work, space required, increased production brought about etc. A material handling equipment with the low... productive cost is selected.

The operating costs are reduced by purchasing flexible material handling equipments, using the princi... of unit load, minimizing idle time for the equipment, increasing speed of handling and by using standard ... handling equipments. A material handling system is said to be economical if the cost of handling per unit weight ... the material for a particular movement is minimum. Economy in material handling can be achieved by :

- employing gravity feed movements
- minimizing distance of travel
- by using a system in which the product from the machine directly falls over material handl... equipment (e.g. by means of chute or conveyor) and carried to destination without any manu... labour.
- proper periodic inspection, repairs and maintenance etc.

PRINCIPLES OF MATERIAL HANDLING

1. **Reduction in handling.** The first principle of material handling is to minimize the material handli... as far as possible. The materials should be moved as little as possible.

The selection of production machinery and the type of plant layout should be such that material handl... may be eliminated as far as possible. Layout improvement or changes in the process may make it possible ... reduce material handling.

Factors that are involved in reduction in handling are thus :

(*i*) Process changes
(*ii*) Layout improvement
(*iii*) Increased size of units handled.
(*iv*) Use of proper equipment.

2. **Reduction in time.** Time is money. Time lost means paying wages to the workers when they ... not doing productive work. Time lost reduces the rate of output and increases unit overhead co... Therefore the time of each move should be minimized.

Time is consumed principally in three things :

(*i*) Waiting
(*ii*) Loading and unloading
(*iii*) Travel time.

Waiting time may be reduced by proper scheduling, well organisation of labour force, providing pro... or sufficient facilities for loading, removing congestion in the plant.

The larger the units loaded or unloaded the greater the reduction that can be made in loading time.

The greater the use of mechanical means (hoists, cranes etc.) more efficient can be loading and unlo... and faster will be the movement of materials.

A great deal of time can be saved by proper routing or through selection of shortest routes.

3. **Principle of "Unit Load".** The principle of "Unit Load" should be applied. According to ... principle, the materials should be moved in lots rather than on individual basis. Optimum num... of pieces should be moved in one unit to utilize the material handling equipments effectively. ... concept of containerization and palletization is applied in deciding the unit load. The principl... unit load avails the economies in the form of reduced loading and unloading labour cost, pac... cost, elimination of damage and pilferage, saving in time and effective utilization of material hand... equipments.

4. **Use of Gravity.** Wherever possible utilize gravity for assisting material movements as it i... cheapest source of motive power.

5. **Safety.** Safe, standard, efficient, effective, appropriate and flexible material handling equip... should be used.

6. **Use of containers.** Design containers, pallets, drums etc. to reduce the cost of handling and damage of material in transit.

7. **Stand by facility.** The provision of stand by facilities should be made so that the ... breakdown may not stop the operations due to non-availability of materials.

8. **Periodical Check up.** The check up repairing and maintenance of the existing material handling equipments should be made periodically.

9. **Avoid interference with production line.** The material handling services should not interfere with the production line.

10. **Flexibility.** The material handling services should be evaluated periodically and necessary changes should be incorporated whenever it is possible.

MATERIAL HANDLING DEVICES

Material handling devices are of three types :

(*a*) Lifting and lowering devices (vertical movement).
(*b*) Transporting devices (horizontal movement)
(*c*) Devices which lift and transport (combination devices).

Lifting and lowering devices :

These devices are used for lifting and lowering the material in a vertical direction only (up & down). These are :

1. Block and tackle.
2. Hand and power winches.
3. Hoists.
4. Elevators.
5. Pillar crane.
6. Overhead crane.

Transporting devices :

These devices are used for transporting the material in horizontal direction these are :

1. Wheel barrows.
2. Hand and power trucks.
3. Industrial narrow railways.
4. Tractors and trailers.
5. Pipe lines.
6. Pumps.
7. Aerial tram ways.

Devices which lift and transport (Combination devices) :

These devices are used for lifting, transporting and lowering the material. These are :

1. Chutes,
2. Hoists with trolleys running on overhead rails.
3. Fork lift truck.
4. Crane trucks.
5. Different types of conveyors.
6. Spiral chutes.
7. Spiral rollers.
8. Cranes.

Some of the material handling equipments are described below :

A block and tackle. Block and tackle is one of the oldest and simplest method of lifting something ... a vertical distance. It is still used by moving men and in hoisting machinery into position. It depends

in general on manpower and gives only the mechanical advantage that is possible for the various rope formations. It is crudest, simplest form of lifting, the most inexpensive in cost, and the most wasteful of manpower.

It is the device that effect vertical motion by winding the rope or cable on a drum. Here, it is possible whether using manpower or other power, to get a much greater mechanical advantage than with a block and tackle.

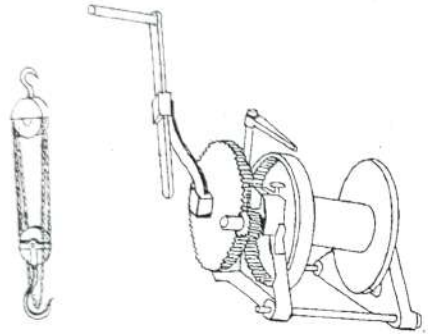


Fig. 6.1. Block and tackle. Fig. 6.2. Winches.

Winches. Winches are frequently used in loading heavy equipment into ships, construction equipment into building, and in similar jobs.

Hoists. Hoists are used for lifting the load vertically. They may be fixed in one place, attached to cranes mounted on monorail trolleys or on a single rail as shown in Fig. 6.3. The simplest type is the chain hoist which is operated by hand. But hoists operated by compressed air or by electric power are most common. The most complicated forms of hoists are those which resemble elevators in every detail except that no operator rides upon them. They are operated by remote control.

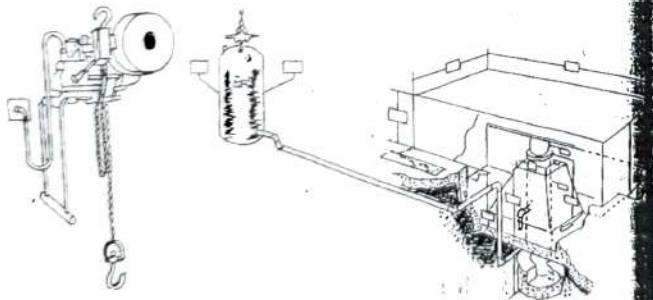


Fig. 6.3. Power Hoist. Fig. 6.4. Elevator (Hydraulic Type)

Elevator. Fig. 6.4 shows hydraulic type elevator. These are differentiated from hoists by the fact that

operator rides with the load. There are many different types of drives for such elevators, but in general electrical drive is most common. Hydraulic elevators are used only where it is dangerous to take the chance of an electric spark, as in acetylene generator houses.

Monorail. Monorail is an I-section beam attached to the ceiling and having either a trolley or carrier moving along it. The material can be transferred along the beam from one place to another.

Winch. It is used to lift loads by using the rope or a cable on a drum. It is used in loading heavy equipment into ships, construction equipment for buildings and in similar jobs.

Cranes. Cranes are used to move materials vertically and laterally in an area of limited length. They may be operated hydraulically, pneumatically or electrically, the important types of cranes are :

1. Pillar crane
2. Overhead bridge crane
3. Gantry crane
4. Jib crane
5. Mobile crane (crane truck)

Pillar crane. A pillar crane may be stationary type or mobile types. It is used for light duty and for lifting loads up to 20 tonnes. All movements to the crane are provided by gearing and electric motor drive.

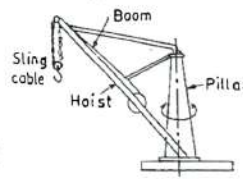


Fig. 6.5. Pillar Crane.

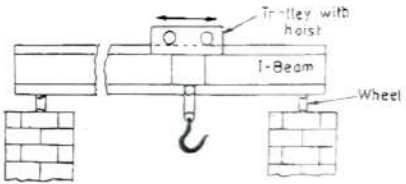


Fig. 6.6. Overhead bridge crane.

Overhead bridge crane. Overhead bridge crane is shown in Fig. 6.6. It has both transverse and longitudinal movements. The crane hook thus moves in a rectangular area can reach to any part of rectangular floor or yard. It is used in foundry, power house, chemical plants, heavy fabrication industry, steel industry

Jib Crane. Fig. 6.7 shows a jib crane. In this type of crane, the hook can move in a circular path. A jib

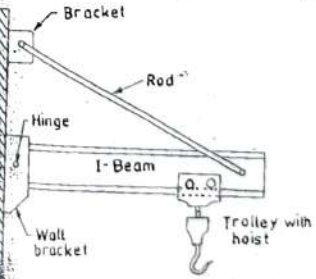


Fig. 6.7. Jib Crane.

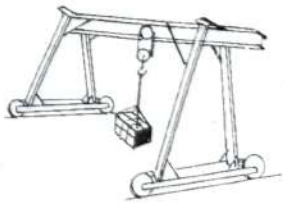


Fig. 6.8. Gantry Crane.

crane is preferred where lifting of the jobs is required in few locations only or where bridge crane cannot be erected. In a jib crane the hoist unit may be mounted on an I-section jib which is in turn supported on a column.

Gantry Crane. A gantry crane shown in Fig. 6.8 acts as an auxiliary to bridge crane. It is provided with wheels and can be moved from one place to another as per requirements.

Hand trucks and wheel barrows. The simplest transporting devices are wheel barrows and hand trucks. These are still in use in number of small industries all over the country. Fig. 6.9 shows a hand truck. Fig. 6.10 shows a wheel barrow or a wheeler. Wheelers are particularly used to handle the materials inside the shops. Wheelers are nothing but a form of a box provided with wheels.

Fig. 6.9

Fig. 6.10

These equipments involve a large amount of manpower for a relatively small load. The chief advantage of this equipment is its very low cost, its great flexibility, and its easy portability from one job to another. However, in many cases, power operated equipment should be substituted for equipment of this kind, which is mainly used because of tradition.

Industrial Railways. Industrial railways are narrow-gauge rail roads. In general, little use is made of such equipment because it requires a heavy investment in the road bed and tracks. It possesses little flexibility, and is difficult to change after some period, if required. Industrial railways were used in the days before the development of rubber tire equipment. They are still found in metal working industries (blast furnaces, copper refineries and steel-rolling operations) and in mining activities, where it is cheaper or more desirable to lay tracks than to pave the entire area.

Fig. 6.11. Wheel hydraulic tripping trailer.

Tractors and Trailers

The use of tractors and trailers for material handling is one of the most common method of horizontal transportation. This method is most flexible as tractors can be connected to different types of trailers. Trailers can be disconnected from tractors, left loaded and can be picked up by different tractors. This system thus has the advantage of great flexibility plus all the advantages of industrial railways, and there is no investment in laying tracks. It is one of the most important methods of handling materials inside the plant or from one building to another.

Railway Equipment. The use of actual railway equipment is advantageous where plants are located a considerable distance and the units handled are extremely large.

Aerial Tramways. Aerial tramways is also a horizontal transportation system in which the load carrying vehicle is supported from the top, usually by means of a cable or its equivalent.

Skids. Skids are used with lift trucks. Goods may be loaded on to skids and then picked up with lift trucks. This is the first improvement over wheel barrows and hand trucks. The skid can be loaded as a unit and transferred from position to position without subsequent loading and unloading. Both skids and pallets raise the load off the supporting surface and allow the easy insertion of the conveying means.

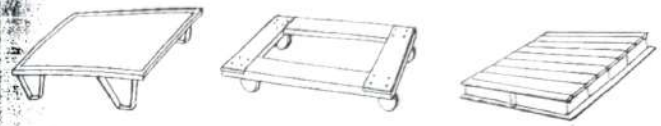


Fig. 6.12. Skids.

Pipe Line. Pipe lines and pumps are also used for horizontal transportations of commodities. Most obvious among these is oil, which is pumped great distances through pipe lines. Gas, principally natural gas, is also carried through pipe lines. Water is similarly transported at various distances.

Slides and Chutes. One of the simplest devices that have both vertical and horizontal motion is a slide or chute. It may be straight or spiral and is static in nature. Gravity is utilized in order to move material down and, if desired, to change the position of the load horizontally. Chutes are common in railway and air line terminal for handling packages and baggages. Chutes are also used in department stores particularly in spiral form to ship stock from reserves on the upper floors to the lower selling floors. Where the sliding down process tends to be slow, the vibrating chutes are used where the materials are moved downwards through vibrations.

Fig. 6.13. Spiral Chute.

Monorails. Monorail is an I-section beam attached to the ceiling and having a trolley hoist moving along it. The material can be transferred from one place to another along the beam. Either the vertical, or horizontal travel, or both, are power operated. This makes possible the handling of relatively heavy material by lifting the load and transporting it.

Lifts. In a multistoried plants material may be lifted up and transported by lifts. It is a fast and safe equipment for floor to floor travel. Buckets or trays can be mounted on the endless chain running from the ground floor to the top floor. The material can be loaded on trays automatically.

Trucks. The trucks are used to move the heavy materials over varying paths. They are either manually operated or power operated. Generally two wheeler, three wheeler or four or more wheeler trucks are used to carry and to move heavy loads. Industrial trucks are preferred :

- when materials are to be picked up and moved intermittently on different routes.
- when materials are of mixed size and weight.
- when it is possible to use unit load.
- when cross traffic exists.
- when distances to be moved are moderate.

The various types of trucks used for material handling are manually operated trucks, power operated trucks, high lift trucks, low lift trucks, fork lift trucks, crane trucks, auto trucks etc. The lifting feature in lift trucks provides clearance from the floor for the skids and permits horizontal transportation.

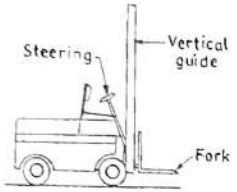


Fig. 6.14. Fork lift truck.

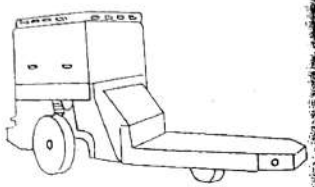


Fig. 6.15. Lift Truck.

Crane Truck. Small crane trucks operate on the principle as lift tucks. They are used for materials cannot be put on skids, or is not available on skids present time, or is much too heavy to handle wit trucks.

It moves quickly over smooth, even and ground. It can be carried at will and to any place. In cranes the solid rubber tyres are used. The cranes are type, as shown in Fig. 6.16 so that the load can be from any position.

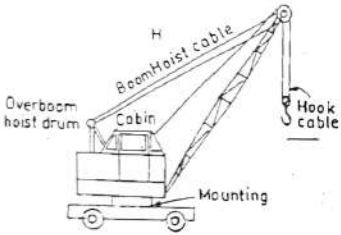


Fig. 6.17. Crane truck.

Auto Truck. Auto trucks need no partic explanation except for the development of tail b (hydraulic gates), which receive the load at ground and elevate it to the level of the truck, so that all m lifting is avoided.

Conveyors. A conveyor is a device which moves materials in either a vertical or horizontal dir between two fixed points. They may be fixed or portable conveyors, straight or circular ones. The ma are fed to the conveyor from some other source at the point of start, they are carried by the conveyor t point of destination. They are driven with the help of power or without the power through gravity. Conve have the advantage that they largely save labour cost, but have the disadvantage that they take up consider space, are relatively fixed and in most cases the investment cost is high.

Use of Conveyors. Conveyors are used in mass production industries where unit loads are uniform required movement of the material is continuous, path and rate of movement of material is not like change. Conveyors have a number of uses, especially in a line layout. The material handling system single product plant layout can be effectively co-ordinated with the process as a whole.

A good system of conveyors besides bringing about low cost transportation can also be employed

1. processing activities performed during transportation;
2. work-holding devices on a moving work-station;
3. a medium for providing storage;
4. inspection of the product in transit;
5. a device for pacing operations and reducing production planning and control activities.

Processing activities that can be performed on materials in transit include head treatment, cleaning, painting, drying, hardening and cooling. Speed and uniformity in quality are obtained by auto control in transit.

By special design of containers, racks and fixtures, the operators can perform a sequence of operation while the material is in transit, thus eliminating pick-up and put-away non-productive activities. The proper re-positioning of the material in the work centre also facilitates the use of both hands of the operator to good advantage.

The material may be inspected, that is, sorted, graded, weighed, counted, checked for size, or tested for various attributes while the work is in transit.

Power conveyors co-ordinate various operations at the required rate of movement, thus effecting means of pacing the work. As a pacing device, conveyors free the supervisors from the need to maintain the required rate of operations, which is executed automatically. Because there is a definite flow of work at a pre-determined rate in a chain of operations tied together, it is easy to attain detailed scheduling. Mechanised pacing facilitates better production control, with a reduced amount of detailed attention and paper work on the part of the planning personnel.

Types of Conveyors :

(*a*) Roller conveyor
(*b*) Belt conveyor
(*c*) Chain conveyor
(*d*) Bucket conveyor, and
(*e*) Screw conveyor

(*a*) **Roller Conveyor.** Roller conveyors are flat, circular or spiral. They consist of rollers supported in frames over which materials are allowed to move. They are driven through gravity. Generally materials having flat bottoms are moved, otherwise boxes or pallets are used.

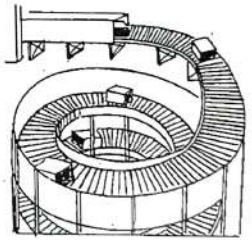


Fig. 6.17. Roller spiral conveyor.

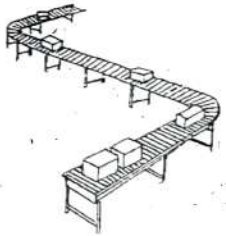
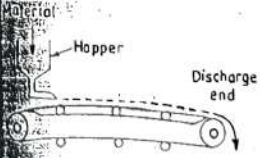


Fig. 6.18. Roller conveyor.

(*b*) **Belt conveyor.** Fig. 6.19 shows a belt conveyor, which consists of endless belt. It has a power driven pulley at one end which moves the belt continuously. It may be flat or elevated with upward or downward flow of materials. Generally, the belt is made from rubber, canvass, fabric, leather, perforated sheets or woven wires. The fixed or portable belt conveyors are used according to the requirements of the production processes.



6.19. Belt Conveyor

Chain conveyor. Chain conveyor consists of overhead mounted endless chain. It is supported from the ceiling and has a fixed path to travel. It saves valuable floor space. The arrangement is such that the lifting

mechanism (may be an electromagnet or a hook) lowers down for loading and unloading of the prod
be handled.

Chain conveyors are used in refrigeration industries for painting and plating of the refrigerator

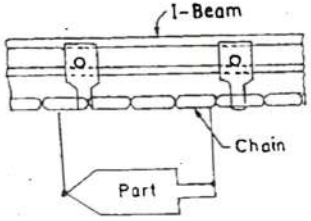


Fig. 6.20. Chain Conveyor

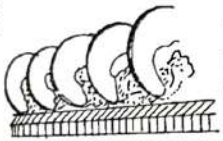


Fig. 6.21. Screw Conveyor.

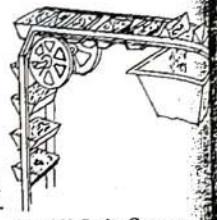


Fig. 6.22. Bucket Conveyor

Bucket conveyor. Bucket conveyors are used to move the granular, powered or liquid materia
buckets may be mounted on a chain or a belt. The movement may be vertical or flat. The vertical mov
may be continuous wherein buckets are hooked in a sequential circular manner, or discrete where buck
hooked for lifting.

Screw Conveyor. Screw conveyors are used principally for transmitting materials in the form of p
or paste with the application of rotating screw. For example, feeding pulverized coal into a furnace.

6.6. RELATION BETWEEN PLANT LAYOUT AND MATERIAL HANDLING

There exists a very close relationship between plant layout and material handling. The material ha
method definitely influences the plant layout and the factory building. Material handling should be cons
as an integral part of the plant layout. Only in this way a sound low-cost method can be designed and in

A good material handling requires a well considered arrangement of production equipment, the p
location of the various departments, a logical sequence of operations within the department, and conv
location of store areas, tool cribs, and the like. The efficient and economical material handling equi
system can be selected and designed for installations only after the floor plan has been adequately or

In the plant layout provision for the receiving and shipping of materials either by truck, t
should be made. A careful arrangement of work centres together with storage areas facilitates the eco
use of mechanical handling.

If it is required to move the materials by hand operated or power operated trucks, sufficient pa
should be provided.

The overhead space must be unobstructed if overhead cranes are to be used for handling the ma

If the building is multi storeyed, elevators, lifts, conveyor of different types must be installed at
locations to enable efficient material handling.

The location of items within a storeroom should provide for accessibility, minimum handling of m
to the point of issue, efficient utilization of space. An adequate amount of space should be provided
receiving area of the store room for inspection and unpacking.

6.7. MATERIAL HANDLING IN PROCESS LAYOUTS

The prime requirement of material handling methods used in process layouts is flexibility-fl
of path and flexibility of size, weight and shape of load.

The types of materials handling equipment that fit this requirement are, in general, mobile trucks
trains, cranes, and fork lift trucks etc.

The time required to set down or pick up a load, is an important characteristic of efficient
handling system; therefore, quick pick up systems have developed around skids and pallets. M

loaded directly on a skid or pallet by the worker as he completes his operation on the part. Without further handling, a skid truck, pallet truck or fork lift truck can pick up the entire load very quickly and move it to its destination.

Therefore, one important consideration in developing the details of layout is to provide easy access to all operations by efficient material handling equipment. The fork lift tuck is designed specially to stack loads so that storage floor area can be used efficiently. Pallets and skids, properly loaded, can be stacked four or five layers high.

Overhead cranes are used to transport and position large, heavy pieces within a fixed area. Supplementary cranes are often required at the workplaces to handle heavy pieces to and from machines.

How much material handling equipment is needed. This has always been a difficult question in process layouts because the demand for transporting capacity is on random basis, and the material handling task vary in time somewhat. It is common even to find material handling equipment idle for a considerable share of time and at the same time to hear complaints that the material can never be moved when it is wanted.

6.8. MATERIAL HANDLING IN LINE LAYOUTS

Materials handling methods and equipment, like the layout itself, tend to be special purpose in nature in line layout. The nature of line layout require some direct means of transportation between operations.

This may be accomplished in some instances by simply arranging flow so that each operator places the job down in such a position that it can be picked up by the succeeding worker. Where the nature of the product permits it, gravity chutes can be used effectively.

Conveyors to fit all types of applications of size, shape, and weight of parts are available commercially. These conveyors may require a considerable amount of special design to fit them in to an effective overall design of a line layout.

The best system of internal transportation for lines integrate the functions of transportation with those processing and storage specially built in type of equipment thus finds a wide application in line layout.

Many processes, such as cleaning, painting and drying, or washing, drying, filling and weighing as in milk bottles, may take place while the material moves.

The special purpose nature of line layout design often makes it worthwhile to design special handling equipment that is integrated with the processing so completely that the entire line functions as a single integrated machine.

6.9. PROCEDURE FOR ESTABLISHING OR IMPROVING A MATERIAL HANDLING SYSTEM

The procedure for establishing an efficient system of material handling or improving existing methods of material handling is as described below :

Objectives to be attained :

1. Eliminate handling operations in the production process wherever possible.
2. Minimize travel distance in handling.
3. Increase speed of processing and attain a reduction of goods in process, faster turn over of working capital, lower overhead cost per unit of output and rapid filling of orders.
4. Attain uniform flow (elimination of bottlenecks) and effective co-ordination of production operations.
5. Achieve minimum loss, spoilage and wastage of materials during processing, handling and storage.

Data to be compiled for analysis :

1. Nature of materials to be moved; bulk or unit, size, weight, care required in handling, type of containers necessary, etc.
2. Quantity and rate of movement, amount of materials to be moved and times required. Handling service required.
3. Distances the materials are to be moved and layout drawings of plant.
4. Direction and variability of travel required (horizontal, vertical or combination of two) and available routes (floor, overhead, outdoor space).
5. Present handling equipment employed and/or available unused equipment.

C. Analysis of the handling problem :

A careful study of the materials handling problem (the foregoing types of data compiled on ma handling) and an appreciation of the possible economies listed above will lead to efficient material han The principle and procedural approach outlined below will guide the analysis towards the developme low cost materials handling system.

1. Study the process and layout :

(*a*) The plant layout should be analysed by means of the flow diagram and the flow process ch arranged for the most economical manufacturing and materials handling activities.

(*b*) Wherever practicable, operations should be eliminated and/or combined to avoid handling

(*c*) Production machinery should be arranged for least handling and shortest transportation d between operations and without backtracking.

(*d*) Definite routes of travel should be provided for all processing, such channelization of the materials makes possible the installation of low-cost-handling devices (*i.e.* monorails conveyors, chutes etc.)

(*e*) Delays and bottlenecks should be eliminated.

(*f*) the flow of parts, sub-assemblies, and final assemblies should be co-ordinated. Bot departmental and inter-plant handling should be properly co-ordinated.

2. Study materials and containers :

(*a*) Unit loads of materials and parts should be as large as practical.

(*b*) Select or design best suited containers for materials, handling equipment and production ope

3. Select handling methods and equipments :

(*a*) Materials-handling methods and devices should be properly integrated with the production as a whole.

(*b*) Select best suited standard handling equipment. Use special handling devices for special h conditions. Select equipment for overall savings, not first cost.

(*c*) When alternate devices are available for a given handling task, choose equipment on the suitability for long run needs, size and capacity, space requirements, flexibility, adoptabil of production, power requirements, durability, purchase price, installation cost and opera maintenance cost.

(*d*) Introduce gravity handling methods wherever possible.

(*e*) Mechanize handling wherever strenuous and costly manual handling and damage to mate occur.

(*f*) Reduce piling, loading, and unloading time through mechanization.

(*g*) Wherever practical use conveyors as work holding devices, for pacing the rate of op performing operations (storage in process, conservation of floor space (*i.e.* overhead h and inspection in transit (*i.e.* checking size, weight).

4. Standardize the handling procedure. After installation of the new system, periodically handling system for compliance with the predetermined standard procedure.

5. Make Cost Study. Compare the cost of the proposed material handling system (purchas equipment and containers, installation cost, labour and other costs) with the saving ove system. Calculate the time it will take for the new equipment and system to pay for itself

QUESTIONS

1. Define material handling. State the functions of material handling.
2. Describe the factors to be considered in material handling problem.
3. Explain briefly : (*i*) Engineering factors (*ii*) Economic factors in connection with material handling.
4. How will you classify material handling devices? Give one example of each type.
5. Write short notes on :

(*i*) Fork lift truck
(*ii*) Principles of unit load
(*iii*) Cranes

6. Suggest material handling equipment commonly used in factories engaged in light engineering production.
7. "Materials handling analysis, plant layout and plant building forms composite study". Justify.
8. State the mechanical handling devices suitable for a plant manufacturing nuts and bolts on a mass-production basis and explain how these devices may affect the layout of the plant.
9. What are conveyors? State their uses.
10. Sketch any two types of conveyors, state their specific uses.
11. Describe the relationship between plant layout and material handling equipments.
12. Explain :–
    (*i*) Material handling in process layout
    (*ii*) Material handling in product layout
13. Describe the procedure for establishing or improving material handling system.
14. Explain the procedural approach to be adopted for analysis of handling problems and development of low cost material handling system.
15. Describe any four material handling equipments used in continuous production.
16. Sketch and describe any two material handling equipments used in small scale production.
17. Describe the following material handling equipments :
    (*i*) Cranes
    (*ii*) Trucks
18. Enumerate the guiding principles of material handling.
19. Describe in brief (in connection with material handling)
    (*i*) Principle of unit load
    (*ii*) Tractors and Trailer
    (*iii*) Slides & chutes
    (*iv*) Mono-rails.
20. Enumerate the factors affecting the selection of material handling equipment in a production shop.