1 INTRODUCTION TO MATERIAL HANDLING

COURSE OBJECTIVES: To provide knowledge on materials handling equipment.

SYLLABUS:

Unit-1 Introduction

Types of industrial transport – classification and characteristics of materials – classification and selection of materials handling.

LEARNING OUTCOMES:

Students will be able to

- understand the basic concepts of material handling equipment.
- select appropriate material handling system.

1.1 Introduction

- ✓ **Materials handling** is loading, moving and unloading of materials.
- ✓ To do it safely and economically, different types of tackles, gadgets and equipment are used, when the materials handling is referred to as **mechanical handling of materials**.

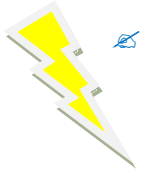
Since primitive men discovered the use of wheels and levers, they have been moving materials mechanically. Any human activity involving materials need materials handling. However, in the field of engineering and technology, the term **materials handling** is used with reference to industrial activity. In any industry, be it big or small, involving manufacturing or construction type work, materials have to be handled as raw materials, intermediate goods or finished products from the point of receipt and storage of raw materials, through production processes and up to finished goods storage and dispatch points.

- ✓ Materials handling as such is not a production process and hence does not add to the value of the product.
- ✓ It also costs money; therefore it should be eliminated or at least reduced as much as possible.
- ✓ However, the important point in favour of materials handling is that it helps production.

- ✓ Depending on the weight, volume and throughput of materials, mechanical handling of materials may become unavoidable.

Based on the need to be of optimum design and application specific to different type of industries, materials handling can be as diverse as industries themself. As a consequence, unfortunately, there is no universally accepted definition of materials handling.

One of the definition adopted way back by the American Materials Handling Society is: **Materials handling is the art and science involving the moving, packaging and storing of substances in any form**. Some of the other definitions are:



- ✍ ***Materials handling is the movement and storage of materials at the lowest possible cost through the use of proper methods and equipment.***
- ✍ ***Materials handling is the moving of materials or product by any means, including storage, and all movements except processing operations and inspection.***
- ✍ ***Materials handling is the art and science of conveying, elevating, positioning, transporting, packaging and storing of materials.***

In one of the definitions, all the functions of materials handling have been refered to which are conveying, elevating, positioning, transporting, packaging and storing. Storage or warehousing is very much a part of materials handling. Materials handling uses different equipment and mechanisms called Materials Handling Equipment. Though in one of the definitions, processing operations and inspection have been specifically excluded from scope of materials handling operations, it is worth mentioning that in specific cases processing or inspection of materials may be accomplished simultaneously with handling activity. One definition also covers the important objective of materials handling which is lowest cost solution.

The essential requirements of a good materials handling system may be summarized as:

i. Efficient and safe movement of materials to the desired place.

ii. Timely movement of the materials when needed.
iii. Supply of materials at the desired rate.
iv. Storing of materials utilising minimum space.
v. Lowest cost solution to the materials handling activities.

Functional scope of materials handling within an industry covers the following:

i. Bulk materials as well as unit materials handing. Bulk handling is particularly relevant in the processing, mining and construction industries. Unit materials handling covers handling of formed materials in the initial, intermediate and final stages of manufacture.
ii. Industrial packaging of in-process materials, semi finished or finished goods, primarily from the point of view of ease and safety of handling, storage and transportation. However, consumer packaging is not directly related to materials handling.
iii. Handling of materials for storage or warehousing from raw materials to finished product stage.

Often materials handling extends beyond the boundary of the industry in the form of movement of raw materials from the sources to the plant or in the form of finished goods from the plant to the points of consumption. These long distance movements of materials are generally termed as transportation of materials through various modes of transport like, road, rail, ship or air.

Transportation is generally excluded from the scope of materials handling. However, at each of the sources and destinations, loading and unloading of materials is necessary and these are referred to as materials handling of these locations.

Some production equipment are fitted with facilities for handling of the materials being processed. Such materials handling equipment are generally considered to be an integral part of the production equipment.

A few typical examples are:

(i) the feeding mechanism in an automatic machine,

(ii) coiler and de-coiler in a strip rolling mill or

(iii) paper feeding and transportation arrangement in a multi-station printing machine.

1.2 OBJECTIVES OF MATERIAL HANDLING

Following are the objectives of material handling:

- ✓ Minimise cost of material handling.
- ✓ Minimise delays and interruptions by making available the materials at the point of use at right quantity and at right time.
- ✓ Increase the productive capacity of the production facilities by effective utilisation of capacity and enhancing productivity.
- ✓ Safety in material handling through improvement in working condition.
- ✓ Maximum utilisation of material handling equipment.
- ✓ Prevention of damages to materials.
- ✓ Lower investment in process inventory

1.3 PRINCIPLES OF MATERIAL HANDLING

Following are the principles of material handling:

1. **Planning principle:** All handling activities should be planned.
2. **Systems principle:** Plan a system integrating as many handling activities as possible and co-ordinating the full scope of operations (receiving, storage, production, inspection, packing, warehousing, supply and transportation).
3. **Space utilisation principle:** Make optimum use of cubic space.
4. **Unit load principle:** Increase quantity, size, weight of load handled.
5. **Gravity principle:** Utilise gravity to move a material wherever practicable.
6. **Material flow principle:** Plan an operation sequence and equipment arrangement to optimise material flow.
7. **Simplification principle:** Reduce combine or eliminate unnecessary movement and/or equipment.
8. **Safety principle:** Provide for safe handling methods and equipment.
9. **Mechanisation principle**: Use mechanical or automated material handling equipment

10. **Standardisation principle:** Standardise method, types, size of material handling equipment.
11. **Flexibility principle:** Use methods and equipment that can perform a variety of task and applications
12. **Equipment selection principle:** Consider all aspect of material, move and method to be utilised.
13. **Dead weight principle:** Reduce the ratio of dead weight to pay load in mobile equipment.
14. **Motion principle:** Equipment designed to transport material should be kept in motion.
15. **Idle time principle:** Reduce idle time/unproductive time of both MH equipment and man power.
16. **Maintenance principle:** Plan for preventive maintenance or scheduled repair of all handling equipment.
17. **Obsolescence principle:** Replace obsolete handling methods/equipment when more efficient method/equipment will improve operation.
18. **Capacity principle:** Use handling equipment to help achieve its full capacity.
19. **Control principle:** Use material handling equipment to improve production control, inventory control and other handling.
20. **Performance principle:** Determine efficiency of handling performance in terms of cost per unit handled which is the primary criterion.

1.4 SELECTION OF MATERIAL HANDLING EQUIPMENTS

Selection of Material Handling equipment is an important decision as it affects both cost and efficiency of handling system. The following factors are to be taken into account while selecting material handling equipment.

PROPERTIES OF THE MATERIAL

Whether it is solid, liquid or gas, and in what size, shape and weight it is to be moved, are important considerations and can already lead to a preliminary elimination from the range of available equipment under review.

Similarly, if a material is fragile, corrosive or toxic this will imply that certain handling methods and containers will be preferable to others.

- **LAYOUT AND CHARACTERISTICS OF THE BUILDING**

Another restricting factor is the availability of space for handling. Low-level ceiling may preclude the use of hoists or cranes, and the presence of supporting columns in awkward places can limit the size of the material-handling equipment. If the building is multi-storeyed, chutes or ramps for industrial trucks may be used. Layout itself will indicate the type of production operation (continuous, intermittent, fixed position or group) and can indicate some items of equipment that will be more suitable than others. Floor capacity also helps in selecting the best material handling equipment.

- **PRODUCTION FLOW**

If the flow is fairly constant between two fixed positions that are not likely to change, fixed equipment such as conveyors or chutes can be successfully used. If, on the other hand, the flow is not constant and the direction changes occasionally from one point to another because several products are being produced simultaneously, moving equipment such as trucks would be preferable.

- **COST CONSIDERATIONS**

This is one of the most important considerations. The above factors can help to narrow the range of suitable equipment, while costing can help in taking a final decision. Several cost elements need to be taken into consideration when comparisons are made between various items of equipment that are all capable of handling the same load. Initial investment and operating and maintenance costs are the major cost to be considered. By calculating and comparing the total cost for each of the items of equipment under consideration, a more rational decision can be reached on the most appropriate choice.

- **NATURE OF OPERATIONS**

  Selection of equipment also depends on nature of operations like whether handling is temporary or permanent, whether the flow is continuous or intermittent and material flow pattern-vertical or horizontal.

- **ENGINEERING FACTORS**

  Selection of equipment also depends on engineering factors like door and ceiling dimensions, floor space, floor conditions and structural strength.

- **EQUIPMENT RELIABILITY**

  Reliability of the equipment and supplier reputation and the after sale service also plays an important role in selecting material handling equipments.

1.5 MATERIAL HANDING EQUIPMENTS

Broadly material handling equipment's can be classified into two categories, namely:

(a) Fixed path equipments, and

(b) Variable path equipments.

(a) **Fixed path equipments** which move in a fixed path. Conveyors, monorail devices, chutes and pulley drive equipments belong to this category. A slight variation in this category is provided by the overhead crane, which though restricted, can move materials in any manner within a restricted area by virtue of its design. Overhead cranes have a very good range in terms of hauling tonnage and are used for handling bulky raw materials, stacking and at times palletizing.

(b)**Variable path equipments** have no restrictions in the direction of movement although their size is a factor to be given due consideration trucks, forklifts mobile cranes and industrial tractors belong to this category. Forklifts are available in many ranges, they are manoeuvrable and various attachments are provided to increase their versatility. Material Handing Equipments may be classified in five major categories.

1. **CONVEYORS:** Conveyors are useful for moving material between two fixed workstations, either continuously or intermittently. They are mainly used for continuous or mass production operations—indeed,

they are suitable for most operations where the flow is more or less steady. Conveyors may be of various types, with rollers, wheels or belts to help move the material along: these may be power-driven or may roll freely. The decision to provide conveyors must be taken with care, since they are usually costly to install; moreover, they are less flexible and, where two or more converge, it is necessary to coordinate the speeds at which the two conveyors move.

2. **INDUSTRIAL TRUCKS:** Industrial trucks are more flexible in use than conveyors since they can move between various points and are not permanently fixed in one place. They are, therefore, most suitable for intermittent production and for handling various sizes and shapes of material. There are many types of truck petrol-driven, electric, hand-powered, and so on. Their greatest advantage lies in the wide range of attachments available; these increase the trucks ability to handle various types and shapes of material.
3. **CRANES AND HOISTS**: The major advantage of cranes and hoists is that they can move heavy materials through overhead space. However, they can usually serve only a limited area. Here again, there are several types of crane and hoist, and within each type there are various loading capacities. Cranes and hoists may be used both for intermittent and for continuous production.
4. **CONTAINERS:** These are either 'dead' containers (e.g. Cartons, barrels, skids, pallets) which hold the material to be transported but do not move themselves, or 'live' containers (e.g. wagons, wheelbarrows or computer self-driven containers). Handling equipments of this kind can both contain and move the material, and is usually operated manually.
5. **ROBOTS:** Many types of robot exist. They vary in size, and in function and maneuverability. While many robots are used for handling and transporting material, others are used to perform operations such as welding or spray painting. An advantage of robots is that they can

perform in a hostile environment such as unhealthy conditions or carry on arduous tasks such as the repetitive movement of heavy materials.

The choice of material-handling equipment among the various possibilities that exist is not easy. In several cases the same material may be handled by various types of equipments, and the great diversity of equipment and attachments available does not make the problem any easier. In several cases, however, the nature of the material to be handled narrows the choice.

1.6 GUIDELINES FOR EFFECTIVE UTILISATION OF MATERIAL HANDLING EQUIPMENTS

The following guidelines are invaluable in the design and cost reduction of the materials handling system:

1. As material handling adds no value but increases the production cycle time, eliminate handling wherever possible. Ideally there should not be any handling at all!
2. Sequence the operations in logical manner so that handling is unidirectional and smooth.
3. Use gravity wherever possible as it results in conservation of power and fuel.
4. Standardise the handling equipments to the extent possible as it means interchangeable usage, better utilisation of handling equipments, and lesser spares holding.
5. Install a regular preventive maintenance programme for material handling equipments so that downtime is minimum.
6. In selection of handling equipments, criteria of versatility and adaptability must be the governing factor. This will ensure that investments in special purpose handling equipments are kept at a minimum.
7. Weight of unit load must be maximum so that each 'handling trip' is productive.
8. Work study aspects, such a elimination of unnecessary movements and combination of processes should be considered while installing a material handling system.

9. Non-productive operations in handling, such as slinging, loading, etc., should be kept at a minimum through appropriate design of handling equipment. Magnetic cranes for scrap movement and loading in furnaces combination of excavators and tippers for ores loading and unloading in mines are examples in this respect.
10. Location of stores should be as close as possible to the plant which uses the materials. This avoids handling and minimizing investment in material handling system.
11. Application of OR techniques such as queueing can be very effective in optimal utilisation of materials handling equipments.
12. A very important aspect in the design of a material handling system is the safety aspect. The system designed should be simple and safe to operate.
13. Avoid any wasteful movements-method study can be conducted for this purpose.
14. Ensure proper coordination through judicious selection of equipments and training of workmen.

1.7 CHARACTERISTICS AND CLASSIFICATION OF MATERIALS

Method to be adopted and choice of equipment for a materials handling system primarily depends on the type of material/s to be handled. It is, therefore, very important to know about different types of materials and their characteristics which are related to methods and equipment used for their handling.

As innumerable different materials are used and need to be handled in industries, they are classified based on specific characteristics relevant to their handling.

Basic classification of material is made on the basis of **forms**, which are

(i) **Gases,**

(ii) **Liquids**

(iii) **Semi Liquids and**

(iv) **Solids**.

Following characteristics of gases, liquids and semi liquids are relevant to their handling.

For gases it is primarily pressure, high (25 psi and more) or low (less than 25 psi). Chemical properties are also important.

For liquids the relevant characteristics are density, viscosity, freezing and boiling point, corrosiveness, temperature, inflammability etc. Examples of common industrial liquids are: water, mineral oils, acids, alkalies, chemicals etc. Examples of common semi-liquids are: slurry, sewage, sludge, mud, pulp, paste etc.

Gases are generally handled in tight and where required, pressure resisting containers. However, most common method of handling of large volume of gas is through pipes by the help of compressor, blower etc. This process is known as **pneumatic conveying**.

Liquids and semiliquids can be handled in tight or open containers which may be fitted with facilities like insulation, heating, cooling, agitating etc. as may be required by the character of the liquid. Large quantity of stable liquids/semiliquids are generally conveyed through pipes using suitable pumps, which is commonly known as **hydraulic conveying**.

Solids form the majority of materials which are handled in industrial situation. Solids are classified into two main groups: **Unit load and Bulk load (materials).**

Unit loads are formed solids of various sizes, shapes and weights. Some of these are counted by number of pieces like machine parts, molding boxes, fabricated items. Tared goods like containers, bags, packaged items etc. and materials which are handled en-masses like forest products (logs), structurals, pig iron etc. are other examples of unit loads. The specific characteristics of unit loads are their overall dimensions, shape, piece-weight, temperature, inflammability, strength/fragility etc. Hoisting equipment and trucks are generally used for handling unit loads. Certain types of conveyors are also used particularly for cartons/packaged items and metallic long products like angles, rods etc.

Unit loads have been classified by Bureau of Indian Standards' (BIS) specification number IS 8005:1976(2).

The classifications are based on:

a) **Shape of unit loads** - (i) basic geometric forms like rectangular, cylindrical, pyramidal/conical and spherical; (ii) typical or usual forms like pallets,

plate, containers, bales and sacks; (iii) irregular forms like objects with flat base dimension smaller than overall size, loads on rollers/wheels and uneven shapes.

b) Position of C.G. (stability) of load.
c) Mass of unit load in 10 steps from 0-2.5 kg to more than 5000 kg.
d) Volume per unit in 10 steps from 0-10 cm3 to more than 10 m3.
e) Type of material in contact with conveying system like metal, wood, paper/cardboard, textile, rubber /plastics, glass and other materials.
f) **Geometrical shape** (flat, concave, convex, irregular/uneven, ribbed etc.) and physical properties (smooth, slippery, rough, hard, elastic etc) of base surface of unit load.
g) **Specific physical and chemical properties** of unit loads like abrasive, corrosive, dust emitting, damp, greasy/oily, hot, cold, fragile, having sharp edges, inflammable, explosive, hygroscopic, sticky, toxic, obnoxious, radioactive etc.
h) Loads sensitive to pressure, shock, vibration, turning/tilting, acceleration/deceleration, cold, heat, light, radiation, damp etc.

Bulk materials are those which are powdery, granular or lumpy in nature and are stored in heaps. Example of bulk materials are: minerals (ores, coals etc.), earthly materials (gravel, sand, clay etc.) processed materials (cement, salt, chemicals etc.), agricultural products (grain, sugar, flour etc.) and similar other materials.

Major characteristics of bulk materials, so far as their handling is concerned, are: lump-size, bulk weight, specific weight, moisture content, flowability (mobility of its particles), angles of repose, abrasiveness, temperature, proneness to explosion, stickiness, fuming or dusty, corrosivity, hygroscopic etc.

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2. IS 8005:1976, Classification of Unit Loads, Bureau of Indian Standards.
3. Apple, J.A., "Material Handling System Design", John Wiley & Sons
4. Allegri, T.H., "Materials Handling: Principles and Practice", CBS Publishers Distributors, N. Delhi.

Section A

1. Define material handling
2. Mention any four objectives of material handling.
3. Mention any four principles of material handling.
4. What do you mean by “Equipment Utilisation Ratio”?
5. Mention some of the fixed path equipments.
6. Mention some of the valuable path equipments.

Section B

1. Explain the objectives of material handling.
2. Explain the principles of material handling.
3. How do you evaluate the material handling system?
4. What are the relationship between plant layout and material handling?

Section C

1. Discuss the factors to be considered while selecting material handling equipment.
2. Discuss the different material handling equipments.
3. Discuss the guidelines for effective utilisation of material handling equipments.
4. Material handling in the restaurant for production and services.
5. Utilisation of material handling equipment.

2 CONVEYOR EQUIPMENT

COURSE OBJECTIVES: To provide knowledge on conveyor equipment.

SYLLABUS:

Unit-2 Introduction

Classification of conveyors, description and uses of belt, Conveyors, Apron conveyors, Roller conveyors, Pneumatic and Hydraulic conveyors, Computer controlled conveyor system.

LEARNING OUTCOMES:

Students will be able to

- understand the basic working principles of various conveyors.
- select appropriate conveyor system for given application.

2.1 Introduction

Different classes of conveyors forming the **conveyor** group is by far the most frequently used materials handling equipment primarily for conveying bulk materials in process industries and also for conveying certain types of unit loads in large quantities.

2.2 BELT CONVEYORS

Definition: A belt conveyor consists of an endless flat and flexible belt of sufficient strength, made of fabric, rubber, plastic, leather or metal, which is laid over two metallic flat pulleys at two ends, and driven in one direction by driving one of the two end pulleys. Material is placed on this moving belt for transportation. The active half of the belt is supported by idler rollers or slider bed. The return half of the belt may or may not be supported, as it generally does not carry any additional load other than its own weight. The endless belt is kept taught by a belt tensioning arrangement.

General Characteristics

1. Belt conveyors operate in one vertical plane, horizontally or with an inclination (up or down) depending on the frictional property of the load conveyed.
2. For changing direction of the materials being conveyed, in the horizontal plane, more than one belt conveyors are needed.
3. Conveying capacity of a conveyor can be controlled by changing belt speed.
4. Belt conveyors are generally employed for continuous flow of materials.
5. Metal/special belts can carry hot, abrasive or reactive materials.

Classification of Conveyor Systems:

Conveyors

A. Belt Conveyor

1. flat
2. trough
3. closed rail.)
4. metallic
5. portable
6. telescoping

B. Chain Conveyor

1. apron or pan
2. slat
3. cross-bar or arm
4. car type/pallet
5. en-mass
6. carrier chain and flat-top
7. trolley
8. power and free
9. suspended tray or swing-tray
2. powered/driven
3. portable

C. Haulage Conveyor

(A special class of chain conveyor in which load is pushed or pulled and the weight is carried by stationary troughs, surfaces or

1. drag chain
2. flight
3. tow

(*a*) over-head
(*b*) flush-floor
(*c*) under-floor

D. Cable Conveyor

E. Bucket Conveyor

1. gravity discharge
2. pivoted bucket
3. bucket elevator (also included under III)

F. Roller Conveyor

1. gravity

G. Screw Conveyor

H. Pneumatic Conveyor

1. pipe line
2. air-activated gravity (air slide)
3. tube

I. Hydraulic Conveyor

Types of Belt Conveyors

Flat Belt Conveyor: In this conveyor, the active side of belt remains flat supported by cylindrical rollers or flat slider bed. The conveyor is generally short in length and suitable for conveying unit loads like crates, boxes, packages, bundles etc. in manufacturing, shipping, warehousing and assembly operations. Flat belts

are conveniently used for conveying parts between workstations or in an assembly line in mass production of goods. Fig. 2.1.1 shows a flat conveyor.

Fig. 2.1.1. A flat belt conveyor with drive control

Troughed Belt Conveyor: In this conveyor, comparatively wide flat belt is supported on troughed carrying rollers or shaped supporting surface so that the two edges of the active side of the belt are elevated from the middle part to form a trough. This provides a greater carrying capacity than a flat belt of equal width for conveying bulk materials or those materials which would slide off flat belts.

These conveyors are used in handling bulk materials of different classes. The return side of the belt is generally kept flat supported on cylindrical rollers. The troughed conveyors which are used within a plant for moving bulk materials from one point to another, are generally termed as "normal" or "transfer" conveyors. These are comparatively of shorter lengths, and path of movements are in straight line in a horizontal or an inclined plane. The stresses in the belts being within limits of cotton fabric belts.

However, troughed belt conveyors are often used for transportation of bulk materials over long distances, by means of a series of conveyors, over paths that are combination of inclines, declines and horizontal sections, following the natural contours of the ground. These are generally termed "long-centre" conveyors. There is no clear demarcation between a normal or long-centre conveyor. Long-center conveyors are those where belt tension is high warranting use of high tension quality belts with less belt stretch, and low acceleration through gradual starting controls for the drive. By using a number of conveyors in series, it is possible to change the direction of

materials movement at the junction of two conveyors, called "transfer terminal".

Long-centre conveyors are used for jobs like:

(i) transportation of the output of mines to the processing plants,

(ii) materials from shipping ports to the storage/transport loading sites,

(iii) materials from outdoor storage yards to inside plants,

(iv) movement of materials between plants etc.

Closed Belt Conveyor: In a closed belt conveyor, the specially fabricated belt, after being loaded with the material, can be wrapped completely around the load. It essentially forms a closed tube moving along with the material. The advantages of a closed belt conveyor are:

(i) it can handle fragile materials safely and without breaking by reducing inter particle collision,

(ii) it can handle fine bulk materials without being swept by air (however, it is not really air tight at loading and unloading points),

(iii) ability to handle corrosive and reactive materials without contamination and

(iv) the tubed belt can travel around bends in more than one plane and hence versatile in layout.

Metallic Belt Conveyor: This is a flat belt conveyor where the flexible belt is replaced by a cold rolled carbon or stainless steel strip belt of thickness from 0.6 mm to 1.2 mm. The ends of the steel strip are lap joint riveted with a single row of special wide flat head rivets. A steel belt runs flat on cylindrical idlers or runs troughed on resilient idlers (made by suitable length of springs). Apart from all rolled strip steel belts, wire-mesh, belts of differ- ent designs have been used. The entire length is made up of short length sections. One of the designs is made up of flat wire spiral sections, shown in Fig. 2.1.2. The wire-mesh belts are more flexible and the design considerations are similar to rubberized textile belt conveyors. Metallic strip belt conveyors are used in food, chemical industry and

for conveying hot and reactive loads. Wire-mesh belts are being widely used to handle unit and lump materials through furnaces (up to 1000°C temperature), as mobile base for baking industry and also for wetting, cooling, dehydrating and similar operations.

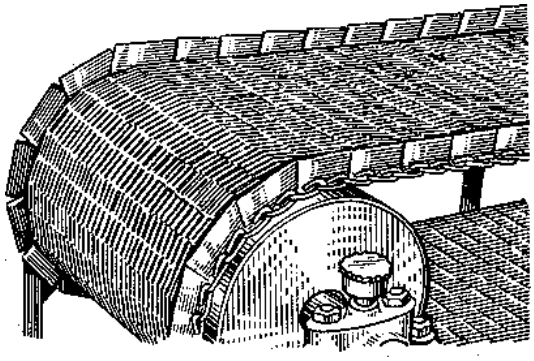


Fig. 2.1.2. Metallic belt conveyor

Portable Conveyor: Short length flat conveyors carried on a wheeled structure is termed portable conveyor. These are particularly useful for loading and unloading of trucks / trans- port vehicles. The inclination of the conveyor can generally be adjusted to suit application.

Apart from above mentioned major types of belt conveyors, there are a few special types worth mentioning. These are:

Chain or Rope Driven Belt Conveyor: In which the specially designed belt is driven by a moving chain or rope, where belt only serves as load carrier, and motion is by a chain or rope conveyor.

Submerged Belt Conveyor: In which a portion of the belt moves through a metallic trough (casing) which is filled with free flowing, powdered material at the loading end. The mov- ing belt with holes, makes the material flow to the unloading end of the trough. Fig. 2.1.3 shows a line drawing of a submerged belt conveyor.

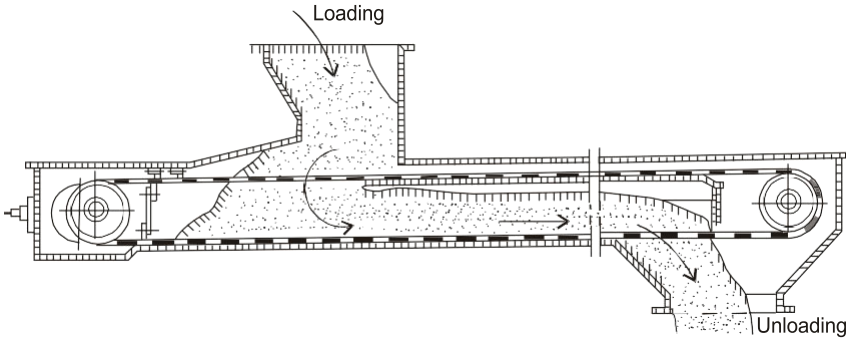


Fig. 2.1.3. A typical submerged belt conveyor

Parts of a Belt Conveyor

(a) **Conveyor Belts:** Belt, which supports and conveys the load, is the essential and most important component of any belt conveyor. Most common type of conveyor belting is rubber/plastics covered textile belting - the internal carcass of woven fabric gives the longitudinal strength of pulling the loaded belt and transverse strength for supporting the load, and the cover of rubber and/or plastics protects the carcass from damage. Specification, requirements and testing procedures of rubber/plastics, covered textile belting for conveyor (and elevator) has been given in IS 1891:1994, part I to V. Part I covers the "general purpose belting" while the subsequent parts cover "heat resistant belting", "oil resistant belting", "hygienic belting" and "fire resistant belting for surface application" respectively.

Belt Construction: Cotton fabric ply constructed rubber covered belting is the mostly used belt for flat and troughed conveyor. The carcass consists of one or more plies of woven fabric or of solid woven fabric impregnated with a rubber or plastic mix, which after vulcanization binds the plies together. The fabric used is made of threads of cotton or polyamide or any other synthetic material or combination thereof, evenly and firmly wo- ven. The carcass is covered by special wear and impact resisting rubber compounds / plas- tics. For the protection of the carcass, layer or layers of open-mesh or cord fabric, termed as "breaker" may be placed between the cover and the carcass, or may be embedded in the cover. Number of fabric plies varies from 3 for shorter belt widths (300mm and above) to a maximum of 12 to 14 plies for belt width of 2000mm. Number of plies can vary within a range for a specific belt width. Steel cord belting is used when good troughability, high operating tensile strength and small elongation are desired. Fig 2.1.4 shows a typical belt cross section.

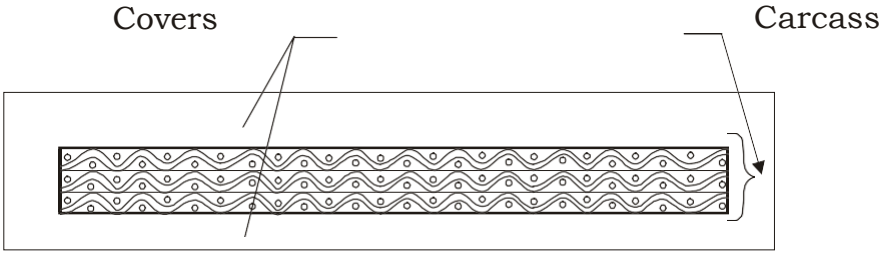


Fig. 2.1.4. Construction of a textile belt

Belt Covers: The primary purpose of the cover is to protect the belt carcass against dam- age. The requirements of the cover is to work satisfactorily in contact with the materials to be carried by the belt. For this purpose, sufficient thickness (not less than 1.0 mm) of top and bottom surface covers of different rubber compounds and plastics are used. Covers in the

following grades are available:

(i) *Grade M24:* Natural rubber compound with superior resistance to cutting, gauging and abrasion.

(ii) *Grade N17:* Compound rubber with high abrasion resistance with inferior cutting and gauging resistance compared to M24 grade.

(iii) *Grade N17(Synthetic):* Composed mainly of synthetic rubber with higher abrasion resist- ance. Belt made of carcass with chemical or other superior bonding system should be used for this grade.

(iv) *Grade HR:* Suitable for handling load at high temperatures, upto 150°C for lumps or 125°C for powdered materials.

(v) *Grade FRAS:* Used for underground mining and processes where fire resistance and antistatic charge properties, are required.

(vi) *PVC Grade:* Used in fire resistance, oil resistance and hygienic belting.

Belt Designation: As per IS 1891 (Part I): 1994, belts are designated by IS No., grade of the cover, the "type" of belting defined by the full thickness breaking strength in KN/m and number of plies. For example, a conveyor belt with cover grade N17 and type 250 having 4 plies shall be designated as: Conveyor Belt IS 1891 (Part I) N17-250/4.

Steel cord belting is designated by prefix "ST" followed by the full thickness breaking strength in KN/m. Example ST-1800.

Belt Width: Unless otherwise agreed between the manufacturer and buyer, the standard widths of belting as per IS specification are:

300, 400, 500, 600, 650, 800, 1000, 1200, 1400, 1500, 1600, 1800 and 2000 mm with a tolerance of □5 mm upto 500mm width and ±1% of belt width for widths higher than 500 mm.

Belt Splicing: Two ends of a belt may be joined either by metallic belt fastners or by vulcanization. Metal fastner joining is easier and acceptable for flat belt conveyors. Vulcanized belt splicing is a superior technique suitable for troughed belt conveyors. The later is a stepped, lapped splice in which several plies of two ends of the belt are vulcanized together to make a joint of strength almost equal to the solid belt. Skilled operator and vulcanizing equipment are necessary for such splicing at coveyor site.

b) Idlers: The rollers used at certain spacing for supporting the active as well as return side of the belt are called idlers. Accurately made, rigidly installed and well maintained idlers are vital for smooth and efficient running of a belt conveyor.

There are two types of idlers used in belt conveyors:

- straight carrying and return idlers, which are used for supporting active side of the belt for a flat belt conveyor and also for supporting the return belt in flat orientation in both flat or troughed belt conveyor.

- troughing idler set consisting of 2, 3 or 5 rollers arranged in the form of trough to support the belt in a troughed belt conveyor. Fig. 2.1.5 shows sketch and photograph of a 3-roll idler.

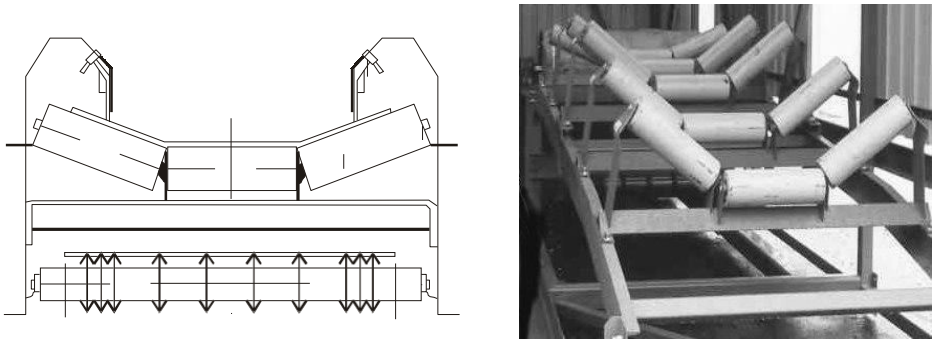


Fig. 2.1.5. Three roll idler : Sketch shows three roll carrying idler with straight return idler in same frame, and photograph shows set of assembled idlers

CHAIN CONVEYORS

Definition:

The term chain conveyor means a group of different types of conveyors used in diverse applications, characterized by one or multiple strands of endless chains that travel entire conveyor path, driven by one or a set of sprockets at one end and supported by one or a set of sprockets on the other end. Materials to be conveyed are carried directly on the links of the chain or on specially designed elements attached to the chain. The load carrying chain is generally supported on idle sprockets or guide ways. The endless chains are kept taught by suitable chain tensioning device at the non-driven end.

General Characteristics

Different types of chain conveyors are used in wide varieties of applications. It is, therefore, not possible to have a set of common characteristics for all these chain conveyors. Special characteristics of individual type of chain conveyors have been described while discussing them.

Chain, compared to belts of a belt conveyor, have certain advantages as well as disadvantages. The major advantages are that the chain easily wraparound sprockets of small diameter, and the drive is positive i.e. no slippage takes place between chain and sprocket. The chain stretch is also little. The disadvantages of chain are its high weight, high initial cost, higher maintenance cost and most importantly, limited running speed because of dynamic loading that come into

play in chain-sprocket drive causing intensive wear at high speeds. Maximum length and maximum lift of chain conveyors are limited by the maximum allowable working tension of the chain used.

Types of Chain Conveyors

(a) **Apron or Pan Conveyor:** This is the most common type of chain conveyor. It consists of one or more strands of endless chain, usually link plate roller type, running in steel guides. Rollers ensure minimum pulling effort in the chain, while roller guides supported on the superstructure of the conveyor, carry the entire load of the materials and chains. The carrying surface of the conveyor is composed of a series of plates or shapes called **apron**, which are attached to the links of the chains through cleats. The bed created by the aprons is used for carrying bulk materials as well as unit loads. When the conveyor aprons have vertical flanges on all sides to form a pan like shape, if is specifically called a **pan conveyor**. Materials carried by the apron is discharged over the sprockets at the driven end, and the conveyor chain with aprons comes back empty on its return Journey. These are generally slow speed conveyors with a speed range of 20 to 35 mpm. Arrangement of a typical apron conveyor is shown in Fig.

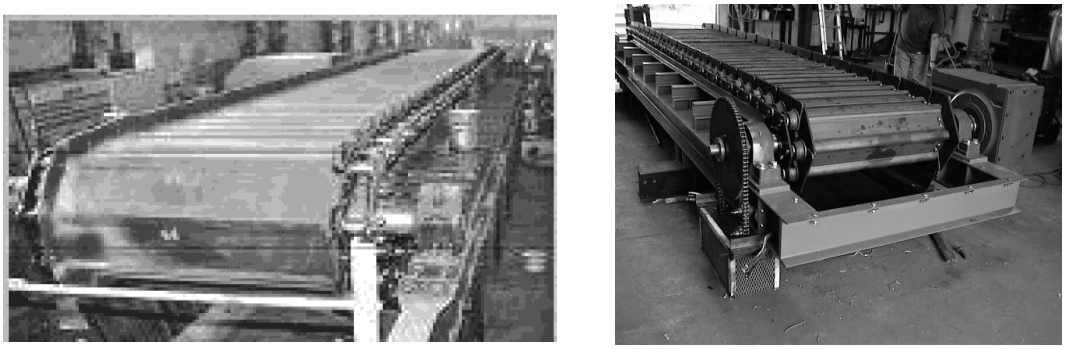


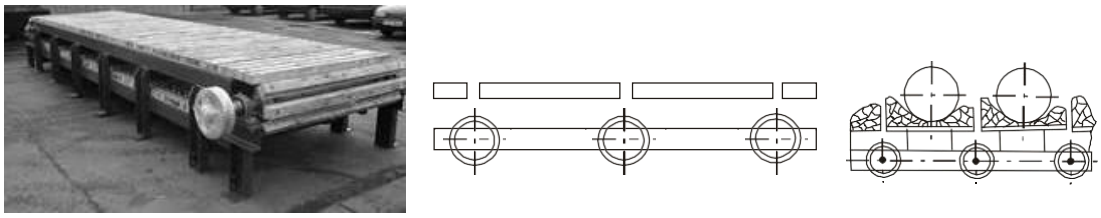
Fig. Photographs of typical apron conveyor

Applications: Generally apron and pan conveyors are used to perform severe duties of convey- ing large quantities of bulk load such as coal, ore, slag, rock, foundry sand etc. These are frequently used for feeding materials to large crushers, breakers, grinders and similar machines. Specially designed aprons are used for conveying unit loads, coils, hot forgings. Part of an apron conveyor may be run through a liquid or water bath for washing of the materials and then allow drainage of liquid from wet materials. Apron conveyors can have flexible

layout to follow combined horizontal and inclined move- ment in the same vertical plane.

Apron/pan design: Depending on the nature of materials to be conveyed, different designs of apron and pan are used. Some of the common designs are:

(i) **Flat, spaced apron:** Conveyor with rectangular shaped flat steel or wooden slat aprons with small gaps between them, providing a flat surface for carrying unit loads are specifi- cally called "**slat conveyor**" [Fig. (*a*)]. Some other designs of flat and spaced aprons with cleats for carrying different shaped object are shown in Fig. (*b*) and (*c*).



Slat Conveyor (*b*) (*c*)

Fig. Flat spaced apron conveyor

(ii) **Corrugated apron:** These are the most common type of apron, made of formed steel, with front and rear edges beaded so that one overlaps the other to form a continuous bed or trough. The overlaps are so made that during turning of the chain over sprockets, the apron ends move relative to each other without creating a gap for leakage of materials or a jam- ming of adjoining aprons or pans. Some of the aprons are plain while some are provided with overlapped vertical end plates to form pans. Corrugated aprons or pans may be fabricated or cast from gray or malleable iron. The pans are designated as leakproof (for carrying fines), shallow, deep and hinged (for carrying chips, trimmings, scrap etc.). Deep pans may be used for carrying materials at an inclination of upto 45°.

(iii) **Special types:** These are used in special applications and are too numerous to be discussed in limited space. Some of the typical examples are the four compartment cast-metal pans used for pig casting. Beaded aprons are used in sugar mills. When deep loads are carried on an apron conveyor, stationary side plates called skirt plates are provided on both sides, fixed to the conveyor frame.

(b) **Cross-Bar or Arm Conveyor:** This type of conveyor consists of a single or two strands of endless chain, to which are attached spaced, removable or fixed arms (or cross members) from which materials are hung or festooned. The arms may be replaced by shelves/trays to support packages or objects to carry them in a vertical or an inclined path.

Special arms are designed to suit specific load configuration. Depending on the design of arms, they are called by different names, some of which are: (*i*) pendent conveyor, (*ii*) pocket con- veyor (shown in Fig), (*iii*) wire mesh deck conveyor, (*iv*) removable-crossbar conveyor,

(i) fixed cross-bar (or arm) conveyor, (*vi*) swing tray conveyor.

(c) **Car-Type Conveyor:** This type of conveyor consists of a series of small platform cars, pro- pelled by an endless chain, running on a closed track. Car-type conveyors may have vertical runarounds over sprockets having horizontal axis. However, more often they are designed with horizontal runarounds (carousels) over sprockets (or sheaves for rope drive) with vertical axis. This type of conveyor is also called a **carousel conveyor** or a **pallet-type conveyor**.

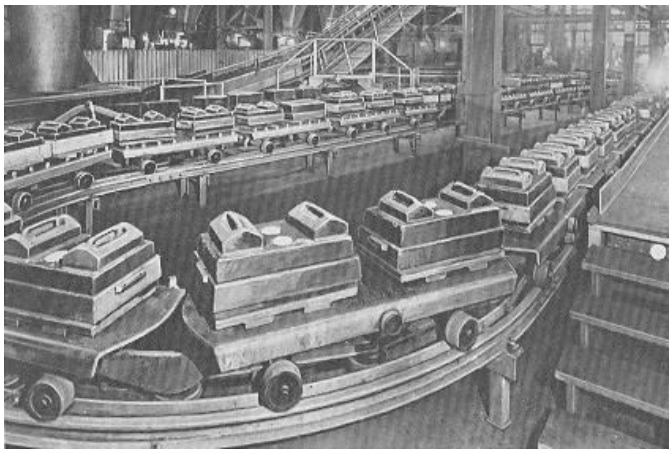


Fig Photographic view of car conveyor

The track is placed more or less in a horizontal plane. The cars may either be permanently attached to the driving chain (or cable) or may be propelled by pusher dogs on chain or rope against lugs on cars. The driving chain is generally positioned at the bottom side of the cars, between the two track rails. Loads may be manually loaded / unloaded, or may be designed for automatic loading, and unloading through tilting of car top at unloading point. Fig. shows a typical car-type conveyor.

Applications: Car-type chain conveyors are particularly used for carrying heavy or irregular shaped large objects like moulds in foundries, coils for rolling plants etc.

(d) **Carrier chain & Flat-top chain conveyor:** Carrier chain conveyor consists of one or more number of endless chains to which may be attached one of the many different attachments for the purpose of carrying unit materials or objects. In many cases, the materials are conveyed while being directly in contact with the chain/chains.

These conveyors have a broad application in practically all fabricating and processing indus- tries. Different designs of attachments are used for different types of materials.

Carrier chain conveyors are generally classified into two basic types:

(i) *Rolling-type carrier chain conveyors:* In this class of conveyor, the chains are provided with rollers moving on tracks for minimum of friction. The materials are supported on the attachments. In a variation of this type of conveyor, the rollers may be used for supporting the objects while the chain acts as the connecting and propelling link for the rollers. The rollers may be shaped to accommodate curved faced objects or may be flat-faced to carry objects with flat surfaces. Rotation of the carrying rollers often causes the objects to move at a higher velocity than that of the chain.

(ii) *Sliding-type carrier chain conveyor:* In this class of conveyor, the loads are carried directly on one or more chains, while the individual chain slides on a track or surface or a trough. Attachments or specially designed links may be used to suit the loads.

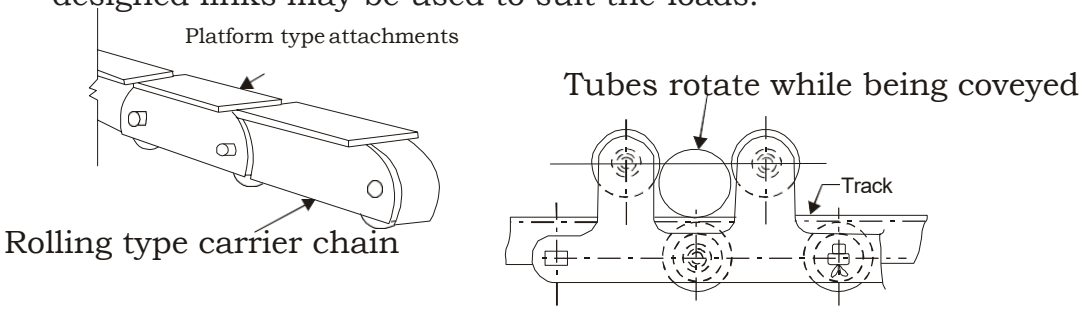


Fig. Different rolling type carrier chain conveyors

Flat-Top chain Conveyor is a particular group of carrier chain conveyors, may be rolling or sliding type, with specially designed chain links or with flat plate attached to the chain links so as to provide a continuous, smooth, level top surface to carry small articles like bottles, cans, etc. at a high speed. These conveyors are widely used in canning and bottling plants.

Different types of chains and/or attachments are used such as hinged-joint continuous flat- top sliding type (Fig.), plate-top sliding or rolling type,

crescent-shaped plate top type. The crescent plate design is particularly suitable for carousel-type operation to turn in a horizontal curve, a typical example being the baggage handling conveyors in the arrival section of an airport.

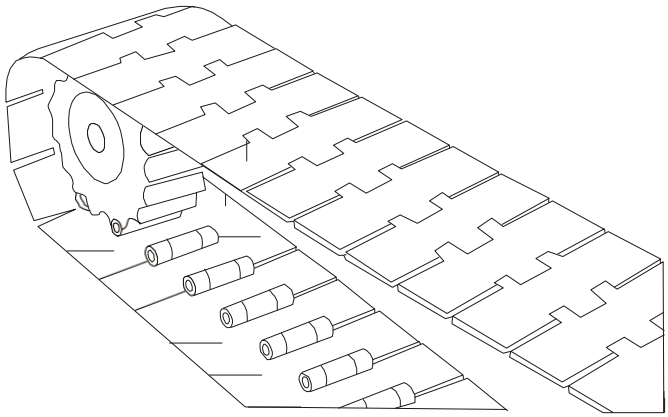


Fig. Hinged joint continuous flat-top sliding conveyor

Trolley Conveyor: These conveyors consist of a series of trolleys supported from an overhead endless track and propelled by an endless chain or cable, with the loads usually suspended from the trolleys. This is one of the most versatile type of chain conveyors which can work in horizontal and inclined paths, vertical curves and horizontal turns to follow complicated routes.

According to the method by which load is conveyed, trolley conveyors are further classified into following three types:

(i) *Load-carrying trolley conveyor:* Which is the main type, in which the trolley and the load carriers are permanently fixed to the pulling chain.

(ii) *Load-propelling trolley conveyor:* In which the trolleys with load carriers travel on track being pushed by pusher dogs attached to the pulling chain or chain trolley. The special advantage of this load-propelling conveyor (also called **pusher trolley conveyor**) is the capacity to divert the load carriers from the main track to a branch track for achieving different operational requirements.

(iii) *Load towing trolley conveyor:* in which the trolleys are permanently secured to the pulling member, and specially designed hooks or rods from the trolley engage and tow floor mounted trucks carrying the load. In this case the conveyor may be made very light as the load in basically carried on the floor, but the advantage of free floor / working space is lost. This particular type of trolley conveyor is also classified as **overhead tow conveyor.**

Power and Free Conveyor: These conveyors are basically a special design of the **Load-pro-pelling or pusher trolley conveyors**. In a normal pusher trolley conveyor the non-powered trolleys, supported from a monorail, carry the load and are pushed by dogs/pushers attached to the chain trolleys mounted on a separate track. A power and free conveyor is one in which the power trolleys run directly above the free trolleys, which run in double channel track, and arrangements are made such that at desired points the non-powered load carrying trolleys may be engaged to or disengaged from the power trolleys.

Schematic diagram of a typical power and free conveyor is shown in the following Fig

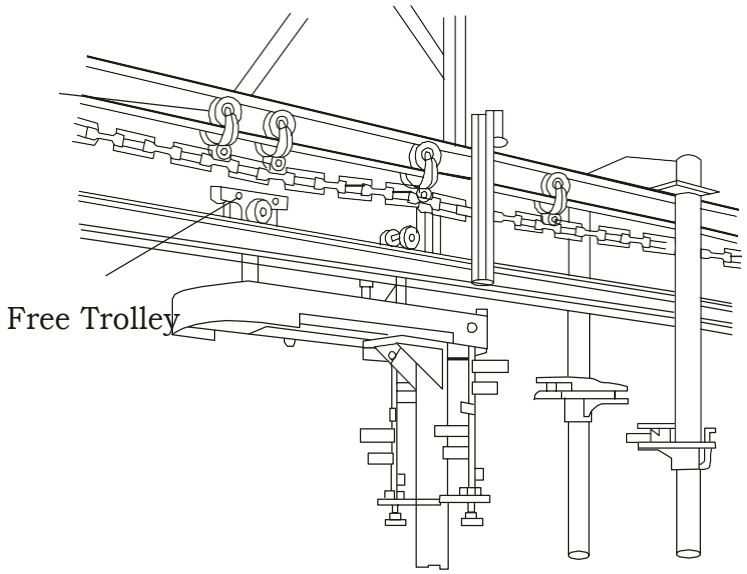
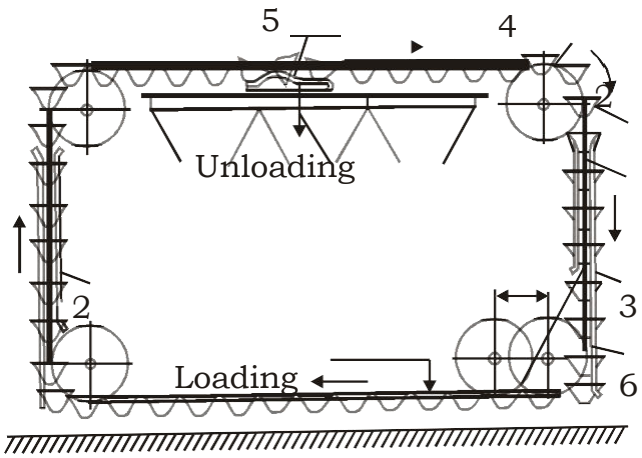


Fig.. Power and free conveyor

(e) **Suspended Tray Conveyor** also known as **Swing-Tray Conveyor:** These conveyors consist of two strands of chains between which are pivot mounted a series of trays to carry in-process movement of various unit loads (forged components, boxes etc.) along complex contours com- prising horizontal and vertical paths in one vertical plane. As the trays are pivot mounted from the links of the chains, the trays along with their loads always remain suspended vertically irrespective of the path of the chain.

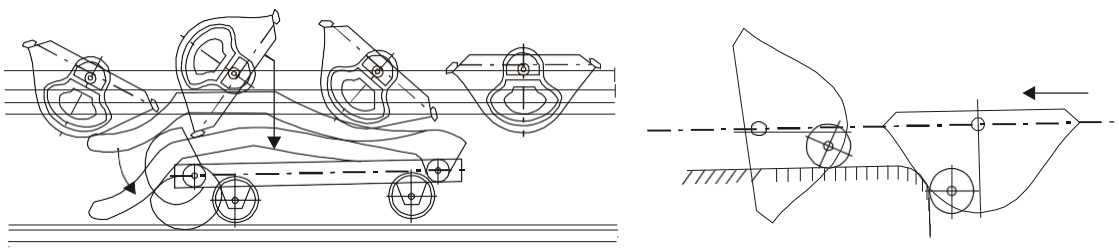
Suspended tray conveyors are loaded on vertical sections manually or automatically by specially designed loading devices. These conveyors are particularly used for raising /lowering of loads between floors, convey materials between processing equipment, carry loads without transfer between interlinked horizontal and vertical sections. The conveyor may be used for carrying load through processing stations like drying, pickling chambers etc. Fig. illustrates a typical layout of a pivoted bucket conveyor showing different components of the conveyor.



1. Pulling chain, 2. buckets, 3. vertical guides (to prevent oscillations), 4. driving sprocket, 5, take-up sprocket, 6. tipping divice.

Fig. Layout of a pivoted bucket conveyor

The design of the trays are adapted to the requirements of loads and method of loading / unloading. The trays may be flat or curved. When the trays are made of steel plates in the shape of buckets for carrying powdered or granular bulk load, the particular conveyor is called **pivoted bucket conveyor**. The bulk material is fed into the buckets on the lower horizontal section and carried through various sections without transfers, and hence is not crushed en-route. The pivoted buckets are discharged at the upper horizontal section automatically by tippers or dischargers. The buckets are fitted with projecting curved cams or guide rollers, which on coming in contact with the arms of tippers, tip the buckets. Fig.6.2.15 shows the two common schemes of bucket tipping devices. Pivoted bucket conveyors are used in power plants in carrying coal and ashes, in cement mills, ceramic industry, stone crushing plants etc..



(a) (b)

Fig. Tipping devices of pivoted bucket conveyor (*a*) movable device with elevating lever and cam on buckets; (*b*) guide rollers on buckets.

Components of Chain Conveyor

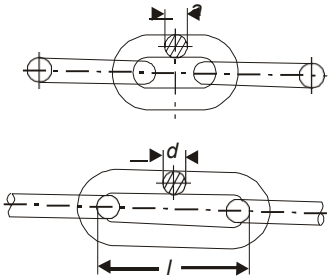
The major components of a chain conveyor are : (*i*) Pulling chain, (*ii*) Sprocket to drive and support the chain, (*iii*) Take-up arrangement, (*iv*) Drive arrangement and (*v*) Various other components specific to various type of chain conveyors.

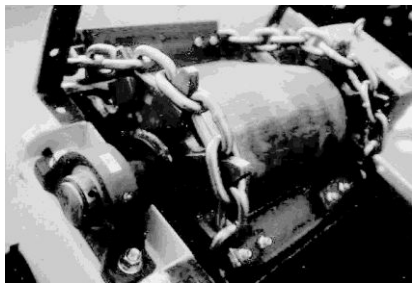
(a)**Pulling Chains:** Different types of chains are used in chain conveyors,

which have their merits and demerits, briefly discussed below:

(i) *Round-link chains* (Fig. 6.2.16) are low in cost and high flexibility in all directions. This have flexibility which is particularly desirable in trolley conveyors. However, limitations of this chain are less contact area, high stretch under load and rapid wear.

(*a*)

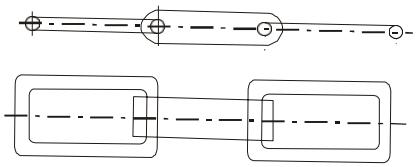




(b)

Round-link chain being driven by sprocket

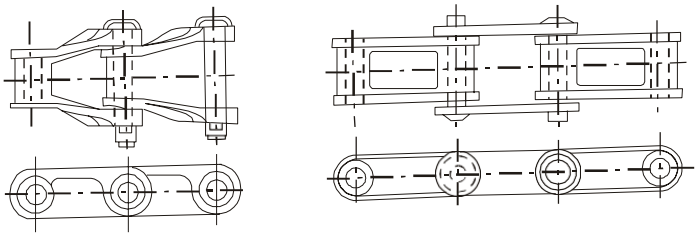
(c)



Short or long-linked welded

Fig. Round-link chain

(ii) *Combination chains* (Fig.) are widely used in many different conveyors. The links are generally of cast malleable iron construction with machined steel pins and may be with or without roller.



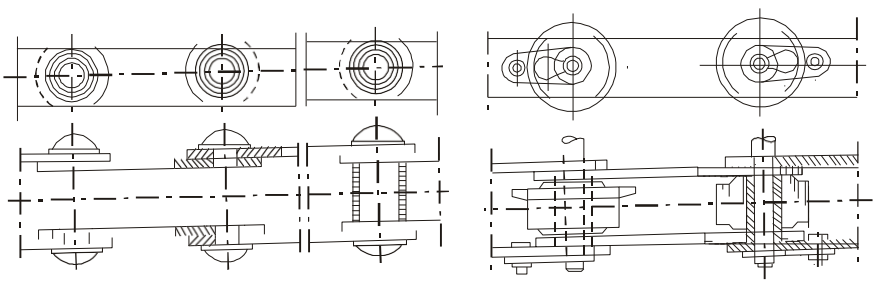
(a) (*b*)

Fig. Combination chain (*a*) without rollers, (*b*) outer link plates of steel

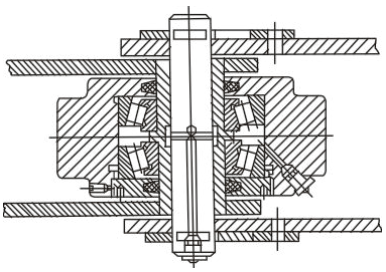
Link-plate chains (Sometimes called leaf chain) are the most common type used in chain conveyors. The link plates allow different types of attachments to be fitted in the chains. The pitch of the chain may be made large enough

(pitch usually vary from 65 mm to 1250 mm) by making the links from steel plates.

Constructionally the link-plate chains may be bush-less chain with or without rollers, and bushed chain with or without rollers, as shown in Fig. 6.2.18. The bushes decrease the wear at the link joints. The rollers fitted with bushes or with antifriction bearing for large size chain (Fig.) generally run on guided tracks or toughs which carry the entire weight of the chain and load being carried, thereby reducing the pull in the chain. Because of these advantages, chain with bush and roller are the preferred ones.



Bushless with or without roller Bushed with roller



Antifriction bearing roller assembly

Fig. Link plate chains

Chain selection is based on largest practical pitch (being cheaper than the shorter pitch chain of equal strength), allowable tension load, capital cost and degree of maintenance needed.

(b) **Sprockets:** The sprockets are made of good grade cast iron with chilled hardened teeth or from cast steel or plate steel. The teeth are machined to suit type of chain used. The advantage of using a large sized sprocket with greater number of teeth is to obtain smoother operation. How- ever, larger the size of sprocket, costlier it is and taking larger space. Thus a compromise is made in selecting the size of a conveyor sprocket. (The pulsating motion of a conveyor chain is explained in section 6.2.5).

(c) **Take-up arrangements:** The most common type of take-ups is ***adjusting screw type*** for posi- tioning the bearing blocks supporting the takeup sprocket shaft. The range of adjustment should be sufficient to permit initial slack-off of the conveyor chains for joining of two links to make them endless

and ample adjustment for initial stretch and subsequent wear / elongation.

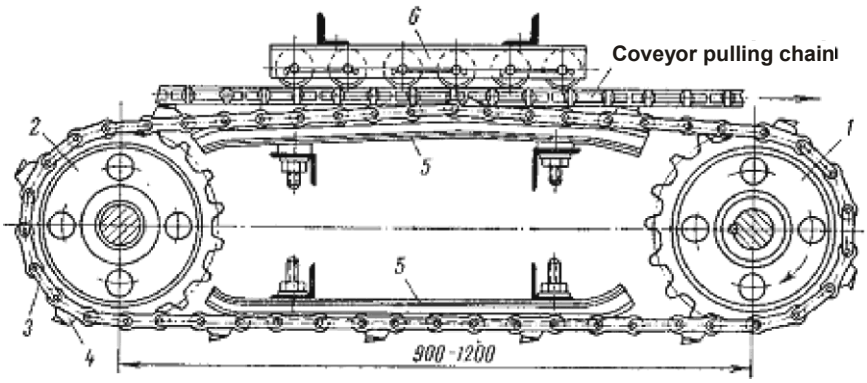
The alternative design is ***counterweighted-type***, providing automatic constant tension in chain. This type provides constant chain tension under variable temperature conditions also.

(d) **Drive arrangement:** Drive for a conveyor generally consists of an electric motor coupled to a speed reduction gear unit which in turn is coupled to the driving sprocket. For a conveyor having a simple configuration (as in an apron conveyor), the drive is located at the sprocket at the end of loaded strands of chain. For conveyors like trolley, car, tray etc. having a complicated path of motion, the drive location is determined by analysis of tension variation in the path of conveyor motion.

Drives may have fixed or variable speed. Variable speed may be achieved by using a variable speed gear box or change speed gear box or multiple speed motor or by having an electrical speed control system.

For a long chain conveyor, synchronously working multiple motor drives at different sections are employed which decrease the total tension in the chain.

A **crawler drive** is employed for giving drive to a straight portion of the pulling chain. The crawler drive arrangement is shown in Fig. 6.2.19. Straight portion of the conveyor chain, supported by the set of supporting rollers, is driven by the dogs of the drive chain.



1-drive sprocket, 2-tail sprocket, 3-drive chain, 4-driving dogs, 5-back-up bars, 6-support rollers.

Fig. Crawler drive

(b) **Frame structures:** Frame structures supporting the entire conveyor, chain guide rails or troughs, skirt plates are the other components which are common to most type of chain conveyors.

Frame structures are generally custom designed to suit the location and application. The frames may be floor supported, set below the floor, be hung from the roof or bracket from wall / columns, as required by the different types of conveyor.

Different types of chain conveyors may need other specific components and structural arrange- ments, which have been mentioned in the discourse

on the individual type of conveyor.

HAULAGE CONVEYORS

Haulage conveyor is a special group of chain conveyors. As the name implies, the material is dragged, pushed or towed by means of a chain or chains, making use of flights or surfaces which are parts of the chain themselves. The weight of the material is generally carried by stationary troughs, surfaces, or wheeled trucks/dollies on rails/floor. In certain designs, the chain may be replaced by cables. These conveyors are run at slow speed (15 to 60 mpm) and being built for heavy duty need little maintenance. However, the chains undergo wear under heavy tension and work in one direction only.

Types of Haulage Conveyors

Haulage conveyors are generally classified into drag conveyor, flight conveyor and tow conveyor.

(a) **Drag chain conveyor:** It is a conveyor having one or more endless chains, which slides in a track or tracks, resting at the bottom of a trough, and materials resting directly on the chain are carried by the chain links. The layers of materials above the chain level are moved by the cohesiveness with the material below.

The troughs or sliding base surface may be made of steel, concrete or even wood. The chain tracks are often made from steel channels.

These conveyors generally work in the same horizontal plane with little inclines, for movement of bulk materials, hot materials, abrasive materials, logs/timber, packages etc. Even cars may be moved in a car assembly line by putting two wheels on one chain.

A few of the typical designs of drag chain conveyors are mentioned below:

(i) *Multiple strands drag chain conveyor :* The multiple parallel chains may be spaced widely upto a few meters apart and may be used to transfer long objects like lumber, hot steel sections etc. placed across multiple strands. This type of conveyor is widely used in trans- ferring hot steel sections in hot bar and section rolling mills. All chains move at same speed.

(ii) *Pusher-bar conveyor :* Consists of two strands of sliding endless chains connected by spaced crossbars. Unit loads resting on a slider bed are pushed by these cross bars. Fig. is a schematic view of a pusher-bar drag conveyor.

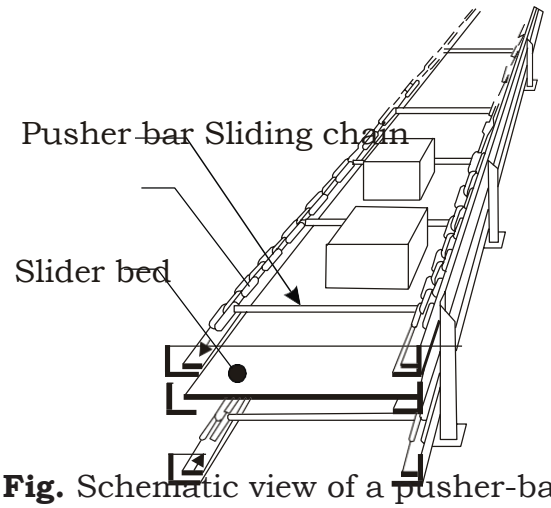


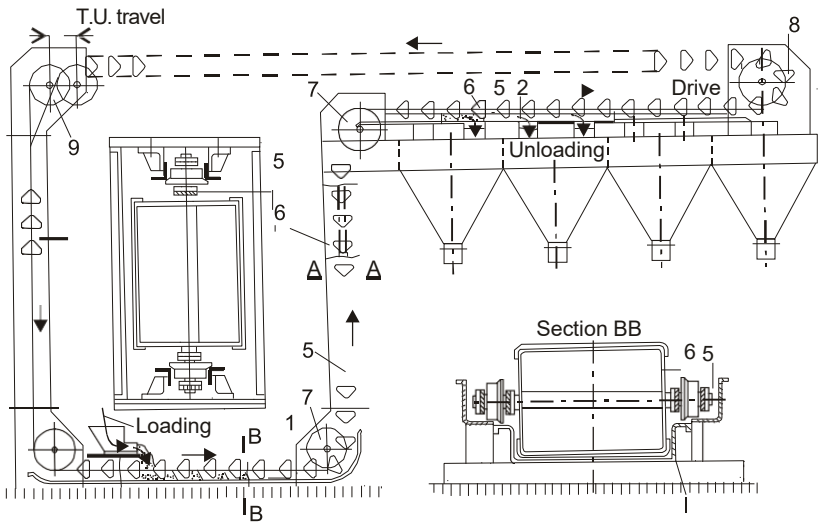
Fig. Schematic view of a pusher-bar drag conveyor

(iii) *Wide-chain drag conveyor :* It consists of a single strand large width chain which can move a bed of bulk materials along a troughed path. The space between one set of link and bottom sliding plate form individual pockets for the bulk materials. These conveyors are widely used for handling refuse materials like clinkers, ashes, sawdust, and also bulky materials like wood chips, coal etc.

(b) **Flight Conveyor:** A conveyor comprising of one or more endless strands of chain with spaced transverse flights or scrapers attached which push granular bulk material along a shaped trough. The material can be loaded at any point into the trough and discharge can also be effected at various points through openings in the trough floor, closed by sliding gates. Both upper and lower strand may be used for transporting materials in opposite directions. These conveyors generally work at speed range of 30 to 50 mpm to handle free flowing materials of small to moderate size to move them in both direction. These are used for handling coal, ashes, sand, gravel, ore, wood chips, saw dust, chemicals, grains, cereals, generally for loading bunkers and bins and also used under floor for removal of metal chips/cut pieces.

One flight conveyor can handle two or more materials simultaneously by making two or more material flow troughs/channels side by side and designing the flights to match individual troughs. These conveyors are built rugged for long life and low maintenance.

When a two-chain flight conveyor have flights made in the shape of fixed buckets, such a flight conveyor is called **gravity discharge bucket conveyor**, also called **V-bucket conveyor**. These can fill up buckets in the horizontal section, move through vertical sections carrying bulk mate- rial and then discharge the material in another horizontal trough section at a higher level for filling up of bins etc. Scheme of such a V-bucket flight conveyor is shown in Fig..



1,2- horizontal trough; 3,4-casing of vertical sections; 5-chain; 6-buckets; 7-turning sprockets; 8-driving sprocket; 9-take-up sprocket.

Fig.. V-bucket flight conveyor

(c) **Tow Conveyor:** This consists of a single strand endless chain which tows floor/ track mounted trucks, dollies or cars on which the materials are placed. Tow conveyors are generally used for handling of unit loads like boxes, barrels, crates, cartons, in the warehouse, in assembly lines and for intra-plant movement. Though the tow conveyors follow a fixed path, the carts can be detached easily from the conveyor and moved to other points.

Tow conveyors are classified into following three groups.

(i) *Overhead tow conveyor :* This type has already been described as "*load towing trolley conveyor*" under "*trolley conveyor*" in section 6.2.3(e).

(ii) *Flush-floor tow conveyor :* In this conveyor the materials are transported on rail bound carts, moved by one strand of endless chain moving in a fixed guide flushed with the floor. The carts are connected to the conveyor chain by removable link like chain with hook, removable dog and rigid drawbar which engage the trolleys and push them.

(iii) *Underfloor tow conveyor :* In this conveyor an endless chain is installed below floor level either supported by trolleys or sliding in a channel or angle track. The floor mounted carts are connected to the conveyor by retractable pin through a narrow slot in the floor, to pick up connecting device on the chain.

Underfloor tow conveyors work at higher speeds than overhead ones. These are widely used in variety of applications including moving automobiles, wash racks, in manufactur- ing assembly lines, warehouses, freight handling terminals etc.

The major limitations are track clogging with refuse and difficult access to maintenance. These conveyors have to be planned before constructing the new building where they have to be installed. Fig. 6.3.3 shows schematic arrangement of an underfloor tow conveyor.

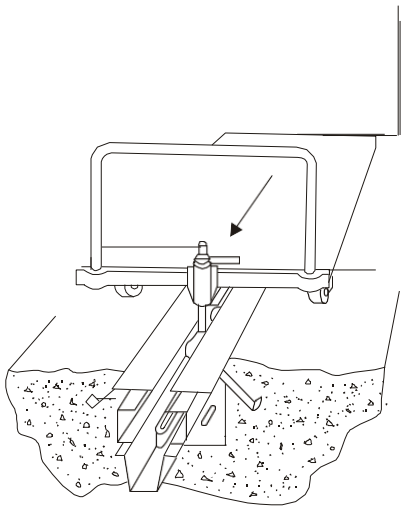


Fig. Underfloor tow conveyor

CABLE CONVEYORS

Definition, Description and General Characteristics

These conveyors form a distinct group of materials handling equipment to transport people and bulk materials in load carrying buckets, using overhead moving cables and/or wire ropes and are com- posed of one or more spans from the loading point to the discharge point/points covering long distances upto several kilometers. These conveyors are also known as **ropeways** or **aerial tramways**.

The characteristic features and advantages of these conveyors are:

(i) As loads are moved at a substantial height from the ground, shortest route between the terminals can be followed independent of the ground contour.

(ii) Wide varieties of materials including human passengers may be transported. These are commonly used for carrying minerals from mines to their processing stations.

(iii) Cost of operation is comparatively less than other transportation systems.

(iv) Materials are moved between distantly located points without the need of re-handling.

(v) Materials can be automatically discharged at the desired point, hence eliminating use of an auxiliary discharging system.

Classification

From design point of view there are primarily two distinct systems of aerial tramways/ropeways, the **bicable** and the **monocable** system.

In the bicable system one or more (commonly two) stationary high-tensioned track cables are used over which carriers are placed from which hang the load carrying buckets. For a continuous bicable system, two stationary cables are needed. The carriers are pulled by one endless traction or pulling rope moving continuously in one direction. The loaded carriers move from the loading terminal to the discharge terminal, while the empty ones move in the opposite direction. For reversible bicable system one track cable is sufficient.

In the monocable tramways system, one endless moving wirerope is used for supporting as well as moving the carriers.

Monorail Tramways is another type of cable conveyor in which the load carriers run on suspended rails, and moved by a moving wire rope. This is essentially a trolley chain conveyor where the traction chain is replaced by a wire rope. These are used for towing load between much shorter distances.

Components of a Cable Conveyor

A cable conveyor basically consists of

(i) one or more cables/wireropes, one of which is driven which pulls the load;

(ii) a number of load carrying buckets or carriers which are hung through hangers from wheeled (2-wheel or 4-wheel type) carriages;

(iii) loading and discharge terminals;

(iv) intermediate towers for supporting the cable/rope and

(v) drive arrangement.

Selection of size of traction rope or carriage supporting static rope is based on the estimated maximum tension in the rope. The construction of rope is selected such that it provides a smooth wearing surface for the carriage wheels, provides better gripping of the carrier with the rope and whose outer layers of wires do not unlay and get loosened. 6 × 7 or 6 × 19 lang lay construction with hemp center is customarily used. Constructional details and breaking strengths, for steel wire ropes for general engineering purposes, is given in Indian Standard IS:2266:1989.

The carriages are generally of 2-wheel or 4-wheel type, the later being used for heavier load.

The rigid hangers are connected with traction rope through grips. These grips may be of

(i) compression type which operate on toggle principle,

(ii) screw type or

(iii) weight-operated type which depends on the weight of the loaded carriers for its gripping capacity.

The carriers are generally buckets of different types to suit specific nature of the load. The usual bucket designs are:

(i) trunion mounted *rotary dump* buckets which may be overturned easily for discharging,

(ii) *end dump buckets* for discharging load from one end and

(iii) *bottom dump buckets* for discharging load from the bottom. Fig. shows a monocable carrier.

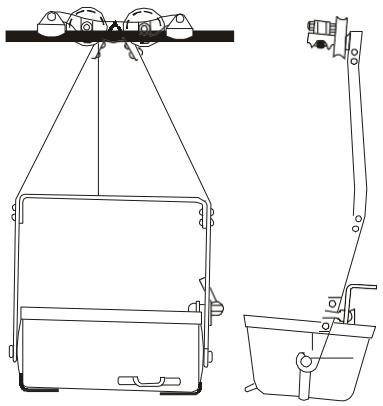


Fig. Monocable carrier with rope grip, of the rotary dump bucket type

Loading or discharge terminals are structural platforms built at the height of the cables/ropes, where arrangements are provided for detaching and attaching the carrier from and to the traction rope by operating the grips, and taking them onto a loop of rail on the platform. At the loading terminal the empty buckets are loaded automatically from storage bins through proper feeders, while at the unload- ing terminal the buckets are emptied. Rope tensioning arrangement is provided at the discharge terminal while rope driving system is placed at the loading terminal. Fig. 6.4.2 shows the layout of a typical monocable discharge terminal.

Cable conveyor drive consists of a suitable power unit coupled to a speed reduction gear box and the driving sheave. The diameter of the driving sheave depends on the rope size and pressure of the rope on the sheave groove. Driving sheave may be rubber-lined. Grip sheaves with toggle jaws spaced around a segmented rim have been used for increasing driving power of the sheaves.

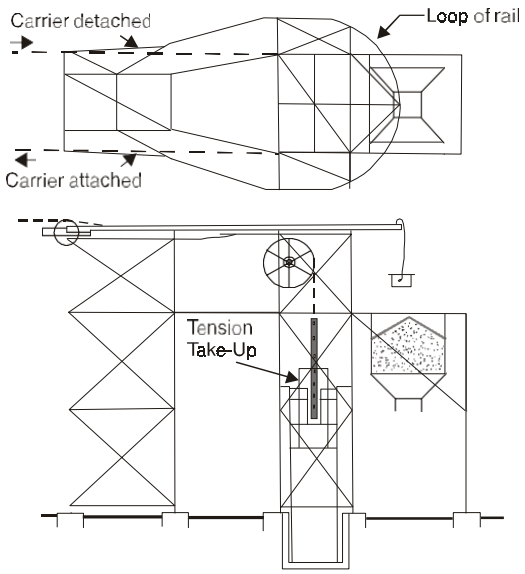


Fig. Typical monocable discharge terminal

ROLLER CONVEYORS

Definition and Characteristics

A roller conveyor supports unit type of load on a series of rollers, mounted on bearings, resting at fixed spacings on two side frames which are fixed to stands or trestles placed on floor at certain intervals. A roller conveyor essentially coveys unit loads with at least one rigid, near flat surface to touch and maintain stable equilibrium on the rollers, like ingots, plates, rolled stock, pipes, logs, boxes, crates, moulding boxes etc. The spacing of rollers depend on the size of the unit loads to be carried, such that the load is carried at least by two rollers at any point of time.

Roller conveyors are classified into two groups according to the principle of conveying action.
These are:

1. Unpowered or Idle Roller Conveyor.
2. Powered or Live Roller Conveyor.

In an unpowered roller conveyor, the rollers are not driven or powered from an external source. The loads roll over the series of rollers either by manual push or push from an endless moving chain or rope fitted with pusher dogs, rods or clamps. Generally these conveyors operate at horizontal plane, but at times a gentle slope is given to these coveyors to aid motion of the loads. An inclination of 1.5% to 3% ensures that the load will roll by gravity. Such conveyors are termed **"gravity roller conveyor"**.

In a powered roller conveyor, all or a selected number of rollers are driven by one or a number of motors depending on the selected drive arrangement. The driven rollers transmit motion to the loads by friction. The powered roller conveyors may be installed at a slightly inclined position, up to 10° up or up to 17° down. The load can be moved in either directions by changing the direction of rotation of the rollers, where these are called reversing conveyors.

Roller conveyors are used for conveying almost any unit load with rigid riding surface that can move on two or more rollers. These are particularly used between machines, buildings, in warehousing as storage racks, docks, foundries, rolling mill

plants, manufacturing, assembly and packaging industry. They are also used for storage between work stations and as segment of composite handling system.

However, the limitations of rollers conveyors are that they can be best used for objects with rigid flat surfaces, and for movement to relatively short distances. Needs side guards to retain the loads from falling off. Gravity roller conveyors have the risk of accelerating loads.

Types of Roller Conveyor

(a) Unpowered Roller Conveyor

An unpowered roller conveyor consists of series of rollers, the frame on which the rollers are placed and the stands also called the *trestles*, on which the framework rests. Because of simplicity of design, competitive cost and trouble free operation, these conveyors are used extensively in handling unit loads in workshops or process plants to convey articles from one working station to another. Unpowered roller conveyors are often used as a storing platform and as such are often termed as **roller table**. These are also used in stores as storing racks and in loading bays for loading / unloading materials from carriages. A gentle slope may be provided in the conveyor to aid movement of the loads on idle rollers. These **gravity roller conveyors** are used to convey load in one direction only. The conveyors can have a curved section to change direction. Material movement between two levels may be done by an inclined or a spirally formed gravity roller conveyor. The spiral form increases the length of the conveyor and thereby controls the velocity of the articles moving down the conveyor. A typical unpowered roller conveyor is shown in Fig.

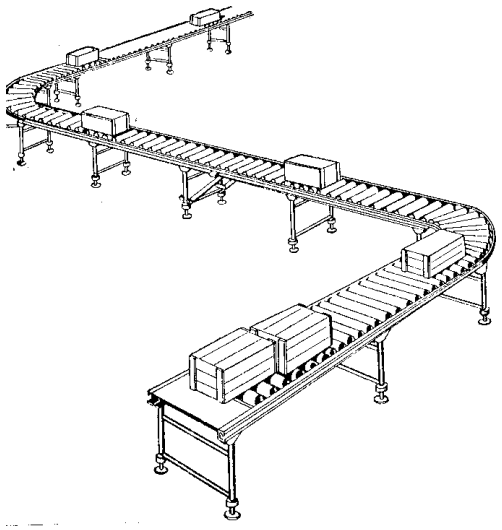


Fig.. General view of an unpowered roller conveyor

Parts of unpowered roller conveyor

(i) *Rollers:* Cylindrical rollers are generally used which are made from ERW steel pipes with cast or fabricated end flanges to accommodate the antifriction bearings (usually ball bearings). The through axles are stationary and roller barrels can rotate freely. These rollers are called idler rollers.

For conveying cylindrical objects (drums, pipes, round steel bars etc.), double tapered roll- ers or wheel rollers are used (Fig.).

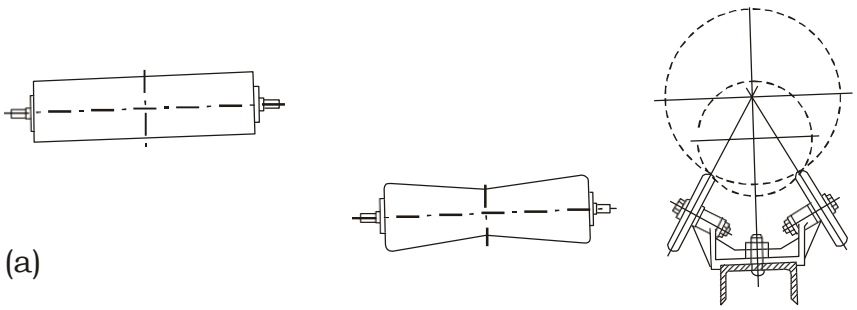


Fig. Types of unpowered conveyor rollers

(a)cylindrical; (*b*) double tapered; (*c*) wheel

The diameter of the rollers depend on the diameter of standard steel pipes available, and vary from about 20 mm to max 155 mm. Heavier the load to be conveyed, larger diameter and heavier wall thickness of the rollers are chosen. Typical sizes of some of the rollers and their weight carrying capacities are given in the following table:

Roller Parameters	**Type of Roller**		
	Medium	**Heavy**	**Extra Heavy**
Roller diameter, mm	73	105	155
Maximum load per roller, kg.	300	600	1200
Axle dia at the journal, mm	20	30	45

(ii) *Frame:* Frame is that part of the conveyor on which the roller axles rest and are fixed to. The conveyor frame is fabricated from angle or channel sections. The roller axles are held in slots cut in the flanges of the frame. The axles are flat machined at the ends so that the axles do not rotate in the slots. Axial movement of the axles are prevented by using split pins or lock plates. For heavy rollers, the axles may be fixed on the frame by clamps. Typical idle rollers with bearing fittings and their attachment to the frame is shown in Fig.

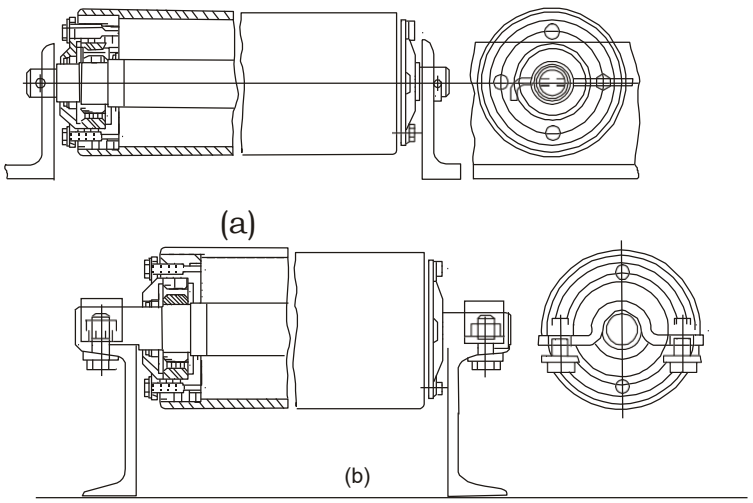


Fig.. Rollers of (*a*) heavy and (*b*) extra heavy type

Side guards may be provided along two edges of the frame to prevent movement of the loads beyond the roller span. Side guards are particularly necessary at the curved sections of a conveyor.

(iii) **Stands or Trestles:** Stands or trestles support the conveyor frames with roller assemblies, from the ground. Stands are generally fabricated from pipes or structural sections, with provision for grouting on the floor. Height of stands are chosen to keep the articles at a convenient level on the conveyor.

Small **portable conveyors** often have telescoping legs for the stands, such that the inclina- tion of the conveyors can be suitably adjusted *in situ.*

Special designs/features

A number of features can be incorporated in an unpowered conveyor to satisfy different func- tional requirements. Some of these are described below.

(i) **Double-row roller conveyor:** This design is used to convey wide and heavy loads. In place of one long and proportionately large diameter roller, two smaller diameter rollers with lengths less than half of the larger roller are used. To support the inner ends of the pair of rollers, additional support frame is required. This design works out to be cheaper than the same width conventional single row conveyor with longer and larger rollers.

(ii) **Curved sections:** These are used for changing direction of the conveyor in the horizontal plane. In this section rollers are arranged radially. Two or more number of cylindrical rollers are used in place of one roller to reduce sliding action of the load on rollers (see Fig.). Minimum sliding action of the load on rollers can be achieved by using single tapered roller (V-roller), but as these are to be made from solid casting or forged section, are costly and seldom used.

(iii) **Switches:** Devices used in a roller conveyor to change the normal direction of the load or divert the load from the conveyor are called switches.

Different types of switches are employed, some of which are as follows:

A *turn-table* (see Fig.) is used for transferring a load from one roller conveyor to a sliding runway or to a perpendicular roller conveyor. This consists of a small length (equal or slightly smaller than the width of the main conveyor) of roller conveyor mounted on a base frame which is fixed on a vertical shaft mounted on bearings. Once the load comes on the turn-table, the turn table can be rotated (manually or by proper mechanism) to the desired angle and the load can be rolled over to the desired runway.

A *hinged section* (Fig.) is a small section of the conveyor which is hinged at one end with the frame/stand of the main conveyor, and can be lifted up to make a passage way through the conveyor line.

An array of *wheel rollers* on *swiveling heads* (castor wheel) are used independently or as a part of a roller conveyor where it is necessary to move the load in many directions.

Deflector is a flat or angle like section placed longitudinally over the conveyor making an angle (may be adjustable or fixed) with the conveyor axis. This acts as an obstruction to the movement of the load and deflects them to one side of the conveyor axis. *Manipulator* consists of one pair of deflectors to bring the loads at the middle section of the conveyor axis. Deflector or manipulator is used on idle conveyors and more commonly with powered roller conveyors with chain/rope pushing facility.

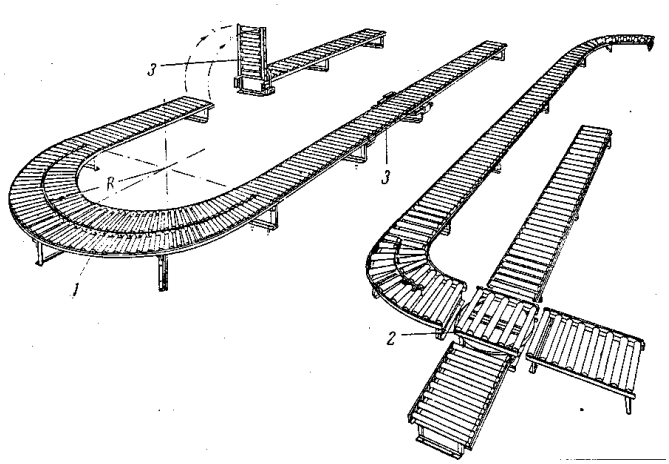


Fig.. Unpowered roller conveyors with curved section1, turn-table 2, hinged section 3

(iv) **Stops:** These are placed at the end of the conveyor to physically stop the moving loads from falling off the conveyor end. **Disappearing stops** may be placed at desired intermedi- ate points in the path of a roller conveyor to stop the moving articles at such points, if required. The stops are simple flat steel plates fixed on rigid legs or fixed to conveyor structure. Disappearing stops may be moved up or down from the top level of the roller by suitable mechanism.

(a) Powered Roller Conveyor

Introduction: In a powered roller conveyor, also called *Live Roller Conveyor*, all or a few of the rollers are driven by one or multiple motors through associated transmission system.

The loads on the roller conveyor are moved by the frictional force caused between the loads and the driven rollers supporting the loads.

Powered roller conveyors are intensively used in heavy process plants like rolling mills to feed heavy and at times hot metal to or take delivery from the mill and to various other process equipment.

The roller conveyors can be *reversing* type to suit the process or may be Non-reversing type which transport materials within the shop.

Parts of powered roller conveyors

(i) **Rollers:** The rollers of a powered conveyor is fundamentally different from those of an unpowered conveyor in that the barrel and the shaft portion are integral so that they can be driven by connecting power to their shaft ends. The integral shafts are mounted on bear- ings housed in the frames at two sides. These are termed as **driven rollers**.

The driven rollers are generally subjected to considerable impact load (specially the reversing type processing conveyors) and hence they are made stronger.

The rollers can be made from solid steel forgings or castings or can be fabricated from heavy section of tubes and solid shafts, machined all over for proper static and dynamic balancing. The diameters can be varying between 400 to 600 mm for roller tables used in heavy slab or blooming mills, down to 250 to 350 mm for general duty transporting conveyors.

Roller pitch is so selected that the load is supported by at least two driven rollers. To prevent sagging of the load between two driven rollers, non powered (idle) rollers may be introduced between two driven rollers.

(ii) **Frames:** The rollers are supported at their journals on two set of frames at two ends. The frames are connected by heavy tie rods to make a composite frame structure suitable for grouting the conveyor frame on its foundation. For a heavy duty conveyor, the framework is usually made from cast steel, and for a lighter duty conveyor, the frames may be fabri- cated from rolled steel plates and sections. Design of the frames largely depend on the drive system employed.

(iii) **Drive arrangement:** Major classification of powered roller conveyor is based on the type of drive arrangement employed.

When one motor drives more than one or all the driven rollers, it is called **Group** or **Multiple drive**. In group drive, generally only one motor with suitable transmission arrangement is used to drive all the driven rollers. For a long conveyor, or from other considerations, more than one motor may be used, each driving a group of rollers in different sections of the conveyor. The transmission of power from the motor to the

rollers vary widely depending on use. In a heavy duty non-reversing conveyor, bevel gear transmission arrangement may be used. The motor, through a gear box drives a shaft placed along the length of the drive side of the conveyor. Power to all the rollers are through set of two bevel gears as shown in Fig.. The drive shaft with supporting bearings and the bevel gears are housed in the box frame, and partially immersed in oil for lubrication. In an alternative design the transmission of power may come to one roller, and the other driven rollers may be connected to this driven roller by series of sprockets and chains.

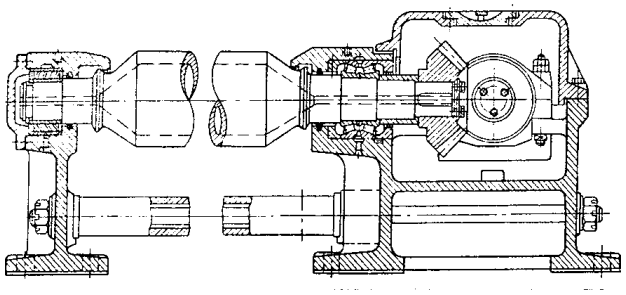


Fig. Roller conveyor with multiple drive through bevel gears

In a light duty powered roller conveyor, the rollers may be driven by one endless flat belt driven below the rollers, and supported by idle rollers such that the belt touches all the rollers and transmit power to them by friction. This is, unlike others, not a positive drive.

When each of the driven rollers are driven by an individual motor, it is called **individual drive**. These motors may be high speed motors transmitting motion through a reducing gear (Fig. 6.6.6). Alternatively, specially designed slow speed hollow rotor shaft motors are used which are directly coupled to the roller shaft. With the availability of better electri- cal control systems, individually driven roller conveyors are getting more popular particu- larly for reversing duty.

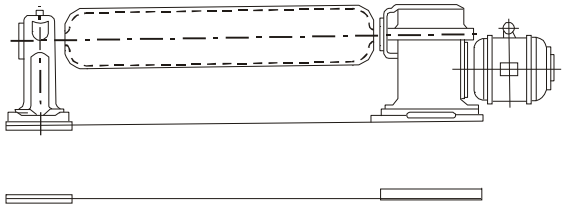


Fig.. Individual drive from flanged motor coupled to gear box

(b) Portable Roller Conveyor

It is a short (up to 7 m) section of roller conveyor mounted on legs and at times with wheels. These may be shifted from one place to another and adjusted in height or

inclination for loading and unloading of trucks. The portable roller conveyor may be idle or driven. Drive is often through an endless belt described above.

SCREW CONVEYORS

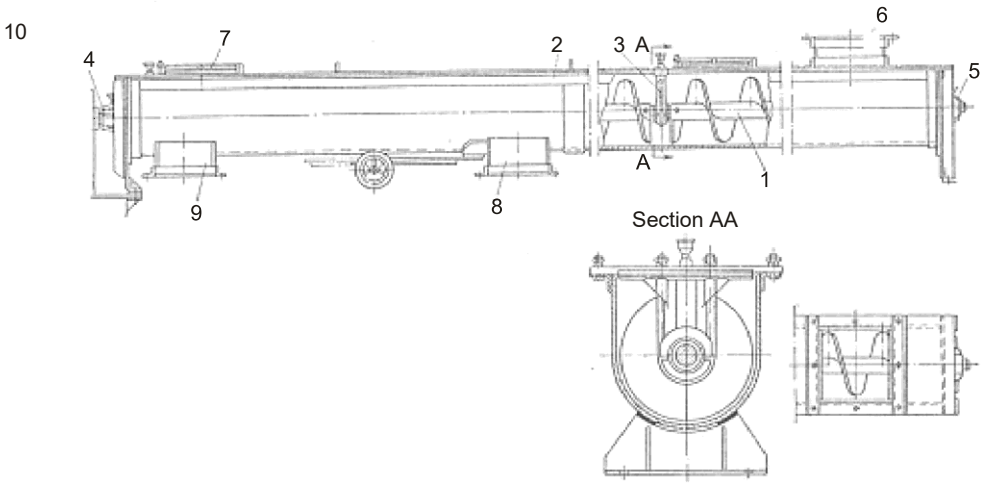
Definition, Characteristics and Use

A screw conveyor consists of a continuous or interrupted helical screw fastened to a shaft which is rotated in a U-shaped trough to push fine grained bulk material through the trough. The bulk material slides along the trough by the same principle a nut prevented from rotating would move in a rotating screw. The load is prevented from rotating with screw by the weight of the material and by the friction of the material against the wall of the trough.

A screw conveyor is suitable for any pulverized or granular non viscous material, and even at high temperature. The conveyor is particularly suitable for mixing or blending more than one materials during transportation, and also for controlling feed rate of materials in a processing plant. Abrasion and consequently certain amount of degradation of the material is unavoidable, hence it is not suitable for brittle and high abrasive materials. It is also not suitable for large-lumped, packing or sticking materials.

Descriptive Specifications

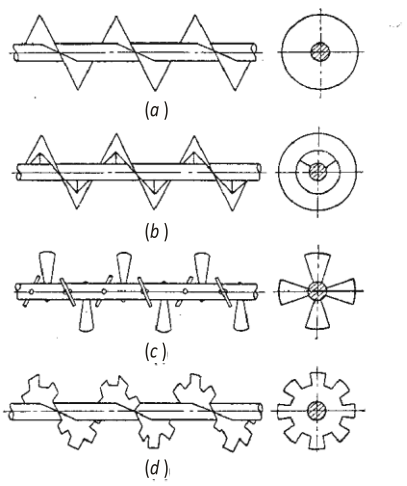
A typical screw conveyor is shown in Fig. 6.7.1. The screw shaft, if short (up to 5 meters), is supported at two ends. But for longer shafts (upto 40 to 50 m), they are supported by bearing hangers, at intermediate points. The shaft may be solid or hollow. Hollow shafts are lighter and can be easily joined to make a long shaft. The screw shaft is driven at one end, and the design may permit discharge of material from the bottom or one end. Opposite handed screw at two sides will cause the center dis- charge. The U-shaped fabricated trough are generally covered at the top to avoid particulate pollution. The bottom portion of the trough is of circular cross section matching the diameter of the screw. Gener- ally a radial gap of 10 mm to 20 mm is kept between the screw and the trough, depending on size of the screw.



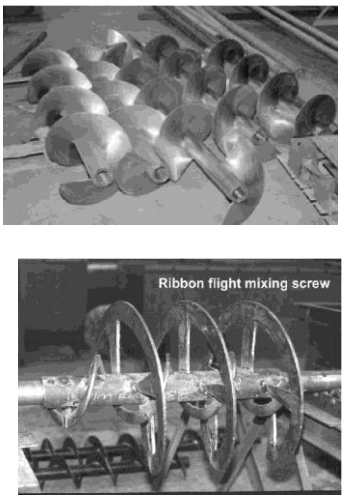
1-shaft with screw; 2-trough; 3-Intermediate hanger bearings; 4-front bearings; 5-terminal bearing; 6-feed hopper; 7-sight glass; 8-Intermediate discharge spout with gate; 9-terminal discharge hopper (open); 10- drive system (motor, gear box and coupings).

Fig. Arrangement of a screw conveyor

Screws of different constructional design and style are used, which are shown in Fig.. Continuous screws are generally made from 4 to 8 mm sheet steel circular section with a hole corre- sponding to the size of the shaft. One radial slit is made in this section, and then formed into one pitch of the screw. The section is welded to the shaft and welded or riveted to each other to form the entire length of the screw. The screw may also be cast integral with the shaft. The paddle type flights consist of cast straight or curved segments fixed to the shaft. A ribbon screw is fixed to the shaft by means of radial rods.



(*a*) solid, continuous; (*b*) ribbon; (*c*) paddle-flight; (*d*) cut-flight



Photographs of different types of screw

Fig. Types of screw used in screw conveyor

The drive unit comprises of an electrical motor, gear box and couplings. Material is fed through the feed hopper fixed on the trough cover. A number of discharge sprouts with rack gears for closing and opening as required, are provided.

Screw conveyors are generally operated horizontally or at a small inclination (10° to 20°). However, there are special designs where the load is moved vertically up or at a small angle to vertical. These are called vertical screw conveyors.

PNEUMATIC CONVEYORS

Definition

Pneumatic conveying is the process of conveying granular / powdered materials by floating the materials in a gas, primarily air, and then allowing it to flow to the destination through a closed pipe. The operating principle common to all types of pneumatic conveying is that motion is imparted to the material by a fast moving stream of air.

Thus any pneumatic conveyor consists of an air supply equipment (blower or compressor), pipelines, product storages, air lock feeders and dust filters.

Advantages and disadvantages of Pneumatic Conveying

Pneumatic conveying system is used for delivery of non-sticky, dry materials via pipelines to various storage or process points which are economically inaccessible by conventional conveyors. The major advantages of using pneumatic conveying system are as follows:

(i) Materials can be picked from one or more points and can be delivered to one or more points in a plant or even outside to a different plant.

(ii) The conveying of materials take place through air tight piping and auxiliary system and hence neither pollutes the environment nor the materials get contaminated with foreign materials.

(iii) It offers plant and operator safety in handling fine powdery materials which may be toxic in nature or fire prone.

(iv) If offers a flexible system. The conveying pipe lines can be routed and rerouted with little efforts as per demand of the operations.

(v) It makes possible unloading of materials from ships, barges, transport vessels directly to storage bins.

(vi) It is self cleaning system, preventing accumulation of materials in the conveying system. Because of this, the same installation may be used for conveying different materials.

(vii) If offers a low maintenance cost system. It also offers a lower cost materials handling system compared to handling and storage of bulk materials in bags or small containers.

(viii) A pneumatic system can be operated automatically and can easily be integrated into manu- facturing processes as feeders.

Despite many advantages cited above, there are certain limitations/disadvantages of pneumatic convey- ing systems. These are:

1. The types of materials suitable for pneumatic conveying is limited to materials which are dry, granulated, pulverized, crushed etc. and essentially free flowing.
2. Friable or too abrasive materials are not suitable to be transported by pneumatic conveyors.
3. The movement of transportation is fixed (uni-directional).

4. Relatively high energy consumption per unit weight of materials transported.
5. The length of pneumatic conveyors are limited. Vacuum systems are limited to 500 m while high pressure systems up to 2 kms or marginally more.

Types of Pneumatic Conveyors

Pneumatic conveyors are broadly classified into following three groups, based on application:

A. Pipeline Conveyor.

B. Air-activated Gravity Conveyor (Airslide).

C. Tube Conveyor.

HYDRAULIC CONVEYORS

Definition and Uses

Moving bulk materials along pipes or channels (troughs) in a stream of water is called **Hydraulic conveying**. The mixture of materials and water is termed as **pulp**. Pump is used for conveying of pulp through pipe under pressure. In channels the conveying takes place down the inclination due to gravity.

A hydraulic conveying system generally consists of a **mixer** where the material and water is mixed to form the requisite pulp. Depending on starting size of the bulk material, the materials may have to be **crushed / ground** in a **crushing plant** and **screening facility**. The prepared pulp is then pumped by a suitable **pumping** and **piping system**. In certain installation a suitable **recovery system** may be incor- porated at the delivery end for dewatering the material.

Hydraulic conveyors are used in many industries, mining operations and construction works. Some of the popular uses are to dispose ash and slag from boiler rooms, deliver materials from mines and sand and water to fill up used mines, to remove slag from concentration plants, to quench, granulate and convey furnace slag to disposal points, to move earth and sand in large construction projects and for land filling etc. A typical hydraulic conveying arrangement is shown in Fig.7.2.1.

Advantages and Disadvantages

The advantages of using hydraulic conveyors are:

(i) High capacity of materials can be conveyed over a considerable length (tens of kilometers).

(ii) Comparatively simple and low running cost equipment are used.

(iii) Conveying can be combined with other processes like cooling, quenching and granulating of molten slags, washing etc.

(iv) Flexibility in selection and subsequent modifications to route.

(v) The conveying process is generally safe and easily controllable.

(vi) Low maintenance costs.

However, there are a few limitations and disadvantages associated with a hydraulic conveyor. Some of the major ones are:

(i) The materials that can be handled are quite limited, only smaller sized bulk materials which do not react or get dissolved in water can be conveyed in a hydraulic conveyor.

(ii) Cannot be used in cold conditions when water may freeze.

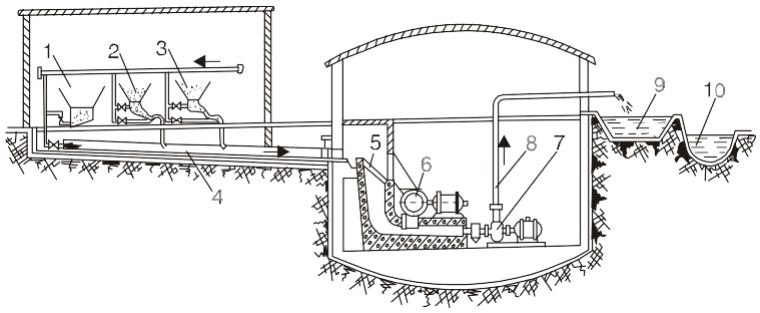
(iii) Increased humidity when operating in close environment.

(iv) Disposal or recirculation of water is often difficult and / or costly.

(v) Crushing and mixing are added power intensive operations.

(vi) Degradation of some materials due to attrition.

(vii) Choking of pipelines particularly at bends / fittings.



1-slag hopper; 2 and 3-ash hoppers, 4-trough, 5-grid, 6-slag crusher, 7-pump,8-pulp line, 9-dump tank, 10-water basin

Fig. 7.2.1. Arrangement of hydraulic installation for slag and ash disposal from power station boiler room

3 INDUSTRIAL TRUCKS

COURSE OBJECTIVES: To provide knowledge on Industrial trucks.

SYLLABUS:

Unit-3 Industrial Trucks

Industrial trucks introduction and types, Purpose of hand trucks, Tractors and trailers, Self-propelled trucks and fork trucks, Automated guided vehicles Theory.

LEARNING OUTCOMES:

Students will be able to

- understand the basic working principles of various industrial ttrucks.
- select appropriate truck for appropriate application.

Industrial vehicles/trucks is one of the most common group of materials handling equipment used in industry as well as in day to day distribution of goods in warehouses, large stores, transport depots etc. In this chapter, operation and constructional features of some of the common types of industrial trucks will be discussed. The adjective "industrial" used before this group of vehicles / trucks is to distinguish these from other group of vehicles like bus, lorry, truck etc. used for transportation of man, live stock or goods.

The entire range of industrial vehicles/trucks are generally sub-classified into two groups viz. **non- powered truck**, (also called **hand trucks)** and **powered trucks**.

The powered trucks can be further subdivided into following three subgroups, for convenience of discussion:

(a) Power Truck.

(b) Forklift Truck.

(c) Tractor.

3.1 HAND TRUCKS

Hand trucks, as the name implies, have no source of motive power, these are generally moved manually or are attached to other powered moving equipment/units. Hand trucks are classified into three sub groups (*i*) **2-Wheel hand truck**, (*ii*) **multiple-wheel hand truck** and (*iii*) **Hand lift truck**.

3.1.1 Two-wheel Hand Trucks

3.1.2

These are generally used for moving unit or unitized loads like bags, barrels, boxes, cartons, bales, cylinders etc. by pushing the truck manually.

Basically it consists of two long handles fixed by a number of cross bars which from the frame to carry the load. Two wheels mounted on an axle is fixed on far end of the frame. Two short legs are generally fixed to the two handles at the other end to allow the hand truck to stay in a horizontal position during loading and unloading of the truck. Constructional feature of a common 2-wheel hand truck is shown in Fig. 3.1.1.

1. Handle 2. Side rail 3. Leg 4. Leg brace 5. Top cross- bar 6. 3rd crossbar 7. 2nd cross- bar 8. 1st crossbar 9. Nose 10. Axle brace 11. Axle 12. Pressed steel wheel 13. Retaining ring 14. Axle bracket 15. Nut, bolt and lock washer

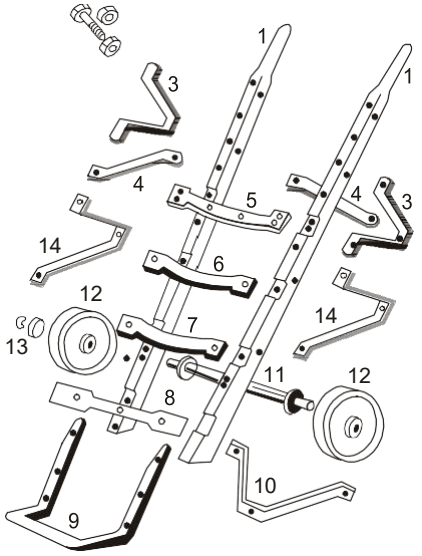


Fig. 3.1.1. Parts of common 2-wheel hand truck

Different varieties of 2-wheel trucks are in use based on the type of loads to be handled. Some of these, which are variations of the basic design, are illustrated in Figure 3.1.2 below indicating the type of load they are used for.

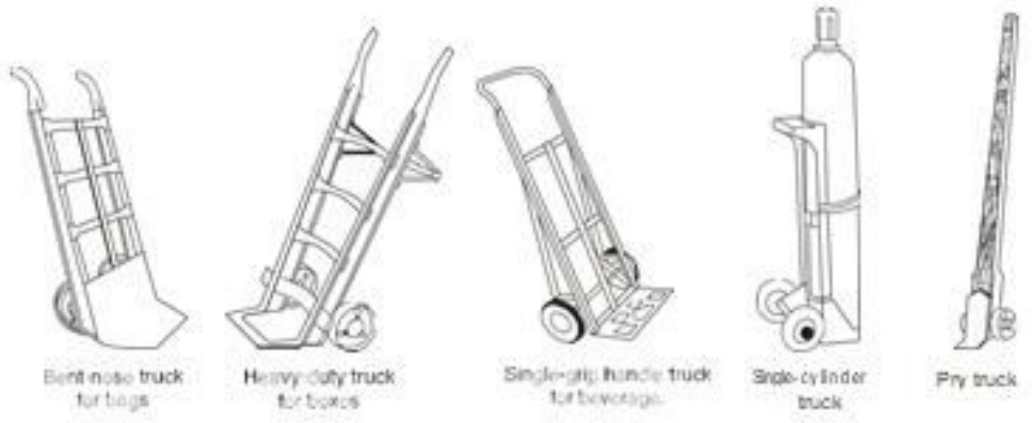


Fig. 3.1.2. Different types of 2-wheel hand trucks

Pry trucks having a crowbar nose, pry up a heavy load and roll it away. These are used for loads too heavy for ordinary 2-wheel trucks. They are often used in pairs by two men.

3.1.3 Multiple-wheel Hand Trucks

These trucks generally consists of a platform or framework mounted on 3 or 4 or more number of wheels. The truck is generally provided with a handle for pushing or pulling the platform. Certain trucks are provided with no handle or detachable handle.

Trucks under this subgroup can be classified in the following individual equipment:

Dollies: These units consists of a wooden or metallic low platform or frame of different shapes (rectangular, triangular or circular) and sizes depending on the load to be carried. The frames are pro- vided with different numbers of wheels, fixed and / or swivel caster type. No handle is provided. These are moved by pushing the load itself. Fig. 5.1.3 shows some of the different design of dollies.

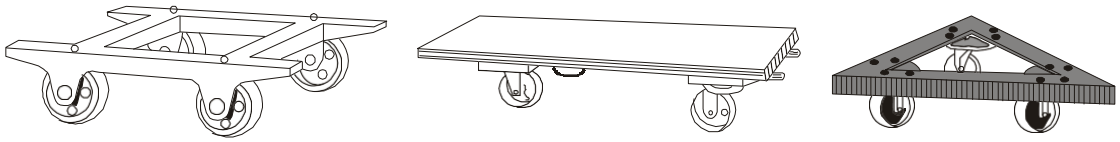


Fig. 3.1.3. Different designs of dollies

Platform Trucks: These are basically larger version of dollies in which metallic frames are generally of rectangular shape and produced in many sizes in light, medium and heavy-duty construction. Handle at one or both ends are provided for

pushing. There are two basic chassis construction from the point of view of wheel arrangement: (*a*) **tilt or balance type** which have rigid wheels at the center of the platform and set of one or two swivel casters located at two ends of the platform permitting maneuverability. (*b*) **non tilt type** where the rigid wheels are at one end and the swivel casters, usually smaller in size, located at the other end, so that all the wheels are active always (Fig. 3.1.4). The plat- form may be provided with corner posts or various types of steel slat racks and frames to avoid slippage / spilling of the load (Fig. 3.1.5). Platform trucks may be built with extra reinforcement and provided with suitable coupler so that they may be used for light-duty trailer service or towline conveyor system.

Fig. 3.1.4. Not tilt type platform truck

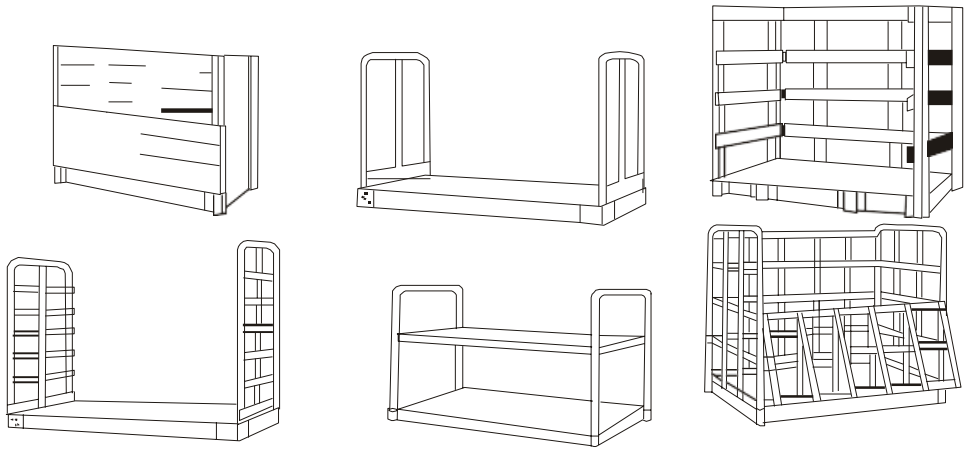


Fig. 3.1.5. Various types of rack bodies used on platform trucks

Semi-live skid platform: These are basically flat platforms with two load wheels on one end and two legs at the other. The skid platform with load is activated by a lift jack, which is a long handle with a pair of wheels and a hook. The hook engages with a coupling at the leg end of the platform and gives a jacking or prying action to lift the legs from ground/floor. The unit thus becomes a 3 wheel platform truck. Fig. 3.1.6 illustrates a semi-live skid platform.

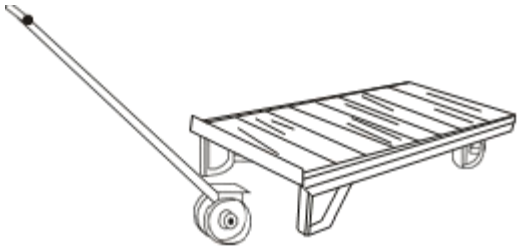


Fig. 3.1.6. Semi-live skid platform

3.1.4 Hand Lift Trucks

These hand trucks are provided with a mechanism of lifting its platform, which can be rolled under a pallet or skid, and raised to lift the pallet or skid with load to clear the ground and then move this load from one place to another. Depending on the lifting mechanism, these are grouped into hydraulic or mechanical type. Hand lift trucks are widely used in small to medium sized manufacturing industries using pallets, skids and/or containers.

Hydraulic lifting mechanism: This consists of a hydraulic ram (single acting cylinder), an oil storage vessel and a plunger pump. The handle of the truck is connected to the plunger of the pump though suitable mechanism, such that when the handle is moved up and down, the pump forces a certain quantity of oil into the ram which through suitable linkage mechanism raises the platform with load. Capacity range of hydraulic hand lift trucks vary between ½ ton to 10 tons. The platform is lowered by releasing a flow control valve to allow the pressurized oil to go back to tank, and the ram is retracted by the load itself.

Mechanical lifting mechanism: This mechanism is operated by a system of levers. The plat- form is raised by actuating a handle, which in turn, raises a pawl that falls into a slot or groove. Lower- ing is accomplished by releasing the pawl. There are single stroke, low-lift mechanisms also. Capacity of mechanical hand lift trucks is generally limited to 1 ton.

Both hydraulic and mechanical hand lift trucks are further classified, based on general constructional features, into: (*a*) **pallet,** (*b*) **platform** and (*c*) **special types.**

(a) A **hand pallet truck** is used for handling pallets. It consists of two strongly built metallic fingers, popularly called forks, connected at one end to give a U-shape. The lifting mechanism is housed at this end. At the outer ends of each fork a wheel is provided, which acts in accord- ance with the lifting system. The connected end is mounted on a pair of large sized wheels which can be steered. Fig. 3.1.7 shows photographic view of hydraulic hand pallet trucks. The Fig. 3.1.8 shows typical operation of the truck where the forks are introduced inside a pallet and the forks are raised with the pallet. Fig. 3.1.9 shows line diagram with important dimensions of such a truck. IS:5007-1988 lays down

recommended dimensions of fingers (forks) of hand pallet trucks in line with recommended pallet dimensions.

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Fig. 3.1.7. Hydraulic hand pallet truck Fig. 3.1.8. Operation of a pallet truck

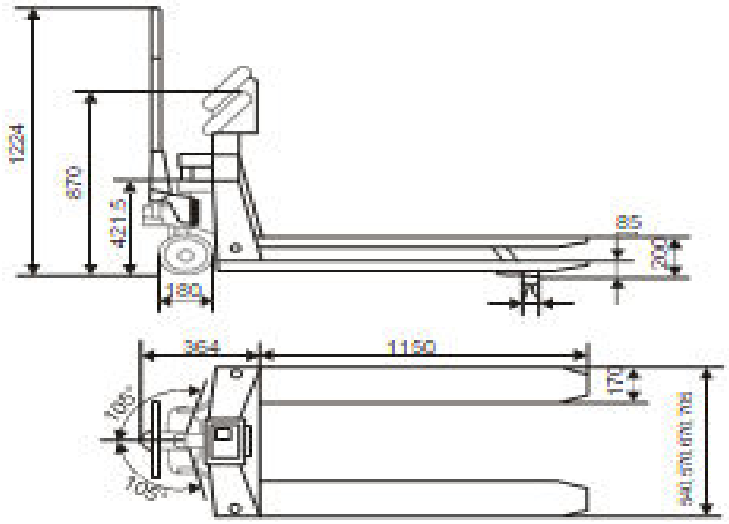


Fig.3.1.9. Typical dimensions of a pallet truck

(b) **Platform lift truck** is similar to a pallet truck excepting that instead of two forks it has a platform, which can be raised. The platform may be solid or of open frame structure. These trucks are generally used with skids. Load capacity and nominal sizes of standard trucks of this kind vary within ranges : ½ ton to 3 tons, 450 mm to 680 mm width, 750 mm to 1800 mm length and lift heights from 150 mm to higher values (see Fig. 3.1.10).

(a) (b)

Fig. 5.1.10. Scissor design platform lift trucks

Mechanical type (*a*) or hydrautic type (*b*)

(c) Lifting feature has been utilized in designing various types of lifting trucks for handling various specialized load in industries. All these are called **special hand lift trucks** as a group. A coil (reel) handling hydraulic lift truck is an example.

3.2 POWER TRUCKS

When a vehicle / truck contains its own source of motive power, it is called a power truck. Power trucks are divided into several categories of equipment. The wide varieties of powered industrial trucks have been classified into the following six groups in BIS specification number IS 7217:1990 and IS 4660:1993:

(i) mode of action
(ii) power source
(iii) type of wheel
(iv) mode of control
(v) height of lift
(vi) mode of travel

Out of these, a few common categories have been discussed below:

3.2.1 Fixed Platform Truck (powered)

These are powered (battery, diesel or gas operated) industrial trucks having a fixed level, non- elevating platform for carrying load. Materials to be moved have to be loaded and unloaded to and from the platform by hand, hoist or carne. Capacities of these trucks can go upto 40 tons. Smaller capacity models are called **load carriers**. Operator normally stands on the truck and runs it. Platform trucks are particularly useful for occasional handling of heavy

loads.

Variations of normal platform truck are (*i*) **drop platform truck,** (*ii*) **drop center baggage truck** in which the central platform between two sets of wheels is very close to floor. Fig. 3.2.1 shows photo- graphic views of different types powered platform trucks.

Fig. 3.2.1. Different designs of platform truck.

3.2.2 Platform Lift Truck (powered)

These equipment are a particular type of powered platform truck, whose platform can be raised and lowered to handle loads on skids. Range of lift of the platform may be "low-lift", upto 300 mm or "high-lift", over 300 mm.

3.2.3 Pallet Lift Truck (powered)

These are similar to platform lift truck in which the platform is replaced by forks to work also with loads on pallets. These are basically forenummer of fork-lift trucks. Low-lift models (Fig. 5.2.2) are used for movement of materials only while the high-lift models are used for stacking of pallet/skids one over another or in storage racks. Different variations of high-lift truck have been built. Some of these are:

Fig. 3.2.2. Pallet lift truck (battery)

(a) Reach truck: In this design the forks can reach out on a pantographic

mechanism which permits the forks to travel forward to engage load, lift it, and then retracts towards the mast before travel starts. These are of great use for warehousing and loading/unloading vehicles.

(b) Side loader truck: In this design the operational direction of the forks is at right angles to the movement of the truck. The major benefit of the design is that the truck need not turn into the load. The truck can move along a narrow aisle of a warehouse, and the fork can load / unload from the rack directly. These are particularly used for narrow aisle working and also for storing long loads (pipes, structural steel, logs etc.). Fig.3.2.3 shows a side loader truck. It needs specially trained operator.

Fig. 3.2.3. Narrow aisle side loader

3.2.4 Walkie Truck

This term implies different types of powered trucks described above, when the operator walks with the truck and operates it by means of controls available on the truck handle. Fig. 3.2.4 shows a walkie pallet truck and a walkie stacker truck.

Walkie stacker

Walkie pallet

Fig. 3.2.4. Walkie trucks

Walkie trucks are smaller, lighter and slower than rider-types, generally powered by battery. These are designed to fill the gap between hand trucks and powered rider-trucks in which the operator stands/sits on the truck.

3.2.5 Straddle Carrier

This is a self-loading powered truck for movement of long and heavy loads including shipping containers. The truck consists of a inverted "U" shaped frame having wheels mounted on outside of the frame. The truck can straddle a load / loads, picks it up with hydraulically operated load carrying shoes, mounted inside the frame, and then move with the load and unload it very quickly at a desired location. Capacities up to 40 tons is common (Fig. 3.2.5).

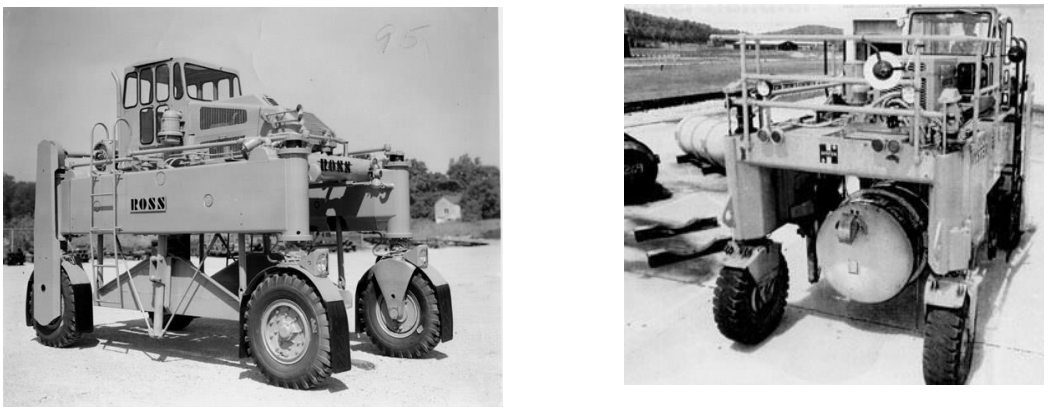


Fig. 3.2.5. Straddle carrier

3.3 FORK LIFT TRUCKS

Amongst the powered industrial vehicle/truck family, most versatile, useful and widely used equipment is industrial lift trucks, popularly called forklift trucks (FLT in short). These are self loading, counterbalanced, powered, wheeled vehicles, with the operator seating on the vehicle, designed to raise, move and lower load on forks or other attachments fastened to a mast which is fixed in front of the vehicle to allow lifting and stacking of loads. forklift trucks are used for lifting, lowering, stacking, unstacking, loading and unloading and maneuvering of medium to large weight, uniform shaped unit loads, intermittently. However, the limitations of these equipment are (*i*) usually requires pallet/skid/ container, (*ii*) requires skilled operator, (*iii*) equipment needs maintenance facility, (*iv*) capacity of these equipment vary from 1ton upto about 60 tons, (*v*) slow travel speed (10-15 kmph) , (*vi*) suitable for short hauls (hundreds of meters).

Other features of a forklift truck are:

(i) The source of power is petrol/diesel or LP gas engine or a battery driven motor.

(ii) The mast may be tilted forward or backward within a range, for better stability during movement with load and also to facilitate loading and unloading. In a particular design the mast may be moved outboard and inboard on tracks laid over the chassis of the truck.

(iii) The mast may be a single mast or may be telescoping in design which allows high lifting of the load for trucks that must run through limited head room areas.

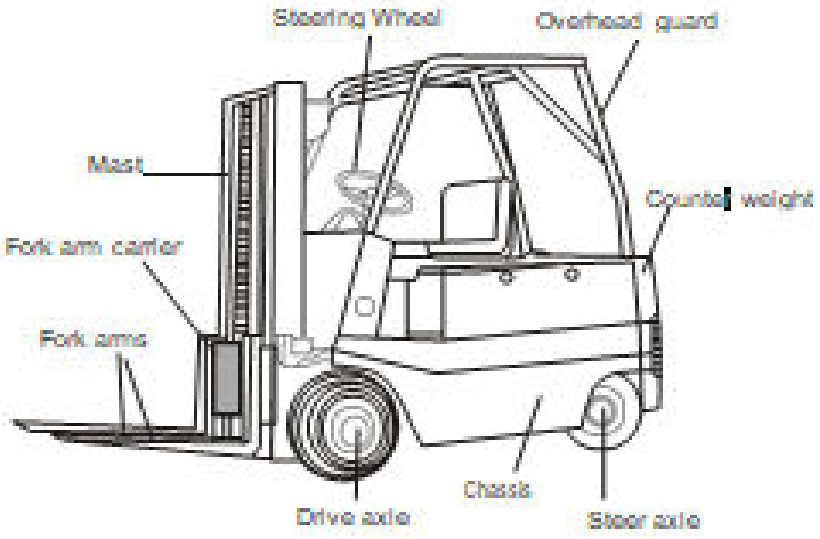
(iv) In certain designs, the forks are independently retractable outboard and inboard through pantograph mechanism. Loads are picked up and placed while forks are outboard but are moved inboard for greater stability during movement.

(v) The operation of the mast and movement of the forks (or any other attachment) are through a hydraulic power pack.

(vi) The body of the truck is purposely built heavy which act as counter load while lifting loads on forks/attachments.

(vii) Solid rubber tyres are provided for operation in different floor conditions. The rear two wheels are steered for manipulation of the forks/attachment fixed in front of the truck.

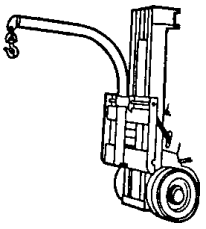
Fig. 3.3.1 is a line diagram showing major parts of a forklift truck.



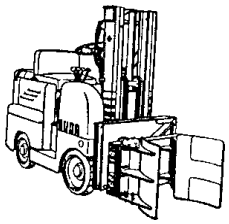
5.1.2 FLT Attachments

Forks of a forklift truck are one of the most common attachments. A pair of forks is used for working with skids, pallets, containers and box shaped loads resting on legs/ packers. However, a wide variety of devices have been designed for attaching to lift trucks to make them useful for many different tasks. Some of the common types of attachments are listed below with their names, short description of their special use and with some of their sketches.

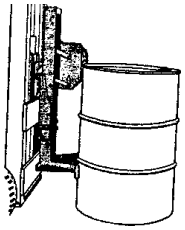
(i) *Boom:* This attachment is fixed with respect to the fork carrier. At the end of the boom, a chain pulley block is provided for lift- ing loads using the hook and slings.



(ii) *Clamp:* These are hydraulic devices for picking up loads like bales, barrels, cartons etc. by gripping them with opposing adjustable plates.



(iii) *Drum grab:* For drum-handling in vertical position.

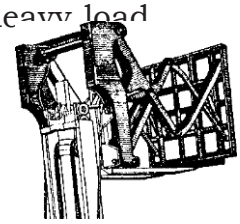


(iv) *Crane:* A crane mechanism is attached to FLT.

(v) *Die handler:* Platform for carrying heavy load

(vi) Drop-bottom container

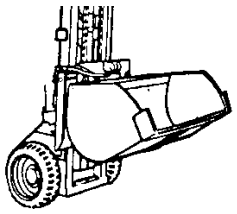
(vii) Load inverter cum pusher



(viii) *Load pusher* (pallet un-loader)

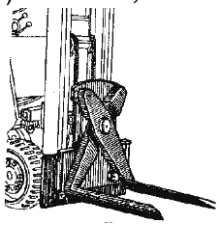
(ix) *Ram:* Fitted to the lift carriage for lifting cylindrical load with a hole (coil etc.)

(x) *Roller platform*



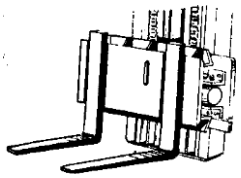
(xi) *Shovel (scoop):* A scoop fitted to the carriage for scooping and carrying loose load.

(xii) *Special forks:* (*a*) brick, (*b*) block, (*c*) extended,(*d*) scissor,

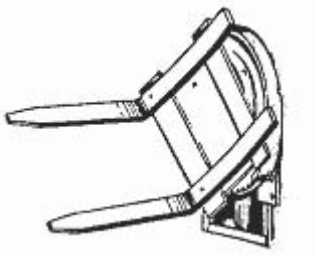


(xiii) *Vacuum:* For handling light and fragile objects by a set of suc- tion pods.

(xiv) *Side-shifter:* With this attachment, a load on truck can be moved from 100 to 150 mm on each side. This helps enormously in storing loads, without any damage to storage racks and merchandise.



(xv) *Rotator:* This is used in conjunctio with a clamp or fork attachment rotate load or for safer grip durir movement with load.



Specifications of FLT

There are different operating parameters or specifications based on which suitability of a particu- lar FLT is determined. The following is a list of major specifications from operational point of view:

(a) Rated capacity (1000 kg, 2000 kg etc.) at specified load center.

(b) Power sources (gas, diesel, battery etc.)

(c) Turning radius.

(d) Physical dimensions (length, width, height)

(e) Mast height

(f) Lift height.

(g) Mast specification (single or telescoping, tilting or non-tilting, retractable or not.)

(h) Travel speed.

(i) Lifting speed.

(j) Floor clearance.

(k) Free lift (movement of fork without mast movement).

(l) Retractable fork or not.

(m) Fork size (length, width, maximum gap between forks etc.)

(n) Attachments provided.

Other important technical specifications are : (*i*) motive power (h.p. rating), (*ii*) power transmission system (disc clutch, fluid coupling etc.), (*iii*) tyre specifications, (*iv*) battery and charger specification etc.

TRACTORS

Tractor is a vehicle, having its own source of motive power, used as a prime mover to haul i.e. to give motion to another or a group of other vehicles which do not have their own motive power, such as trailers, semitrailers, transfer cars etc.

Tractors are used in a wide field of activities, starting from agriculture to earth-moving, municipal waste handling, construction and industries. A tractor may be fitted with different attachments to do different jobs like sweeping sidewalks, plough snow, excavate ground, scoop loading, bull dozing etc.

Industrial Tractor

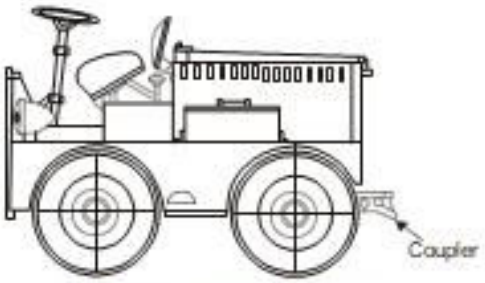
The industrial tractors are generally grouped into (*i*) wheel type which are primarily used for movement of one or more trailers for interplant or intraplant transportation, and (*ii*) crawler type which are mostly used in outdoor and storage yard service at slow speeds and for short hauls.

The most important specification of a tractor is it's **draw-bar pull rating.** According to this rating, they are classified as small (100 kg normal to 500 kg), medium (250 kg normal to 750 kg), large (1.0 tons normal to 5 tons maximum) and extra large (up to 35 tons). Other specifications are physical dimensions, weight, horse-power, number of wheel drive, front or rear wheel-steer, walkie or rider type etc.

The small and medium tractors are often battery operated walkie type. However, an "electronically guided type" of tractor requires no operator which follows a white line painted or a wire embedded in the floor. These are used for point to point pick-up and delivery of trailers. These may be programmed for automatic decoupling of trailers and give signals of arrival at two ends. Large and extra large tractors are powered by an internal combustion engine fueled

by diesel or gas and are essentially rider type. A two-wheel tractor depends on working in conjunction with the attachments or load carrier for balance. Steering of these tractors is done by pivoting about one of the two wheels, thereby resulting in very small turning radius *i.e.*, high maneuverability of these tractors.

A coupler is secured to the rear of the tractor body for quick coupling and uncoupling of the trailers/ transfer cars.



Battery operated tractor without cabin

Typical farm tractor

Tractor fitted with attachments on both ends

Crawler tractor bulldozer

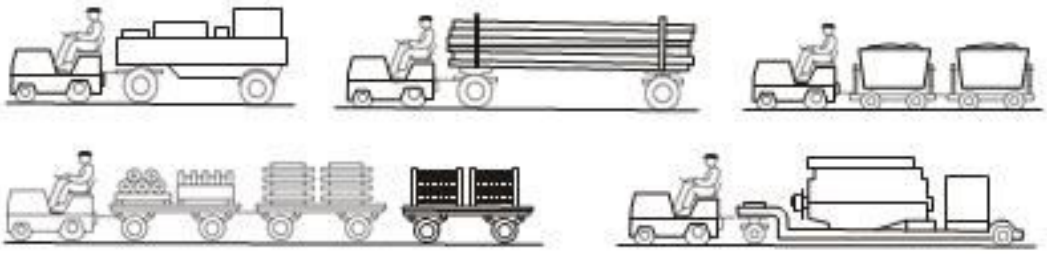
Trailer

Trailers are load bearing wheeled vehicles or cars without any motive power, designed to be drawn by a tractor or truck. Trailers are classified as semitrailer and full trailers.

A semi trailer is a truck-trailer having one or more axles and constructed so that a part of its weight is carried by the truck/tractor. A full trailer is constructed to carry almost all its weight on its own wheels. Number of axles may be one or more. The tractor has to give only the pulling force for its motion.

More than one trailer may be pulled at a time by a tractor when it is called as

a tractor-trailer train. Trailers can be of different shapes and sizes.



Use of tractors with different trailers

Single axle box type trailer

Tractor with semitrailer

4 Auxiliary Equipment

COURSE OBJECTIVES: To provide knowledge on Auxiliary Equipment.

SYLLABUS:

Unit-4 Auxiliary Equipment

Hoppers and Gates, Auxiliary Equipment, Feeders – Chutes, Applications and Advancements.

LEARNING OUTCOMES:

Students will be able to

- understand the basic working principles of various industrial trucks.
- select appropriate truck for appropriate application.

There are many other equipment or gadgets which are used in the field of materials handling but are not directly or independently used for movement of materials, and hence cannot be termed as materials handling equipment. But these very large group of items are used in conjunction in with conventional materials handling equip- ment to make them function better, more efficient, more versatile. Without some of these, certain func- tions of the handling equipment would not be possible at all. These equipment or gadgets are called auxiliary materials handling equipment.

There exist innumerable number of auxiliary equipment. Many of these auxiliary equipment are of standard design and specifications and built by specialist manufacturers. There are also many auxil- iary equipment which are application specific, and developed by the user organisations.

Use and working principle of some of the common auxiliary equipment have been briefly discussed below.

GATES

Gates are used in conjunction with various bulk materials storage hoppers (bins, silos etc.) to close or open the outlet and adjust discharge of materials in batches from the hoppers. According to the principle of operation, gates are divided into three main groups (i) slide gates, (ii) trough gates and (iii)pivoted gates.

Slide Gate is a flat plate valve which slide in guides, and is actuated by hand operated rack-pinion or lever mechanism. The design is simple but under material load, it may be difficult to move gate, the slideways may be blocked and lumps of material has a tendency to wedge in when gate is closed. These gates are, therefore, generally used with small lumped, free flowing materials and where gate operation is infrequent.

Trough Gate consists of a trough hinged at the hopper outlet. When trough is in raised position, it keeps the outlet closed, but when lowered, it allows flow of material using the trough as a chute. Trough gates exclude jamming and allow control of flow. Its large height projecting below hopper outlet and the force required for closing are the disadvantages.

Pivoted Gate is a part of cylindrical plate pivoted about its horizontal axis, which can be pivoted easily up and down to close or open the hopper outlet. The gate may be made of one or two sectors. This type of gate can be operated with less effort but not good for controlling material flow rate.

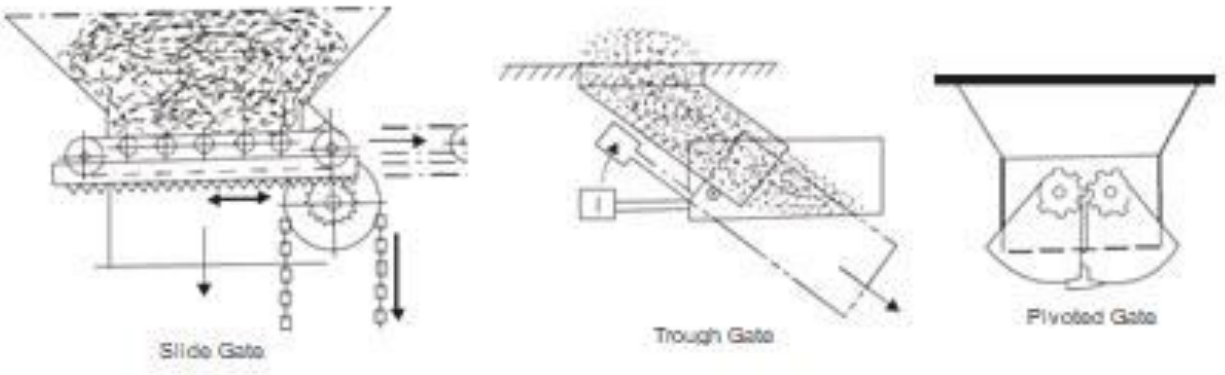


Fig. Schematic diagrams of gates

FEEDERS

Powered feeders are used for continuous and controlled flow of bulk materials from a storage to a MH equipment or to a processing equipment.

Bulk material feeders are generally installed near the outlet of a material hopper and serve to unload the hopper in a controlled rate. Desired flow is achieved by varying infinitely the rate of operation of the loading element.

Different types of feeders are used primarily depending on the properties of the materials, like lump size, flowability, specific weight, and also on flow rate, hopper shape etc. The major types are (i) belt feeders (ii) apron feeders, (iii) screw feeders (iv) oscillating feeders, (v) vibrating feeders and (vi) rotary disk feeders.

Another type of feeders are used for feeding components one by one, from a large quantity of small components, into the workplace or the processing machine. These are called bowl feeders.

Some of these bulk material feeders and component feeders have been briefly described below:

Belt Feeders are small length flat belt conveyor, the working side of belt being supported by closely spaced idle rollers, and no support for the return belt. The conveyor is provided with stationary skirt boards. Belt speed is low. Belt feeder is put just below the outlet of a hopper with a flow control valve which regulates flow. Belt feeders are used for granular, small sized and less often for medium lumped materials. Fig. shows the basic scheme of a belt feeder.

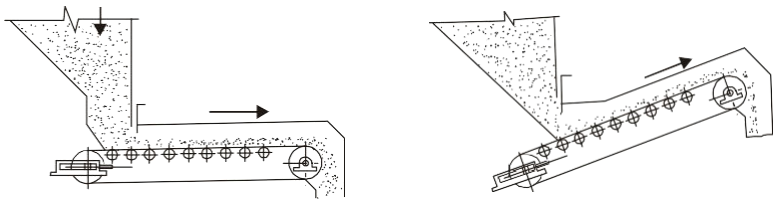


Fig. Belt feeder, (a) horizontal, (b) inclined

Apron Feeders are similar to belt feeders, may be installed horizontal or inclined, where the belt conveyor is replaced by an apron conveyor. An apron feeder is directly placed under the outlet of a hopper without any valve. The speed of the feeder is infinitely variable from 0.05 to 0.25 m/sec to control discharge flow rate. This type of feeder is generally used for heavy, medium to large sized materials. Fig. -shows the schematic diagram of an apron feeder.

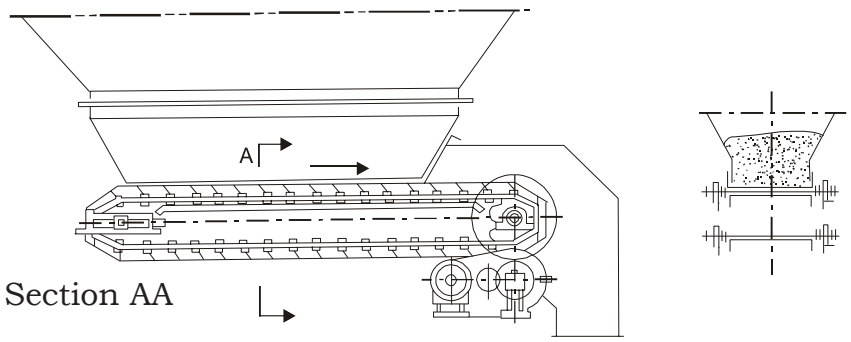


Fig.. Apron feeder

Screw Feeders are used for materials which do not deteriorate on crushing. These are essentially small length screw conveyors.

Oscillating Feeders consist of a horizontal or slightly declined table with side boards, placed below the hopper outlet. The table is given a reciprocating motion (50 mm to 175 mm) at a frequency of ranging from 20 to 60 strokes per minute. In the forward motion it carries some material forward, but during return stroke the material cannot go back due to dam of material from the hopper, and, therefore, spills over the front edge of the table.

Vibrating Feeders. A vibrating feeder consists of a trough or tube mounted on a stiff base frame with springs in between to convey bulk material through vibration. Inclination and stiffness of springs determine the vibrating angle and position of resonance. The feeding of material takes place on the micro-throw principle.

Vibratory feeders are classified based on the source of vibration exciters which are either (i) electromagnets or (ii) mechanical exciter.

In **electromagnetic vibrating feeders**, the frequency of vibration is 50 Hz, and the feeding rate is controlled by vibration amplitude by controlling voltage across magnet through thyristor controller.

In **mechanical vibrating feeder**, either direct force exciters or unbalanced motor excit- ers are used. Direct force exciter comprises of two shafts fitted with unbalance masses, rotated in opposite direction through a set of gears and generate linear motion. In the later system, two unbalanced motors are used for each feeder for generating linear motion. In both the systems, both amplitude and frequency is varied simultaneously by varying the speed of the exciter motors.

Vibro feeders are available for either base mounting or suspension mounting arrangement. These feeders handle all types of bulk solids from very large lumps to fine grains, wet or dry, hot sinter, etc.

Fields of application for electromagnetic feeders include controlled feedings from bins to scales, mills, filling devices, crushers, process equipment, dryers, coolers etc. Application of mechanical vibro feeders include sinter and palletising plant, deep bunker discharge, blast furnace burden plant, for dust feeding under electro filter, feeding rotary kilns, sand feeding in foundry, knock-out stations in foundry,

sand and gravel industry, cement, lime and gypsum plant, mining industry (coal, ore), chemical industry, food processing etc.

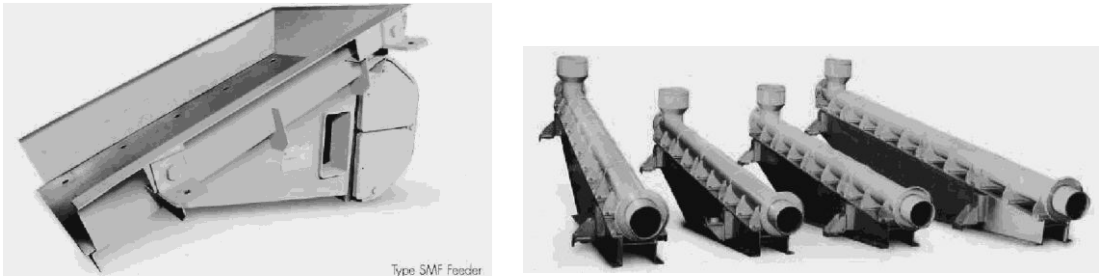


Fig. Electromagnetic vibrating feeders

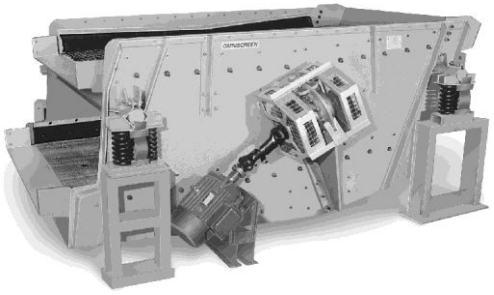


Fig. Mechanical feeder with direct force exciter

Disk Feeder consists of a motor driven disk shaped table, a telescopic spout fitted with the outlet of the hopper above, and a scraper blade which can be radially fed in or out on the disk. The table is rotated slowly, telescopic spout is adjusted to keep desired gap between spout and table and then the blade is adjusted in position to allow a definite amount of the material formed below spout mouth, to be scarped and fed below.

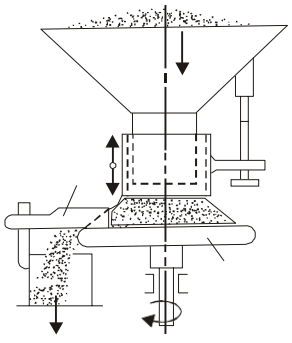


Fig. Disk feeder

Bowl Feeders: Rotary or vibrating bowl feeders are used for feeding small components into high speed processing equipment. Various designs of feeding bowls are used to suit different sized and shaped components. A few schematic diagrams are shown below.

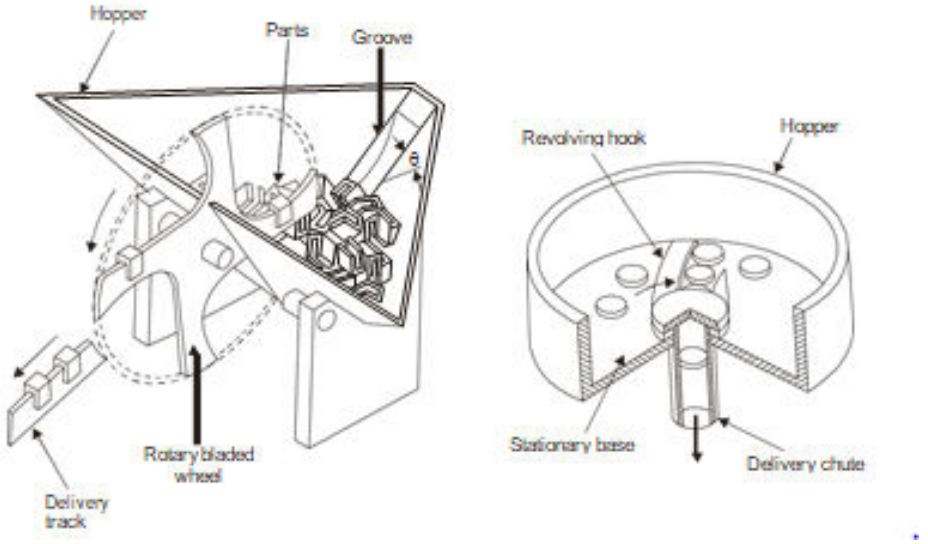


Fig. Bowl feeders for feeding components

CHUTES

Chutes are inclined connections between two systems of materials handling equipment or production equipment, in the form of troughs of definite geometrical cross section or pipes, which convey unit or bulk load by gravity. A chute may connect two conveying mechanisms, two process equipment or may be installed between one materials handling equipment and one processing equipment.

Depending on the load to be handled, chutes are made of various size, shape and material:

Troughs: For bulk materials, rectangular or round shaped troughs are used. These may be lined by cast iron or hard plates or glass tiles for abrasive materials. Bowl feeders to processing equipment are always connected by trough like chutes to deliver the components in correct orientation to the exact location. Suitable change in cross section or cut-out left on the chute can correctly orient the components and/or discard the defective or wrongly oriented component.

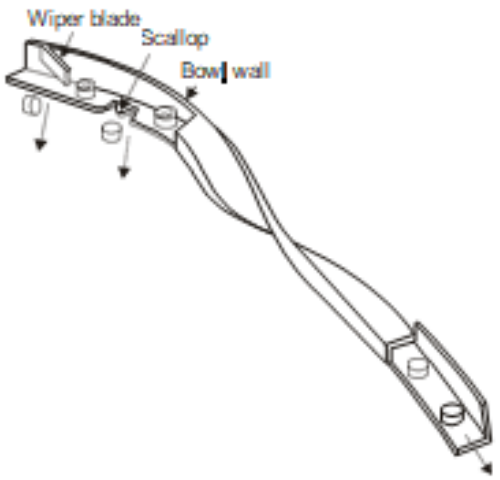


Fig. Trough chute to feed bottle caps in correct orientation

Pipes are used for dusty or liquidous materials. Swinging pipe is used to distribute the material along a circular path.

Ladders and Spiral Chutes: These are used to lower loads vertically. They retard velocity of descend and prevent landing of load with impact.

Transfer Slides: These are used to roll unit loads of round shape down an incline by gravity. They generally comprises of two rigid guides made of round or profiled steel, mounted on a framework. The loads roll over and are also guided by the two guides.

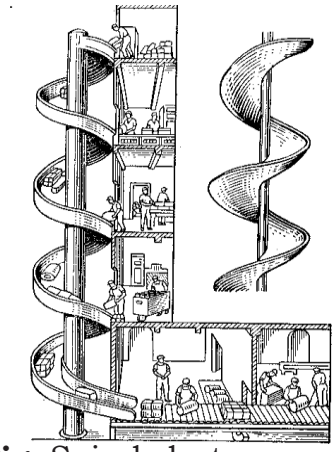


Fig. Spiral chute

POSITIONERS

Positioning is defined to be the task of orienting materials into the workplace or at point of use. It is a component of material handling at the workplace. Positioning is conventionally a manual operation performed by the operator at the processing equipment. The purpose of a positioner is to perform the positioning operation independent of the operator, as well as better, and thus achieve increased production, higher safety, less fatigue of the operator and less rejection.

Depending on the product and processing needs, various manufacturers design and fabricate the desired positioners in-house. Most of the fixtures used in workplace also act as positioners for the jobs. How- ever, some of the standard positioning equipment, which are classified under different heads, are mentioned below:

Positioning Holding Fixtures

(i) Universal vise which can be tilted horizontally and vertically, or may be positioned at any orientation through ball-and-socket joint.

(ii) Welding positioner are made as standard equipment for large and small jobs and consist of simple to complex mechanism.

(iii) Turning-roll positioner for positioning large cylindrical jobs during welding.

(iv) Magnetic bench positioner.

(v) Elevating platform can also act as a positioner for a tall job where manual work like welding, cabling, fitting etc. has to be done.

Manipulators and Chargers

Forging manipulators, furnace chargers, cake pushers in coke ovens, roller table deflectors and manipulators (refer section 6.6.2) are examples of above type of positioners.

Tables, Lifts, Bridges and Ramps

(i) Positioning tables are essentially tables whose height can be adjusted to hold job at the level at which it can be manipulated easily. Examples are sheet feeding table, die-handling table, spring operated tray positioners etc.

(ii) Hydraulic lifts are common positioning devices for lifting and lowering a heavy object. The operator can easily control this. These are used in any process and manufacturing plants, departmental stores, vehicle service centre etc.

(iii) Bridges are specially designed platform to bridge the gap or height difference between the dock edge or surface to the carrier floor, and allow use of hand trolleys or powered trucks to load or unload materials between dock and carriers. Examples are dock board to bridge gap, dock leveler to bridge height, portable dock etc.

(iv) Ramp is a portable device for placing at the door of a carrier or building to bridge the vertical distance to the ground by a sloping runway.

5 Hoisting Appliances

COURSE OBJECTIVES: To provide knowledge on hoisting appliances.

SYLLABUS:

Unit-4 Auxiliary Equipment

Types- Description and uses of chain- Description and uses of ropes- Types and description and purpose of crane hooks- Grab buckets, lifts, Excavators

LEARNING OUTCOMES:

Students will be able to

- understand the basic working principles of various industrial trucks.
- select appropriate truck for appropriate application.

Hosting equipment are usually powered equipment used for lifting and lowering unit and vary- ing loads intermittently. In certain equipment while lifting and lowering, shifting of the load can also be accomplished, within an area known as the reach of the equipment. The primary function of hoisting equipment is transferring through lifting and lowering operations.

A variety of equipment fall under the heading of hoisting equipment starting from hoists, different types of elevators and cranes. Excepting for elevators, these equipment generally utilize a drum, wire rope, pulleys and load lifting attachments for performing the lifting and lowering (i.e. hoisting) motions.

Hoisting equipment can be stationary, portable or travelling type. Often hoisting equipment are mounted on powered vehicles like truck, rail or ship, when the movement of the lifted load is not limited to a fixed area of operation.

PARTS OF HOISTING EQUIPMENT

Chain and Chain Sprockets

The types of chains used in hoisting equipment are

(i) welded load chains and

(ii) roller chains. Welded chains are used in low capacity hoisting machines (hoists, winches, hand operated cranes etc.) as the main lifting appliance as slings for suspending load from the hook or other lifting attachments. Welded calibrated chains are employed as hand operated

chain for driving the traction wheels of hoists and hand operated overhead cranes

Welded chains are manufactured by joining one gap of individual chain links by hammer hot forging or by resistance welding of two half links. Resistance welded chains are more accurate and have increased strength.

Disadvantages of the welded chain are their

(i) heavy weight,

(ii) susceptibility to jerks and overloads,

(iii) heavy wear of the links,

(iv) low safe speed of movement,

(v) sudden failure without previous indication etc.

On the other hand the advantages are their

(i) flexibility in all directions,

(ii) possibility of using small sized pulleys and drums,

(iii) simple design and manufacturing process etc.

The diameter of welded chain pulleys or drums are, however, should not be less than 20d, where d is the diameter of rod of each link.

Roller chains are composed of plate links, hinge-jointed by pins.

Chains may be made with two plates or for heavier duty with upto twelve plates. Roller chains are used for both hand operated hoists as well as electrically driven equipment like hoists or winches for lifting heavy load at slow speeds (about 15 mpm) and in guideways.

Roller chains are superior to welded chains in many ways namely in reliability as links are made from solid plates. Roller chains have high flexibility in the plane of rotation and hence sprockets of smaller diameter may be used.

The friction in the joints are also less hence more efficient.

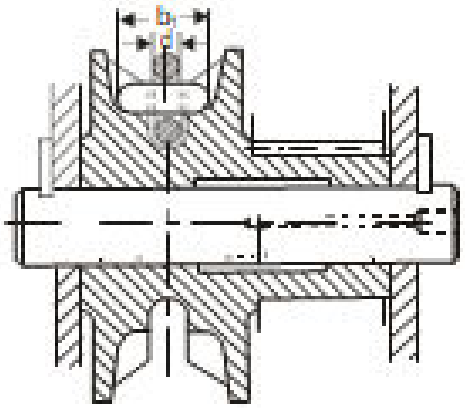
However, the major limitation of roller chain is that it cannot be used to carry weight at an angle to the plane of rotation of the links. In such a case excessive bending load of the plates tend to damage/break the pins. It is because of this drawback, the roller chains have largely been replaced by steel wire ropes in the power driven hoisting equipment.

Sprockets for welded chains:

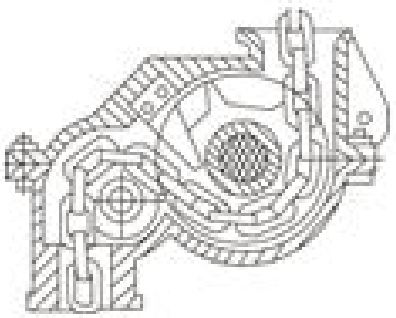
These sprockets are used in hand operated hoists and winches for driving the mechanism for hoisting load and travelling of the hoist trolleys.

These are generally made of gray cast iron and, in special cases, steel casting.

Around the periphery of the sprocket, as – cast pockets are provided which conform in shape and size to the links of the chain used. Alternate links sit at right angles to each other, as shown in Fig , and pull in the chain is transmitted through the partitions between pockets, to the sprocket. Sprockets are made with minimum number of teeth ensuring compactness and low cost. The minimum number of teeth is 4. The arc of contact between the chain and sprocket should be at least 180° to avoid jumping off of the chain. If arc of contact is less, chain guide, as shown in Fig. or a guide block is provided. Both chain and sprocket need to be lubricated to reduce frictional resistance.



Chain sprocket.

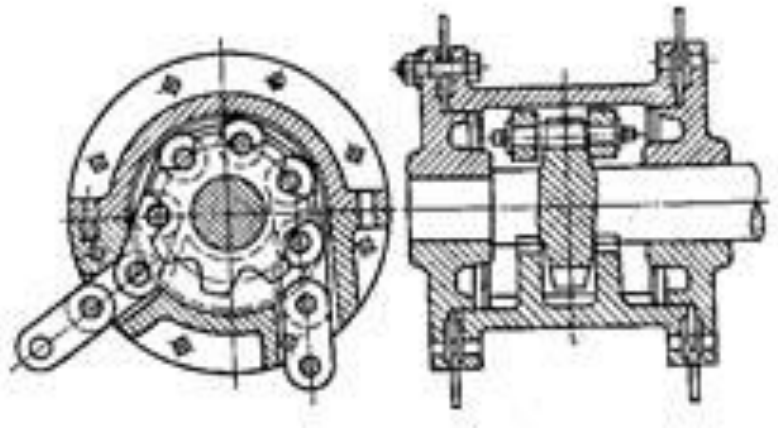


Chain guide

Sprockets for roller chains

These sprockets are also used for hand-operated hoists and winches over 10 tons capacity. Mate- rials used are cast iron, forged steel or steel castings. The teeth are machined in milling machine. Minimum number of teeth used is usually 8. To prevent the chain from slipping off the sprocket, and to ensure safe working, sometimes the sprocket with chain is enclosed in a housing, as shown in Fig. 8.1.3.

When load is lifted very high by means of a winch where chain is the pulling member, a chain collector is generally used to collect long end of the chain.



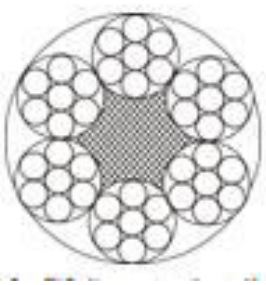
Sprocket with chain is enclosed in a housing.

Steel Wire Ropes and Drums

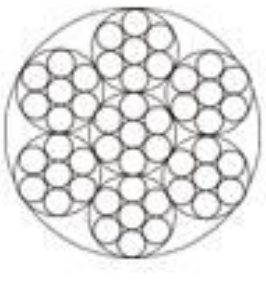
Steel wire ropes are extensively used as a flexible lifting media in hoisting machinery. The major advantages of using steel wire ropes compared to chains are the following:

- Lighter weight.
- Flexibility of operation. Load can be lifted with connecting ropes making large angles with the vertical.
- Greater reliability of operation. Rope does not give away suddenly without any notice. The outer layers of the wire ropes undergo intensive wear and always break from outside. This gives prior warning for changing of the rope before complete failure.
- Wire rope is less susceptible to damages from jerks which is very common in hoisting operations.

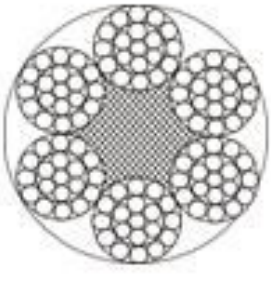
Wire ropes are made from steel wires, cold drawn and specially heat treated to an ultimate strength of 130 to 200 kg/mm2. Number of steel wires are twisted to make into a strand and number of such strands are twisted over a core made of hemp, asbestos or wire of softer steel. Constructional details and breaking strength of steel wire ropes are specified in Indian Standard IS:2266:1989, “Steel Wire Ropes for General Engineering Purposes-Specification”. Cross section of a few selected wire ropes as per above IS is shown in Fig.



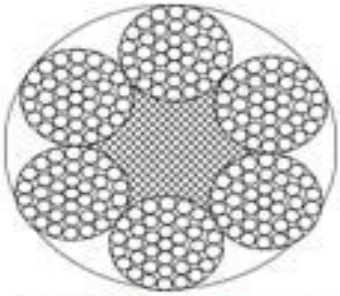
6 × 7(6-1) construction with Fibre Core (CF) 8 to 12 mm diameter



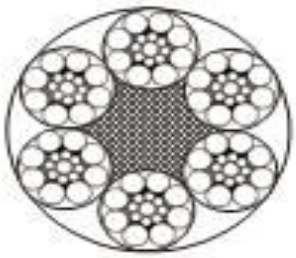
6 × 7(6-1) construction with Steel Core (CWF) 8 to 12 mm diameter



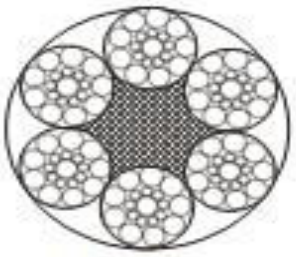
6 × 19M(12/6-1) construction with Fibre Core (CF) 8 to 52 mm diameter



6 × 37M(18/12/6-1) construction with Fibre Core (CF) 8 to 64 mm diameter



6 × 17 S (8-8-1) with Fibre Core (CF) 8 to 52 mm diameter



6 × 19 S (9-9-1) with Fibre Core (CF) 8 to 52 mm diameter

Regular lay ropes, where directions of twist of the wires in the strand is opposite to the twist of the strands, are most commonly used. In a parallel (Lang) lay rope, the twist of the wires are in same direction as those of the strands. These ropes are more flexible, less susceptable to wear, but they tend to spin when hanging freely with a load. The parallel lay ropes are generally used in lifts and hoists working in guideways (i.e. the loads cannot spin) and also as haulage ropes. Rope constructions 6 × 19, 6 × 37, 6 × 61 and 18 × 19 are commonly used for cranes and hoists.

Rope drums

The purpose of a rope drum is to store length of wire rope on the face of the drum. Wire rope under tension from the weight of the load being lifted, can be

coiled in by rotating the drum, and uncoiled by rotating the drum in opposite direction.

Life of wire rope depends on the D/d ratio and number of bends the rope has to undergo.

D = drum diameter and d = diameter of the rope. The diameter 'd' of rope is measured over a pair of opposite strands.

The minimum permissible diameter of a rope drum or pulley is found from the relation:

$$D > e_1 e_2 d.$$

Where, D = drum/pulley diameter measured over the bottom of the rope groove, mm

d = rope diameter, mm.

e_1 = factor depending on the type of hoisting equipment and its service

e_2 = factor depending on rope construction. It is generally taken to be 1for cross lay and 0.9 for parallel lay.

Pulley systems

Combination of several movable and fixed pulleys or sheaves, intended to achieve a gain in force or gain in speed, is called a pulley system. Fig. shows a few pulley systems employed for gain in force. In a simple pulley system, a single pulley is mounted one one shaft.

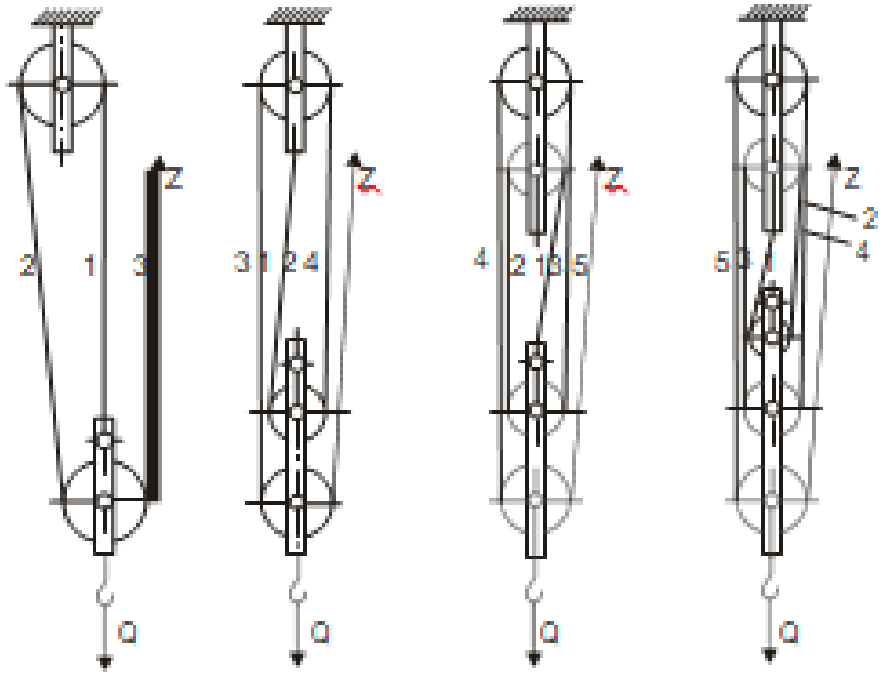


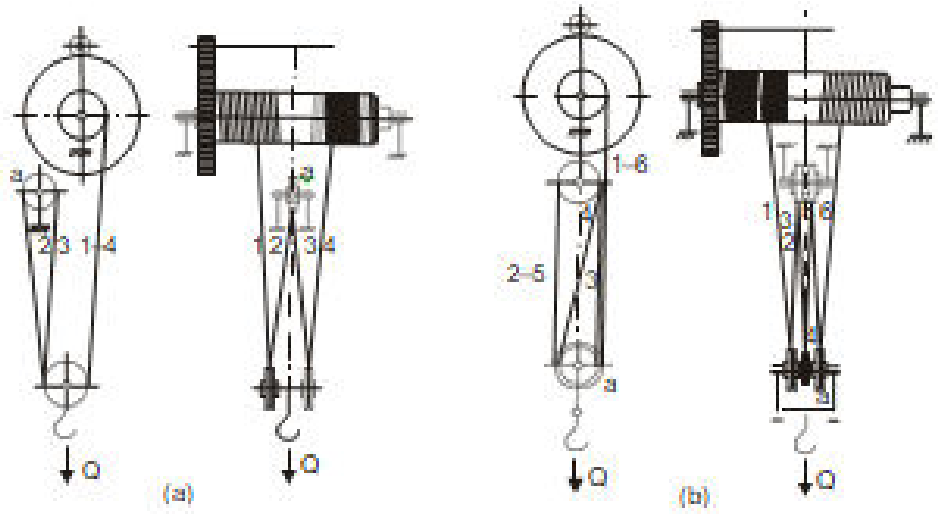
Fig. Simple pulley systems employed for gain in force

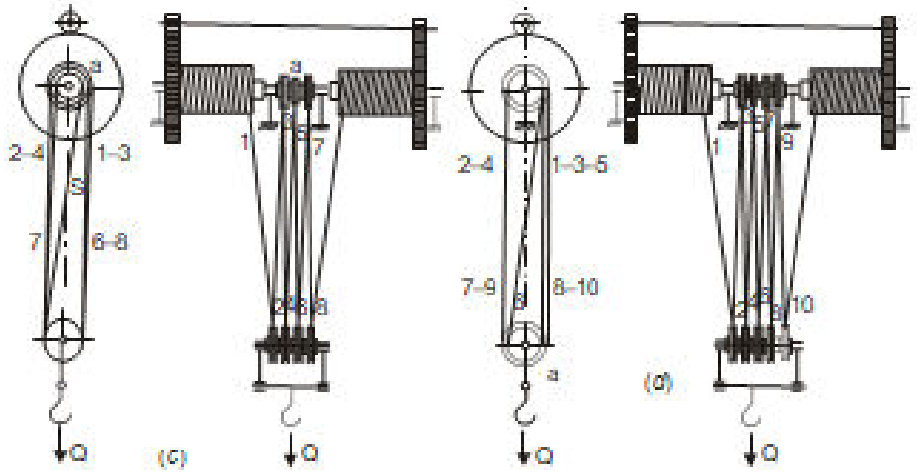
The shortcomings of directly suspending a load from the rope end or from employing simple pulleys for gain in force during hoisting the load are:

The different parts of rope are in one plane and this may allow load to sway freely at right angles to the plane of rope.

Because of coiling of rope in drum along its length, the load also moves in a horizontal direction.

By using multiple pulley systems, these shortcomings can be avoided, specially in electrically driven winch or crane hoisting mechanism. The load is raised in a strictly vertical direction and with much less tendency of sway. With use of multiple pulley systems, the force acting on the ropes are reduced and size of rope and consequently size of drum can be reduced. This reduces the size, weight and cost of the entire mechanism. Fig. 8.1.7 illustrates multiple pulley systems used for gain in force. In multiple pulley system, Load is hung from more than one pulley mounted ona common shaft.





In these systems, the two ends of the wire rope are fixed on a drum or on two drums with right and left hand helical grooves. The rope passes from one half of the pulley system to the other by means of a compensating pulley 'a' (this is a slightly smaller pulley put in between a multiple pulley system with odd number of pulleys) which simultaneously equalises the lengths of rope parts when they stretch non-uniformly.

Fig. 8.1.7(*a*) shows a multiple pulley system with four parts of rope, which are generally used to carry upto 25tons. The transmission ratio i =2 as the length of rope being wound around each half of the drum is 2h, where h is the lifting height. The rope speed is c = 2v. The system efficiency is about 0.94.

The figures b, c, d are different multiple pulley systems with following particulars:

Figure	rope parts	i	load limit, tons	efficiency, η
Fig. (b)	6	3	50	0.92
Fig. (c)	8	4	75	0.9
Fig. (d)	10	5	100	0.87

Arresting Gears and Brakes

In hoisting equipment, use of arresting gears or brakes is of paramount importance to prevent the raised load from getting lowered of its own weight, when the raising effort is withdrawn.

Arresting gear is used to hold the load lifted by winches. The common arresting gears are

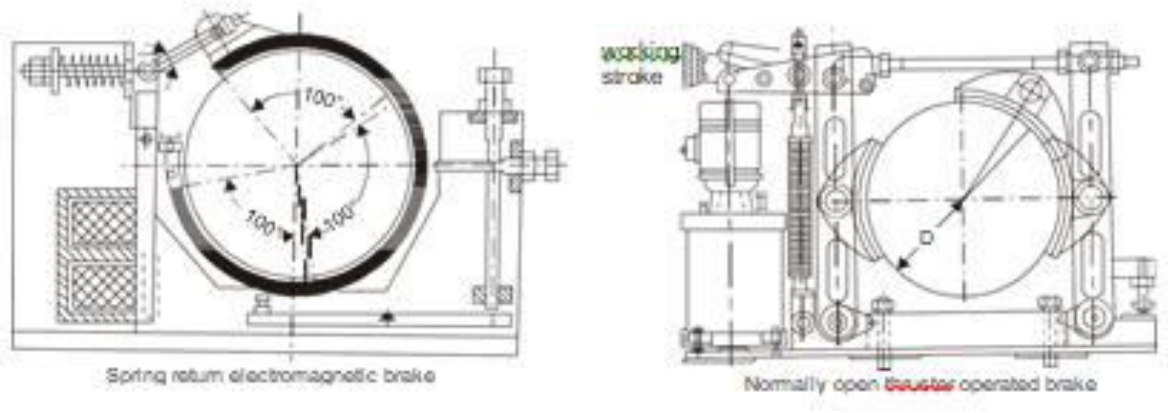
(a) **Pawl and ratchet** mechanism *i.e.* ratchet gearing. This comprises of ratchet wheel and a pawl. The ratchet teeth can be arranged external or internal to the wheel. The teeth are so designed that the ratchet wheel runs free over the pawl when the load is being raised, but the pawl gets engaged with ratchet tooth when the ratchet wheel tries to rotate in opposite direction (lowering direction of load). During lowering of load, the pawl has to be kept deliberately away from ratchet path.

(b) Roller ratchet or roller clutch is used as an arresting gear in combination with a brake.

Brakes are used for dual purpose of holding the suspended load at rest and for controlling the speed of lowering of load. Some of these brakes are to be operated while some are automatic. Operated brakes include shoe, band, cone, disk brakes etc. Centrifugal brakes and brakes applied by weight of the load are the automatic types.

Actuation of the operated brakes may be through pulling a handle or by pressing a pedal which are termed as mechanical brakes. Actuation can be through energizing magnet by AC or DC electricity (electromagnetic brakes) or may be by hydraulic means (electro-hydraulic thrustor brakes).

The electromagnetic brakes and electrohydraulic thrustor brakes can be used as controlled brakes. Moreo- ver, these brakes can also be used as fail safe device. Normally these are in open condition (brake is not engaged), but actuates when the power fails. Fig. shows line diagrams of an electromagnetic brake and a thrustor brake.



Load Handling Attachments

The common attachments used with various hoisting equipment are

(A) **hooks**,

(B) **grabs** of different types,

(C) **grab buckets** for bulk load,

(D) **ladles** for liquid materials,

(E) **electro magnets** etc.

These different attachments are discussed below:

(A) **Hooks:** The common method of lifting unit load by hoisting equipment is to sling the load by chain or rope and suspended it from the hook of the hoisting

equipment. To facilitate handling of loads by hook, many manufactured goods or packages are provided with hooking facilities (rings, bails, holes etc. through which a hook may be readily introduced).

After forging and machining operations, the hooks are annealed. The inner diameter of the hook should be sufficient to accommodate two strands of chain or wire rope. The load is always carried by four elements sling with two loops. The body of the hook is generally of trapezoidal section while it ends at the top in a round section working under tension. The top part of the shank is threaded for suspension from a **crosspiece**. Hooks are mandatorily to be tested under testing load and got certified before use.

Some of the common types of hooks are as follows:

- **Standard hooks** are the most commonly used hooks which have a single curved horn
- **Ramshorn hooks** have two horns like that of a ram. Saddles of each horn is smaller than the saddle of a standard hook of same capacity.
- **Solid triangular eye hooks** are used in cranes of capacity over 100 tons. The disadvantage of these hooks is that the sling rope must be passed through the eye first, before they are attached to the load.
- **Hinged triangular hooks** are made up of a few components, and are much simpler to produce.

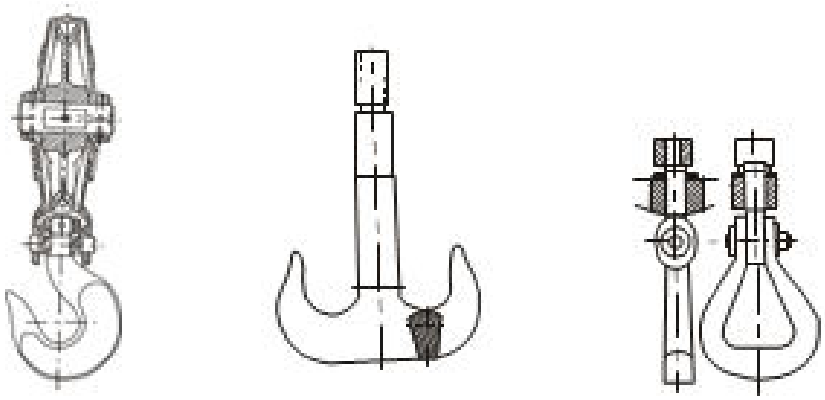


Fig. Standard, ramshorn and hinged triangular hooks

Suspension of hooks

The cylindrical shank portion is generally fitted to a crosspiece provided with machined trurnions at the ends. If the hook is fitted with a thrust bearing resting on crosspiece top, the hook may be rotated freely even with load. The crosspiece is pivoted in the side plates of casings usually reinforced with straps or shackles made of plate steel. Two or more rope pulleys/sheaves may be mounted on the ex- tended trunnions of the crosspiece or multiple pulleys may be fitted in the casings. Fig. 8.1.10 shows a few of the many different arrangements of suspending hooks with crosspieces and casings with sheaves.

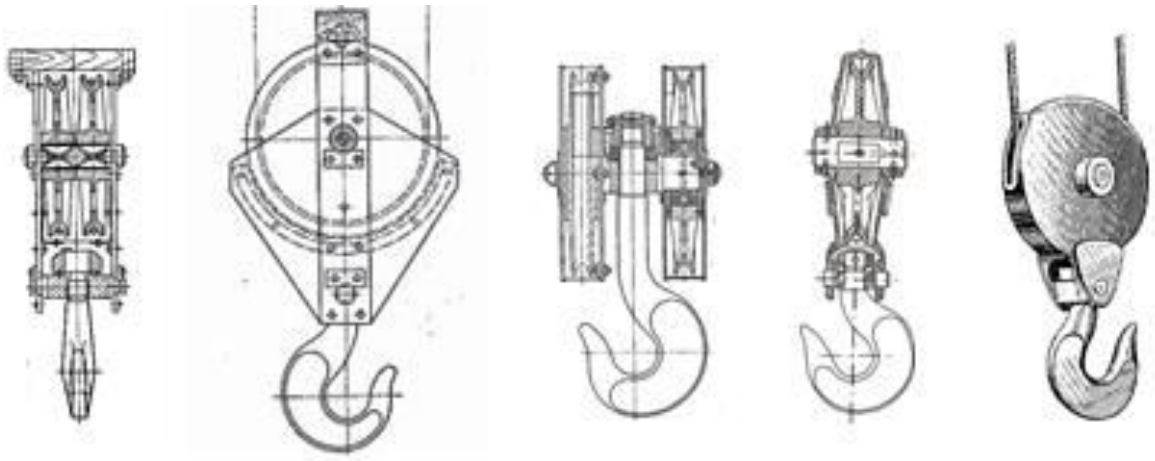


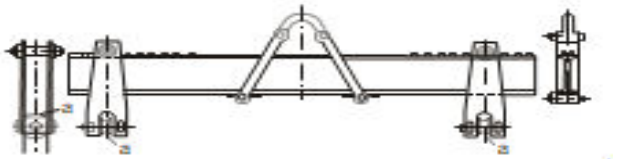
Fig. Different arrangements of suspending hooks with crosspieces and casings with sheaves.

Grabs: For quick suspension and release of typical types of loads, certain specific grabs are used. The special performance requirements of these grabs are:

(i) conformation to the shape and properties of the load.
(ii) quick grabbing and releasing.
(iii) adequate strength and reliability.
(iv) safety to men and loads.
(v) convenience of use.
(vi) low weight.

Some of the common grabs in use are briefed below:

(a) **Carrier beams** are employed to lift long and heavy loads. Fig. shows a carrier beam with adjustable shackles from which the loads are suspended.

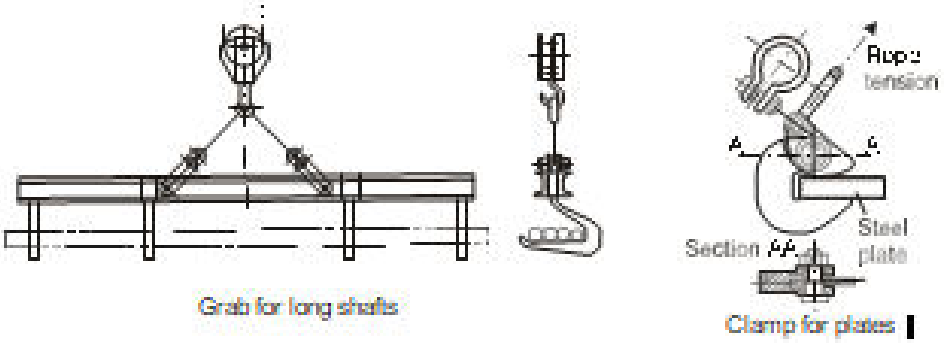


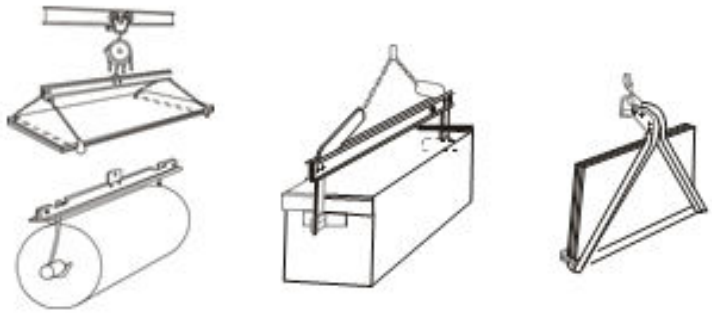
Carrier beam with adjustable shackles for a foundry crane

(b) **Crane grabs and clamps** of different styles are used for handling different types of load.

(i) carrier type grabs are used for carrying short or long shafts.
(*ii*) Clamps are used to grip sheet or plate type loads.

Following Fig. exhibits a few types of grabs and clamps





(c) **self closing tongs** are used for automatic grabbing of different shapes. The tongs are made self closing to avoid manual intervention during grabbing. Fig. shows a few self closing tongs.

(B) **Grabbing attachments** are used for lifting loose/bulk materials by means of a crane and transferring them. There are basically two types of these grabbing attachments for loose materials:

(a) **Tubs:** These are box type structures made from steel sheets. The tubs are provided with doors at the bottom or sides which can be opened by pulling a rope from the crane for automatic dumping of the contents inside the tub. However, these tubs have to be filled up manually or by using some other materials handling equipment. The tubs are provided with bails for suspending them from a crane hook.

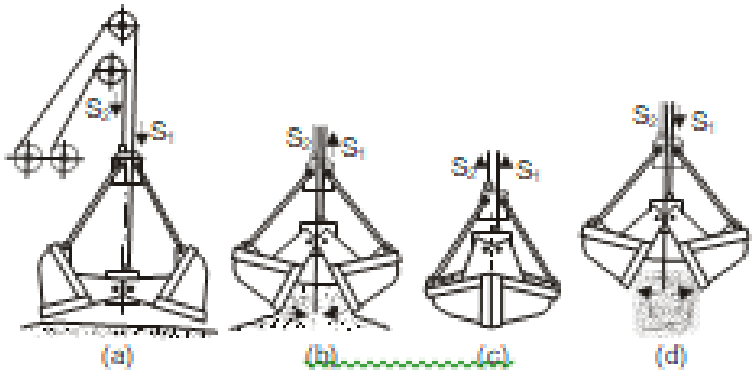
(b) **Grab buckets:** These are specially designed bucket attachments which scoop

loose materials and dump them mechanically through manipulation of ropes from the crane. Grab buckets are used for handling large amount of loose materials through cranes.

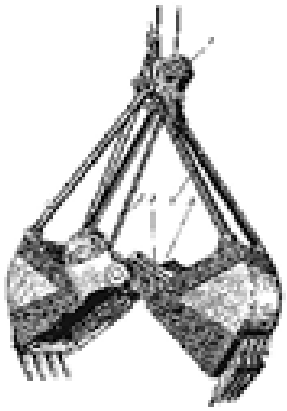
The bucket essentially consists of two clam shell like scoops with rounded bottoms which are hung by four rods from a top cross-member. The inner ends of the scoops are also hung from another movable cross-member. All the joints are provided with pins for pivot action. The top and bottom cross-members are suspended through ropes from a crane.

The principle of operation of a double-rope grab bucket is shown in Fig.. When the rope S1 for bottom cross-member is loose, the grab buckets open up due to its own weight. At this position the bucket is lowered until the two scoops gets into the material. The rope S1 is then tightened when the lower cross-member moves up and closes the scoops with material inside. In this closed condition the grab bucket is transferred, and at desired point, the rope S1 is again loosened when the buckets open on its own and scooped materials' weight and discharges the materials.

There are many designs of clamshell buckets where number of ropes may be 1, 2 or 4, or scoops are operated by special mechanisms. Fig. also shows an asymmetric grab bucket design which are simple in design and close the scoop edges well.



Stages of operation of a double-rope grab bucket


Asymmetric grab bucket

(A) **Ladles:** Ladles made from plate steel and having a refractory lining are used for carrying hot liquid metal. Small ladles or crucibles may be handled manually. But large ladles are conveyed in ladle cars, but more commonly by cranes. A crane ladle essentially has a bail. Smaller ladles may be tilted (for pouring) manually and medium size ladles by hand wheel actuated mechanism. However, large ladles are tilted by special devices actuated from the crane itself.

(B) **Electromagnets:** Electro lifting magnets are used to handle magnetic materials of differ- ent shapes and sizes like ingots, steel structurals (beams, rails etc.), plates, scraps, pigs, metal chips etc. The particular advantage of using magnets for lifting is that it does not need any time for fixing or releasing of the load. It is also very

convenient for stacking of such items to a large height without labour. However, electromagnet has the risk of materials falling off in the event of a power failure. The other disadvantage is the large weight of the magnet itself which reduces the capacity of the hoisting crane.

Electromagnets are particularly popular in steel plants, fabrication yards and scrap yards. The magnets are generally hung from the crane hook through chain slings.

HOISTS

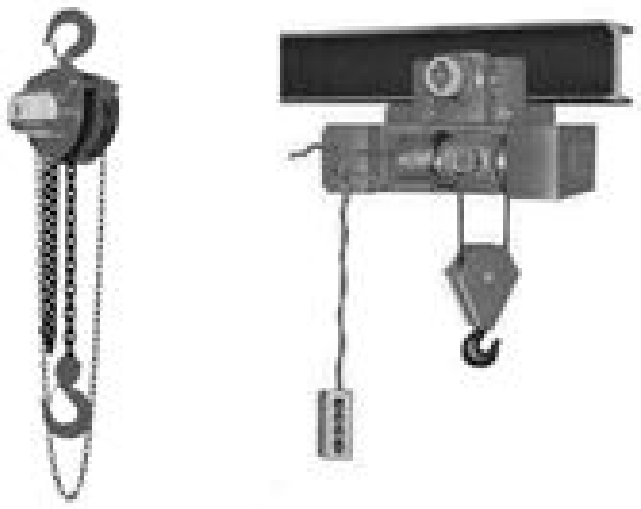
Definition, Characteristics and Uses

Hoist is an apparatus for raising or lowering a load suspended from a hook on the end of a chain or wire rope. A hoist may be fixed i.e., stationary, base mounted or supported from overhead by a clevis or hook. It may be travelling type mounted on a track (Fig.).

Hoists are rugged, dependable, simple to operate and inexpensive. Their installation is easy. Operation of a hoist can be by hand through pulling of chain, compressed air or electricity (operated by pendant switch box).

Hoists are truly the basic hoisting equipment. These are extensively used in manufacturing industry, workshop, godown, truck terminal, construction & erection site and even in small garage for handling relatively light loads. These are used for loading and unloading of varying jobs from machines, transfer of loads between work places. Hoists supplement overhead travelling cranes, when put on a monorail.

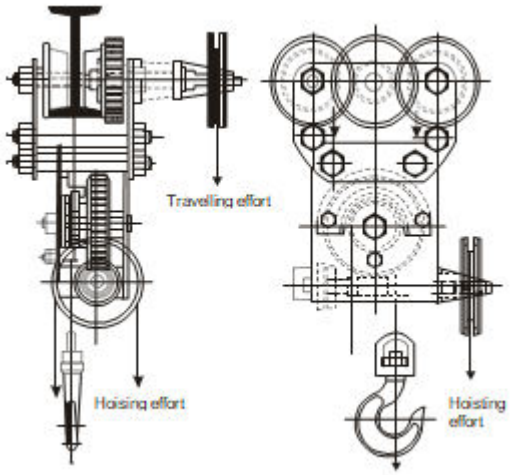
Limitations of hoists are that they are used for relatively lighter loads (2 to 3 tonnes), they are relatively slow, have limited travel distance and fixed direction determined by the track.



Constructional Features

(A) **Hand operated Hoists:** A hand operated hoist essentially consists of a

large diameter welded chain sprocket which is rotated by pulling of an endless chain. The sprocket is connected to another smaller chain sprocket through a system of gearing with large speed reduction. The gearing may be planetary spur gear system or may be worm-worm wheel arrangement. For this gearing system, the torque applied at the input sprocket is multiplied at the output sprocket, and a heavy load may be lifted with comparatively lighter pull at the input chain. When a worm-worm wheel is used, the gearing system is self locking, but in spur gearing system an arresting arrangement (generally ratchet-pawl) is provided to avoid descend of the load by its own weight. The entire sprocket and gearing system is enclosed in a frame. In case of a travelling hoist, the main hoist frame is fixed to the bottom of a 4 wheeled trolley frame. The wheels are supported on the track. The bottom flanges of an I-beam is the most commonly used track. Pair of wheels on one side are provided with two spur gears which are connected by a smaller gear in the middle. On the shaft of this small gear is fitted a chain sprocket. On rotating this sprocket by pulling of an endless chain, the trolley moves on its track, and carries the load to the desired point. Fig. shows the constructional features of a typical hand operated worm-geared trolley hoist.



In smaller capacity hoists, the trolley may be moved by simply pulling it by a chain. These are termed as hand pushed trolley hoist.

Electric hoists: An electric motor driven hoist has one or two rope drums for coiling and uncoiling the hoisting wire rope. The hoisting motor drives the drum through a planetary gearing sys- tem. The gearing system with high reduction ratio serves dual purpose of increasing torque as well as reducing speed of hoisting. 2-speed motors may be used for obtaining two hoisting speeds. The lower speed is employed at the start of hoisting or at the finishing stage of lowering the load, to avoid heavy jerk on the rope and pulley system or impact of the load with the floor. The rope is connected with a hook (see Fig).

The trolley for travelling hoist may also be powered by another motor. Motion from the

motor is gener- ally transmitted to the wheel through three pairs of spur gears. The motors of an overhead electric hoist is controlled by a pendant switch box hanging from the hoist frame at a convenient height for operation from floor level.

Specifications

Irrespective of its type (hand or electric or pneumatic), the most important specification of a hoist is its maximum load hoisting capacity. The next important specification is maximum operational lift or height. For travelling hoist, the important specifications are the size of I-beam track and the minimum radius of curvature through which the trolley can be maneuvered. For electric hoist, the hoisting speed/s and travelling speed are two important specifications. Overall size of the hoist, chain or wire rope size etc. are the other specifications an user will be interested in.

Hoist manufacturers manufacture different types of hoists in different standard capacities and lifts and all the relevant specifications are indicated in their product catalogues.

Freight Elevators / Lifts

Such a freight elevator/lift consists of a box type **cage** or **car**, which moves vertically up and down through the designed opening kept in the floors, called shaft of the elevator. The movement of the car is guided by guide rails laid vertically in the shaft. The car is suspended from and moved up and down by a hoisting mechanism, located at the top of the shaft. The hoisting mechanism may either be (*i*) drum winch type or (*ii*) traction-type, as shown in Fig. In the drum-type, one end of wire rope is firmly attached to the drum, and the other end to the elevator car top. A counterweight, usually equal to the weight of empty car plus one third of the duty load, is used for increasing the load lifting capacity of the winch motor of given rating.

However, winch type mechanism is bulky and may pose difficulty in accommodating the winch at shaft top. In such cases, the traction-type mechanism consisting of multiple rope and multiple groove sheave, driven by a motor through gear box is used Beneath both the car and counterweight, spring type buffers are provided for shock absorption. Proper drive controls and indication instruments for knowing position of the car are provided. Freight elevator/ lift is provided with automatic brake which operates if the rope snaps and the car develops high acceleration.

The speed of freight elevators are kept low, while the pas- senger lifts in high rises are quite fast (500 mpm or higher).

Cars of a freight elevator may be designed to suit type of materials they have to carry and for automatic loading by devices like:

(i) fork lift truck or platform truck

(ii) tow truck or trailers

(iii) roller conveyor

(iv) overhead monorail conveyor etc.

Fig. shows a schematic view of an elevator showing the car supported in guide, the

traction-type hoisting mechanism, counterweight and buffer springs.

6 Cranes

COURSE OBJECTIVES: To provide knowledge on cranes.

LEARNING OUTCOMES:

Students will be able to

- understand the basic working principles of various cranes.
- select appropriate crane for appropriate application.

CRANES

Crane is a materials handling equipment for lifting or lowering a load by a hook and moving (transferring) it horizontally, in which the hoisting mechanism is an integral part of the equipment. A crane may be driven manually or by power and may be fixed or mobile. Equipment like stackers, lift trucks, power shovels, backhoes, excavators and other hoisting equipment not discussed in this chapter are not included in the category of crane.

A crane essentially consists of (*i*) a steel structure, (*ii*) a hoisting mechanism or a winch mechanism with its pulley and pulley system, (*iii*) suitable load handling attachment /s and (*iv*) drive and controls.

The major classification of cranes is based on whether they are stationary or mobile. However, it is to be noted that, even for the stationary cranes, some structural component of the crane is capable of move- ment for transferring the load within reach of its movement. Movements of components of these station- ary cranes may be linear, revolving or combination of both.

Revolving cranes: The characteristic feature of these cranes is presence of a structural arm called **boom**, which can be rotated through 360° about a vertical axis. These cranes are also called **rotary crane** or **slewing crane**. Boom may be strut or struss type. The lower end of the boom is affixed to a mast, base, carriage or support against which it can be pivoted and moved up and down which is called **luffing** or **booming**. The upper end of the boom supports a hook or other end attachments for lifting of load. Different types of cranes are grouped under this classification.

Mechanism employed for rotating the boom is called **slewing mechanism**. Usually three different types of slewing mechanisms are used which are:

(i) Crane superstructure revolves together with the pillar or column which is mounted on bearings. Jib cranes generally fall under this category.

(ii) The boom rotates about a pillar fixed on a foundation or in the crane truck.

(iii) The entire crane superstructure is mounted on **turntable** which rotates about and secured to its non revolving part. The turntable of the crane rests on a number of rollers running or a circular rail erected on the foundation or on the crane truck. Rack and pinion or cogwheel drives are generally employed for rotating the turntable.

Luffing is another important motion of the boom of a crane. It is the up and down motion of the boom about a pivot joint at the inner (base) end of the boom. Luffing motion of the boom can be imparted by applying various mechanism like (*i*) rack and pinion, (*ii*) nut and screw, (*iii*)

segment gears, (*iv*) crank and link, (*v*) hydraulic cylinder and (*vi*) hoist drum and rope reeving system. Luffing motion is very important to reach loads lying at different distances from a stationery crane. It is to be noted that the capacity of a crane varies at different boom angles, which are indicated by the crane manufacturers.

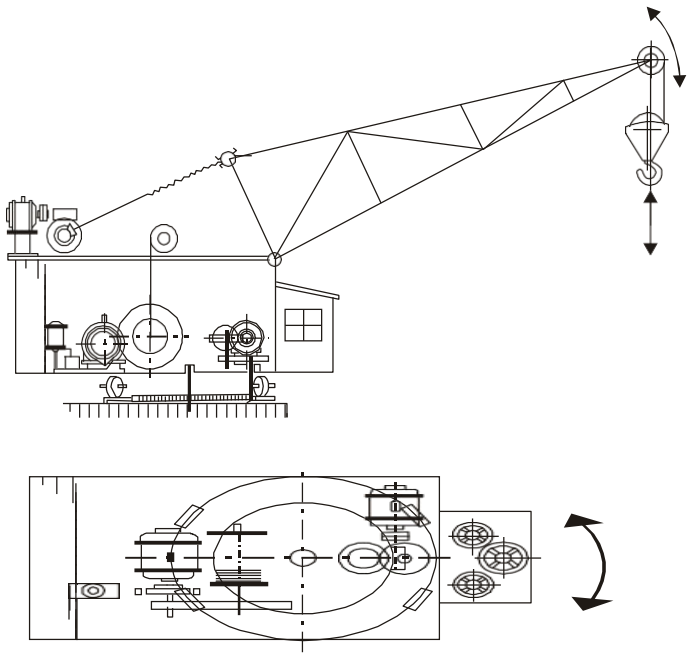


Fig. Rotation and luffing motion of a turn table crane

Types of cranes

There are different types of cranes under each classification, based on their constructional features and specific uses. Some of the common types are:

Stationary Cranes

(i) Jib crane
(ii) Overhead Travelling crane (also called Bridge crane)
(iii) Gantry crane

Stationary Revolving Cranes

(i) Wharf crane
(ii) Pillar crane
(iii) Tower crane

Mobile Cranes

(i) Truck/wagon mounted crane
(ii) Crawler crane
(iii) Railway/Locomotive crane
(iv) Floating crane

Definition, descriptive specifications, characteristics, features & uses and some of the design variations of the above types of cranes are discussed below.

Jib Cranes

It is a stationary crane consisting of a vertical member (called pillar or column) from which extends a horizontal swinging arm called **jib**, carrying a trolley hoist or other-hoisting mechanism.

The jib is generally made from a standard I-beam section, and can rotate in a horizontal plane (i.e. no luffing motion) between 180° up to 360°, so that loads can be lifted and deposited within the sector of circle having its radius equal to the length of the boom. The extreme end of the arm is often supported from the vertical member by a tie rod.

Above description matches with other types of crane like tower cranes, pillar crane etc. However, the difference is basically in terms of size and capacity and thus in specific applications. A normal jib crane is generally limited to a jib length of 8meters and hoist capacity of 15tons. A typical jib crane is shown in Fig.

Jib cranes are inexpensive and widely used in manufacturing industries for:

Fig. A jib crane

serving individual or a group of work places in machine shops.

(i) loading and unloading of vehicles.

(ii) handling ladle, casting and mould in a foundry.

(iii) moving loads across shop bays and thus supplementing on overhead traveling crane

Different design variations of a jib crane is possible which are as follows:

(A) **Revolving pillar jib crane** in which the pillar or vertical column consists of a structural pipe. On

Fig. Revolving pillar jib crane

the top of the col- umn a thrust bearing of sufficient capacity is mounted, on which the jib constructed from a standard I-beam is mounted. The jib can rotate by 360° on the fixed column. The column base is bolted to the floor/ foundation or directly grouted in foundation. A manual or powered trolley type hoist is mounted on the jib. Stops are provided at the end of the track to pre- vent over travel. Fig. 8.5.3 shows photograph of such a jib crane.

(B) **Swinging pillar jib crane** in which the jib and it's tie rod are connected to the vertical column through swinging fitting supports, welded with the column. The fittings allow swinging of the jib and the tie by about 180° about the fixed column.

(C) **Swinging bracket supported jib crane** is similar to a swinging pillar jib crane, excepting that there is no independent vertical column. Instead, the swinging fittings are wall-bracket type which are fixed on a vertical wall. This jib crane has maximum 180° rotation.

(D) **Revolving mast jib crane** is one in which the vertical column or mast is supported at the top and bottom on bearings. The jib is bolted or welded to the column. The jib is supported by tie rod. The jib can rotate along with its supporting column. Fig. shows such a jib crane.

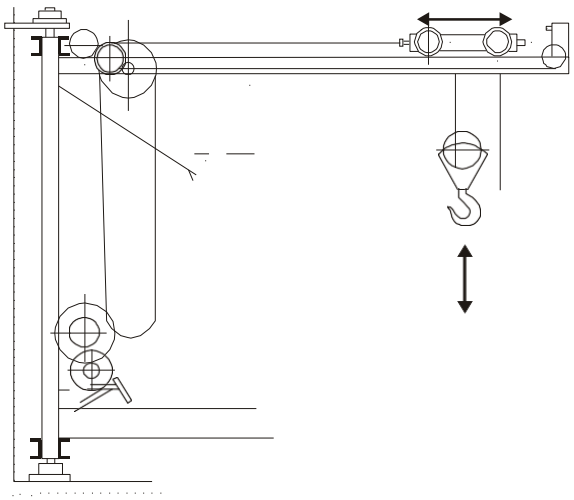
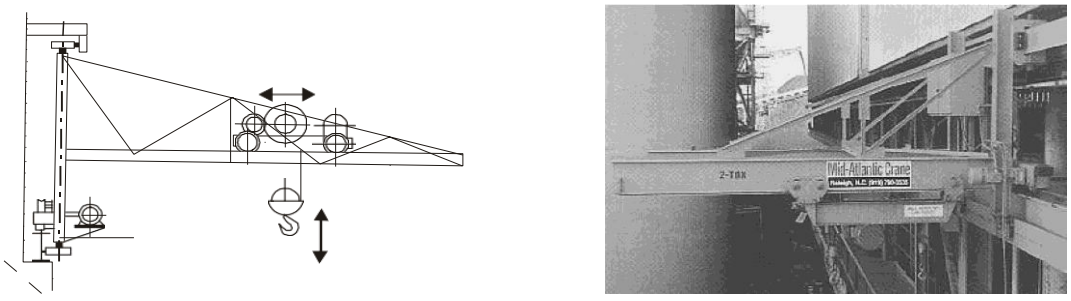


Fig. Revolving mast jib crane

(A) **Rotary girder jib crane** is similar to a swinging bracket supported jib crane without a tie rod. Instead, the end of the jib is supported from a trolley by a chain, while the trolley is supported from a circular girder fixed to the roof or roof strusses.

(B) **Travelling jib crane** is a special type of jib crane which consists of a cantilevered arm similar to the bridge girder of a overhead traveling crane. One end of the girder is held from the side wall, and supported over wheels on rails laid parallel to the wall. A motorised arrangement drives the wheel and makes the arm to travel along the wall. The hoisting device travels along the arm. Travelling jib crane serves the purpose of a bridge crane for lighter loads. Fig. shows the schematic diagram as well as a photograph of such a crane.



(a) Schematic view (b) Photographic view

Fig. Traveling jib crane

(C) **Fixed-tower hammerhead jib crane** is a special type of jib crane, which is built in capacities from 6 te to as high as 350 te. The jib of this crane is of struss structure and looks like the head of the hammer, hence the name. The jib is mounted on a fixed tower. The front portion of the jib supports rail upon which one, two or three crane trolleys travel, and the rear portion of the jib houses the machinery for hoisting, trolley travel and slewing arrangement as well as necessary counterweight. When two trolleys are used, they are arranged to be operated individually or simultaneously. Fig. shows a hammar head jib crane.

A. Tower
B. Trolleys
C. Operator's cab
D. Machinery house
E. Pintle
F. Pintle bearing
G. Revolving gear
H. Hoist blocks
I. Hammerhead jib

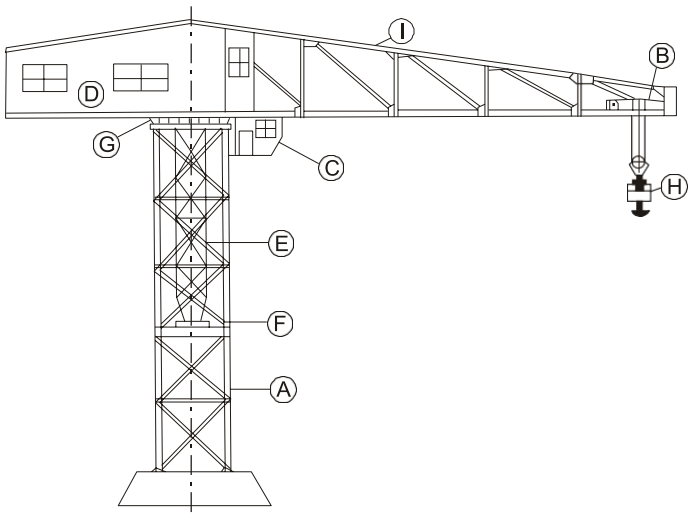


Fig. Fixed-tower hammerhead jib crane

Overhead Travelling Cranes or Bridge Cranes Definition & descriptive specifications

These cranes essentially consists of one or more hoisting devices mounted on a bridge consisting of one or two horizontal girders, which are supported at each end by trucks riding on elevated runways installed at right angles to the bridge. Runways are installed on building columns, overhead strusses or frames, much above floor level. The hoisting device moves along the bridge while the bridge moves along the runway.

Depending on the lifting capacity of these cranes, the hoisting device may be a hand operated trolley type hoist, an electric hoist or a drum-type **crane trolley or crab**. Crane trolley is an independent machine consisting of the drum-type hoisting equipment built on a framework, which is fitted with runner wheels, and driven by a motor through gearings. The hoisting motion is also motorised. Fig. is a line diagram of crane trolley. The long travel of a bridge may also be manual through chain operation or motorised.

Control of all the movements (hoisting, cross travel of hoist- ing devices and long travel of the bridge) of an electric over- head travelling (abbreviated as EOT) crane can be through

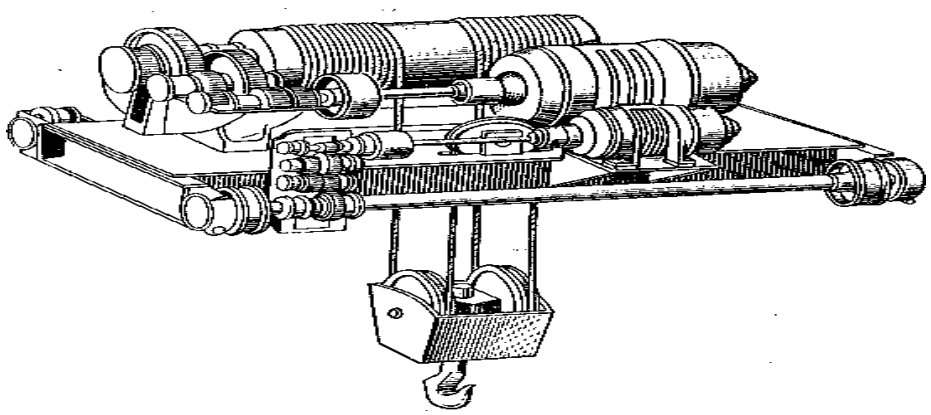


Fig. Crane trolley

Pendant from floor, or may be remote operated through radio or other devices. Many of these cranes are provided with a cab fixed to the bridge, from which an operator controls the crane. Electrical power is fed to the crane by means of festooning cable or from bare con- ductors

running along the runway through collectors connected with the bridge structure.

Fig. View of an overhead travelling crane

Characteristics and uses

The major advantage of overhead travelling bridge crane is that it does not interfere with work on floor. It can move materials over the working zone. Other characteristics are:

(i) It can reach the entire rectangular area bounded by the bridge length and runway length.

(ii) Runways can extend beyond the building, supported by columns erected suitably.

(iii) Capacities may vary from small value (1 ton) to up to 1000 tons.

(iv) Bridge cranes are designed and built as per requirement by specialist companies.

(v) Requires heavy frame work and are expensive.

(vi) Requires trained operators.

These cranes are mainly used in heavy machine shops, foundries, steel plants, assembly and repair shops, warehouses and yard storages. With appropriate hoisting attachments like slings, grabs, grab buckets, magnets etc. these crane can handle an extremely wide range of large, heavy and awkward unit loads as well as bulk load.

Types of bridge crane

Bridge cranes are classified according to the load capacity as follows:

(a) Light duty—up to 5 tons. May be hand propelled.

(b) Medium duty—5 to 20 tons, used in factories and warehouses.

(c) Heavy duty—20 to 50 tons, used in foundries, heavy shops.

(d) Extra heavy duty—over 50 tons, used in steel plants, docks etc.

The medium and heavy duty crane bridges are essentially electrically driven.

Design wise the traveling bridge crane may be classified as.

(*a*) **Top running** or (*b*) **Bottom running** (under slung).

The bridge girders of a top running crane are carried on top of the end trolleys (Fig. 8.5.9). The girders of the bottom running crane are suspended from the end Trolleys. The hoisting device is also top running or bottom running in corresponding designs. Bottom running bridge crane are generally limited to 10 tons capacity.

Major specifications of a bridge crane are :

(*i*) Lifting capacity, (*ii*) Span of the crane, (*iii*) Hook lift, (*iv*) Hoisting speed, (*v*) Hoist travel speed and (*vi*) Long travel speed of bridge.

The specifications are generally limited to 1000 ton lifting capacity, 40 m span, 10 to 20 mpm hoisting speed, up to 30 mpm hoist travel speed, and 60 to 150 mpm bridge travel speed. Two speeds of hoisting are provided in many cranes as demanded by the application.

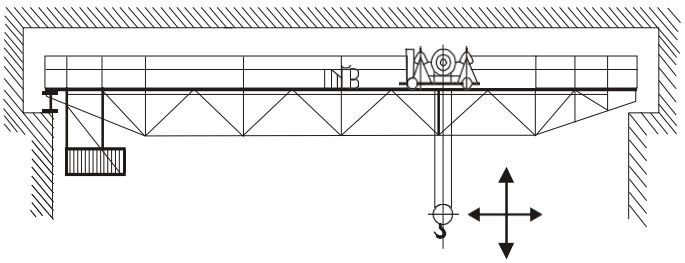


Fig. Double girder top running bridge crane

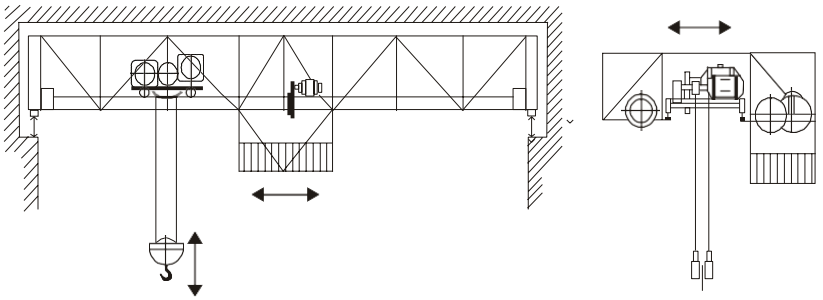


Fig. Top running bridge crane with bottom running crab

Gantry Cranes

Definition, Characteristics and Uses

Gantry cranes have a girder or bridge, on which the hoisting device/s operate, similar to an overhead travelling crane, except that the bridge is rigidly supported on two or more legs with wheels which run on fixed rails or runways at the level of the floor. The movement of the gantry crane may be done manually or through motor.

The characteristics of a gantry crane are :

(i) Can be used indoors or outdoors.

(ii) Relatively easy to change its location.

(iii) Simple operation.

(iv) Long life and low maintenance.

These crane are used for loading and unloading carriers, outdoor storage operations, for handling unit or even bulk materials where movement is short. These cranes serve purpose of a bridge crane and are used where installation of a bridge crane is not possible. Limitation of these cranes are their limited movement and capacities up to a maximum of 300 te.

Types of gantry crane

A few types of gantry cranes are possible based mainly on the design of the legs:

(i) **Fixed gantry crane** whose both legs are fixed on floor

(ii) **Portable gantry crane** in which both legs are fitted with small wheels which can travel on plain floor. These are generally of small capacity up to 3 te.

Fig. Portable gantry crane

(iii) **Semi-gantry** or **single leg gantry crane** is a gantry crane with one end of the bridge is rigidly supported on one or more movable legs supported on fixed rail or runway, the other end of the bridge being supported by a truck running on an elevated rail or runway.

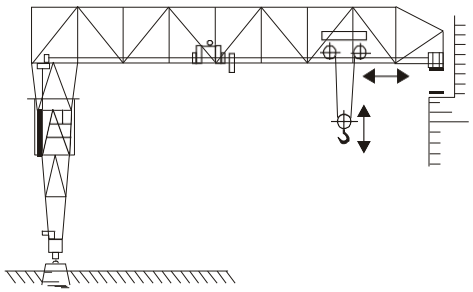


Fig. Semi-gantry crane

(iv) **Cantilever gantry crane** in which the bridge girder is extended beyond the crane runway on one or both sides. Its runway may be either on the ground or elevated.

Fig. shows photograph of a large capacity outdoor gantry crane.

Fig. 40 tegantry crane

Wharf Cranes

Wharf cranes are versatile machines which are extensively used in shipyard and port for unloading and loading of ships to and from jetty and can handle a variety of cargo. These cranes essentially consist of a long boom which is mounted on a 3600 rotating frame which is supported on the sub-structure fixed on foundation or travelling on rails along the jetty. The boom can be luffed up and down thus moving the load towards or away from the crane. A sheave is provided at the tip of the boom and ropes with a hook or grab bucket, depending on

the type of load to be handled, is suspended from the sheave. The load is moved up or down by pulling the rope. The luffing motion in the boom is often **level luffing** type, which is explained later.

Depending on the design of the sub-structure, wharf cranes are grouped into following types:

(a) **High pedestal wharf crane.**

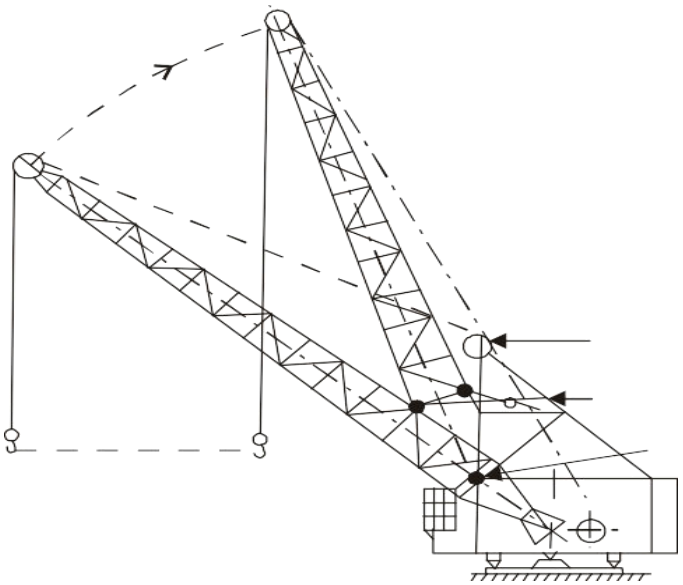
(b) **Portal crane** in which the sub-structure is a gantry structure. The gantry may be fixed in foundation or on wheels which can run on fixed rails or runways.

(c) **Semi-portal crane** which uses a semi-gantry sub structure.

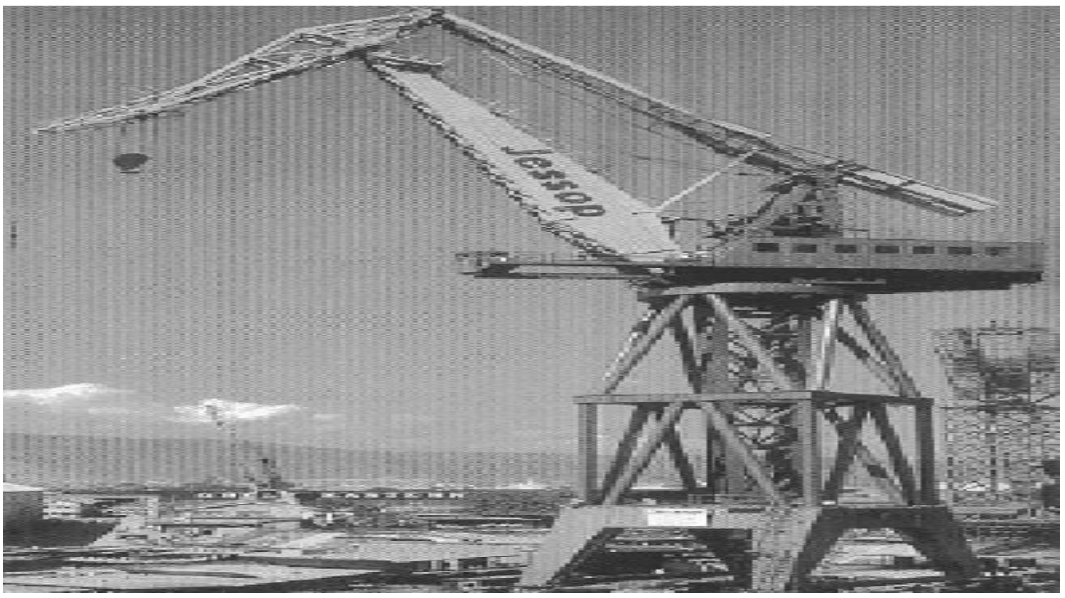
Fig. shows photograph of a wharf crane.

Courtesy : TRF Limited, Calcutta

Fig. 10 te capacity shipyard wharf crane



Boom Fulcrism



Courtesy : Jessop & Co. Ltd., Kolkata Four bar link boom

Fig. Level luffing cranes

(i) **Swing lever type level luffing mechanism.** In this design, the guide pulley is connected with a particular point of the boom through a link in such a way that when boom is luffed, the relative positions of the top and guide pulley go on changing in a manner that some length of rope will be delivered out or taken in such that the load remains at the same height.

(ii) Using a **four bar link** type boom. In this design, the front portion of the boom known as **jib lever**, gets folded with respect to the rest part of the boom, which form a four bar link, when the boom is moved up or down. This allows the top pulley fixed at the end of the front portion of the boom, to remain at the same horizontal level and achieve level luffing.

Courtesey : TRF Limited, Kolkata

Fig. 26 te level luffing kangaroo type portal crane in luff out and luff in positions

Technical specifications of wharf crane

The capacity of dock side wharf cranes generally varies from 3 tons to 20 tons and an outrich of 30 m maximum to 6m minimum. The inclination of the boom with horizontal, at the maximum

out reach condition is kept about 34°. Typical specifications of high pedestal balanced level luffing wharf cranes, as per "Electric Crane" by H.H. Broughton are shown in Table 8.5.1.

Stability of wharf crane

The margin of stability of a wharf crane is defined to be the percentage additional load required to bring the crane to the point of tipping, while handling any load at any radius from the centre of the crane and the boom is at right angles to the direction of the track on firm level ground.

IS:4594-1968, "Code of Practice for Design of Portal and Semi-portal Wharf Cranes" provides in clause 4, the condition of tipping and margin of stability of wharf crane under storm condition and under service condition. As per the above standard, the following stability requirements should be met.

(a) **Stability under storm condition:** The crane is subjected to a wind force of not less than 150 kg/mm^2 and a margin of stability of 25% of this wind force shall be met.

(b) **Stability under service condition:** (*i*) 50% of the safe working load at the operating radius without causing any undue stress on centre pin or the centre column; and (*ii*) 75% of the safe working load at the operating radius and subjected to a wind force of 25 kg/mm^2 acting at the same time, without any of the track wheels leaving the track.

Pillar Cranes

It is a stationary crane consisting of a vertical member (pillar) held fixed in position at the base to resist overturning with a constant radius revolving boom supported at the outer end by a tension mem- ber, and carrying an end pulley over which the lifting rope with hook is suspended.

Tower Cranes

A crane in which a horizontally swinging, usually non-luffing boom is mounted on a tall vertical mast or tower. A travelling hoist operates on the rails fixed to the boom, which is suitability counterloaded. A tower crane may be fixed standing on a tripod. It may also be mounted on rails, on a crawler or a truck, when it is called a **mobile tower crane**.

These cranes are used for construction of tall buildings and erection of technological structures, blast furnaces, chimneys, air turbines etc.

A crane erected upon and supported by a building or other structure, which may be raised or lowered to different floors or levels of the building or structure is called a **climber tower crane**.

Fig. shows a tower crane in working position.

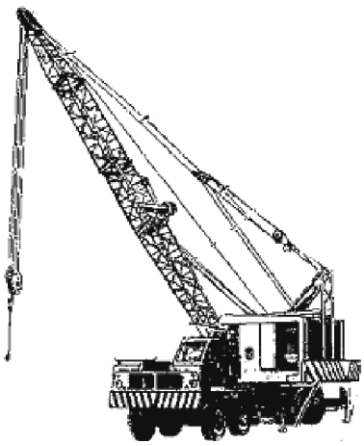
Truck and Wagon Cranes

This is one type of mobile crane in which a boom-type crane is mounted on a motor truck or wagon frame or rubber-tired chassis. It consists of a rotating superstructure (for slewing boom), operat- ing mechanism, boom and the source of power for operation.

Capacities of such cranes vary from a fraction of a ton to about 50 te. Basic crane rating is the maximum allowable lift with the shortest boom at its minimum operating radius. Rated capacities are generally 85% of tipping load.

In a **full swing-turntable truck crane**, the revolving turntable provides 360° rotation in either direc- tion. The luffing motion is obtained by spooling rope or by hydraulic cylinder, and hoisting motion is by spooling rope. Booms for small cranes may be of one-piece construction or telescoping for variable length. Large cranes may use long two-piece booms. Long booms may require use of a boom support. During operation, the truck is supported on outriggers to avoid overturning or rolling of the truck. Power source is generally I.C. engine.

Figure shows two different designs of truck mounted cranes:



Full swing turntable luffing boom

Non-swing hydraulic cylinder luffing boom

Fig. Truck mounted cranes

These cranes are used for interplant and intra-plant heavy load movement as well as in various civic service needs.

Crawler Cranes

Cranes consisting of superstructure with power plant, operating machinery and boom, mounted on a base equipped with crawler treads for travel.

Crawler cranes are slow in speed but can work outdoors on field. Capacities vary from about 1 ton to 100 tons. Rated capacities are generally 75% of tipping load. The booms may be full-swing turntable type, part-swing type (270° arc) or even nonswing type. Crawler cranes are widely used in outdoor mechanical constructional jobs. Many of these are adaptable for use as **shovels**, **backhoes** and **draglines** for handling bulk materials. Fig. 8.5.19 shows a typical crawler crane.

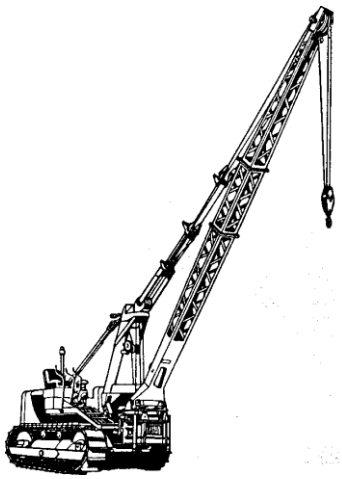


Fig. A typical crawler crane

Railroad / Locomotive Cranes

A **railroad crane** is a single-flange wheel, rail mounted travelling crane. The **locomotive** crane is a boom-type mobile crane consisting of a self-propelled locomotive car operating on a railroad track, upon which is mounted a rotating body supporting the power-operated mechanism, together with a boom capable of being raised or lowered at its head end from which is led the wire rope with hook, connected with the hoisting mechanism.

Floating Cranes

Cranes fitted on a floating body like ship, barge, boat, etc. are called floating cranes. These are used for handling material on, around and from the water. They are specifically used for salvage work, harbour clearing, dredging, excavating, pipe-laying, alongshore, and off-shore construction, ship serv- icing, ship repair and bulk-cargo loading or discharging. Capacities may vary from small to as large as 800 te.

DERRICKS

Derrick is an apparatus consisting of one or two masts or fabricated strut members supported at the bottom by a pivoting arrangement and held at the top by guys or braces, with or without a boom, for use with a hoisting mechanism and operating rope, for lifting and lowering a load and moving it hori- zontally.

Derricks are principally used in construction work for erection of technological structures and heavy components to a height. Advantages of derricks are: (*i*) inexpensive, (*ii*) very easy to erect and dismantle, (*iii*) simple in design and may be fabricated easily at the working site, (*iv*) a number of derricks may be used together for manipulation of a large and/or weighty component.

Derricks may be of different types. Some of the common types of derricks have been described below:

Guy Derrick: A fixed derrick consisting of a mast mounted on a turntable and capable of being rotated, supported in a vertical position by guys, and a boom whose bottom end is hinged or pivoted to move in a vertical plane with a reeved rope between the head of the mast and the boom point for raising and lowering the boom, and a reeved rope from the boom point for raising and lowering the load.

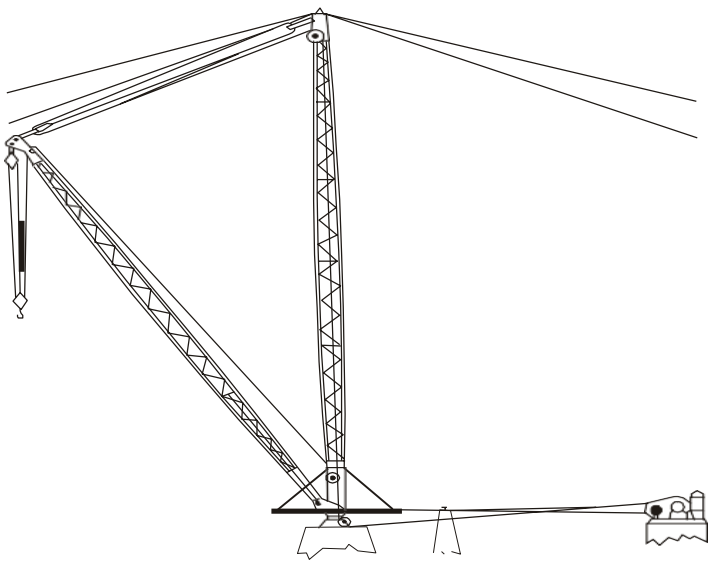


Fig. Guyed derrick

Gin Pole Derrick: A derrick without a boom. Its guys are so arranged from its top to permit leaning the mast in any direction. The load is raised and lowered by ropes reeved through sheaves or blocks at the top of the mast.

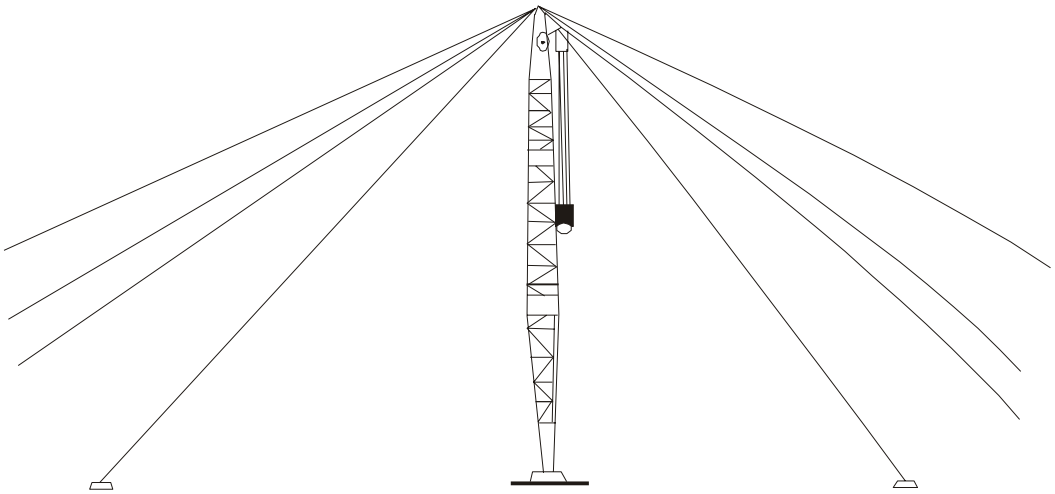


Fig. Gin Pole derrick

(a) **A-frame Derrick:** A derrick in which the boom is hinged from a cross mem- ber between the bottom ends of two upright members spread apart at the lower ends and joined at the top; the boom point secured to the junction of the side members, and the side mem- bers are braced or guyed from this junction point.

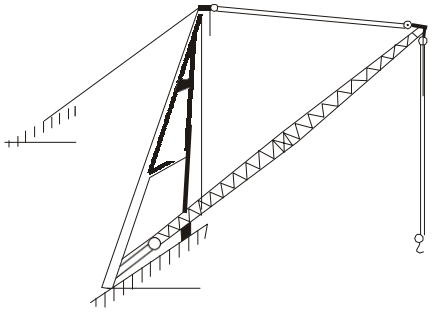


Fig. A-frame derrick

(b) **Stiffleg Derrick:** A derrick similar to a guy derrick except that the mast is supported or held in place by two or more stiff members, called stifflegs, which are capable of resisting either ten- sile or compressive forces. Sills are generally provided to connect the lower ends of the stifflegs to the foot of the mast.