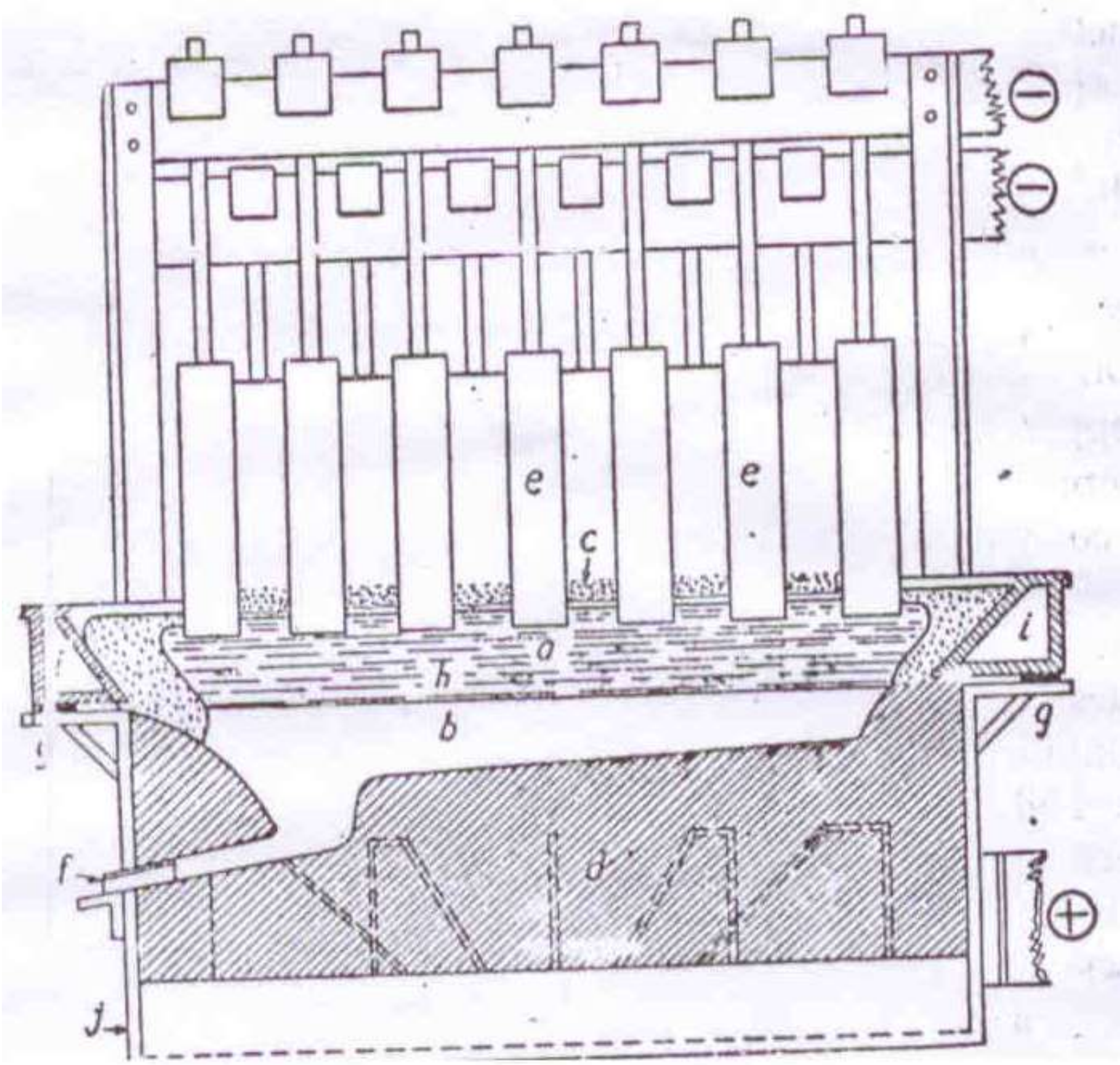


Figure – 17 : The Hoopes' Cell

a – Molten electrolyte, b – Molten aluminium alloy (anode), c – Frozen crust, d – Carbon lining, e – Cathode, f – Tap hole, g – Insulator, h – Molten aluminium, i – Water jacket, j – Steel shell

Because of many good properties the metal is used in aerospace industries, cooking utensils, electric wires, structural frames like windows, sheets, foils, posts, panels, furniture etc.

Copper and Its Alloys

Ore occurs as native ores, oxidized ore and sulphide ores. The major production of world is obtained from sulphide ores. Copper content vary in ores is between 1 – 3%. The Copper metal is manufactured by laborious method and treatment is adopted depending on the quality of copper ore. A general outline of manufacturing Cu metal is as follows:

a. Ores (usually pyrites) are cleaned, crushed and then calcined in reverberatory furnace.

b. Calcined ores are mixed with silica and coke. The mixture is smelted in blast furnace.

c. Metal obtained is oxidized in Bessemer Converter giving blister copper.

d. The blister copper is refined by -

   1. Fire refining in reverbaratory furnace with the help of pulverized coal or oil as fuel.
   2. Electrolytic refining up to purity of 99.99%.

It is important that the ores of copper be ROASTED before smelting. There are different furnaces used for roasting of copper. Herreshoff's furnace (Figure – 18) is the most popular. During the process arsenic and antimony (As and Sb) volatilize and sufficient required amount of 'S' left to produce matte of required grade for smelting.

The object of smelting is to produce Fe matte consisting mixture of sulphides of Cu and along with gold and Ag and a slag which contains minimum of copper and it is being carried out in Reverberatory or Blast furnace Reverberatory furnace (Figure – 19). Size depends on capacity desired; commonly 120' long are used with silica lining. Fuels used are pulverized coal, oil or natural gas the blast furnace is rectangular rather than circular for better output with varying size of 8 – 80' long.

The matte thus obtained is converted into blister Cu by blowing air through it. A matte containing 40% Cu is best suited for conversion. The converter used resembles the

Bessemer converter for steel making (Figure – 20) with the difference of air blast entering through the side in case copper converter. The capacity varies between 7 – 70 tonnes. The refractory lining is magnesite. The blast pressure varies from 6 – 18 psi. When blow is over the molten metal is cast into moulds. The product is called Blister Copper. The time of blow is about 2 ½ to 3 hours.

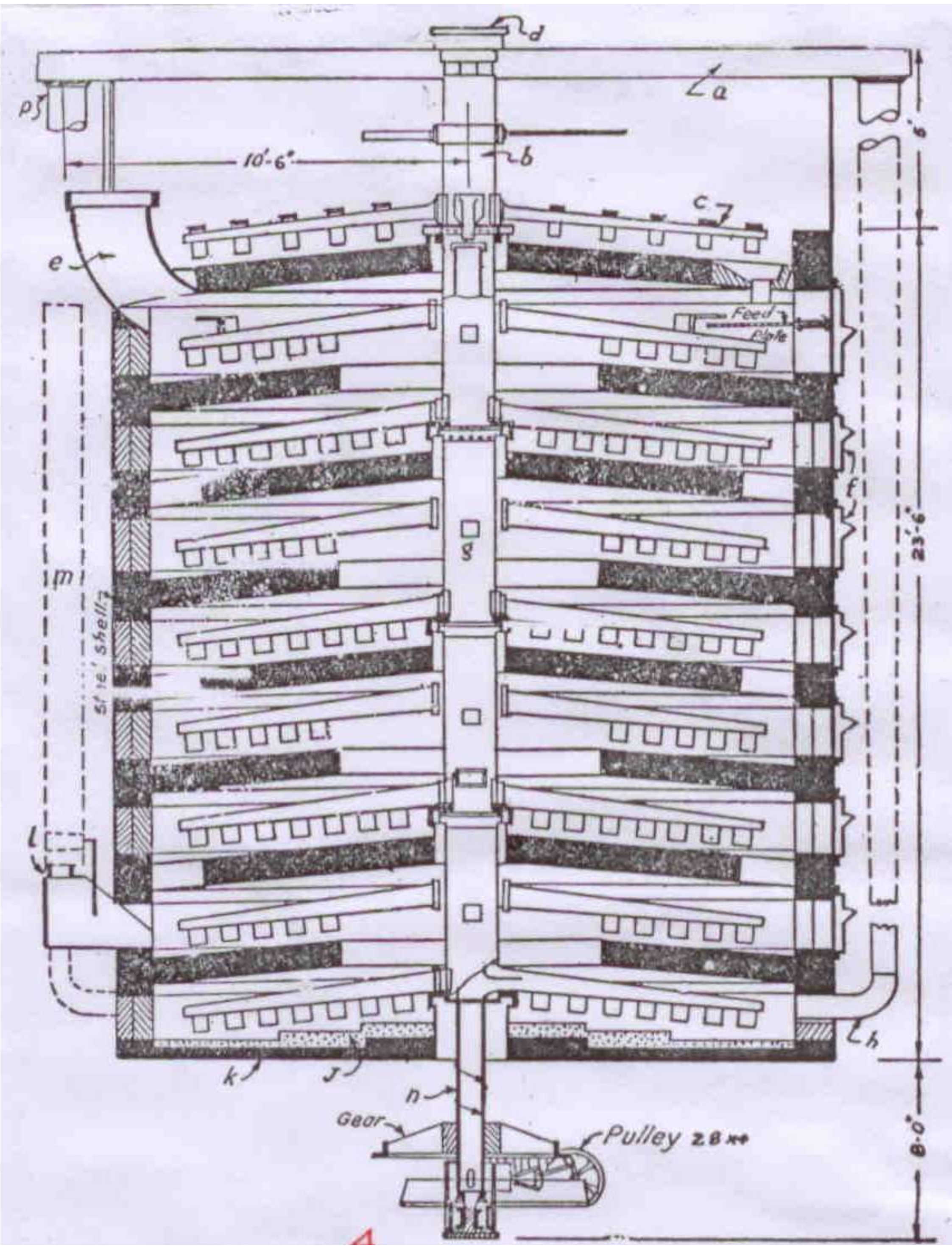


Figure – 18 : Herreshoff roaster

(a) Top frame, (b) Shaft top, (c) Dry arm, (d) Thermometer opening, (e) Gas outlet, (f) Door, (g) Dia. of drop hole, (h) Hot-air blow, (j) fire-brick, (k) Insulation brick, (l) Limestone feeder, (m) Hot-air return pipes, (n) Shaft bottom, (p) Blast gate with charge

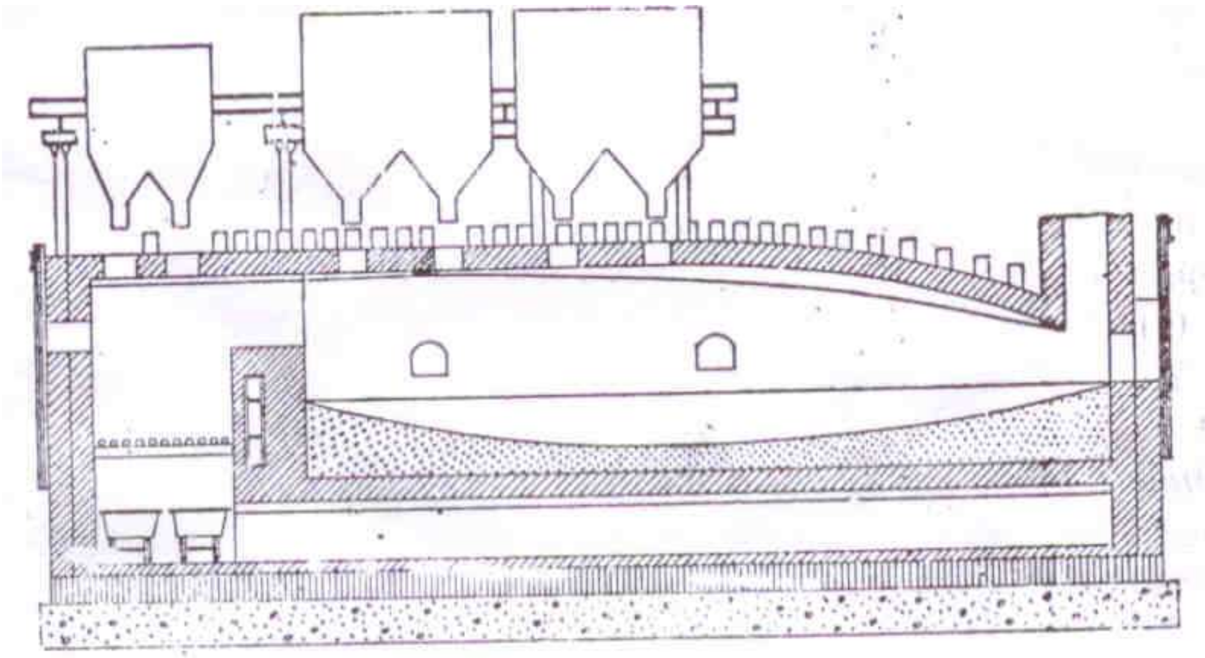
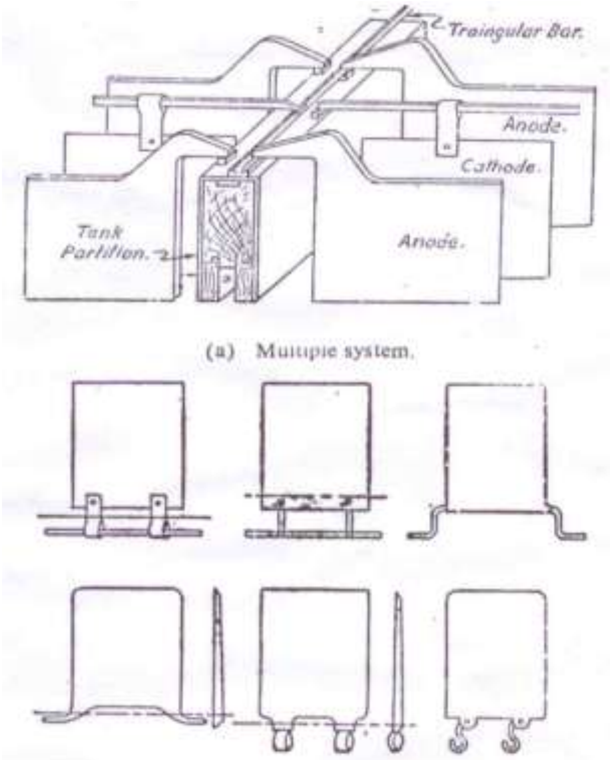


Figure – 19: Reverberatory smelting furnace for copper ore

The blister copper is refined by –

(i) Fire refining
(ii) Electrolytic refining

Fire refining is carried out in Reverberatory furnace in which S is removed as SO_2.



(b) Electrode Shapes

Figure – 20 – Electro-refining of Copper

For electrolytic refining first refining is done up to 99.3% then final refining is done by – (i) Multiple system and (ii) Series system according to arrangement of electrodes. The first system is advantageous and most popular. The following Figure – 20 shows Electrorefining of Copper.

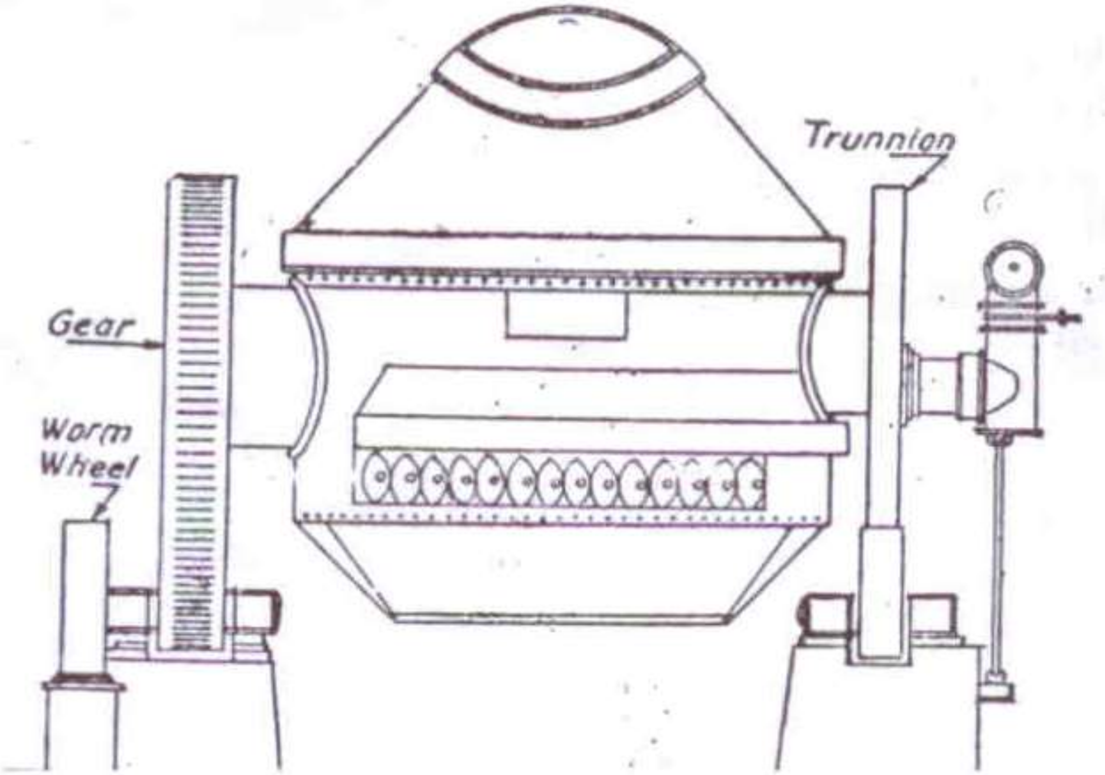


Figure – 21 : Copper converter

The other methods of extracting copper are –

(a) Using flash smelting technique (Figure – 22).

(b) Hydrometallurgy of copper (Figure – 23).
Manufacture of copper by Indian Copper Corporation Ltd.

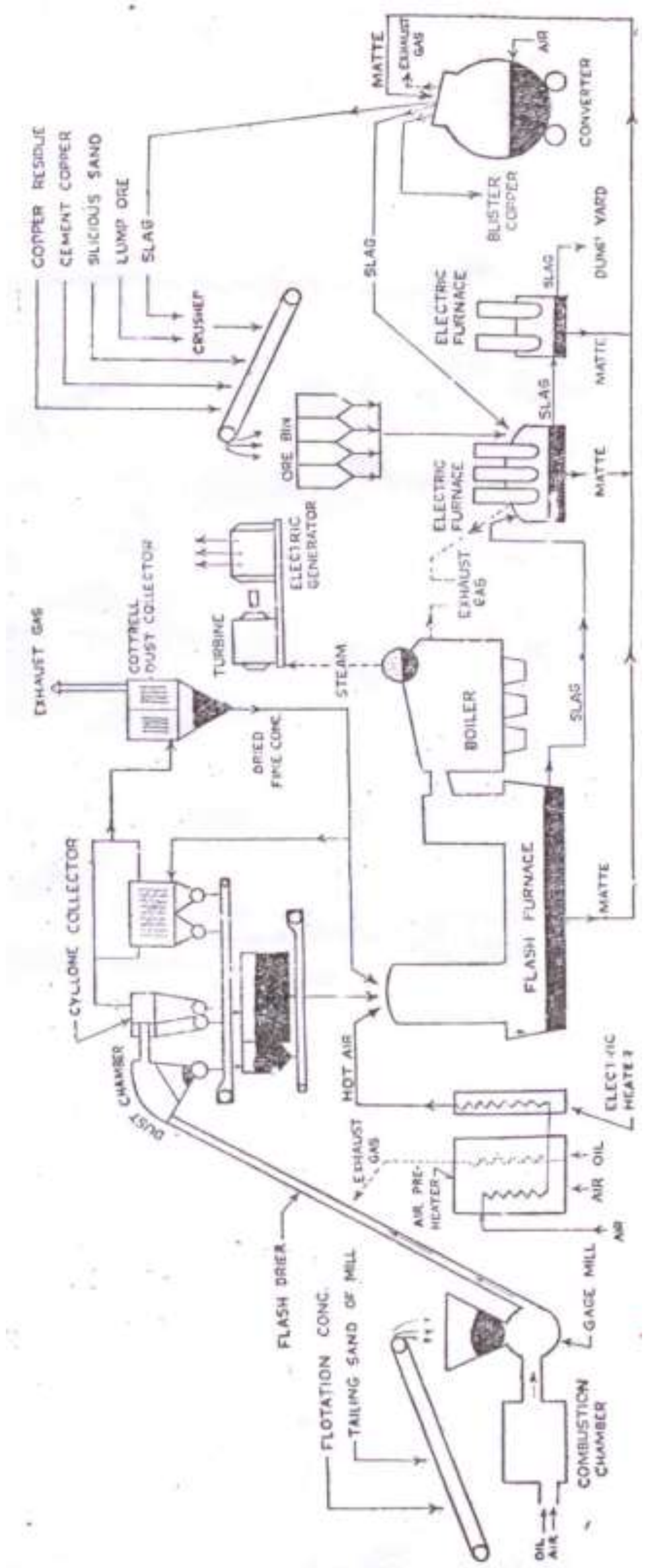


Figure – 22 : Diagrammatic flow-sheet for extraction of Copper using flash-smelting technique

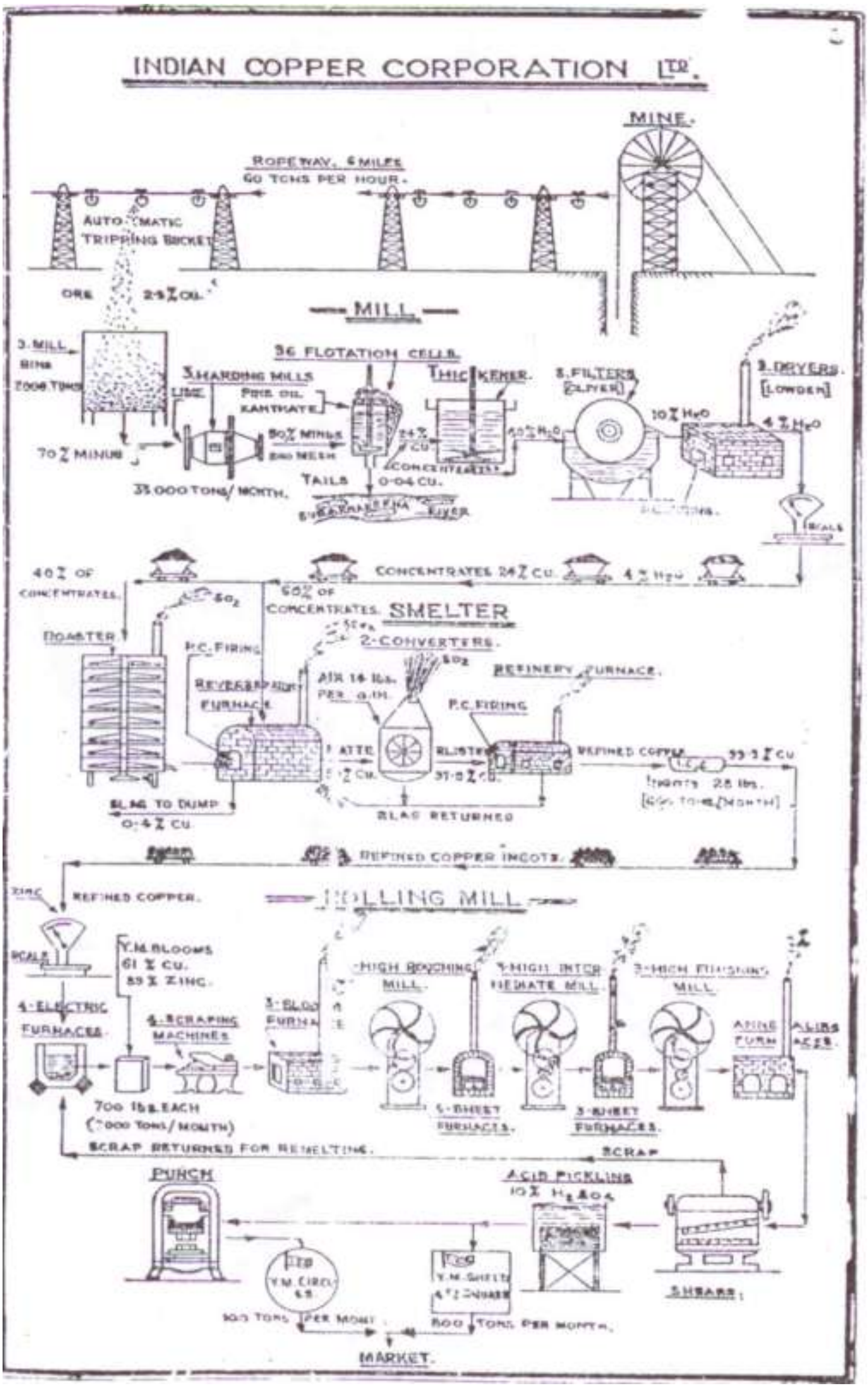


Figure – 23 : Diagrammatic flow-sheet for extraction of Copper using Hydrometallurgy

Zinc

Main ores are Zinc – blende – Zns (67% Zn) and
Calamine – Smithsonite $ZnCO_3$ (52% Zn)

Two methods of manufacture

A. Pyrometallurgical
B. Hydrometallurgical

For Pyrometallurgical operations three steps are needed –

(i) Roasting of blende to ZnO
(ii) Distillation of ZnO with Carbonaceous materials to metallic zinc
(iii) Refining of metallic zinc

From Roasted ore, Zinc is obtained by three methods :

(1) Belgian, (2) Silesian and (3) Belgo-Silesian method

Belgian process is the oldest method for extraction of Zn. Zinc vapours are condensed to liquid Zn in condenser set in the mouth of retort. The whole operation takes 24 hours. The following Figure – 24 is of Belgian retort furnace.

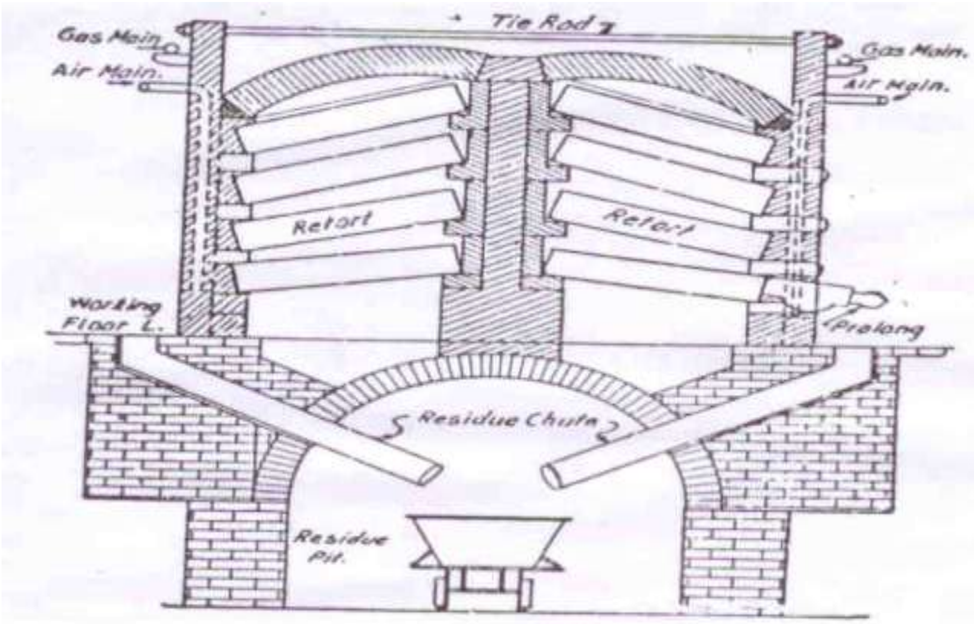


Figure – 24 : Belgian retort furnace

The most common methods employed are vertical retort method, electrolytic process or blast furnace process. Some methods are represented by **Figures 25 and 26**.

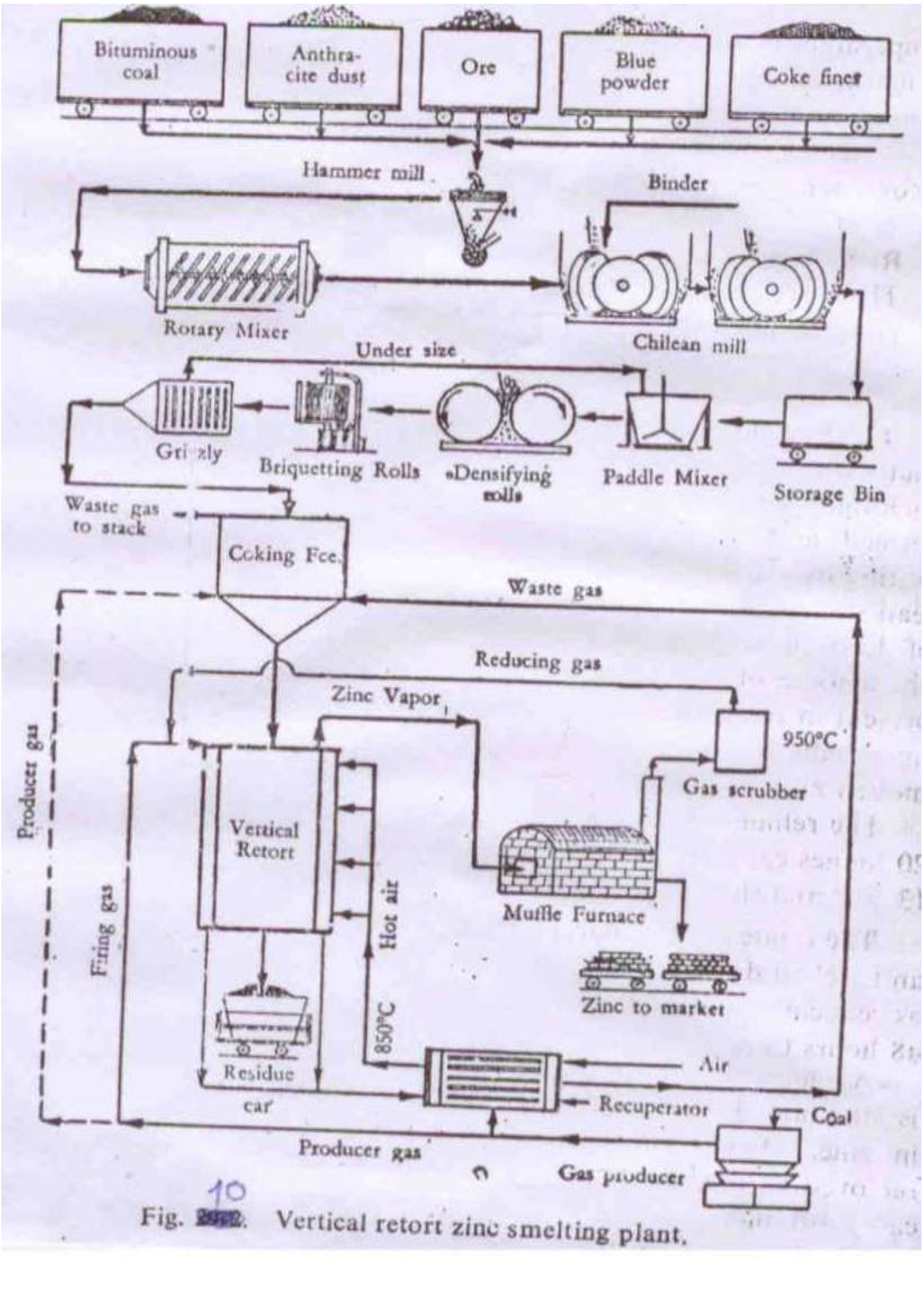


Figure – 25 : Vertical Retort Zinc Smelting Plant

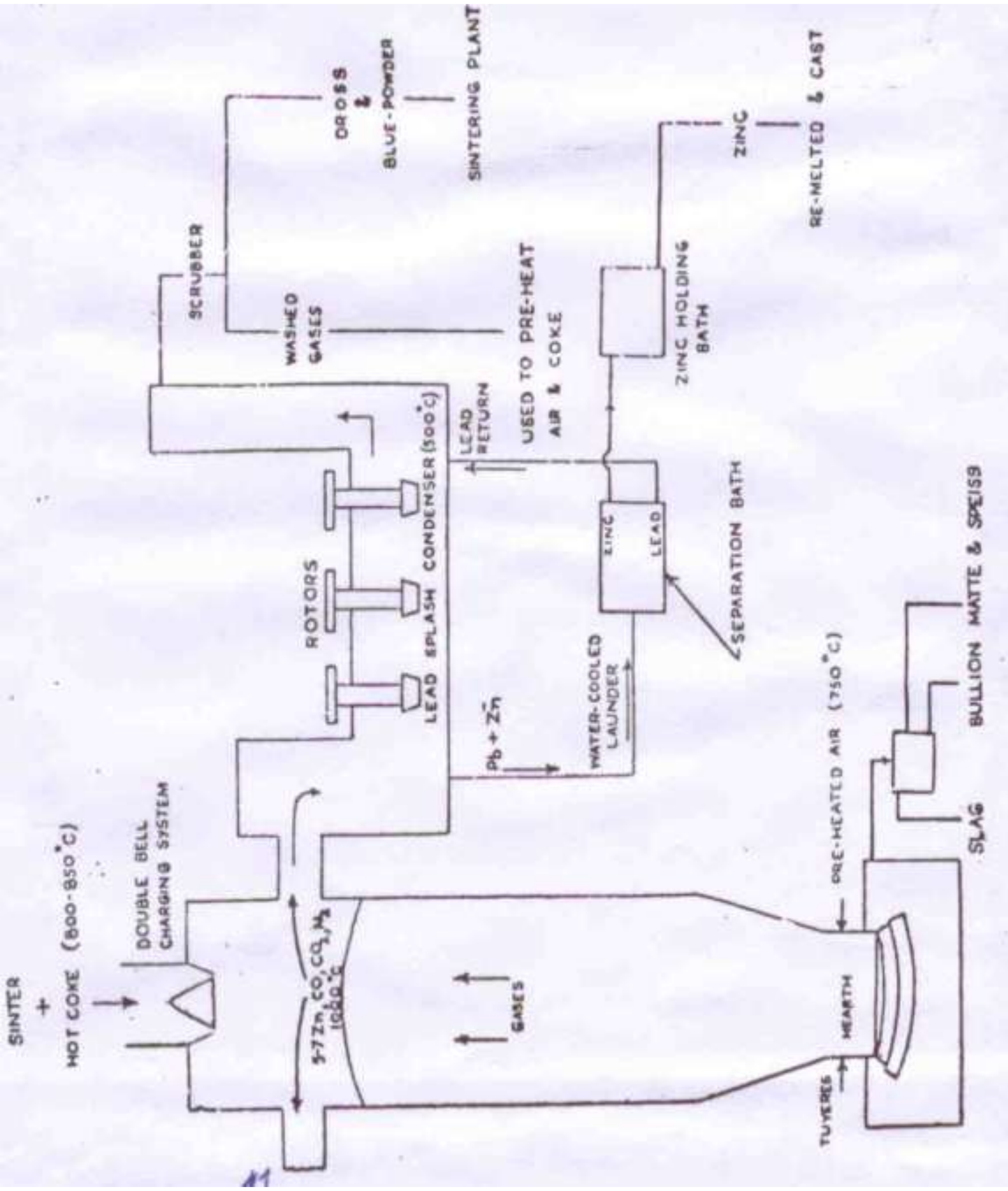


Figure – 26 : Layout of a zinc blast furnace plant

The main use of Zinc is in electric cells and for galvanizing iron sheets, and lining of drinking water storage tanks. Also used for preparation of Alloys, paints etc.

Tin Metal Extraction

Main ore Tinstone or Cassiterite (SnO_2) contains 78.6% Sn. The following Figure – 27 shows the flow sheet of tin extraction carried out by dry methods wet or electrolytic method.

Tin is mainly used for plating, lining of lead pipes, preparation of alloys and solder. Also used for protective coatings to utensils, cans for food, fruits and milk industry. Tin foils are used for silvering, wrapping of cheese, chocolates, tobacco, toilet soaps etc.

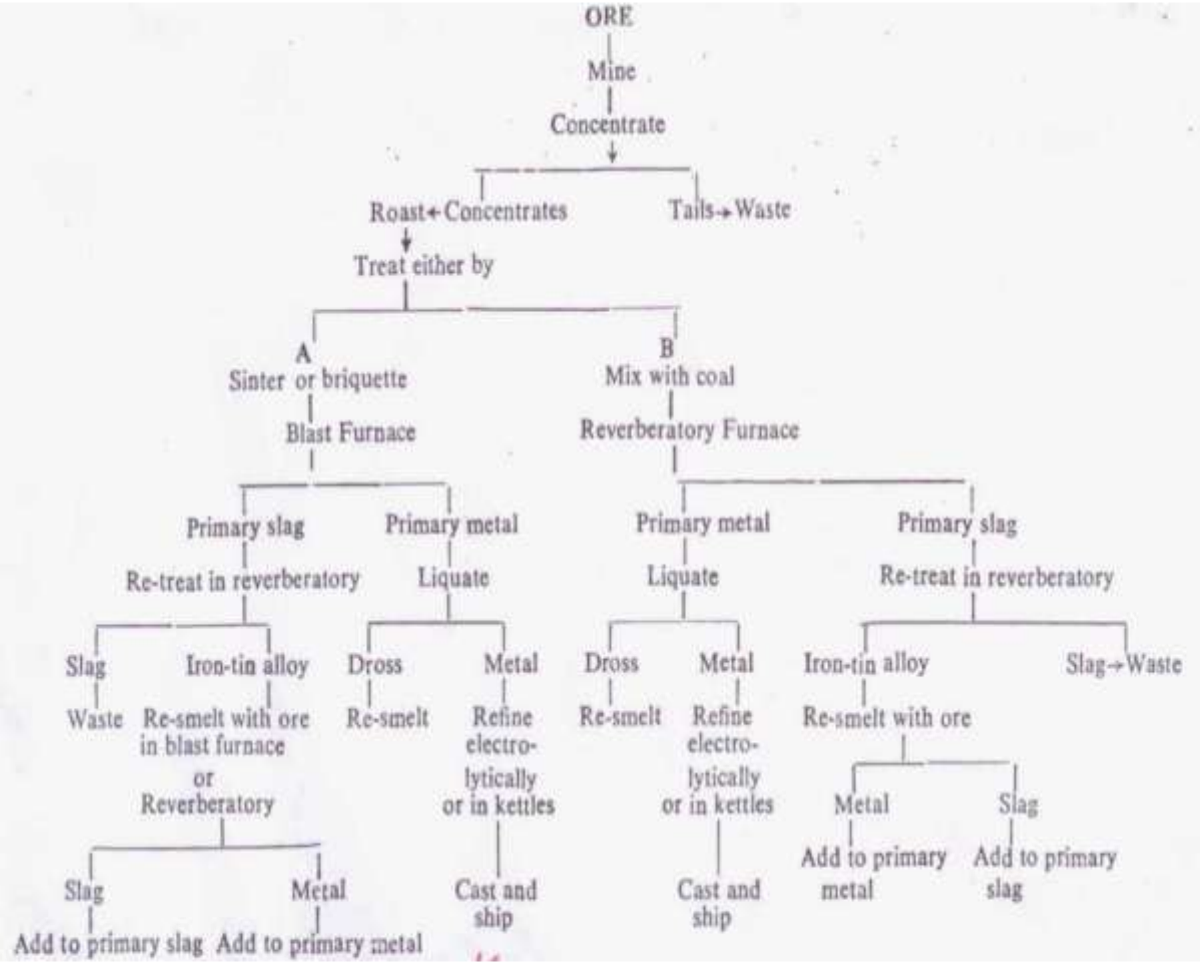


Figure – 27 : Outline of tin extraction

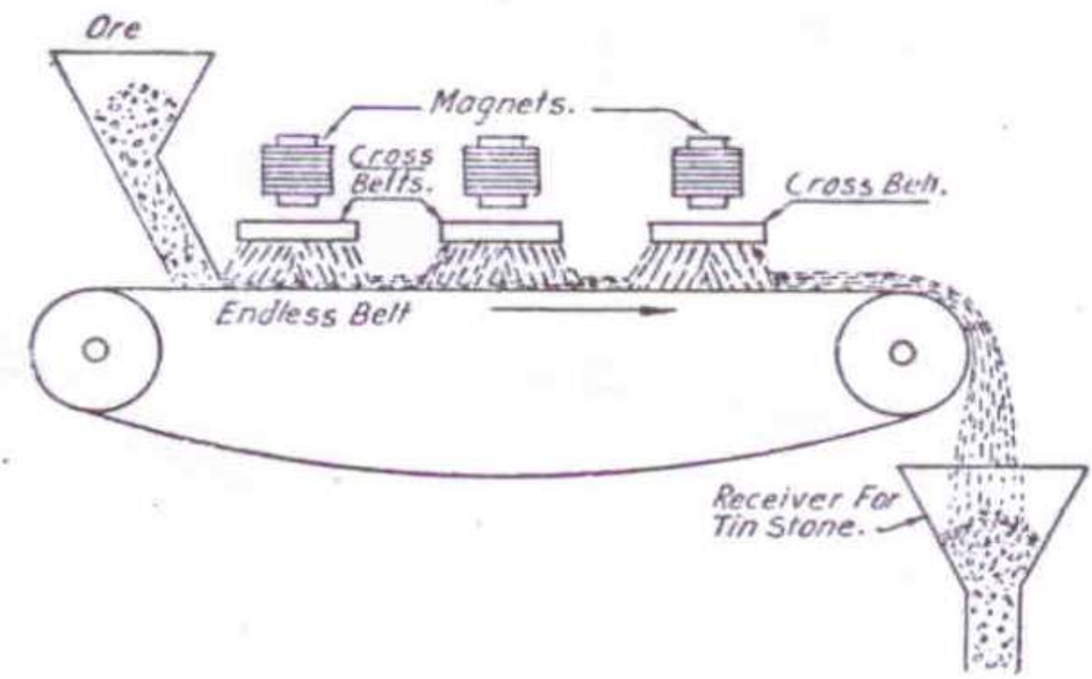


Figure – 28 : Diagram of magnetic concentration for tin stone

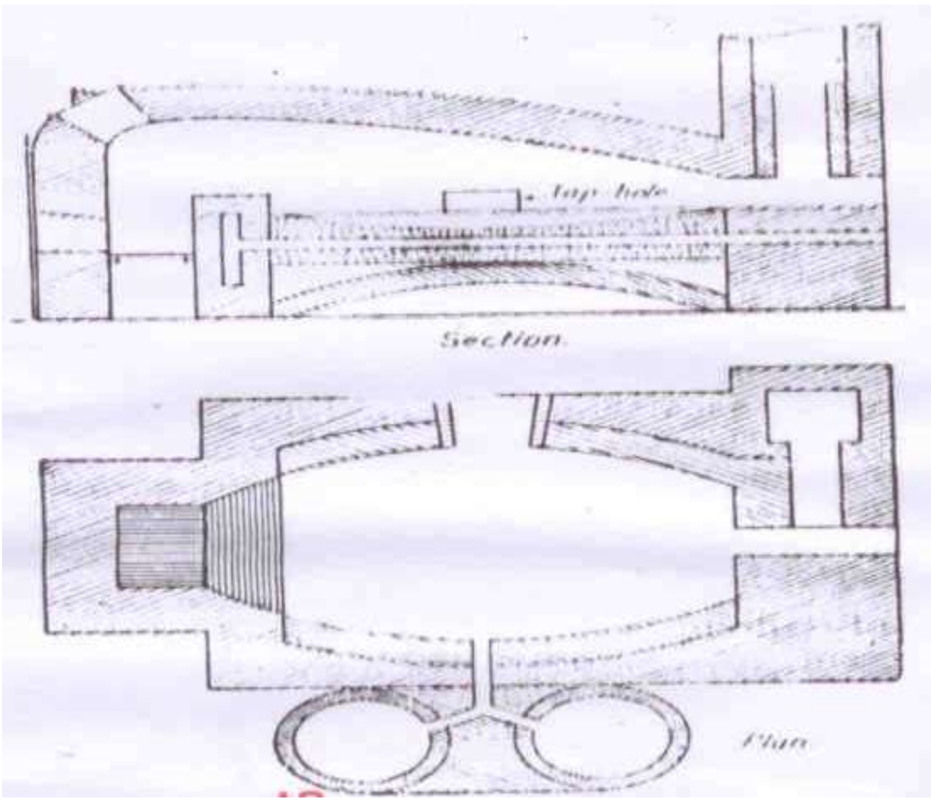


Figure – 29 : The smelting furnace

In general steps for manufacturing are as follows:

1. Ore crushed and washed to remove impurities (Figure – 28).

2. Then it is calcined and cooled and washed with water.

3. It is smelted in furnace with coal. Reduction temperature is 1000 – $1100^{0}C$. It is shaft type of furnace or in reverberatories. Reverberatory furnaces have advantages (capacity 20 – 30 tonnes) (Figure – 29) oil/producer gas used for firing with preheated air. It is important to avoid loss of tin in slag operation is performed in two stages.

4. Refining of metal – carried out in stages as <u>Liquation</u> (melting and temperature maintained above fusion part of tin) <u>Tossing</u> i.e. operation of being ladled from one kettle to another (to oxidized some impurities) Finally <u>Polling or boiling</u> to obtain purer tin (one to three HRS).

<u>Lead – (Pb)</u>

Lead and zinc are commonly associated in mineral deposits. Mainly three basic ores of lead are –

(a) Galena – Pbs (Pb 86.6%)
(b) Anglesita – Pb SO_4 (Pb 68.3%)
(c) Cerussite – Pb CO_3 (Pb 77.5%)

ONLY lead smelting unit in India is at Tuhdoo near Asnosol. Except Zawar Mines no other area is identified for mining of lead and zinc.

There are various processes for manufacture of lead depending on types of ore. For Galena ore the process can be described in brief in following steps : (Figure – 30 Flow Sheet):

1. ORES – Ground and sieved $\rightarrow$ for separation of impurities sent to floatation machine.

2. The concentrate is mixed with coke, iron ore, limestone and slag with high % of lead and this charge is smelted in Blast furnace at a temperature of 1200 – 1300^{0}C. The molten lead obtained is called 'BASE-BULLION' or work lead which is cast into pigs $\rightarrow$ finally sent to refinery for desilverizing (Figure – 32).

3. the impure lead is further purified in a Reverberatory furnace or in lead blast furnace (Figure – 33).

   Lead is soft with melting point of 327^{0}C with specific gravity of 11.36 kg/m^3. It is widely used for making shots, bullets, alloys, gas pipes, storage cells, printing types, damp proof courses of buildings, cable coverings, lead oxide for paints, etc.

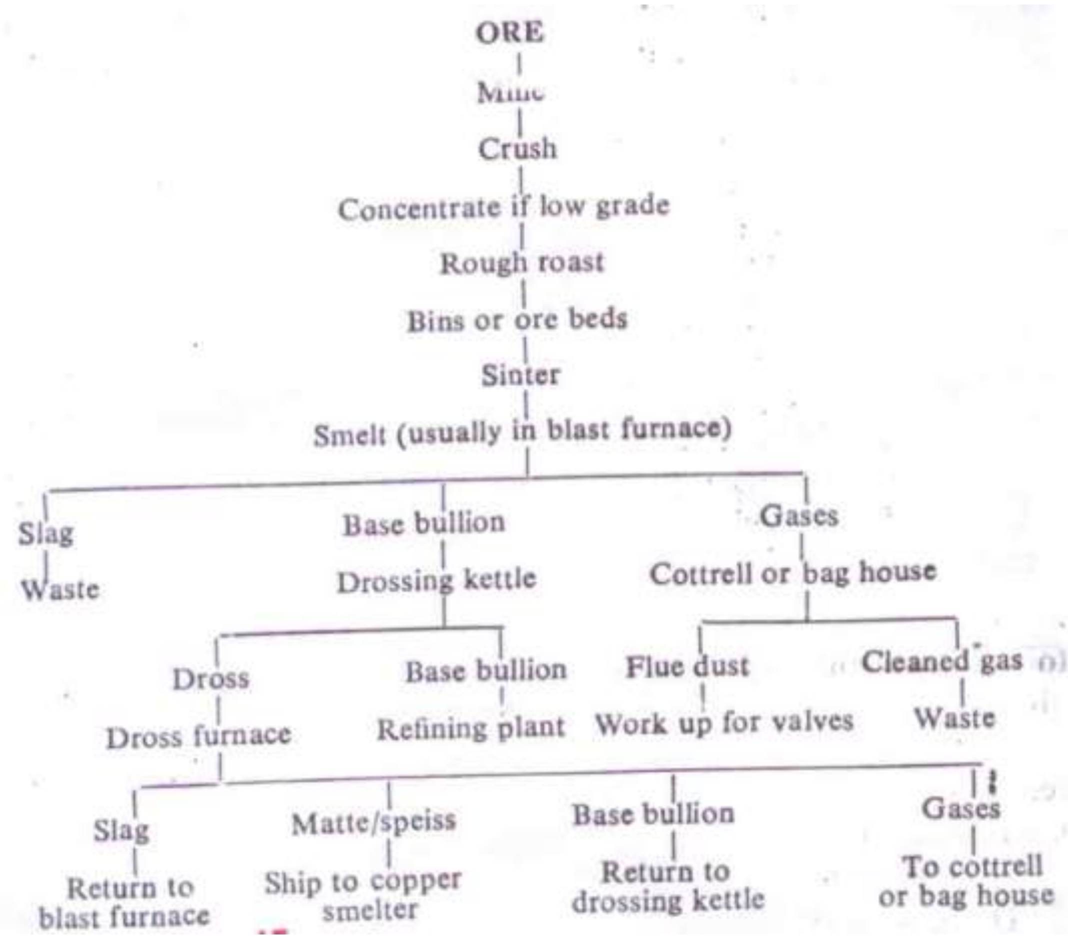
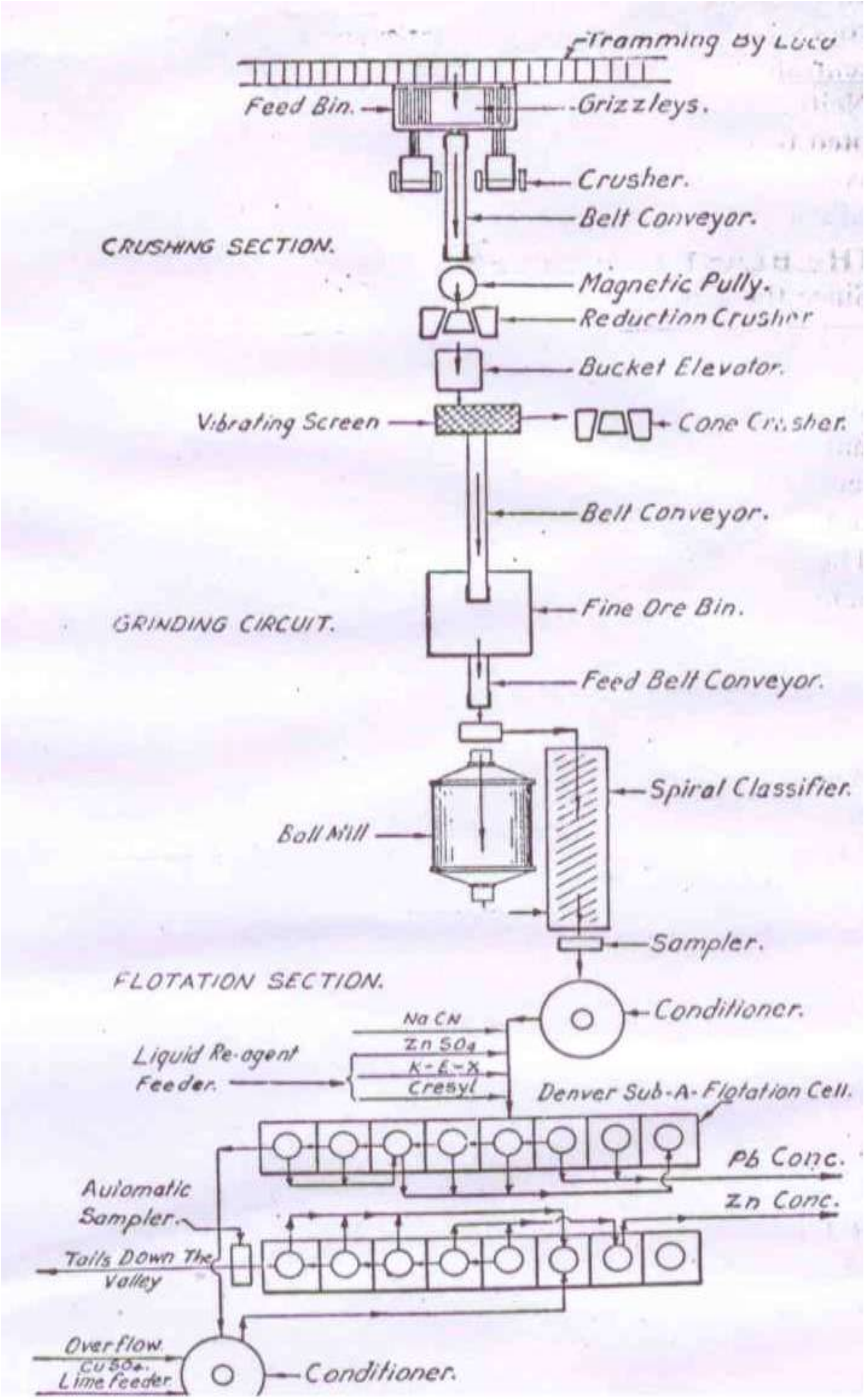


Figure – 30 : Usual treatment of a sulphide lead ore (Flow Sheet)



Ca CO_3

Figure – 31 : Flow-sheet for lead-zinc differential floatation

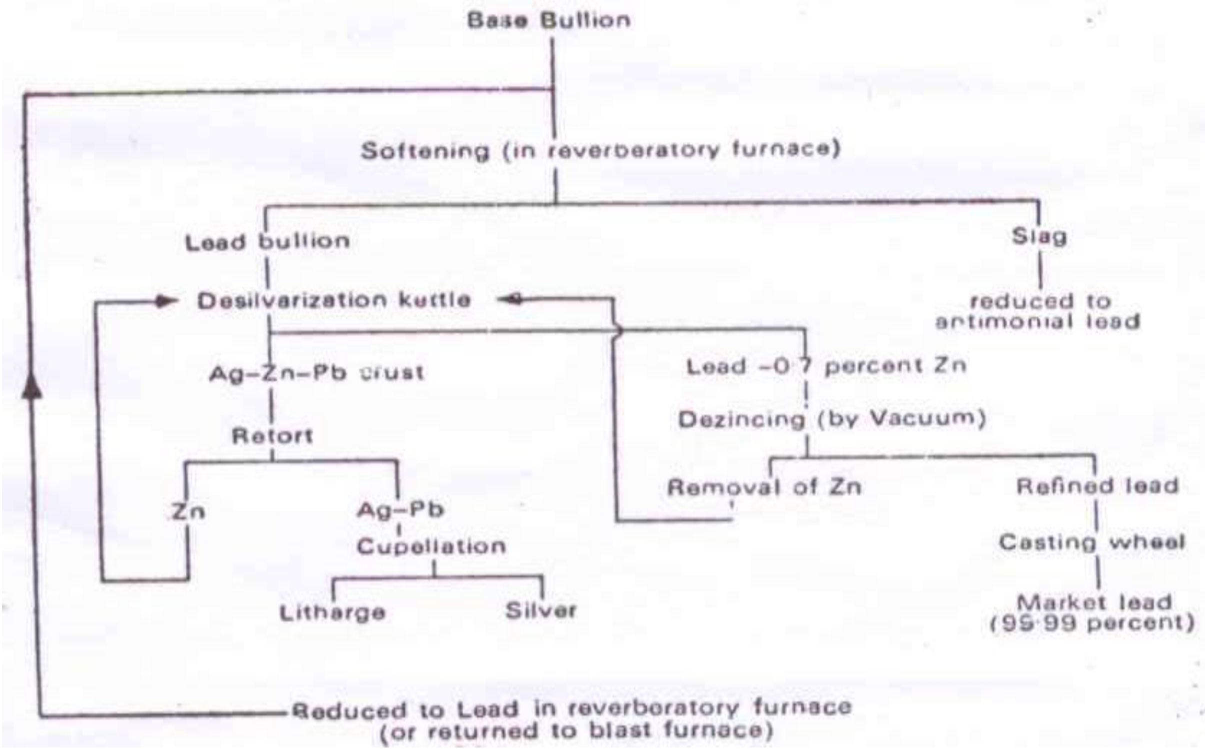


Figure – 32 : Lead refinery flow-sheet

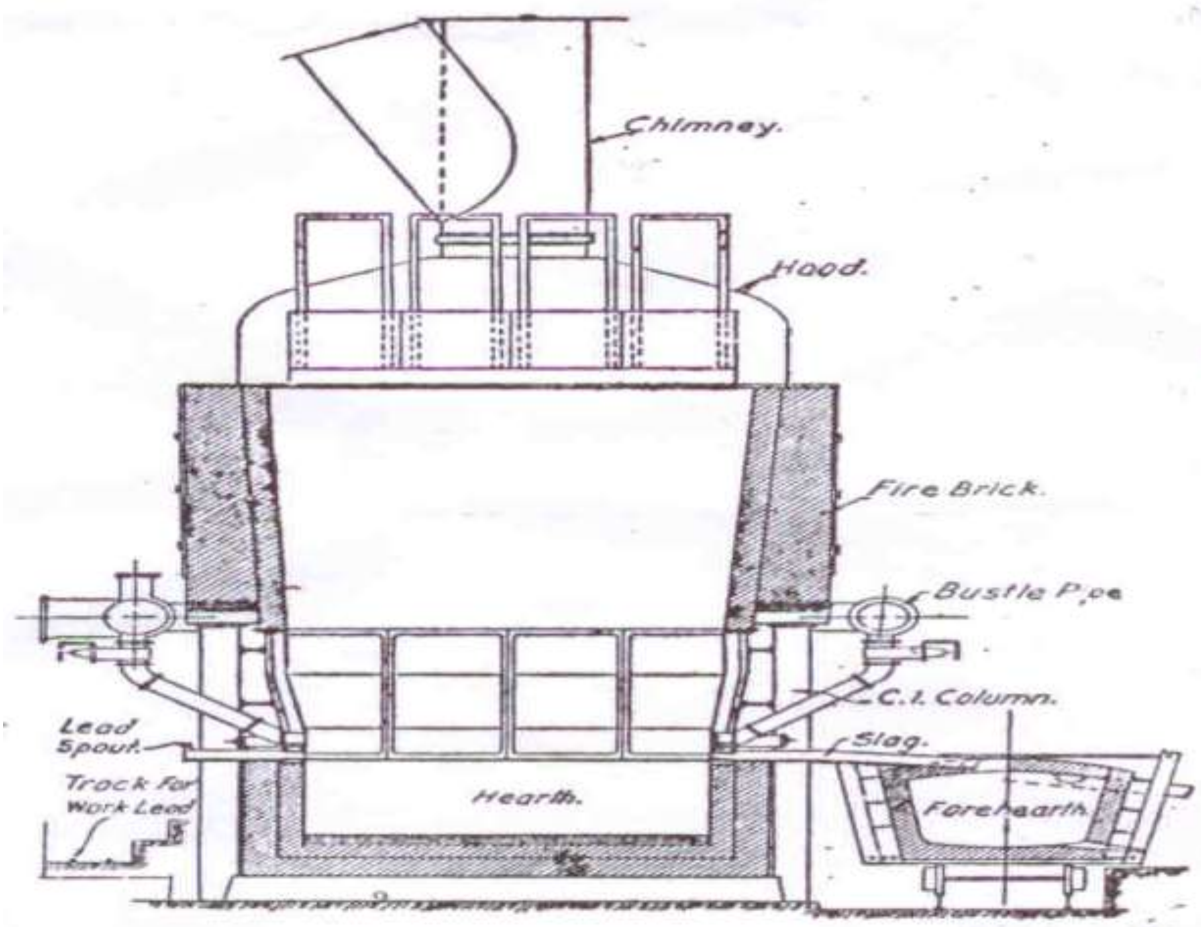


Figure – 33 : Lead blast furnace

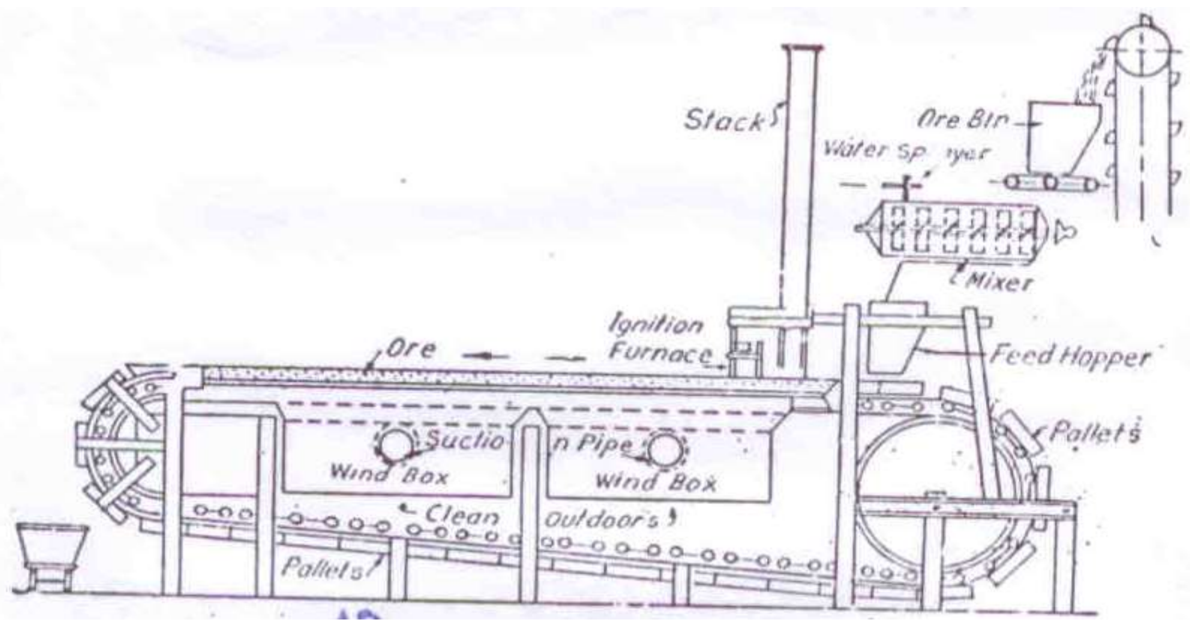


Figure – 34 : Dwight-Lloyd sintering machine

Sintering machine used for making big pallets from fines of ores so that their wastage be avoided. The dressing operation is also carried out and ore is agglomerated which is suitable for blast furnace charge.

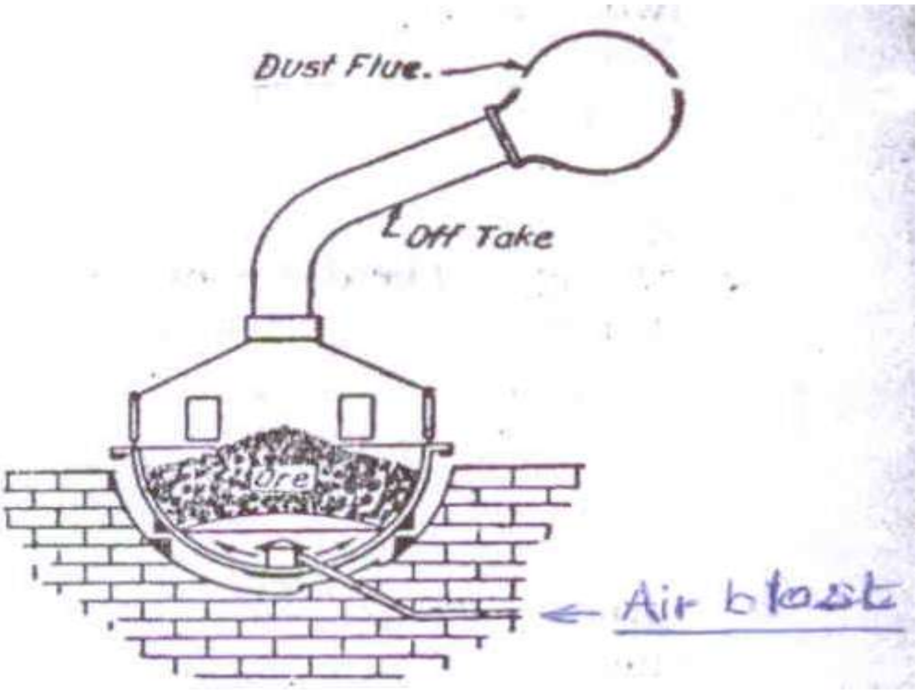


Figure – 35 : Huntington – Heberlein roasting pot

Roasting pot made of Cast Iron 10’ dia. and 5’ deep. Charge 8 – 10 tonnes. Time 4 – 6 hours. The charge is further charged into blast furnace.

Few Non-Ferrous Alloys of Engineering Importance

A. Aluminium Alloys

Aluminium alloys finds enormous uses in engineering industries for different components when alloyed with small amount of copper, silicon, manganese, iron and nickel.

Important alloys are –

(i) Aldural

Known as Alciad with a coating of 5% aluminium on duralumin to improve sea water corrosion resistance.

(ii) Aluminium Bronze

90 – 78% Cu and 10 – 22% of Al strong, hard, light, malleable yellowish brown and elastic, yellowish brown alloy. Good corrosion resistance used for pump rods and die casting as it is a substitute for Brass.

(iii) Duralumin

Very important alloy of aluminium. Composition – 94% Al, 4% Cu, Mg, Mn, Si and iron each 0.5%.

It possesses important property of 'Age hardening' used for aircraft, automobile industries, electric cables, surgical and orthopedic supplements or gadgets etc.

(iv) Y – Alloy

Compo 92.5% Al, Cu – 4%, Ni – 2% and Mg – 1.5%.

Good conductor of heat and possesses good strength at high temperature. Used for piston of engines, cylinder heads, gear boxes, propeller blades etc.

B. **<u>Copper Alloys</u>**

Main Categories

Brasses Bronzes

(i) **<u>Brass</u>**

Cu and Zn alloy with small amount of other elements except tin. Stronger than copper.

Common brass are :

- <u>Cartridge brass</u>
  70% Cu, 30% Zn with high tensile strength used for cartridges, tubes, springs etc.

- <u>Muntz metal or yellow metal</u>
  60% Cu, 40% Zn. High strength and used for castings and condenser tubes. Popular for hot working processes.

- <u>Navel brass</u>
  60% Cu, 39% Zn, 1% Sn. Used for marine and engineering castings condenser tubes, pump parts, motor boat shaftings etc.

- <u>Red brass or red metal</u>
  85% Cu, 15% Zn. Good corrosion resistance, superior to Cu and used for electrical sockets, plumbing lines.

- <u>Yellow brass</u>
  65% Cu, 35% Zn. Strong and also known as standard brass. Used for plumbing accessories, lamp fixtures, grille work, screws, rivets, tubes etc.

- <u>White brass</u>
  10% Cu, 90% Zn. Addition of Cu imparts hardness and strength. Mainly used for Ornamental work.

(ii) **<u>Bronze</u>**

The bronze is an alloy of Cu and Sn with other elements.

Common types of bronzes are :

- <u>Bell metal</u>
  82% Cu and 18% Sn. Hard and brittle and possesses property of resonance. Hence used for making bells.
- <u>Gun metal</u>
  88% Cu, 10% Sn and 2% Zinc. It is tough strong and hard. Good resistance to sea water corrosion. Suitable for castings. Used for bearings, bolts, nuts, bushings and for many items in navel constructions.

- <u>Manganese bronze</u>
  56 – 60% Cu, and remaining amount of Zinc with small amounts of Mn – 1% maximum Al, lead and iron each between 0.4 to 1%. Alloy has very good corrosion resistance to sea water and dilute acids. Used for various ship fittings, shafts, axles and other parts etc.

- <u>Phosphor bronze</u>
  89% Cu, 10% Sn and 1% phosphorous. Alloy is hard and strong. Alloy is highly resistant to sea water and has high endurance limit. Used for springs, gears, bearings, worm wheels, pump parts. It is easy to cast with sound castings.

C. **<u>Lead Alloys</u>**

Lead Alloyed with Sn (tin) form solders. When alloyed with tin and antimony maked Bearings known as Babbits or White metal. With tin, antimony and copper it makes 'type metal'.

D. **<u>Magnesium Alloys</u>**

These alloys are light and easily worked. Mainly used for construction of aeroplanes, chair frames, engine parts.

Two important alloys of magnesium:

Dow metal	-	4 – 12% Aluminium, 0.1 – 0.4% manganese and balance magnesium.
Electron metal	-	4% zinc, small percentage of Cu, Fe, Si and balance magnesium.

E. Copper – Nickel Alloys

Copper-Nickel	2 – 30% Nickel and rest copper. These alloys are used for surgical instruments, coins, utensils, ornaments, condensers and heat exchanger tubes.
Nickel-Silver	10 – 35% Nickel, 25 – 35% Zinc and 25 – 50% copper. Because of its silvery-white appearance it was known as German-Silver. They used for plumbing fixtures, camera optical parts, utensils, name plates etc., automobile fittings, food handling equipments. It has good resistance to atmospheric corrosion and organic acids.
Monel-metals	65% Nickel, 30% copper and 5% other metals like iron, manganese. Properties of this alloy is maintained at high temperature. Available in various grades depending on its use. Mainly used for textile and chemical industries, valves, tubes, propeller shafts of ships etc.

Technical Specifications :

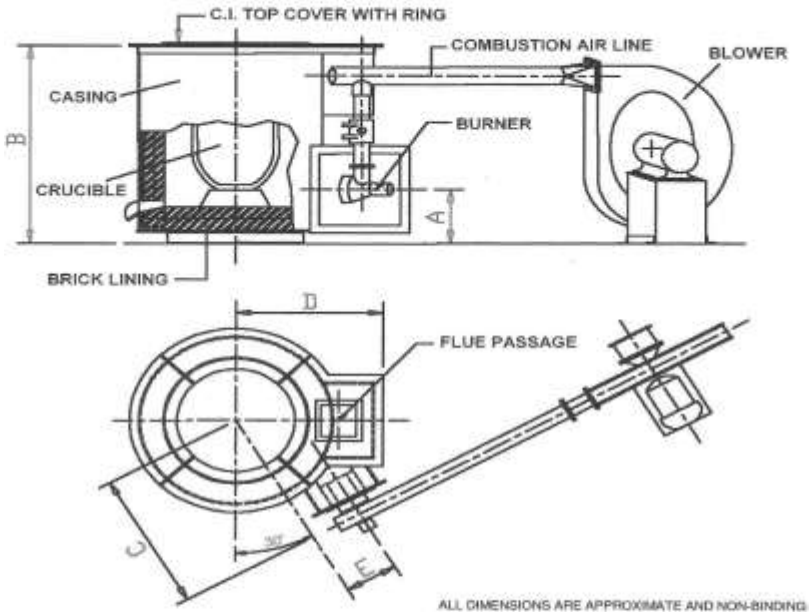
BALEOUT FURNACE WITH MELTING AND HOLDING UNITS FOR NON-FERROUS METALS :

The furnace is refractory-lined and supplied as complete package which includes blower, burner, and crucible. The durable body is constructed from thick reinforces mild steel plates. The crucible is available in options of either cast iron, graphite or silicon carbide.

The furnace is supplied with oil burner. Combustion air is provided by centrifugal blower. Preheated oil at constant temperature and pressure is supplied to the burner by a heating and pumping unit.

The burner fires tangentially inside the shell lining into a circular combustion space so that the hot gases surround the crucible, ensuring uniform heating. Waste gases pass out through a flue at one side, allowing reasonable working conditions for operator. Normally the flue discharge is upward for top exhaust. Optionally, waste gases can be collected in a fume extraction hood for discharge outside the production area.

Other accessories – Oil Service tank, Outflow heater, Fume extraction unit, Motor starter, Semi-rotary pump for oil tank.



MODEL	CHARGE IN KG AL	MELT TIME IN MIN		LITRES PER 100 KG AL	DIMENSIONS IN MM				
		FROM COLD	SUBSEQ CHARGE		A	B	C	D	E
B-3	150	120	90	22-25	350	934	980	820	300

ROTARY MELTING FURNACE :

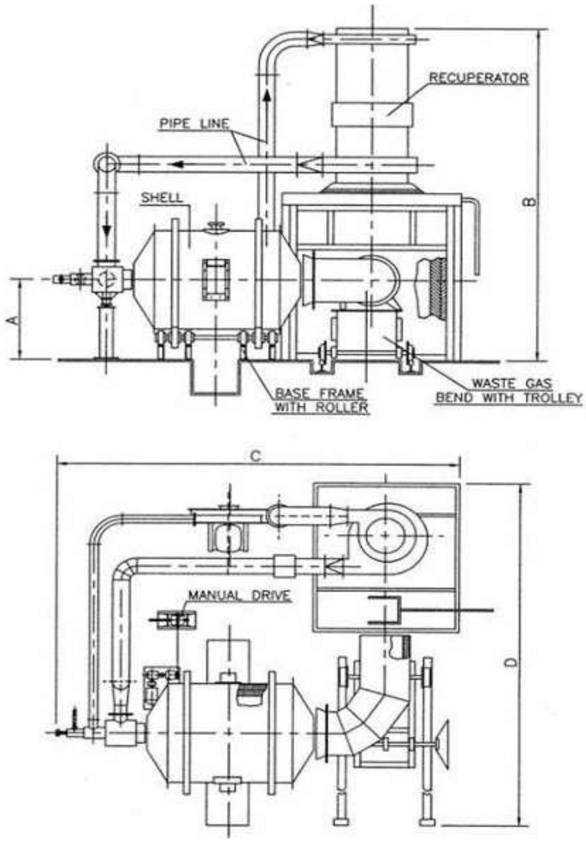
The furnace is designed primarily to melt iron but can also melt aluminium, copper, copper alloys, etc. When melting non-ferrous metals, the batch capacity as well as combustion system will change.

The furnace consists of a cylindrical shell fitted with two steel tyres supported on rollers mounted on a fabricated steel frame. The shell has two spouts and two lifting trunions and is rotated by friction between the tyre and rollers, which are driven by a motor via a worm reduction gear. Manual drive provision is optional.

A low air pressure burner capable of operation with preheated air is fitted. The burner can fire HSD, LDO, furnace oil or LSHS. Gas firing options are also offered.

A cylindrical radiation-type recuperator utilizing the waste products of combustion is provided to heat the combustion air. The recuperator is mounted either on fabricated structure or on brick-lined chamber. It receives the products of combustion from the furnace through a waste gas bend trolley. The furnace is charged by removing the trolley.

Other accessories – Oil Service tank, Outflow heater, Semi-rotary hand pump, Fume extraction unit, Motor starter, Lining material and ramming fixtures.



Model : RMF – 1000
Charge : 1000 Kg for Iron
Dimensions

A	:	1390 mm
B	:	6575 mm
C	:	5820 mm
D	:	7300 mm

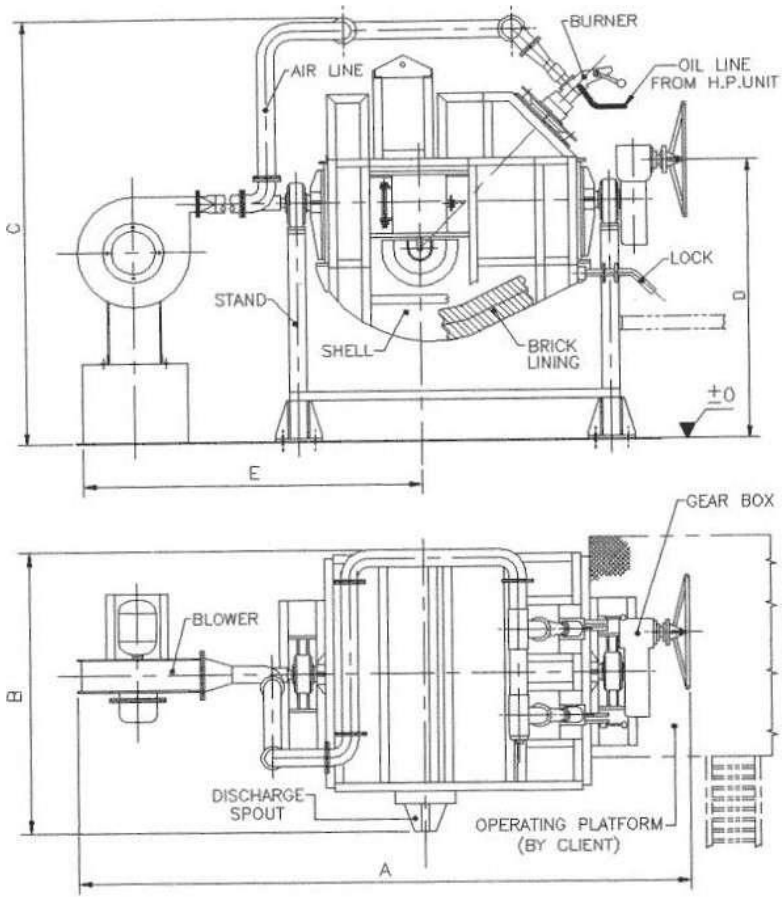
REVERBERATORY FURNACE :

Reverberatory furnaces are used primarily for melting copper and its alloys such as bronze and brass, and other metals such as aluminium, lead and zinc. The furnace is supplied with refractory lining, tilting gear arrangement, blower and burner.

The furnace is constructed from reinforces mild steel plates of substantial thickness, and is supported on a heavy fabricated stand through trunions on anti-friction bearings. The furnace is provided with tilting gear arrangement on one side shaft extension comprising a worm, worm wheel, bevel gears and large hand wheel for easy manual operation (motorized drive arrangement with inching facility is optionally available).

The furnace is fitted with self-proportioning oil burner. The burner is arranged to fire directly inside the shell lining. Waste gases pass out through vertical flue passage which also serves as a charging door, enabling the charge to be preheated before melting. Products of combustion may be collected in an optional fume extraction unit for discharge outside the shop.

Other accessories – Oil Service tank, Outflow heater, Semi-rotary pump for oil tank, Fume extraction unit.



Model : RV-10

Capacity :

Brass : 450 Kg

Aluminium : 150 Kg

Dimensions

A : 4800 mm

B : 1625 mm

C : 2500 mm

D : 1550 mm

E : 3050 mm

ELECTRIC INDUCTION FURNACE :

1.	Furnace Capacity	: 500 Kgs
2.	MF Power (KW)	: 250 KW
3.	Transformer Capacity	: 315 KVA
4.	Solid State Power Panel Efficiency	: 95%
5.	Frequency	: 1000 Hz
6.	Maximum Mains	: 280 KVA
7.	Mains PF	: 0.94 (min at rated mains voltage & max power setting)
8.	Load Matching	: by automatic frequency shifting with constant power tracking
9.	Steel Melting Rate @ 1675^{0}C for Steel Scrap 100% yield	: 440 Kgs/hr
10.	Energy Consumption @ 1675^{0}C for Steel Scrap 100% yield	: 550 KWH/Ton
11.	DM Water Requirement	: 500 Litre
12.	Over Head Storage Tank Capacity	: 10000 Litre
13.	Cooling Tower Duty in LPM for temp. drop from 42^{0}C to 32^{0}C	: 225
14.	Underground Storage Tank Capacity	: 30000 Litre

Questions :

(a) Show classification of various ferrous alloys.

(b) Write note on manufacture of pig iron.

(c) Enumerate types of pig iron.

(d) Describe various processes of manufacture of wrought iron.

(e) Write short note on Cast Iron and its process of manufacture.

(f) Explain following :-

- Bessemer process
- Open hearth (furnace) process
- Oxygen process
- Kaldo process
- Electric arc furnace process
- Manufacture of aluminium
- Copper and its Alloys
- Zinc
- Tin metal extraction
- Ferrous and non-ferrous alloys of engineering importance.

UNIT - 2

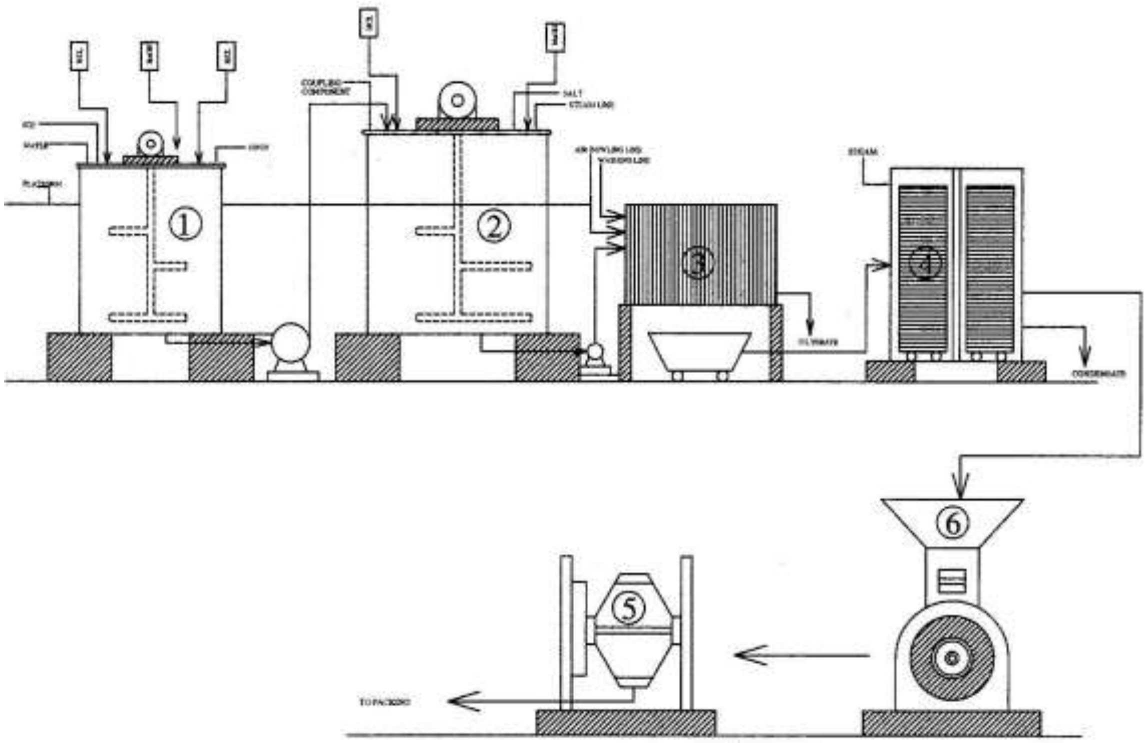
CHEMICAL (DYES)

OBJECTIVES :

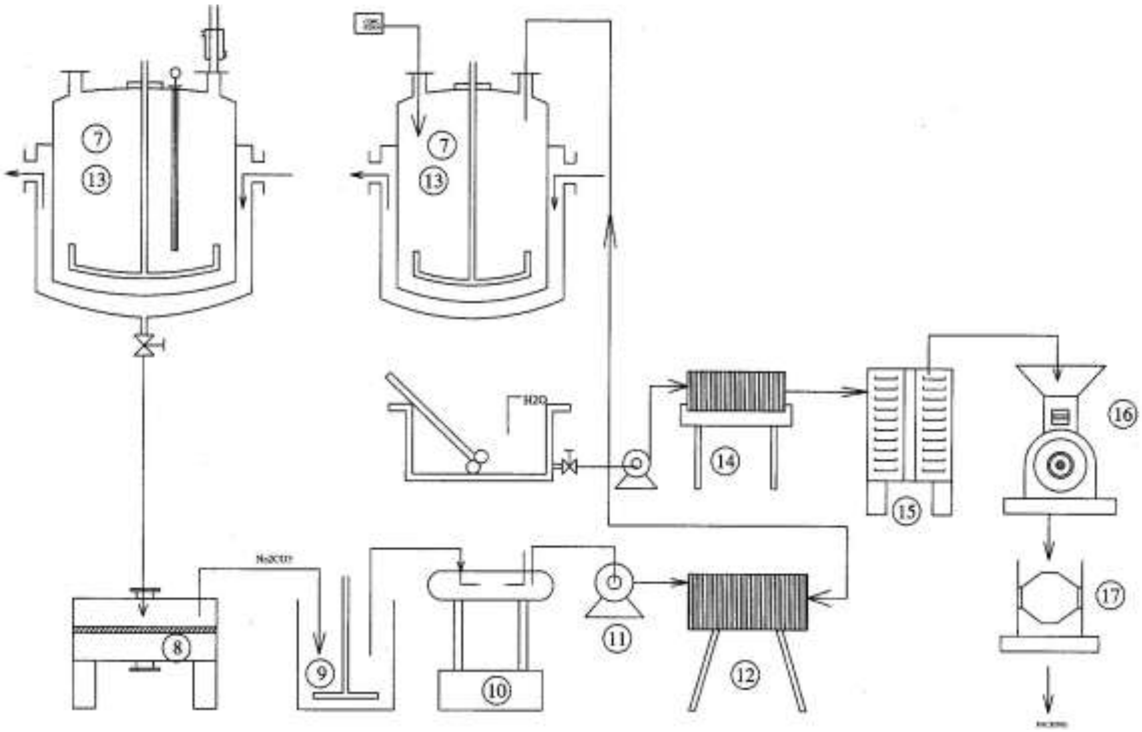
By the end of this chapter students will learn about :-

- Flow chart for manufacture of AZO dyes
- Flow chart for manufacture of VAT dyes
- Brief description of manufacturing process and products
- Process control and quality control
- Technical specifications of machines

Flow chart for the manufacturing of Azo Dyes



Flow chart for the manufacturing of VAT Dyes



1. Glass lined reactor for Diazotization Coupling
2. Glass lined reactor for
3. Wooden plate and frame filter press
4. Vacuum Dryer
5. Mixer
6. Pulveriser
7. Glass lined reactor
8. Filter Box
9. Dilution tank
10. Steam Distillation Unit
11. C.I. Pump
12. Wooden Filter Press
13. M.S. Reactor for Pasting
14. Wooden Filter Press
15. Tray Dryer
16. Pulveriser
17. Mixer

Brief Description of Manufacturing Process and Products

Dyestuff manufacture is extremely complex on account of the large number and variety of reactions, intermediates and final products involved. Depending on economics of the scale of operation and specialization, the big units manufacture most of the intermediates and also the end products. Smaller units manufacture only some of the intermediates and final products. Among the long series of reactions are Sulphonation, nitration, amination, catalytic reduction and oxidation, hydroxidation, alkylation, carboxilation, diazotization and coupling cyclizations and condensations etc. These are followed by unit operations such as precipitation, filtration, drying, grinding, blending and finally packing.

Reaction Chemistry and Process Description

In the Glass Lined reactors, the diazotization and coupling reactions takes place where the azo group i.e. N = N is formed. Azo dyes have the basic structure:

AR – N = N – AR' where AR and AR' are two aromatic groups.

The unit containing the nitrogen-nitrogen double bond is called an azo group. The nature of the aromatic substituents on both sides of the azo group controls the colours of the azo compounds as well as the water-solubility of the dyes and how well they bind to a particular fabric.

e.g. To prepare the azo dye 1-(4-hydroxyphenylazo)-2-naphthol by the diazonium coupling reaction of naphthalen-2-ol with the benzenediazonium ion obtained from 4-aminophenol:

There are several important steps in the experiment which have to be carried out carefully. The benzenediazonium salt solution is unstable and prone to deteriorate (decompose) upon standing at room temperature. The solution should always be kept at below 10 °C and should be used as soon as it is generated.

Naphthalen-2-ol dissolves poorly in acidic aqueous solutions. To prevent naphthalen-2-ol from precipitating out prematurely, the addition of the acidic benzenediazonium solution to the naphthalen-2-ol solution should be slow. The mixture forms a thick paste during addition. Stir the mixture efficiently to facilitate the reaction.

The black precipitate formed during the reaction is then filtered by passing through a filter press. The product is then washed thoroughly. Next Vacuum drying is carried out followed by various unit operations and finally our final product azo dye is obtained.

In view of the highly corrosive acids, alkalies and oxidizing agents used, high pressure reaction and hazards of toxicity, fire and explosions, specialized plant, machinery and equipment are needed and stringent precautions are followed in the operation of the plant and processes in dyestuff industry. Some of the plant and equipment used are listed below:

Reaction Kettles - Wooden Vats, M.S. rubber lined, brick lined, glass lined, cast iron or stainless steel.

Tanks of various types with heating and cooling devices.

High Pressure Autoclaves

Evaporation Units

Distillation Units

Heat Transfer Units

Crystallizers

Various types of Pumps for transferring liquids and semi-liquids

Various types of filters and filter presses

Driers of different types such as Air Driers, Vacuum Driers, Grinders, Pulverisers, Ball Mills.

Blenders or mixers

Some of the auxiliary equipment which provide the services or the utilities for the dyestuff industry are the following:

Boilers for Steam

Ice plants for providing Ice.

Brine and Chilled Water Plants to provide Brine and Chilled Water.

Cooling Water Units

Compressed Air Units

The above service equipment and the service lines for conveying the above services or utilities including electricity to different process points form a large proportion of the total value of Machinery and Equipment used in dyestuff industry.

The final and essential stage of the manufacture of a dyestuff is the standardization of shades, concentration and physical form on which depend the dyeing properties. In view of various intermediate stages involved, some variation in purity of the dye from batch to batch result in spite of rigid quality controls and process controls. Standardization may involve mixing different batches of the same dye to get the desired shade.

The desired market grades and shades may not be readily available in the final product and frequently a dye has therefore to be “shaded” with a second dye or sometimes even with two or three dyes keeping in mind the need for individual dye in a mixture to have a very similar dyeing fastness properties. The dilutants or reduction materials used in standardization should be such that they facilitate the application of the dyestuff or at least innocuous. Some of the dilutants added to finished dyestuff are:

Sodium Chloride
Sodium Sulphate
Sodium Bicarbonate
Sodium Carbonate
Other Dispersing Agents

Process Control and Quality Control:

In view of the requirement to obtain a product of standard quality and optimum yield, temperature, pH, concentration, pressure etc. need to be regulated rigidly and the material in process has to be tested in the plant laboratories at various stages. A well equipped laboratory is attached to each manufacturing plant. The final product, its shade and concentration, market grade etc. are tested and rated in the Quality Control Laboratories which are independent from the manufacturing plants.

CVSRTA

TECHNICAL SPECIFICATIONS OF EQUIPMENTS & MACHINERY

1. Glass lined reactor for Diazorization

Model	:	AE 250 Glass lined reactor
Capacity	:	Vessel : 250 litres (nominal) 334 litres (total)
Dimension	:	OD 700 mm and overall height 1030 mm
Weight	:	Approximately 810 kg empty with accessories
Code	:	ASME VIII, Div 1 Unstamped
Design pressure	:	Inner vessel : F.V / + 6.0 Bar g Jacket : F.V / + 6.0 Bar g
Design temperature	:	-25^{0}C to 200^{0}C
Material of construction	:	Inner Vessel Body Material as per DIN 17155H1/ EN 10028-2 P235 GH or equivalent, Jacket material DIN 17155H1/ EN 10028-2 P235 GH or SA516 Gr60 or equivalent, Nozzle necks on inner vessel are of forged steel 'C ' clamps for body flange and manhole flange of forged steel.
Exterior finish	:	Pre-treatment removal of rust by blasting 1 coat of red epoxy primer
Lining	:	Pfaudler 9100 Blue.
Process nozzles	:	Top Head : 2 nos. 50 mm dia. 3 nos. 80 mm dia. 1 no. 80 mm dia. for Agitator entry 1 no. 150 mm dia. for Handhole assembly with 50 mm dia. sight glass

		Bottom Dish: 1 no. 76 mm x 50 mm Glass lined bottom outlet valve GPF – 202
		Main flange and all glass faces will be provided with PTFE envelope type gaskets with corrugated stainless steel ring and CAF inserts
Jacket nozzle	:	2 nos. 40 mm dia.
Drilling standard	:	Split backing flanges – PN – 10 DIN 2673
Supports	:	4 nos. side bracket / leg supports
Hydraulic test pressure	:	Pressure tested in accordance with code.
Stress relief	:	All hearing cycles will be as required for glassing process.
Other NDT	:	In accordance with code.
Corrosion allowance	:	1.5 mm external : Inner vessel 1.5 mm internal : Jacket
Agitator	:	Impeller agitator at 96 RPM
Baffle	:	Baffle Thermowell for impeller agitator.
Drive	:	Drive consisting of cast/fabricated box section leg type drive stool. ▪ Worm Reduction gear box, Radicon / Elecon make. ▪ Belt drive.
Shaft closure	:	Single dry mechanical seal of Hi-fab / Leakproof make.
Motor	:	3.0 hp (2.2 kW0 Flame proof, Crompton / BBI make.

2. Glass lined reactor for Coupling

Same as Serial No. 1

3. Wooden plate and frame Filter Press

* Material to be filtered (Ltrs.)

  Operating temperature (^0C)

  Operating pressure (kg / cm^2)

  Flammable / Non-flammable / Others

* Type of plate
  Chamber / plate & frame

* Plate size

* Cake thickness
* Number of chambers

* Material of filter press plate
  C.I. / P.P. / Wood

* Filter press body
  C.I. commercial / C.I. graded / M.S.

* Material of flanges
  M.S.R.L. / C.I. / S.S. / P.P.

* Type of closing device

  Ratchet closing

  Manually operated hydraulic closing mechanism with hand pump.

  Electrically operated hydraulic closing mechanism.

CVSRTA

* Filtrate discharge
Closed / Open

* Washing
Simple / Thorough

* Dip collection tray
M.S. / S.S. / P.P. / F.R.P. / Other

Auto shifter
Plate shifting device.

4. <u>Vacuum Dryer</u>

Specifications:

1.	Overall size	:	1500 mm W x 2000 mm H x 1000 mm D Dryer shall be mounted on channel legs.
2.	M.O.C.	:	Outer shell is made out of 6 mm thick SS 316 plate with 50 mm thick glasswool insulation on the vacuum chamber outer surface, the insulation enclosed with tag welded 16 gauge SS 304 panels fitted in a SS 304 angle frame.
3.	Design temperature	:	100 Deg. C’
4.	Working temperature	:	80 Deg C’
5.	Design pressure	:	Shell 1 kg per sq cm. to full vacuum Jacket / hot plates 5 kg per sq. cm.
6.	No. of hot plates	:	12 nos. + 1 no. dummy shelf SS 316 Size: 1250 x 900 x 25 mm

7.	No. of trays	:	36 nos. SS 316 size 16” x 36” x 1 ¼” with mirror buffing polishing.
8.	Door	:	SS 316, 8 mm thick 1 no. door fitted with heavy duty hinges.
9.	Locking arrangement	:	The door is locked to the dryer chamber with SS 304 “I” bolts.
10.	Nozzle	:	All the nozzles are as per ASA 150, raised face Vacuum inlet of 150 NB Heating plates heeder inlet 1” and outlet ½” Two no. view glass of 100 NB with toughen glass. Vacuum chamber drain of ½” BSP N2 purging for vacuum breaking of ½” BSP Vacuum gauge connection of ½ BSP.
11.	Testing	:	The vacuum dryer shelves are hydro tested at 5 kg per sq. cm. in assembled condition. The vacuum chamber also tested for leaks under vacuum.
12.	Finish	:	The door is buffed to a dull/matt finish from outside and inside all material contact part will be mirror buffing polishing.

5. Mixer

* Mixer used for

  Mixing Blending Dissolving

  Emulsion Solid suspension

  Gas dispersion Crystallisation

  Any other

* Degree of agitation

  Gentle

  Medium

  Violent

Name	Solid/ liquid/ paste	% wt.	Bulk density gms/cm^3	Specific gravity gms/cm^3	Temp. ^0C	Viscosity	pH

* Desired cycle time – charging / mixing / heating / cooling / discharge (minutes)

* Jacket – heating or cooling media

  Type temp ^0C. pressure kg/cm^2

* Operating pressure Vacuum Type of seal

* Are the solids :

crystalline	Crumbly	slimy	sticky	pasty	hygroscopic

* Particle size analysis

Percentage								
Micron								

* Is process

  Continuous? If yes, production rate.

* Batch capacity

  M^3, Batches per day

* Material of construction

6. **<u>Pulverizer</u>**

* Name of material

* Apparent loose density in cu. ft.

* Size of feed   Feed temperature ^{0}C   Specific heat

* Final moisture   Total H_2O. %

  Surface moisture. %

* Product fineness

* Maximum permissible product temperature. ^{0}C

* Type of heat   Direct   Indirect   kcal value of fuel

* Source of heat	Gas		pressure (psig)
	Oil		kind
	Steam		pressure (psig)
	Waste heat		temperature ^{0}C
* Elevation above sea level			
* Electric supply	Phase	Cycles	Volts
* Type of final dust collection equipment			

7. Glass lined Reactor

Same as Serial No. 1

8. Filter Box

SS 316 conical type filter with dish type top lid and conical bottom fabricate with main body 6 mm thick and 5 mm thick plate jacket and inside perforated basket with 'J' type locking arrangement with silicon gasket with mirror buffing polishing.

Size: 420 mm OD x 700 mm H

9. Dilution Tank

Capacity	:	6000 litres
Material of construction	:	S.S. 316
Size	:	1700 mm dia. x 2400 mm height
Thickness of shell	:	5 mm
Thickness of dished ends	:	6 mm
Dia. of manhole	:	400 mm
Dia. of sight glass	:	100 mm
Dia. of light glass	:	100 mm
Dia. of vent	:	50 mm
Dia. of outlet	:	50 mm

Spare nozzle	:	32 mm dia., 25 mm dia. x 50 mm dia. with blind flanges.
Dia. of sampling	:	15 mm
Supports	:	Channel supports
Finishing	:	All S.S. internal parts mirror polished and outer surface are satin polished. All M.S. surface painted with metal primer and coated with enamel paint.

10. <u>Steam Distillation Unit</u>

Type	:	Sieve tray type vertical cylindrical sections. Material of construction of all contact parts S.S. 304 Body flant M.S. (Boiler quality) with S.S. 304 liner. Skirt support IS 226
Nozzle necks	:	A 312 TP 304 seamless
Nozzle flanges up to 100 NB	:	S.S. 304
Solid nozzle flanges 150 NB and above	:	CS plates flanges with S.S. 304 liner
Size	:	700 I.D. x 6800 mm height
Thickness of shell	:	6 mm
Thickness of dished ends	:	6 mm nominal 5 mm minimum
Thickness of body flanges	:	40 mm thick C.S. (Boiler quality) with 10 mm thick S.S. 304 liner.
Supports	:	Skirt support of size 700 mm x 4050 mm height x 6 mm thick.
Trays	:	24 nos. S.S. 304 quality trays. Thickness 3 mm with 6 mm perforation trays supported on tie rods with appropriate spacers.
Radiography	:	Dished ends – full.
Other major butt welded joints	:	Spot (10%)

Polish	:	Internals given mirror polish while dished ends have satin finish from outside.
Empty weight	:	2200 kg

11. C.I. Pump

* Capacity m^3 / hr

* Liquid to be pumped

  Specific gravity
  pH
  Temperature (^{0}C)

  Vapour pressure (at above temperature)
  Viscosity

  Aeration conditions

* Solids in suspension

  Hard, soft, gritty, crystalline
  Specific gravity
  Quantity (% by weight)
  Particle size (mm)

* Duty

  Continuous intermittent delivery head (m)

  Suction head or lift (m)
  Total dynamic head (m)
  Pipeline, Material
  Diameter Length
  Fittings

* Service conditions

  Contamination

  Crystal formation due to temperature drop

* Type of pump

Direct coupled	Rubber lined
V-belt drive	Hard iron
Overhead V-belt drive	

* Drive

  Power supply
  Volts
  Phase
  Cycle

12. Wooden Filter Press

Same as Serial No. 3

13. M.S. Reactor for Pasting

Capacity	:	7000 litres
Type	:	Vertical cylindrical with welded top and bottom dished ends.
Material of construction	:	All contact parts in process fluid S.S. 316 L
Internal coil	:	S.S. 316 L seamless
Limpet coil	:	S.S. 304
Nozzle necks up to 100 mm dia.	:	S.S. 316 L / S.S. 304 seamless pipe.
Nozzle necks above 100 mm dia.	:	Fabricated from plates provided with 100% radiography.

Nozzle flanges for nozzles up to 100 NB	:	S.S. 316 L / S.S. 304
Nozzle flanges for nozzles 150 NB and above	:	C.S. plates with S.S. 304 liner.
Size	:	1800 mm ID x 2500 mm Tan to Tan height.

Thickness

Shell	:	8 mm
Dished ends	:	10 mm nominal 8 mm minimum
Baffles	:	2420 mm length x 85 mm width x 8 mm thick
Number of baffles	:	2
Limpet coil	:	80 mm dia. x 3 mm thick ellipsoidal
Internal coil	:	40 NB x Schedule 10S ASTM A312 TP S.S. 316 L seamless
Radiography	:	Dished ends – full
Other major butt weld joints	:	Spot (10%)
Polish	:	Internals given mirror polish while top dished ends have satin finish from outside.
Agitator	:	Driven by means of 15 hp, 1440/720 rpm dual speed flame proof (FLP) motor through a suitable speed reduction gear box to give final output rpm of approximately 100 and 50 to the shaft. Shaft is of 80 mm dia. and made out of S.S. 316 L bar. The shaft is provided with 2 nos. turbine type impellers fabricated out of S.S. 316 L plates. Agitator complete with necessary couplings, bearing, housing, water cooled stuffing box and M.S. support stool.

14. Wooden Filter Press

Same as Serial No. 3

15. Tray Dryer

1.	Size	:	1450 mm L x 550 mm D x 1100 mm H (1) Outer surface 12 swg M.S. sheet (2) Inner surface 18 swg SS 316 sheet With 1 no. door fitted with food grade neoprene gasket.
2.	Insulation	:	With glass wool 60 mm thick.
3.	Exhaust fan	:	1 no. S.S. 316 fan fitted with 20 mm pedestal type bearing.
4.	Fan drive	:	½ hp, 1440 rpm, 3 phase motor 1 no.
5.	Steam coil	:	SS 316 standard size ¾" OD, 16 gauge fin tube with header – 2 nos.
6.	Thermometer	:	Standard make FLP digital indicator-cum-controller with PT-100 RTD sensor.
7.	Trolley & tray	:	SS 316, 18 gauge size 16" x 32 x 1 ¼" 12 nos. tray with SS 316 angle fix type trolley.
8.	Starter	:	Standard makes FLP push button type – 1 no.
9.	Filter	:	SS 304 5 micron inlet air filter – 1 no.
10.	Finishing	:	Outside enamel paint and inside all SS contact part will be mirror buffing polishing.

CVSRTA

16. **Pulvarizer**

Same as Serial No. 6

17. **Mixer**

Same as Serial No. 5

UNIT - 3

PHARMACEUTICAL

OBJECTIVES :

By the end of this chapter students will learn about :-

- Flow diagram for manufacturing of Tablet, Injection, Liquid oral, ointment and fine chemical department.
- Machinery used in manufacture of above products.
- Technical specifications of machinery used in manufacture.

Flow Diagram :

Raw material receipt at R.M. Stores and kept in Quarantine.

↓

Sample of raw material taken for quality control dept. and labeled as 'under testing'.

↓

Q.C. passed material – taken as stock – labeled as 'passed'.

↓

Q.C. failed material - labeled as Rejected to be returned to supplier

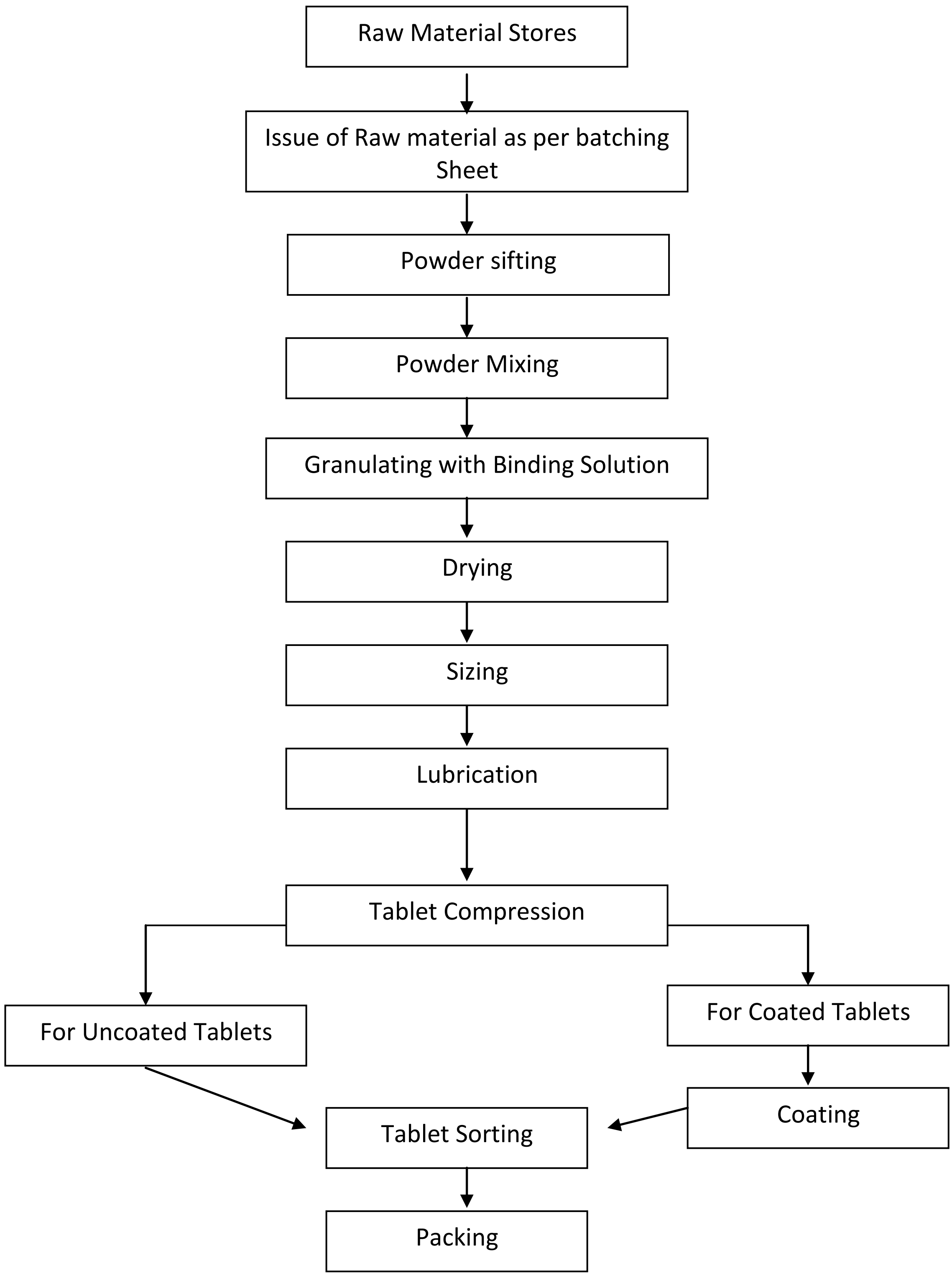
Raw material issue as per batching sheet in presence of production and quality control chemist.

↓

Raw material taken to manufacturing department and recheck weight.

Up to this, procedure is common for all – Tablet Manufacturing, Injection Manufacturing, Liquid oral, Ointment and Fine Chemical Department.

Tablet Manufacturing Process



TABLET MIXING SECTION

Raw material in powder form is weight checked and sieved in a sifting machine to remove foreign particles.

↓

Raw material mixed in a mixer and required binder added

↓

Passed through roll compactor (if required)

↓

Material dried using fluid bed or tray drier / if granulated using binder solution / paste

↓

Passed through fitz mill/granulator to have desired sized granules.

↓

Lubricated

↓

Kept in air tight drums for further dispatch to compression.

Here “In Process Quality Control” (I.P.Q.C.) is performed to get a better-desired result of the tablet. If need be, required reprocessing is carried out.

TABLET COMPRESSION

Mixed powder is loaded to compression machine to have desired sized and shape of the tablets with required dose. Physical checking like – measurement, Dissolution Test (D.T.), friability test, Hardness etc are done intermittently. If necessary machine is reset/adjusted.

Tablets required to do coating is sent to coating departments for sugar coating /film coating.

Tablets are dried in tray drier if required

Tablets are sent for sorting to check – if broken/damaged in the handling. Good tablets are sent to quarantine

Final quality control is performed to give permission for packing.

TABLETS PACKING DEPARTMENT

Tablets are strip packed / blister packed / container packed as per requirement of marketing.

↓

Packed in Transport worthy final pack and sent to finished goods stores for further dispatch to market.

INJECTION MANUCTURING

Recheck the weights of raw materials before starting the solution preparation.

↓

Start mixing of ingredients as per batching sheets in clean area under laminar flow units – in aseptic/bacteria free condition – air conditioned – positive pressure, filter the solution and keep ready for primary packing.

↓

Quality control department – takes the sample for analysis and if approved – taken for primary packing. Failed material – either sent for reprocess or discarded.

↓

Primary packing materials like – Ampoules – Vials, are washed with distilled water – dried and sterilized in an oven and kept ready for primary packing.

↓

Q.C. approved solution/materials is taken for ampoule/vial – filling sealing machine.

↓

Autoclaved for leak testing and final sterilization before secondary packing.

INJECTION PACKING

Ampoules/Vials are visually inspected for suspended particles/any foreign material present and proper sealing.

↓

Good ampoules/vials are labeled – manual/machine and packed in secondary pack – carton with name of manufacturer, content of the material, batch no, license no, manufacturing date and expiry date etc.

After Q.C. release, the material is sent in a transport pack to finished good stores for further dispatch to market.

PHARMACEUTICAL MANUFACTURING

Pharmaceutical products are broadly classified for as follows :

(a) Tablets
(b) Syrups and suspension
(c) Capsules – soft sules and hard gelatin
(d) Injectables – intravenous and intra muscular
(e) Ointments – eyes and skin
(f) Dry powders for oral and injectables
(g) Eye, nose and eardrops.

For manufacturing, In Process Quality Control (I.P.Q.C.) and Quality Control (Q.C.) of above product, one need to satisfy following conditions : -

- Manufacturing licenses from Food and Drug Administrative (F.D.A.) authorities.
- A competent Chemist approved by F.D.A.
- I.S.O., W.H.O. & U.S.A. F.D.A. approval in appropriate cases.

Use of best raw material is prime requirement of any industries; pharmaceutical industries have to use the best available material for best quality product.

The raw material received from market is kept in quarantine in raw material stores till it is tested and approved by Q.C. department. Q.C. approves raw material as "**PASSED**". The passed raw material weight is checked, labeled and recorded as stock.

TABLET MIXING

PROCESS DESCRIPTION	MACHINE USED
Weighing of raw material as per batching sheet	Weighing machine
Check weight of ingredients before mixing	Weighing Machine
Sieve it through shifter to remove foreign particles	Sifter
Prepare binder solution	Kettle with heating and stirring arrangement

PROCESS DESCRIPTION	**MACHINE USED**
Mix the ingredients with binder, lubricant to form granules.	S.S. Mixer / Blender
Pass through roll compactor/fluid bed drier/Tray drier	Roll Compactor Fluid bed/tray drier
If need be, pass through colloid mill to have required particle size	Colloid mill/Fritz mill
Pass through granulator to have even size of granules	Oscillating Granulator
Keep in air tight container with proper label – batch no., name of product with date & weight for further processing to compression	
Ensure giving sample for Q.C. to test the consistency.	
After approval of Q.C. – forward the in process product to tablet compression.	

TABLET COMPRESSION

For Coated and Uncoated tablets :

The entire area is under air conditioning and filtered air with local dust collector (at the point of dust generation)

PROCESS DESCRIPTION	MACHINE USED
Tablet compression – double layer, two core, single core in different shape and size	Rotary machines – 16, 27,36 stations, Presscoata, Reciprocating and High speed machine
Tools used	Dies and punches of different sizes
Tablet testing	Friability test, hardness tester, D.T. machine, weighing balance

After compression, the uncoated tablets are sent to I.P.Q.C. and if passed the tablets are forwarded to packing department in sealed containers labeled with product name, batch number, manufacturing date, I.P.Q.C. approval.

TABLET COATING

Tablets required to be coated are sent to coating section for sugar coating/film coating/enteric coating. The tablets are coated in coating pans with hot air supply system and spraying gun for film coating or manually. The coating pans are made out of S.S. plates with different sizes as per requirements.

Dust collection system is installed with water scrubber.

The coated tablets are checked by Q.C. department and after their approval sent for packing with proper label.

TABLETS PACKING

Tablets uncoated/coated are sorted on sorting belt for breakage/damage or improper shape before it is packed. The packing is done as under :

- Container - Automatic counting machine is used or shovel counters are used.
- Strip packing (Aluminium or glass in foil) – strip-packing machine is used.
- Blister packing - Blister-packing machine is used.

Each container/strip or blister pack is marked with following:

– manufactures name,
– manufacturers license number
– ingredients used
– batch number
– date of manufacturing
– date of expiry
– maximum retail price.

The product is packed in shippers' bulk packing for further dispatch to finished product stores and to market.

SYRUP DEPARTMENT

The procedure to get the raw material from raw material stores for preparation of syrup is the same as described for tablet department.

Most of syrup preparations are sugar based. For dissolving sugar, heated demineralised water collected in 1000 to 2000 litres of S.S. tank with mechanical stirrer is used for rapid mixing. Sugar syrup is filtered through filter press and collected in another tank to add different ingredients/vitamins. If need be, this mixture is passed through homogenizer to get the desired consistency. Quality control department again tests this and after their approval it is pumped to packing department.

By and large the machinery used in preparation of syrup department are S.S. tanks of different sizes with steam heating systems and mechanical stirrer, Filter press, Pumps, Homogenizer, Demineralised water plant.

SYRUP PACKING

By use of pump the syrup is transferred to liquid filling machine. Empty bottles are washed in the washing machine and made totally hygienic for filling the liquid. The bottles are thoroughly inspected to ensure that it is dirt free, without breakage or any abnormality. The bottles are filled with two head, four head, six head or multi head filling machines. In case of suspensions, the product is kept under stirring to prevent settling down of material in tank.

The filled bottles are sealed with capping machine, inspected for the right quantity of liquid and proper sealing before passing through labeling machine.

The following data is in corporated on the labels of filled bottles :

– manufactures name,
– manufacturers license number
– ingredients used
– batch number
– date of manufacturing
– date of expiry
– maximum retail price.

After labeling the bottles are packed in cartons with necessary insert – further packed in shippers bulk packing. Final Q.C. check is carried out before sent to finished product stores and dispatched to market.

CAPSULES

Empty gelatin capsules are stored in air conditioned rooms.

The required dry powder is prepared in a form of a mixture by blending in air-conditioned-filtered air controlled area.

The empty gelatin capsules are opened by the capsule filling machine; dry powder is filled in and the capsules are cap/sealed as per batching sheet.

Randomly checking for correct weight is carried out on a micro-balance.

Cleaning and polishing is carried out on polishing belt and further checking for any defect and sorting is carried out on inspection belt. These capsules are taken for quality control and approved capsules are packed in sealed drums and sent to packing department.

The filled capsules are either strip packed/blister packed or container packed as per requirement.

The machinery involved in this process are:-

- Mixer / blender
- Capsules filling and sealing machine
- Capsules polishing machine
- Inspection belt

INJECTABLE PRODUCTS

The entire department is fully air conditioned, under positive pressure and the conditioned air is passed through HEPA filters and guarded with micro V filters, not only to have dust free air but air free from bacteria.

The air flow is graded to have + + + pressure at solution preparation, filtration, ampoules/vials filling and sealing under Laminar flow unit to + + pressure in the internal passage to + cloth change room. The air-filtration system is classified as class 1000, 10000 & 100000 based on filtration capability.

Apart from all this, U.V. tubes are used at critical places to ensure bacteria free environment.

Before entering the injection department, it is mandatory to change the dress including footwear (sterile and germ free) with headgear.

The entire department is fumigated and made germ/bacteria free before starting the department after holiday. In case of any power failure in between, this procedure is followed.

Only after obtaining the assurance from Q.C. department that the area is bacteria free (count is nil) then only the manufacturing activity in the department is commenced.

Machinery involved are:-

(1) Double distilled water unit
(2) Ampoule filling sealing machine\
(3) Vial filling sealing machine.
(4) S.S. body Transfer pumps.
(5) Laminar flow unit.
(6) Bulk sterilizer / Autoclave
(7) Seitz filter and membrane filters
(8) S.S. vessels, filter holders
(9) Glass wares
(10) D.M. water plant.
(11) Ampoules washing machine with double doors (inter locking) drier.
(12) Vials washing machine with double doors (inter locking) drier.
(13) Weighing balance
(14) Ph meter and conductivity meter

This being a sterile area, any product going inside the area, has to be sterilized in autoclave at 121^{o}C for 30 minutes to make it bacteria free and fit for use in sterile area.

The raw material is passed through hatch under U.V. light.

The special garments - boiler suit, head gear, mask, hand gloves, shoes, ampoules and vials are steriled through double door autoclave – one opening from non sterile and another opening from sterile area. In order to avoid air contamination provision is made to open these doors one at a time - either from inside or from outside.

Certain eye drops and eardrops are also prepared here in vials. Glucose bags/bottles are also prepared in sterile area and sent for individual and bulk packing.

Filled ampoules and vials are taken out from sterile area and tested for its leakage if any. Good ampoules and vials are washed and dried and checked/inspected on machine or manually for any leakage or suspended particles.

Only good quality ampoules and vials are taken for labeling with following information :

– manufactures name,
– manufacturers license number
– ingredients used
– batch number
– date of manufacturing
– date of expiry
– maximum retail price.

INJECTION PACKING

Ampoules and vials are taken for individual and bulk packing with insert if any to packing department and delivered to finished goods stores after Q.C. release for further dispatch to market. Here automatic ampoules and vial labeling machine are used and the rest of the packing is done on belt conveyer.

OINTMENTS

S.S. vessel with stirrer and S.S. jackets are used to prepare ointments. The ointment prepared is than filled in collapsible tubes on tubes filling machine and crimped on crimping machine.

Sterilized eye ointments are prepared in same way, but all the activities are carried out in sterile conditions as is the case with injectable products.

The label on final product contains following information :-

- manufactures name,
- manufacturers license number
- ingredients used
- batch number
- date of manufacturing
- date of expiry
- maximum retail price.

DRY POWDER

Dry powder if sterile, is manufactured and packed in sterile area. Mixing, filling and packing is carried out and packed in washed and sterilized vials. The label on final product contains the information as above.

FINE CHEMICAL PLANTS

Different sized, shaped and capacity S.S., M.S., Lead lined, S.S. lined, Glass lined reaction vessels with stirrer, jacket are used as per the need of the chemical reactions, grouped together and installed as per the need to have benefit of gravity feed and minimized transport. Hazardous chemicals are transferred and taken to reactor under vacuum/pressure to prevent any hazard to the operator/chemist. Maximum care is taken to train the operator to handle various chemicals under supervision of approved chemist to avoid any hazards. Use of acid and alkaline proof hand gloves, safety goggles aprons, safety shoes are mandatory.

For exothermic reaction the addition of chemicals is precisely controlled by addition funnel with valve and cooled with refrigerated brine/water through its jackets. Wherever crystallization is involved suitable material of construction, crystallizers are used to carry out the activity. As soon as the reaction is completed, as per the need/suitability of chemicals, mixer is taken to different types of filters like Buckner filter, can filter, centrifuge/hydro extractor having suitable material of construction. Here the powder is separated from the liquid (mother liquor). The powder is dried in fluid bed drier/tray drier and the mother liquor is taken for solvent recovery/distillation section for its further recovery of chemical. Maximum care is taken that no effluent is generated. If this is unavoidable than the waste chemicals are collected in huge effluent treatment plant – gets neutralized and treated for its B.O.D./C.O.D. (Biological and chemical oxygen demand). Coagulated, aerated and harmless chemicals are either used in garden or thrown in the nearby nalah or sent to the effluent disposal yards maintained by Government/Industrial Associations.

High pressure autoclave is used for hydrogenation or under pressure reaction with necessary service lines and desired speed drive to get reaction and end product.

Useful byproduct is made to sell to avoid effluent generation.

UTILITY SERVICES

Utility services consist of :

- Steam boiler
- Thermic fluid heater
- Air Compressors
- Vacuum pumps
- Water/barometric ejector
- Refrigeration/air conditioning plant
- Cooling towers
- Diesel generator

TECHNICAL SPECIFICATIONS :

Tablet Manufacturing :

1. Vibrating sifter with 8, 10, 12, 20, 30, 40, 60 and 100 numbers sieves – 2 nos.

Model	:	30 GMP
Size	:	30”
Make	:	Sam Techno Mechanical Works

2. Multi mill (granulator) with 0.5 mm, 1 mm, 1.5 mm, 2 mm, 2.5 mm, 4 mm, 8 mm and 10 mm screens.

Model	:	STD
Make	:	Sam Techno Mechanical Works

3. Fluid bed dryer

Capacity	:	60 kgs
Make	:	Grovers Pvt. Ltd.

4. Planetary mixer

Model	:	350 S
Capacity	:	350 litres
Make	:	Sam Techno Mechanical Works

5. Oscillating granulator

Make	:	Shruti Industries

6. Octagonal blender

Capacity	:	800 litres
Material of construction	:	S.S. 304
Make	:	Bectochem Engineering

7. Single rotary tablet compression machine

Type	:	CMD4
No. of station	:	20
Make	:	Cadmach Machinery Co. Pvt. Ltd.

8.	Dust extraction unit		
	Type	:	700 B – 1
	Make	:	Cadmach Machinery Co. Pvt. Ltd.
9.	"Cad-Clean" Tablet cleaning system		
	Make	:	Karnavati Engineering Ltd., Mehsana
10.	Tablet friability tester		
	Make	:	Cambell
11.	Tablet disintegration tester		
	Make	:	Ketan
12.	Table hardness tester		
	Make	:	Ketan
13.	Tablet inspection belt		
	Length	:	1 mtr
	Make	:	V. Raghunathan Engineering Works
14.	Strip packing machine		
	Model	:	6A – B – 72 A
	No of tracks	:	6
	Make	:	Hemsons Pvt. Ltd.
15.	Industrial vacuum cleaner		
	Make	:	Eureka Forbes Ltd.
16.	Weighing balance		
	Capacity	:	150 kgs
	Make	:	Essae Terakode Pvt. Ltd.
17.	Automatic high speed line bottle washing machine		
	Capacity	:	120 units per minute
	Make	:	Harsiddh Industry

18. Tray dryer

No. of trays	:	48
Make	:	Grovers Pvt. Ltd.

19. Automatic dry syrup powder filling machine

Capacity	:	100 units per minute
Make	:	Amba Engineers

20. Automatic ROPP cap sealing machine

Capacity	:	120 units per minute
Make	:	Balaji Pharmaceuticals

21. Automatic high speed bottle labeling machine

Model	:	AVL – 200
Capacity	:	100 units per minute
Make	:	Amba Engineers

22. Automatic dry syrup bottle drying machine – 2 nos.

Capacity	:	10,000 bottles per dryer per 8 hours
Make	:	Excellent Engineers

23. Bottle inspection table / conveyor

Capacity	:	60 – 100 bottles per minute
Make	:	Lakshmi Engineering Works

24. Strip defoiler

Model	:	GMP

25. Carton shredding machine

26. P.P. Strapping machine

Model	:	EMC – 011
Make	:	Eagle Manufacturing Co.

27.	Capsule filling machine – 2 nos.		
	Model	:	SA 9
	Make	:	Pam Pharmaceutical & Allied Machinery Co. Ltd.
28.	Dehumidifier		
	Model	:	TNV 2000
	Low pressure	:	200 psi
	High pressure	:	600 psi
	Motor HP	:	1.5
	Make	:	Tropical Nortex
29.	Weighing scale		
	2 nos.		
	Capacity	:	800 gms
	Make	:	Penta
	4 nos.		
	Capacity	:	1 kg
	Make	:	Omega
	2 nos.		
	Capacity	:	100 gms
	Make	:	Omega
30	Rotary tablet machine :		
	Number of stations	:	16
	Maximum operating pressure	:	6.5 p.s.i.
	Maximum tablet diameter	:	19 mm
	Maximum depth of fill	:	20 mm
	Maximum thickness of tablet	:	12 mm
	Output of tablets per minute	:	260 to 466
	Diameter of dies	:	38.100 mm
	Length of dies	:	23.812 mm
	Diameter of punch body	:	25.349 mm
	Length of upper punch	:	133.6 mm
	Length of lower punch	:	133.6 mm

HP	:	2
Motor	:	960 rpm, 50 c/s, 440 V, ac
Height of the machine	:	1700 mm
Floor space	:	870 x 1200 mm
Net weight	:	950 kg
Gross weight	:	1125 kg
Case dimensions	:	1300 x 1200 x 1800 mm

31. Double rotary tablet machine :

No. of tablets per minute	:	760 – 1580
Maximum tablet diameter	:	15.8 mm
Maximum depth of fill	:	17.4 mm
Pressure	:	10 psi
HP of motor	:	3
Speed of motor	:	1420 rpm, 3 ph, 5 c/s, ac
Height of the machine	:	1670 mm
Lubrication	:	By oil pump and oil cups
Floor space	:	1140 x 1400 mm
Net weight	:	1170 kg
Gross weight	:	1420 kg

32. Press coat machine :

Output (coated tablets per minute)	:	176/496
Output (uncoated tablets per minute)	:	352/992
Maximum diameter of coated tablet	:	20.6 mm
Maximum diameter of core	:	14.2 mm
Maximum thickness of core	:	4.7 mm
Maximum fill core side (when used as a single compressing machine)	:	20.6 mm
Maximum fill coating side (when used as a single Compressing machine)	:	11.1 mm

HP of motor	:	3
Motor speed	:	1440 rpm
Height	:	1830 mm
Floor space	:	1670 x 1440 mm
Weight :		
Net	:	1727 kg
Gross	:	2089 kg

33. Tablet coating machine :

Capacity :

750 mm pan	:	45 kg
900 mm pan	:	80 kg
1050 mm pan	:	100 kg
Speed of pan	:	15 to 31 rpm
Air flow at outlet	:	90 cu.ft./min
Heater	:	1 kw
Motor	:	2 hp, 940 rpm, 440 V, 3 ph, 50 c/s, ac
Height	:	1600 mm
Floor space	:	1420 x 1370 mm
Net weight	:	345 kg

34. Fluid Bed Drier :

Capacity	:	60 kg
Type	:	Steam heated
Size of the shell	:	2290 high x 1220 wide x 1525 mm deep

The shell is manufactured from 16 G. thick mild steel sheets and is reinforced with mild steel sheets, mild steel angles and sections having plain external finish. All the mild steel components of the drier are painted in mist grey enamel paint and all the stainless steel components are buffed to a bright finish.

Fluidization retarding chamber :

The chamber is having a diameter of 940 mm x 350 mm high and is manufactured from 18 G. thick S.S. 304 sheets. It has an observation window and clamped to the discharge finger bag chamber with the help of four sturdy clamps. The chamber is provided with static absorption rings having sharp tapered spokes and provisions is made to earth the same.

Discharge finger bag chamber :

The chamber is having a diameter of 940 mm x 600 mm high and is manufactured from 16 G. thick mild steel sheets. It is provided with a ducting which is fitted with an excess pressure flap manufactured from rubberized asbestos sheets. The chamber also houses a set of discharge finger bags manufactured from special cotton cloth. The bags hang on a cage and can be shaked by operating a handle fitted outside the shell.

Product container :

The drier has a product container having top internal diameter 940 mm x lower diameter 710 x 400 mm high. It is provided with a S.S. 304 diffuser plate fitted with S.S. 304 sieve of Dutch weave type. The container is manufactured from 18 G. thick S.S. 304 sheets and mounted on a mild steel tubular stand fitted with sturdy shiveling castors.

Heating :

Air inside the drier is heated by tubular steam heaters manufactured from copper tubing having bronze rectangular fins. These finned tubes are silver brazed to copper headers on both sides and are provided with 12 mm flanged steam inlet and condensate outlet connections. The heater battery is hydraulically tested to withstand 250 p.s.i. pressure and can be suitable for operation on 40 p.s.i. steam pressure. The maximum temperature attained in the drier is 80^0C and is indicated by 100 mm dial type thermometers.

Air circulation :

Air from drier is discharged to the atmosphere by a curved blade induction fan which is driven by a 10 hp vertical electrical motor. The fan is dynamically balanced to avoid vibrations.

The unit is complete with steam heaters, electric motor, product container, discharge finger bags and a switch board all internally connected suitable for operation on 440 volts, 3 phase, 50 c/s, ac supply.

INJECTION DEPARTMENT

1. Horizontal rectangular sterilizer :

Type	:	Double door – direct steam operated
Size	:	600 x 900 x 1200 mm

Double wall glass wool insulated and S.S. 304 covering consisting of :

Jacket :
The jacket of mild steel except for a portion of 300 mm width on the sterile side of stainless steel 304 quality.

Chamber :
The Chamber made of stainless steel 316 quality and highly polished.

Door :
The door on the sterile side made of 12 mm thick S.S. 304 plate and the shooting boots and hub and all other parts of the door made of S.S. 304 quality.

The door on the non-sterile side made of 12 mm thick mild steel plate and the inside of the door clad with S.S. 304 quality. The doors fitted with pressure locking arrangement, so that the doors will not open when the chamber is under pressure.

The baffle is provided for a spreading steam into the chamber.

The sterilizer is operated by steam.

The steam is supported on a sturdy mild steel tubular stand.

The sterilizer is hydraulically tested as follows :

Jacket	:	40 psig
Working pressure	:	16/18 psig
Working temperature	:	$121^{o}C$

The following accessories are fitted to the unit :

- Pressure gauge and compound gauge.
- Dial thermometer.
- Safety valve.
- Ejector for 125 mm of mercury vacuum.
- Steam trap along with steam strainer and check valve.
- Connector for insertion of multiple probes.
- Provision of sterile air inlet pipe with ball valve and non-return valve for breaking vacuum.
- S.S. loading carriage made of S.S. 304 quality with three shelves.
- S.S. 304 Trolley with locking arrangement on the sterile side.
- M.S. Trolley with locking arrangement on non-sterile side.
- S.S. 304 flush mounting panel on the sterile side with visual indicating lights on both sterile and non-sterile side.
- Pneumatic door interlocking arrangement.
- Thermograph unit.
- Pressure reducing valve.

2. Rotary vial washing machine

Model	:	ARVW – 120
Capacity	:	120 vials per minute for 2 ml to 15 ml vials 90 vials per minute for 30 vials
Capacity of distilled water tank	:	350 litres per minute
Make	:	Ambica Engineering Works

3	Dry heat sterilizer with double door (DHS-4)		
	Size	:	80” x 72” x 52”
	Capacity	:	48 trays
	Temperature	:	0 – 300^0 C
	Make	:	Lester & Dynamics (India)
4.	Super ultra clean semi-automatic ampoule washing machine suitable for 1, 2, 3, 5 ml ampoules		
	Model	:	SUC – 2000 SAR
	Make	:	Supersonics Associated Industries
5.	Jet Wash for Jet ultrasonic cleaning machine with S.S. transfer pump and tank		
	Capacity	:	100 litres
	Make	:	Supersonic Industries
6.	Ampoule inspection machine for 3 ml ampoules with S.S. loading hopper		
	Type	:	AVI
	Make	:	Saral Engineering Co.
7.	Ampoule inspection machine for 2 ml ampoules with S.S. loading hopper		
	Type	:	AVI
	Capacity	:	6 objects at a time
	Make	:	Saral engineering Co.
8.	Vial inspection machine for 2 ml vials with S.S. loading table		
	Type	:	AVI
	Make	:	Saral Engineering Co.

9. High speed automatic sterile powder filling and rubber stoppering machine

Model	:	AHPF – 250
Container size	:	19 to 38 mm
Container height	:	1” to 3”
Stopper size	:	20 mm
Electricals	:	230 / 440 V, 50 Hz, 3 phase, 35 KVA
Air supply	:	30 psi at 1 cfm
Vacuum	:	18” Hg at 1 cfm free air
Make	:	Ambica Engineering Works

10. Automatic high speed 8 head aluminium cap sealing machine

Model	:	AHCS – 350	
Capacity	:	100 – 300 vials per minute	
Vial size	:	Diameter	14.5 to 80 mm
		Height	30 to 180 mm
Cap sizes	:	13, 20, 30 mm diameter	
Make	:	Ambica Engineering Works	

11. Automatic single head aluminium cap sealing machine

Model	:	SH80
Capacity	:	80 vials per minute
Make	:	Fabrica Steel Corporation

12. Semi automatic vial sealing machine for autofil machine

Make	:	Precitech Enterprises

13. Semi automatic double head ampoule filling and sealing machine for 1, 2, 3, 5 and 10 ml ampoules – 2 nos.

Model	:	OP/AFS/SS/2
Capacity	:	2400 – 3600 ampoules per hour
Filling range	:	0.5 to 10 ml
Make	:	S.P. Automatics

CVSRTA

14.	Fully automatic triple head ampoule filling and sealing machine		
	Type	:	CAF/300
	Capacity	:	40 – 75 ampoules per minute
	Filling range	:	1 ml to 25 ml
	Make	:	Cadmach Machinery Co. (P) Ltd.
15.	Laminar air flow unit – 2 nos.		
	Model	:	1006
	Options	:	021, 031, 033, 037, 041
	Blower	:	7 x 4
	Motor	:	¼ - 2 hp, 1440 rpm, 230 V, 4.4 amp
	Prefilter size	:	16" x 24" x 2" – 2 nos.
	Final filter size	:	36" x 24" x 6" – 2 nos.
	Make	:	Klenzaids Engineers Pvt. Ltd.
16.	Air curtain with 3 phase induction motor of 5' 3" size.		
	Make	:	R.P. Products
17.	S.S. Manual membrane filter holder with Teflon screen – 3 nos.		
	Size	:	142 mm
	Make	:	K.N.K. Engineers
18.	Semi automatic vial sealing machine		
	MUS-1 for 20 mm vials		
	Make	:	Master Mechanical Works
19.	Electrically heated vertical Autoclave with perforated basket		
	Size	:	18" x 30"
	Make	:	Monita Industrial Corporation
20.	Automatic single head sealing machine		
	Model	:	SRS – 80
	Make	:	Fabrica Steel Corporation

SYRUP DEPARTMENT

1. Complete liquid line for 2500 to 3000 bottles per hour comprising the following machinery:

   - **Rotary bottle washing machine :**

     Rotary bottle washing machine is designed to clean various types of bottles or similar containers by subjecting each to a series of distinct processing operations.

     The washing is by means of powerful water jets in four different sections of varied durations. The first section provides fresh water jet that removes floating dirt particles. The containers are then subjected to hot detergent wash in the second section. The next operation is with fresh water and is of little longer duration, so that the bottles are completely washed from inside. The fourth section is meant for D.I. water-rinsing for a short duration. There is also a continuous water spray from the top to wash the bottles from outside.

     The rotary platform which carries the bottles completes one revolution in one minute. There are 16 manifolds each having four bottle holders each with a jet nozzle in centre. The rated capacity is approximately 3000/3500 bottles per hour.

     The machine is provided with two S.S. 304 tanks, one for hot detergent and the other for fresh water, both fitted with an independent monoblock transfer pump with 1/2 hp electric motor to work on ac, 440 volts.

     The hot detergent tank is fitted with thermostatically controlled heaters. After the wash the detergent is collected back in the tank and re-circulated, through an appropriate filter mesh.

The second tank has a fresh water inlet with float valve. The D.I. connection is provided on the machine. The machine is fitted with pump.

The driving mechanism is arranged at the bottom in a closed cabinet. The friction drive transfers the motion to an aluminium larger pulley mounted on the main shaft. The machine works on 1/2 hp, ac, 440 volts electric motor.

The machine is suitable for different size of bottles with neck diameter up to 50 mm and body diameter from 32 mm to 75 mm maximum.

- **Automatic liquid filling machine :**

Volumetric as per standard specifications with four S.S. 304 filling units of 260 cc capacity fitted with 1.5 hp electric motor for the main drive and 1/2 hp electric motor (dc) for the conveyor drive. The machine works on ac, 440 volts, 3 phase supply. The capacity of the machine is about 40 to 80 fills per minute. All the contact parts are made out of stainless steel AISI – 304 quality with PDP Cheveron ring piston complete. The movement of the bottles are arranged from left to right on the conveyor.

- **Stainless steel filling tank :**

S.S. 304 filling tank is for the automatic liquid filling machine. The tank is provided with 4 outlet nozzles fitted with feeding pipe. A float arrangement is also provided for maintaining constant level complete with cover. The capacity of the vessel is approximately 150 litres. The size of the tank is 600 x 600 x 450 mm.

- **Fully automatic R.O.P.P. round bottle capping and sealing machine :**

Fully automatic R.O.P.P. round bottle capping and sealing machine complete with rotary hopper with a chute for any standard size between 22 and 28 mm diameter.

Head-set and pressure blocks are specially designed and made of hardened steel spinning rollers and fitted with ball bearings.

A suitable star plate ensures synchronized movement of bottles to the sealing head and carries sealed bottles to the outlet conveyor. The machine is provided with a conveyor belt with guide rails, which can be adjusted for different size of bottles. The movements of the bottles are arranged from left to right on the conveyor.

An unscrambler unit with independent drive is provided on the incoming side.

The electrical equipment consists of 1.5 hp main drive and 1/2 hp motor drive for the hopper as well as a 33 hp drive for the head-movement, complete with suitable starters and also pilot lights mounted on a panel board.

The machine is complete with hopper chute to take 22 mm to 28 mm diameter caps and pressure block for any size of cap diameter between 22 and 46 mm and star wheel for one size of bottle from 25 to 80 mm diameter.

- **Inspection table :**

Inspection table consists of a slat conveyor drive which bifurcates at the centre for double line inspection and again combined into single outlet. Complete with an independent drive with variable speed control and light arrangement.

- **Gumming and labelling machine :**

Gumming and labelling machine is a fully automatic round the bottle labelling machine with mechanical conveyor system designed to label cylindrical containers of various sizes. The speed of the machine is controlled by turning the hand wheel fitted by the side of the machine.

The rated speed of the machine is 60/90 per minute depending on the size and type of the bottles.

The machine consists mainly of gumming turret label magazine and vacuum turret (Delivery Turret) synchronised with a rotating drum mechanism.

The movement of the bottle is timed into the machine by a feed worm screw fitted near the entry of the bottles to the labelling mechanism. The movement of the bottles are arranged from left to right on the conveyor.

A repressing belt arrangement is provided on the further end of the conveyor which presses the label to stick properly.

A no bottle no label arrangement is also provided. The machine is driven by one hp electric motor, which in addition to the principle drive to the label gum turret and label transfer turret.

An unscrambler unit with independent drive is also provided on the inlet side. The machine is suitable for the following minimum and maximum size of bottles and labels.

Label size	:	Minimum 50 x 25 mm
		Maximum 120 x 90 mm
Bottle size	:	Minimum 30 mm dia.
		Maximum 80 mm dia.

PACKING DEPARTMENT

1. Vertical automatic vial labeling machine with vacuum pump, motor with gear unit, SS 316 conveyor belt.

Model	:	AHL 150
Capacity	:	60 to 150 vials per minute
Vacuum	:	15 mm
Size of container	:	20 to 70 mm

Size of label

Length	:	Minimum	20 mm
		Maximum	130 mm
Height	:	Minimum	16 mm
		Maximum	90 mm
Make	:	Ambica	

2. Horizontal ampoule / vial labeling machine – 3 nos.

Model	:	AHL – 100
Capacity	:	For 1 ml to 25 ml ampoules
Make	:	Amba Engineers

3. Wonder shrink pack machine with cooling fan

Model	:	SW TC 148 VSD
Brand	:	IDEM
Height of passage	:	200 mm
Length of heating zone	:	1500 mm
Heater capacity	:	9.8 kw
Total power	:	11 kw
Exhaust fan motor	:	1 hp
Motor make	:	Remi
Make	:	Wonderpack Industries Pvt. Ltd.

4.	Automatic cartooning machine		
	Model	:	CP 120
	Cartoon size		
	Minimum	:	25 mm W x 20 mm H x 75 mm L
	Maximum	:	100 mm W x 70 mm H x 220 mm L
	Output	:	Up to 120 cartoon per minute with 25 x 20 mm size
	Electricals	:	4 kw, 10 amps, 230 V, AD, DC 24 V

Attachment

a. Leaflet arrangement
b. Turn table feeding
c. Ampoule feeding arrangement
d. Electro pneumatic skip feeding arrangement

	Make	:	Pam Pac Machines Ltd.

5. Inspection conveyor belt of 7 feet length and 32” width of S.S. table with S.S. channel and independent drive.

Width of PVC belt	:	12”

Packing conveyor belt of 16 feet length and 32” width of S.S. table with independent drive.

Width of PVC belt	:	9”

Conveyor belt with wooden table of 18 feet length and width of 32”

Conveyor belt – 5 nos.

Width	:	9”

Conveyor belt – 3 nos.

Width	:	72”

Visual inspection belt

Size	:	6’ 6”
Make	:	Ambica Enterprises

6. High speed cartoon coding machine – 2 nos.

Type	:	AU-2
Capacity	:	120 cartoons per minute
Make	:	Nimach Engineering Co.

7. Hand operated cartoon / label coding machine – 2 nos.

Make	:	Magumps

8. High speed label coding machine – 2 nos.

Type	:	AU – 1
Capacity	:	120 labels per minute
Make	:	Nimach Engineering company

9. Bag sealing machine – 2 nos.

1 no.

Model	:	PISH 200
Capacity	:	200 mm

1 no.

Model	:	PISH 300
Capacity	:	300 mm
Make	:	Pack-O-Matic

10. Vertical high speed automatic vial labeling machine with turn table and gear unit

Model	:	AHL – 300
Capacity	:	300 vials per minute

Vacuum pump

Model	:	VPF 10

Capacity	:	5.88 Cfm, 1420 rpm, 0.5 hp
Make	:	Ambica Industrial Corporation

11. Pilot shredding machine for cartoon / label

Model	:	IM
Brand	:	Pilot shredder 4000

12. Semi auto P.P. box strapping machine – 2 nos.

Model	:	EMC 011
Strapping speed	:	3 seconds per strap
Maximum package size	:	60 mm to any size
Tightening strength	:	25 kgs (maximum)
Width of strap	:	6 mm to 15 mm
Electrical load	:	1/3 hp, 240 V, 50 Hz
Make	:	Eagle Manufacturing Company

13. Automatic sticker labeling machine (microprocessor based)

Model	:	Fixoname – HSC
Capacity	:	80 to 150 container per minute
Compressed air required	:	4 kg/sq. cm.
Attachment	:	Pneumatic IM Printer (EPP-RC)
Make	:	maharshi Udyog

14. Scorpio semi auto capsule counter

Disc size	:	Size 0 – 100's with machine Size 2 – 100's with machine Size 0 – 15's extra Size 2 – 15's extra
Make	:	Magnose Engineering Company

15. Semi automatic R.O.P.P. bottle sealing machine

Size	:	38 mm
Capacity	:	30 to 50 bottles per minute
Make	:	Master Mechanical Works

16. Strip packing machine – 2 nos.

Model	:	G4V
Capacity	:	30 to 40 strip per minute
Number of track	:	4
Motor	:	½ hp, 1440 rpm
Motor make	:	Remi

<u>Gearbox</u>

Gearbox	:	Reduction Gearbox
Size	:	17
Ratio	:	15
Make	:	C.P.E.C.
Diameter of motor pulley	:	5”
Diameter of gearbox pulley	:	5”

‘V’ belt B-28, vibrator no. 659 with 3 nos. rubber bushes, S.S. hopper with standard assembly.

Foil holder assembly, S.S. chute channel, release pin, S.S. bowl, dust tray, M.S. grille guard, vibrator control box, sealing rollers with back gear, conveyor arrangement with PVC belt.

Make	:	Gansons

17. Wall thermometer – 4 nos.

Temperature range	:	0 – 110^0 C

18. Blister packing machine for capsule packing – 2 nos. with

a. PVC heat roller

Capacity	:	60 to 240 blister per minute

b. Blister formation roller by vacuum and cooling

c. Vibrating hopper of S.S. 316 with photosensing unit

d. Coding unit

e. Digital display control panel

f. Rotary vacuum pump

Capacity	:	100 LPM

g. Changeover part for embossing

h. Changeover part for size ‘0’ and size ‘2’ capsule

Type	:	Pharma-pack 240 CH
Make	:	Precision Gears Pvt. Ltd.

19. Blister packing machine for capsule packing with screen heating and chilled water supply arrangement

Type	:	Pharma-pack 240
Capacity	:	60 to 240 blister per minute
Make	:	Precision Gears Pvt. Ltd.

20. Capsule recovery machine from rejected strip

Type	:	Blipstrip
Make	:	PLH Enterprises
Supplied by	:	Expo Colourpacks Pvt. Ltd.

21. Shrink wrapping machine with

a. S.S. 316 frame

b. S.S. 316 panel and entire closing

c. S.S. 316 rod for conveyor

d. Nickel chrome plated sockets

Model	:	TC/104
Length of inlet	:	400 mm
Width of tunnel passage	:	400 mm
Height of the passage	:	250 mm
Standard length of heating zone	:	750 mm
Length of outlet cooling zone	:	300 mm
Maximum pack size	:	750 mm L x 250 mm B x 100 mm H
Temperature	:	30 – 250^0 C
Material	:	PVC / LDPE (shrinkable)
Power load	:	6.7 kw
Make	:	IDEM, Wonder Pack Industries

22. Fully automatic tube packing machine

Type	:	PAC
Make	:	Wimco Ltd.

23. Hand operated aluminium trayer sealing machine – 6 nos.

24. Labeller – 10 nos.

Make	:	Monarch & Integrated Innovators

25. Portable belt conveyor

Make	:	J.T. Jagtiani

QUALITY CONTROL DEPARTMENT

1. Ultra violet visible recording spectrophotometer with Graphic printer and plotter

Model	:	UV 240
Printer model	:	PR-1
Make	:	Shimadzu
Supplied by	:	Sanjay Scientific Corporation

2. Single pan balance

Model	:	HS 1AR
Capacity	:	160 gm
Accuracy	:	0.1 gm
Make	:	Mettler

3. Gas chromatograph

Model	:	Omega-Vir
Make	:	Netel Chromatographs

4. Chromatograph's Integrator with printer

Integrator model	:	CI-10
Printer model	:	LDC/Milton Ray
Make	:	Anamed Instruments Pvt. Ltd.

5. Penitometer

Range	:	0 – 400 mm

6. Gas station with three gas purification panels

   Nitrogen panel consists of oxygen trap, moisture and hydrocarbon trap

   Hydrogen and air panel consists of only moisture trap.

Make	:	Chromatopak Analytical Instrumenta-tion India Pvt. Ltd.

7. Hot air drying oven

Size	:	18" x 18" x 18"
Power	:	1.5 kw
Make	:	Expo
Supplied by	:	Mehta Pharma Chem

8. Muffle furnace with digital temperature controller

Model	:	TC-60
Size	:	9" x 4" x 4"
Electricals	:	1.6 kw, 230 V, 1 phase
Make	:	Shivani Scientific Industries

9. Colony counter

Make	:	Cintex Industrial Corporation

10. Spectro photometer (Turbidmeter)

Model	:	Spectronic – 20
Electricals	:	230 V, 50 Hz, 0.5 amps
Make	:	Bauch & Comb
Supplied by	:	Ketan & Co.

11. Incubator

Capacity	:	32^0C to 35^0C
Electricals	:	1 kw, 230 V, 1 phase
Make	:	Shivani Scientific Industries
Supplied by	:	Ketan & Co.

12. B.O.D. Incubator with digital temperature controller

Range	:	22^0C to 25^0C
Make	:	I.E.C.
Supplied by	:	Ketan & Co.

13.	Laboratory autoclave		
	Size	:	12” dia. x 12”
	Maximum pressure	:	7 kg per sq. cm.
	Watt	:	2
	Make	:	Excellent Engineers
	Supplied by	:	Shivani Scientific Industries

14. High performance liquid chromatograph with U.P.S.

a.	Intelligent UV/VIS detector		
	Model	:	UV – 975
b.	Intelligent HPLC pump – 2 nos.		
	Model	:	PU – 980
c.	Two line degasser		
	Model	:	DG – 980 – 51
d.	Integrator		
	Model	:	80 T 17

Make : Jasco

15.	Digital polarimeter		
	Model	:	DIP 370
	Make	:	Jasco
16.	Hot air drying oven		
	Electricals	:	2 kw, 230 V, 1 phase
	Make	:	Shivani Scientific Industries
	Supplied by	:	Ketan & Co.

OINTMENT DEPARTMENT

1. Wax melting pan with lid

Capacity	:	300 litres	

Jacketed vessel for essential oil heating arrangement.

Material of construction	:	Inside	S.S. 316
		Outer side	M.S.
Capacity	:	300 litres	
Size	:	700 mm dia. x 800 mm	
Make	:	Hitendra Metal & Allied Industries.	

2. Ultra violet portable water filtration unit with 2 micron and 5 micron filters and Ultra violet lights.

Head	:	30 mm
Disc	:	40 LPM
Motor	:	0.5 hp, 250 V, single phase
Make	:	Polar
Supplied by	:	Saam D. Mehta

3. Fully automatic ointment mixer with agitator, homogenizer, pump, control panel, devacuumisation arrangement and S.S. 316 ladders stand and online S.S. 316 filter.

Capacity	:	1,000 litres
Material of construction	:	S.S. 316
Type of agitator	:	Anchor type
Type of homogenizer	:	Steam jacketed
Motor	:	10 hp, 3 phase
Motor make	:	Bharat Bijlee
Make	:	Tapasya Engineering Works Pvt. Ltd.

4. Colloidal mill with S.S. 304 water jacket, S.S. 304 stand and 4 nos. of castor wheel

Type	:	R – HMG – J
Electrical load	:	3.7 kw, 6.5 Amp, 2850 rpm, 415 V, 3 phase
Make	:	Kamavati Engineering Ltd.

5. Automatic tube filling and closing machine with S.S. jacket, hopper of 50 kg capacity with electrical heating arrangement and one extra S.S. jacketed hopper of 50 kg capacity without electrical heating arrangement.

Model	:	Linbus / 150
Type	:	Double head
Capacity	:	150 tube per minute
No. of station	:	10
Make	:	Subnil Packing Machines Pvt. Ltd.

6. Tube filling, closing and crimping machine – 2 nos. with S.S. hopper of 50 kg. capacity and 24 nos. cap.

Type	:	G A B
Capacity	:	60 tubes per minutre
No. of station	:	6 3 stations for pressing 2 stations for folding 1 station for coding
Make	:	Wimco

CAPSULES DEPARTMENT

1. Tray dryer with thermostatic control

Capacity	:	24 trays
Make	:	Magumps

2. Roll compactor

Type	:	CMRC – 200 / 100
Capacity	:	100 to 300 kg/hour
Roll size	:	200 mm dia. x 100 mm width
Roll surface	:	Corrugated
Roll RPM	:	6 to 22 rpm (by step pulley drive)
Feed screw speed	:	16 to 50 rpm (by PIV drive)
Roll motor	:	10 hp, 960 rpm, 415 V, 3 phase, 50 Hz
Make	:	Cadmach Machinery Co. Pvt. Ltd.

3. S.S. 316 Drum mixer

M.S. Frame with 1 hp motor and gear box – 2 nos.

S.S. 316 Drums of 200 litres capacity water – 3 nos.

Make	:	Moinita Industrial Corporation
Make	:	Magumps

4. Multi mill unit with round S.S. screens

Screens	:	0.5, 1, 1.5, 2.5, 6 mm
Capacity	:	200 kg per hour
Motor	:	3 hp
Make	:	Magumps

5. Semi automatic capsule filling machine

Model	:	S A8 - 105
Capsule size	:	0, 2
Output	:	21,600 to 28,000 capsules per hour
Hard gelatine capsule size range	:	00 to 5

Compressed air	:	140 litres per minute at 7 kg per sq. cm.
Vacuum	:	1,000 litres per minute displacement and 22” Hg vacuum.
Make	:	Pam Pharma & Allied Machinery Co. Pvt. Ltd.

6. Automatic capsule filling machine

Model	:	AF – 040
Capacity	:	40,000 capsules per hour
Capsule size	:	0 and 2

<u>Accessories</u>

a. Capsule sorter elevator

Model	:	SE – 100
Size	:	‘O’

b. Auto sorter for loose caps

Size	:	‘O’

c. Automatic De-dusting and polishing machine

Model	:	DP – 100

d. Air displacement unit

e. Filled capsule elevator

Model	:	FCE – 100

f. Empty capsule sorting unit

Model	:	ECS – 100

g. Interchangeable section for AF 40

h. Interchangeable section for SE 100

Size	:	‘2’

i. Interchangeable section for auto sorter

Size : '2'

j. Auto sampling and auto control unit for AF 40

Make : Pam Pharma & Allied Machinery Co. Ltd.

7. Automatic capsule de-dusting and polishing machine

<u>Accessories</u>

a. Filled capsule sorter

Model : FS – 100

b. Polishing and de-dusting unit

Model : DP – 100

c. Air displacement unit

Make : Pam Pharma & Allied Machinery Co. Pvt. Ltd.

8. Digital weighing scale

Model : DS 410

Capacity : 150 kgs

Minimum capacity : 400 gms.

Lease count : 0 – 60 kg x 20 gm

60 – 150 kg x 50 gm

Temperature range : 0 – 45^0C

Electrical load : 5 W, 220 V, 50 Hz

Make : Essae – Teroaka Pvt. Ltd.

9. Automatic capsule line

Consists of:

a. Automatic sorting machine
S.S. 316 hopper
Change part for capsule
size : ‘0’ and ‘2’

b. Filled capsule elevator

c. De-dusting and polishing unit with thyristor controlled D.C. drive
Model : DP – 100

d. Empty capsule sorter

e. Air displacement unit (ADU) with DOL starter

Make	:	Pam Pharma & Allied Machinery Co. Pvt. Ltd.

10. Air dry unit

Model	:	D50 – 0025
Inlet flow	:	25 Scfm
Inlet air pressure	:	100 psig
Inlet air temperature	:	100^0 F
Air flow at O/P port	:	18 Scfm
Cabinet	:	M.S. duty powder coated
Tower and body	:	Aluminium
Desicont	:	Activated alumina
Elostomers	:	Nitrite and polyurathyne
Make	:	Shavo – Norgren (India) Pvt. Ltd.

CVSRTA

FINE CHEMICALS

1. Reactor complete with internal coil and accessories.

Capacity	:	7000 litres
Type	:	Vertical cylindrical with welded top and bottom dished ends.
Material of construction	:	All contact parts in process fluid , S.S. 316 L
Internal coil	:	S.S. 316 L seamless
Limpet coil	:	S.S. 304
Nozzle neck up to 100 mm dia.	:	S.S. 316 L/S.S. 304 seamless pipe.
Nozzle neck above 100 mm dia.	:	Fabricated from plates provided with 100% radiography.
Nozzle flanges for nozzle up to 100 NB	:	S.S. 316 L/S.S. 304
Nozzle flanges for nozzle above 150 NB and above	:	C.S. plates with S.S. 304 liner
Size	:	1800 mm ID x 2500 mm Tan to Tan height.
Thickness :		
Shell	:	8 mm
Dished ends	:	10 mm nominal 8 mm minimum
Baffles	:	2420 mm L x 85 mm W x 8 mm thick with level marking on 1 no.
No. of baffles	:	2
Limpet coil	:	80 mm dia. x 3 mm thick ellipsoidal.
Internal coil	:	40 NB x Schedule 10S ASTM A312
Radiography	:	Dished ends – full
Other major butt wells joints	:	Spot (10%)
Polish	:	Internals given mirror polish while top dished ends have satin finish from outside.

Agitator	:	Driven by means of 15 hp, 1440/720 rpm dual speed flame proof (FLP) motor through a suitable speed reduction gear box to give final output rpm of approximately 100 and 50 to the shaft. Shaft is of 80 mm dia. and made out of S.S. 316L bar. The shaft is provided with 2 nos. turbine type impellers fabricated out of S.S. 316 L plates. Agitator complete with necessary couplings, bearing, housing, water-cooled stuffing box and M.S. support stool.

2. Centrifuge machine

Type	:	Three pendulum suspension

Specifications :

6 mm thick S.S. 304 basket 1500 mm dia. x 500 mm height riveted to C.I. cone dynamically balanced.

C.I. cone lined by 2 mm S.S. 304 sheet on top and bottom face.

5 mm thick S.S. 304 outer cover.

3.2 mm thick S.S. 304 fully opening cover.

C.I. bottom main base liner with 2 mm S.S. 316 sheet at contact parts.

20 hp flame proof motor.

D.O.L. starter.

Flame proof limit switches – 2 nos.

Lifting bag arrangement.

Canvas bag.

Oil seals.
Fluid coupling unit.

3. Glasslined reactor

Design and manufacturing code	:	ASME Section VIII Division – I
Glass lining code	:	JIS – R – 4201
Design pressure	:	Vessel - F.V./7 kg/cm^2 Jacket - F.V./ 7 kg/cm^2
Design temperature	:	Vessel – 200^oC / 2600^oC Jacket – 200^oC / 2600^oC
Maximum operating pressure	:	Vessel - F.V./6 kg/cm^2 Jacket - F.V./ 6 kg/cm^2
Maximum operating temperature	:	Vessel – 100^oC / 2600^oC Jacket – 100^oC / 2600^oC
Corrosion allowance (base metal)	:	Vessel – 1.5 mm Jacket - 1.5 mm
Final hydrotest pressure	:	Vessel – 6 kg/cm^2 Jacket - 6 kg/cm^2
Radiography	:	Vessel - Full Jacket - L & C Spot except sealer joint.
Weld joint efficiency	:	Vessel – 100% Jacket – 85%

Stress relief	:	Vessel - By process Jacket - No
Glass	:	OCTA 88-200
Glass lining thickness	:	0.8 mm to 2.0 mm
Spark test	:	At 10000 volts

<u>Material and specifications :</u>

Plate material	:	SA 516 or equivalent
Forgings	:	SA 105 or equivalent
Pipes	:	SA 106 Gr. B or equivalent
Gaskets	:	PTFE with CAF inserts (for glasslined nozzles)
Supports, drive stands & others	:	IS 2062
Painting	:	Zinc Chromate primer – 2 coats.

<u>Agitator :</u>

Type	:	Three blade propeller	
RPM	:	Regular	- 96
		Maximum	- 120

Or

Type	:	Anchor	
RPM	:	Regular	- 48
		Maximum	- 48

Shaft sealing	:	Gland packing \ stuffing box or Single dry running seal or Double mechanical seal

Thermometer pocket	:	a. Finger type baffle-cum-thermowell for propeller type reactors. b. Straight thermowell for anchor type reactors.
Support	:	Agitators are self supported on intermediate bearing assembly consisting double taper roller (back to back) bearing.
Drive system	:	Agitator is coupled with reduction gear box with flexible coupling. Reduction gear box is coupled to motor by flexible coupling or pulley.
Reduction gear box	:	Elecon / Radicon / CPEC or equivalent.
Flame proof motors	:	Crompton / Siemens or equivalent.
Other features	:	- Spring loaded opening device for manhole. - Handhold assembly where manhole is not possible. - M10 / M6 nuts are welded on jacket for holding insulation with suitable means. - Glasslined blind flanges are fitted on all open glass lined nozzles. - Agitating nozzles are fitted on jacket inlet nozzles used for entry of steam / water. - Temperature sensing facility through flush bottom valve. - Different type of jackets (limpet coil / spiral / double jacket). - Conical bottom vessels.

- Hastelloy ot Tantalum Tip for thermometer pocket for better temperature sensing.

4. S.S. 316 Centrifugal transfer pump

Capacity	:	6 m^3/hr
Type	:	CHP – MTH – 25
Size	:	2 x 1 – 10.5
Motor	:	5 hp, 1700 rpm

5. Vertical holding tank (cylindrical type) with accessories,

Capacity	:	6000 litres
Material of construction	:	S.S. 316
Size	:	1700 dia. x 2400 mm ht.
Thickness of shell	:	5 mm
Thickness of dished ends	:	6 mm
Diameter of manhole	:	400 mm
Diameter of sight glass	:	100 mm
Diameter of light glass	:	100 mm
Diameter of vent	:	50 mm
Diameter of outlet	:	50 mm
Spare nozzle	:	32 mm dia., 25 mm dia. x 50 mm dia. with blind flanges.
Diameter of sampling	:	15 mm
Supports	:	Channel supports
Finishing	:	All S.S. internal parts mirror polished and outer surface are satin polished.

All M.S. surface painted with metal primer and coated with enamel paint.

6. Condenser :

Capacity	:	15 m^2
Type	:	Shell and tube

Material of construction :

Shell side	:	S.S. 316 L
Bonnet side	:	S.S. 304
Size	:	Shell 300 dia. x 3000 mm long x 5 mm thick.
Tube sheets	:	32 mm thick S.S. 316 L – 2 nos.
Baffles	:	5 mm thick – 8 nos.
Tie rods	:	12 mm – 4 nos.
Bonnet side flange	:	28 mm thick S.S. 304 - 2 nos.
Tubes	:	80 nos. x 20 mm dia. x 2 mm thick x 3 m long S.S. 316 L seamless.
Radiography	:	Spot (10%)
Polish	:	All external surface of bonnet side given satin finish.

7. Nautadryer complete with all accessories :

Working Capacity	:	1000 litres
Maximum load	:	600 kg of wet pharmaceutical powder having average bulk density of around 0.6 gm/cc.
Container	:	6 mm thick S.S. 316
Swing arm	:	S.S. 316 casted
Mixing screw	:	S.S. hollow pipe with S.S. lining.
Cover	:	6 mm thick S.S. 316 welded dished top.
Nozzles and fittings	:	500 mm dia. S.S. manhole with cover. Cover provided with 125 mm dia. sight glass. 323 mm dia. S.S. flanged nozzle for vapour outlet/mounting of dist filter. 125 mm dia, light glass. 150 mm dia. full port S.S. ball valve pneumatically operated for discharge.

		25 mm NB S.S. flanged nozzle connection for mercury type manometer / vacuum gauge.
		50 mm dia. S.S. nozzle.
		S.S. flanged nozzle with matching blank near apex of cone for mounting lump breaker.
		S.S. flanged nozzle for mounting gear box.
Jacket	:	Carbon steel 15 mm pipe limpet coil 75 mm NB pitched for circulating hot water at maximum pressure of 3 kg/sq. cm. gauge complete with water inlet, water outlet, airvent, drain etc.
Support	:	4 nos. of M.S. legs.
Gearbox	:	SKX 85 L
Drive of screw	:	5 hp, 1440 rpm, foot mounted FLP motor suitable for group IIA and IIB gases working on 415 V, 3 phase, 50 cycles, ac supply.
Drive of arm	:	0.75 hp, geared FLP motor suitable for group IIA and IIB gases working on 415 V, 3 phase, 50 cycles, ac supply.
Special feature	:	Mixer designed for full vacuum. The rotary joint of swing arm and the rotary joint of swing arm head provided with mechanical seal of DURASEALOL.

Lump breaker	:	Comprising of specially designed S.S. impeller mounted on S.S. shaft, driven by means of 5 hp motor through belt and pulley arrangement. Unit complete with bearing housing, mechanical seal, tie rods etc.
Dust filter	:	Comprising of S.S. vessel with M.S. jacket provided with adequate number of cartridges offering filter area of approximately 2.4 sq. m. provided with FLP solenoid valves and timer.
Condenser	:	Shell and tube type condenser having surface area of 4 sq. m. Tubes, shell and baffles of S.S. 316 and bonnets of carbon steel. The vapours on shell side and cooling water/brine on the tubes side. The tube side has two passes complete with necessary nozzles and fittings provided with saddle support.
Receiver	:	Gross capacity - 400 litres, vertical, cylindrical shell with welded top and bottom dished end complete with suitable nozzles, light glass, sight glass and M.S. leg supports. All contact parts fabricated out of S.S. 316.

8. Distillation Tower :

Type	:	Sieve tray type vertical cylindrical sections. Material of construction of all contact parts S.S. 304. Body flange M.S. (Boiler quality) with S.S. 304 liner. Skirt support IS 226.

Nozzle necks	:	A 312 TP 304 seamless
Nozzle flanges up to 100 NB	:	S.S. 304
Solid nozzle flanges 150 NB	:	C.S. plates flanges with S.S. 304
and above	:	liner.
Size	:	700 I.D. x 6800 mm height
Thickness of shell	:	6 mm
Thickness of dished ends	:	6 mm nominal 5 mm minimum
Thickness of body flanges	:	40 mm thick C.S. (Boiler quality) with 10 mm thick S.S. 304 liner
Supports	:	Skirt support of size 700 x 4050 height x 6 mm thick
Trays	:	24 nos. S.S. 304 quality trays. Thickness 3 mm with 6 mm perforation trays supported on tie rods with appropriate spacers.
Radiography	:	Dished ends – full
Other major butt welded joints	:	Spot (10%)
Polish	:	Internals given mirror polish while dished ends have satin finish from outside.
Empty weight	:	2200 kg

EXERCISE

1. Draw flow diagram for manufacture of Tablets, Syrup (Liquid oral) and Injections.

2. Write short notes on :
   - Tablet mixing
   - Tablet compression
   - Tablet coating
   - Tablet packing
   - Injection manufacturing
   - Syrup manufacturing
   - Ointment and eyemide
   - Fine chemical plants

3. Provide data to be collected while taking inventory of following machinery to get current prices :-
   - Rotary tablet machine
   - Press coat machine
   - Tablet coating machine
   - Fluid bed dryer
   - Horizontal rectangular sterlizer
   - High speed automatic sterile powder filling and rubber stoppering machine
   - Laminar air flow unit
   - Rotary bottle washing machine
   - Automatic liquid filling machine
   - Stainless steel filling tank
   - Fully automatic R.O.P.P. round bottle capping and sealing machine
   - Vertical automatic vial labelling machine with vacuum pump, motor with gear unit
   - Automatic cartooning machine
   - Blister packing machine for capsules
   - Shrink wrapping machine
   - Wax melting pan
   - Fully automatic ointment mixer

- Colloidal mill
- Roll compactor
- Automatic capsule filling machine
- Reactor with internal coils and accessories
- Centrifuge
- Glass lined equipment
- Condenser
- Nautadryer
- Distillation tower

UNIT - 4

PLASTICS

Objective :

By the end of this chapter students will learn about :-

- Compression and transfer moulding
- Thermoforming
- Rotational moulding
- Extrusion
- Coating
- Monofilaments
- Calendering
- Blow moulding
- Injection moulding
- Techincal specifications of equipment

MOULDING AND FORMING OF PLASTICS

There are many processes used to mould a plastic product. In each process, the plastic must be softened or plasticized. It is then formed or moulded in a mould. The mould does the actual shaping of the plastic. After the part has cooled, it is removed from the mould. Each process has certain advantages and disadvantages. The process selected will usually be determined by the design of the part. The product's use and the volume of parts to be sold per year will also affect the type of process chosen.

Compression and transfer moulding

Most thermoset plastics are processed by compression or transfer moulding. The injection moulding of thermosets will eventually replace compression and transfer moulding. Typical compression moulded parts include dinnerware and switch and outlet plates. Buttons and cooking utensil handles are also compression moulded. Phenolics, ureas, and melamines are typical thermosets that are compression or transfer moulded.

Compression moulding

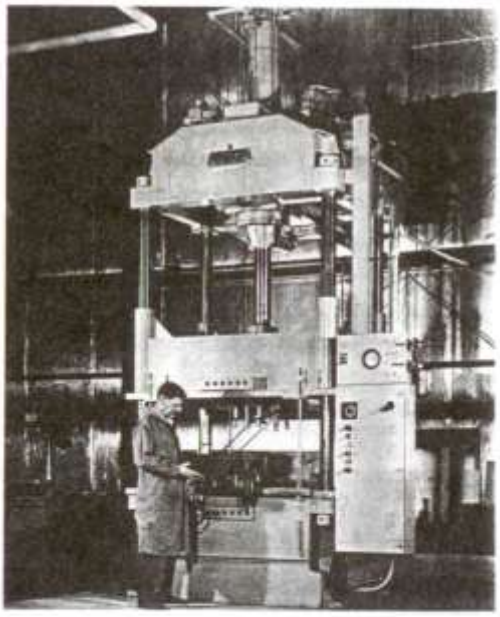


Figure 4-1

Figure 4-1 shows a typical hydraulic press used for *compression moulding*. The mould is mounted to the platens of the hydraulic press. The platens and mould are usually heated by electricity. The mould cavity is usually sprayed with a mould release prior to moulding. A mould release helps to keep the moulded part from sticking to the mould cavity.

A premeasured amount of moulding material is placed in the mould. The mould is closed under pressure for about 15 seconds. It is then opened to allow gas to escape. The mould is again closed under pressure for 5 to 10 minutes, as shown in **Figure 4-2**. After the cure , the mould is opened and the part is removed. The part is not cooled in the mould. In thermosets, a chemical reaction takes place. The part hardens in the mould.

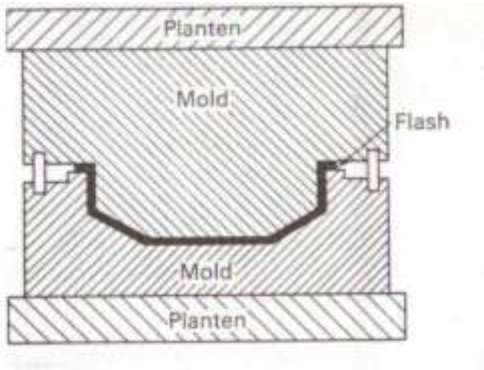


Figure 4 -2.
A flash mould is a typical mould used for compression moulding.

Time, pressure, and temperature are variables. They vary depending on the design of the part and the material used. Temperatures vary from 275^0F to 400^0F (135^0C to 205^0C). Cycles may be as short as 5 minutes or as long as 15 minutes. Pressure will vary from 1,000 to 8,000 pounds per square inch.

Some thermoplastics are compression moulded. Vinyl phonograph records and many acrylic lenses are compression moulded. A big advantage to compression moulding is that very accurate parts can be moulded because of the high pressures. The grooves of a record must be accurate for proper sound reproduction.

Single or multiple – cavity moulds for compression moulding are expensive to produce. Equipment for the process is not as expensive as other processing methods such as injection moulding. There is usually flash around the part that must be removed. This operation adds to the cost of the product. *Flash* is a thin fin of plastic that leaks out of the mould where the mould halves go together. A thermoset part will not soften again. Scrap parts cannot be reused as with thermoplastics. Cycle times are longer in compression moulding than in other processes. This is why many thermosets are now being injection moulded.

Transfer moulding

Transfer moulding is a variation of compression moulding. It is shown in **Figure 4-3**. Parts that have thin sections or metal inserts must be transfer moulded. Automobile distributor caps are transfer moulded because of the metal contact points. Automobile coil tops are also transfer moulded.

A preheated *perform* or tablet is placed in the transfer chamber. As the mould is closed, the plastic melts in the chamber. The plunger forces the melted plastic into the mould cavity. Since the plastic is melted as it flows into the mould, it will flow around inserts and into thin sections. If a powder were placed in the mould cavity, it would not flow properly.

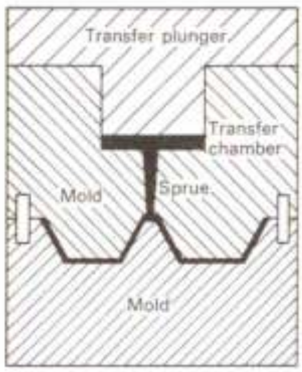


FIGURE 4–3
A mold used for transfer molding. Note the transfer chamber used to melt the plastic before it is forced into the mold cavity.

Thermoforming

Thermoforming is the oldest and easiest method used to form a plastic product. Typical thermoformed products are luggage, briefcases, and utility trays. Thermoforming techniques can be classified as mechanical, vacuum, or pressure forming. Thermoplastic sheet is used for thermoforming. The type of plastic selected depends on the product to be moulded. The plastic is softened or plasticized by radiant electric heater. The plastic is forced into or over a mould by pressure. Any thermoplastic can be formed by thermoforming. Cellulose acetate, high-impact polystyrene, and ABS are the most common.

Mechanical forming

Mechanical forming uses a mould made up of two parts. This type of mould is called a *matched mould.* Matched moulds are very expensive because they must fit perfectly together. The mould halves must be highly polished so that the surface of the part will be smooth. The mould can also be engraved to give a textured finish to the part. Other thermoforming techniques require only one half of a mould.

In mechanical forming, a piece of softened plastic is placed between the open mould halves. The mould is closed in a press to mechanically form the product. Production matched moulds are usually cored for cold water. This will speed up the time for cooling the formed part. The part is then removed and trimmed.

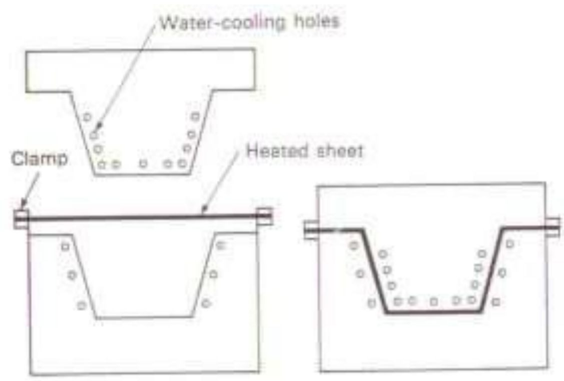


FIGURE 4-4
Mechanical forming is used to form very accurate parts.

Figure 4-4 shows a typical matched mould. This technique of thermoforming is used to make accurate parts. Excellent detail such as lettering or texturizing can be done with mechanical forming.

Vacuum forming

Vacuum forming is the most common method of thermoforming. A plastic sheet is plasticized and then clamped over a mould. A vacuum is drawn through small holes in the mould. The plastic is formed against the shape of the mould. The vacuum does not do the forming. The vacuum removes the atmospheric pressure from below the sheet of plastic. There is a pressure differential developed by the vacuum. The atmospheric pressure above the sheet, 14.7 pounds per square inch, forces the plastic over or into the mould.

The biggest disadvantage to thermoforming is that the sheet thins out as it is stretched during forming. The amount of thinning depends on the shape of the mould. Many different techniques have been developed to cut down on the nonuniform wall thickness caused by stretching. Straight, draped, plug-assist, and snap-back forming are techniques of vacuum forming.

Straight vacuum forming

Figure 4-5 shows *straight vacuum forming*. In this technique, the plastic is drawn into a mould cavity. The plastic is softened and clamped to the mould. Atmospheric pressure is removed from the mould cavity by the vacuum. Atmospheric pressure above the sheet forces the plastic into the mould. The wall thickness of the product is very uneven in straight vacuum forming.

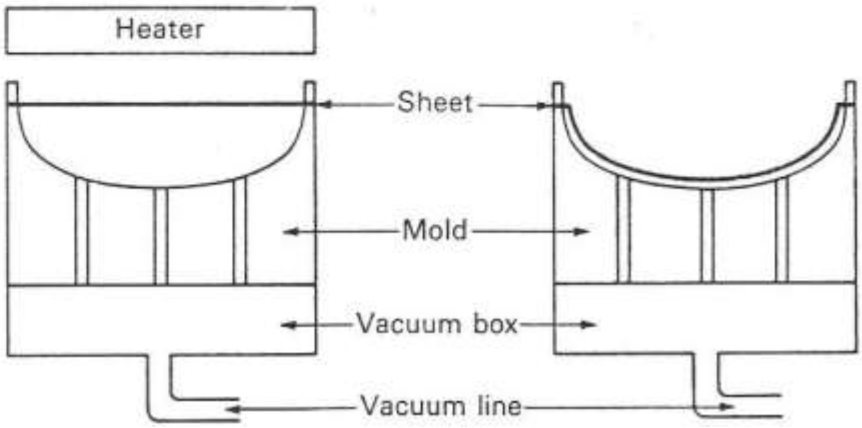


Figure 4-5
Straight vacuum forming.
The plastic is formed into the mould

Drape vacuum forming

Drape vacuum forming is shown in **Figure 4-6**. In drape forming, the softened plastic is draped over the mould and then the vacuum is drawn. Atmospheric pressure forces the plastic over the mould. Drape forming has the advantage of a more uniform wall thickness in the moulded part.

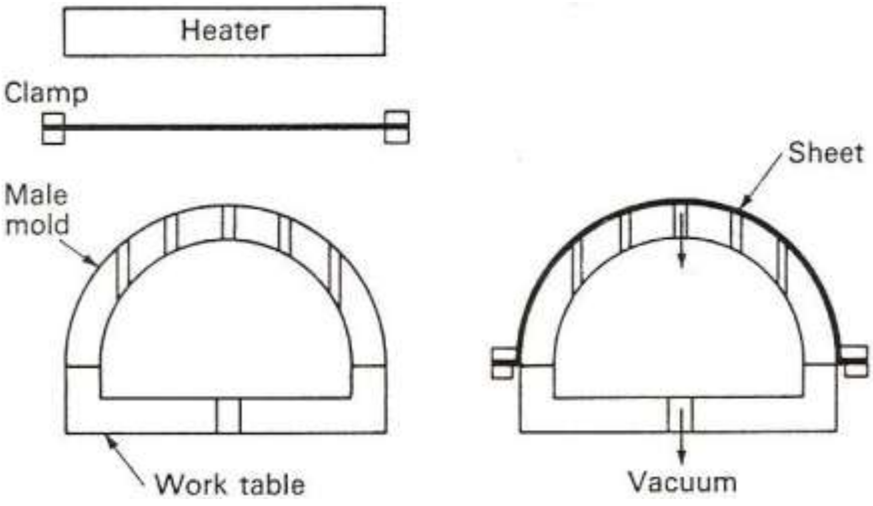


Figure 4-6

Drape vacuum forming.

The plastic is draped or stretched over the mould prior to pulling the vacuum.

Plug-assist forming

The deeper the mould cavity, the more the plastic has to be stretched. The plastic thins out more in the corners than on the sides. For deep draws, a *plug-assist* technique is used, as shown in **Figure 4-7.**

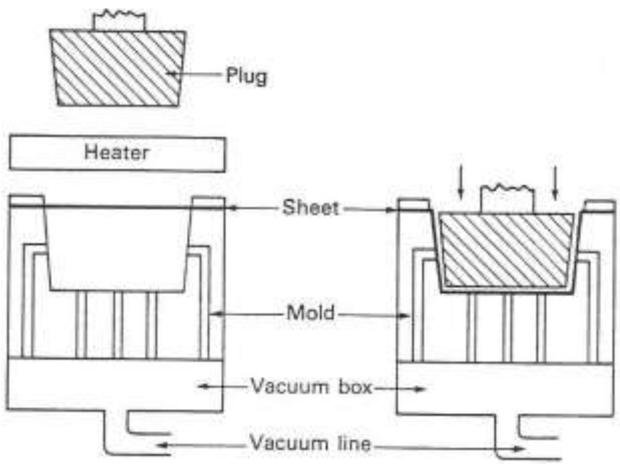


Figure 4-7

Plug-assist forming.

The plug prestretches the plastic into moild cavity prior to forming.

This technique eliminates thinning in the corners.

Electric heaters are used to soften the plastic. After heating, the sheet is clamped and sealed to the mould cavity. A plug comes down from above and prestretches the plastic. The vacuum is then drawn to remove atmospheric pressure below the sheet atmospheric pressure above the sheet forces it into the mould cavity. The plug has the same general shape as the mould cavity.

Snap-back forming

Even material distribution in deep draws can also be done by *snap-back forming,* as shown in **Figure 4-8**. The softened plastic is sealed to a vacuum box. A vacuum pulls the sheet partially into the box. The mould comes down from above into the box. The vacuum in the box is shut off and the plastic snaps back onto the mould. A vacuum is then applied to the mould to completely form the product.

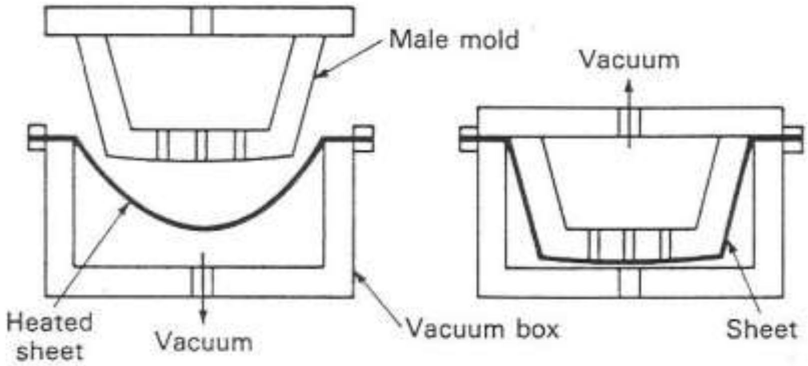


Figure 4-8

Vacuum snap-back forming is another method to help eliminate thin corners. The plastic is drawn into the vacuum box and then snapped back to the mould.

Drape, straight, plug-assist, and snap-back forming are the most common forming techniques. Slip-ring and billow snap-back forming are other techniques used in thermoforming.

Pressure forming

Pressure forming uses air pressure to form the product. It is shown in **Figure 4-9.** The plastic is clamped between the mould cavity and a hot blow plate. A slight amount of air pressure through the mould cavity holds the sheet against the hot blow plate. After the sheet is softened, the air pressure is shut off. Air pressure is forced through the hot blow plate, which forces the plastic into the mould activity.

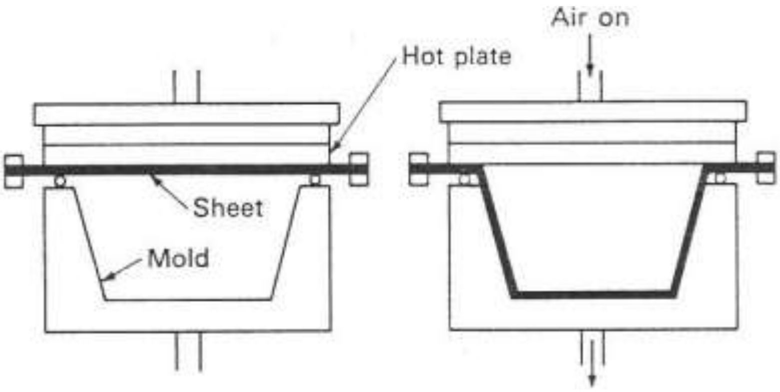


Figure 4-9

Pressure forming uses air pressure to form a product after the sheet has been heated by a plate.

A variation of pressure forming is called *free-blow forming*. A plastic sheet is heated and clamped over a pressure box. Air is forced through the bottom of the box and blows the plastic into a bubble. The size of the bubble is controlled by the amount of air pressure. Clear acrylics are used in this process to make airplane canopies and sky lights.

Even with the various techniques of thermoforming, the product always will have a nonuniform wall thickness. Other methods of moulding a product will make a more accurate part. Accurate products cannot be thermoformed. Another disadvantage of thermoforming is the secondary trimming operation. The excess plastic must be trimmed from the part, as shown in **Figure 4-10**. This operation adds to the cost of the product, and creates a lot of scrap plastic. The scrap plastic cannot be reused as easily as in other processes.

Figure 4 – 10

All thermoformed products must be trimmed after forming. This adds to cost of the product.

Sheet plastic is an expensive secondary product. An extrusion company buys plastic pellets and makes the sheet. A thermoformer buys the sheet to make his finished product. An injection moulder buys pellets to make his finished product.

Equipment and mould costs are less expensive for thermoforming than for other process. The moulds can be made out of wood, epoxy, cement, or cast aluminum. Other processes require expensive steel machined moulds.

Generally, thermoforming is a low production process. But small plastic cups can be produced at very high rates. When the demand for a thermoformed product becomes high, a higher production process such as injection moulding is usually selected. Some parts, because they are large, cannot be made except by thermoforming.

Many large products such as gasoline service station signs can only be made by thermoforming because of their large size. Large thermoformers can handle a 9 feet x 36 feet sheet of plastic. Boats as large as 8 feet x 23 feet are now being thermoformed. See **Figure 4-11**.

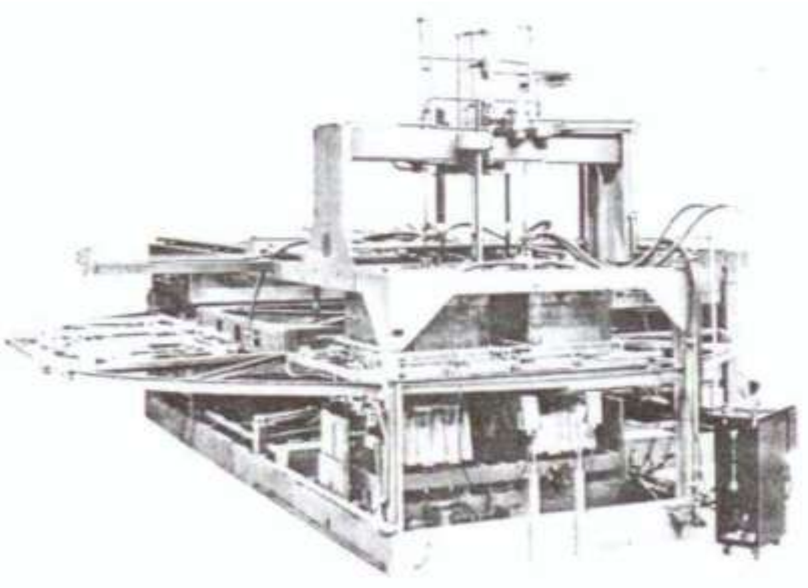


Figure 4 – 11

An industrial rotary thermoformer. The stations rotate from the loading-unloading station heating and forming stations.

A big market for thermoforming is in packaging. Many kinds of meat trays, cups, and egg cartons are thermoformed. Thermoformed tubs are used for cottage cheese, butter, and margarine. Skin and blister packaging are done on thermoforming equipment. In skin packaging, the item is placed on a printed perforated card. A thin plastic sheet is softened and vacuum formed tightly over the entire surface. Plastic bubbles are thermoformed for blister packaging. The product is placed in the bubble, which is heat sealed to a printed card.

Small products such as margarine tubs and cups can be thermoformed at very high rates. An extrusion unit extrudes the sheet plastic that is fed to the thermoformer. Multiple moulds are used to form the product. The product then goes to a trimming station where it is die cut and decorated. It is then boxed for shipment automatically.

Rotational moulding

Rotational moulding is often called *rotomoulding, rotocasting, or rotational casting.* Rotational moulding is unique in that it is the only moulding process where a completely closed, hollow, seamless product can be made. Open products can be made by trimming away the unused areas. Parts of the mould can also be insulated to mould open ends. This will eliminate cutting and trimming. Typical products that are rotationally moulded are mannequins, balls, footballs, and hobby horses. Many musical instrument cases are also made by rotational moulding.

In rotational moulding, a premeasured amount of plastic is placed into the open mould. The mould halves are then clamped together. The mould is rotated in an oven for a period of time and then cooled. The amount and type of plastic, temperature, and time are determined by the design of the product.

The plastic used in rotational moulding must be a liquid or a material that acts like a liquid. *Plastisols* are generally used for inflatable products such as footballs. Plastisols are vinyl dispersions. Powdered plastics will act like a liquid. Almost any kind of powdered plastic can be used. Polyethylene and polypropylene do not have to be inflated. They are stiff enough to support themselves.

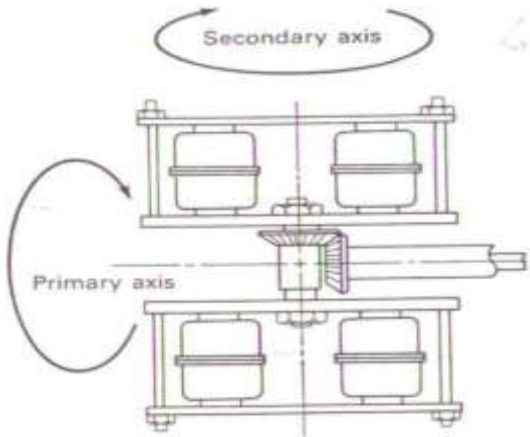


Figure 4 – 12

A dual rotational mould holder showing the primary and secondary axes. The two directions of rotation will mould the hollow part.

Figure 4-12 shows a typical mould assembly. A premeasured amount of plastic is placed into each mould. The moulds are then closed and clamped in the mould holder. The entire unit is placed into the oven. Temperature ranges are 325^0F to 900^0F (165^0C to 465^0C). Most polyethylenes and vinyls are processed at about 400^0F (205^0C). After the unit is in the oven, it is rotated in two axes. These axes are at right angles to each other. A ratio of 4:1 is a general purpose ratio. This means that the primary axis rotates 4 times to 1 rotation of the secondary axis. Generally, the primary axis rotates about 10 to 12 revolutions per minute while the secondary rotates at about 2 to 3 revolutions per minute. The heat causes the plastic to melt and coat the inside of the mould as it is rotated. After the plastic fuses on the inside of the mould, the moulds are sprayed with water to cool the plastic.

A big disadvantage to rotational moulding is that it is a low production process. The average moulding cycle will run about 15 to 20 minutes. The process is used for products that are too large for other processes. It is also used for small products that do not have a large demand. Multiple moulds called *spiders* can be used to increase production for small parts. The cut-off point is generally 10,000 parts. If the demand for the part is less than 10,000 annual units, injection or blow moulding would be more economical.

One limiting factor in rotational moulding is the practical size of the oven. The amount of weight the rotating arm can support will also determine size. Containers as large as 6½ feet in diameter by 10½ feet high are now moulded. Containers from 300 gallons to 2,400 gallons are moulded by rotational moulding.

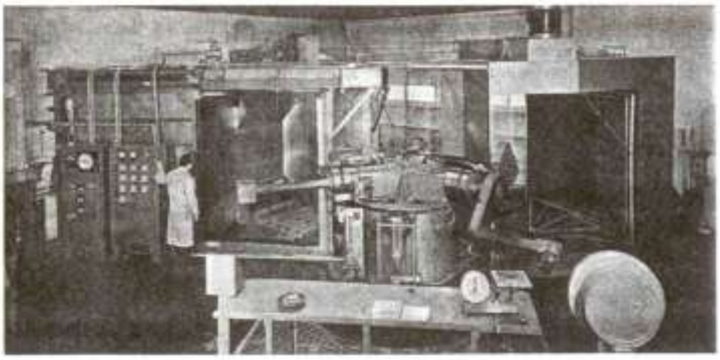


Figure 4 – 13

A three-arm rotational moulder. The oven is located to the right and the cooling chamber is to the left. The mould loading-unloading station is in the centre.

An industrial rotational moulder is shown in **Figure 4-13**. this unit has three rotating arms. Some units have four arms. With a four-arm unit, two arms are in the oven at the same time. This is because the heating part of the cycle is the longest. In the three-arm unit, one arm is at the loading and unloading station. Here the moulded parts are removed. A mould release may be applied prior to filling the moulds. At the same time, the second arm is rotating in the oven. The third arm is in the cooling chamber. The rotation is controlled by timers. At the proper time, the arms move to the next station. The arm in the cooling chamber moves to the loading and unloading station. The arm in the oven moves to the cooling chamber, while the arm from the loading station goes into the oven.

One big advantage of rotational moulding is that inexpensive moulds can be used. Very little pressure is used in rotational moulding. Sheet metal and cast aluminum moulds can be used. The first plastic trash can was made using a galvanized trash can as the mould.

There is little or no waste in rotational moulding. There are no sprues or runners as in injection moulding. The thickness of the part can be easily controlled. If the part is too thin, more material can be added. Less material can be added if the wall is too thick. Many processes require a new mould to change wall thickness. Parts can be moulded with thickness ranging from 1/32 to 1 inch (0.8 to 25 mm). Parts with intricate contours can be easily moulded. Since there is no pressure, there will be no stresses moulded into the part.

There are other processes similar to rotational moulding. One is called the *rock and roll* method. The mould is rotated in one plane or direction. At the same time, it is rocked up and down in the other direction. In the *Engle process*, the mould is not rotated. The mould is filled with powder and placed in an oven. The plastic begins to fuse to the walls of the mould from the heat. After the desired thickness is obtained, the mould is removed from the oven. The excess powder is dumped from the mould. The mould is placed back into the oven to fuse the inside surfaces of the part.

EXTRUSION

The extrusion process converts raw thermoplastics in powdered or granular form into a continuous melt stream which is formed by a die into a variety of shapes. End products include pellets packaging fibers; sheet; pipe; tubing; profile for the construction, automotive and appliance industries; fibers; insulation covering; extrusion coated webs; parisons for extrusion-blow moulding; and foam for cups, insulating sheet, packing material, and other uses.

Single-screw extruder

By far the most common and most versatile extruder in use today is the single-screw extruder. A schematic of a typical single screw extruder is shown in figure 4-14 given below.

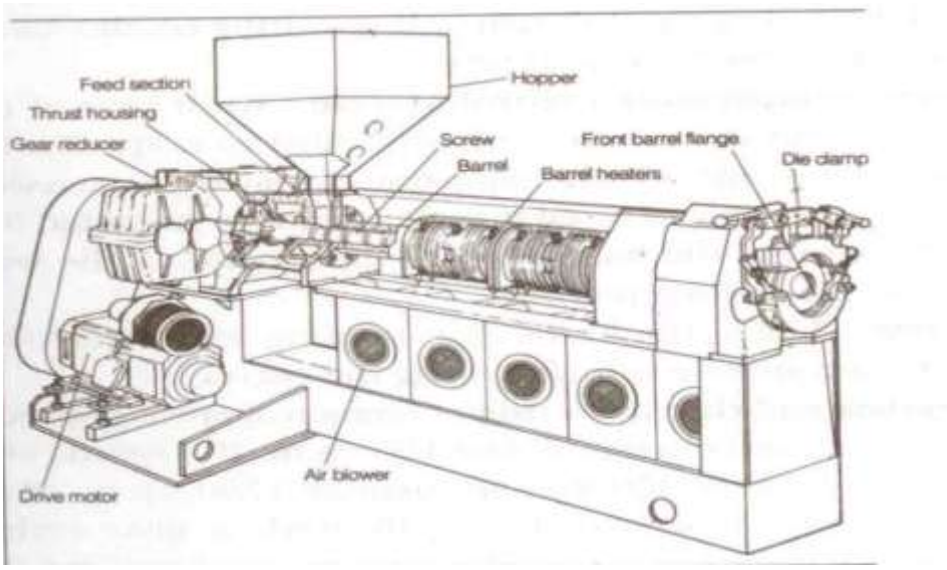


Figure 4-14

Single screw extruders are characterized by two dimensions; the bore diameter (D) and the length of the barrel in bore diameter of L/D ratio. For example a 2½ in 20:1 L/D extruder has a barrel bore of 2½ in ID and a barrel length of 50 in. (2½ x 20 diameters in length).

Common commercial sizes of extruders range from 2 to 8 in. Machines are available as small as ¾ in. for laboratory or specialized use and as large as 24 in. or more on special order. Common L/Ds range from about 5:1 minimum through 34:1 and to 40 + :1 for some multiple venting application. Generally the shorter machines (through 20:1) are applied to elastomer processing; the longer one (20:1 L/D and above) are applied to thermoplastic processing.

Extruder barrel and feed section

The section barrel of single-screw extruder usually is a long thick-walled tube of alloy steel into which a hard, highly crystalline wear resistant alloy has been centrifugally cast. After the casting the bimetallic tube is straightened and honed, usually to a tolerance of ± 0.001 in. on the ID. The barrel must tolerate an internal pressure of 10,000 p.s.i. without elastic deformation above the 0.15% strain at which the internal alloy will cack in tension.

Attached to the feed end of the barrel (often as a separate casting) is an opening into the barrel bore for raw material feeding. It usually is jacketed for room temperature water cooling to prevent premature melting of polymer.

Barrel heat input and extraction mechanisms

The barrel must be provided with means to both add and extract heat. Though heaters vary in design, the most common ones are cast aluminum. The heater halves are clamped to the barrel to provide intimate contact between the steel of the barrel and the aluminum of the heater. The heat sink is either air of a liquid coolant.

The heaters are arranged in zones, often 4 to 5 on a 24:1 L/D extruder. Auxiliary systems provide heat sinks for heat absorption. Probably the simplest is a blower mounted under each zone heater to blow air over the surface of the heater extracting heat from it and depositing it into the plant ambient air. The blowers are switched on an off either by automatic controllers or manually.

Where greater heat extraction is needed, a liquid cooled system is used. The preferred liquid is distilled water which may or may not be boiled into steam depending upon design and operating conditions. Alternatively, organic heat transfer fluids may be used.

Barrel temperature control system

Each zone of the extruder, and also the head or die, must be controlled to a specific temperature, depending on the process. The temperature usually is sensed with a tip sensitive thermocouple or resistance thermometer mounted in hole drilled through the steel of the barrel just to the outside of the wear-resistant layer close to the melting polymer.

Screw

Inside the barrel is a rotating feed screw that picks up polymer and advances it into and along the barrel.

Gearbox and thrust bearing

Common operating speed of medium size extruders range between 50 and 150 rpm. The speeds of medium hp drive motors i.e. 40 to 200 hp are usually 1750 rpm. Motor speed is reduced to the screw speed usually with a gear reducer which simultaneously increases the available torque as it reduces the speed.

The gearboxes supplied by extruder manufacturers may be horizontal or vertical. They may have helical, herringbone or worm gears, 2½ in. and larger extruders use helical or herringbone gearboxes.

Drives

The most common extruder drives are statically rectified d.c. drives operating on 460 V, three phase power. As the armature voltage is reduced from nameplate rating to zero, the speed reduces linearly to zero, while maintaining full load torque capability.

D.C. drives usually are equipped with tachometers and drive regulators which hold speed within 1% regulation and 2% long-term drift. The signals from these tachometers can be fed into coordinate modules and master references to drive the extruder speed up and down with process line speeds, tandem extruders, co-extrusion extruders, etc.

Though the power factor drops off materially. D.C. drives tend to be relatively efficient in energy use. Other types of drives that are used include eddy current a.c. motors, and hydraulic drives.

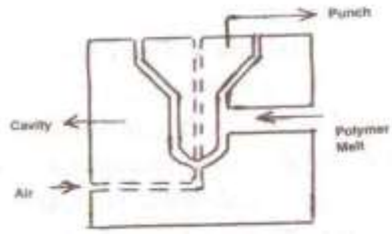
Venting

Some polymers contain small amounts of volatile monomer moisture or entrapped gases which adversely affect the extruded product. These may be removed through vents in the barrel.

TYPE OF DIES FOR FILM EXTRUSION

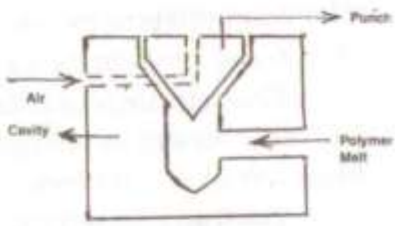
1. **Side-fed die for blown film**

In such die, polymer melt is fed to die from side and melt is divided in two streams. This has disadvantage of Joint/weld line, where film can be weak in strength.



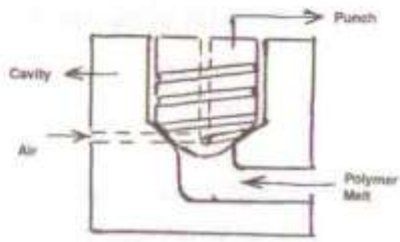
2. **Bottom-feed die for blown film**

In such die, polymer melt is fed to die from bottom of punch and hence does not involve any weld line problem. This is most common type of die.



3. **Spiral flow die**

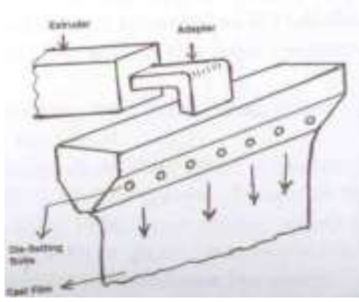
There are different varieties such as 2 start, 4 start, 8 start, spiral flow dies. This spiral flow die gives distinct advantage of better homogeneity of melt, even distribution of melt pressure and better melt stability.



4. **T-die (coat hanger die)**

This type of die is generally used for:

- Cast film extrusion
- Stilt tape extrusion for woven sacks
- Extrusion coating
- BOPP film co-extrusion



EXTRUSION OF PLASTIC FILMS

Introduction

The use of plastic films in India has shown phenomenal growth during past decades especially in packaging. Films play a major role in not only packing the product, but also protecting and displaying the products.

Most common films that we come across are made from LDPE, HDPE, HMHDPE, LLDPE, PVC, PP, etc. which form the commodity films. These films have good mechanical properties and reasonably good water barrier properties and medium shelf life of product packed.

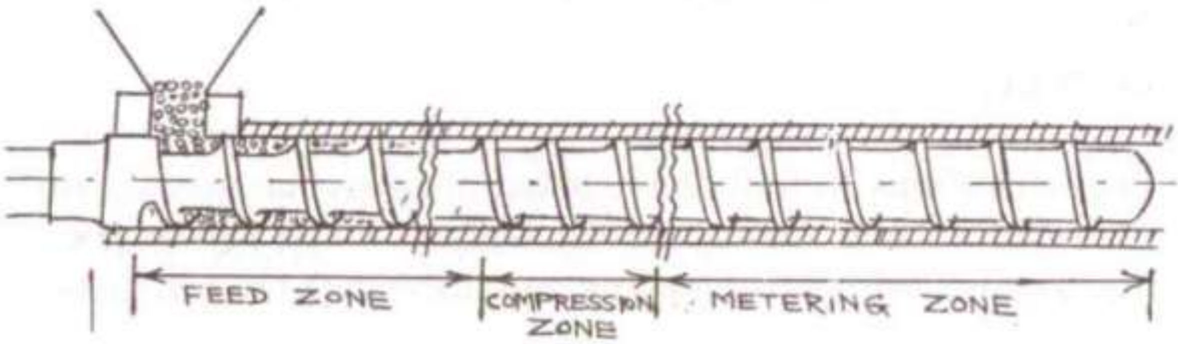
There are specialty films which are higher priced and high performance i.e. superior water and gas barrier properties giving longer shelf life and also aesthetic appearance of printed films. These are made from Biaxially oriented polyester (BOPET), bi-axially oriented polypropylene (BOPP), Mono-axially oriented polypropylene, Cellophane, Oriented nylon (OPA), Oriented polystyrene (OPS).

There are high specialty plastics which impart excellent barrier properties to extend shelf life of production packed. They are very expensive and are normally used in combination with other commodity plastic films. Such plastics include polyvinylidene chloride (PVDC), Ethylene vinyl alcohol (EVOH) and Ionomers. These plastics are used with commodity plastics by way of blown film co-extrusion 3,5 and 7 layers.

Processing

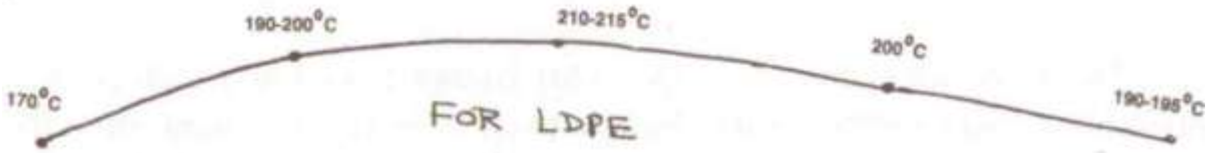
Films are produced by a process called Extrusion, which comprises of converting plastic granules into a continuous uniform melt and forcing the melt through a die into various desired shapes such as film, sheet, tubing, pipes and rods. The process of extrusion is carried out in an extruder. Extruder consists of cylindrical barrel in which a screw rotates and help to convert solid plastic granules into homogenous molten plastic mass and to convey the same to the die continuously. The size of extruder is defined by diameter of its screw.

SCHEMATIC DIAGRAM – EXTRUSION PROCESS



HOPPER COOLING HELPS TO AVOID BRIDGING

TEMPERATURE PROFILE (CAMEL BACK)



For MDPE - 180^0C to 220^0C For HDPE - 190^0C to 230^0C

For PP - 190^0C to 240^0C For LLDPE - 190^0C to 240^0C

POLYMERS	SCREW DETAILS		
	L/D RATIO	COMPRESSION RATIO	
LDPE LLDPE MEPE HDPE PP	24:1 to 30:1 24:1 to 26:1 24:1 to 26:1 24:1 to 26:1 24:1 to 26:1	3.40:1 2.5:1 to 3:1 3.4:1 3:1 to 3.4:1 3.5:1 to 3.8:1	PITCH = DIAMETER HELIX ANGLE = 16.5^0 to 17^0

Mixing sections	-	Maddock type
For better melt	-	Mixing pins / rings
Homogenisation	-	Grooved barrels

Material of construction

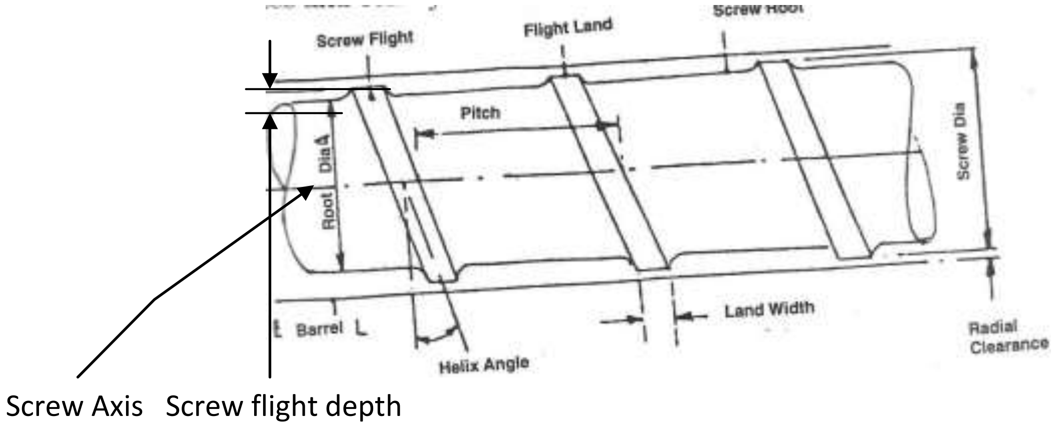
Screw : Nitrided steel or carbide metal

Barrel : Nitrided steel

New superior materials : (A) Titanium carbide composites (FERROTIC)
For hard facing (Trade name "FERRO-TIC")
Cobalt - Nickel alloys are gaining acceptance for wear resistance.
No abrasion screw - Xaloy, Pulasky, USA, have deposition process for metalurgically bonding tungsten carbide to surface of screw.
Xaloy – 800 barrel with tungsten carbide bonding has superior resistance to wear and corrosion.

Components of extruder are described below

Hopper	It is mounted at the opening end of the barrel for the entry of raw material. The raw material passes through the vertical opening in the feed section into the extruder barrel.
Barrel	Barrel is a cylindrical housing, which is heated and cooled externally and in which the screw rotates.
Screw	Screw is a helical flighted shaft which when rotated mechanically homogenizes and conveys the material being processed.



Screw flight	The helical metal thread of the screw.
Flight land	The surface at the radial extremity of the flight constituting the periphery or outside diameter of the screw.
Screw diameter	The diameter developed by rotation of flight land about the screw axis.
Root diameter	Diameter at the root of the screw flight.
Helix angle	The angle of the flight at the periphery relative to a plane perpendicular to the screw axis.
Pitch	Distance in axial direction between two consecutive flights.
Flight depth	Distance in the radial direction from the periphery of the flight to the root.
Diametral screw clearance	The difference in diameter between screw and barrel bore.
Radial screw clearance	Half the diametral screw clearance.

Screw zones

A typical screw is divided into three zones:

1. **Feed zone**

   The function of this zone is to receive material coming from hopper and feed it to compression zone. The root diameter in feed zone is minimum and is generally constant over the entire zone length.

2. **Compression zone**

   This zone has a gradual decreasing depth or decreasing pitch of screw, because of which material is gradually compressed and compacted. Transition of material from solid form to molten form takes place in this zone, because of heat and shearing action.

3. **Metering zone**

   This portion of screw acts as a pump and it delivers molten material to the die at a constant rate. Flight depth in this zone is generally less than that in feed zone and is constant throughout.

Important terms associated with the screw design

Compression Ratio (CR)	:	It can be expressed as a ratio of volume of the screw channel at feed opening to volume in the metering zone. In case of screws with constant pitch, CR is the ratio of depths at feed end metering end.
L/D Ratio	:	It is the ratio of length of the screw, which is the distance from the forward edge of feed opening to the screw tip, to the barrel bore diameter.

These two design parameters are specific to the type of polymer. The recommended values of L/D and CR for PE are 24 to 28:1 and 2.5 to 3.0:1 respectively. Many a times mixing sections in the screw are recommended for processing LLDPE.

Heating and cooling systems

Controlled heating is provided using external electrical resistance or induction heaters arranged in several groups or zones along the barrel. Thermocouples are fitted at regular intervals on barrel for temperature measurement and control. Cooling is done using blowers of cooling water jackets to remove excess heat from the polymer melt.

Breaker plate and screens

Breaker plate is to break spiral motion of melt and support screen pack.

Screen pack, which is a combination of screens with different mesh sizes, is used as a filter.

The screen pack combinations, which generally used are 40/60/40, 60/80/60 or 40/60/60/40 mesh.

Downstream equipments

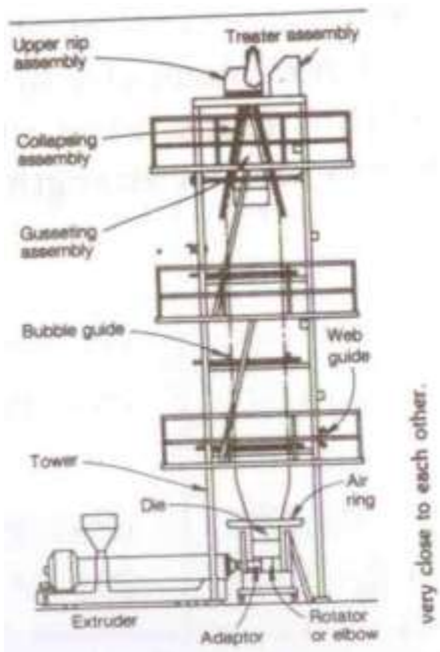
Blowers, quench tank, guides, winders, cutter slitter etc. constitute the downstream equipments for an extruder, which change according to the type of extruder and also the product being processed.

Now film extruders with either oscillating platform, rotating die or oscillating haul-off (take up) assembly are developed, which enable to obtain better quality hump free film rolls.

Different types of film processing techniques

1. Blown film process

It is a process in which a plastic tube after extruding through an annular die is inflated by air to desired diameter, cooled collapsed and wound in the form of rolls.



2. Blown film extruder

In India, blown film extrusion process is found economical and is used by most of the processing units. In this process, there are two types:

(a) Single layer blown film extrusion and
(b) Multi-layer (2 to 5 layers) blown film co-extrusion

The film properties achieved in this process are dependant on various processing conditions, such as Blow Ratio, Processing Temperature Profile, Draw Ratio, Relation of screw speed and haul-off speed, film thickness uniformity. Frost line height (FLH) and adjustment of cooling air through air ring, etc.

(i). **Blow-up Ratio (BUR)**

This is the ratio of diameter of film bubble to diameter of die. This is calculated by simple formula:

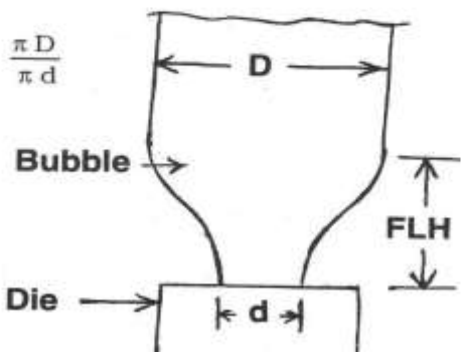
$$BUR = \frac{Perimeter\ of\ bubble}{Perimeter\ of\ die} = \frac{\pi D}{\pi\ d}$$

where,

D = Diameter of bubble
d = Diameter of die

$$\pi = \frac{22}{7} = 3.14$$

Simplified approx formula is $d \sim \frac{LFW}{1.5\ x\ BUR}$



Higher the blow ratio, better are mechanical properties (Tensile, Impact etc.) due to better orientation of molecules in cross direction (transverse direction). For LDPE and LLDPE films, Ideal BUR is 2:1 to 2.5:1 which results in good balanced mechanical strength of film in both machine and cross directions.

Following table give ready values of Blow Ratio in relation to size of diameter of die and lay flat width (LFW) of blown film. LFW of film is half of cut open width of blown film.

Die Diameter	Blow Ratio				
Inch (mm)	1:1	1.5:1	2:1	2.5:1	3:1
	Values of Lay Flat Width, inch (mm)				
2 (50)	3.14 (80)	4.71 (120)	6.29 (160)	7.86 (200)	9.43 (240)
3 (75)	4.72 (120)	7.07 (180)	9.43 (240)	11.80 (300)	14.15 (360)
4 (100)	6.29 (160)	9.43 (240)	12.58 (320)	15.72 (400)	18.86 (480)
6 (150)	9.43 (240)	14.15 (360)	18.87 (480)	23.58 (600)	28.30 (720)
8 (200)	12.60 (320)	18.87 (480)	25.16 (640)	31.45 (800)	37.73 (960)

For LDPE, LLDPE and HDPE films, processing at Low Blow Ratio, (sometimes less than 1:1) is not advisable, since orientation of molecules is insufficient and unbalanced, which results in inferior mechanical strength of the resultant films.

For TQPP film, normal blow ratio used is 1.2:1 to 1.5:1 for HMHDPE films, high blow ratio of 4.5:1 to 5.5:1 is used.

(ii). **Processing Temperature Profiles**

Adequately high temperature profiles results in good mechanical properties of blow films. Normally camel back profile is found useful i.e. lower in feed zone and gradually increasing in compression and metering zones and then gradually reducing in cross head and die zones.

Typical temperature profiles for film extrusion for popular plastic materials are as under:

LLDPE Film Grades	Barrel Zones	Crosshead	Die Zones
Heavy duty (0.2 MI)	170/195/205	200/190	185/180^{0}C
Milk packing (0.5 MI)	160/185/195	190/85	180/170^{0}C
General purpose			
Packing (2 MI)	160/180/185	185/180	170/160^{0}C
(4 MI)	150/170/170	160/155	150/145^{0}C
Heavy duty (1.0 MI)	160/185/195	190/185	180/170^{0}C
General purpose (2	160/180/185	180/175	175/170^{0}C
MI)	170/220/230	210/220	200/190^{0}C
HMHDPE film grade	170/195 to	200/190	190/180^{0}C
TQPP film grade (10	200/205		
MI)			

(iii). **Frost Line Height (FLH)**

This is the distance between the die and the zone where the bubble solidifies and assumes it's final diameter. This FLH is dependent on the rate of cooling by air from cooling ring. Higher the rate of cooling, lower is FLH and vice-versa.

Normally recommended FLH for various plastic blown film materials are as under:

1. For LDPE and LLDPE blown film extrusion, one foot to two feet, depending on diameter of the bubble.
2. For PP blown extrusion, 6 inches to 10 inches.
3. For HDPE blown film extrusion, 6 inches to 15 inches.
4. For HMHDPE blown film extrusion, FLH is as high as two feet to four feet, depending on diameter of bubble.

(iv). **Film Thickness Control**

Film thickness is controlled by adjusting screw speed and Nip Roll speed.

(v). **Thickness Variation Control**

It is very essential to control film thickness in narrow range, preferably within $\pm$ 5%. This variation is controlled by –

(a) Setting the die gap uniform all along the periphery, with help of the die setting bolts. It is ideal to have 8 to 10 nos. die setting bolts.

(b) Adjusting air flow of air cooling ring.

The film with low variation in thickness has superior and reliable mechanical properties and is free from thick bands or humps on the roll, which enhances the printing quality of the film.

3. <u>Cast Film Process</u>

Polymer melt is extruded through a flat die either onto a rotating chilled roll or into a water quench tank, where the melt is rapidly cooled and frozen to form a film called the cast film.

Advantages of this process over blown film extrusion are:-

(1) Superior transparency and clarity of film
(2) 4 to 5 times higher output, since no limitations on cooling of film.

The only limitation of cast film process is relatively lower orientation and strength of film in transverse direction.

4. <u>Co-extrusion Film Process</u>

It is a process in which two or more polymers processed on separate extruders are passed together through a common die to form a film. It can be either a blown or cast film process. This process is widely used for producing barrier films, stretch films etc. Co-extrusion film process leads to a co-extruded film or multilayer film.

Such films offer specific advantages such as higher shelf-life superior mechanical properties of the film and pouches (tensile strength, puncture resistance, impact strength), better heat seal strength, better hot track strength etc. due to the combination of different plastic materials used in the multi-layer structures.

Some of the multiplayer structures based on polyethylene and their applications.

	Material combination		Important fields of application
1.	LDPE + LLDPE in 2 or 3 layers		Milk film, carrier bags, general packaging
2.	LDPE / EVA LLDPE / EVA LLDPE / LEPE		Heavy duty bags, stretch packaging, medical articles.
3.	HDPE / EVA		Blood plasma, bakery goods, foodstuffs

4.	HDPE / LDPE or LLDPE LDPE / HDPE / LDPE LLDPE / HDPE / LLDPE		Bakery goods, foodstuffs, tomato concentrate, pet food, cornflakes.
5.	LDPE / TL / Nylon-6 / TL / LDPE or LLDPE / TL / Nylon-6 / TL / LDPE		Packing of meat, sausage, cheese, ham, fish, ready made meal
6.	LDPE / HDPE		Vanaspati ghee pouches
7.	LLDPE / LDPE / HDPE		Edible oil pouches – short shelf life
8.	LLDPE / TL / Nylon-6 / TL / Ionomer		Edible oil pouches – longer shelf life

STRETCH – EXTRUSION PROCESS

In this process, after primary extrusion, the product is again reheated and stretched / oriented in one or two directions (machine and transverse directions) in order to impart superior mechanical properties to final products.

Examples of such stretch extruded products are :

1. Biaxially oriented PP films and polyester films, having superior mechanical properties and barrier properties.
2. Flat tapes for HDPE and PP woven sacks also known as 'Raffia'.
3. PP and HDPE monofilaments, twines and sutli.
4. PP, Nylon-6 box strappings.

In above process, the extruded product is re-heated and then stretched in machine direction and transverse direction. The stretch ratio depends on type of plastic, for example for PP it is 1:7 to 1:8 and for HDPE it is lower 1:5 to 1:6. After stretching the product is again heated (PP to about 130^0C to 135^0C and HDPE to 100^0C to 120^0C) for purpose of stress-relaxation in the product. After this, the product is ready for final winding.

In secondary operations, flat tapes are taken on looms for weaving, monofilaments on rope making machine, etc.

Flat tape stretch extrusion line : This is versatile line, since with only the change of die other products monofilaments or box strappings can also be produced.

Popular applications of BOPP film are :-

- Wrapping of cigarette cartons and tobacco packing
- Packing of potato chips, noodles, sevia, etc.
- Packing of bakery products.
- Paper print laminations
- Pressure sensitive adhesive tapes.
- Printed synthetic paper applications, visiting cards, invitation cards, calendars, technical brochure etc.

Popular applications of HDPE woven sacks and cloth are :-

- Packing of fertilizers and chemical powders.
- Tarpaulin (black or blue) covers for protection on trucks.

Polypropylene woven sacks are preferably used for packing of cement, since same are more suitable to withstand hot-filling of cement powder. PP woven cloth is also preferred for bulk bags (250 kg, 500 kg bags) since the same is stronger than HDPE woven cloth.

BLOWN FILM EXTRUSITON : TROUBLE SHOOTER'S GUIDE

Faults	Remedies
Gels and fish eyes	- Increase the back pressure by using finer screen/adding another screen to improve homogeneity. - Prevent decomposition inside the system and burnt particles on die lips. Clean die often. - Increase the processing tempe-ratures.
Black / foreign particles	- Check for contamination in material. - Keep hopper covered and full, to prevent dusty air entering the extruder. - Carry out purging or cleaning of die set in case of suspected oxidation of polymer.
Die lines and scratches	- Check and remove nick and burrs on die lips, if any. - Clean the die and also the head when necessary. - Purge sufficiently when changing to a material of different melt-flow index. - Increase the head temperature. - Avoid internal decomposition.
Orange peel appearance	- Increase extrusion temperature. - Check the heaters which may be defective.

	- Increase the back pressure by adding screens.
Pot marks	- Usually due to high moisture content. Avoid stocking granules in open air, damp and cold buildings.
Ripples on film	- Check moisture in freshly opened bag and pre-dry granules in case of moisture content at 70-80^{0}C. - Check land length of die and increase the same if necessary. - Inspect temperature profile. - Maintain proper freeze line height. - Control excessive output.
Uneven thickness around circumference	- Adjust die opening with the help of centering screws. - Check the uniformity of cooling air flow throughout the circumference of the bubble. - Check for defective heaters of other hot / cold spots on die. - Always maintain proper freeze line height (FLH).
Variation in thickness of film in machine direction	- Check regularity of screw speed. - Check regularity of haul-off speed. - Maintain optimum processing tempe-ratures.
Bubble instability (vibrating or shaky bubble)	- Check temperature and thickness uniformity of melt at the die. - Check constancy of air pressure inside the bubble. - Add additional bubble guide bars.

	- Decrease the air flow to the cooling ring. - Avoid outside drafts, shield the system from doors, windows and other air currents.
Wrinkles and creases	- Check uneven thickness
(A) In blow film	- Check variation in width - Reduce freeze line height - If film is too cold, reduce cooling or increase extrudate temperature or lower take-off rolls. - Adjust and clean collapsing boards, check for smooth and drag-free passage through flattener and nip rolls.
(B) On the reel of finished film	- Align the nip rolls correctly ensure that two nip rolls are parallel and the pressure across the face of rolls is uniform. - Ensure that the winder shaft pulls the film at even and just adequate tension. - Use anti-crease or smoothing foils for removing creases. - In case of wrinkles due to static electricity on passage of film. Use static eliminator.
Blocking	- Improve the cooling of bubble. - Reduce the temperatures at die and head.

(A)	Internal surfaces	-	Reduce pressure at nip rolls.
		-	Supply cooling water to one of nip rolls.
(B)	External surfaces	-	Discharge the static electricity before wind up rolls.
		-	Check for excessive intensity of corona treatment.
Poor strength		-	Adjust relation of linear speed and blow ratio to correct balance. Extrude with a blow ratio of 2:1 to 2.5:1
		-	Lower the frost line
		-	Check for die lines which may weaken the film.
		-	Use the polymer with lower melt flow index, if possible.
Poor optical properties		-	Increase blow ratio between 2 to 2.5:1
		-	Raise frost line.
		-	Raise melt temperature.
		-	Reduce cooling rate by passing a lower volume of air.

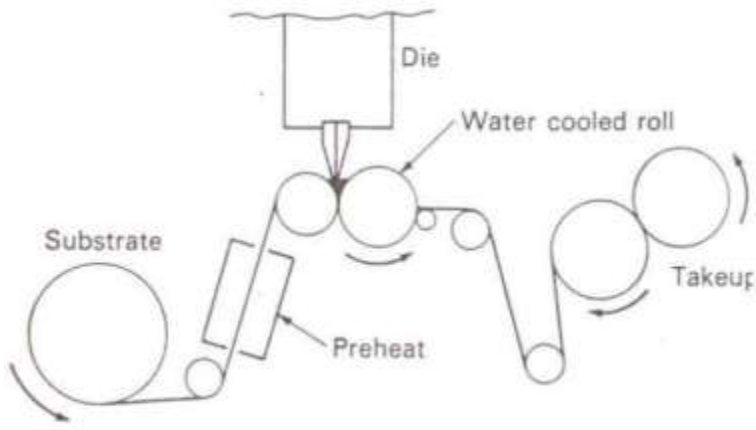


Figure 4-15
A coating unit to place a plastic coating on cloth or paper.

Coating

Figure 4-15 shows the process of coating. Many different materials can be coated with plastic. Paper used for milk cartons is coated with a plastic. The back of carpeting in automobile is coated with plastic. This prevents salt and water from rusting the floor of the car. In the process, the *substrate, or* material to be coated, is preheated to about 200^0F (93^0C). The heated substrate passes through several rollers where plastic is extruded and rolled onto the material. A water-cooled roller is used to cool the plastic. The substrate is then wound up into a roll on the take-off unit.

Wire and cable coating

Copper and aluminium wire can be insulated with plastic. A group of plastic insulated wires can be made into a cable with extrusion. The wire is pre-heated and then pulled through a die. As it goes through the die, plastic is extruded around the wire. The wire is then drawn through a water bath to cool the plastic.

Monofilaments

Monofilaments are threadlike strands of plastic. The plastic is extruded through a die that has many fine holes. As the monofilaments are extruded, they are drawn through a water bath and then wound on spools. Polystyrene monofilaments are used for toothbrushes and scrub brushes. Nylon is used for fishing line. Polypropylene monofilaments can be woven into rope. The plastic rope is stronger than a natural fiber rope of equal diameter. It is used around swimming pools and for tying up boats. The plastic rope floats and will not rot. Many shirts, slacks, and sport coats are woven with cotton and polyester monofilaments.

Calendering

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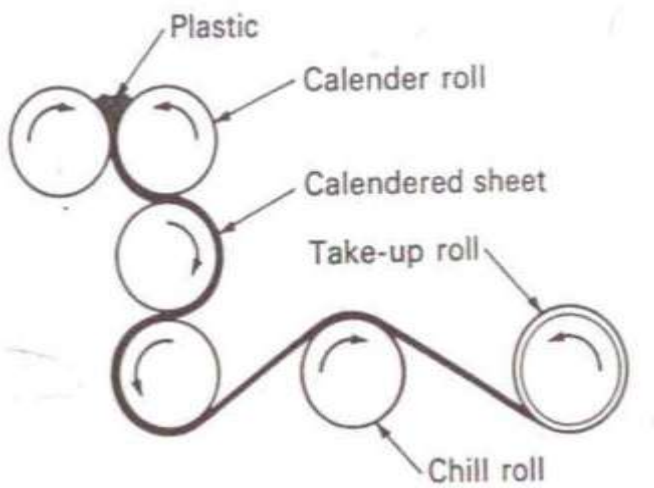


Figure 4-16
Calendering is another process to make plastic and sheets

Calendering is not an extrusion process. It is another process to make plastic film and sheeting. **Figure 4-16** shows the calendaring process. A hot rubberlike mass of plastic is forced into a sheet in the first set of rollers. The plastic is gauged to the proper thickness by the gauging rollers. A chill roll is used to cool the plastic. The thickness of the sheet can be controlled better by calendaring than extrusion. Color and material changes are easier than in extrusion.

Electrical tape, window shades, and shower curtains are calendered. Calenders can also be used to coat paper and fabric with plastic. The rollers could be embossed to give the plastic a textured pattern.

Blow moulding

Blow moulding is the second most important plastic processing method. Plastic bottles are rapidly replacing glass ones. All plastic bottles are made by blow moulding. It is a very high production process. Many small products that are uneconomic for rotational moulding can be blow moulded.

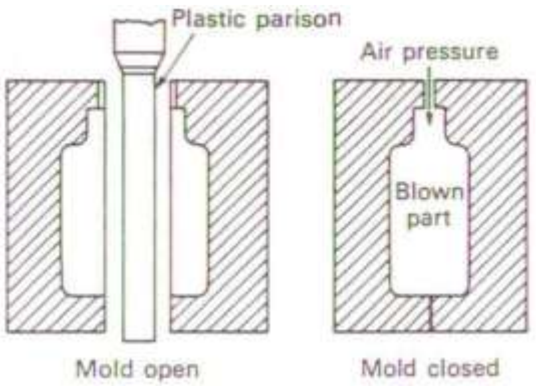


Figure – 4-17

In blow moulding, a tube or a *parison* is extruded between an open mould, as shown in **Figure 4-17**. the mould closes and pinches off or seals the top and bottom of the parison. Air is injected into the parison and blows it up to take the shape of the mould cavity. After the part cools, the air is shut off and the part is removed from the mould. The parison is formed by using a ram or a screw extruder. A newer process injection moulds the parison.

One problem with an extruded parison is that it thins out. As the parison gets long, gravity begins to take over. The upper part of the parison next to the die opening thins out. Bottles that have irregular shapes present problems. The bottle will be thinner in the larger diameters of the bottle. To help eliminate both problems, the parison can be programmed. This method of programming will make the parison thicker where the larger diameter of the bottle will be. As the parison thins out from gravity, the programmer will automatically make the parison thicker.

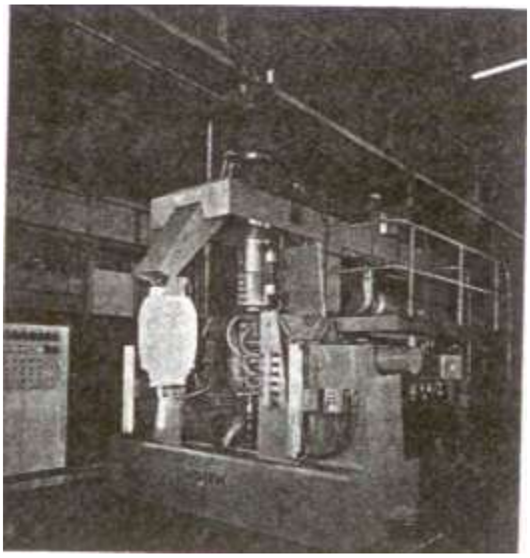


Figure 4-18

An industrial blow moulder with a completed 30 gallon container (Fischer-Voith Plastics Machines Incorporated)

There are many different types of blow moulding set-ups. The machine can vary from a single cavity to a rotary system with over 20 moulds. **Figure 4-18** shows a typical production extrusion blow moulder. Very large products will usually require an *accumulator*. While the bottle is being blown and cooled, the extruder fills an accumulator or storage chamber with a very large volume of plastic. After the part is removed from the mould, a ram forces the plastic out of the accumulator and through the parison die. Blow moulders range in size from very small to a moulder which will extrude a 220 pound parison. The unit takes only 10 seconds to extrude the parison, which is then blown into a 300 gallon conainer.

The injection moulding of a parison or preform for blow moulding is a new process. It is limited to bottles that are one quart or smaller. The bottle is more accurate because the preform is injection moulded to the general shape of the finished bottle. The bottle wall thickness is very uniform compared to an extrusion blow moulded bottle. The threaded neck and top of extrusion blown bottle require trimming. The pinch-off on the bottom of the bottle also must be removed. This additional trimming operation adds to the cost of the product. The trimmed plastic must be granulated and reused. This will consume additional energy. An injection blow moulded bottle does not require any trimming operations.

At least two moulds are needed for injection blow moulding. One mould is needed to mould the preform and another for blowing the bottle. Even with the added cost for moulds, injection blow moulding is more economical for small bottles than extrusion. Bottles will also have better gloss and clarity than extruded blown bottles.

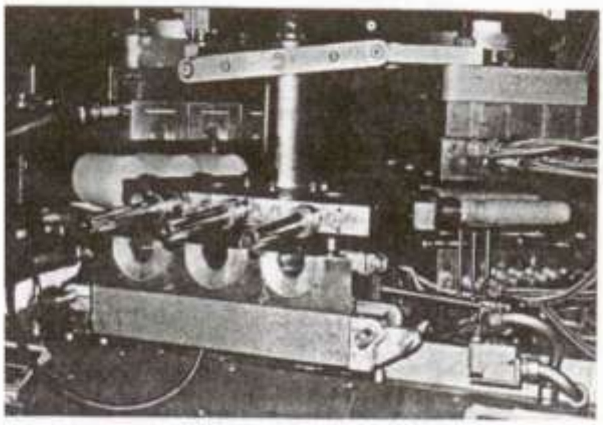


Figure 4-19
An Injection blow moulding machine. The bottles have been stripped from the front mandrels. The injection moulded parisons are coming out of mould to right. The parisons are blown in the mould to the left.

Figure 4-19 shows an injection blow moulding machine. Notice that there are two sets of moulds and three sets of *mandrels.* Each set has three mandrels. The completed bottles have been stripped from the center set of mandrels. The preform mould is located to the right. The mould on the left is used to blow the bottles.

The mandrels move in a counter-clockwise direction. The preform from the right mould will move to the blowing mould. At the same time, the empty mandrels will move to the perform mould. The blown bottles then move to the unloading station.

Many thermoplastics can be blow moulded. The most popular plastics are polyethylene and polypropylene. Vinyl is used for clear bottles. There is very little pressure involved in blow moulding. Mould costs are less for blow moulding than compression or injection moulding. Cast aluminum moulds are the most common. Some high production moulds are machined from steel. The moulds are cored for water cooling.

Injection moulding

Injection Moulding is a process of forming an article by forcing the molten plastic material under pressure into a closed metal structure known as mould where it is cooled and solidified into the countours of the mould and subsequently released by unmeshing two halves of the mould.

It is the most important plastics processing method. Over 60 percent of all thermoplastics are injection moulded. It is a very fast high production process. Thermosets are now being injection moulded. Injection Moulding is used for the formation of intricate plastic parts with excellent dimensional accuracy. Typical injection moulded products include pails, refrigerator containers, and chair seats and backs. Disposable products such as plastic cups, knives, forks, and spoons are injection moulded. Radio and television cabinets and control knobs are also injection moulded.

Injection moulding is used to mould many furniture parts using high-impact polystyrene. The fronts of drawers and door panels for dining room and bedroom furniture are injection moulded by many companies. Mirror and picture frames are also injection moulded. The mould is engraved with a wood grain pattern. The moulded part is then finished to match the rest of the furniture. Plastics have the advantages of being less expensive. Also, plastics do not warp or split as wood sometimes does.

ADVANTAGES OF INJECTION MOULDING

i. Accuracy in weight of moulded articles.
ii. Choice of desired surface finish and colours.
iii. Choice of ultimate strength of moulded articles.
iv. Faster production and lower rejection rates.
v. Faster start-up and shut-down procedures.
vi. Minimum wastage.
vii. Stability of processing parameters.
viii. Versatility in processing different raw materials.
ix. Option in article sizes by changing the mould.
x. Minimum post-moulding operations.

CVSRTA

INJECTION MOULDING MACHINES

Injection moulding machines can be classified by the type of injection unit and clamping unit used.

CLAMPING UNIT (Locking Unit)

Many types of locking unit have been divised, most of which can be classified into two types namely :

1) Direct Hydraulic Locking Systems.
2) Toggle Systems.

1. Direct Hydraulic Locking Systems :

The basic hydraulic locking system is shown in figure 4-20. This system uses a large diameter hydraulic cylinder mounted in the rear platen. The moving platen of mould is attached to the cylinder ram which both opens and closes the mould and provides clamping force.

The advantage of the system are :

- The cylinder is self lubricating and the system has few moving parts.
- Variation in mould heights are easily accommodated.
- The ram speed is controlled by varying the oil flow rate.

Main disadvantage of this system is that it is frequently necessary to move around large quantities of pressurized oil which is wasteful both in terms of power consumption and time.

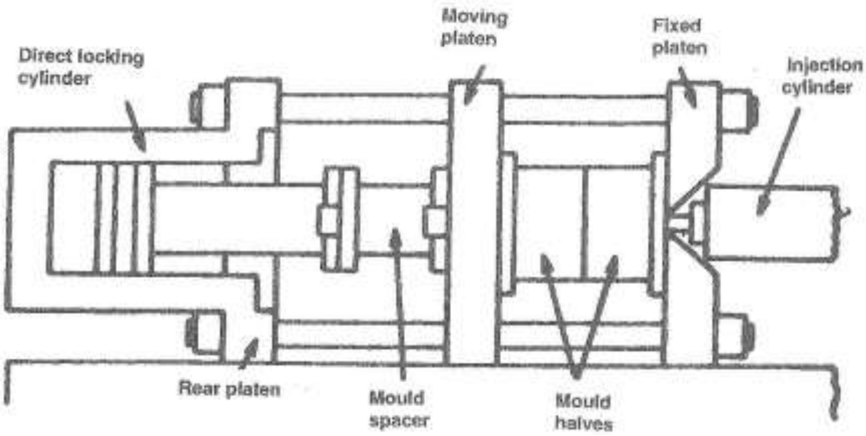


Figure 4-20 Simple Direct Hydraulic Locking System

(The design illustrated incorporates a mould spacer which is useful in reducing the length of stroke of the ram, which is limited to the mould opening necessary to eject the moulding.)

2. Toggle Systems :

A simple form of toggle mechanism is shown in Figure 4-21. By means of the toggle, rapid mould closing may be effected by a small locking cylinder. However, as the toggle bars come into line, the rate of movement of the mould platen slows down to protect the mould surfaces from damage.

If the unit has been properly set only a small force is required to keep the bars in position to provide high clamping force.

The main disadvantage of toggle systems are greater susceptibility to wear and tear of moving parts and the greater care needed to set the system for the correct mould height.

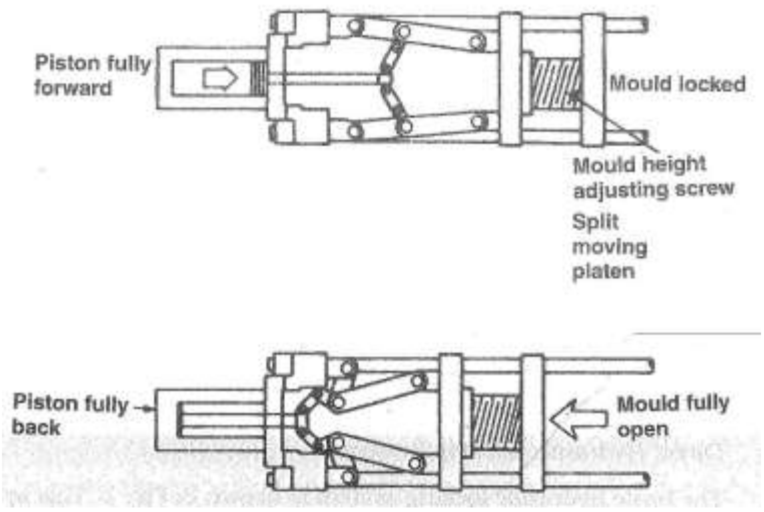


Figure 4-21 Simple Double Toggle Mould Locking System

Injection Unit

Two injection units can be used at the same time to mould two-color parts such as adding machine and typewriter keys. Foams can also be injection moulded for structural parts in furniture.

An injection moulder is made up of a barrel which is heated to the desired temperature by electrical band heaters. The plastic is stored in a hopper which feeds plastic to the barrel. Cold water is circulated around the base of the hopper so that the plastic does not melt. If the plastic were to melt, it would clog the hopper opening.

There are two basic types of injection moulders. The old type is called a *plunger or ram injection moulder*. The newer type is called a *reciprocating screw injection moulder.* The plunger or the screw moves the plastic through the barrel and out the nozzle into the closed mould.

Plunger injection moulder

Figure 4-22 below shows a *plunger injection moulder.* The plunger or ram is in the forward position and has just filled the mould cavity. The plunger moves back and plastic pellets drop into the barrel. The plunger then moves forward to pack the barrel. Heater bands are used to melt the plastic. After the part has cooled, the mould is opened and the part is removed. After the mould is closed, the plunger moves forward. As the plunger moves forward, melted plastic is forced past a torpedo and out the nozzle into the closed mould. While the part is being cooled, the cylinder is refilled for the next shot. This cycle is repeated over and over.

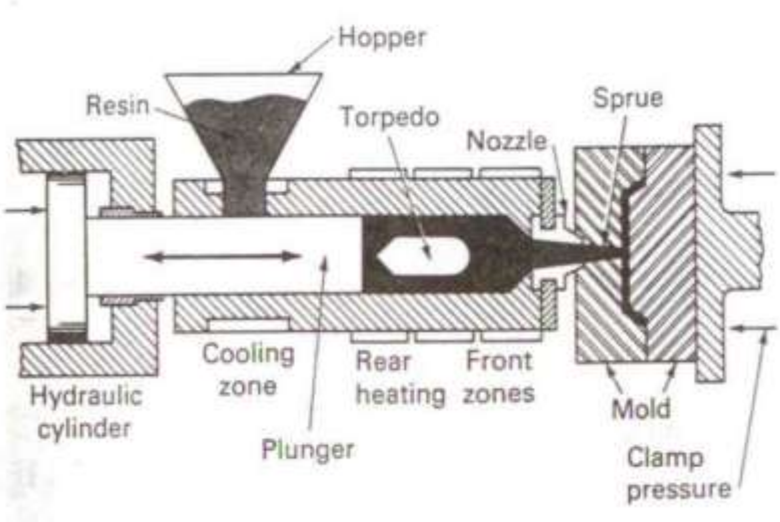


Figure 4-22
A cross-section of a plunger injection moulder showing the main parts.

The *torpedo* is used to force the plastic tightly against the heated barrel to melt the plastic. It also helps in the mixing of color into the plastic. Even with the torpedo, the plastic is not mixed or melted as well as with the screw injection moulder.

Reciprocating screw injection moulder

A *reciprocating screw injection* moulder is similar to the plunger injection moulder. The difference is that the plunger and torpedo have been replaced by a reciprocating screw. The screw is called reciprocating because it will move back and forth. The advantage of the screw is that it will mix color into the resin better than a plunger type. The screw also creates frictional heat in the plastic as it rotates. The amount of plastic that is forced into the mould can be controlled more accurately in a screw machine.

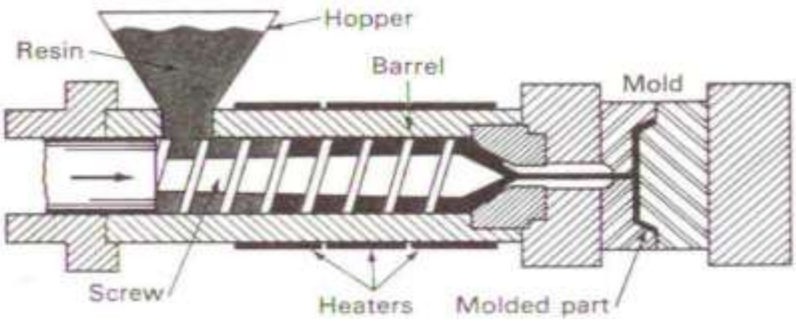


Figure 4-23

A cross-section showing a reciprocating screw injection moulder and the main parts.

A reciprocating screw injection moulder is shown in **Figure 4-23**. The mould has just then filled and is in the forward position. While the part is being cooled, the screw begins to rotate. The plastic pellets drop into the feed section of the screw from the hopper. As the screw rotates, the pellets are fed from the feed section to the compression section where they begin to melt. The plastic continues past the metering section and is fed in front of the screw. Since the mould is filled, the plastic cannot go out the nozzle. Pressure is built up between the screw and the nozzle. This pressure begins to push the screw back until the required amount of plastic for the shot is in front of the screw. A special tip on the screw keeps the plastic from leaking back over the screw.

The mould is opened after the part has cooled and is removed. The mould is closed and the screw moves forward forcing the plastic into the mould. The cycle is repeated over and over. Very accurate parts can be moulded on a screw machine. Less external heat is needed from the band heaters because of the frictional heat generated in the plastic by the screw.

Small injection moulders may use air pressure to move the plunger and a mechanical method to hold the mould closed. Large injection moulders use hydraulic pressure to move the plunger or screw. Hydraulic clamping devices are used to hold the moulds closed. The moulded part can be removed by hand or automatically from the mould. The design of the part and mould will determine which method of part removal is used.

All machines can be run by manual operation. But this type of operation is usually done on only small machines. Each part of the cycle must be controlled by the machine operator. The moulded parts will not be consistent with manual operation. Semiautomatic operation is used where the part must be removed from the mould by hand. The cycle is automatic until the mould opens. The operator must open the gate to remove the part. Closing the gate will cycle the machine again.

Automatic operation usually eliminates the need for an operator. In automatic operation, the mould opens and the part is ejected from the mould. The machine continues to the next cycle without interruption. Much higher production rates can be achieved on automatic operation. Timers are used to control all parts of the cycle. Higher production rates and fewer machine operators will result in a lower cost of production.

MACHINE SPECIFICATIONS

To determine suitability of moulding machine for an injection moulded product, the following machine specifications need to be checked :

- Maximum shot weight capacity of the machine should be more than total weight of article/articles (in case of multicavity mould) plus the runner system.
- Injection pressure should be sufficient to fill the cavities without any short shots.
- Clamping Tonnage required to hold the mould in locked condition should be adequate (otherwise there will be flashes).
- Daylight opening of the machine should be higher than sum total of mould height, plus space required for removal of articles.
- Minimum mould height for the machine should be less than actual height to be mounted.
- Distance

Equipment and moulds

The size of an injection moulder is determined by the size of the shot and the clamping pressure. The *shot size* is the maximum amount of plastic by weight that can be delivered at one time. General purpose polystyrene is used to determine shot capacity of a machine. Sizes of machines vary from ¼ ounce to 800 ounces. The larger the capacity, the larger the pressure needed to fill the mould. As injection pressure goes up, so must clamping pressure. If injection pressures overcome clamping pressures, the plastic will leak out or flash between the mould halves. Clamping pressures may go as high as 3,000 tons on large machines. Injection moulding equipment is very expensive. Large machines may cost up to half a million dollars. See **Figure 4-24**.

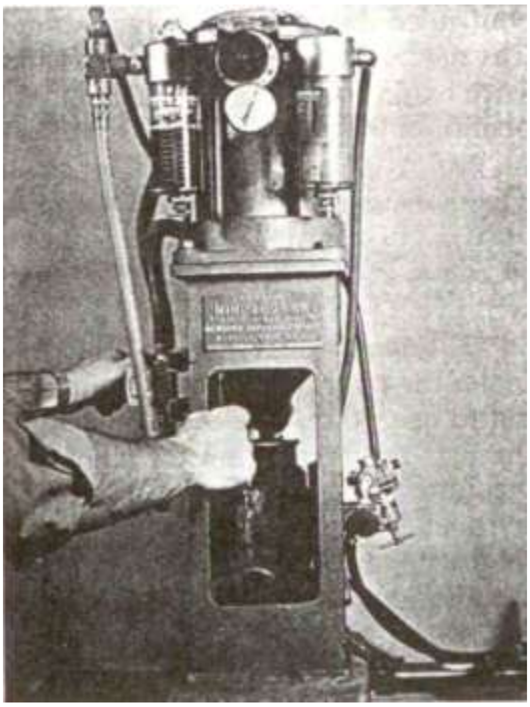


Figure 4-24
A 3/4 ounce laboratory injection moulder

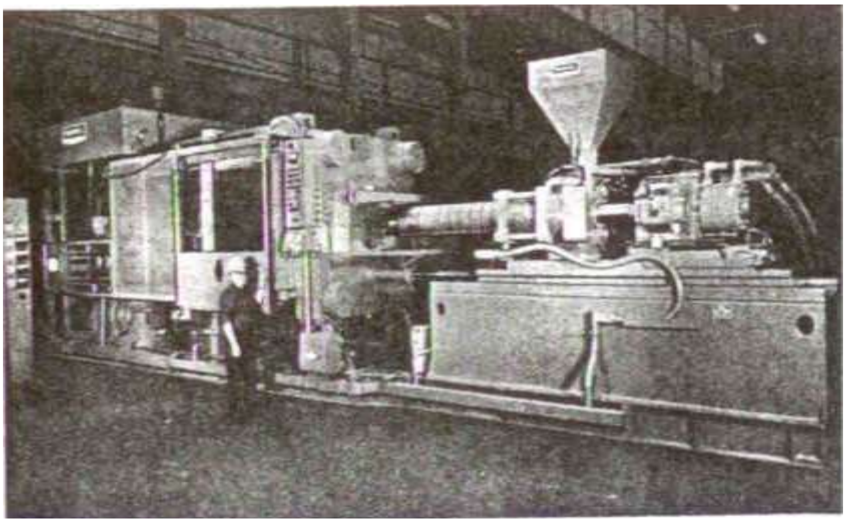


Figure 4-25
An industrial 250 ounce, 1500 ton clamp injection moulder. (Farrel Company)

Moulds are also very expensive for injection moulding. Because of the very high pressures, moulds must be made out of heavy steel. Machining and polishing costs are high. To increase production, many moulds have more than one cavity. During one cycle, several parts are made instead of one. Moulds are cored for water heating or cooling. See **Figure 4-25**.

Moulded parts

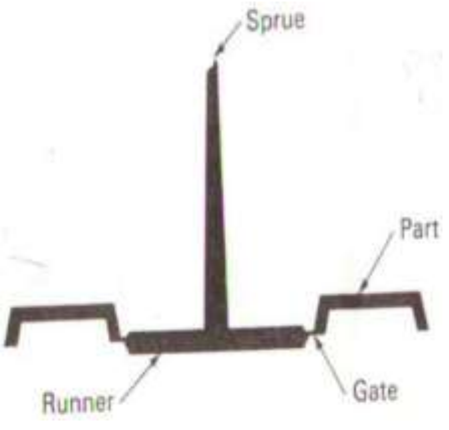


Figure 4-26
An injection moulded two-cavity part showing the sprue, runner, and gate.

The plastic leaves the barrel through the nozzle. The plastic flows from the nozzle through a tapered sprue bushing in the mould. A runner is used to channel the plastic to each mould cavity. There is a small restriction between the runner and the cavity called the *gate.* **Figure 4-26** shows the parts of a moulded shot. The sprue and runner must be removed. If the part is thermoplastic, it can be granulated and reused again. Some moulds are designed to eliminate the sprue and runner.

Moulding variables

There are three major moulding variables that must be controlled for good parts. The variables are temperature, pressure, and cycle time. On large automatic machines, these variables are easier to control than on small machines. Most moulding problems can be corrected by adjusting the variables. All are interrelated and changes should be made one at a time. Sufficient time must be allowed for each change to take effect. Ten or fifteen parts should be moulded before another change is made.

The temperature of the material and mould are very important. If the material temperature is too high, the plastic may burn or degrade. A high temperature will also cause flashing. *Flash* is a fin of plastic around the part. The plastic leaks out between the mould halves. A longer cooling time will be needed if material temperature is too high. The mould cavity will not fill if the material temperature is too low.

The temperature of the mould will affect cooling time. As the mould heats up from each part, the cooling time must be increased. If mould temperature is too cold, the plastic may not flow into the mould properly. The proper mould temperature is determined by the material and design of the mould. Mould temperature may vary from almost freezing to about 160^0F (71^0C).

Injection pressure is another important variable. If pressure is too high, it will overcome the clamping force and cause flashing. If the pressure is too low, the cavity will not fill. Temperature and pressure are very closely related. Temperature will vary for thermoplastics from 375^0F to 500^0F (184^0C to 260^0C). If the cavity is not filling, an increase in temperature or pressure or both may be needed to fill the cavity. If the mould is flashing, a lower temperature or pressure or both may be needed.

The cycle time is the third moulding variable. A *cycle* is the total time required to mould a part from start to finish. The machine is adjusted as to temperature and pressure. The barrel is first purged. Purging is done to clean the barrel. The cycle is then set up. The cycle time is dependent on the material and the design of the part. On large machines, all parts of the cycle are controlled by timers.

The object of injection moulding is to make a good product in the shortest possible time. Each part of the cycle can be varied to produce a good part. A typical cycle is made up of: (1) injection, (2) dwell, (3) extrusion, (4) cooling, and (5) ejection.

The time needed to fill the mould cavity is called *injection time*. As the part cools, it shrinks and pulls additional material from the sprue. It will pull in additional plastic if dwell or pressure is maintained until the gate cools. *Extrusion* is the part of the cycle where the barrel is refilled for the next shot. Adequate time must be allowed so that the part cools. If the part is removed too soon, it will warp. Time is also required to open the mould, remove the part, and close the mould. The cycle then starts over again.

A uniform cycle must be set up to mould good parts. If 40 seconds is spent on one cycle and 20 seconds is spent on the next cycle, the parts will not be the same. If the parts are not good using the cycle, then parts of the cycle must be changed. Make one change at a time and mould 10 to 15 parts. Remember that the cycle time is also related to the other moulding variables.

Moulding thermosets

Thermosets can be moulded using an injection moulder that has been modified. In the moulding of thermoplastics, the barrel is heated over 500^0F (205^0C) and the mould is cooled to about 150^0F (66^0C). The opposite is done for the moulding of thermosets. The barrel heaters are fastened to the mould. Heated water lines from the mould are connected to the barrel. The barrel is heated to about 130^0F to 240^0F (55^0 to 116^0C). A special screw is also needed to mould thermosets. Thermosets can be moulded much faster on an injection moulder than on compression or transfer presses.

Activities

1. Build your vocabulary:

a.	compression moulding	e.	rotational moulding
b.	flash	f.	calendaring
c.	thermoforming	g.	injection moulding
d.	vacuum forming	h.	moulding variables

2. Obtain a mould and compression mould six acceptable parts.

3. Set up a display of at least ten extrusion products.

4. Obtain two moulds and thermoform two acceptable products.

5. Mould two different products in rotational moulding using plastisol and a powdered plastic.

6. Write a report on either extrusion or blow moulding. Include a description of the process, advantages, disadvantages, and product applications.

7. Set up and injection mould two different products using different plastics. Mould at least six acceptable parts from each mould.

8. Collect at least six plastic products. See if the group can determine which process was used to mould the products.

9. Design and make a mould for thermoforming.

10. Using a rod die, set up and extrude at least 10 feet of acceptable plastic rod.

11. Using your phone book or one from a nearby city, make up a listing of companies according to the products that they mould.

12. Visit a local moulding company and make a report to the group.

13. Design and mould a blister package for the parts that you have injection moulded.

14. Make up a display of the materials that are used for injection moulding.

15. Make a list of the six moulding processes and list at least five product applications for each process.

TECHNICAL SPECIFICATIONS

1. Plastic Injection Moulding Machine

Type	:	Plunger
International size	:	54 – 25
System	:	Hydraulic
Standard injection plunger dia.	:	26 mm
Theoretical short capacity in poly sterine	:	40 gm
Injection force	:	3.0 tonnes
Injection plunger stroke	:	150 mm
Injection position	:	Centre
Plasticising capacity	:	4 kg/hr
Hopper capacity	:	5 kg
Barrel heating wattage maximum	:	0.600 x 3 kw
Nozzle heater	:	0.200 kw
Temperature controller blind electronic probe F.e.	:	50 to 400^{o}C
Electronic timer	:	0 – 30 sec.
Barrel retraction	:	6 mm
Nozzle retraction	:	3 mm
Die locking position convertible H x V	:	Convertible position
Injection system horizontal	:	Direct cylinder

Clamping unit :

Die clamping force theoretical	:	20 tonnes
Die mounting space V x H	:	250 x 160 mm
Die mounting pattern H x V	:	250 x 250 mm
Die opening stroke	:	150 mm
Die height maximum	:	250 mm
Die height adjustment	:	50 mm
Day light	:	400 mm
Tie rod hard chrome plate	:	35 mm dia. x 2
Die opening and closing speed	:	Adjustable
Free cycle	:	5 seconds
Built in power pack	:	Hydraulic

Pump motor	:	3 hp
Hydraulic oil required	:	120 litres
Heat exchangers	:	3 hp
Hydraulic pump	:	Gear pump model 8 R
Directional controlled valve	:	Electrical
Valve mounting system manifold	:	3 CETOP
L x W x H of the machine	:	2.1 x 0.55 x 1.6 m
Machine weight	:	450 kg
Total electrical load	:	6 kw

2. 75 mm PP/HDPE slit film plant

Output	:	60 kg per hour of a single screw 75 mm extruder
Extruder	:	75 mm single screw extruder mounted on a sturdy frame of heavy steel sections.
Capacity	:	80 kg
Screw diameter	:	75 mm
Material	:	Nitro alloy steel and Nitrided
L/D ratio	:	24:1
Barrel	:	To suit 75 mm diameter screw
Material	:	Nitro alloy steel – nitrided
Heating system	:	Band type heaters
No. of zones	:	3 zones on barrel
Total heating load	:	19.50 kw
Hopper	:	Steel fabricated with glass window for visual inspection of raw material level.
Cooling arrangement	:	Feed section cooled by water recirculation through a jacket. Blowers for barrel cooling in 2nd and 3rd zones.

Main drive	:	30 hp, dc motor with thyristor control for infinite speed variation.
Transmission system	:	‘V’ belts from motor to reduction gear box. Chain and sprocket drive from gear box to screw. Safety guards are provided. Screw is mounted in a cast bearing housing having thrust bearings which are so designed so as to withstand the thrust developed during extrusion.

Cross-head and die

Die size	:	175 mm dia. hard chrome plated.
Die setting	:	Centering screws provided to adjust die lip gap.
Type	:	Bottom fed type
Heating zones	:	2 nos.
Heating system	:	Band type heaters
Total heating load	:	5.00 kw

Air cooling ring and blower

Construction	:	Aluminium cast air cooling ring for cooling the film bubble. The ring has a circular casing with many air entries and circular insert as an air guide for air impinging on the film bubble.

Blower	:	One number with damper valve for air flow control.
Blower drive	:	5 hp, ac motor.

Air compressor

One number for blowing of the film (complete with pipeline and air flow control cock).

Compressor drive	:	1 hp, ac motor.

Control cabinet

Fabricated from steel sheets and mounted on a robust fabricated frame. It includes :

Solid state temperature controllers

Thermocouples

Ammeters

Main isolator switch with fuse unit

Voltmeter for main supply voltage

Energy regulator

Fuse units, connector plates for heaters outgoing connections.

Controller switches, contactors, relays, pilot lamps, etc.

On-off push-buttons for the motors of blower and compressor.

Vertical take-off unit :

Nip rollers	:	Mounted in ball bearings
Material of construction (Nip rollers)	:	Ebonite roller Rubberised roller
Nip roller's length	:	600 mm
Nip roller drive	:	0.5 hp, dc motor with reduction gear box and rectifier control.
Speed variation	:	From 2 to 20 m/min (infinite variation)
Bubble guide	:	Collapsible wooden flattening boards to guide bubble into nip rollers.

Vertical tower structure	:	Fabricated from steel sections. Guide rollers fitted in tower to guide layflat downwards.
Height of tower frame	:	4500 mm from floor

Preliminary take-off :

Provided with guide rollers to maintain proper tension of film.

Sitting arrangement	:	Multi slitter with required number of blades to slit 96 tapes for side slitting arrangement.

First goddet :

Consists of a robust fabricated stand on which the rolls are supported on heavy bearings.

Rolls :

Material of rolls	:	M.S. chrome plated
Upper rollers :		
Diameter	:	300 mm
Length	:	600 mm
Bottom rollers :		
Diameter	:	150 mm
Length	:	600 mm
Goddet drive	:	3 hp, dc motor and gear box with chain and sprocket arrangement.
Speed variation	:	Infinite variation through rectifier control.
Range	:	From 2 to 20 m/min

Pressure roller	:	Rubberised roller mounted on first goddet roller and last goddet roller to prevent slippage of tape during operations.

Orientation hot plate :

Specifically designed for orientation of PP and HDPE tape. It consists of a robust stand, fabricated from a heavy steel sections and S.S. 304 plates. Heating to the hot plate is through hot oil circulation to ensure uniform heat distribution and uniform temperature throughout the plate. Suitable gear pump for hot oil circulations, one temperature controller, heating and pumping unit, are provided.

Width of S.S. 304 plate	:	600 mm
Length of plate	:	1800 mm
Pump	:	5 hp, ac
Heating load	:	12 kw

Second goddet :

Consists of a robust fabricated stand on which the rolls are supported on heavy bearings.

Rolls :

Material of rolls	:	M.S. chrome plated
Upper rollers :		
Diameter	:	300 mm
Length	:	600 mm
Bottom rollers :		
Diameter	:	150 mm
Length	:	600 mm
Goddet drive	:	7.5 hp, dc motor and gear box with chain and sprocket arrangement.

Speed variation	:	Infinite variation through rectifier control.
Range	:	From 15 to 150 m/min
Pressure roller	:	Two nos. rubberised roller one each on first and last goddet rollers to prevent slippage of tape during operation.

Stabilization oven :

The oven is fabricated from heavy steel sections and sheets. It is specially designed to function at maximum efficiency with reduced power consumption and insulated to minimize heat loss. Air flow is from a high pressure blower driven by a suitable ac motor. Heating is by electric open coil heaters arranged in the lower chamber. The baffling arrangement of air provided ensures maximum utilization of heat energy. Hot air is recycled. Solid state temperature controllers ensure the maintenance of constant temperature by automatic on-off control of heaters.

Blower drive	:	2 hp, ac motor
Heating load	:	18 kw
Oven dimensions	:	600 mm width x 2440 mm long

Third goddet :

It consists of a robust fabricated stand on which the rolls are supported on heavy bearings.

Rolls :

Material of rolls	:	M.S. chrome plated

Upper rollers :

Diameter	:	300 mm
Length	:	600 mm

Bottom rollers :		
Diameter	:	150 mm
Length	:	600 mm
Goddet drive	:	3 hp, dc motor and gear box with chain and sprocket arrangement.
Speed variation	:	Infinite variation through rectifier control.
Range	:	From 15 to 150 m/min
Pressure roller	:	One no. rubberised roller on last goddet roller to prevent slippage of tape during operations.

Master head :

It consists of one rotating drum mounted on a sturdy structure, driven by the third goddet drive by belt and pulley arrangement. All the tapes are taken onto this drum at start up and then onto the cheese winders.

Cheese winders :

A set of 96 cheese winding units designed fro uniform criss-cross winding of tape. Each winding unit is driven by an individual torque motor with independent on-off switch control. The automatic traverse arrangement consists of hardened cam and follower. The traverse drive is by special timer belt.

Individual torque control is provided for each cheese winding unit for precise and independent adjustment of winding tension. In addition to this group controllers are provided.

The cheese winders are mounted on a sturdy structure. The cheese base is a plate on which the complete assembly is made.

3. HM-HDPE blow film plants

Screw diameter	:	45 mm
Main drive	:	15 hp, dc
Extrusion cpacity	:	22 kg/hr
Layflat width	:	150 to 600 mm
Minimum gauge	:	40 g
Dies (spiral type)	:	25, 50, 75 mm
Nip roll size	:	750 mm
Winder	:	Type – Four station Drive – Torque motors
Connected load	:	27 kw
Overall dimensions	:	6300 x 2400 x 4500 mm

4. Plunger type injection moulding machine

Plasticizing capacity (Polystyrene)	:	18 kg/hr
Shot capacity (Polystyrene)	:	75 gm
Diameter of injection plunger	:	32 mm
Maximum load on injection plunger	:	7.5 tonnes
Stroke of injection plunger	:	228 mm
Maximum no. of shots per shift	:	1200 nos.
Space between tie-bar	:	241 x 241 mm
Mould opening	:	241 mm
Maximum mould thickness	:	241 mm
Day light opening	:	482 mm
Minimum mould thickness	:	150 mm
Mould clamping force	:	45 tonnes
Capacity of hopper	:	12 kg
Electric motor	:	3 ph, 1440 rpm, 5.6 kw/7.5 hp
Heating unit consumption	:	2 kw
Heat controlled by (thermotrols)	:	3 nos.
Nozzle diameter	:	19 mm
Ejector in platen	:	Side and centre
Diameter of locating ring	:	110 mm

Depth of locating ring	:	5 mm
Capacity of oil tank	:	160 mm
Floor space	:	2540 x 560 mm
Total height of the unit	:	1660 mm
Gross weight	:	1500 kg

5. Semi automatic blow moulding machine

Capacity	:	Minimum – 1 litre
	:	Maximum – 10 litres
Screw diameter	:	65 mm
L/D ratio	:	20:1
Motor	:	12.5 hp
Heating load	:	9.850 kw
Plasticizing capacity	:	40 – 50 kg/hr(normal)
Parison control in stages	:	3
Gross weight	:	2.5 tonnes
Net weight	:	1.5 tonnes

Questions :

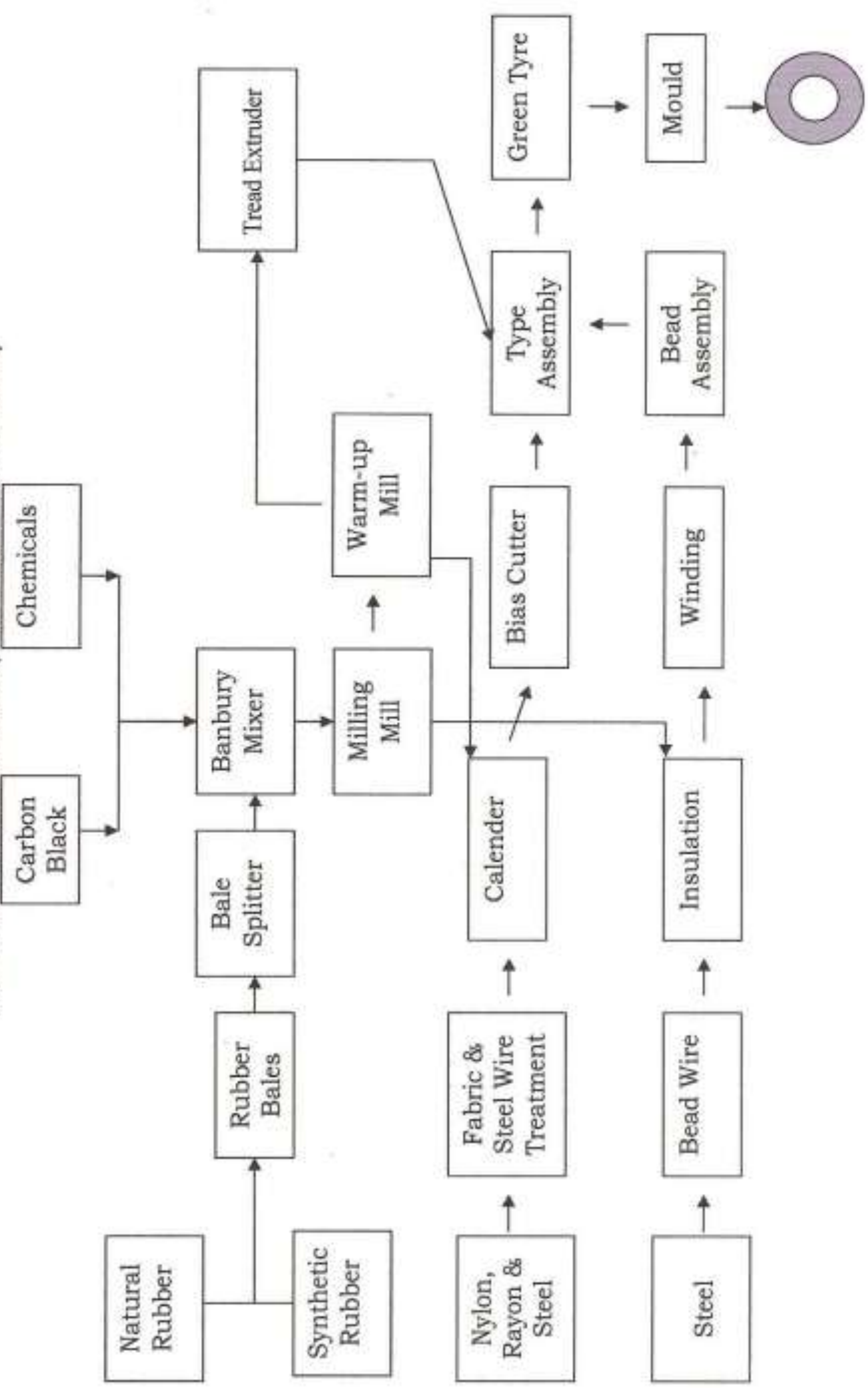
(a) Explain moulding and forming of plastics.

(b) Write short notes on
- Extrusion
- Blown film
- Coating
- Monofilaments
- Blow moulding
- Injection moulding

(c) Provide data to be collected while taking inventory of following machines to get current prices :
- Plastic injection moulding machine
- PP/HDPE slit film plant
- HM-HDPE blown film plants

UNIT – 5

RUBBER (AUTOMOBILE TYRE)



PROCESS FLOW DIAGRAM (TYRE MANUFACTURING)

Automobile Tyre Manufacturing Process

In the tyre industry the finished product is not obtained by assembling different components as is observed in most other manufacturing.

In the tyre industry, the assembled components need to be further processed before obtaining a final finished product.

A tyre is made of 3 important components : (1) Tread Rubber (outer portion)

(2) Carcass (inner portion)

(3) Bead (side of the circular portion)

The manufacturing of a tyre is a four stage process:

* Component processing
* Component making
* Component assembling
* Moulding, curing and finishing

Component processing:

The two processes are:

* Preparation of rubber compound
* Preparation of fabric by dipping in latex

Preparation of rubber compound:

Large bales of raw rubber are cut into smaller pieces which are masticated and mixed with chemicals.

Common chemical compounds like Carbon-black sulphur, accelerators, retarders, processing aids, etc. are mixed with rubber or masticated rubber. This is known as mother stock or master batch. As per the technical specifications, mother stock is mixed with carbon black and other chemicals. This process of mixing is carried out in large mixers or open mills. This rubber compound is used for making tread, under tread, insulation and as topping for fabric preparation and bead.

In preparation of the rubber compound both natural and synthetic rubber is used as per specifications of the Rubber Manufactures Association and as per the end use. Normally for truck tyres, Natural Rubber is used & for Car tyres Synthetic Rubber is used. This is due to the various properties of these rubbers.

Preparation of fabric:

The fabrics used in tyre industry are cotton, rayon polyester and nylon and for Radial tyres high tensile steel belt known as Beakers are used. The rayon and nylon fabrics are first dipped in a latex mix to obtain better adhesion of cord/rubber. It is then given a cover of rubber compound by passing it though a 3 or 4 roll calenders. Cotton fabrics just need to be dipped and topped with rubber compound to meet requirements for different products. Nowadays cotton & Rayon usage has been stopped due to less strength of these fabrics compared to Nylon or Polyester fabric.

Dipping:

A dipping mixture consists of latex and chemicals. The chemicals are mixed with soft water and are treated at specific temperature and then blended with latex and water. This is known as DOPE. Fabric rolls are passed through a tank of DOPE and the amount of coating depends on the speed of the roll of fabric passing through the tank. The treated rolls are dried and are kept in a hot cellar to remove any trace of moisture before they are taken out for toping or calendaring.

Spreading:

A coating of certain types of cotton fabrics is not carried out by the process of dipping but spreading. Rubber compound is cut into small pieces and is placed in containers filled with solvents until a semi-liquid mass is obtained. This is passed through a mixing machine in which a required quantity of solvent is added till a smooth dough of consistent viscosity is obtained. The fabrics are dried in a separate eight drum drier and then fed into a spreading machine where it is coated with dough. At present this process is rarely used due to fire hazards, less productivity, quality, consistency, etc.

Topping:

The dipped or spread fabrics are then given a coating of thin film in a calendar machine by a compound first warmed up in a warming and feeding mill. A calender machine consists of 3 or 4 rolls with a very thin opening through which fabric roll is passed. In a 3 rolls Calender the fabric is topped up with rubber only on one side and again it has to be passed through the Calender to top up the other side. whereas in a 4 roll calendar both the sides gets topped up simultaneously.

Frictioning:

A topping compound is pressed on top of fabric but in a frictioning process, the compound is pressed between the textile cord in fabric rolls. The frictioning fabric is usually used as CHAFER for covering the beads.

Cotton, nylon, polyester, steel belt and rayon are used according to the strength required for the type of tyre. In India, Nylon is most widely used as fabric in manufacturing a tyre.

Making components:

Rubber compound, fabrics and wires are converted into components of tyres by

* Extrusion
* Calendering
* Fabric / Steel Wire Cutting
* Bead making.

Extrusion:

In the extrusion process a rubber compound is forced through a die of an Extruder after warming it up and tyre treads are produced as per the required dimensions. Rubber tube is also produced in this manner. Components such as treads & tubes are produced by this process.

Calendering :

A calendaring process is used for producing coated fabric & coated steel wire fabric. Components such as plies, breaker, chafer, etc. are produced by cutting of calendered fabric & steel wire fabric.

Component assembling:

It consists of two major processes –

- Bead making
- Cover making

Bead making:

A ring of bead wire coated with a rubber compound is formed on a former machine. It is then wrapped with fabric and then it is covered with bead filler to obtain a complete bead.

Cover making:

In cover making, fabric, plies, insulation, bead breaker, chafer, undertread are placed on a former to give a raw cover. The amount of fabric piles etc. needed to produce a raw cover depends upon the specifications required for the type of cover.

Tyre Building

All these components like tread, plies, beads are now joint together to make a green tyre in the shape of a drum. First the beads are fitted on the sides of the tyre building machine drum. Over these, plies are fixed which are already cut as per the requirement on the Bias cutter. The no. of plies usually varies from 4-16 as per the size and strength of the tyres. Once the plies are stuck one over the other then the tread is fixed over the plies.

After fixing up all the components the green tyre in shape of a drum gets produced.

In the case of Radial tyre, before application of belts, the green tyre is expanded from cylindrical to a torodial shape. The belts and the tread are then assembled. This can be done in two stages or in one stage where drum can be expanded to the torodial shape in the same stage.

Moulding, curing and finishing:

A process of vulcanizing is known as curing. The green tyres are cured in moulds and the method used depends on the technological requirements.

The process of moulding is carried out in three stages –

* Bagging
* Moulding and curing
* Debagging and finishing

A curing bag is placed inside the green tyre which is then put into hydraulic moulds. In small tyres, the process of bagging and debagging is carried out manually. For big tyres the bagging and debagging process is carried out by machines. The mould is heated from outside by steam & the inside portion is heated by passing stream/hot water. The cured tyre is trimmed and the finished product is packed after inspection. In modern machines, bagging and debagging is not required. The inside curing of a green tyres is done through a diaphragm attached to the moulding press known as Bag-o-matic Press. The cured cover coming out is taken to the finishing section for trimming and inspection.

In good old days the moulding was done in an autoclave and the curing time and pressure depended on the size of the cover. This process has been stopped as it affects the productivity & quality of the tyres.

Radial Tyre Curing :

Radial tyres with wire cord bodies are vulcanized in special segmented moulds to avoid distortion of tyre components.

Manufacturing process of tube making:

In the process of tube making, the rubber compound is heated and passed through extruding machines and the tubes coming out are cut into specific lengths. Rubber tubes need the fixing of valves on them and their ends needs to be joined. The valves are attached to the tubes by special adhesives and ends are joined in a joining machine. Curing of tubes is then carried out by slightly inflating them with air. The tubes are then ready for inspection and packing.

- **Brief description and function of major machines :**

Banbury mixer:

Banbury mixers are of two types:

(i) Tangential (ii) Intermeshing rotor type

A tangential mixer is similar to a two roll mill with an enclosed chamber. Its main purpose is to mix carbon black oil, processing aids & chemicals into the rubber compound. But today they are designed to increase the output and control properties of rubber which is fully automotised.

Modern day mixers are both manual and automatically controlled units with monitoring capability for each phase of mixing. The latest mixers provide excellent quality, uniformity and output.

Mixers can be batch or continuous type. The advantage of a batch mixer is that it can accept materials of various shapes and forms. A continuous mixture requires continuous weighing and feeding of the ingredients and are used to provide pellets or a granular form of rubber.

Open roll mills:

Open roll mills are used for uniform dispersion of ingredients in rubber as per specifications and formula. The rubber compound is warmed up and then fed to internal batch mixers.

Extruder:

Extruders are mainly screw type. The screw pushes the material through a die for making rubber compound in the form of pellets or rubber sheets after passing through a pair of rollers. Extruders are designed with respect to diameter, length, speed of screw and pressure needed for extrusion. The extruders are also designed for minimum temperature rise and decrease in temperature of compound during the time it is passing through the extruder.

Calender:

A calender consists of three iron rolls. Calenders are used to provide rubber sheeting of different lengths and thickness. Calenders are also used for coating fabrics, cord and wire with rubber for construction of tyres and conveyor belts. The temperature control of rolls is carried out by using cored or rolls drilled with holes. An automatic temperature control device used with drilled rolls provide excellent temperature control. The speed of roll is controlled by a single motor drive with gears or a variable speed motor for each roll is used. Modern calendars have built in provisions for bending rolls and altering the relative position of rolls. It provides for a uniform thickness of material. Automatic adjustment of the roll position and bending produce an accurate thickness of the rubber sheets.

Vulcanizers:

Vulcanizers are press curing type devices. It moulds articles by compression transfer or injection methods. A saturated steam, electrically heated platens or radio frequency waves are used as heat sources. The pre-heated compounds are press cured without scorching so that proper desired shape is obtained with minimum time consumption and after removing from the mould it should have an attractive surface in finished form.

CVSRTA

DESCRIPTION OF AUTOMOBILE TYRE MANUFACTURING PLANT

1. Banbury Mixer

A Banbury mixer size & dimensions depend on its capacity. It varies from 45liters – 165 liters.

Body

Size	:	11

Mixer equipped with drop type discharge door and a conversion drive for processing rubber.

Mixer specifications

Floating weight	:	Cylinder diameter 400 mm
Design type	:	Double cable 'V' bottom
Finish	:	Chromium plated
Design type	:	Standard feed

Dust stops

Design type	:	'SSA' TH & CP
Wearing ring material	:	Steel plated

Chamber sides

Design type	:	DR. SIDE 562 mm
Bore surface	:	Farrel Alloy 13

Rotors

2 Wiring

Surface material	:	Chromium plated
Type of motor bearings	:	Roller
Lubrication by	:	Circulating oil system

End plates

Design type	:	'SSA'
Finish	:	Farrell Alloy 10
Type of cooling	:	By water

Discharge door

Design type	:	Drop construction radial
Door surface	:	Farrell Alloy 10

Gear drive

Type	:	Standard drive
Rating	:	500 hp
Input	:	992 rpm
Output	:	162 rpm
Shaft rotation	:	Anti-clockwise
Input shaft dia.	:	156 mm
Key way	:	45 mm W x 19 mm D x 340 mm L
Main drive motor	:	500 hp, 992 rpm, 440 V

2. <u>2100 mm Mixing Mill</u>

Equipped with Bull gear pinion drive.

Drive motor	:	250 hp at 1000 rpm

Rolls

Drive (back) roll

Material	:	Chilled C.I.
Design	:	Coned
Finish	:	Smooth
Maximum temperature	:	120 deg. C
Speed	:	20 rpm

Adjustable (front) roll

Material	:	Chilled C.I.
Design	:	Drilled
Finish	:	Smooth
Maximum temperature	:	120 deg. C
Speed	:	22.5 rpm

Journal boxes		
Lining material	:	Copper Alloy
Friction ratio	:	1.14:1
Base plates	:	Fabricated
Mill base	:	Fabricated
Drive base	:	Fabricated
Guide mechanism type	:	Fixed
Roll adjustment mechanism		
Type	:	Manual connected to journal box by pull back arrangement Oil re-circulating
Emergency stop device	:	Overhead type
Stockpan	:	Steel fabricated with rollers underneath
Drive specification		
Gear drive	:	Flender S2N – 320
Drive method		
Bull gear pinion	:	140 T/26 T
Gear pinion ratio	:	1.14:1

3. <u>Cracker Mill</u>

Size	:	1500 mm
Working roll size	:	560 mm dia. x 1524 mm face width
Bak roll surface speed	:	30.5 m/min maximum
Friction ratio	:	1:1.3

Rolls

Chilled cast iron rolls internally cored, fully machined working face and journal diameter ground finished with necessary galvanized iron spray pipe with spray holes. Each roll end is equipped with open bell mouth piece. Surface hardness is 500 $\pm$ 25 BHN having a chill depth of 15 – 20 mm. The back roll is corrugated with contours.

Roll housing and caps

Roll housing and caps are of heavy duty cast steel. The necessary machined surfaces are provided on the top caps to accommodate various mill accessories. Frames are bored to accept nip adjustment mechanism.

Roll journal boxes

Roll journal boxes are of close grained cast iron with wear resisting full bronze bushes. The bearing surfaces have high surface finish to suit the clearance of the individual roll journal. Aluminium labyrinth oil seal is provided at both ends of bearing boxes.

Base frame

Base frame is fabricated by heavy duty steel. Base frame is separate for main machine and drive but are combined through dowels for ease of alignment and assembly at site. The machine and the drive is bolted down to this frame.

Guides

Guides are of fixed design mounted on bearing boxes with a provision for raising and lowering to adjust the gap between roll and guide. The guides are machined from single steel section and the curved contours coming in contact with the roll working surface is provided with Polyamide type material.

Roll adjustment

The front roll journal boxes are provided with pull back type arrangement along with adjusting screw for the movement of front roll. The adjusting screw is of carbon steel while the nut is cast steel. Shear pins fabricated in steel is supplied and provided between the journal box and nip adjusting screw to safeguard the rolls when overloaded.

Mill pan

Mill pan is fabricated from heavy gauge sheet steel mounted on rollers or fixed in position.

Lubrication system

Lubrication system comprising of oil tank with strainer, level gauge, oil circulating motorized pump, filter, heat exchanger, pressure switch and relief valves with necessary distributing headers. Inter-connecting piping is provided for lubricating the bush bearings in the bearing boxes.

Grease nipple lubrication is provided for nip adjustment screw assembly.

The lubrication return lines have drain manifolds for visual inspection. The lubrication unit is with rotary gear pump driven by motor. Splash type lubrication is provided for bull gear and pinion.

Safety device

Safety device is overhead wire type. The limit switch is mounted on the mill caps and connected to the control panel.

Gearbox

The helical gearbox with a service factor of minimum 1.5. The gearbox is with hardened and ground gears and complete with splash lubrication system.

Bull gear, pinion and connecting gears

The bull gear is of high grade cast steel with hob cut teeth. The pinion is of EN Alloy forged steel with hob cut teeth. The connecting gears are of Cast Steel Grade-I with hob cut teeth having friction ratio of 1:1.3. These gears are mounted on Mill Housings and is totally enclosed in a heavy gauge sheet steel enclosure.

Motor and control panel

150 kw, 990 rpm, AC motor and controls.

Coupling

All input/output couplings including brake drum is provided.

Brake unit

Pneumatically operated brake including brake drum is provided. Control voltage for all solenoids is 110 volts.

4. Tyre Building Machine

Function

This machine is ideally suited for building green tyres of bead size from 500 mm to 750 mm. The stitching of beads, ply and bead done by means of a cam controlled triaxial stitcher.

Capacity

Drum diameter	:	530 to 990 mm
Drum shoulder set	:	400 to 900 mm
Drum centre line from floor	:	950 mm
Maximum ply width	:	1400 mm
Bead dia. range	:	500 to 750 mm
Drum shaft speed	:	280/140 rpm
Electrical supply	:	415 V, 50 Hz, 3 phase
Air supply	:	7 kg/sq. cm. (100 psi)

Machine details

Head stock assembly

The drum shaft is supported on adequate capacity bearings for the overhang and the lead, in a fabricated head stock. The drum shaft is driven by a two speed AC motor through 'V' belts. A quill with necessary brake drum for collapsing the drum is supported on the drum shaft so as to rotate freely over the drum shaft. An adapter is provided at the end of the drum shaft for outer head setting. A pneumatically operated inner head adapter can also rotate and allows the bead setter ring to take any position, radially pneumatically operated shoe type brakes are provided for drum collapsing.

Stitcher

A triaxial stitcher mounted on the opposite side of the operator is connected to the base by a bracket. The stitcher rolls mounted on the lever of an integrally cast pneumatic cylinder move in all three axis at different speeds. The movement of stitcher rolls is guided to stitch over the correct profile of drum by means of cam and limit switch arrangement.

Control panel (electrical)

A machine mounted control panel consisting of a control transformer, protective fuse and switch fuse unit mounted on the top of head stock. A push button panel is mounted at the front of the driving head for operator's convenience. A joy stick is mounted on the front side to control all the movement of the stitcher unit.

Instruments and controls

A filter regulator and lubricator unit and the solenoid valves are mounted at the rear of the driving head and complete piping is provided for the air cylinders. A set of foot switches are mounted at the front of the machine to control the machine operation and a set of limit switches and cam controls the stitches movement.

5. <u>Three Roll Calender with Conveyor Belt System</u>

Design	:	3 rolls
Roll diameter	:	650 mm
Width of roll body	:	1650 mm
Processing speed	:	6-24 m/min
Control range	:	1:4
Principle of drive	:	Central drive
Drive side	:	Right hand drive in processing direction
Roll adjustment rate	:	2.2 mm/min
Press roll dia.	:	260 x 1550 mm
Lubrication	:	Central grease lubrication other than bearings.

Foundation plate : Grey cast iron connected to each other by means of bolted cross connection stone bolt are raised to secure the foundation bolt.

Motor

Main motor	:	150 kw, DC
Installation output	:	5 kw, DC
Secondary drive	:	8 kw, DC

Leonard set consisting of:

Control generator	:	188 kw
Driving motor	:	235 kw
Exciting generator	:	8 kw
Total connecting output	:	245 kw
Kind of protection	:	1P 445 TRA-II
Operating voltage	:	U = 440 V, 50 c/s
Control voltage	:	U = 230 V, 50 c/s
Direct voltage produce	:	U = 440 V
Armature	:	220 V

6. **Truck Tyre Curing Press**

Size	:	2200 mm
Size of tyres being vulcanized	:	From 18 – 24 up to 30.5–32R
Tyre maximum external diameter	:	1820 mm
Tyre maximum internal diameter	:	610 mm
Tyre profile width (maximum)	:	745 mm
Maximum pressing strength	:	740 t
Steam chamber inside diameter	:	2200 mm
Mould height	:	From 600 up to 900 rpm
Production capacity when building tyres size 30.5-32R pcs. per hour	:	0.32

Working media

Steam for shaping in bladder:		Not more than 4.5 kg/sq.cm.
Steam for vulcanization in steam chamber	:	6 kg/sq. cm.
Steam for vulcanizing in bladder	:	16 kg/sq. cm.
Superheated water for vulcanization in bladder	:	25 kg/sq. cm.
Water for bladder cooling	:	4 kg/sq. cm.
Water for hydraulic drive	:	25 kg/sq. cm.
Air in control system	:	2 kg/sq. cm.
Vacuum in bladder	:	Not more than 400 mm Hg
Superheated water temperature	:	185 $\pm$ 5 deg. C
Mould closing and opening time	:	90 seconds

Motor power

Vertical stroke reducer	:	33 kw
Inclined stroke reducer	:	23 kw

Overall dimensions

Length without diaphragm valve post	:	4632 mm
Length together with a post	:	5900 mm
Width	:	3515 mm
Height in open position	:	4810 mm
Height in close position	:	4995 mm
Maximum	:	5620 mm

Weight without diaphgram valve post	:	56370 kg.

7. Horizontal Bias Cutter

Fabric width	:	1524 mm
Conveyor belt width	:	1610 mm
Machine frame width	:	1750 mm

Features of the machine

Let-off unit, liner re-rolling, festooner, conveyor, cord winding unit.

Nylon cord cutting for motorcycle tyre, scooter tyre, industrial tyre, passenger tyre, bus and truck tyre.

Fully automatic operation

Photocell for cord width

Rotary cutter driven by cable cylinder

Cutting angle	:	45 degree – 90 degree
Cutting speed (maximum)	:	18 pcs. per minute
Cutting accuracy (maximum)	:	$\pm$ 1.5 mm
Power source	:	415volts, 3 phase, 50 Hz, AC

8. Extruder with 8" Cooling Line complete with

Stamping conveyor including swinging portion, shrinkage conveyor, table above cushion mill, automatic weighing frame solution applicator, upward conveyor, downward conveyor, conveyor before skiver, acceleration table, gravity roller table.

Flap conveyor chain made out of S.S. 304 quality.

110 kw, DC, 1500 rpm motor for 8" hot feed extruder.

DC motors for cooling line – 7 nos.

Thyristor converter panels for 8" hot feed extruder with conveyor line and 24" cushion mill.

8” Hot feed extruder with tread head

L/D ratio	:	6:1
Screw speed	:	Variable up to 60 rpm
Motor	:	150 hp, 1500 rpm, DC motor with thyristor control drive panel.

The extruder is comprised of the following assemblies:

Bead plate assembly.
Feed hopper housing and screw/barrel assembly.
Tread head.
Drive transmission assembly.

Bead plate assembly

Bead plate fabricated from steel sections and plates for mounting drive motor, transmission gearbox and extruder assembly.

Feed screw assembly

The screw is machined from alloy steel, heat treated and hard welded flights having been duly ground finished. The screw is also hollow bored for cooling/heating and fitted with delivery pipe along with necessary support spiders and rotary joints.

Cylinder barrel/liner assembly

Cast steel barrel liner with bi-metallic liner having hardened inner bore to provide high wears resistance. Helical baffles are provided in the liner bore to provide for efficient steam heating/water cooling.

Feed hopper assembly

Feeding section of the barrel with an undercut to facilitate continuous taking up of the feedstrip by screw. The feed hopper is fabricated from cast steel.

The feed hopper assembly provided with a power feed roll geared directly from the feed screw mounted on bush bearings to uniformly feed the extruder.

A clear gap between the rear end of the barrel and the thrust bearing housing provided to preclude extruder feed stock or oil leakage/seepage from creeping either way.

Tread head

The tread head complete with die plate, clamping arrangement pneumatically operated by cylinders mounted on top as well as bottom wedges along with necessary piping and manually operated valves, suitable for an opening of 800 mm (W) x 35 mm (H). The head of horizontal split is designed to facilitate cleaning of rubber. The size of the air cylinder is such that positive clamping pressure is exerted on the die at all times and suitable for operation on a minimum air pressure of 5.5 kg/sq. cm. and maximum pressure of 7 kg/sq. cm.

Gearbox

Gearbox is totally enclosed with parallel shaft, double reduction type with heavy duty, heat treated and ground gears of helical design and shaft mounted on heavy duty radial and thrust antifriction bearings. The gearbox output shaft is of special design to carry thrust bearings and also hollow to mount the screw and provide access for heating/cooling system. The thrust bearing has full flow lubrication with a sight glass in the return line to monitor the flow. Suitable lube failure pressure switch is incorporated. The lubrication pump is provided.

9. Cushion Mill

The mill consists of:

Rolls, mill housing and caps, roll journal boxes, base frame, guides, roll adjustment, mill pan, lubrication system, safety device, gearbox, bull gear, pinion and connecting gears, motor and control panel, brake unit, etc.

Rolls

Chilled cast iron rolls internally cored, fully machined working face and journal diameter ground finished with rotary joints for heating and cooling. Surface hardness of 500 ± 25 BHN having a chill depth of 16-21 mm. Both rolls are plain.

Mill housing and caps

Heavy duty cast iron. The necessary machined surfaces provided on the top caps to accommodate various mill accessories. Frames bored to accept Nip adjustment mechanism.

Roll journal boxes

Close, grained cast iron with wear resisting full bronze bushes. The bearing surfaces have high surface finish to suit the clearance of the individual roll journal. Aluminium labyrinth oil seal is provided at both ends of the bearing boxes.

Base frame

Base frame is made out of heavy duty steel and common for main machine and drive. The machine and the drive bolted down to this frame.

Guides

Fixed design mounted on bearing boxes with a provision for raising and lowering to adjust the gap between roll and guide. The guides machined from single steel section and the curved contours coming in contact with the roll working surface are provided with polyamide type material.

Roll adjustment

The front roll journal boxes are provided with the pull back type arrangement along with adjusting screw for the movement of front roll. The adjusting screw is made out of carbon steel while the nut is made out of cast steel. Shear pads are made out of cast iron.

Mill pan

Fabricated from heavy gauge sheet steel and fixed in position.

Lubrication system

Lubrication system comprising oil tank with strainer, level gauge, oil circulating motorized pump, filter, heat exchanger, pressure switch and relief valves with necessary distributing headers. Inter-connecting piping is provided for lubricating the bush bearings in the bearing boxes.

Grease nipple lubrication is provided for nip adjustment screw assembly.

The lubrication return lines have drain manifolds for visual inspection. The lubrication unit is provided with rotary gear pump driven by a motor. Splash type lubrication is provided for bull gear and pinion.

Safety device

Overhead wire type. The limit switch is mounted on the mill caps and is connected to the control panel.

Gearbox

The worm reduction gearbox has a minimum service factor 1.6.

Bull gear, pinion and connecting gears

The bull gear to high grade cast iron with hob cut teeth.

The pinion of EN Alloy forged steel with hob cut teeth. The connecting gears of Cast Steel Grade-I with hob cut teeth having friction ratio of 1:1.3. These gears mounted on Mill Housings and totally enclosed in a heavy gauge sheet steel enclosure.

Motor and control panel

40 hp, 1500 rpm, DC motor and controls.

Brake unit

Pneumatically operated brake including brake drum is provided. Control voltage for all solenoids are 110 volts.

Working roll size	:	300 mm dia. x 600 mm face width
Front roll surface speed	:	2-25 m/min
Friction ratio	:	1:1.3
Size	:	600 mm

10. Light Truck Radial Type Tyre Building Machine – 1 Stage

The machine consists of:

Head stock assembly, tail stock assembly, stitcher, service (front and back), hydraulic unit, control panel and operation panel, piping and wiring inside machine, side tread splice press, building drum body, building drum spacer, ply lock unit, bead setting ring, light marking projector, etc.

Applicable tyre size

Bead size	:	375 mm, 385 mm, 400 mm, 410 mm, 430 mm
Drum shoulder width	:	300 – 600 mm
Drum diameter	:	434 – 518 mm
Maximum ply overhand (each side)	:	125 mm
Tyre construction	:	2-0, 1-1, 3-0, 2-1 ply lock.
Building drum	:	10 segments expanding drum
Main motor	:	3.7 kw, DC
Main shaft center line height	:	840 mm

Ply lock system : Plate finger ply down bladder turn up

Stitcher

Tread stitcher	:	Traverse type
Under stitcher	:	Bladder roller type
Chafer stitcher	:	Rotary type

Servicer

Front rack	:	4 stories
Back rack	:	1 storey

Dimension of shell

Carcass	:	32 x 900 mm
Chafer	:	32 x 300 mm
R.C.	:	32 x 900 mm, 32 x 450 mm

Hydraulic unit	:	18.5 kw, 6 pole, AC motor
Hydraulic pressure	:	70 kg/sq. cm. and 40 kg/sq. cm.

Control

Operation made according to automatic sequence set by Pin board.

Utility sources

Electric power source	:	415 V + 5%, - 10%, 50 Hz + 2%, 3 phase
Compressed air	:	7 kg/sq. cm.

UNIT – 6

PAPER AND PAPER PRODUCTS

PULP SECTION

OBJECTIVES :

By the end of this chapter students will learn about :-

- Process flow and functions of machines used in pulp and paper machine sections.
- Paper manufacturing process
- Technical specifications of machinery

	NAME OF MACHINE		FUNCTION
1.	Hydropulper ↓	:	Slushing waste paper. Waste paper is fed in the pulper along with water and pulp slurry is being made. Rotor of pulper is fitted with knife which is being driven by motor. Pulping time differs for raw material to raw material as per product to be made.
2.	Pump ↓	:	For lifting stock from one place to other place.
	Sand Trap ↓	:	To pass stock through the channel. Heavier particles are settled down by gravity.

3. Dump chest : Storage facility.

4. Pump : Stock lifting.

5. Dilution pit : For water addition to get a better effect at later stage for sand separation.

5A. High Density Cleaner : Here sand/pins is being separated out by the action of centrifugal force developed with the stock. It is of vertical cone shape.

6. Turbo Separator : Plastic is being separated from the stock. As plastic is unwanted material, its removal is a must. Screen is fitted inside and stock is being passed through the screen. As its reject contains some pulp so again it is being passed through one vibrating screen. From this screen only plastic is separated. Turbo Separators are in series – Two/Three nos. as required. Last separator has fine hole in screen.

7.	Centricleaner stage	:	This is also one type of cleaning equipment. Fine particles like sand etc. are being separated out downward from the stock by the same principle i.e. centrifugal force. As pulp slurry is lighter, it will go upward and unwanted material is being separated out from bottom cone.
8.	Thickner	:	From the name itself it is clear that its purpose is to thicken the stock. As in centricleaner stage we need diluted stock so it is needed to thicken. The stock again for better refining effect at a later stage.
9.	Thickner chest	:	Storage chest
10.	Pump	:	Used for lifting stock
11.	Refiner	:	Before refiner pulp is in lumps form so its cutting/shearing is required to achieve a better formation of the paper. Refiner is used to solve this purpose. It is just like a grinder and to achieve homogenous slurry. It also increases the water retention capacity of pulp.

12.	Refiner chest	:	It is a storage chest. It has agitator-propeller type at the bottom to keep the mass homogeneous.
13.	Service or mixing chest	:	This is a storage chest. Here, the required chemicals like Rosin, Alum, Gum, Dyes etc. are mixed with certain proportion as required as per quality. It has agitator/stirrer at bottom to get homogenous pulp.
14.	Pump	:	For carrier
15.	Machine chest	:	This is the final chest in pulp section. From this chest, pulp is being supplied to machine house.

PAPER MACHINE SECTION

	NAME OF MACHINE		FUNCTION
	Machine chest		
1.	Pump	:	Used for lifting pulp.
2.	Constant level box	:	From the name itself, it is clear that pulp is being fed at constant head to get a proper head and to avoid fluctuation in quality of stock.
3.	Fan pump	:	This is the main pump where GSM etc. is being controlled. Proper percentage of water and stock is being mixed here as per GSM of paper required.
4.	Three stage centricleaner	:	This is second stage cleaning equipment to get better result as far as cleaning is concerned.
5.	Pressure screen	:	This is screening equipment, oversize material is being taken back by the screen. Pulp, knots etc. is being separated out.

6.	Head box ↓	:	In the head box diluted stock is being stored at a certain height to get proper velocity of the slurry which is being fed to the moving wire. It has holly roll (perforated) rotating to keep stock homogeneous.
7.	Wire part ↓	:	This is an endless wire. Moving continuously and paper web is being formed here itself. Maximum water from the stock is being drained out by gravity and vacuum boxes to achieve dry content gradually.
8.	Press section (three stage) ↓	:	Here water is being separated out by passing the paper webs between two rolls nip without affecting the formation of the web. Water being squeezed out from the web. The bottom press roll has felt circuit – endless, running with synchronized velocity of paper machine.

9.	Pre dry section ↓	:	Paper web is being dried out gradually by passing through these steam heated cylinder. Steaming is being done gradually to get proper drying. Condensate is collected in cylinder which is removed continuously by syphon or bucket system from inside. To achieve glaze in the paper, it is being passed through this big diameter steam heated cylinder (Machine Glaze Cylinder). It has felt circuit – endless.
10.	Size press or M.G. Cylinder (option for coating unit) ↓	:	Coating is being done to improve the print- ability effect on the paper.
11.	Post dryer section ↓	:	This is another section of dryer for gradual removal of moisture from the web.
12.	Coating section (Coating for Duplex Board or other one or two side boards/paper) ↓	:	In this section also coating is being done to achieve uniform surface to improve print- ability, chemicals like china clay etc. is being used as chemicals here. Coating process has more than one layer. Coating process has more than one layer. Coating thickness is 6 GSM to 11 GSM.

13. After dryer section : Dryer section to remove remaining moisture which is being added in the coating section.

↓

14. Cylinder stack (Calender Stack) : Its purpose to flatten the sheet to get a uni-form caliper (thickness) which is very essential in printing purposes.

↓

15. Pope reel : paper is being wind up continuously and it is being removed after certain interval and another reel is being fitted.

↓

16. Online cutter or reel winder : For sheet order. This is online sheet cutter. Sheet is being cut as per the requirement of the customer and wind on the reels.

Paper Manufacturing Process

Manufacturing of paper is broadly divided into –

* Pulp making from basic raw materials
* Converting pulp into paper according to the required quality

Additionally, there is a subsidiary process which recovers the alkali originally used in the process of pulp making. This is known as soda recovery(only for Cooking plant).

Manufacturing process for pulp from raw materials

In India, bamboo is the main raw material used for pulp and papermaking. Other Raw materials are bamboo, wood of the broad leaf species known as hard wood, soft wood, sabai grass, bagasse, rice straw etc. The bamboo or other wood is chipped into small size by chippers. Grass and rice straw are also cut into small lengths in order to facilitate cooking in digesters.

The raw material after chipping is cooked in the pressure vessel known as a digester. For the purpose of cooking, liquors containing sodium hydroxide, sodium sulphate and sodium carbonate are used. In the pulp industry this liquor is known as '**white liquor**'. This white liquor is recovered back from the spent liquor obtained after digestion; white liquor once utilized is not fully lost. This spent liquor is termed as '**black liquor**' in the industry. The digestion/cooking is carried out under steam pressure ranging from 3.5 to 7.5 kg/sq.cm. for a duration of 3 to 6 hours. Pulping can also be carried out with different processes with different chemicals. By this cooking process, about 55% of raw material is extracted in the form of spent or black liquor as mentioned above. By this process lignin and other wood components are removed leaving behind cellulose fibre. The remaining material after cooking is known as unbleached or brown pulp.

The mixture of unbleached pulp and black liquor as obtained after cooking undergoes a process of 'Screening' by passing it across screens having large size round perforations. This is required to catch undigested bamboo or any other foreign material and their knots. These screens are known as knotters.

The pulp and black liquor when free of impurities like knots and other foreign particles is passed through Brown Stock Washers consisting of a number of washers. Spent liquor is almost completely washed out of pulp and collected in large storage tanks. From these storage tanks it goes to soda recovery section for conversion into white liquor so that it can be used in digestion.

Unbleached or brown pulp is used for products falling under the category of unbleached paper. In order to manufacture white and coloured paper, unbleached paper needs to be bleached further. The washed unbleached pulp is passed through equipment known as Sand Traps, Rifflers, Screens and Centricleaners in order to remove impurities like sand, grit, foreign material and other specky material. This provides cleaned pulp which is further bleached.

Chlorine is the chemical used for bleaching of unbleached pulp. It can be either used as such, or in combination with lime; when used in combination of chlorine and lime it is known as bleaching powder if it is in the solid form, or bleaching liquor if in liquid form. Bleach liquor is prepared on site by all paper mills. Pulp and chlorine or bleach liquor after mixing are retained in tall bleaching towers. These towers are made out of concrete and have a glazed tile lining on the interior surface. Until the chlorine or bleach liquor has reacted with impurities in the pulp they are retained in towers. In order to wash out impurities from pulp it is passed through rotary washers. The pulp is bleached in three stages :

* Chlorination
* Caustic extraction and hypo stages or chlorination
* Hypo and Hypo

This can be extended to further stages; the more the stages, the better is the quality of pulp.

The unbleached and bleached pulp obtained above needs further treatment and therefore it is taken to a Stock Preparation Section. In this section, pulp is treated as required based upon the quality of the finished product. The treatment involves the following stages :-

* Physical treatment known as 'Beating'
* Chemical treatment to mix certain chemicals and dyes

Beating imparts strength whereas the adding of chemicals and dyes give the desirable characteristics, such as, surface for a good writing and printing, smoothness and/or pleasing appearance to the paper.

The equipments used for beating :

- Beaters / refiners of different designs and make.

The chemical mixed with pulp are :-

- China clay, soap stone powder, rosin size and alum, whitening agents, such as, tinopal and dyes.

Even starches and vegetable gums are used depending on the quality of paper required.

China clay and soap stone powder impart smoothness and opaqueness to the sheet so that it prints well on both the sides. In order to give partial water proofing to the sheet so that paper becomes impervious to the water contained in the ink, rosin size and alum are used.

Tinopal and dyes give whiteness. Starches and gums increase strength of the paper sheet. The pulp, after beating and mixed with chemicals, is called STOCK or STUFF.

Conversion of pulp into paper :

Actual paper making starts after preparation of STOCK. Stock passes through stock chest before feeding it to the paper machine. It is passed through centricleaner and centriscreens to remove all undesirable particles. The stock travels through machines in a very diluted state, approximately 99% of water to one part of fibre. The paper machine consists of an endless web of woven wire cloth where the stock flows. Bulk quantity of water from stock is removed by wire by gravity, suction and pressure. A dandy roll between the suction boxes acts as to shut the web end to impress any required watermark, and for including any laid lines.

The wet web of paper is passed in between a pair of rolls placed one over the other, while doing so, the wet paper is supported on a woolen blanket. The pair of rolls is known as wet press and the woolen blanket is known as felt. Generally, there are three sets of presses. The function of the presses is to extract water further as far as possible from the wet paper sheet and to smoothen out the sheet. The paper sheet contains 60% to 65% moisture when it comes out of the press. In order to get air dry paper, the wet sheet is passed on the heated surface of a rotary dryer. The sheet is then passed through highly polished rolls stacked one over the other. The stack of rolls is known as calender. The process of passing the paper through it is called calendaring. This gives a smooth finish to paper. The paper sheet is then wound and a reel is made. Reels of different sizes are made with a slitter and rewinder.

Soda recovery process :

The spent liquor obtained after digestion of bamboo and other raw material is not drained as it contains soda. The soda content from spent liquor can be recovered by a process known as the soda recovery process. The spent liquor is stored in big storage tanks and pumped from the pulp mill to the soda recovery plant for manufacturing white liquor. The white liquor so recovered is re-used for cooking bamboo in the pulping section as discussed earlier and this process is continuous in a closed system.

The spent liquor stored in big storage tanks is first passed through a fine screen to remove the fibrous material. It is then concentrated, thickened by evaporating it in multiple effect evaporators. Due to this, the solid contents of spent liquor are increased from about 15% to 55%. This liquor is very viscous like honey at room temperature but is in fluid state at 94 – 101^{0}C. The required quantity of salt cakes known as sodium sulphate are mixed with this thickened liquor and the mass is then fed to the hearth of a specially designed recovery boiler. In this process, lignins, resins and pitch extracted from bamboos and other raw materials burn out and large quantities of steam produced from heat, generates soda and other salts which are incapable of burning and are thrown out in the form of smelt in the hearth of the boiler. This smelt is a mixture of soda ash, sodium sulphide and caustic.

Since the temperature prevailing in the hearth areas of the boiler is very high, the ash of this recovered salts gets fused and is let out from the boiler in a molten form. The cooking liquor is prepared from this by any of the suitable methods. The steam and white liquor as recovered above are again used for cooking bamboo and other raw materials indefinitely with small additions of salt cake in spent liquor as make-up chemicals.

The recovery of alkali by the above process is not 100%. There are losses at various points of process both in the Pulp Mill as well as the recovery section; losses are in the range of 7% to 13%.

TECHNICAL SPECIFICATIONS

PULP SECTION OF A PAPER PLANT

1. Rotary Spherical Digester

Capacity	:	28 cu.m.
Diameter	:	3810 mm
Working pressure	:	7.5 kgs/sq.cm.
Design pressure	:	8.0 kgs/sq.cm.
Rotation	:	0.33 rpm
Power requirement	:	10 hp
Hydraulic testing pressure	:	16.5 kgs/sq.cm.
Welding joint efficiency	:	0.85
Shell wall thickness	:	20 mm
Manhole size	:	Elliptical 1000 mm x 750 mm

Materials of construction

Shell	:	Boiler quality tested steel plates IS-226
Bearing housing	:	Cast iron
Bearing	:	Phosphorous bronze
Manhole cover	:	IS 226
Trunnion	:	Cast steel fitted with carbon ring

Accessories

Safety, relief and blow off valves
Rotary steam glands
Non-return liquor valve – 2 nos.
Non-return steam valve – 1 no.
Non-return water valve – 1 no.

Drive

Reduction gearbox, ratio 1:50. A worm gear and worm wheel for final rotation of 0.33 per minute.

Manhole

Manhole with quick opening type cover in elliptical shape with a sealing ring.

Balance

Digester is statically balanced.

Liquor inlet and outlet arrangements

Liquor feed arrangement is through trunnion. A 50 mm dia. C.I. pipe is provided inside the shell and liquor is sprayed through 6 mm dia. nozzles.

Trunnion

A cast steel trunnion with 325 mm O.D. fitted to the digester shell by bolts at the either ends with trunnion to save steam leakage.

2. <u>Hydropulper</u>

Effective capacity	:	4.5 cu.m.
Total volume	:	6.0 cu.m.
Batch capacity	:	250 kg. per charge
Defibrate time of waste paper	:	30 minutes
Defibration efficiency	:	80-90%
Capacity	:	10 BD tonne per day
Consistency with re-circulation arrangement	:	4%
Total height	:	1200 mm
Diameter	:	2500 mm
Power requirement	:	50-60 hp
R.P.M.	:	200-225

Material of construction

Trough	:	M.S. plates, thickness 8 mm in a polygonal (with 12 sides) shape. Four supporting legs in cylindrical shape fitted with base plates.
Strainer	:	Stainless steel 304 quality

Stationery blades	:	Carbon steel (CR-40 hard over-lays by electric arc welding)
Impeller	:	Cast steel / Steel fabricated
Housing	:	Grey cast iron fitted with two roller bearing – one thrust bearing with stuffing box. Glands, water sealing arrangement pulley 'V' belt, 4 grooves, D – Section.
Size	:	750 mm O.D.

Circulation device

Stock pump KMW type size 200 mm / 125 mm

Materials of construction

Body	:	C.I.
Shaft	:	EN8
Impeller	:	S.S. 304
Inlet distance pieces	:	S.S. 304

Hydropulper is fitted with stand for motor with adjusting plate.

3. **Blow Tank**

Capacity	:	100 cu.m.
Dia. of the tank	:	4500 mm
Height of the tank	:	8000 mm
Thickness of the shell	:	15, 16, and 18 mm
Vapour outlet dia.	:	500 mm
Cooked material inlet dia.	:	200 mm

Materials of construction

Shell	:	M.S. plates		
Headers	:	M.S.		
Block liquor injection nozzles:		S.S. 304		
Heads	:	Bottom	-	Torispherical
		Top	-	Elliptical
Supporting beams	:	M.S. girders		

Inlet nozzle is provided on the top of the tank. Outlet is provided in one side of the bottom. One manhole is provided at the top of the tank for cleaning and maintenance. A vapour inlet is provided on the top.

In the bottom part of the tank two agitators are provided for agitation of the pulp. One KMW pump with size 250 mm x 200 mm is provided for recirculation of the pulp. Equipment is complete with six back liquor injection nozzle.

4. <u>Beater</u>

Capacity	:	500 kg. B.D. pulp per batch
Consistency	:	5-7%
Type	:	Hollander type breaker beater
Beating time	:	2.5 – 3 hours
Inlet freeness	:	20-22^0 SR
Outlet freeness	:	40-45^0 SR
Power requirement	:	80 hp
R.P.M.	:	160
Dia. of the roll	:	1275 mm, face 1300 mm
Average weight of the roll	:	6 tonnes
No. of knives in roll	:	72
No. of bed boxes	:	3
Trough volume	:	10 cu.m.

5. **M.S. Washing Drum**

Dia.	:	1200 mm
Face	:	1500 mm

Materials of construction

Pedestals	:	C.I.
Spiders	:	C.I.
188 mm dia. shaft	:	EN8
Roll knives	:	High carbon chromium steel
Bed plate knives	:	High carbon steel
Bearing housing	:	Grey cast iron
Bearing	:	Gun-metal
Beater shaft pulley	:	C.I.
Lubrication	:	One oil ring is provided for self lubrication.

Beater is complete with lifting and lowering arrangement.

Beater shaft pulley	:	5 groove, D-Section dia. 1500 mm

Motor

HP/RPM	:	80/960
Motor pulley	:	5 groove, D-Section dia. 250 mm

6. **Disk Refiner**

Capacity	:	15 tonnes per day
R.P.M.	:	750 – 1000
Peripheral speed	:	30 – 42 m/second
Power requirement	:	75 hp
Consistency	:	4%
Output freeness	:	25-30^0 SR
Inlet freeness	:	22^0 SR

Materials of construction

Body	:	Cast iron
Shaft	:	EN8
Disc	:	Ni-Chrome hard steel
Base plate	:	Cast iron
Coupling	:	Cast iron
Bearing housing	:	Cast iron fitted with self aligned roller bearing, thrust bearing, balanced statically.

Drive : 75 hp, 960 rpm, 440 V, 3 phase, 50 c/s

7. Vibrating Screen

Capacity	:	22 tonnes per day
Perforation size	:	3-4 mm dia.
Consistency	:	0.5 – 0.8%
Power requirement	:	5 hp

Materials of construction

Frame	:	Mild steel
Screen	:	Stainless steel 304 quality
Pedestals	:	Cast iron
Chute	:	Mild steel

Drive : 5 hp, 960 rpm motor

Construction

Screen basket slightly inclined is fixed on the frame with 4 springs and is eccentrically oscillated by an electric motor.

A shower pipe is provided on the top for residual control and washing of pulp.

8. Decker Thickner

Capacity	:	10 tonnes per day
Inlet consistency	:	1%
Outlet consistency	:	4-5%
Horse power	:	7.5
Diameter of the drum	:	1200 mm
Face of the drum	:	3000 mm
Vat	:	R.C.C.
R.P.M.	:	10

Materials of construction

Shaft	:	EN8
Spider	:	C.I.
Longitudinal rods	:	9 mm, 100 nos. brass
Backing wire	:	Phosphorous bronze
Bearing housing	:	Grey cast iron fitted with ball bearing, both ends sealed with rubber sealing, 5 mesh half round supporting wire.
Shower	:	A pressure shower is provided on the top of the thickner drum. Inlet and outlet flange connecting piece fabricated out of mild steel.
Coupling material	:	C.I. with rubber pads.

Drive : 70 hp, 960 rpm motor

9. Potcher Washer

Dia.	:	150 mm

Materials of construction

Trough	:	R.C.C.
Shaft	:	EN8
Bearing housing	:	G.M.
Washing drum	:	C.I. side plate

10. High Density Cleaner

Capacity	:	15 tonnes per day
Operating consistency	:	4 – 4.5%
Throughput	:	550 litres per minute
Pressure drop	:	2.0 mw
Rotary disc. Speed	:	1440 rpm
Power required for the disc	:	2.5 hp
Shaft dia.	:	50 mm
Length of the tube	:	2230 mm
Volume of dirt chamber	:	10 cu.m.

Materials of construction

Accept exit pipe	:	Stainless steel 304 quality
Disc.	:	Stainless steel 304 quality
Sleeve	:	Stainless steel 304 quality
Shaft	:	EN-8

A gland window has been provided in the dirt collecting chamber.

Inlet nozzle	:	Provided on the top
Bearing housing	:	C.I.
Collecting chamber	:	C.I.
Body	:	C.I.
Motor	:	Vertical, 25 hp, 1440 rpm

11. Agitator

Type	:	CR3 KMW horizontal Agitator side entry at the bottom.
Chest capacity	:	50 cu.m.
Pulp consistency	:	6%
Shaft dia.	:	75 mm
Impeller dia.	:	660 mm
Shaft speed	:	300 rpm
Shaft power requirement	:	25 hp

Materials of construction

Impeller	:	Stainless steel 304 quality
Sleeve	:	Stainless steel 304 quality
Bearing housing	:	Cast iron
Grouting rings	:	Cast iron
Shaft	:	EN8
Bearing	:	Roller bearing (spherical)

Drive :		'V' belt drive, groove 3, C Section
Pulley	:	C.I. size 500 mm dia.
Motor pulley size	:	150 mm dia.
Electric motor	:	25 hp, 960 rpm, 440 V

12. <u>Conical Refiner</u>

Type	:	R1
Capacity	:	30 B.D. tones per day
Final freeness	:	30^0 SR ($25^0 – 30^0$ SR)
Inlet freeness	:	$20 – 22^0$ SR
Rise in freeness	:	$5 – 8^0$ SR
Inlet consistency	:	4%
Power requirement	:	70 hp

Materials of construction

Body	:	Grey cast iron
Shaft	:	EN-8
Shell	:	Stainless steel 304 quality
Plug	:	Stainless steel 304 quality
Housing	:	Cast iron
Sole plate for refiner	:	Cast iron

Paper making section

Paper machine complete with following specifications etc.

Type of paper to be manu-factured	:	Kraft variety of 34-80 gsm
Capacity	:	13 – 15 tonnes per day
Operating speed	:	30 – 120 metres per minute
Drive	:	Line shaft
Head box	:	Open type
Table rolls	:	21 nos.
Suction box	:	6 nos.
Wire length	:	22 m
Suction couch	:	1 no.
Suction press	:	1 no.
M.G. cylinder	:	3.6 m dia.
Pope reel	:	1 no.

40 TPD DUPLEX BOARD-CUM-PAPER MACHINE WITH M.G. CYLINDER

Mould Section

Cylinder moulds	:	2 nos. counter flow type 2 nos. Uniflow type 1 no. Extractor mould
Mould face	:	2850 mm
Mould dia.	:	1250 mm
Couch roll face	:	2850 mm
Couch roll dia.	:	400 mm
Cylinder mould vats	:	4 nos. in S.S. 304 construction with manifold.
Showers	:	5 nos. in S.S. 304 with fan jet nozzle
one for each mould.		
Turning roll	:	1 no.
Dia.	:	390 mm
Face length	:	2650 mm

Baby Press

Top roll	:	2 nos. 450 mm OD x 2650 mm face bone hard rubber covered
Bottom roll	:	2 nos. 450 mm OD x 2650 mm face rubber covered
Felt roll	:	26 nos. 175 mm OD x 2650 mm face bone hard rubber covered
Felt stretchers	:	2 sets manual
Felt guides	:	2 sets manual
Suction tubes for holding sheets	:	4 nos. in S.S. 304 construction with HDPE lips having 10 mm opening
Felt cleaning Uhle boxes	:	2 nos. in S.S. 304 construction with HDPE lips having 10 mm opening in top felt circuit.

Showers	:	1 no. low pressure in S.S. 304 quality construction for felt cleaning.
Save all trays	:	2 nos. in S.S. 304 quality construction under the bottom Baby Press Roll. 1 no. in S.S. 304 quality construction under the Uhle boxes.
Frames	:	Entire frames for mould and Baby Press section are made out of M.S. Loading of Presses and mould couch rolls are through pneumatic cylinders. The sheet is lowered before the dandy on the fourdrinier through the carrier felt.

M.G. Section

M.G. cylinder	:	1 no. C.I. MG 3650 mm dia. x 2650 mm face suitable for an operating steam pressure of 3.5 kg/cm^2
Touch rolls	:	1 no. 600 mm dia. x 2650 mm face rubber covered.
Nip loads	:	1st nip - 50 kg 2nd nip - 70 kg
Felt rolls	:	6 nos. steel rolls 175 mm dia. x 2750 mm face, identical to Dryer Felt rolls.
Lead rolls	:	1 no. BHRC roll 230 mm dia. x 2750 mm face.
Doctors	:	3 nos. standard Vickerys oscillating doctor blades.
Stretchers	:	1 no. manual stretcher is provided for the glazing felt.
Guide	:	1 no. manual guide for the glazing felt is provided.

Technical Data

Grade	:	Speciality Papers
Substance range	:	60 – 180 GSM
Wire width	:	2850 mm
Web at reel	:	2450 mm
Maximum production at reel based on at 60 GSM	:	40 MTD gross surface sized paper reel.
Production speed	:	60 – 200 m
Design and drive speed	:	250 mpm

Open Type Headbox

Wire width	:	2850 mm
Type	:	Open with taper inlet header and manifold
Throughput	:	3000 lpm minimum 8000 lpm maximum with recirculation of 10% of flow rate.
Slice width	:	2750 mm Vertical movement 0 – 50 mm Horizontal movement – Nil Slice profile correction through micro adjusters.
Rectifier rolls	:	2 nos. Throat position - 160 mm dia. Slice position - 160 mm dia. Holes - 24 mm dia.
Cross pressure control	:	By Lucite tube.

All the wetted parts are in S.S. 316 quality. All surfaces coming in contact with stock are lined with S.S. 316 quality.

EXERCISE

1. Draw the process flow diagram of Pulp section along with brief functions of machinery used.

2. Draw the process flow diagram of Paper machine section along with brief functions of machinery used.

3. Provide data to collected at the time of taking inventory of following machinery to get current prices :

   - Rotary spherical digester
   - Hydro pulper
   - Blow tank
   - Beater
   - Washing drum
   - Disk refiner
   - Vibration screen
   - Decker thickner
   - High density cleaner
   - Conical refiner

UNIT – 7

PRINTING, BINDING AND PUBLISHING

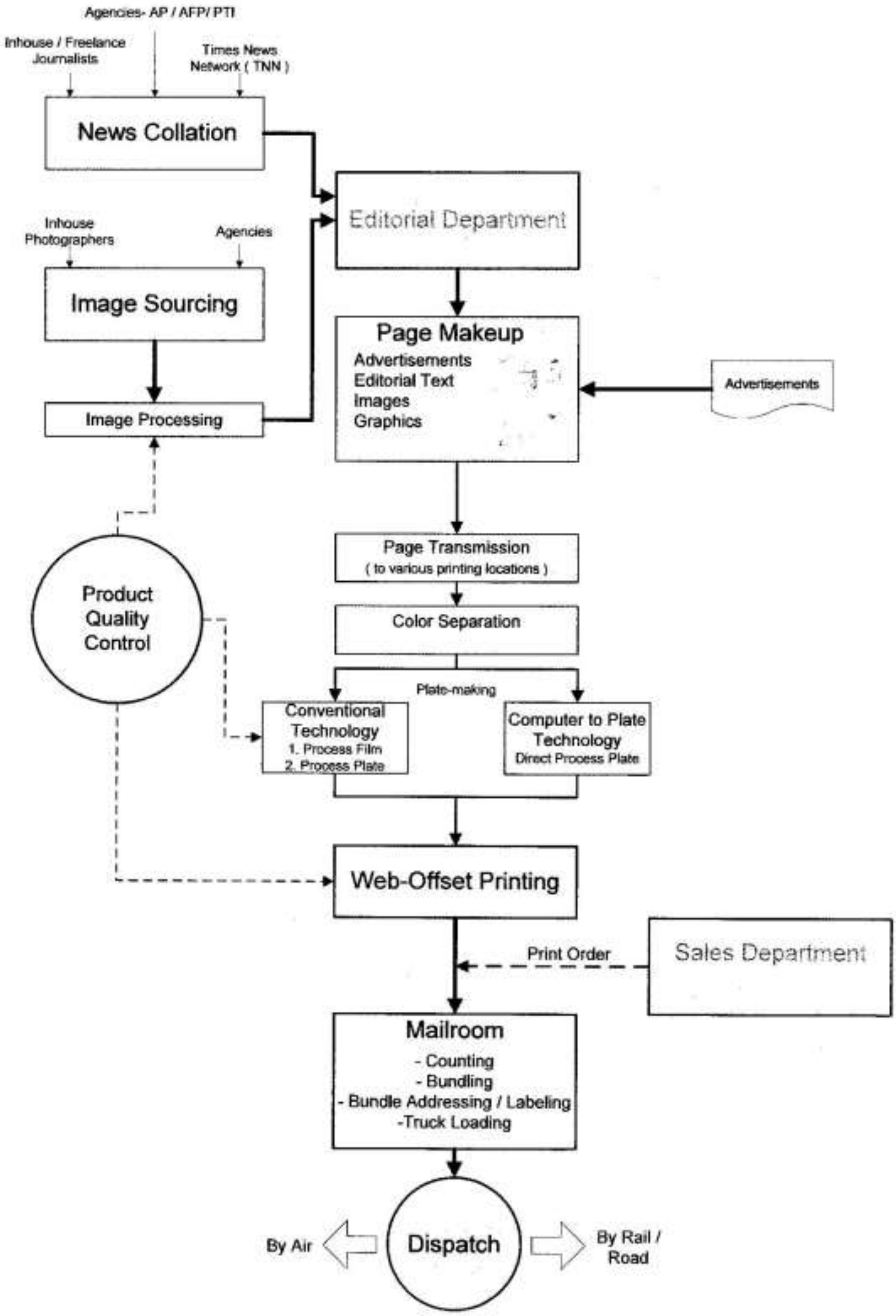
OBJECTIVES :

By the end of this chapter students will learn about :-

- Process flow diagram
- News and images sourcing
- Advertisement booking
- Image processing
- Editorial department
- Transmission to printing centres
- Colour separation
- Printing plate preparation
- Web offset printing
- Mailroom/dispatch
- Machines used

FLOW DIAGRAM

Newspaper Publishing Workflow



Process Study

1. **News and Images sourcing :**

   News and Images are sourced from professional agencies like AP, AFP, PTI etc and also from Times News Network, in-house journalists and photographers. The updates are made 24x7 to dedicated servers via V-SATs, leased lines and the internet.

2. **Advertisement Booking :**

   The Marketing team sells print space and the advertisements, mostly in the digital form are uploaded to designated servers. These advertisements are then placed on the final page before the page is released to the Editorial department for completion.

3. **Image Processing :**

   The images selected for print from the central basket by the Editorial department are specially processed and modified for the intended newsprint substrate viz Standard newsprint or Glazed newsprint.

4. **Editorial Department :**

   The Editorial department selects stories, articles and images from the central basket and completes the page with the advertisements already in place. The software used is a Page Makeup software like Quark, PageMaker etc.

5. **Transmission to printing centres :**

   The final pages in the Portable Document Format are transmitted to printing locations which may be local or anywhere across the world. The communication channels may be leased lines or satellites.

6. **Color Separation:**

The digital page files are separated into the process color separations viz, Cyan, Magenta, Yellow and Black.

7. **Printing Plate Preparation :**

The conventional method involved the transfer of the digital images to process films with the help of Image setters and then exposed on pre-sensitised printing plates. The advance in technology has made the process film nearly redundant and instead exposes the digital images directly onto the printing plate. This technology is better known as CtP or Computer to Plate imaging.

8. **Web Offset Printing :**

The printing plates are mounted on web offset machines where the newsprint is in the roll form and the paper feed is continuous. It uses the lithographic process, employing an emulsion of process inks and water to get the desired print on paper.

9. **Mailroom / Dispatch :**

The printed copies are counted and bundled along with labels indicating the number of copies and the dispatch destination.

The copies are dispatched to their respective destinations by Air / Rail or Road.

Machines :

1. Information Technology Instruments

Telephone,
E-mail
Internet connection
Fax
Computer modem
Scanners

2. Laser printers

Speed,
paper size,
no. of colour

3. Developer

Size of plate
Ink ---► Water ---► Gum ---► Heating ---► Bending

4. Metroliner printing set consisting of

- Monotone printing unit
- Uniflow 2/1 folders
- Three colour satellite printing unit

General data :

Electric supply	:	400/440 V, 3 Ph, 50 Hz
Machine mechanically geared for cylinder revolutions per hour	:	32500 copies
Maximum paper roll width	:	1727 mm
Maximum paper roll diameter	:	1065 mm
Core diameter	:	76 mm
Reel sidelay	:	$\pm$ 19 mm
Nominal printing diameter	:	356 mm
Nominal cut-off (printing size)	:	560 mm
Plate thickness	:	0.3 mm
Plate stagger	:	90 deg.
Maximum blanket thickness (including packing)	:	2.03 mm
Printing cylinder circumferential adjustment	:	$\pm$ 1.5 mm
Printing cylinder sidelay adjustment	:	$\pm$ 1.5 mm

The equipment can produce broadcast or tabloid products in single (collect) or in double production.

Page Format (Broadsheet)		
maximum	:	432 mm x 560 mm
Print area maximum	:	409 mm x 530 mm

Operating speeds :

Operating speeds for optimum production vary depending on type and size of product.

Practical sustained operating speeds for various products (running 40/52 gsm newsprint) are :-

Broadsheet in Double Production

8 - 12 pages	:	45000 I.P.H.
14 - 18 pages	:	50000 I.P.H.
20 - 22 pages	:	55000 I.P.H.
24 pages plus	:	50000 I.P.H.

Tabloid in Double Production

8 - 12 pages	:	30000 I.P.H.
16 - 24 pages	:	45000 I.P.H.
28 - 36 pages	:	50000 I.P.H.
40 - 44 pages	:	55000 I.P.H.
48 pages plus	:	65000 I.P.H.

5. Metroliner monotone printing unit

This is a blanket-to-blanket perfecting unit printing recto and verso simultaneously.

Both blanket cylinders and both plate cylinders are fitted with bearers on both the drive and operating sides of the unit.

In production, the plate and blanket cylinders run bearer to bearer but there is no bearer to bearer contact between the two blanket cylinders. The cylinders are sized to create true rolling between the plate and blanket cylinders.

When the press stops, the blanket cylinders are separated pneumatically as also are the plate cylinders from the blanket cylinders.

In a similar manner, when the press stops, the ink for 'me' rollers, the ink feed rollers and (in the case of the colour deck only), the dampener for 'me' rollers, are thrown off pneumatically.

A sequential start up system supplied as part of the press package, controls these functions during start-up in a timed sequence.

General construction :

Arch type design with the inking as dampening system in each leg.

Heavy side frames firmly secured to one piece bed plate.

Unit completely enclosed.

Monotone units can be converted to three colour units by the addition of a half deck.

Web lead tapes :

Each unit is fitted with a motorized web lead tape assembly on the operating side of the press. The tapes terminate after the unit impression adjacent to the upper platform level.

Web Infeed :

Fixed speed driven infeed assembly with pneumatically operated rubber backing roller.

Bearers :

Both plate cylinders and both blanket cylinders are fitted with bearers on the drive and operating sides of the unit. The bearers are 50 mm wide in chrome-manganese steel, hardened and tempered. Their flatness in contact is a measurement of condition and is usually observed by using a piece of foil run between them.

Plate cylinders :

The plate cylinders are solid steel forgings, mounted on tapered roller bearings. They are given as electrolytic nickel plating as a final chrome covering.
The plate lock-up handle plates are one or two pages wide x one page deep. The plate lock-up springs and other components are made out in stainless steel 304 quality. These are staggered at 90 deg.

The plate cylinders are fitted with register pins.

Blanket cylinders :

The blanket cylinders are made of solid steel forgings, mounted on tapered roller bearings. They are given an electrolytic nickel plating and a final chrome covering.

The 'T' bar blanket lock-up system with 90 deg. stagger is used.

Wash up devices :

Each ink train has its own wash up device in the form of a steel container and a plastic scrapper blade which is manually operated to throw into contact with the auxiliary ink drum.

Ink feed system :

Each ink system has an undershot centre divided ink fountain which works as pivot for easy cleaning. The ink fountain roller is electrically driven proportional to press speed.

The system consist of :

Knurled gear driven steel ink transfer roller.

Rubber transfer rollers	120 mm diameter – 2 nos.
Rubber distribution roller	120 mm diameter
Rubber for 'me' roller	133 mm diameter
Rubber for 'me' roller	140 mm diameter

Copper plated ink drums with three step oscillation – 2 nos.

Dampening system :

Dampening system located in the unit aisle, adjacent to the upper ink drum where the dampener fluid is applied consists of :

Motor driven variable speed roller rotating within a S.S. 304 quality pan.
Motor driven fixed speed spiral brush.
Rubber transfer roller 127 mm diameter.
The system is supplied with four one-page-wide dampener supply stops.

In order to reduce waste at the initial start up, an automatic floor function introduces a surge in the supply of dampener solution, thus speeding plate clean up.

Proportional dampener :

The speed of the steel dampener roller is related to press speed. The relationship can be varied so that a non-linear proportional control results.

The curve of press speed/roller speed is electronically generated from straight lines, one device for folder. All units selectable to a folder follow this curve, but each roller speed is further variable via the unit control and the master dampener control at the folder desk.

Ink feed adjustment for open fountain system :

Ink feed control is an electro-mechanical function for each 32 zones across the printing unit. Engagement of each zone adjustment screw is by means of a solenoid device which connects to traverse shaft driven by a selsyn motor responding to signals entered by the operator at the unit facia.

The format for ink adjustments is :

'8' Ink zone selection/increase/decrease switches.
'8' zone ink increase/decrease switch.
4 page selection switches.
Adjustment indicator dial, graduated 0 – 25.

By operating the 'page selection switch' followed by selecting the relevant ink zone adjustment switch, the zone adjustment screw is engaged and its forward or reverse rotation increases or decreases the ink feed gap thus controlling the ink adjustment.

Unit control facia :

Each unit id fitted with a motorized web lead tape assembly on the

Panel of ink control switches - 2 nos.
Ink adjustment meters – 2 nos.
Oil flow warning light.
Controls for running circumferential and lateral adjustment (for register).
Ink feed switches with ON/OFF and MASTER locations – 2 nos.
Link for me switch with ON/OFF and MASTER locations.
Speed control for each of the two dampener fountain motors.
Speed control for each of the two ink fountain motors.
Indicator light for each of the two dampener fountain motors.
Indicator light for each of the two ink fountain motors.
Impression switch with ON/OFF and MASTER locations.

Infeed switch with ON/OFF and MASTER locations.
Key operated switch for engaging or cutting off the supply of power to the unit.

Note :
When any switch is in the 'MASTER' position, the operator at the press control desk has overall control of that function.

6. Drive to standard metroliner unit

All drive functions for the metroliner mono unit is confined to the drive side of the machine; there will be no gearing on the operating side.

The principle source of the drive transmission is the main gearbox located below the unit and under the press room floor. The gearbox houses horizontal shaft supported on two double row sealed bearings.

Keyed to the horizontal shaft is a spiral bevel pinion meshing with a spiral bevel gear for continuing the drive transmission to the press unit by means of a vertical shaft.

The vertical shaft is supported by double row tapered roller bearings at the bottom and by a single row ball bearing at the top. Near the top of the vertical drive shaft spiral bevel gears transmits the drive to the printing cylinders by means of a helical gear compounded with the spiral bevel.

The spiral bevel gear and its compound helical gear rotate on two ball bearings.

Where the mono unit is associated with a half deck immediately above, thus creating a three colour unit, the spiral bevel gears at the top of the vertical shaft are supplied as a triple set with clutch facilities enabling reversing when running in the three colour mode.

The main gearbox is fitted with a large oil sump and a mechanical oil pump. These serve a pressurized circulating system supplying oil to the plate and blanket cylinder bearings, blanket cylinder sleeves, the unit drive-gears, the vertical drive assembly, the oscillating drum drive, and oscillating drum eccentrics and bearings.

The horizontal shaft in the main gearbox connects to the main horizontal drive by means of a clutch on one side of the box and a coupling on the other. The drive system is designed for co-axially mounted electric drive motors.

The main drive gearbox fitted with a drain value.

The main drive gearbox is fitted with an oil flow warning switch.

7. Metroliner three colour satellite printing unit

The metroliner three colour unit can be used for printing spot colour or, alternatively, it can be set up for printing three colours and thus, in conjunction with an adjacent monotone printing unit, it is possible to print four colours on one side of the web.

Four colour printing using this method is standard metroliner printing procedure.

The metroliner three colour unit is reversible which gives the possibility of printing spot colour Recto or Verso on one web.

When printing in the spot colour mode, there is a lifting device for raising the chrome plated common impression cylinder thus increasing the clearances between that cylinder and the blanket cylinders of the mono unit below, thus minimising dangers of web warp up.

The chrome plated common impression cylinder has, as a standard fitting, a cleaning device which is operatable during the press run when it cleans the cylinder, thus minimising the effects of the ink set off.

All three plate cylinders within the three colour unit are fitted with motorized running sidelay and circumferential register adjustment.
The dampening system on the upper deck only has an aisle location adjacent to the plate cylinder where the dampening fluid is applied.

Motor driven variable speed roller rotating within a S.S. 304 quality pan.

Motor driven fixed speed spiral brush.

Stainless steel 304 quality oscillating drum.

Rubber for ‘me’ roller 127 mm diameter.

The system has four one-page-wide dampener supply stops.

In order to reduce waste at the initial start up, an automatic flood function introduces a surge in the supply of dampener solution, thus speeding plate clean-up.

The control facia is conveniently located and it generally follows the design for the monotone unit.

There is, however, a dampener for 'me' switch with ON/OFF and MASTER locations.

Apart from the foregoing, in other respects the design features of the Metroliner three colour printing unit is similar to those applying for the Metroliner monotone printing unit.

8. Uniflow 2/1 folder

General :

The maximum capacity of the folder is nine full width reels in double production (72 pages) or seven full width reels in single production (112 pages collect).

Drive transmission :

The main source of the folder drive transmission is a gearbox situated blow press room level, and continuing by means of various supplementary drive transmissions to the principal elements of the folder.

RTF :

The roller-top-of former is approximately 232 mm diameter, the main features are :

Constructed from knurled and ground pulleys, split where possible.
Three bearings mounting : operating side, drive side and at the press centerline.
Gear driven slitter assembly with pneumatic throw off.
Nylon propellers with pneumatic pressure control.

Former :

Chrome plated former is fitted with a press mounted air blower and capable of sideway movement (± ½ inch).

Rollers-point-of-former :

Two free running forming rollers are located at the base of the former. Running adjustment in the horizontal plane is provided.

Draw rollers :

Three sets of gear driven draw rollers located below the former. The rollers are with remote setting control.

Folding couple :

Folding device, delivering to the operating side of the machine and comprising :

Folding cylinder two copies in circumference with two pin mechanisms and one pin cam, two folding blades and two cutting rubbers.

Cutting cylinder one copy in circumference with one set of collect needles and one knife case of the latest design incorporating two hard wearing plastic cushions.
Folding and cutting cylinders both run on tapered roller bearings.

Second fold rollers :

The second fold rollers are untimed.

Delivery fly:

The folders have five pockets files, five blades wide.

Delivery belts :

A belt delivery conveys the copies from the delivery fly to a point on the edge of the lower folder frame. A connection is fitted for newspaper conveyor.

Lubrication :

A pumped oil circulation system lubricates the main drive gearbox and all the main geared drive transmissions.

In certain applications' sealed-for-life bearings are used.

Safety features :

Scanners at the second-fold-rollers and at the delivery belts.

Torque clutch on drive folding cylinder.

Both systems electrically interlocked with press stop circuits.

The folder is adequately protected by a system of guards.

Counter :

Counter at each folder.

9. Reels and tensions

The reels and tensions consists of the following :

Cross shaft assembly :

The cross shaft assembly is mounted on the press supporting structure. It comprises a central shaft to which are keyed to three arm spiders for supporting three paper rolls each 107 cm diameter. Rotation of the assembly is achieved via gear driven by 1.5 kw motor.

The spider keying is arranged to permit spider adjustment to accommodate quarter, half, three-quarter and full width reels. The fractional width reel can be located to suit pagination.

Paper reel chucking is achieved by quick action lock-up in conjunction with self expanding chucks suitable for cardboard reel cores.

Sidelay adjustments of the cross shaft assembly is achieved hydraulically providing 19 mm about a centre-line.

Pneumatic tension control :

Web tension is applied by static belts. The tension system is operated via a position sensitive counter-loaded governor roller.
A filter lubricator is provided to a compressed air supply of 6.3 kg/sq.cm minimum.

The tension is set by a control located o the folder desk.

Controls :

The reel-stand controls are housed in the operating side press support members which carries the cross shaft assembly :-

Tension ‘ON/OFF’ switch
Tension ‘ON’ lamp (white)
‘Position’ push-button
Press drive ‘Slower’ push-button
Press drive ‘Stop’ push-button’
‘Safe’ lamp
‘Ready’ lamp

Cross shaft assembly ‘Forward/Reverse’ push-buttons are provided on one side face of the operating side support column and are duplicated on the drive side spider. A switch for sidelay control ‘Margin Right/Off/Margin Left’ is provided on the other side of face of the operating side support column. This control function is duplicated at the folder desk.

Dampener fluid supply system :

The press is equipped with a proportioner and a circulator.

10. The press drive and substructure

The press is powered by drive motors co-axially mounted on the press drive shaft.

A feature of the main drive equipment is group inching in either the forward or reverse direction.

The press drive is geared to suit 65000 impressions per hour, at which speed the horizontal drive shaft will run at 2166 rpm.

The press is mounted on heavy cast iron columns complete with base plates, leveling pads and leveling screws.

The main horizontal shaft clutches are of the internal gear type and designed to give maximum efficiency combined with minimum wear and noise emission. The clutches can be operated from press room floor level and are electrically interlocked with the press drive controls.

The main horizontal shaft couplings is all metallic flexible power couplings and do not require lubrication or maintenance.

The main drive boxes are provided with a drain valve. In each drive box, an oil flow light is employed to prevent breakdown due to lack of oil.

The alarm system includes a flashing light on each unit and on the folder. This light is duplicated on the main press control console.

Each unit folder can be engaged and disengaged electrically and mechanically.

11. Details of drive etc.

Main drive motor :

2166 rpm, dc motors to BS 2613/70. Drip proof, force-ventilated with fan, filter and air pressure switch. Double shaft extension wall mounting.

Rating	:	Continuous with constant full load torque over 100:1 speed range.
Supply	:	D.C. variable voltage
Characteristic	:	Shunt wound
Terminal box	:	Undrilled gland plate
Shaft extension	:	Double shaft extension suitable for mounting co-axially with the press lineshaft.
Windings	:	Class ‘F’ insulation

Press control station :

Control station supplied for mounting at the folder delivery.
Press drive push-buttons INCH/CRAWL/FASTER/SLOWER/STOP.
Press drive indicator lamps READY (red), SAFE (green).

Tachogenerator :

Tachometer per folder for press drive electronic speed control reference. Press mounted with drive from main dive lineshaft.

Type	:	BD2510
Output	:	100 V/1000 rpm
Mountings	:	Foot
Drive	:	Toothed belt

Audible alarm :

The drive system incorporates a delay time on START/INCH functions such as that the alarm sounds for a predetermined period before the press starts.

The alarm re-activates if the INCH or START functions lapse for more than a predetermined time.

Audible alarm per folder.

12. Press protection system :

In order to protect the press from damage and to save time during make-ready, a co-ordinated system of detectors, severers and trolleys is employed. The system is interlocked to protect the press for every web lead. The components of the system are :

Cooksey finger-type web break detectors (including double detectors at unit).
Electro-pneumatic web severers at the reel position.
Cooksey web propulsion trolleys.

13. Dust extraction system :

A composite dust extraction system arranged to extract paper dust at each roller-front-of-turning bar, at the folder 'RTF' and at each rotary folding mechanism.

The system comprises :

Collector units incorporating filters, explosion relief panels and quick released dust collectors.

Motorised extraction fan with outlet silencer mounted on the clean air side of collector unit.

Extraction hoods at the roller-front-of-turning bars.

A set of extraction hoods at the folder 'RTF'.

A set of extraction hoods at the folding mechanism.

A set of press-mounted interconnecting ducting which will terminate adjacent to the folder.

14. Autopaster

The autopaster is capable of splicing the web at any production speed. It is equipped with a pre-drive to accelerate the new reel to paste speed and this device also serves to control tension during the transition period as the new reel rotates into contact with the tension belts. A separate assembly, carrying the brushes and cut-off knife is lowered and retracted as part of the splicing sequence.

Control of the butt size is provided over the range 100 mm to 127 mm in 3 mm increments.

Controls :

The paster pilot electronics, power supplies and other 'RTP' control gear are housed in a sheet steel panel suitable for mounting in the reel room adjacent to the reel stand with which it is associated.

The paste cycle is automatic but push-button control is provided for standby/service purpose.

Additional reel stand controls.

'Paste Speed' lamp.

'Paste' push-button.

'Reset' push-button.

Digital Pilot 'ON/OFF' switch.

Digital 'ON' lamp.

One lamp per reel stand, which is illuminated during the paste cycle is mounted at the folder desk, together with one only 'Tail' light to alert the operator when a splicing has been completed.

EXERCISE

1. Write short note on process of printing of newspaper.

UNIT – 8

BREAD MAKING

OBJECTIVES :

By the end of this chapter students will learn about :-

- Process flow
- Brief description and functions of various main process and ancillary equipment
- Technical specifications of machinery

PROCESS WRITE-UP

Bread making is an art which has been practiced from time immemorial. With the advancement of science and technology, bread making transitioned from the traditional domestic art to the status of baking technology.

The main raw-material wheat flour is fermented by the action of yeast and converted into a wholesome food. The basic ingredients for bread making are flour, water, yeast and salt. Various other raw-materials are added to the basic ingredients to add richness and flavour to the bread. A step by step description of the processes is given below:

1. <u>Sifting</u>

   Maida flour is sifted in a sifter. This process removes any foreign material present in it and provides aeration. The sieved flour goes directly into a mixer or is collected in a mixing bowl in required quantity.

2. <u>Mixing</u>

   Mixing is done in two steps. In the 1st step sifted flour yeast and water are blended together to form a light dough. In the 2nd step all other raw-materials are blended to the dough and mixed until the dough develops into a homogenous, pliable and extensible mass.

3. <u>Bulk fermentation</u>

After the 1st step of mixing the dough is kept aside in a specially designed fermentation room for 1 ½ to 3 hours under controlled conditions of temperature and humidity. Here yeast acts on the available sugars in flour producing carbon-dioxide gas. During the process the dough rises and becomes lighter acquiring the typical fermented flavour.

4. <u>Dividing</u>

The fermented and remixed dough is taken to a machine called Bowl Hoist where the bowl is locked safely with a liver and lifted automatically until it tilts enabling the dough mass to be dumped into a receiver called the 'Hopper'. The hopper is attached to the divider machine. The dough is then divided for each loaf of bread in a 'Divider'. The curling operation is done by a cutter and plunger. The weight of the divided dough is frequently checked on an ordinary balance, placed nearby the machine.

5. <u>Rounding</u>

The divided dough pieces are rounded and shaped like balls in the machine called Rounder.

6. <u>Intermediate proof</u>

The rounded dough balls pass through an intermediate prover, where the dough is given a rest period of 7 to 8 minutes. This allows the dough to relax and become pliable and extensible again.

7. <u>Moulding</u>

The dough pieces coming out of the inter prover are flattened into thin sheets, rolled into cylindrical shape by the action of rollers, a curling chain and a pressure board. This machine is called moulder.

8. Panning

The moulded dough then passes through an oiling machine and falls automatically in greased baking moulds/tins.

9. Final proof

The baking tins with the dough are placed in the traveling trays of the final prover chamber. Here the dough pieces are allowed to rise to the desired volume under controlled conditions of temperature and humidity. The proof time of the dough can be controlled by adjusting the traveling time of trays within this chamber. Careful handling of the moulds / tins is required at this stage, because a well risen dough is likely to collapse or fall if handled roughly. The developed dough is then fed into the baking oven.

10. Baking

The proved dough is then baked in a baking oven which works on light diesel oil. The baking temperature and time are electronically controlled. Here the yeast action which was initiated at the time of mixing stops as the yeast cells are inactivated due to high temperature prevalent in the oven. Here the bread is baked-starch is gelatinized excess moisture is evaporated and crust develops golden brown colour due to caramelization and other browning reactions. The oven has travelling trays which enable loading and unloading of oven from the same position. The unloaded bread is taken on a conveyor to a ‘Depanner’ where bread is depanned automatically using vacuum rubber cups. The empty moulds/tins travel back to the ‘Panner’ where they are again fed with moulded dough. Depanned bread are stacked on trolleys and placed in a cooling tunnel. Here a fan blows fresh air on to the bread and the heat emitted by the bread is removed by an exhaust fan. The bread is cooled and ready for slicing in 2 to 3 hours.

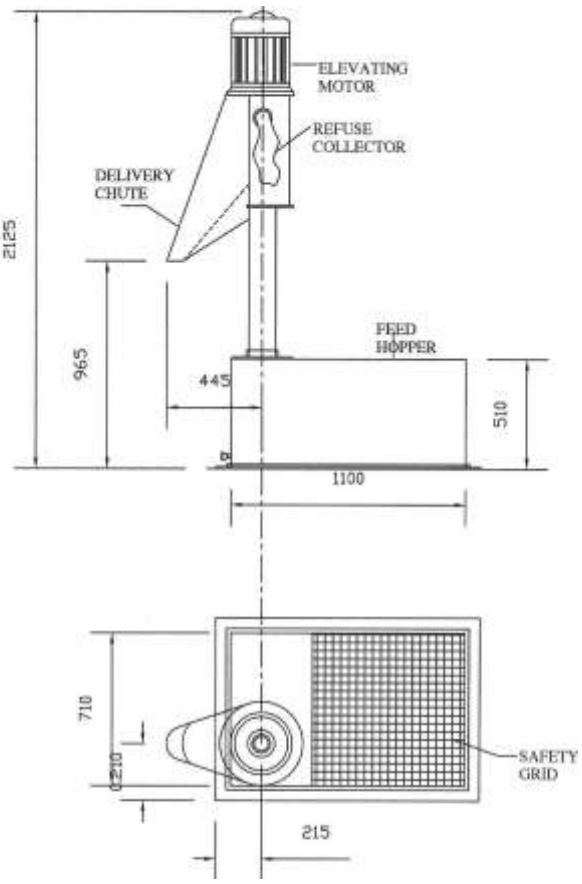
11. Slicing and packing

Cooled bread is fed on to the slicer-end of a slicing and bagging machine. The bread is sliced into the required number of slices using a band slicer. The sliced bread passes on to the bagging section. Here a pouch/bag fixed on wicket rods gets opened and a bread moves into it. The mouth of the bag is then tied securely using a twist the ribbon.

The sliced and bagged loaves of bread move out on conveyors and are collected in baskets. These baskets of bread are then transferred to the marketing section, ready for dispatch to various places.

BRIEF DESCRIPTION AND FUNCTIONS OF VARIOUS MAIN PROCESS AND ANCILLARY EQUIPMENT

1. **Flour Handling Equipment**

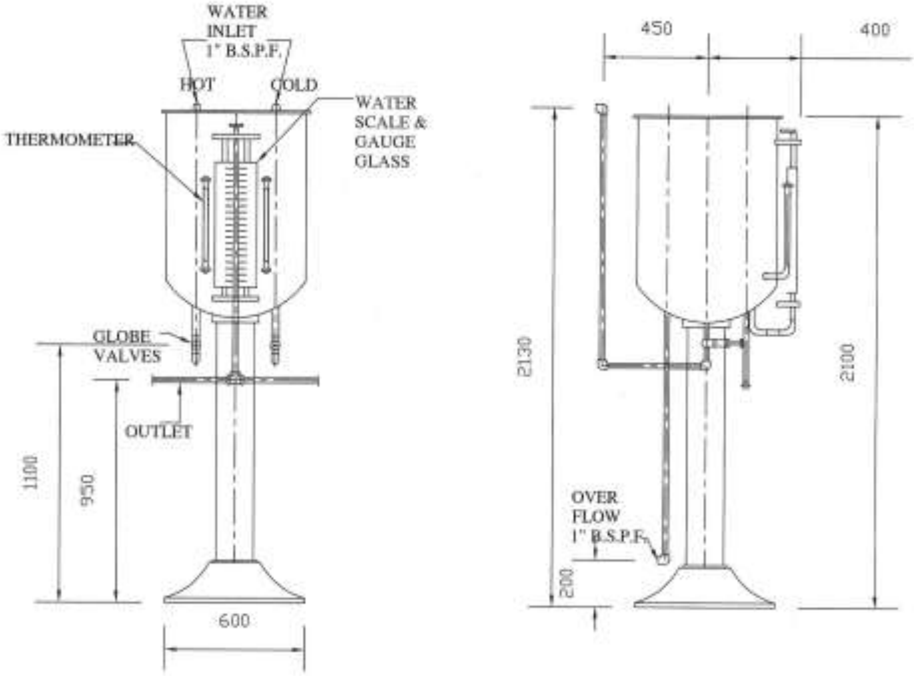


Flour Sifter

The function of flour handling equipment is to (1) sift the flour (2) to remove the foreign materials (3) to loosen and aerate the flour (4) to blend the flour.

The flour handling equipment is fabricated out of M.S. sheets and one number horizontal spiral conveyor and one number of vertical spiral conveyor are arranged in the manner to take the flour to the sifting head. The sifting head consists of screen made out of perforated M.S. sheet and contains 4 numbers nylon brushes. The flour is pressed by these brushes against the perforated sheet and is discharged through hopper chute. The foreign material is transferred to a collecting bag.

2. **Water Tempering Tank**

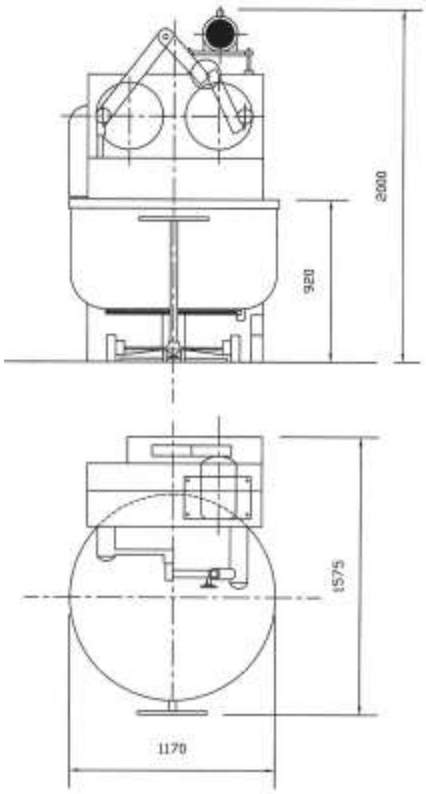


Tempering and Measuring Tank

The water-tempering tank is to supply the water at the required temperature and the measured quantity of the water to be mixed in the flour and also to regulate the desired temperature of the water. The water-measuring tank is fabricated out of stainless steel sheet with inlet and outlet connections for plain water, chilled water, hot water. It has a graduated scale in front and a dial thermometer to read out the level of the water and the temperature.

The water measuring tank is insulated and cladded with stainless steel sheet.

3. **AMF-Sterling Dough Mixing and Kneading Machines**



Twin Arm Dough Kneader

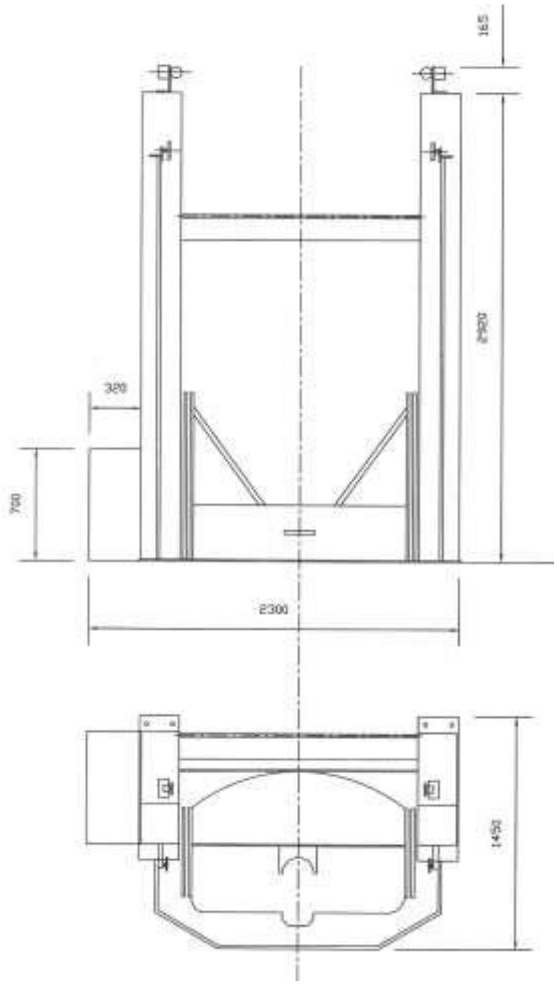
The basic principle of a dough kneader or mixing machines is to mix the ingredients properly and develop the dough suitable for bread processing.

The entire machine is fabricated out of M.S. plates with balance gears at the top head. The mixing and kneading arms are fitted with crank disc in the front of the machine. The dough bowls are fitted and are given rotation by bowl rotating arrangement provided at the base of the machines.

4. **Fermentation Room**

The function of the fermentation room is for fermenting the dough after mixing under controlled conditions. The condition of the fermentation rooms are maintained in such a manner that the temperature of the room is maintained in between 78^0 to 82^0 F and humidity of the room is maintained between 75% to 80% RH. The conditions are maintained by an air-conditioning unit, heating equipments and humidifier.

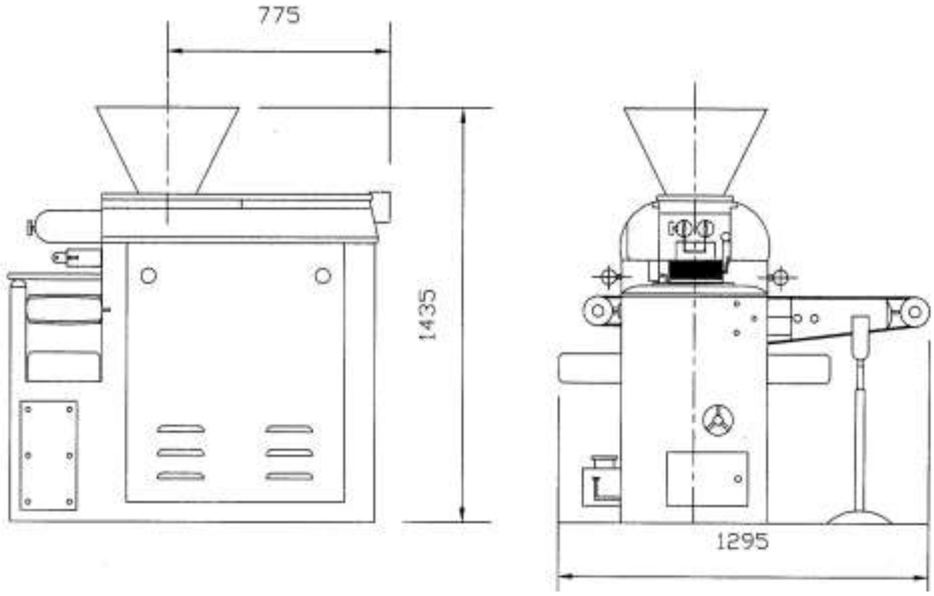
5. **Hoist**



Dough Bowl Hoist

The function of hoist is to lift the bowl loaded with fermented dough and to transfer this dough into the hopper of Divider Machine.

6. **Divider (Single Pocket or Two Pocket Type)**

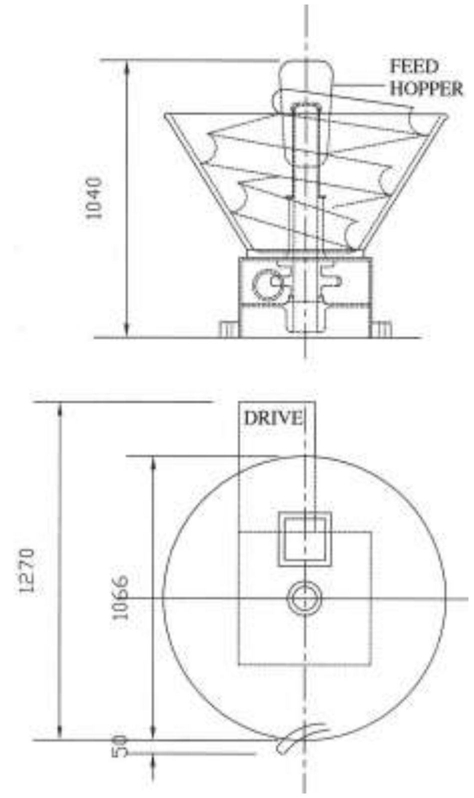


Two Pocket Divider

The purpose of this machine is to equally divide the dough into preset volume. The dough is of the constant pressure volumetric measuring type. It is, therefore, necessary that while using the divider one has to take care to ensure that the divider is adjusted frequently so that the dough is divided to the exact desired weight. The output range of a single or two pocket divider is 20 to 40 pieces per minute.

7. **Rounder**

The basic principle of this machine is to give round shape to the divided pieces of the dough so as to make it possible to mould properly. The rounder also makes slow stretching of the gluten continuously to improve the elastic property of the dough which will ensure good volume of the bread. Apart from the above function, it also forms the proper seal to the surface of the dough to ensure the distribution of gas throughout the dough and also to ensure that the gas will be retained in the dough during the intermediate proofing.



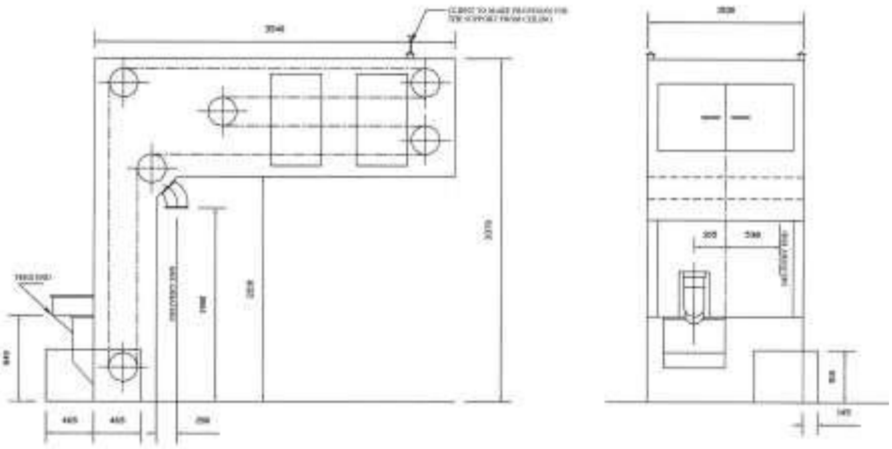
Rounder

Cone type rounders are used with rounder spiral at the centre. The cut dough pieces from divider falls into the centers of the cone which rotates along with the spiral which gives the round shape to the divided dough at the discharge stage.

8. **Intermediate Proover**

The basic function of the intermediate proover is to give rest and aerate the dough pieces. After the divider and the rounder if this rest is not given before moulding, the dough will be rubbing in the moulder and will not make up into satisfactory loaves.

The machine is fabricated out of M.S. sheets in the box form having the chain tracks. The hollow bush pin chain travels on the track throughout the length of inter proover. The chain carries IP trays having six pockets. The number of trays provided in the each intermediate proover is between 76 to 95 numbers. The trays are made out of plastic/fibre glass/stainless steel.

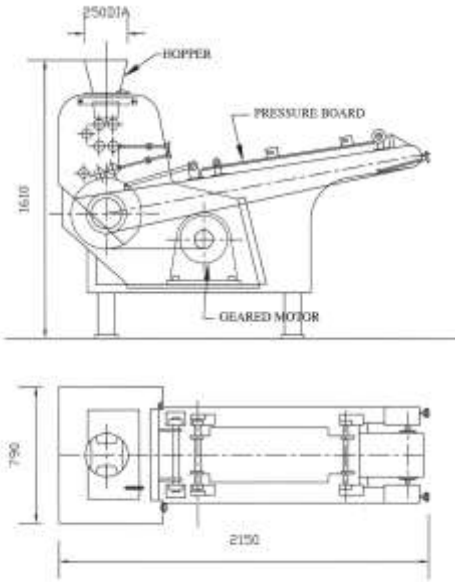


Inter Proover

The round dough pieces are allowed to travel between 6 to 10 minutes where dough pieces are transferred into tray pockets and where they remain until they are discharged on the dough conveyor, leading to moulder.

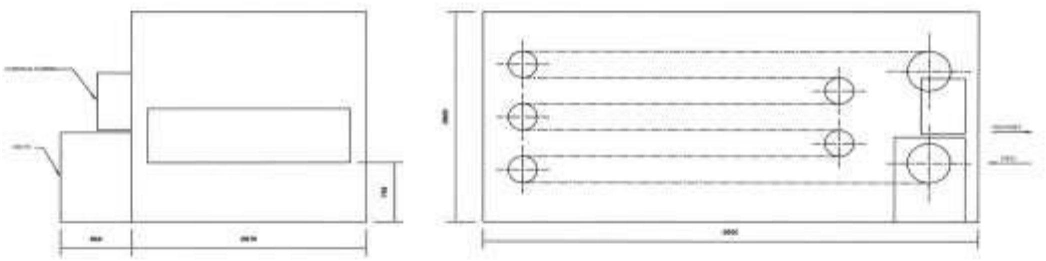
At the entry of the intermediate proover an arrangement of dusting the dough PCS with flour is also provided to avoid any sticking of the dough pieces of the pockets.

9. **<u>Moulder and Panner</u>**



The moulder and panner is a very important item of machinery and it plays an important role in finishing of the product and final make up stage of the dough. In the process of moulding, the dough is shaped into sheet by the teflon rollers and curled and passes through the pressure board and then deposits into the pan automatically by the panner. The purpose of moulding is to give uniform shape of the bread piece. The moulding head consists of three sets of rollers out of which two sets of rollers are Teflon sleeved and the gap between the rollers can be manually adjusted to the desired size.

10. **<u>Final Prover</u>**



Final Prover

The purpose of the final prover is that the action of the yeast is speeded up by higher temperature and the gluten also becomes more mellow.

The final prover is a mechanical swinging tray type in which the trays are carried on endless chains through a chamber maintained at the desired temperature and humidity. The prover is arranged for manual operation being loaded and unloaded at the same end.

The chains are carried on tracks for the horizontal runs and on sprockets at all turning points. All shafts are mounted in sealed grease-packed ball bearings. Lubricators are fitted to provide lubrication of chain rollers and pins. Automatic spring loaded chain tensioning is provided in addition to screw take-up for adjustment.

The prover is fitted with an intermittent drive. The drive unit consists of an electric motor with vee belt drive to a reduction worm gear. Proof time may be varied by means of an electronic timer mounted on the electrical control panel which controls the pause time of the trays.

The electrical control panel is mounted on the feed end of the prover. It is fitted with push buttons for the drive, proof time control and switches for the heating and humidity. The panel contains an isolating switch, electric motor starter, electronic timer, fuses and relays.

The air conditioning equipment consists of four galvanized steam heating coils and galvanized steam humidifier mounted in the lower section of the prover.

Control devices are fitted to provide adjustment of temperature and humidity within the prover and to automatically maintain the desired conditions during operation.

These proof boxes are manufactured out of insulated panels and are having the arrangement of maintaining the temperature and humidity in the proof chamber.

Maintenance

The floor should be cleaned every week and the drainage outlet should be kept clean.

The insure of the prover casing should be thoroughly cleaned and where the slightest sign of rusting shows the sheets should be scraped clean and painted with corrosion-resistant paint.

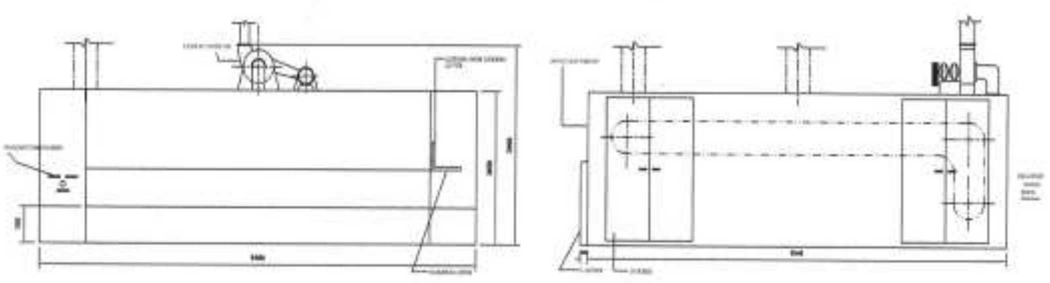
Every three months all trays should be removed and cleaned. Any tray pins which are badly worn should be replaced.

Swing trays which have become bent or twisted should be immediately removed, straightened and examined for fracture. When replaced the tray must swing freely on the tray pins.

The tension of the conveyor chains should be kept in adjustment so that the chain on the slack side of the sprocket can be moved slightly by hand.

Vee belts generally stretch during operation. Careful attention should be given to all vee belt drives to ensure proper performance. If the vee belts become hot or squeal when starting up the belts are too loose and should be tightened. They should be tightened sufficiently to transmit the drive and should not be over tightened.

11. Baking Ovens



Swing Tray Oven

The function of the baking oven is to bake the proofed dough to the desired level. The yeast present in the dough is killed, the carbon-di-oxide gas is fully released. The protein, starches are fully smelled and the maximum expansion of the loaf takes place. The uniform temperature of the oven forms the walls of the load and gives the final crust colour to the loaf.

The oven is a travelling bread baking oven fitted with swinging trays and is heated by oil. The oven trays are 8 feet, 1 in long and is supplied in 11" and 16 ½" width. A unique feature of the oven is that steam formed during baking is retained in the baking chamber to produce a highly glazed finish on upright varieties of bread and rolls.

It is a fabricated steel construction with completely separate inner and outer casings. The inner casing is fully welded to give a steam-tight baking chamber and is insulated with mineral wool. The outer casing provides a flush exterior and is fitted with access doors where required.

The fabricated steel trays are carried on two hollow bearing pin conveyor chains which are automatically tensioned by means of a spring loaded front shaft.

The front of the oven is designed so that two trays remain stationary at the oven mouth allowing trays being unloaded in the lower position and loaded in the upper position.

The oven drive shaft and the front tension shaft are carried in self-aligning bearings. Graphite bushes are fitted to the drive shaft. These require no lubrication or maintenance but require frequent checking for undue wear and tear.

The oven is fitted with an intermittent drive. The drive motor and worm reduction gear are mounted at the rear of the oven. A shear pin is provided in the drive to protect the oven from damage in the event of an overload. Provision has been made to allow the oven trays to be moved by hand in the event of a power failure and prevent burning/over baking of breads.

The oven is equipped with a fully automatic oil burner unit designed to burn light diesel oil. The burner is the pressure atomizing type with electric spark ignition and is equipped with photocell flame failure protection. Safety devices are also included to guard against circulating fan failure.

Thermostatic control of the burner operating on the “on-off” system is provided by a control pyrometer connected to a series of thermocouples mounted in the oven chamber.

The oven chamber is heated by tubular radiators through which hot gases are circulated by means of fan and then returned to the furnace for reheating. There is a radiator positioned between the upper and lower tray runs. A radiator is also positioned below the lower tray run. The distribution of hot circulating gases to each adjustable and provision is also made for setting the lateral distribution within each radiator. A fully insulated explosion relief door is incorporated in the duct work.

The whole of the furnace tunnel is lined with special refractory bricks to withstand combustion temperature and to ensure long life.

Incorporated in the design of the oven is a means by which steam formed during baking is retained in the chamber. This enables a highly glazed finish to be obtained on upright varieties of bread solely by utilizing the steam produced during baking. If at the commencement of baking, the oven is loaded with upright bread, it is necessary to supply steam initially to the oven chamber. A steam injector is fitted for this purpose. If a quantity of lidded bread is baked first, sufficient steam is retained in the chamber to give the desired glaze when the change is made to upright bread.

A steam relief damper is fitted to the oven to allow steam to be evacuated from the oven when required.

All motor starters, fuses and circuit isolating switches are mounted on a panel housed inside the outer casing near the front of the oven. Push buttons, burner indicating light and baking time indicator are mounted at the front of the oven.

A separate box is provided for mounting the control pyrometer adjacent to the oven away from high temperature and vibration.

Operation of Mechanical Equipment

Starting up

The oven should be lit up a sufficient time to allow the chamber temperature to reach that set on the pyrometer controller up to ½ hour before loading is commenced. Under normal conditions the oven will heat up at the rate of approximately 400^0 F per hour.

Turn on the isolating switch in the electrical control panel.

Start up the oil firing equipment in accordance with the following sequence:

1. Start the circulating fan. This closes the suction switch.

2. Set the pyrometer controller to the desired oven temperature.

3. Check that the manual safety switch on the protect relay is in the reset position.

4. Open the oil cock in the oil line to the burner.

5. Turn on the burner switch which is mounted adjacent to the burner.

The ignition should start immediately, the burner should follow about 15 seconds later and a flame should be established. The red burner lamp also lights up.

Running

There should be no further attention required as the burner is now under the control of the pyrometer controller. This should be set at the baking temperature so that best use of the automatic on-off control is obtained.

At the time of lighting up, the main drive should be started. This ensures that all trays are heated evenly. During heating up the oven door if provided should be kept closed.

If it is desired to commence baking upright varieties of bread or rolls, the steam should be turned on 5 minutes before loading is commenced.

If lidded bread is baked first, the oven will have generated sufficient steam to glaze upright varieties after several trays have been loaded.

Naturally the point at which this stage is reached is dependent on the size of the oven and the dough weight in the oven. As a guide a 50 tray oven requires approximately 1400 lbs. of dough weight to have been loaded into a dry oven before self-steaming is achieved.

During baking excess steam may be evacuated from the chamber by means of the steam release damper which is controlled from the front of the oven.

When loading tins, care must be taken to place them centrally across the trays so that the tray hangs vertically. Failure to do this may result in tins falling off during baking causing a jam-up and consequent disruption to production.

Closing down

Close down the oil firing equipment in accordance with the sequence.

1. Turn off the burner switch. The burner shuts down and the red lamp goes out.

2. Close the stop cock in the oil line.

3. Stop the circulating fan.

Important note

Circulating fan must operate for 15 minutes after extinguishing burner.

Switch off the main drive and turn off the isolating switch in the electrical control panel.

Open has steam release damper fully for five minutes to purge the oven of steam. Close the damper. Clean out the floor inside the oven front and close the oven door.

Lubrication of Oven Chains

Regular lubrication of oven chains is most important to ensure long chain life.

The oven chain lubricant is a specially designed heat resistant lubricant with a wear base. The water is used to carry the lubricant to the moving parts of the chain.

The lubricant should be applied when the oven temperature is approximately 250^0 F as the water will evaporate before the lubricant reaches the bearing surfaces if the oven is too hot. On the other hand rust may be formed before evaporation takes place if the oven is too cool.

Before applying the lubricant make sure that the chains are clean and if any rollers do not rotate freely they should be freed by means of Stillson grips.

The lubricant is prepared for use by thinning down with clean warm water to the consistency of paint. Apply with a paint brush getting the lubricant well down between inner and outer links and between the inner links and rollers.

The surface of the lubricant should be kept covered with water in its container when not in use.

The lubricant should be applied at least once a week and should be used just prior to heating up so that the rising oven temperature will insure evaporation of the water before rust can be formed.

General Description of Oil Firing Equipment

The oil firing equipment comprises oil burner and safety devices to provide protection against fan and flame failure.

The oil burner limit is driven by motor controller by a relay direct coupled to the fan and oil pump.

L.D.O. is pumped from the oil filter via a built-in pressure regulator to the nozzle at the required pressure of approximately 120 p.s.i. The pressure regulator does not admit oil to the nozzle until the required pressure is reached. If the oil pressure rises above the required figure, the pressure regulator by-passes the excess oil back to the pump intake. Primary air is supplied by the centrifugal type fan in the body of the burner. The supply is controlled by the setting of the air shutter on the micro screw adjuster. Ignition of the burner is by a spark across two electrodes. The ignition is continuous whilst the motor is running.

The burner is thermostatically on-off controlled by a pyrometer controller with thermocouples in the baking chamber. When the controller calls for heat, a relay is energized starting the burner and when the temperature has reached the controller setting, the relay is de-energized and the burner stops. Whilst the burner is operating the red indicator lamp is alight.

Safety protection is provided as follows:

In the event of flame failure, a photo-resistor mounted in the burner air tube operates a flame relay causing a safety switch heater to begin heating and after 30 seconds, unless the burner has re-ignited, the switch will warp out. This shuts down the burner, and the alarm bell will ring. The burner can only be restarted by the actuating of the manual reset lever on the Honeywell relay, and the alarm bell will stop ringing. It is necessary to wait about 70 seconds for the switch to cool down before this can be done.

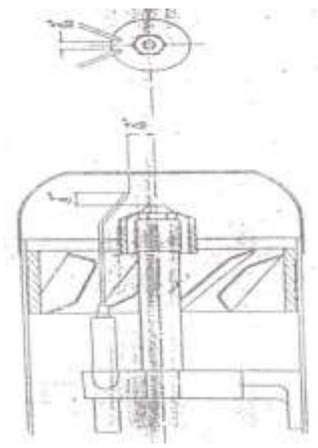
Secondly, if the circulating fan ceases to run the suction switch opens and this stops the burner, and the red indicator lamp will go out.

Safety Shutdown

(a) Failure to Ignite

If the burner fails to ignite the flame relay will operate, and the safety heater switch will warp out after 30 seconds, and the red indicator lamp will go out and the alarm bell will ring. Likely causes are listed below and each of these should be checked in turn.

(i) Oil line stop cock not open
(ii) Empty oil tank.
(iii) Blockage in oil line.
(iv) Electrodes are dirty.
(v) Electrodes not in proper position. The correct setting for this is shown on the following diagram.



(vi) Dirty photo-resistor glass.
(vii) Loose electrical connections.

(b) Flame Failure Shutdown

This will have the same effect as Failure to Ignite.

The same checks are also necessary.

(c) Circulating Fan Shutdown

When the circulating fan shuts off, the suction switch will open and the burner will stop. The red lamp will then go out. Check for the following possible causes:

(i) Overload on the motor which could be caused by seized fan bearings.
(ii) Failure of the electrical supply.
(iii) Overheating of the motor.
(iv) Broken vee belts.

Weekly Operational Checks

1. Thermostatic control

This is automatically checked daily if the starting sequence is followed.

2. Flame failure protection

Whilst burner is running shut off the oil stop cock. Then proceed as for the flame failure shut down waiting till the manual safety switch in the Relay has cooled before restarting.

3. Circulation

Switch off the circulating fan whilst the burner is running. The burner should stop.

Maintenance of Burner Unit

Burner

It is recommended that arrangements be made for regular servicing of the oil burner.

Once every week withdraw nozzle from the burner head. Check the electrode setting and make sure that the photo-resistor glass is clean.

The nozzle tube can be withdrawn from the assembly by slackening off the grub screw and the nozzle removed for cleaning. This should be done by soaking and washing in lacquer thinners, removing any particles of carbon with a sharpened match or tooth pick. On no account should any metal object be used on the nozzle parts. When re-assembling the nozzle, it should be held vertical with the orifice downward to assist in locating and seating the disc.

Furnace brickwork

Inspect the furnace brickwork every month for any displacement or other defects. Special high temperature refractories are to be used for the furnace linings and replacements to be made accordingly, if any.

Auto Lidding of Simplex Oven

Description

The mechanism in Simplex auto lidding provides for bread to be baked with the lids either lying on top of the tins, or alternatively, locked in the raised position, approximately 7.5/8" above the trays. Simplex auto lidding has no drive as such, it simply makes use of the movement of the trays to actuate toggle links to raise or lower the lids as required. Lidding is controlled by a spring loaded self locking lever which may be placed in two positions marked "Lidded" and "Non-Lidded". Lids on the trays in the loading and unloading positions are always raised regardless of the setting of the lidding control lever.

Two toggle links fitted to either end of the tray as shown in **Figures 1 and 2,** control the position of the lids by means of cams which act on the centre or control roller of the links. The cams consist of two welded steel frames attached to either side of the vertical run of the oven, and through these cams pass the link and stabilizers at the end of the trays.

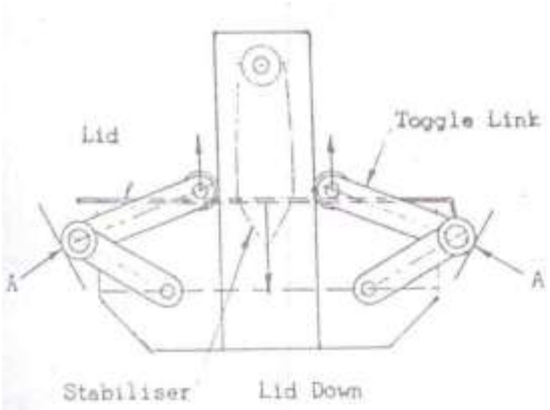


Fig. 1

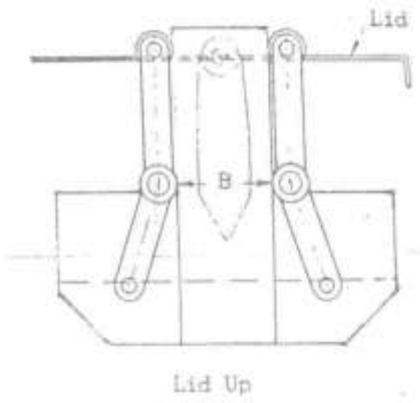


Fig. 2

The control rollers on trays passing through the cams first contact the elevating cams which push the rollers in the direction of arrow A. **Figure 1**, until the lids are fully raised and locked up, as shown in **Figure 2**. The elevating cams are placed in the vertical return run as shown in **Figure 3**, so that the lids are raised ready for unloading as soon as the trays emerge from the baking chamber.

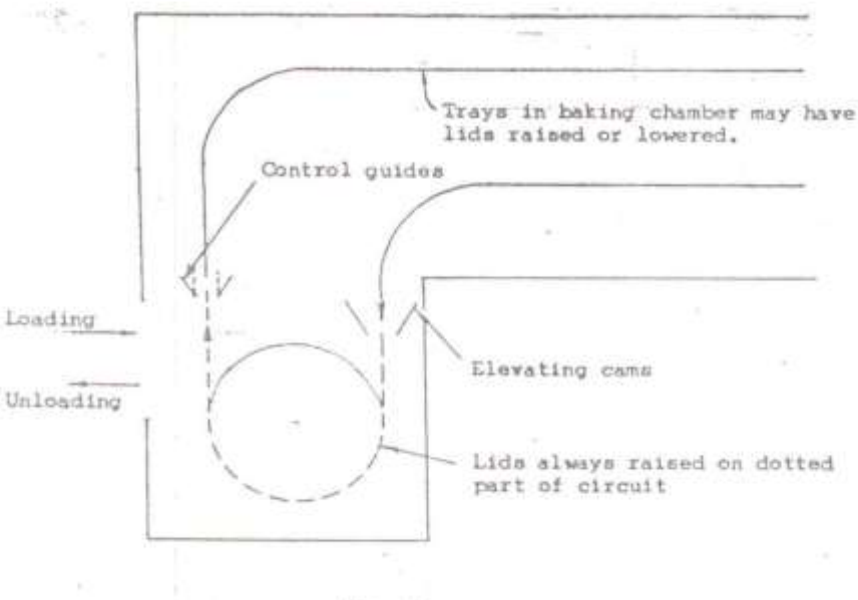


Fig. 3

Trays proceeding from the loading position, pass the control guides which may be set either to miss the control rollers or alternatively, to push them outward in direction of arrow B **Figure 2**, thus lowering the lid until it is resting on the tin.

Trays are fully stabilized for the whole of the time they are passing through the cams, this includes the time at loading and unloading positions. Raising and lowering of the lids is completely controlled at all times, resulting in an extremely gentle and practical noiseless action.

Operation

Set lidding control lever in desired position, either "Lidded" or "Non Lidded", when trays are stationary. Changing the setting when the trays are moving could result in improper lidding of the tray passing through the control guides and is therefore to be avoided.

When loading, ensure that tins are placed centrally across the trays to prevent undue tilting which could result in a jam up. Under no circumstances must anything be placed on top of the lids as this also could cause severe damage to the lids and trays.

Maintenance and Lubrication

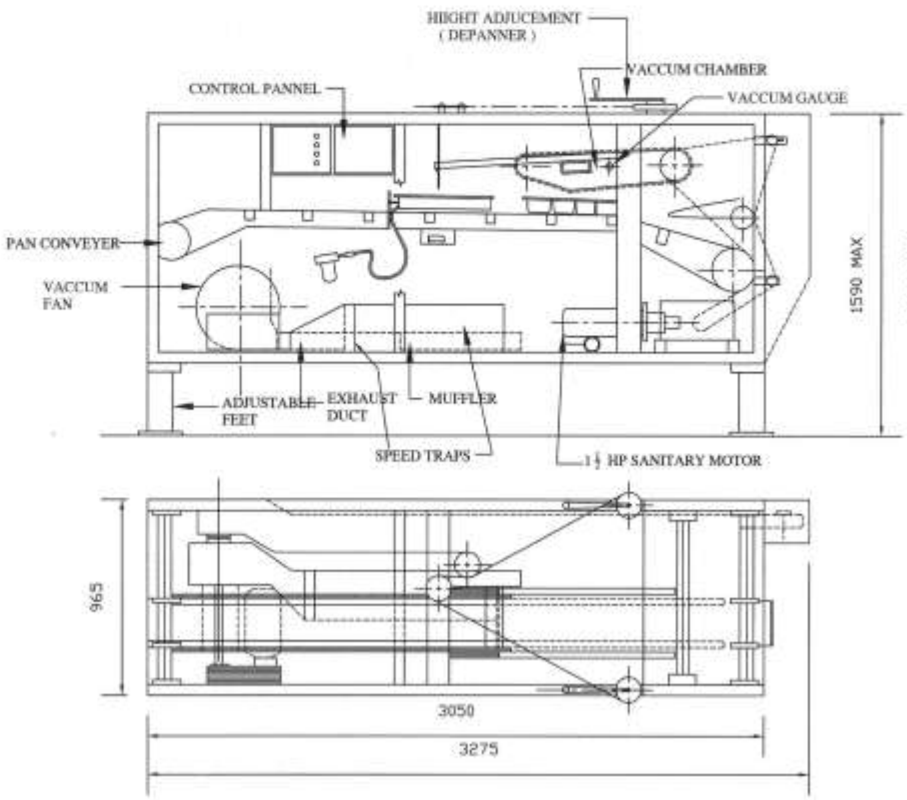
Trays

Once a week Lubricate joints and rollers of each toggle link with oven chain lubricant. Access to the front toggle links is obtained through loading door, and to the rear links, through rear oven doors. Regular and thorough lubrication of toggles links and pins is essential for the trouble free operation of the auto lidding. Apply with paint brush getting the lubricant well down between inner and outer links and between inner links and rollers. Check all rollers to ensure freedom of movement and free all tight ones by means of Stillson grips. The lubricant should be applied when the oven temperature is approximately 250^0 F.

12. **De-Tinner / De-Pan-Ovac**

The basic function of this machine is to remove bread automatically from the bread baking tins at a very fast rate. The hot bread baking tins at a very fast rate. The hot bread tins are diverted to the tin cooling system and the hot bread is conveyed to the collecting table, from where the breads are lifted and stacked in trolleys for cooling purpose before these are sliced and packed.

The machine is fabricated structure consisting of slat band conveyor for conveying the bread baking tins with bread. A vacuum conveyor assembly placed over the slat conveyor with aluminium cup holders with rubber cups. An exhaust blower is attached to the vacuum cup conveyor assembly for creating vacuum which helps in removing the baked product from the tins. A common drive arrangement with reduction gear box is provided at the bottom of the machine to give drive to the slat chain and vacuum conveyor assembly.



De-Panner

13. **Tin Cooling System**

Tin cooling system fixed on the conveyor with ducting and axial flow fans/blower fans for circulating the forced cool air over the tins to cool them sufficiently before the panning stage.

14. **Slat Band Conveyor System**

All the plans are provided with 7 ½ inches x 1.5" pitch slat band conveyor. The slat band conveyor system is provided all around the final prover and ovens for easy flow of loaded and empty tins. The slat band conveyors are made out of M.S. case hardened steel and blackodised.

The conveyor systems provided are working on the fabricated steel structure which supports the slat band chain running over the sprockets and the drive is given through reduction gear boxes. The same system is adopted for wire conveyors also for conveying breads.

15. **Cooling Tunnel**

Every unit is provided with cooling tunnel(s). The basic principle is to enable fast cooling of the baked products and to prevent excessive hardening of the baked product. This also helps in reducing the cooling loss.

The cooling tunnel is a static chamber fitted with inlet and exhaust fans made out of M.S. fabricated channels. The inlet and exhaust is provided through axial flow fans forcing the air over the product and exhausting the hot air. In most of the bakeries air washing system is also provided with a cooling fan for forcing the cooled air on to the product during the summers.

16. **Automatic Slicing and Wrapping Machines**

These are highly specialized machines consisting of 3 sections viz. slicing, synchronizing and wrapping sections. The slicing section slices the bread with the help of reciprocating knives through which the breads are passed and sliced.

The Synchroniser carried the sliced bread up to the wrapper feed point and feeds the sliced bread into the wrapping machine. The wrapping machines wraps the bread in the wax paper which is in the form of rolls. The wax paper covers sliced bread and seals the same with the help of heat sealers and is finally discharged on to the conveyor for collection and filling into the bread baskets.

BRIEF DESCRIPTION AND FUNCTIONS OF ANCILLARY EQUIPMENTS

1. **Air Compressor**

These compressors produce compressed air at 100 to 250 lbs per square inch. The compressed air is used for cleaning all the bakery equipments as well as in the air jet system of Depanovac machines.

2. **Boilers**

Package type of boiler are used for steam generation. These boilers are of non-I.B.R. category and are of coil type. These boilers are fitted with oil burners and are completely automatic with various controls and satches.

The basic use of the steam, generated by these boilers is used in heating and humidifying the final proves. A part of the steam is also used in the mixing section for preparation of GMS emulsion and in fermentation rooms for maintaining required temperature during the extreme winter season.

3. **Air Conditioning and Chilled Water Plants**

The essential equipment of the cold store are motor, compressor, air handling unit, controls and insulated storage space fitted with heavy insulated door. The temperature is maintained by providing evaporative coil with air handling arrangement. The refrigerant is circulated into evaporative coil with the help of the refrigeration compressors and refrigerant is cooled by the shell and tube type of water circulated or air cooled condensers. Each cold store is provided with one stand by compressor.

4. **Fermentation Room**

The fermentation room is also equipped with air conditioning and heating equipments. The temperature and humidity of the fermentation room is also maintained at the desired level. It consist of evaporative coil with air handling equipment along with the electrical heaters. The electrical heaters are used during the winter season where the temperature has to be raised to the desired level. The fermentation room equipment also consist of refrigeration compressors of suitable capacity with water circulated shell and tube type of condensers with standby compressor. The humidity is maintained by water spray nozzles / humidifiers.

5. **Chilled Water Plants**

The chilled water is used in the process for maintaining the dough temperature. The chilled water equipment consist of water chillers, tank coil systems, refrigeration compressors and refrigeration condensers.

In air conditioning equipment, Freon Gas is used as refrigerant. All the water cooled condensers are connected by the suitable pumping system to the cooling towers which brings down the temperature of the water after it is circulated through the condenser system of the refrigeration plants.

Apart from the above process and ancillary equipments the following important bakery equipments also for the purpose of carrying out production and dispatch:

1. Bakery equipments

(i) Weighing scales

Precise weighing scales of various capacities. The weighing scales are provided for weighing various ingredients to be added into the product very precisely as per the laid-down formulations and also to check the incoming quantity of the raw materials received in the stores along with the monitoring of finished product weights before dispatches.

(ii) Bread baking tins

Bread baking tins of various sizes as per requirements.

(iii) Bread cooling trolleys

Sufficient number of bread cooling trollies for cooling the baked product before the slicing and packing are required to handle full production capacity of one line.

(iv) Morries trollies

For material handling pallet trucks / Morries trollies are provided in various sections as per the need.

(v) Bread baskets

Bread baskets for handling the finished product which is sent to the market through the delivery vans.

2. Other installations

(i) H.T. and L.T. Electrical Installations

The H.T. and L.T. electrical installation is provided in the bakery unit to give continuous un-interrupted power supply for running of the various equipment. The power supply is available at high voltage from the respective state undertakings. This H.T. supply through the H.T. equipments is fed to the step down transformer to convert the high voltage supply into the low voltage supply at 415 volts from operating the equipments. After the transformer installation, L.T. distribution board is provided and the supply is then further, distributed to various points in the bakery.

(ii) Water Supply Installation

Bakery requires its water supply installation to receive water from the municipal corporation or any other source. The tube well installation is provided for getting the water supply within the premises. The underground or overhead storage tanks distributes the water to various points in the bakery.

(iii) Oil Installation

Underground/overhead oil storage tanks along with its complete installation to the required equipments through service tanks.

(iv) Fuel Oil Installation

Fuel oil installations by providing bulk storage tanks either underground installation or overhead installation along with service tanks and pipe lines for supply of fuel oil to the ovens and boilers.

3. Fire Fighting Equipments

The installation of the fire fighting equipments at the various strategic locations for fire fighting is a statutory requirement. The various types of fire fighting equipments as per the class of fire and as per the recommendation of the local fire authority are required to be provided.

4. Delivery Vans / Staff Cars

Baking is requires one or two staff van / cars and sufficient numbers of the delivery vans.

TECHNICAL SPECIFICATIONS

1. **Flour Sifter**

Capacity :

Designed for aerating and sifting flour at rate of 2.5 Tonne per hour.

Electrical Characteristic :

Elevating Conveyor Motor : 3 HP, 960 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. cage TEFC Induction motor.

Horizontal Conveyor Motor : 3/4 HP, 960 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. cage TEFC Induction motor.

Simplicity of operation :

Flour from bags is dumped into the Feed Hopper, where it is conveyed to the removable perforated steel sifting head and delivered to the bowl. The residual flour is diverted into the refuse collector.

Net Weight : 320 kg

Gross Weight : 410 kg

2. **Water Tempering and Measuring Tank :**

Capacity :

Overflow capacity : 190 Litre
Sliding Scale : 165 Litre

Simplicity of operation :

It is designed for supplying water at a constant ad pre-determined temperature to Dough Kneader bowl. A large instantaneous reading thermometer facilities quick adjustment of the mixing valves.

Net Weight : 320 kg

Gross Weight : 410 kg

3. Twin Arm Dough Kneader :

Capacity :

Designed to mix and knead maximum up to 220 kg of flour per batch or 300 kg of Dough per batch.

Electrical Characteristic :

5 HP, 1440 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. cage TEFC Induction motor.

Simplicity of operation :

All controls are positioned for easy operation. It is simple and quick to lock the bowl in position and engage the worm with the worm wheel. The Mixing Arm can be run idle by operating the hand wheel while the Kneading Arm can be tilted outwards using a special spanner supplied with the machine.

Net Weight : 1400 kg only mixer
1650 kg with Bowl

Gross Weight : 1600 kg only Mixer
1900 kg with Bowl.

4. <u>Dough Bowl Hoist :</u>

<u>Capacity :</u>

Designed to lift the Dough Bowl used with Model 9543 Dough Kneader to deliver the dough into Divider Hopper.

<u>Electrical Characteristic :</u>

<u>Drive Motor :</u> 2 HP, 1440 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. cage TEFC Induction motor.

<u>Safety of operation :</u>

To ensure absolute safety of operation a limit switch is provided to automatically stop the machine when safety guard is opened.

<u>Net Weight</u> **:** 3200 kg

<u>Gross Weight</u> **:** 4000 kg

5. <u>Two Pocket Divider :</u>

<u>Capacity :</u>

Designed to scale dough into pieces having equal weights ranging from 225 gm to 1020 gm with variable output from 2000 to 3000 dough pieces per hour.

<u>Electrical Characteristic :</u>

2 HP, variable speed electric motor, 400/440 volts, 3 phase, 50 c/s.

Simplicity of operation :

All controls are positioned for quick and easy operation. Weight adjustment is simple and positive by means of a weight regulating hand wheel. The output of the Divider can be varied by means of speed regulating hand wheel.

Net Weight : 1100 kg

Gross Weight : 1250 kg

6. Rounder :

Capacity :

Design to mould 400 gm to 1000 gm dough pieces at the rate of 3600 pieces per hour into uniform smooth spherical shapes for subsequent first proof.

Electrical Characteristic :

3/4 HP, 940 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. cage TEFC Induction motor. Motor and Switchgear can be supplied to suit voltages etc.

Simplicity of operation :

The dough pieces from Divider are fed into the Hopper and discharged straight through from the outer edge of the Conical Table into the hopper of the Inter Prover.

It is simple and quick to remove the spiral trough for maintenance.

Net Weight : 530 kg

Gross Weight : 650 kg

7. **Inter Prover :**

Capacity :

Proof Time in Minutes :

OUTPUT	DOUGH PIECES PER HOUR			
No. of Laps	2400	2200	2000	1800
6	10.7	11.7	12.9	14.3
5	8.9	9.7	10.7	11.9
4	7.0	7.7	8.5	9.4

No, of Trays : 74 nos. Six pocket trays.

Max. Capacity of pockets : 1000 gms.

Electrical Characteristic :

Motor : 1 HP, 1440 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. cage TEFC Induction motor. Motor and Switchgear can be supplied to suit voltages etc.

Simplicity of operation :

All controls are positioned for quick and easy operations. It is simple and quick to set the loader flaps to make 4, 5 or 6 laps of tray circuit to give different proof time without changing the speed of the drive. The drive speed can be varied to give max. desired output by the hand wheel provided at drive unit.

Net Weight : 1000 kg

Gross Weight : 1200 kg

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8. **Straight Moulder:**

Capacity :

Design to mould dough pieces weighing 400 gm to 1000 gm to produce length between 150 mm to 350 mm to give output up to 2300 dough pieces per hour..

Electrical Characteristic :

Motor : 2 HP, 400/440 volts, 3 phase, 50 c/s, 230 RPM Geared motor.

Simplicity of operation :

CONTROL : All controls are positioned for quick and easy operation. It is simple and quick to change over from 400 gm to 1000 gm settings.

Safety of operations : To ensure absolute safety of operation, both front and rear hinged vision doors are fitted with micro switches which automatically stop the moulder when either door is opened.

Net Weight : 700 kg

Gross Weight : 1000 kg

9. **Final Prover :**

Capacity :

1800 loaves of 800 gms size per hour based on 60 minute proof.

Electrical Characteristic :

Drive Motor : 1 HP, 1000 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. Cage TEFC Induction Motor.

Important Features :

Final Prover body consists of heavy steel sections and mounted on a rigid steel base. It is corrosion protected. Access doors are provided for normal maintenance.

Conveyor system consists of 101 Swing type galvanized trays carried on 6” Pitch Chain running on steel track on either side. Air conditioning system ensures to maintain desired temperature and humidity during the operation.

Net Weight : 12 Tonne

Gross Weight : 15 Tonne.

10. Swing Tray Oven :

Capacity :

1800 Breads of 800 gms suze per hour based on 30 minutes bake.

Electrical Characteristic :

Drive Motor : 1.5 HP, 1440 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. Cage TEFC Induction Motor.

Circulating Fan Motor : 10 HP, 1440 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. Cage TEFC Induction Motor.

Extraction Fan Motor : 1.5 HP, 1440 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. Cage TEFC Induction Motor.

Important Features :

Oven body consists of inner and outer walls, mounted on heavy steel base and thoroughly insulated. Suitable openings are provided for temperature measuring equipment, inspection windows, light boxes etc. with a walk in space for maintenance.

Oven Conveyor system has 50 Swing Type Trays supported on 4” Pitch Chain and carried on tracks at each side. Trays have automatic lidding/non-lidding arrangement.

Automatic oil Jet burner suitable for working on Light Diesel Oil is provided in the heating system. Controls are provided for oven conveyor system, burner operations, baking time, temperature etc.

Net Weight : 15 Tonne

Gross Weight : 17 Tonne.

11. Depanner :

Capacity :

Designed for De-panning breads from standard size Bread Straps at the rate of12 to 35 sets per minute.

Electrical Characteristic :

Vacuum Fan Motor : 10 HP, 3000 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. Cage TEFC Induction Motor.

Drive Motor : 1.5 HP, 1440 RPM, 400/440 volts, 3 phase, 50 c/s, Sq. Cage TEFC Induction Motor.

Simplicity of operation :

CONTROL : All controls are positioned for quick and easy operation. It is simple and quick to change the speed of the conveyors and to adjust the height of the Cup Conveyor for different size of bread straps.

Safety of operations : To ensure absolute safety of operation, limit switch is provided to alarm and stop the machine when the bread straps get jammed on the pan conveyor.

Net Weight : 2200 kg

Gross Weight : 2600 kg

EXERCISE

1. Draw process flow diagram of bread making.
2. Give brief description and functions of various process and ancillary equipment.
3. Provide data to be collected at the time of taking inventory of machinery used in bread making to get the current prices.

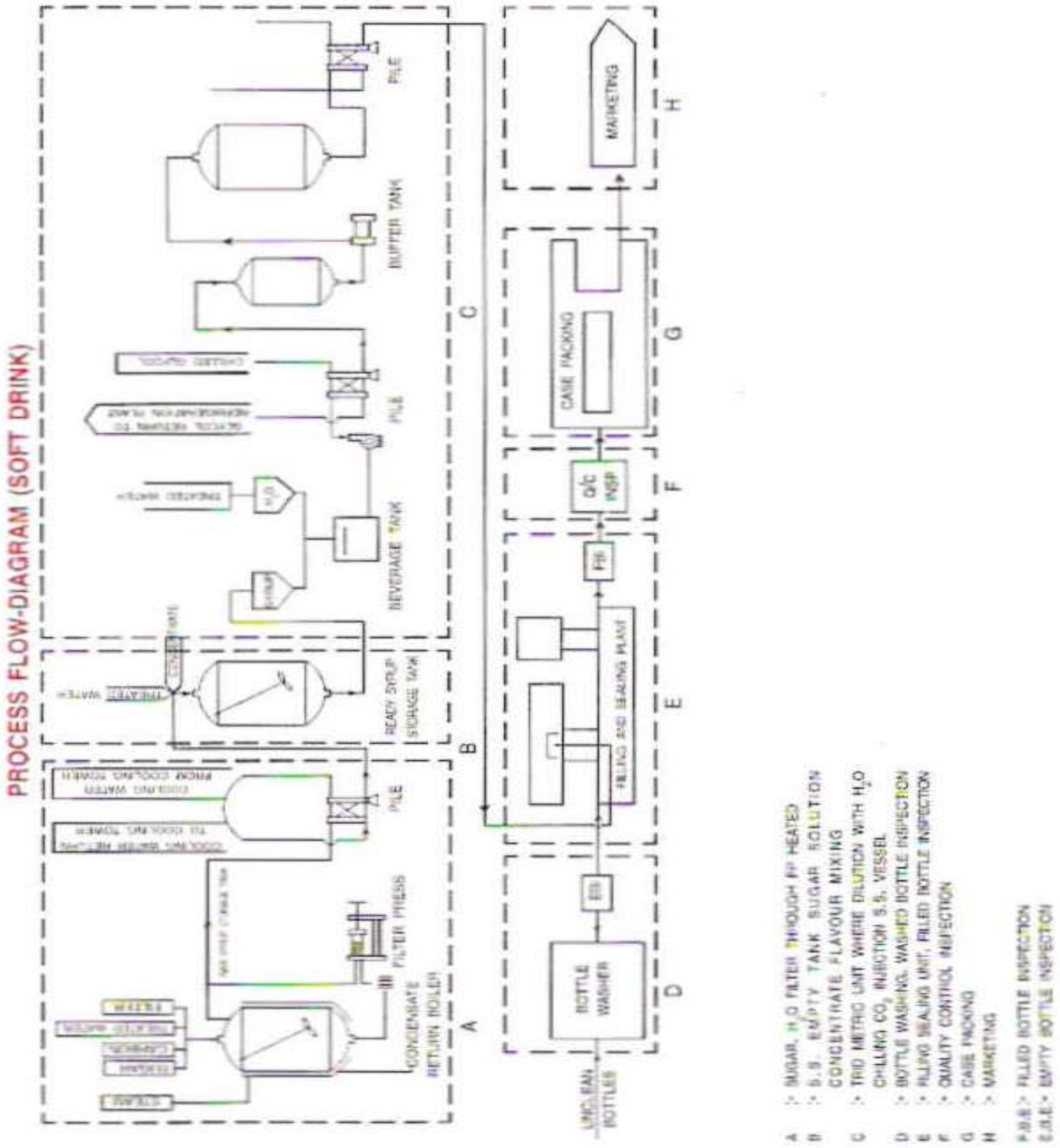
UNIT - 9

MANUFACTURING PROCESS OF SOFT DRINK

OBJECTIVES :

By the end of this chapter students will learn about :-

- Process flow
- Manufacturing process



Manufacturing Process of Soft Drink

The following steps are involved in the manufacturing process of beverage drinks:

* Water treatment -
  - (i) Chemical treatment to raw water for process water.
  - (ii) Softening treatment to borewell water for bottle and boiler cleaning.
* Sugar syrup preparation
* Concentrate syrup preparation
* Bottle washing and empty bottle inspection
* Proportionating unit – dilution – chilling and carbonation
* Filling, sealing and filled bottle inspection
* Case packing
* Marketing
* Quality control assurance laboratory

Water treatment :

(i) Chemical treatment to raw water for process water.

Raw water obtained from the municipal source is stored in a tank (generally of R.C.C. construction) and then transferred to a chemical treatment tank (mechanical agitators are provided in each of the tanks and tanks are generally of R.C.C. construction). Where lime-ferrous, sulphate-bleaching powder treatment is given to reduce the alkalinity, turbidity and micro-organisms. After treatment, required settling time is given for flock settlement at the bottom of the tank. After that chemically treated water containing 8 ppm (parts per million) – 10 ppm residual chlorine (Cl_2) is transferred to overhead storage tanks (generally these tanks are of R.C.C. construction).

From there it passes through –

* Sand filter (for removing suspended impurities)
* Carbon filter (for removing residual chlorine)
* Micron filter (for removing turbidity)
* Ultraviolet sterilizers (for killing micro-organisms)
* Sugar syrup preparation room
* Concentrate preparation room

(ii) Softening of bore well water

The raw water from bore well is collected in storage tanks (normally of R.C.C. construction) where automatic chlorination (8 ppm – 10 ppm) takes place. Sufficient contact time is given to kill micro-organisms; water is then passed through sand and carbon filters for removing suspended impurities and residual chlorine respectively. Ion exchangers (softners) reduces total hardness of the water up to less than 10 ppm. Softer water is then collected in overhead tanks and then subsequently passed through ultraviolet sterilizers (UV lamps). This water is used for bottle washing, boilers, cooling towers, generators and for plant cleaning purposes.

Sugar syrup preparation :

For preparing sugar syrup – white crystal sugar, carbon powder filter, citric acid and water in required quantities are heated to about 75^0 C in a steam jacketed tank with a mechanical agitator. On achieving the required temperature, appropriate contact time is allowed for better inversion. Hot sugar syrup is then passed through the filter press for removing impurities and through a plate heat exchanger for reducing the temperature. This clear, odourless, colourless sugar syrup is kept in S.S. mixing tanks.

Concentrate syrup preparation :

For preparing concentrated syrup, sugar syrup is mixed with acid flavour, colour and other ingredients along with treated water. The mixing takes place in S.S. mixing tanks with mechanical agitators. The prepared concentrated syrup is kept for ageing as per the required standard for different flavours. In order to maintain standard mix with required volume, treated water is added.

Bottle washing and empty bottle inspection :

Empty bottles received from market are pre-inspected for chipped glass, straw removing, rustiness and washed with hot water on a washing machine, they are then thoroughly cleaned, washed, sterilized and finally rinsed with soft water.

Proportionating unit :

Concentrated ready syrup is mixed with treated filter water for dilution depending upon the flavours in the mixing tanks. The mix passes through chilling plate heat exchanger for carbonation with carbon dioxide gas. The carbonation is different for different flavours.

Filling, sealing and filled bottle inspection :

Bottles from the washing machine are filled with a carbonated beverage to a proper level and sealed on an automatic filling and sealing machine. Subsequently they are inspected for the proper level of liquid, crown crimping and dirt. Finally bottles are put in crates for marketing.

EXERCISE

1. Write short note on manufacturing process of soft drink.

REPORT WRITING

Please refer the book- ***Valuation on Plant & Machinery (Theory & Practice) by Kirit P. Budhbhatti*** for the details on this subject.

CASE STUDIES

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Kirit P. Budhbhatti

Chairman, CVSRTA

Please refer the book- ***Valuation on Plant & Machinery (Theory & Practice) by Kirit P. Budhbhatti*** for the details on this subject and following Case Studies:

<u>Case Study- 1</u>

A Lathe Machine has been purchased at the cost of INR 50,000 in the year of 2016. New similar lathe machine is available at INR 60,000 as on date of valuation.

The **Valuer's** findings are as below.

• As per companies Act, 2013 the useful life of such machinery is 10 years.
• Salvage Value is 5% of Replacement Cost New
• Other cost/charges/taxes/duties/loadings are included.
• The date of valuation is 31st March 2018.

(1) What is Acquisition cost of the Lathe Machine in INR?
  (a) 50,000
  (b) 60,000
  (c) 1,00,000
  (d) 40,000

Ans. (a) Acquisition Cost is INR 50,000.

(2) What is Current Replacement Cost of the Lathe Machine in INR?
  (a) 50,000
  (b) 60,000
  (c) 1,00,000
  (d) 40,000

Ans. (b) Current Replacement Cost (CRC) = INR 60,000.

(3) What is the Salvage Value of Lathe Machine in INR?
  (a) 18,000
  (b) 3,000
  (c) 12,000
  (d) 10,000

Ans. (b) Salvage Value = CRC * 5% = 60,000 * 5% = INR 3,000.

(4) What is the balance useful life of Lathe Machine using Life as per companies Act, 2013?
  (a) 10 Years
  (b) 2 Years
  (c) 8 Years
  (d) 12 Years

Ans. (c) Balance Economic Life = 10 Years – 2 Years = 8 Years.

(5) What is the amount of accumulated depreciation considering straight line method in INR?

(a) 60,000
(b) 57,000
(c) 50,000
(d) 11,400

Ans. (d) Depreciation = 60,000 * (1-5%) * 2/10 = 11,400.

(6) What is the Depreciated Replacement Cost of the Asset in INR?

(a) 48,600
(b) 40,500
(c) 11,400
(d) 60,000

Ans. (a) Depreciated Replacement Cost = CRC – Depreciation = 60,000 – 11,400 = 48,600

Case Study- 2

Company ABC has established a Ceramic Production Unit in the year 2014. In 2014, the company purchased new Kiln, manufactured in the year of 2014. The said asset has been capitalized in the assets register at the Acquisition cost of 1.5 Crore. The company has started commercial production in the year of 2016.

The **Valuer's** findings are as below.
• Index for Ceramic Production Line in 2014=100.3, in 2016=79.9, in 2018=79.2
• As per companies Act, 2013 the useful life of such machinery is 15 years.
• Salvage Value is 5% of Replacement Cost New
• Other cost/charges/taxes/duties/loadings are included.
• The date of valuation is 31st March 2018.

(1) What is Gross Block of the Kiln in INR?
(a) 2.0 Crores
(b) 1.18 Crores
(c) 1.5 Crores
(d) 1.68 Crores
Ans. (c) Gross Block i.e. Acquisition Cost i.e. INR 1.5 Crore.

(2) What is Current Replacement Cost as New of the Asset?
(a) 2.0 Crores
(b) 1.18 Crores
(c) 1.5 Crores
(d) 1.68 Crores
Ans. (b) Here, Indexing will be calculated based on year of Purchase i.e. 2014.
Current Replacement Cost (CRC) = Acquisition Cost * (Index in 2018 / 2014) = 1,50,00,000 * 79.2/100.3 = 1.18 Crores

(3) What is the Salvage Value of the asset?
(a) 5.75 Lakhs
(b) 5.6 Lakhs
(c) 4.8 Lakhs
(d) 5.9 Lakhs
Ans. (d) Salvage Value = 1.18 Crores * 5% = 5.9 Lakhs

(4) What is the balance useful life of the asset in books of the company?
(a) 13 Years
(b) 11 Years
(c) 15 Years
(d) 10 Years
Ans. (a) Balance Useful Life can be estimated from Year of commercial production i.e. 2016.
Hence, Balance Economic Life = 15 Years – (2018-2016) = 15 – 2 = 13 Years

(5) What is the amount of depreciation considering straight line method of depreciation as per Companies Act, 2013? (Salvage Value = Residual Value)

(a) 14.95 Lakhs

(b) 16.95 Lakhs

(c) 29.89 Lakhs

(d) 19.00 Lakhs

Ans. (d) Depreciation = Acquisition Cost * (1- Salvage Value) * Age/ Useful Life = 1.5 * (1-5%)* (2018-2016)/ 15 = 19 Lakhs

(6) What is the Net book value as per Companies Act, 2013?

(a) 82.00 Lakhs

(b) 108.49 Lakhs

(c) 131.00 Lakhs

(d) 96.05 Lakhs

Ans. (c) Net Book Value = Acquisition Cost – Depreciation = 1.5 Crore – 0.19 Crore = 1.31 Crores

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Case Study- 3

A Car has been purchased at the cost of INR 6,00,000 in the year of 2015. New similar car is available at INR 8,00,000 as on date of valuation. Currently, the car is in non-working condition and required cost to cure is INR 40,000.

The **Valuer's** findings are as below.

- As per companies Act, 2013 the useful life of such machinery is 10 years.
- Salvage Value is 5% of Replacement cost new
- Other cost/charges/taxes/duties/loadings are included.
- The date of valuation is 31st March 2018.

(1) What is Historical cost of the Car in INR?

(a) 4,00,000
(b) 6,00,000
(c) 8,00,000
(d) 10,00,000

Ans. (b) Historical Value of the car i.e. Acquisition Cost is INR 6,00,000

(2) What is Current Replacement Cost of the Car in INR?

(a) 6,00,000
(b) 10,00,000
(c) 8,00,000
(d) 10,00,000

Ans. (c) Current Replacement Cost (CRC) = INR 8,00,000

(3) What is the Salvage Value of the Car in INR?

(a) 10,000
(b) 40,000
(c) 30,000
(d) 20,000

Ans. (b) Salvage Value = CRC * 5% = 8,00,000 * 5% = INR 40,000

(4) What is the balance useful life of the Car as per companies Act, 2013?

(a) 10 Years
(b) 8 Years
(c) 7 Years
(d) 3 Years

Ans. (c) Balance Useful Life = 10 Years - 3 Years = 7 Years

(5) What is the Depreciated Replacement Cost (DRC) of the Asset?

(a) 1,71,000
(b) 5,60,000
(c) 5,32,000
(d) 4,92,000

Ans. (c) DRC = CRC – Depreciation – Cost to Cure
= CRC - CRC * (1- Salvage) * Age/ Useful Life - Cost to Cure
= 8,00,000 - 8,00,000*(1-5%)*3/10 - 40,000 = 5,32,000

(6) What is the Reinstatement Cost for the Purpose of Insurance?

(a) 6,00,000
(b) 8,00,000
(c) 2,80,000
(d) 5,60,000

Ans. (b) Reinstatement Cost i.e. Current Replacement Cost = 8,00,000

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Case Study- 4

A CNC Turning Centre Machine purchased from Italy in the year of 2014. As per the copy of Invoice, CIF Value of the said machine is 25,000 EURO. Other charges at the time of purchase are capitalised as INR 2,50,000 in the Assets Register for the said asset.

The **Valuer's** findings are as below.

• The same machine from same supplier is available after negotiation at the CIF value of 28,000 EURO as on date of valuation.

• Transport Charges from Manufacturing Unit of CNC Machine to the port of Import is 200 EURO. Sea Freight is INR 1,00,000. Transport charges from Port of Discharge to the factory location is INR 20,000

• Applicable Taxes and Duties are 26.85% on CIF Value.

• Loading and Unloading Charges at the port is INR 10,000.

• Installation & Commissioning cost of Machinery is INR 1,00,000.

• Exchange Rate: in 2014 1 EURO = 60 INR and 1 EURO = 81 INR as on date of valuation

• Other cost is included if any.

• The date of valuation is 31st March, 2018.

(1) What is the Acquisition Cost of the machine in INR?

(a) 19,30,000
(b) 17,50,000
(c) 20,30,000
(d) 22,68,000

Ans. (b) Acquisition Cost is EURO 25,000 x 60 = INR 15,00,000 + INR 2,50,000 = 17,50,000

(2) What is the payable amount of Taxes and Duties to import the same machine on the date of Valuation?

(a) 3,00,000
(b) 4,51,080
(c) 6,08,958
(d) Cannot be determined

Ans. (c) Taxes & Duties are 26.85% of CIF value EURO 28,000 * 81 = 22,68,000
Payable amount on Taxes and Duties = 22,68,000 * 26.85% = INR 6,08,958

(3) What amount buyer pays as freight charges in INR to import the machine purchased at CIF value as on date of Valuation?

(a) 20,000
(b) 1,20,000
(c) 1,00,000
(d) 1,36,200

Ans. (a) Only Transport charges from Port of Discharge to the factory location can be considered which is INR 20,000

(4) What is the cost of replacement of the machine in INR?

(a) 29,06,958
(b) 30,06,958
(c) 29,96,958
(d) 29,76,958

Ans. (b) Replacement Cost = CIF Value + Freight + Taxes + Loading & Unloading + Inst. & Comm.

= 28,000 * 81 + 20,000 + 6,08,958 + 10,000 +1,00,000

= INR 30,06,958

(5) If factory is placed in SEZ and benefited by 100% relief from Taxes and Duties. What should be the cost of replacement of machine?

(a) 22,98,658
(b) 23,98,000
(c) 24,98,658
(d) 22,68,000

Ans. (b) Replacement Cost = CIF Value + Freight + Loading & Unloading + Inst. & Comm.

= 28,000 * 81 + 20,000 + 10,000 + 1,00,000

= INR 23,98,000

Case Study- 5

Company X has purchased a Corn Flex Production Line in year of 1995 at INR 2,00,000.

The **Valuer's** findings are as below.

- As per Companies Act, 2013 the useful life of such machinery is 15 years.
- The machinery is in good working condition and well-maintained
- Machinery is capable to work economically for further 5 years.
- Quotation Received for Corn Flex Production Line of INR 6,12,969 including all
- Salvage Value is 5% of Replacement Cost New
- Other cost/charges/taxes/duties/loadings are included.
- The date of valuation is 31st March, 2018.

(1) What is useful life of Corn Flex Production Line?

(a) 15 Years
(b) 5 Years
(c) 28 Years
(d) 23 Years

Ans. (c) Useful Life = Age + Balance Economic life = (2018-1995) + 5 =28

(2) What is the replacement cost of Corn Flex Production Line in INR?

(a) 2,00,000
(b) 65,256
(c) 6,12,969
(d) 6,18,989

Ans. (c) Current Replacement Cost = Quotation Price = INR 6,12,969

(3) What is the amount of depreciation considering Straight Line Method in INR?

(a) 3,88,214
(b) 4,78,335
(c) 1,94,107
(d) 5,03,510

Ans. (b) Depreciation= (Replacement Cost – Salvage Value) * (Age/ Useful Life) = 6,12,969 * (1-5%) *(23/28) = 4,78,335

(4) What is the Depreciated Replacement Cost in INR?

(a) 3,88,214
(b) 1,03,986
(c) 1,94,107
(d) 1,34,634

Ans. (d) Depreciated Replacement Cost = Replacement Cost - Depreciation = 6,12,969 – 4,78,335 =1,34,634

(5) What is the salvage value of the machine in INR?

(a) 20,000

(b) 30,648

(c) 10,000

(d) 35,648

Ans. (b) Salvage Value = Current Replacement Cost * 5% = 30,648

(6) What is the Book value of the machine as per Companies Act, 2013? (Salvage Value = Residual Value)

(a) 1,34,620

(b) 10,000

(c) 30,648

(d) 2,00,000

Ans. (b) Book Value as per Companies Act, 2013 will be the residual Value of the Machine as the machinery has completed its Useful Life of 15 Years. Residual Value = Acquisition Cost * 5% = 2,00,000 * 5% = 10,000

Case Study- 6

The company XYZ has commissioned the integrated automated plant to produce refined Soya Oil in 2011. Acquisition cost of the said asset is INR 8.0 Crore. The plant is in closed condition since last 5 years. Oil extraction unit, a section of integrated line, is not functioning economically due to higher cost of extraction which leads to higher cost of refined Oil than market price. The integrated plant cannot be redesigned/ modified to run economically.

The **Valuer's** findings are as below.

- As per companies Act, 2013 the useful life of such machinery is 15 years.
- The total estimated cost of new plant is INR 10 Crore as on date of valuation.
- Salvage Value is 5% of Replacement Cost New
- Other cost/charges/taxes/duties/loadings are included.
- The date of valuation is 31st March, 2018.

(1) What is the historical cost of the asset in INR?

(a) 10.0 Crores
(b) 15.9 Crores
(c) 8.0 Crores
(d) 19.4 Crores

Ans. (c) Historical Cost of the asset is Acquisition Cost i.e. 8.0 Crores.

(2) What is the replacement cost of the asset in INR?

(a) 10.0 Crores
(b) 15.9 Crores
(c) 8.0 Crores
(d) 19.4 Crores

Ans. (a) Replacement Cost is the total estimated cost of new plant i.e. 10.0 Crores.

(3) What is the balance economic life?

(a) 5
(b) 0
(c) 8
(d) 7

Ans. (b) Here, plant is not capable to run economically. Hence, Balance economic Life is Zero.

(4) What is the amount of depreciation considering Straight Line Method in INR?

(a) 4.43 Crores
(b) 8.6 Crores
(c) 9.5 Crores
(d) 3.73 Crores

Ans. (c) Asset is fully depreciated as it has no balance economic life.
Depreciation = 95% of Current Replacement Cost = 95% * 10.0 Crores = 9.5 Crores

(5) What is the depreciated replacement cost of the asset using Straight Line Method in INR?

(a) 5.57 Crores
(b) 9.50 Crores
(c) 40 Lakhs
(d) 50 Lakhs

Ans. (d) Depreciated Replacement Cost = Replacement Cost – Depreciation = 10.0 – 9.5 = 0.5 Crores

(6) What is the salvage value of the plant in INR?

(a) 50 Lakhs
(b) 40 Lakhs
(c) 80 Lakhs
(d) 60 Lakhs

Ans. (a) Salvage Value = 5% of GCRC = 10.0 *5% = 50 Lakhs

Case Study- 7

Mr. X has purchased a new car in the year of 2010. The Acquisition Cost is INR 4 Lakhs. The valuer has inspected the car to derive the market value. Car is in working condition and well maintained. Four similar instances which he observed in similar working condition and well maintained are mentioned below.

(1) Car with Year of Manufacturing (YoM) of 2010 is available for sale at INR 2.5 Lakhs.

(2) Car with YoM of 2008 has been sold a month before the date of valuation at INR 1.8 Lakhs.

(3) Car with YoM of 2008 is available for sale at INR 2.1 Lakhs.

(4) Car with YoM of 2010 has been sold a month before the date of valuation at INR 2 Lakhs.

The **Valuer's** findings are as below.

• As per companies Act, 2013 the useful life of such machinery is 10 years.

• Salvage Value is 5% of replacement cost new

• Other cost/charges/taxes/duties/loadings are included.

• The instances are most relevant to the asset and no other specific issues are found in them.

• The date of valuation is 31st March 2018.

(1) Which is the most accurate approach to derive the market value based on available data?

(a) Cost Approach

(b) Market Approach

(c) Income Approach

(d) Cannot be determine

Ans. (b) Market Approach

(2) Which is the most suitable instance for deriving the market value?

(a) 1

(b) 2

(c) 3

(d) 4

Ans. (d) Instance 4 is the most suitable instance. It has same YoM in comparison with the subject asset. Further, the sold instance has been given priority over available instance as it removes the factoring of discount/negotiation

(3) Order for the suitability of available instance.

(a) 2,4,3,1

(b) 4,1,2,3

(c) 4,2,1,3

(d) 1,4,3,2

Ans. (b) Highest priority should be given to same/nearest year of manufacturing. Further, sold instances should be given priority. Considering the same, the sequel should be 4123.

(4) Out of these, which one is the least important factor for the analysis of comparable?

(a) Make & Model

(b) Year of Manufacturing

(c) Usage of the Car (in Kilometer) and Condition

(d) Alloy Wheels in the Car

Ans. (d) Factor a, b, and c are essential for market approach. Availability of alloy wheels is not as critical as other points

(5) What is the Gross Block of the Asset?

(a) 4 Lakhs

(b) 2.5 Lakhs

(c) 6.8 Lakhs

(d) None of the above

Ans. (a) Gross Block of the asset is Acquisition Cost of the asset i.e. 4 Lakhs

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Case Study- 8

A new Gantry Crane has been purchased in the year of 2013. Similar Crane is available at an Ex Work cost of INR 10,00,000 as on date of valuation. Total Insurance & Freight to the factory premise is INR 20,000. Applicable Taxes are INR 50,000 (assume that no rebate on tax is available). Loading & unloading charges at the premise is INR 5,000. Installation & commissioning cost is INR 30,000. Foundation cost is INR 10,000. Preoperative Expenses are 2.5% of Ex Work and applicable expense/ taxes/ insurance / charges etc. as mentioned above. Interest Cost is 9.8% applicable on total cost.

The **Valuer's** findings are as below.

- As per companies Act, 2013 the useful life of such machinery is 15 years.
- Salvage Value is 5% of replacement cost new
- Other cost/charges/taxes/duties/loadings are included.
- The date of valuation is 31st March 2018.

(1) What is the % loading (includes applicable freight, charges, insurance, taxes etc. except Preops & Interest) on Ex Work?

(a) 20
(b) 11.5
(c) 16.5
(d) 13.5

Ans. (b) Here, Loading = Ex Work + Ins. & Freight + Taxes + Load & Unload + Foundation Cost + Erec. & Comm.

= 10,00,000 + 20,000 + 50,000 + 5,000 + 10,000 + 30,000
= 11,15,000
% Loading = 11,15,000/10,00,000 = 11.5%

(2) What is the amount of preoperative expenses in INR?

(a) 22,575
(b) 34,000
(c) 27,875
(d) 55,000

Ans. (c) Preops = 2.5% of (Ex Work + Ins. & Freight + Taxes + Load & Unload + Foundation Cost + Erec. & Comm.)

= 2.5% of (10,00,000 + 20,000 + 50,000 + 5000 + 10,000 + 30,000)
= 27,875

(3) What is Cost of Interest in INR?

(a) 1,12,002

(b) 1,20,002

(c) 1,18,596

(d) 1,22,006

Ans. (a) Interest Cost = (Ex Work + Ins. & Freight + Taxes + Load & Unload + Foundation Cost + Erec. & Comm. + Preops)

= (10,00,000 + 20,000 + 50,000 + 5,000 + 10,000 + 30,000 + 27,875) * 9.8%

= 1,12,0028

(4) What is the current replacement cost in INR?

(a) 10,00,000

(b) 11,41,911

(c) 12,54,877

(d) 6,41,916

Ans. (c) Current Replacement Cost (CRC) = 10,00,000 + 1,15,000+ 27,875 + 1,12,002 = 12,54,877

(5) What is the amount of depreciation considering Straight Line Method in INR?

(a) 2,93,272

(b) 6,00,000

(c) 4,93,272

(d) 3,97,378

Ans. (d) Depreciation = 12,54,877 * (1-5%) * (5/15) = 3,97,378

(6) What is Depreciated cost of Replacement in INR?

(a) 7,00,000

(b) 7,48,639

(c) 8,48,639

(d) 8,57,499

Ans. (d) Depreciated Replacement Cost = CRC – Depreciation = 12,54,877 - 3,97,378 = 8,57,499

Case Study- 9

Company ABC has purchased a Vertical Centring Machine(VMC) at the FOB cost of USD 60,000 from China in 2015.

The Valuer's findings are as below.
• Total Insurance & freight to the factory location is INR 2,00,000 from port of loading.
• Applicable Taxes & Duties and Other Incidental Expenses are INR 10,00,000
• Useful life of machine is 15 years as per companies Act, 2013.
• Salvage Value is 5% of replacement cost new
• Exchange Rate: in 2015 1 USD = 60 INR, in 2018 1 USD = 65 INR
• Negotiated FOB price of VMC is USD 65,000 as per Quotation received.
• The date of valuation is 31st March 2018.

(2) What is the Historical FOB Price in INR?
(a) 37 Lakhs
(b) 36 Lakhs
(c) 42.25 Lakhs
(d) 48 Lakhs
Ans. (a) FOB Price = USD 60,000 * 60 = 36 Lakhs

(2) What is the current replacement cost in INR?
(a) 48.52 Lakhs
(b) 54.25 Lakhs
(c) 40.42 Lakhs
(d) 50.42 Lakhs
Ans. (b) Current Replacement Cost (CRC) = FOB Price * Exchange Rate + Insurance & Freight + Taxes and Duties
= 65,000 * 65 + 2,00,000 + 10,00,000
= 42,25,000 + 2,00,000 + 10,00,000
= 54.25 Lakhs

(3) What is the ratio of Current Replacement Cost to historical FOB Value in INR?
(a) 1.51
(b) 1.24
(c) 0.85
(d) 1.55
Ans. (a) CRC / FOB Value = 54.25 Lakhs / (USD 60,000 * 60) = 1.51

(4) What is amount of Salvage Value in INR?

(a) 5.42 Lakhs
(b) 2.71 Lakhs
(c) 1.80 Lakhs
(d) 2.12 lakhs

Ans. (b) Salvage Value = CRC * 5% = 54.25 * 5% = 2.71 Lakhs

(5) What is the amount of depreciation considering Straight Line Method in INR? (Useful Life = Total Economic Life)

(a) 10.85 Lakhs
(b) 8.12 Lakhs
(c) 10.31 Lakhs
(d) 6.15 Lakhs

Ans. (c) Depreciation = CRC * (1- Salvage Value) * Age/ Useful Life = 54.25 Lakhs * 3/15 * (1-5%) = 10.31 Lakhs

(6) What is the Depreciated Replacement Cost in INR?

(a) 32.46 Lakhs
(b) 43.40 Lakhs
(c) 39.96 Lakhs
(d) 43.94 lakhs

Ans. (d) Depreciated Replacement Cost = CRC – Depreciation = 54.25- 10.31 = 43.94 Lakhs

Case Study- 10

A Valuer has been appointed to carry out the liquidation valuation of the assets of a Ship Building Company as per the Insolvency and Bankruptcy Code, 2016. The company was involved in construction of Merchant & Defense vessels and offshore Rigs. The tangible assets comprise Plant & Machinery of Capital Assets, Capital Work in Progress, Raw Material, Stocks & Spares and Work in Progress.
Valuer has followed 'Ex –situ' approach after appropriate study of Industry outlook and purpose of exercise.

(1) A list of Steel Plates (to be used as Raw Material) has been provided which comprises the specifications/details like qty. size, weight, material grade which covers around 35,000 Metric Ton of Steel Plates. Which information/data is least important/ not required for the said Asset?

(a) Steel Grade
(b) Level of corrosion
(c) Loss of asset
(d) Cost of Dismantling

Ans. (d) Steel Plates are in loose condition which does not require any cost of dismantling

(2) A list of Plant & Machinery has been provided which contains details of year of manufacturing, make, model, capacity, condition of asset and qty. Which data/factor is least important/not required for the said purpose?

(a) Cost of Dismantling
(b) Plant Layout showing process flow /machinery at each stage
(c) Obsolescence
(d) Bargaining power of Buyer

Ans. (b) The said valuation is carried out with the consideration of 'Ex Situ' Condition. No operation in the said premise is exercised further, hence details related to Plant Layout is not required

(3) A list of Consumable items for auxiliary supply (like Lubricants, Special Purpose Gases, Paints, Coolants etc.) has been provided. Which factor is least / not important while deriving the liquidation value?

(a) Quantity of each item
(b) Expiry Date of Material
(c) Material Storing Capacity and Preservative Condition
(d) Required quantity per Annum

Ans. (d) The plant is not expected to run in future as per the said valuation exercise. Hence quantity required per Annum in not required.

(4) A list of store items has been provided which comprises imported items like winch, Propeller, Gen Sets. Which information is/are required to carry out the Valuation of said assets?

(a) Asset specific liabilities towards Custom Duty
(b) Application / Functionality
(c) Cost of maintenance
(d) All of above

Ans. (d) Here, all the details mentioned in a,b, and c are important. They are required to estimate the market value and subsequently liquidation value

(5) A list of Capital Work in Progress is provided which comprises the assets which are turnkey project items like Jetty, Ship Lift Facility, Fabrication Line etc. Which is the most critical/ important details for the said Valuation Exercise?

(a) Progress Report of CWIP Project
(b) CWIP as a Percentage of Gross Block
(c) Expected Date of Completion of Project
(d) None of the above

Ans. (a) Progress Report of CWIP is most important details. Other details are superficial/ least important due to liquidation valuation

(6) A list of Work in Progress assets which comprises the under-construction vessels/Rigs etc. Which information is least /not important to carry out the Liquidation Value?

(a) Progress Report of WIP Project
(b) Demand of Specific Rig/ Ship
(c) Facility in the shipyard to complete the under construction Ship/ Rig
(d) Facility in the shipyard to take out the under construction Ship/Rig

Ans. (c) The said valuation is carried out with the consideration of 'Ex Situ' Condition. No operation in the said premise will be exercised, hence details related to Facility in the shipyard to complete the under construction Ship/ Rig is least important/ immaterial.

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Case Study- 11

Company PQR is in the manufacturing of Switchgear Units has provided the Fixed Asset Register (FAR) as on date of Valuation. FAR comprises the assets since 1967 which covers around one Lakh line entries. No other documents have been provided pertaining to the Plant & Machinery. A Valuer has to carry out the valuation based on the Asset Register for a going concern on “as is where is basis” in ‘in Situ’ condition. Further, the company wants a valuer to rework on FAR and provide the grouping of the assets as per IndAS 16.

(1) Considering the complexity of FAR, valuer wanted to categories it to apply/calculate various factors like Depreciation, Cost to cure, Obsolescence etc. What is/are relevant details to Categories the line entry?

(a) Varity of Class of Assets e.g. Land, Building, Plant & Machinery, Vehicles etc.
(b) Description of Asset
(c) Different site location
(d) All of the above

Ans. (d) All of the Above

(2) Set the priority to derive the Market Value for following information with an assumption that available market information/data is accurate enough for the consideration.

1. Resale Market Instance
2. Quotation, Open Source of Information etc.
3. Use Capacity Benchmarking Method based on available Quotation, Open Source of Information etc.
4. Indexing on Acquisition Cost

(a) 1,3,2,4
(b) 1,2,3,4
(c) 1,4,2,3
(d) None of the above

Ans. (b) 1,2,3,4

(3) Which factor is not to be considered to derive the market value using Cost Approach for the said valuation exercise?

(a) Bargaining power of Buyer
(b) Cost of Dismantling
(c) Obsolescence
(d) Depreciation

Ans. (b) The valuation exercise is in ‘In Situ’ condition hence cost of dismantling is not to be considered.

(4) What should be the most suitable consideration for the balance economic life (balance useful life) of an asset where the age of the machinery exceeds the useful life defined by companies Act,2013?

(a) Zero
(b) Can be given 1 year
(c) Zero value should be given for such assets
(d) Should be given based on the condition and capability to function economically

Ans. (d) Balance Economic Life should be given based on available machine specific details, professional Judgment and Site Inspection

(5) Grouping of the line entries can be done for the assets which must have following characteristics as per IndAS 16.

(a) Same useful life, Age and Salvage Value
(b) Same Balance Life
(c) Part of same Section/ Plant
(d) Same Functionality

Ans. (a) As per Ind AS 16 deprecation calculation should remain same while grouping the assets which is possible when Age, Useful Life and Salvage Value are same.

(6) Assets/ entries with following description can be grouped together

(a) Economizer & De-aerator
(b) "3 Nos. Cooling Tower" & "2 Nos. of Cooling Tower" with same year of installation, used in same departments
(c) Condenser & Draft Fan
(d) Condenser & Supercharger

Ans. (b) As mentioned in (5), required characteristics are satisfied in entries of Cooling Tower as they have same Age, Useful Life and Salvage Value

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Case Study- 12

A coal based thermal power plant was established in the year of 2002. The plant has been functioned successfully till 2015. Since 2015, the plant is in non-working condition due to non-availability of Coal. Company management has decided to sell their assets in the market considering numerous issues with the plant. Answer following question based on the said facts.

(1) For which unused store item buyer will ask for highest discount?
- (a) Steel Plates
- (b) Transformer
- (c) DG Sets
- (d) Instrumentation Items

Ans. (d) In store, all items are unused. Buyer bargains for higher discount where he finds less/ no competition. In other words, for items which are of specific use and buyers are limited. Thus, buyer has higher bargaining power for such items and expect higher discount. Here, Instrumentation Items has limited application amongst other items mentioned in the options.

(2) For which store item buyer will ask for lowest discount in terms of Market Rate of new items which has been kept in store?
- (a) Steel Plates
- (b) Transformer
- (c) Wire Rope
- (d) Instrumentation Items

Ans. (a) Considering the above-mentioned explanation, steel plates have wide application and invites many buyers which leads to lower discounting percentage.

(3) Power Plant is having higher unit cost of power generation due to higher coal consumption per unit power generation which makes plant unviable to function? Which type of obsolescence is this?
- (a) Economical Obsolescence
- (b) Functional Obsolescence
- (c) Technological Obsolescence
- (d) None of the above

Ans. (c) The plant is not performing because of higher coal consumption, which proves the technical inefficiency of the plant which is considered as Technological Obsolescence.

(4) Power Plant is having higher value per unit cost of power generation due to higher cost of coal which makes plant unviable to function? Which type of obsolescence is this?

(a) Economical Obsolescence
(b) Functional Obsolescence
(c) Technological Obsolescence
(d) None of the above

Ans. (a) The plant is not performing because of higher value of coal, which is an external factor / market driven factor, which is considered as Economical Obsolescence.