Institute of Aeronautical Engineering

(Autonomous)

Dundigal, Hyderabad – 500 043

PLANT LYOUT AND MATERIAL HANDLING

B.Tech VIII SEM (JNTUH – R15)

Prepared by :

Dr. Paidi Raghavulu,
Professor

UNIT-I

SYLLABUS

- Classification of layout.
- Advantages of Layout & limitations of different layouts.
- Layout design procedure.
- Over view of the Plant layout

Plant Layout- Introduction

- The term Plant layout is mainly used to represent the physical arrangement of a plant and different parts of a plant. The arrangement of machines, equipments and other industrial facilities like receiving and shipping departments, tool rooms, maintenance rooms and employee amenities which helps in attaining rapid and interrupted flow of production activities at minimum cost is usually referred to as plant layout.
- The layout decisions mainly deals with the location on & arrangement of the production, support, customer service and other industrial facilities.

Definition of Plant Layout

According to ‘Knowels & Thomson’ Plant layout deals with

- Planning and arranging manufacturing machinery, equipment and services for the first time in completely new plants.
- The improvements in layouts already in use in order to introduce new methods and improvements in manufacturing procedure.

SCOPE OF PLANT LAYOUT

- Plant layout has broad scope of operations as it not only deals with the primary decisions of machines and other facilities, but also concerned with all the improvements that have to be made to the existing layout based on the subsequent developments in the production methods.
- In simple terms, a plant layout is a floor plan which is meant for determining and arranging the machinery and equipment of a plant at the most suitable place such that both the materials flow and handling can be obtained at low cost.

PRINCIPLES OF PLANT LAYOUT

1. The principle of Minimum Travel: Operations manager must design layout in such a way that the distance between operations is minimum which intern helps in avoiding the labor & time wastages there by reducing the cost of material handling.

2. The Principle of Sequence: The machines & operations must be arranged sequentially. This principle is effectively attained in product/ line layout.
3. The Principle of Usage: The available space needs to be optimally utilized. This principle has wide acceptance in towns and cities where a piece of land is very much expensive

4.The Principle of compactness**:** All the significant factors need to be fully integrated and related, producing a well integrated and final layout.

5. The Principle of Safety & Satisfaction : The layout must have provisions for safety of workers. It must be planned, based on the comfort and convenience of the workers for making them feel satisfied.

6. Principle of Flexibility: The layout must allow improvements with less difficulty and at minimum cos.

7. The Principle of Minimum Investment: The ideal layout must provide savings in fixed capital investment not by ignoring the installation of required facilities but by efficiently and optimally using the available facilities (economies of scale).

OBJECTIVES OF A GOOD LAYOUT

The main objective of a plant layout is to optimally arrange all the factors of production in such a way that it facilitates

-low production cost and

-Increased returs to scale.

For attaining this objective , the plant engineer should consider following secondary objectives while developing a plant layout.

1. By minimizing and controlling the material handling & Transportation costs.

2. To eliminate the hurdles and points of overloading by making use of appropriate line balancing techniques.

3. To provide adequate space and to establish proper locations for both production centers and service centers.

4. To minimize the waiting time of semi finished goods.

5. To provide safe and adequate working conditions there by minimizing accidents.

6. To ensure that the space available is utilized optimally.

7. To make provisions for adequate flexibility in the designed layouts so that the minute changes in product design or changes in material specification can be accommodated easily.

8. To make the plant maintenance simple & easy.

9.To design and locate the workstations adequately to facilitate uninterrupted flow of material and movement of men.

10. To encourage the effective utilization4. Cellular manufacturing layout/ group technology layout

11. To maintain high turnover of work in progress.

12. To effectively design the layout for improving productivity and quality of product.

Factors Influencing the Plant layout

The various factors influencing the plant layout decisions are :

1. Materials : some arrangement must be done for purpose of storing and moving the raw materials into plant until they get converted into finished products. The nature, type & form of raw material (ie liquid /solid, seasonal , market conditions,/ Material specification.
2. Product: The nature of product(Size, demand) influences the type of layout required. Production of ship-building, the product is fixed where as the production resources such as men & machinery needs to be brought towards the product. The demand of product also affects the layout(Storage, handling)
3. Machinery: The size and type of machinery which dictated by the product type, quantity of production , management policies.

4. Type of Industry: Plant layout decisions also influenced by the type of industry.

-Synthetic Industries: In these type several elements undergo production process to form finished product.

Ex: Chemical , paper industry

- Analytical Industries: In these type, conversion of raw material into different elements.

ex: sugar mill produces sugar bagasse, molasses, jaggery apart from sugar crystals.

- Extractive Industries: Such industries extract one element from the group of elements . ex: extraction of a metal from ore

6: Location: The location of the plant also affects plant layout in different.

a: type of building is decided by the terrain and size of the site.

b: location : influences the plant layout decisions in following ways.

- Size & Topography:decides the type of building to be constructed.
- Mode of transportation:
-Fuel requirementss of the firm:
-Future expansion of the firm: if village site is selected , the expansion of the concern my be influenced by the addtion of one or more wings to the present construction. When the urban is selected, expansion is influenced by addition of several stories to the present construction. Based on no. of story , thev material handling requirements can be determined wich influences the plant layout.

7. Managerial Policies: Layout is influenced by managerial policies which are as follows.

a: The production volume & scope for expansion.

b: The level of automation required.

c: Production or purchase of equipment.

d: Desire for rapid delivery of goods to customers, policy of purchasing.

e: Personnel policies.

TYPES/CLASSIFICATION OF PLANT LAYOUTS

- A plant layout mainly deals with the arrangement and grouping of machines which are used for producing goods. Mostly grouping is employed on different product lines. The selection of a particular layout relies on many factors.

1. Process layout/ Functional layout/ Job-shop layout.
2. Product Layout/ Line processing layout/ flow line layout
3. Fixed position Layout / Static Layout.
4. Cellular manufacturing Layout/ Group Technology Layout
5. Combination Layout/ Hybrid Layout.

PROCESS/FUNCTIONAL/JOB SHOP LAYOUT

Process Layout : is a type of layout which is characterized by the presence of similar machines or similar operations at specified location. It is known by different names. It is also called as functional layout or Job shop layout or bath production layout.

In Process layout: The machines are grouped on the basis of their operational characteristics. Ie machines that are performing the same operation are installed at a specific location.

All drilling m/cs are installed in drilling dpt. All lathe machines are installed in Turning dpt. All welding m/cs are installed in welding dept.

2. PRODUCT /LINE PROCESS / LINE/FLOW LINE LAYOUT

- Product Layout: refers to the sequential or orderly arrangement of machines in one line based on sequencing rules.

It is also called as Straight line Layout

or

Layout for serialized manufacture

In this layout , there exists several machines such that the partly processed products (WIP) of machine becomes an input for the other machine.

3. FIXED POSITION /STATIONARY / STATIC LAYOUT

Fixed Position Layout: In this type of layout, material remain at a fixed place and the complete job is done at a fixed station with materials.

-men and machines are moved to the place of materials for the necessary operations.

- This type of layout is suitable for
- hydraulic turbines, ship building, Locomotive Industry.

4. CELLULAR MANUFACTURING LAYOUT/ GROUP TECHNOLOGY LAYOUT

- Similar shape operations are made as a group or cellular and respective are installed as a group

5. COMBINATION/ HYBRID LAYOUT

- This layout contains a mix of process and Product layout .
- This layout is considered for special production line.

ADVANTAGES OF PROCESS LAYOUT

1. Process layout provides greater flexibility in Production
2. A special machinery is used for performing specific job, efficient supervision can be made/achieved.
3. A low investment on machines and equipment as general purpose machines are used.
4. It provides greater scope for expansion as the production capabilities can be increased easily.
5. It helps in optimum utilization of production recourses such as men and machine equipments.
6. The breakdown of the equipment can be handled in process layout by allotting the work to other machines or other work station.
7. Process layout motivates the individual worker by offering increased incentives based on his performance.

DISADVANTAGES OF PROCESS LAYOUT

1. It is very much difficult to transfer the materials in process layout as mechanical devices are not able to efficiently handle the materials.
2. More space is required for its functioning.
3. It is very much difficult to control the various activities.
4. It is associates with high cycle time as the WIP needs to move to different work stations for their processing.
5. If more number of WIP units get accumulated near single m/c , it results in congestion problems.

ADVANTAGES OF PRODUCT LAYOUT

1. Mechanical devices are used for handling materials, which helps in bringing down the cost of material handling.
2. Helps in avoiding the obstructions in production.
3. Highly economical as it requires less time for processing.
4. It motivates the group of workers by providing higher incentives to increase their performance level.
5. Offers better production control.
6. It requires small floor area for producing a single unit of product.
7. It reduces WIP and minimizes the investment.
8. Both mistakes and the defective items can be easily detected.

DISADVANTAGES OF PRODUCT LAYOUT

1. Lack of flexibility in production operations
2. It is not possible to supervise the operations.
3. Has less scope for expansion.
4. It is very expensive.
5. A Single breakdown of equipment along a production line can interrupt the whole system.

LAYOUT PLANNING

- The engineering or planning department is responsible for designing and installing a layout.
- In the manufacturing and service organizations, the layout planning deals with the arrangement of resources so that the performance of the operating system could be improved.
- A set of tools and techniques can be provided by the layout planning which helps the operations manager to locate resources and also for assessment of alternatives for locating the resources.

LAYOUT PLANNING TOOLS & TECHNIQUES

The different techniques that are available and useful for layout planning are

1. Templates
2. Operations Sequence Analysis.
3. Line balancing.

1.Template: It is a two dimensional technique which is the most commonly used. Templates are the design patterns which consists of a thin plate, made up of wood or metal and which serve as a gate for performing mechanical activities.

- It constitutes the scaled representation of the physical object of the layout.

-Templates are fixed for preparing plans, for drawing several possible layouts. The best possible option can be explored by eliminating the unnecessary handling and backtracking of materials.

- It is usually employed for re-designing the existing department/building

- For verifying the layout design configuration decided by other layout technique.

2. Operations Sequence Analysis: It is an early approach to process type layout. It develops a good plan for arranging the departments graphically so that the layout problem get an optimal solution. Through the operations sequence analysis, the relative locations of operating department with respect to one another can be predicted.

3. Line Balancing: it is an important activity of an assembly line operation, which is mainly used for the equitable distribution of work among the employees so that total number of employees can be greatly reduced. Line balancing is not an easy task because there are different alternative methods that can be far more easily applied than line balancing for the decision of work. Some of the methods used by operation researchers to study line balancing problems include linear programming, dynamic programming and other optimal methods.

Steps followed in designing a layout

1. Statement showing the objectives, scope and factors that need to be considered
2. Gather the primary data on sales forecasts, production volumes, production schedules, part lists, operations and their sequences.
3. Development of flow process charts, flow diagram, string diagram, templates and so on.
4. 4. establishment and the design of the production process.
5. Material flow pattern is planned and complete material handling plan is developed.
6. Computation of the requirements of work centres and equipments.
7. Planning is done for individual work centres.
8. Selection of proper material handling equipments.

9. Identifying the storage requirements
10. Planning for the auxiliary and service facilities.
11. Identification of routing, service department, employee facilities and requirement of space for each work station
12. Outlining the specification of building so that the requirement s of the layout can be fixed.
13. Development of floor plan for representing the location of doors, windows, stair case, lifts other infrastructural facilities.
14. Preparation of tentative or drafts layout plans.
15. Preparation of a comprehensive layout drawing which can be even accepted by top management.
16. Preparation and design of work schedules for layout installations.

CLASSIFICATION OF LAYOUT DESIGN PROCEDURES/ EVALUATING METHODS.

The design procedure s for layout are broadly classified into two type. They are,

1. manual methods
2. computerized methods

1. The manual methods are conventional type and are sub-divided as follows.

1a) travel chart method

1b)systematic layout planning

1c) local-distance analysis method

2.Computerized methods are constructive type and improvement type algorithms and they are classified as follows.

2a) Automated layout design program (ALDEP)

2b)Computerized Relation ship Layout planning (CORELAP)

2c)Computerized Relative Allocation of Facilities Technique. (CRAFT)

2d)Computerized Plant Layout and Evaluation Technique. (PLANET).

2e)Computerized Facilities Design (COFAD)

MANUAL LAYOUT DESIGN PROCEDURE

1a) Travel chart method:

- Travel chart method is a technique used for determining the overall flow of materials. The travel chart is used to identify the most active departments when materials move from one department to the other.
- In this method, the optimal solution can be reached by considering the trial and error method wherein the active departments are located centrally so as to minimize the non-adjacent flows.
- The travel chart is drawn by using circles for representing the work stations and lines for the transportation of loads across the work centres and departments.

Procedure:

1. identify the departments which maintain the adjustment links with the other departments.
2. in facility outline, the most active departments must be located at the central position.
3. By trial and error method, other departments must be located in such a way that the non-adjacent flows could be minimized to a great extent.
4. By eliminating all the non-adjacent moves, the optimal solution is said to have obtained.

Manual layout design procedure

1b) systematic layout planning method

- Some production systems like service systems, make use of systematic layout planning wherein the amount of material that flows between the departments may not be critical for the development of an appropriate facility layout.
- In this method, a chart is prepared in which ratings are given for representing the relative importance of locating one department close to another department and is termed as “Relation ship chart or Richard Mutrher’s half matrix”. The important ratings are expressed with code letters a,e,I,o,u,x which are called as “nearness codes”. A;long with nearness code, a reason code is also used which is indicated by a number that depends on a variety of reasons for locating any two departments, adjacent to each other.
- When the problem is formulated in systematic layout planning (SLP) method, based on the sequential steps in general design, the process starts as shown in below flow chart.

UNIT-II

Syllabus:

- Heuristics for plant layout, ALDEP, CORELAP, CRAFT
- Group Layout, Fixed position layout
- Quadratic assignment model, Branch and bound method

HEURISTICS FOR PLANT LAYOUT

- When there is no method which guarantees an optimal solution with reduced computational effort, in such situation we aim at a solution which is not necessarily optimal but which is near optimal. The method to get such a solution is known as heuristic method. Here an attempt is made to strike a compromise between the computational effort and the quality of the solution.

HEURISTICS TO SOLVE THE LAYOUT PROBLEMS

- Computerized Relative Allocation of Facilities Technique (CRAFT)
- Automated design layout design program (ALDEP)
- Computerized Relationship Layout Planning
- (CORELAP)
- Plant Layout Evaluation Technique (PLANET)
- Plant Layout Evaluation Technique (PLANET)

CLASSIFICATION OF COMPUTER PROGRAMS OF PLANT LAYOUT:

a)**Construction of Algorithms** : Computer programs help in constructing the algorithms. A construction algorithm includes the proper selection and placement of activities (dpts), thus helps in obtaining successive design layout.

b)**Improvement of Algorithms:** This perception of computer program provides an idea about improvement in the quality of layout problem. In order to improve the quality design layout, the activities (departments) are interchanged from the initial existing layout.

PROGRAMS ARE MOST COMMONLY USED IN DESIGNING A PLANT LAYOUT.

1. Computerized Relative Allocation of Facilities Technique (CRAFT)
2. Automated design layout design program (ALDEP)
3. Computerized Relationship Layout Planning (CORELAP)
4. Computerized Facilities and Design (COFAD)
5. Plant Layout Evaluation Technique (PLANET)

Model 2, 3 are construction algorithm which generate layout by successive addition of facilities to locations. Model 1 is an improvement algorithm which takes , an input and improves to optimal solution in a number of iterations.

COMPUTERIZED RELATIVE ALLOCATION OF FACILITIES TECHNIQUE (CRAFT) :

- CRAFT is the first improvement algorithm which is most widely used in plant layout design. This algorithm minimizes the material handling cost between the departments. CRAFT not only helps in designing layout by considering material handling cost, but also provide advancement in designing layout by considering the interpretation not material flow. Initially CRAFT performs the evaluation of given layout, hence considers the effects on design layout by interchanging the departments. A pair wise exchange criteria gives an optimum results, to minimize the transportation cost between the departments. The interchanging of the departments continues to extreme limit, where no further improvements can be made. In this locations are exchanged w.r.t similar are or with common border. It allows some departments to be fixed in position so that there is no chance of exchanging the locations.

INPUT REQUIREMENTS OF CRAFT

- Total number of Departments
- Number of interchangeable departments
- Number of fixed departments with their location.
- Location of those departments.
- Area of each department.
- Initial Layout
- Flow data (matrix which shows no of unit loads moving between all departments
- Cost per unit distance (cost matrix)

STEPS INVOLVED IN CRAFT:

Step-1: note the input requirements.

Step-2: compute centroids of all the departments in the present layout.

Step-3: Form the distance matrix by using centroids.

Step-4:. Given data on flow, distance and cost, compute the total handling cost of the present layout.

Step-5: Find all the possible pair wise interchanges of departments based on concept of common border or equal area.

Step-6: for each possibility, interchange the corresponding centroids and compute approximate costs.

Step-7: Find the pair of departments corresponding to minimum handling cost from among all the possible pair of interchanges.

Step-8: Is the cost in the previous is less than the total cost of the present layout?. If yes, go to step-8. If not go to step-11.

Step-8: Inter change the selected pair of departments. Call this as the NEW-LAYOUT. Comput centrods, distance matrix and total cost**.**

Step-9: is the cost of new layout is less than the cost of the present layout?
If yes go to step-10. If not go to step-11.

Step-10: The new layout is here after considered as the present layout. The data on centroids, layout matrix and the total cost is retained. Go to step-5.

Step-11: Print the present layout as the FINAL LAYOUT.

Step-12: stop the process.

The above algorithm is schematically represented with help of flow chart.

ADVANTAGES OF CRAFT :

- Possibility of changing the input shapes
- CRAFT allows fixing of special locations.
- Computation speed of RAFT is fast and economical in operations.
- It can perform Mathematical operations easily.
- It is possible o check earlier interactions to run the program.
- It can be used for office layouts.

DISADVANTAGES OF CRAFT :

- Due to the need of initial layout, the program is strictly applied only to modify the already existing layout or to plan the new layout where borders (outline) are known.
- Distance between the departments is represented as a straight line.
- It requires manual adjustments.
- It does not provide the assurance of having lowest possible cost layout.
- It is difficult to improve the program produced by heuristic and sub-optimal procedure (CRAFT)
- While feeding the input data in a program, it requires an attentive construction.
- It requires better adaptation for resettlements.
- The solution obtained from CRAFT program mainly depends on the path
- It considers the unpleasant relationships.
- CRAFT is restricted to 40 departments.

2 AUTOMATED LAYOUT DESIGN PROGRAM (ALDEP)

- ALDEP belongs to the construction type program, which builds the layout with out using the existing layout. It also considered as an improvement program due to the evaluation process of accepting or rejecting the given layout. It builds the layout by placing the most related departments, size required and based on the closeness rating (ie, A or E) of A, E, I, O, U, X. it adds continuously the other departments till the placement of all activities has been completed. This process is continued till all the departments are placed in he layout and no department should be available for placing with high closeness rating. At this stage , score is computed for layout in terms of numerical values. This procedure is repeated for several times and evaluates the best layout with maximum layout score.

INPUT REQUIREMENTS OF ALDEP:

- The number of departments in the layout.
- Area of each department.
- Length and width of layout
- The values of closeness for the pairs of department based on Relationship chart.
- Minimum Department Preference (MDP) value
- Sweep width.
- The least possible score for an acceptable layout.
- Total number of layouts to be generated.
- Building outline and scale of layout printout.
- The location and size of each prohibited area (if present)

STEP BY STEP PROCEDURE OF ALDEP ALGORITM

STEP BY STEP PROCEEDURE OF ALDEP

STEP-1: Give the input in following manner.

- The number of departments in the layout.
- Area of each department.
- Length and width of layout
- The values of closeness for the pairs of department based on Relationship chart.
- Minimum Department Preference (MDP) value
- Sweep width.
- Number of iterations to be carried out (N)
- Current iteration number (I)
- Location and sie of fixed department (if present)
- Score of the current layout.
- The least possible score for an acceptable layout.
- Total number of layouts to be generated.
- Building outline and scale of layout printout.
- The location and size of each prohibited area if present

STEP-4: check for the availability of non selected department in catgory –B

If it is non empty, then choose a non selected department in category –B itself corresponding to maximum REL value and place that dept in the layout.

If it is empty, then select a department randomly from category –A, and place it in the layout.

STEP-5: check for e placement of all departments n the layout. If an department is found to be unplaced, follow the STEP-3, otherwise determine the score for the layout.

STEP-6: check whether the computed score of the layout is higher than the current best layout

If yes, call the new layout as the current best layout and save corresponding score.

If no , cancel the new layout.

STEP-7: check for the current iteration number ie I=N. I yes , print the current best layout as final layout and its corresponding score as a final score.

If no, increase the iteration number as (I=I+1) and follow step

ADVANTAGES OF ALDEP:

- It can affix the particular locations which are available under certain limits.
- The solution or result obtained from ALDEP is available with in t definite area.
- The possibility of developing several replacements in order to obtain the optimum solution of layout.
- The possibility to have majority of inter-relationships.
- The capacity of degenerating multiple level of layouts

DISADVANTAGES OF ALDEP:

- It does not calculate the movement cost.
- Honor can not be given to unpleasant relationships.
- The method of determining score is suspicious or undefined.
- The process of evaluating production is complicated.
- It does not consider the mandatory space configuration.
- Restricted to only upto 63 departments.

COMPUTERIZED RELATION SHIP LAYOUT PLANNING (CORELAP)

- Computerized Relationship Layout Planning algorithm is a chart for construction of layout. The layout in CORELAP can be generated by locating the rectangular shaped departments, if departmental area and layout scale allows their representation in a rectangular form. CRELAP has the capacity to manage upto 70 number of departments.

INPUT REQUIREMENTS OF CORELAP

- The number of departments in the layout.
- Area of each department.
- Length and width of layout.
- The closeness Relationship value based on Relationship chart. (REL chart)
- Scale of output
- Building length to width ratio
- Department pre-assignment.

STEP-BY-STEP PROCEDURE OF CORELAP

STEP-1 : Provide basic input data in the following manner.

- The number of departments in the layout.
- Area of each department.
- Length and width of layout.
- The closeness Relationship values based on Relationship chart. (REL chart)
- Scale of output
- Building length to width ratio
- Department pre-assignment

- STEP-2: Consider scale as 1 square = 600 sq.m

Compute no. of square units for all the departments.

no of squares = dept. area /Area per square in layout

STEP-3: By using R EL- chart, ompute totl closeness rating for all the departments

STEP-4: Select department with highest TCR value. The selected department occupy 1 square and it is placed in the centre of layout matrix.

STEP-5. Check the closeness relationship of first selected dept with other departments. And note the corresponding closeness value . now select maximum REL value dept.

Select that department which has maximum REL Value as 3rd seleced dept.

STEP-6: Repeat the above procedure with unassigned departments

Apply above procedure till all the departments are selected.

Select 1st priority dept as a first in placement order

Select 2nd priority dept as a second in placement order

Select 3rd priority department as a third in placement order

Select 4th priority dept. as a fourth in placement order.

Select 5th priority dept as a fifth in placement order

.
.
.
.
.
.

GROUP TECHNOLOGY (CELLULAR) LAYOUT

- Group Technology (Cellular) layout: is a type of layout where the machined are arranged in the form of cells. Each cell may function either as a product layout within large shop or a process layout. The cells in a cellular layout are engaged in producing single parts of same machine having same features and those requiring the same production setting. The figure shown below shows a cellular manufacturing layout.

SUITABILITY OF GROUP TECHNOLOGY (CELLULAR) LAYOUT:

- Group Technology layout or cellular layout helps in producing products having different parts
- This layout can be applied in the work centres having easily movable machine tools.
- This layout can be used when the production of a product is independent of its capacity

OBJECTIVES OF GROUP TECHNOLOGY (CELLULAR) LAYOUT

- To increase the rate of production.
- Improves operator's experience, due to repletion of operations.
- Reduces material handling and work in process inventory
- To improve human relations as a group (cell) consists of few operators, which form as small unit team.
- Reduces product cost there by it makes economical.

ADVANTAGES OF (GROUP TECHNOLOGY) CELLULAR MANUFACTURING LAYOUT

- Increases reliability of components.,
- Increases effective machine operation.ncreases Productivity.
- High costing accuracy.
- Increased customer service.
- Increased order potential.
- Reduced planning effort.
- Reduced paper work.
- requires low setting time.
- low machine down time.
- low work in progress.
- low work movement.
- Reduced over all production time.
- Reduced over all cost

DISADVANTAGES OF CELLULAR MANUFACTURING (GROUP TECHNOLOGY) LAYOUT

- It involves less manufacturing flexibility.
- Increases the machine down time as machines are grouped as cells which may not be functional throughout the production process.
- this group technology layout may not be feasible for all situations.
- if the product mix is completely dissimilar, then we may not have meaningful information.

STEPS INVOLVED IN GROUP TECHNOLOGY (CELLULAR) LAYOUT

Step-1. Grouping of parts : The parts are grouped into families depending upon the operations to be performed,

Step-2. Path allocation: The flow path will be allocated depending upon the part families, Product type and sequential order of eperations..

Step-3. Processing of Parts: the parts are processed into respective cells.

THE METHODS EMPLOYED FOR DEVELOPMENT OF GROUP TECHNOLOGY LAYOUT :

i) Empirical Methods **ii) Analytical Methods**

- **Empirical Methods:** In this method, the job/components/parts to be processed are made as families and machines/ facilities are divided into groups. This method is used for simple cases and can be performed without any managerial aid. This method can be illustrated in detail by considering an example.
- **Example:** Manufacturing of 80 parts in a plant. The parts are made into families bade on their process operations as follows.

parameters	Familiy-A	Family-B
Number of parts	50	30
Opertionso be carried out	Milling, drilling, grinding & finishing	Turning, welding, finishing and painting

- It can be observed that the Machines/Facilities can be made into groups as follows.
- Group-1: Milling (M), Drilling (D), Grinding (G)
- Group-2: Turning (T), Welding (W)
- Group-3: Finishing F), Painting (P)
- Therefore
- , by trial and hit method, layout can be developed as shown in figure below.

Analytical Methods:

This method is carried out in two steps.

Step-1: Codind/ classification

Step-2: Production flow analysis

- **Coding/classification :** A code number is provided to each part depending upon its type and operation. Codes will be alphabets or variables to describe the parts. This system can be specific to type (unstandard) or standard type. Computerized/EDP coding/ classification system is usually employed in many industries.
- Example:

  "BRISCH" is a coding / classification system and consists of 9-digits. Every individual digit represents a specific parameter as shown below

Digit	Representation
I	Material
II	Shape
III	Size-dimension
iV	Priority of operation
V - IX	Path of operations in ascending order

b): Production Flow Analysis:

- In production flow analysis, the flow path of parts will be analyzed. The sequential steps to obtain an optimum path is as follows.
- Identification of initial operation for all parts.
- Grouping of machines / facilities according to first operation.
- Analyzing of second operation for all parts.
- Grouping of machines / facilities according to second operation.
- The above steps are repeated to enhance the complete job work through every machine / facility.
- In this process no backtracking is allowed throughout the process.

FIXED POSITION / STATIONARY LAYOUT:

- In this type of layout, material remains at a fixed place and the complete job is done at a fixed station with materials.
- It involves the movement of men and machines to the product which remains stationary for the necessary operations. In this layout, major component remains in a fixed location and tools machinery and men as well as other pieces of material are brought to this location.
- The movement of men and machines to the product is advisable because the cost of moving them would be less than the cost of moving the product which is very bulky.
- This type of layout is followed in the manufacture of bulky and heavy products such as
- Hydraulic turbines, ship building, Locomotive Industry. Construction of building requires fixed location layout because men, cement, sand, bricks, steel, wood and others are taken to the site of construction.

ADVANTAGES OF FIXED POSITION LAYOUT:

i. capital investment is minimum
ii. continuity of operation is ensured.
iii. Less total production cost.
iv. Less material movement.

DISADVANTAGES OF FIXED POSITION LAYOUT

i. machine and tools etc. take more time to reach at the work place.
ii. highly skilled workers are required.
iii. complicated jigs and fixtures may be required in fixing jobs and tools **etc.**

ADVANTAGES OF CELLULAR MANUFACTURING LAYOUT.

i. Increases reliability of components.,
ii. Increases effective machine operation.
iii. Increases productivity.
iv. High costing accuracy.
v. Increased customer service.
vi. Increased order potential.
vii. Reduced planning effort.
viii. Reduced paper work.
ix. Requires low setting time.
x. Low machine down time.
xi. Low work in progress.
xii. Low work movement.
xiii. Reduced over all production time.
xiv. Reduced over all cost

COMPARISION BETWEEN GROUP LAYOUT & FIXED POSITION LAYOUT:

Group Layout

- In his layout the machines are grouped into families depending on the sequential order of the job operations
- This layout is also called as cellular layout
- This layout helps to produce products having different parts.
- Used when the production of product is independent of its capacity.
- Cost of handling material is very less
- Semi skilled operators are needed to perform work
- Easy customer service.
- reduced planning effort.
- low machine down time.
- . reduced over all cost

Fixed position layout

- In this layout primary the product is very heavy and is kept in fixed location. The tool, machinery , men an other materials will be transferred to fixed location
- This layout is also called as static layout.
- Find its application in manufacturing heavy products like locomotives, ship, boilers, air crafts and generators.
- When the cost of transferring the bulk volume of material is very high.
- Highly skilled workers are needed to perform work
- It is very difficult to position the material, object or machines.
- More planning effort is required
- Increased over all cost

QUADRATIC ASSIGNMENT PROBLEM

- Quadratic Assignment Problem (QAP) is a technique of evaluating the prime solution for ‘n’ number of departments to ‘n’ number of locations.
- The term “Quadratics” means the product of two decision variables and it is a second order function. The term ‘assignment’ means matching each of the department with specific location. Thus QAP is modeled to facilitate layout for each department with specific location. QAP is a second degree function of variables and constraints are linear functions of variables.

QUADRATIC ASSIGNMENT PROGRAMMING METHOD.

Assumptions made:

- Net income/revenue from operating plant is equal to the difference of gross revenue and cost of primary input excluding handling cost between plants.
- Flow of material is independent of plant location.
- Transporting cost of unit material is independent pf plant and its location.
- Number of departments/ facilities will be equal to number of locations.

Evaluation of optimum Solution with QAP for plan layout.

- Notations used in this technique are ;
- ‘ a_{ij} ‘ is net income/ revenue from operating plant ‘i’ at location ‘j’
- ‘f_{ik}’ is material flow from plant ‘I ’ to plant ‘k’
- ‘c_{jl}, is transporting cost of unit material fro location ‘f’ t location ‘l’
- ‘n’ total number of plants/locations.
- ‘x_{ij} =1 represent plant ‘I’ is at location ‘j’
- For this condition, QAP can be formulated as

- $a_{ij.} X_{ij}$ --- . $F_{ik} . c_{ij} . x_{ij} . x_{kl}$ -------- (1)
- Subjective constraints

- . X_{ij} =1, I =1,2,3,4……n

- . X_{ij} =1, j =1,2,3,4……n

- X_{ij} € { 0, 1}, I, j = 1,2,3,4…….n
- If ‘a_{ij}, is locating and operational cost of plant ‘I’ at location ‘j’ then equation (1) becomes

- $a_{ij.} X_{ij}$ + -. $f_{ik} . c_{ij} . x_{ij} . x_{kl}$ -------- (2
- Subjective to constrains as same mentioned above

For Facility Layout Problem:

Notations used in this technique are ;

‘ a_{ij} ‘ is fixed cost of locating facilities ‘i’ at location ‘j’

‘f_{ik}’ is material flow between facilities ‘ i’ and ‘k’

‘c_{jl}’ is cost per unit flow of material between locations ‘j’ t location ‘l’

For this condition, Lawler introduced a new decision variable

Ie., $b_{ijkl} = \{ f_{ik} . c_{jl} + a_{ij}$ if i =k and j=l

$\{ f_{ik} . c_{jl}$ if I # k and j #l

Therefore the objective function of QAP is given as

$X_{ij} + \sum b_{ijkl} . x_{ij} . x_{kl}$ -------- (3)

(constraints are similar as mentioned above)

Subjective constraints

$\sum X_{ij} = 1$, I =1,2,3,4……n

$\sum X_{ij} = 1$, j =1,2,3,4……n

X_{ij} € { 0, 1}, I, j = 1,2,3,4…….n

BRANCH AND BOUND METHOD

- Branch and bounding method: This method is used for arriving at an optimal solution to the problem of Quadratic assignment is Branch and Bounding.
- Procedure is explained wit example of assigning of four machines in available four locations.
- The W_{ij} be the flow of material f movement between machines ‘I’ and ‘j’ and is shown in below table .
- ‘d_{ij} ‘ be the distance between locations ‘ i’ and ‘j’ , and is given distance matrix.

.

Location / Machine	1	2	3	4
1	0	3	0	1
2		0	3	0
3			0	2
4				0

Distance matrix

Location / Location	1	2	3	4
1	0	1	2	6
2		0	3	5
3			0	4
4				0

Flow matrix

Our problem to the machines are assigned to available locations so as to minimize the total cost of material handling.

Solution:

Step-1 : compute the lower-bound to the problem.

The total cost will contain the sum of six elements. Each element being the product of product of one of the element of the flow matrix W and distance matrix.

Arrange the elements of flow matrix in descending order.

The array can be written as A = { 5. 3, 2, 1, 0, 0)

Similarly, the elements of distance matrix are arranged in ascending oder.

The array can written as B = { 1, 2, 3, 4, 5, 6}

The dot product of A and B = 5*1 +3*2 + 2*3 + 1*4 + o*5 +)*6 } = 5+6+6+4= 21

The cost for optimal layout will be 21 or more.

Hence the Lower-bound to the problem = 21

Solution:

- Step-2: perform Branching from the starting node.

  Suppose machine-1 is assigned to location-1, for this condition compute the cost of material handling.

The elements of the flow matrix which represent material movement associated with machine-1 are

- $W_{12,}$ $W_{13,}$ W_{14} (5, 0, 1) . let these be is designated by set P_1 = (5, 0.1)
- Distances from m/c -1 to other available locations are d_{12} , $d_{13,}$ d_{14} (1, 2, 6) . Let these be designated by set Q_1 = (1, 2, 6)
- When m/c -1 is assigned to location-1, the other machines 2, 3, and 4 can be assigned to locations 2,3 and 4.ed with these machines designated as set R = { $W_{23,}$ W_{24} W_{34} } = { 3, 0, 2 }
- The distance associated with locations 2, 3 and 4 designated as set S = { d_{23} , $d_{24,}$ d_{34} } = { 3,5, 4}
- The cost of the layout will consists of six elements with following steps.

- Crete vectors by arranging set P_1 in descending order and set Q_1 in ascending order find their dot product . call this C_1= $P_1 . Q_1 =$ (5, 1, 0) . (1, 2, 6) = 5*1 + 1*2 + 0*6) = 8
- Cerate vectors by arranging set R in descending order and set S in ascending order .find their dot product. Call this as C_2
- Find the lower bound by adding C_1 and C_2, LB = $C_1 + C_2$

- For present case , the lower-bound =LB= { P1 descending . Q1 ascending + R descending . S in ass }
  = { (5, 1, 0). (1,2,6) + (3, 2, 0). (3,4, 5) } =
  = { 5 + 2 + 0 } + { 9 + 8 + 0} = 7 + 17 = 24

- Similarly , the lower-bound , when facility-1 is assigned to locaction-2, location-3 and location-4 can be evaluated and results are shown in following table.

Table: Lower-bounds when facility-1 is assigned to locations 1,2,3 and 4

Facility-1 is assigned to	***Lower-bound***
Location-1	***24***
Location-2	***22***
Location-3	***26***
Location-4	***32***

Facilitiy-1 can be assigned in four feasible ways. Therefore , the options can be pictorially represents as in figure: 9.4

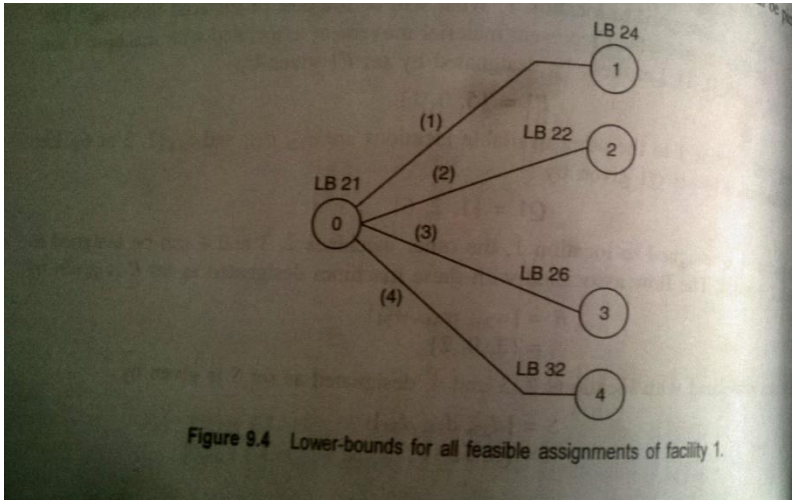


Figure 9.4 Lower-bounds for all feasible assignments of facility 1.

UNIT-III

- INTRODUCTION TO MATERIAL HANDLING SYSTEMS
- MATERIAL HANDLING PRINCIPLES
- CLASSIFICATION OF MATERIAL HANDLING EQUIPMENT
- RELATIONSHIP OF MATERIAL HANDLING TO PLNAT LAYOUT

MATERIAL HANDLING- definition

- Material handling is defined as movement of material of any form (raw material, finished, packaged, solid, liquid, gas,, light and heavy) from one location to another location, either in a restricted path by manual or mechanical aids. The movement may be either horizontal, vertical or may be combination of both.
- Material handling involves all those activities that are responsible for efficient movement of goods either with in a plant or a warehouse or between a plant and a transportation agency.

IMPORTANCE OF MATERIAL HANDLING:

Importance of material handling can be studied under following aspects.

- Movement: It is associated with the transfer of goods into and out of storage facilities or within these facilities. Efficiency of material handling can be achieved by efficient transfer of goods to, from and within the storage facility.
- Time: Aspect of time can be studied from production and customer's perspectives. In case of production, it refers to the time required for bringing the raw materials to the production site. Efficiency is said to have been achieved, if it has to encounter problems of work stoppage, higher inventories and increased space of storage.
- Quantity: Quantity refers to the amount of raw materials/finished goods transferred from/to an organization. It accurate estimation results in delivering right product to the right customer at the right time in right quantity.
- Space: Space refers to the warehouse/plant capacity used by the material handling equipment. Such space will be fixed. However, efficiency of operations can be achieved by efficiently utilizing this space.

OBJECTIVES OF MATERIAL HANDLING:

1. Increased usage capacity: It is mainly focused to increase the effective usage capacity of a warehouse. Both horizontal and vertical capacities of a warehouse needs to be utilized in an efficient manner, such that the firm must achieve both economies of scale and scope.
2. To minimize Aisle Space: 'Aisle space' refers to a passage present between the rows of shelves. If materials are handled with care, this can be reduced to a great extent so as to accommodate more quantity of materials than they have been used to do it before.
3. Reduces Handling Frequency: In case of logistics management, materials initially move from the source to the warehouse, then they can be transferred to an order selection areas where they can be picked up and made into orders and then finally, to their shipment areas where they are ready for final consumption by the customers. During all these stages, several unnecessary movements of goods can be practiced by a firm which has to be avoided in order to enhance the operational efficiency of warehouse. Thus, firms should design material handling system
4. Develops Effective Working Conditions:

   It focuses mainly on the development of secure and safe working environment where employees develop s sense of safety while working in an organization.

5)Automated Movement: Automated material handling system reduces the Burdon of manual labor by combining them with automated systems, because there are certain areas where operations cannot be performed with out making use manual labors. The best example might be the activities associated with the order picking area. Hence, an organization needs to develop an environment in such a way that it would stimulate people to perform the job efficiently.

6)Improved Logistics Service: It helps in improving the efficiency of logistics system by effectively fulfilling the customer requirements. It is responsible for the conveyance of goods to customers on time and in proper quantities. Due to efficient movement of goods into warehouse or properly locating the stock or by accurately filling the orders and also by properly preparing orders for shipment to customers, material handling forms a crucial component of an outbound logistics. This objective is greatly emphasized by the logistics manager which makes him to strive hard to ensure that the customer's orders and the production requirements are responded and met quickly and efficiently.

7) Eliminating short-distance warehouse movements

8) Minimizes Cost: By incorporating flexible material handling within the customer service programs.

FUNCTIONS OF MATERIAL HANDLING

1. It selects the type of machine, equipment and plant layout, so that the material handling requirements can be minimized.
2. It includes the choice of convenient, effective and protected material handling equipment.
3. It helps in reducing the material handling cost by considering the following..
4. minimum movement of semi finished products during the manufacturing.
5. Planning of movement of number of parts under one unit
6. Minimizing the travelling distance between the departments.
7. By increasing operational speed of handling through mechanization.
8. Removing backtracking and duplicate handling.
9. use of gravity for material handling.

JOBS OF MATERIAL HANDLING

Material handling performs the following operations.

(i) It receives the incoming raw material and delivers (ie shipping) the outgoing products.

(ii) It transports the materials to its processing area by handling in work place or in line or in interdepartmental or in intercompany .

(iii) It carries and stores the products at a suitable place.

(iv) In addition to the above operations, it can help in transport arrangement, products delivery etc., depending upon the requirement

CHARSCTERISTICS /FEATURES OF MATERIAL HANDLING EQUIPMENT:

- **A) Materials**
  (i) Bulk (in huge quantity)
  (ii) Packaged
- B) **Movement of materials**
  (i) In horizontal direction
  (ii) In vertical direction
  (iii) Both horizontal & vertical direction
- **C) Supervision required for an equipment**
  (I). More
  (ii) Less
  (iii) Automatic or semi-automatic type
- **D) Path to be followed for materials**
  (I) Variable
  (ii) Flexible
  (iii) Fixed area
- **E) Mode of speed**
  (i). Variable
  (ii) Fixed
  (iii) Fixed or variable
- **F) Source of power for the operation of an equipment.**
  (I) Electric. Power
  (ii). Power from. I.C engine
  (iii) Manual power
  (iv) Gravity power

MERITS/ADVANTAGES OF MATERIAL HANDLING SYSTEMS

- It reduces the time required for handling the materials
- Reduction in material handling & indirect labor cost.
- Improvement on productivity
- Better usage of floor space & facility
- Least fatigue to the worker
- Improved work environment
- Reduction in bottle necks
- Greater flexibility
- Improvement in safety & reduction in accidents.
- Improved material flow (Less back tracking
- It promotes a protected and clean material handling without any difficulty.
- it eliminates the idle time of workers and machines.
- Increases the flow rate of materials from one workstation to another..
- material handling is a secured process.
- Compact and better stocking of materials in good location available in plant.

****** END OF MID-I *******

MID-II
PRINCIPLES OF MATERIAL HANDLING

Several principles of material handling are employed for better utilization, safer operating conditions, lower costs and better performance of material handling

- **1. planning principle:** The material handling systems should have well planned methods which consisted of objectives of performance, needs and characteristics of the product.
- **2. Standardization Principle**: To achieve the objectives of performance of handling system, standardize the material handling method, equipment, control without influencing flexibility, modularity and the amount of material moving through the system.
- **3.Work principle:** Minimize the material handling work without affecting the level of service required at the operations and productivity.
- **4. Ergonomic principle:** To ensure safe and effective operations for the human worker, the capabilities and limitations should be adapted, designed at the time of material handling task and equipment.
- **5. Unit load principle:** Unit load should be sized and arranged in a manner, which completes the objectives of material flow and inventory at each stage of supply chain.

PRINCIPLES OF MATERIAL HANDLING contd..

6. Space utilization principle: The overall space available should be used efficiently and effectively.

7. System principle: For the formulation of coordinated and operational system, the material movement and storage activities should be fully integrated.

8. Automation principle: The material handling system should be automated or mechanized to improve operational efficiency, reduce manual labour and operating cost.

9.Environmental principle: The designing and selection of equipment and material handling system depends on the criteria of environmental Impact and energy consumption.

10.**Life cycle cost principle**: The system should have thorough economic analysis for entire life cycle of the material handling system and equipments.

VARIOUS TYPES OF MATERIAL HANDLING EQUIPMENTS

The material handling equipments are broadly classified into various types based on four categories.

1.) Design features

2) Nature and type of work

3)Working area

4)movement or motion of materials

VARIOUS TYPES OF MATERIAL HANDLING EQUIPMENTS

1. Design features: According to design they are classified as

1.1. Hoisting equipment

1.2 conveying equipment

1.3 surface and overhead equipment.

2. Nature and type of work: Equipments used for the movement and storage of materials at site are classified as

2.1 **transporting equipments** such as industrial trucks, cranes, conveyors.

2.2. **Positioning equipments** such as hoists, lifts, parts feeder, levelers etc.

2.3. **Unit load formation equipments** such as pallets, bags, crates, tote pans, cartoons etc.

2.4 **storage equipments** such as storage carousel, sliding racks, pallet racks, mezzanine etc.

2.5Identification and control equipments such as magnetic stripe, bar codes, radio frequency tag, machine vision etc.

3. Working area: In this category, equipments are classified as

3.1. **Unrestricted Area:** equipments such as trucks, tractors, carts etc.., which are restricted to move in any **direction.**

3.2 Restricted Area: Equipments such as gantry cranes, overhead travelling cranes and stacker cranes, which are confined to working area.

3.3 Line Restricted: Equipments such as lifts and elevators, conveyors, AGV's etc .. Which follows a continuous specified path for transportation of materials.

3.4 Position Restricted: Equipments such as job cranes and other industrial robots which are fixed units and works in specified areas from its position.

3.5 Auxiliary Equipments: Equipments used to improve the effectiveness of handling such as unit load carriers, dispatch Equipments, assembling and securing Equipments.

4.Movement or Motion of Materials: According to path of move the equipments are classified as,

4.1 Vertical motion (for lifting and lowering)

4.2 Horizontal motion (for transportation)

4.3 combined horizontal and vertical motion

CONVEYORS:

1.0 **Roller conveyors**: Roller conveyors contain a series of rollers or tubes along their path. Position of rollers is perpendicular to the direction of motion of conveyor.

1.1) **Power Roller conveyors:**

1.2)**Non-powered Roller Conveyors:**

1.3) Skate wheel conveyors:

2. Belt conveyors: Belt conveyors use a belt made of rubber, which is a reinforced elastomer. The operation of belt conveyors is carried out in a continuous loop. Half length of belt is used to carry and deliver the items or materials where as other half length id is for return path

2.1) Flat belt: These are used for individual parts or pallets

2.2) **Troughed Belts:** These are used for Bulk materials like gravel, coal, grain

3.**Power and Free Overhead Trolley Conveyor**:

4 Elevator: Elevator is a group of Equipments used in material handling to transfer the bulk quantity of materials from lower heights to upper heights. There are four types of elevates and are as follows.

- **4.1)Bucket elevators**
- **4.2)Fright elevators**
- **4.3) hoist elevators**
- **4.4) lifts**

1.0 **Roller conveyors**:

- Roller conveyors contain a series of rollers or tubes along their path. Position of rollers is perpendicular to the direction of motion of conveyor. The rollers are placed in a fixed frame which elevates the conveyor path above the floor level from several inches to several feet.'s.
- For this purpose tote pans or pallets or cartons are employed. When the rollers rotate the unit loads carried by flat pallets or tote pans moves forward.
- Roller conveyors are two types
- 1.1) **Power Roller conveyors:** These are driven by means of chain or belts.
- 1.2)**Non-powered Roller Conveyors:** These are driven by gravity. Hence the path has sufficient downward slope to overcome the rolling friction.
- To deliver the loads from storage compartment in between manufacturing operations, roller conveyors are employed. It can also be used in sorting/merging operations.
- **1.3) Skate wheel conveyors:** Skate. Sheet conveyors contain skate wheels rotating on shafts which are connected to a frame to roll tote pans, pallets and other containers located along their path. This the design and operation of these conveyors is same as that of roller conveyors with a difference that these conveyors use skate wheels in place of services of rollers.
- The weight of skate wheel conveyors is very low compared to the roller conveyors. Therefore the loads should be light in weight as the contacts between the loads and conveyors are highly concentrated.

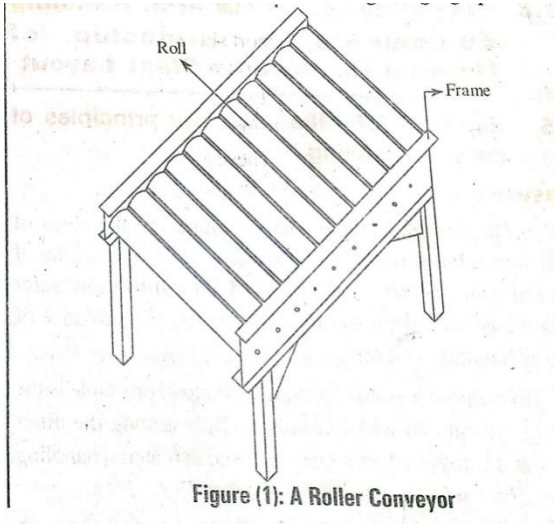


Figure (1): A Roller Conveyor

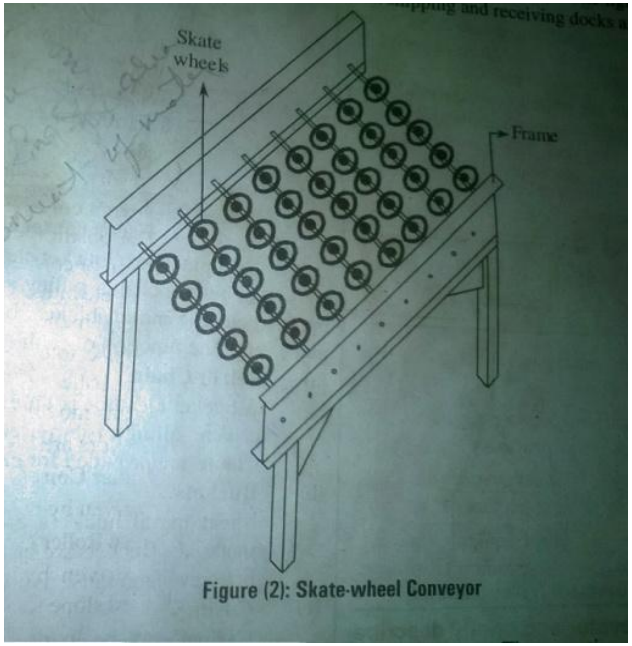


Figure (2): Skate-wheel Conveyor

2.0 BELT CONVEYORS:

- Belt conveyors use a belt made of rubber, which is a reinforced elastomer. The operation of belt conveyors is carried out in a continuous loop. Half length of belt is used to carry and deliver the items or materials where as other half length id is for return path.
- A frame containing support sliders or rollers along its forward loop is used to support the conveyor belt. A drive roller is provided at one end of the conveyor to power the belt.
- Belt Conyers are two types
- 1. Flat belt: These are used for individual parts or pallets
- 2. Troughed Belts: These are used for Bulk materials like gravel, coal, grain

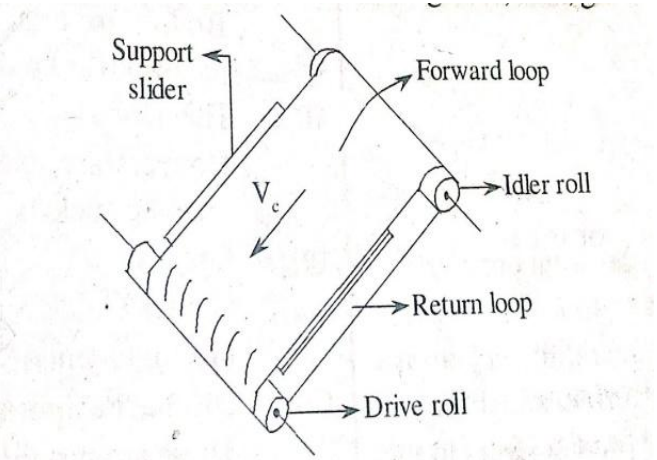


Figure (3): Belt (Flat) Conveyor

3.POWER AND FREE OVERHEAD TROLLEY CONVEYOR:

- This type of conveyor equipment consists of a wheeled carriage fixed with trolleys engaged on the tracks or beam. The track includes upper and lower track. The lower track carries from trolleys spaced along a fixed track. While the upper track carries continuously moving endless chain. When the driving chain is connected to the trolley from upper track, the load travels from one path to another path. When the driving chain is disconnected then the trolley becomes idle. This conveyor is applicable in factories to move parts and assemblies in the production system. This conveyor is used for storage and delivery of materials or parts

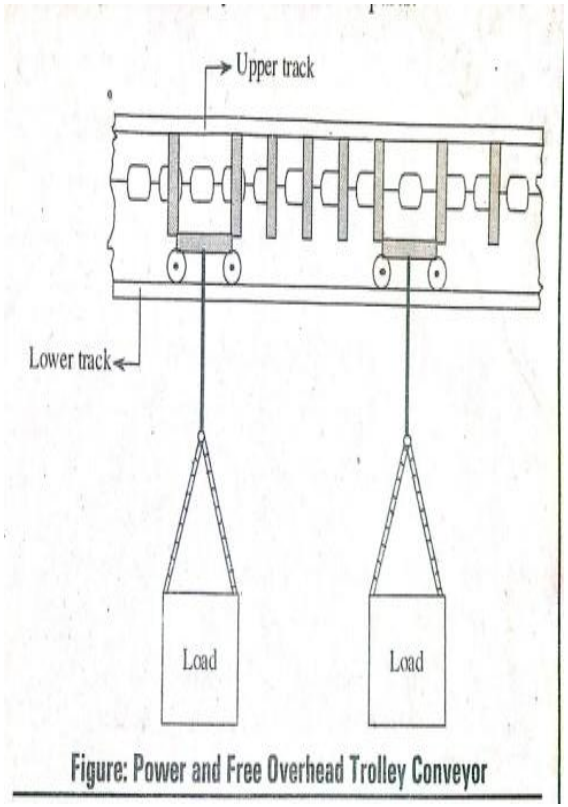


Figure: Power and Free Overhead Trolley Conveyor

4 ELEVATOR:

- Elevator is a group of Equipments used in material handling to transfer the bulk quantity of materials from lower heights to upper heights. There are four types of elevatos and are as follows.
- (**i)Bucket elevators**
- **(ii)Fright elevators**
- **(iii) hoist elevators**
- **(iv) lifts**
- 4.1) **Bucket elevators:** It is a simple ,reliable and powered equipment used for lifting bulk materials from lower heights to upper heights. It is driven by chain or belt drives on which, metallic buckets are attached. The buckets move in uni-direction and lifts the materials from lower surface by scooping and delivers to the upper surface by centrifugal action.

Bucket elevators- Components

The function of each equipment is as follows.

- .**Belt chain:** A bucket elevator has endless chain driven or belt driven pulling system used to pull the buckets. Belts/chains are provided for carrying the buckets.
- **Buckets**: Sheet metal buckets are used for handling bulk materials. Buckets are fastened to chain/belt by means of screw and nuts, rivets etc.
- **Casing:** Casings are provided for converging the entire elevator. There are three casings provided for bucket elevator ie., upper casing, lower casing and intermediate casing.
- **Drive unit:** Drive units are provided for driving the pulleys using belt drives. These units are situated at the upper end casings and are driven using the electric motors.
- **Brakes:** Brakes are attached to pulley/shaft for preventing the backward motion of the elevator when it is not in use.
- **Hoppers:** Hoppers are used for filling the bulk material into metal buckets.
- **Guides:** Guides/Guide sprockets are provided for preventing misalignment of belts and chain in bucket elevators.
- **Discharge Spouts**: These are provided at the upper portion of casing for discharging the bulk material from the metallic buckets.
- **Manholes:** These are located at the lower casing for checking the operation of an elevator.
- Hence, the bucket elevators are used for delivering the bulk materials such as coke, coal, carbon, ash, aluminium. Ore, pulverized chalk etc., from lower heights to upper height in vertical or inclined direction.

4.1.1 CLASSIFICATION OF BUCKET ELEVATORS

Based on the method of unloading (discharging) and bucket spacing, **bucket elevators are categorized** into three types

- TYPE-I or centrifugal discharge elevators
- TYPE-II or Continuous discharge elevators
- TYPE-III or positive discharge elevators1.TYPE-I or centrifugal discharge elevators

1)**TYPE-I or centrifugal discharge elevators**

- In **type-1 elevators ,** the buckets are positioned at an uniform pitch to avoid interface during the loading and unloading. This elevators uses both belt or chain drives to drive pulley's. The loading and unloading is carried out by scooping and centrifugal action respectively. This type of elevators are basically used for vertical structures and. For practical appositions, which includes all kinds of free flowing and small lump materials such as grains, coal,
- Sand, clay, sugar, dry chemicals etc. The speed of this elevator ranges from 2 1.1 to2 mpm.

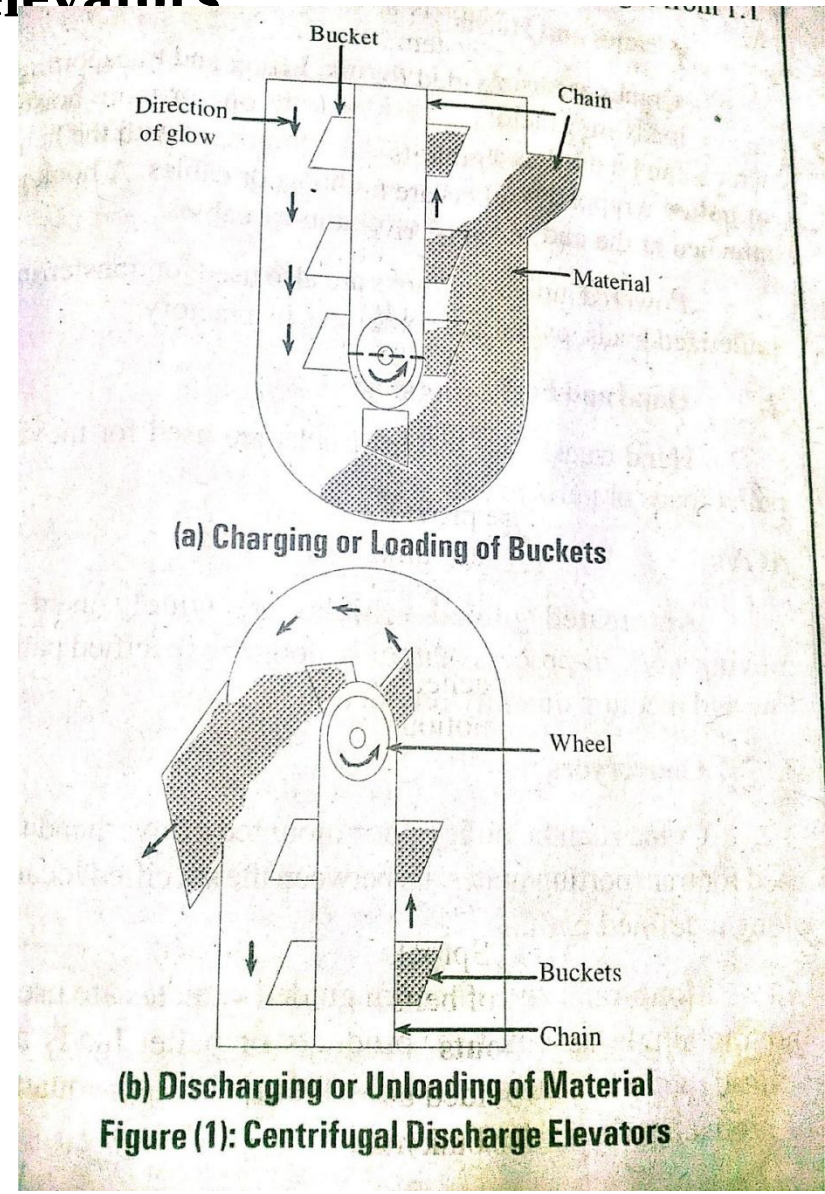


Figure (1): Centrifugal Discharge Elevators

2)TYPE-II or continuous Discharge Elevator:

- The construction of type-III elevator is similar to type -I elevator, except that buckets are side mounted on two strands of chain. The buckets are equally spaced on chain to avoid interference. To inver the buckets for complete unloading, buckets are provided with a pair of Snub Sprockets incorporated under head Sprockets. The loading is carried out by scooping or digging action of bucket and unloading is through centrifugal action. The speed of this elevator ranges from o.6 to o.67 mpm. An inclined type-III elevator especifically suitable for perfect gravity discharge applications. Light weight materials, fluffy sluggish and slightly sticky materials are more suitable for this elevator.

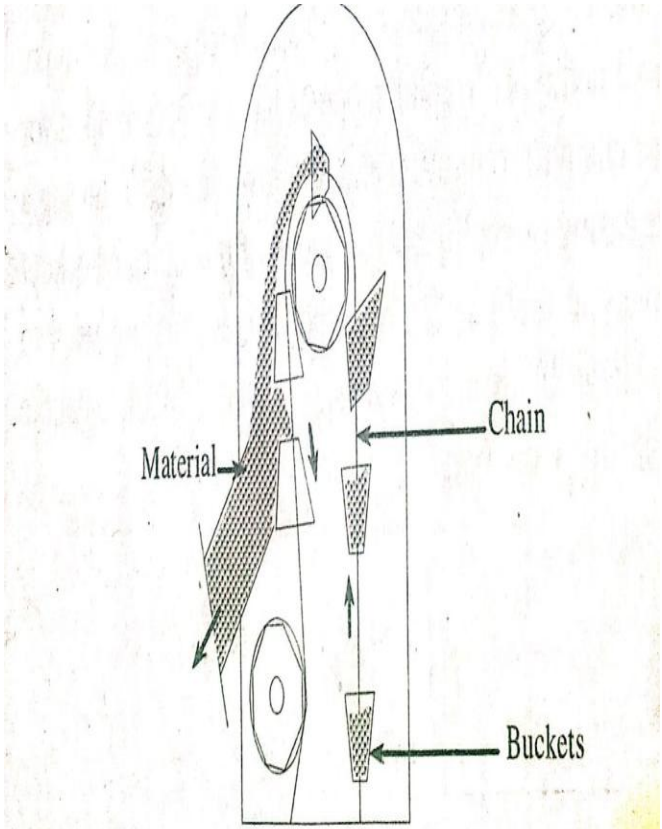


Figure (4) : Discharging of Type-III Elevator

3).TYPE-III or positive Discharge Elevators

- The construction of type-III elevator is similar to type -I elevator, except that buckets are side mounted on two strands of chain. The buckets are equally spaced on chain to avoid interference. To invert the buckets for complete unloading, buckets are provided with a pair of Snub Sprockets incorporated under head Sprockets. The loading is carried out by scooping or digging action of bucket and unloading is through centrifugal action. The speed of this elevator ranges from o.6 to o.67 mpm. An inclined type-III elevator specifically suitable for perfect gravity discharge applications. Light weight materials, fluffy sluggish and slightly sticky materials are more suitable for this elevator.

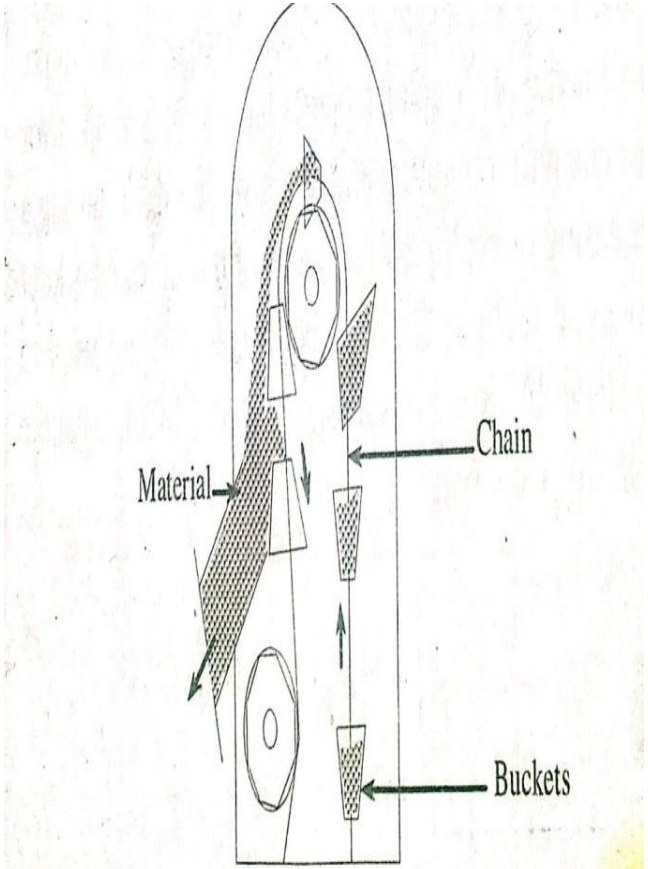


Figure (4): Discharging of Type-III Elevator

HOW MATERIAL HANDLING IS RELATED TO PLANT LAYOUT

It has been observed that plant layout is closely interrelated to material handling system, as good layout provides the minimum rate of material handling and eliminate re-handling. The material handling parameters to be considered in designing plant layout are

1. **Excess movement of materials**: Can cause damage to materials and effects the valuable time of workers in shifting the materials. Hence a well planned plant layout reduces the material handling

2.Time Utilization: Saving the worker's productive time by providing a good plant layout, enhances an effective production. Plant layout should have minimum workman travel and clearly identified well-named functional areas, distinct areas for raw materials, tools, work-in-process, inspection of finished goods, et .

3. Economical use of Space: An important perception in plant layout is space. All the machines and equipments have to be arranged in sequential and well-planned manner such that , no empty space should be wasted. There should be a possibility of optimum choice of expansion in future.

4.Use of Miscellaneous Tools: The effective utilization of bins, trolleys, racks, trays, conventional packing techniques, conveyors, chutes, inclined planes and gravity feed-bins reduce material backtracking and unnecessary movement of workers. Thus effectiveness in manufacturing can be obtained.

Therefore, a good plant layout provides an effective material handling. System which ensures minimum material handling.

DIFFERENT TYPES MATERIAL HANDLING EQUIPMENT ASSOCIATED WITH DIFFERENT PLANT LAYOUTS

- The different types of material handling equipment associated with different plant layouts are
- 1. Cranes, hoists,
- Industrial truck → Fixed position layout
-
- 2. Hand trucks, forklift,
- trucks. Automated trucks → Process Layout
- AGV's.
-
- 3. Conveyors. → Product layout
- 1.1.**Cranes and Hoists:** Cranes are used lowering, lifting and transporting heavy loads in a factory. Provided with one or more hoists which can be used as a load lifting component with the help of pulley wrapped with ropes or chains or cables. A hook is attached at the end of rope or chain or cables.
- **1.2 Powered industrial trucks** are also used for transferring palletized loads, palletized container in a factory.
- 2.1 **Hand and Forklift Trucks:** Hand trucks and forklift trucks are used for moving pallet loads or parts in a factory.
- **2.2 AGV's**: Automated guided vehicles are widely used for moving work-in-process materials along the specified path in low and medium quantity production.
- 3 **Conveyors:** Mono-rails and other rail guided vehicles are used for moving single assemblies, products or pallet loads along defined routes in a factory and also for moving large quanties of products over a fixed routes.

UNIT – IV

- **BASIC MATERIAL HANDLING SYSTEMS:**

CLASSIFICATION OF BASIC MATERIAL HANDLING SYSTEMS:

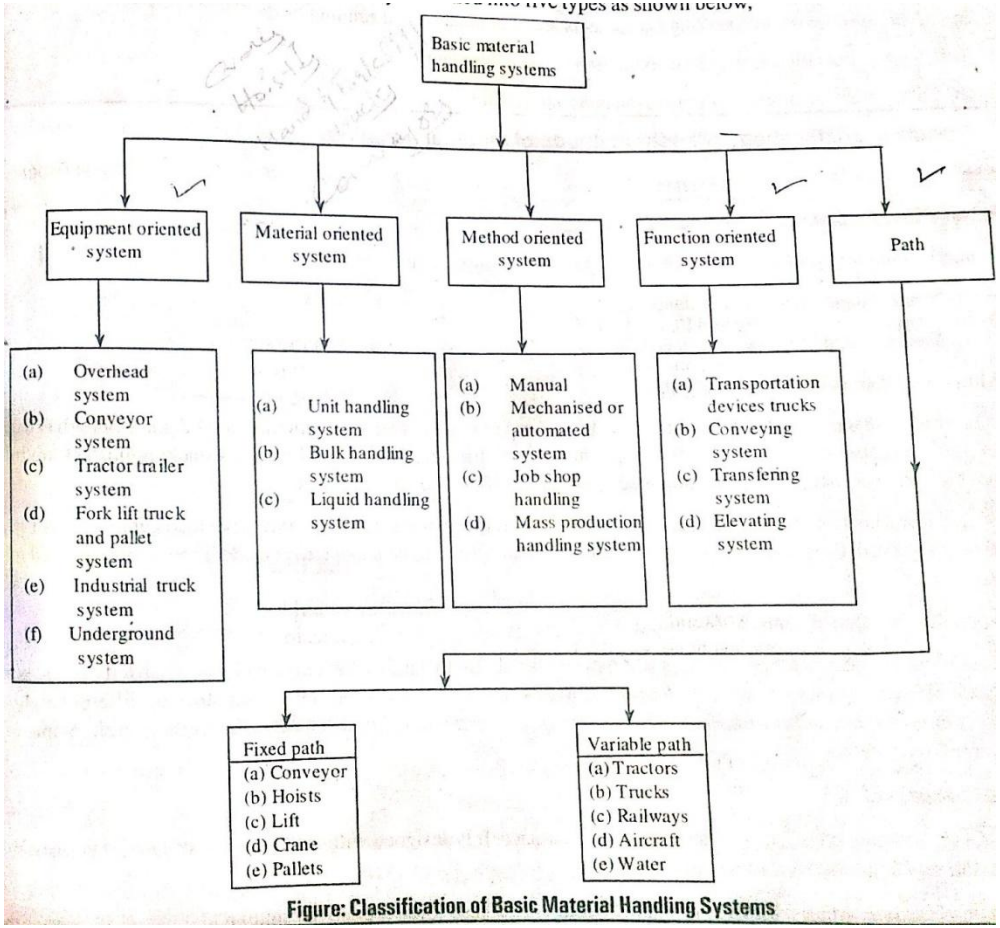


Figure: Classification of Basic Material Handling Systems

1. EQUIPMENT ORIENTED SYSTEM:

- Over head system
- Conveyor system
- Tractor trailer system
- Fork lift truck and pallet system.
- Industrial truck system
- Under ground system.

2.0 MATERIAL ORIENTED SYSTEM:

- Unit material handling system.
- Bulk handling system.
- Liquid handling system.

METHOD ORIENTED SYSTEM

- Manual system
- Mechanized or Automated system.
- Job shop handling
- Mass production handling system.

4. FUNCTION ORIENTED SYSTEM

- Transportation devices, Trucks
- Conveying systems
- Transferring system
- Elevating system.

5a: FIXED PATH ORIENTED SYSTEM

- Conveyor
- Hoists
- Lift
- Crane
- Pallets

5b: VARIABLE PATH ORIENTED SYSTEM.

- Tractors
- Trucks
- Railways
- Aircraft
- Water

FACTORS TO BE CONSIDERED WHILE SELECTING MATERIAL HANDLING EQUIPMENT.

- The plant lay out (product and process layout)
- The type of process (either continuous or intermittent flow process)
- The sequence of operations to be performed for product.
- Type of process (is it batch or JIT process)
- The plant building construction details
- The existing material handling equipments.
- The final cost of product.
- The physical & chemical properties of the material to be handled.
- The flexibility, reliability, speed and efficiency of material handling equipment.
- The noise of machines and exhaust gases of material handling equipment.
- The future costs of handling equipments maintenance & running costs.
- The depreciation rate of equipment.
- The safety of employees during the material handling.

MANUAL METHOD OF MATERIAL HANDLING

In industries, manual handling of materials is the major part of unskilled labour. In this method, the worker has to lift and move the heavy loads by activities such as lowering, pushing, pulling etc. This method includes stacking/un stacking loads on pallets, stacking shelves, lifting and lowering loads, moving trolleys and packing stock. when the worker performs these kind of activities due to improper handling or excessive loads, it may result in either physical risk or injury to the worker (s). Therefore, safety measures have to be taken into consideration during manual material handling.

MECHANICAL MATERIAL HANDLING

- This method of material handling arises when the materials are to be handled beyond the physical capacity of the workers. In this method, different equipments are used to move, store, motion control and protect the materials. The different equipments that are most commonly used are cranes, elevators, conveyors, platform trucks, forklift trucks, electric hoists, etc.

FORK LIFT

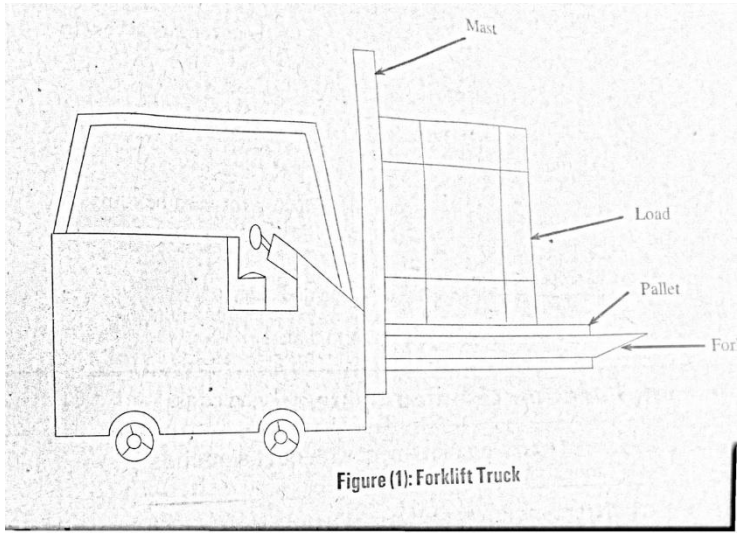


Figure (1): Forklift Truck

FLAT FORM TRUCK

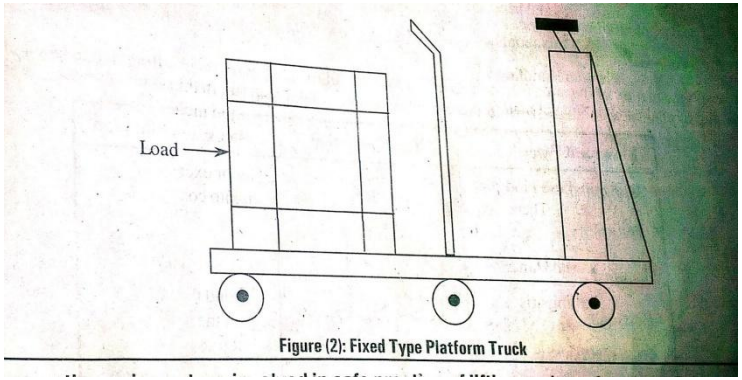


Figure (2): Fixed Type Platform Truck

FUNCTION ORIENTED MATERIAL HANDLING SYSTEM

TRANSPORTATION SYSTEM OR EQUIPMENT

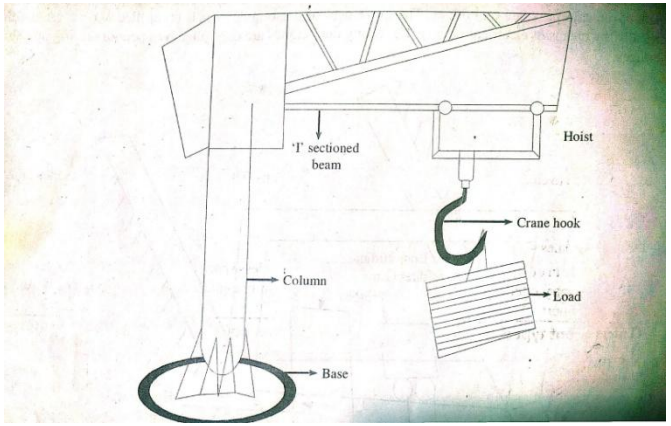
- hand truck .
- Narrow gauge rail road
- Industrial tractors and trailers.
- walkie trucks
- Skids
- Dollies

ii) CONVEYING SYSTEMS or EQUIPMENTS:

- Belt conveyors
- Chain Conveyors
- Roller Conveyors
- Screw conveyors
- Bucket conveyors
- Elevating conveyors

iii. TRANSFERRING SYSTEM OR EQUIPMENT

- **Cranes:** These are the material handling Equipments used for lifting or lowering the material or load. The cranes are power driven or operated manually.
- **Jib cranes:**



- **Overhead cranes:**

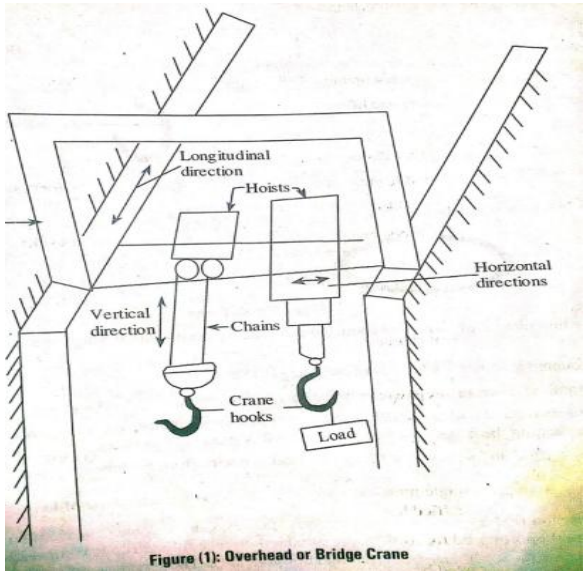


Figure (1): Overhead or Bridge Crane

- **Gantry cranes:**

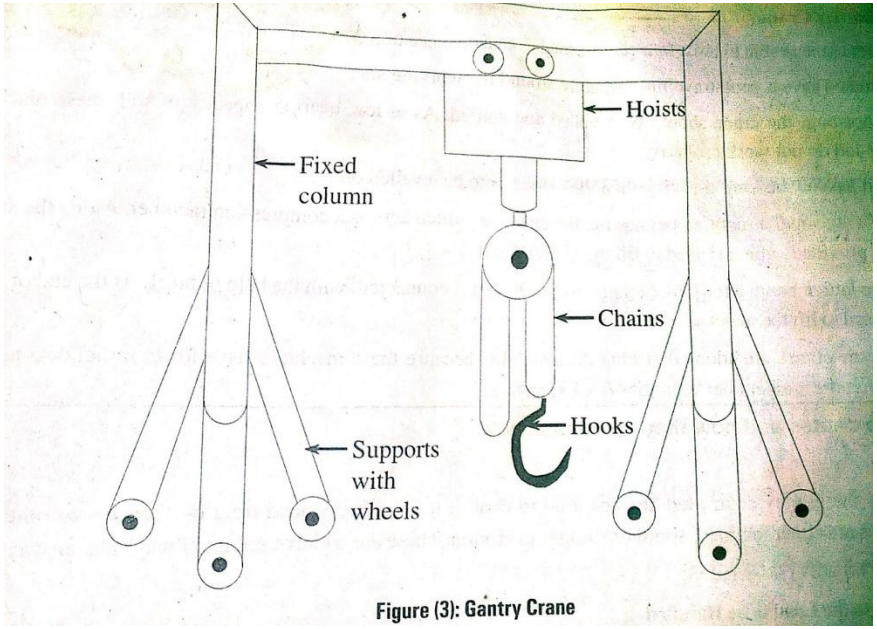
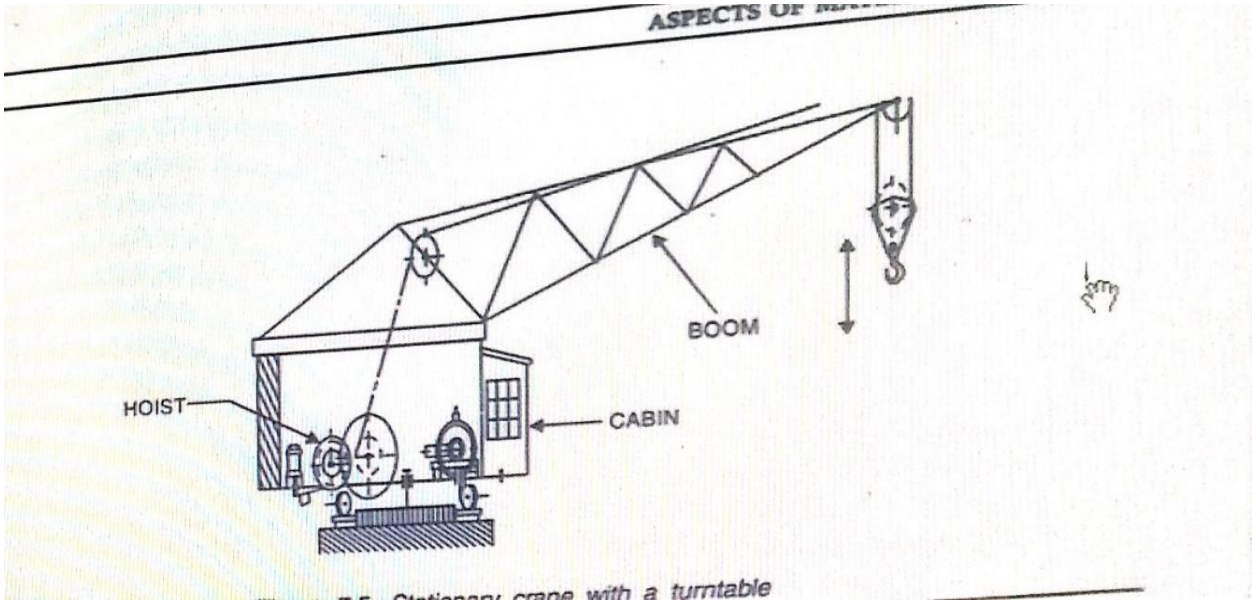


Figure (3): Gantry Crane

- **wharf cranes:**



iv) ELEVATING SYSTEMS OR EQUIPMENT.

- **Drum type elevators**
- **Traction type elevators**
- **Bucket elevators**

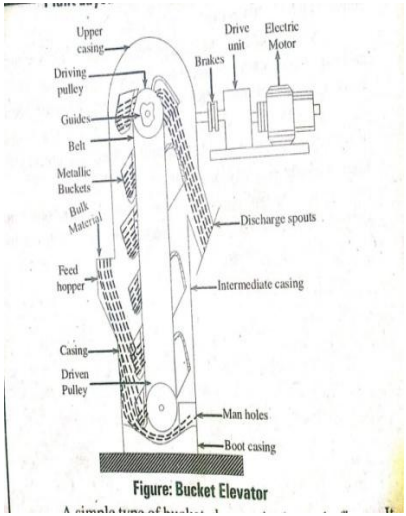


Figure: Bucket Elevator

PATH ORIENTED MATERIAL HANDLING SYSTEM
OR
EQUIPMENT

i. **The path followed**: The path followed for material handling is tabulated as follows.

Movement Type	Representation	Angle of Inclination
Horizontal	→	0°
Vertical	↑	90°
Inclined	↗	<+90°
Declined	↘	<−90°
Straight(Plan view)	—	–
Curved (Plan view)	⌒	–

ii. The course followed

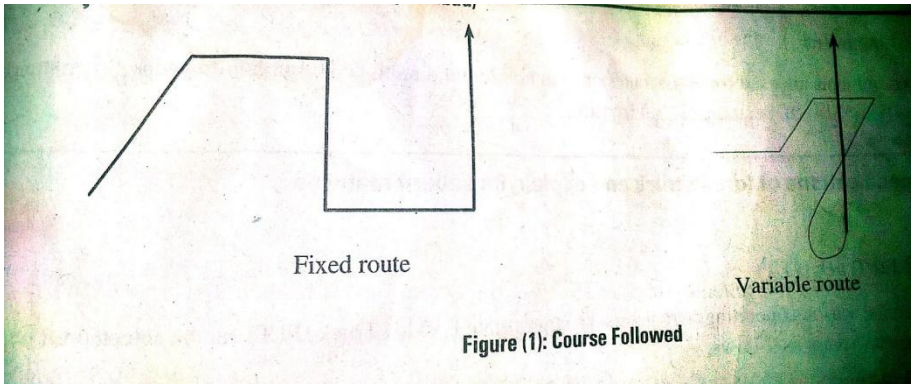


Figure (1): Course Followed

iii. THE TYPE OF MOTION FOLLOWED:

The different types of motions followed are represented by figure which is as follows.

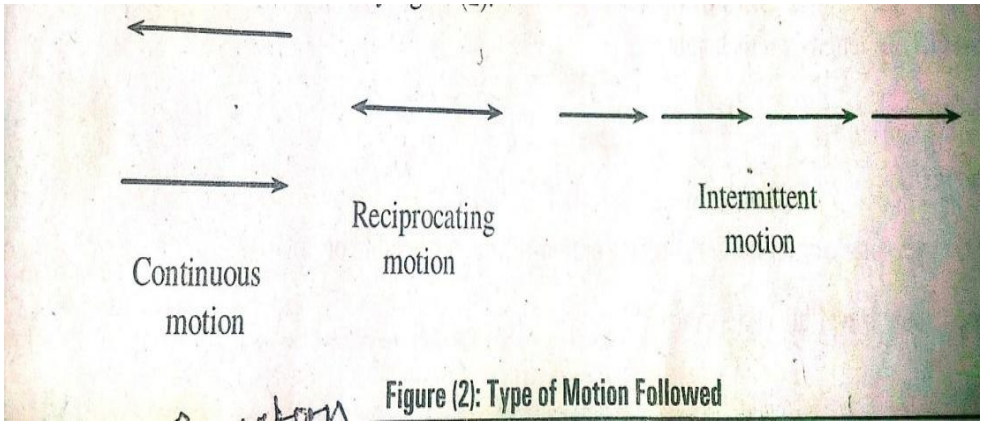


Figure (2): Type of Motion Followed

UNIT – V

1 ASPECTS OF ANALYSIS:

Cost analysis is performed to reduce the cost of material handling system. For different plants cost of material handling will be different. The aspects of cost analysis are as follows.

- cost of handling division.
- Handling process as part of the operation.
- Individual costs related to handling
- Total factory cost of handling

i. **Cost of handling Division:** The cost of handling division is related to functions within a accountable frame work, which includes tool rooms, receiving shipment, packing, crating, internal transport, storage of raw material, in process and finished goods.

ii. **Handling Process as part of the operation:** Handling process is an integral part of the operation and it deals with handling, machining, setting or positioning time of the component. Internal handling cost is given by.

- Internal handling cost: Labour cost of dept* handling time/ total time.

iii. Individual costs related to handling: Individual costs related to material handling system includes, equipment cost, maintenance cost remuneration to the operators, handlers, fitters, checkers, etc.

iv. Total Factory cost of Handling: The cost of handling in a factory is the sum of cost of handling divisions, handling process as part of the operation and individual costs related to handling.

VARIOUS COST CONSIDERATIONS IN MATERIAL HANDLING

i. Initial cost of equipment
ii. Installation cost
iii. Operating cost
iv. Cost of suppliers, repairs, maintenance etc.
v. Depreciation cost.
vi. Taxes and insurance cost
vii. Obsolescence cost.
vii. Auxiliary equipment cost.
ix. License cost
x. interest on investment cost.
xi. Rental of space
xii. Probable salvage cost

i**. Initial cost of Equipment**: The cost of equipment to be purchased varies from model to model depending upon the operations to be performed. The firm has to bear this cost to meet the requirement according to its standard.

ii. Installation **cost**: Generally, the initial cost is done by the manufacturer. In some cases while installing, the equipment has to be rearranged or if any kind of alteration required has to be done according to the building structure. This cost has to bear by the installer.

iii. **Operating cost:** The cost of operation includes power cost, labour cost, supervision cost, running cost, etc. These cost has to be minimized in order to enhance the productivity.

iv. **Cost of supplies, Repairs, Maintenance etc:** The industry has to bear any failure of the component, repairs or general maintenance cost of the equipment. The maintenance can be carried out by either industry personnel or agency experts. If the maintenance is carried out by industry personnel then, they have to carry inventories and must train the persons who are involved in this job. Thus, the cost of maintenance will be increased. If the maintenance is carried by agency experts then, the cost of maintenance will be reduced.

v. **Depreciation cost:** The cost starts when the equipment is installed and operating at full swing. It mainly deals with replacing the old equipment with a new one. It should be kept as low as possible.

vi. Taxes and insurance cost: The local taxes and the insurance cost has to be borne by the firm according to state or central government acts.

vii. Obsolescence cost: This cost is similar to that of depreciation cost. It deals with replacing the equipment with a new equipment which is technologically superior to the older one. This cost also should be minimum as possible.

viii. Auxiliary **equipment cost**: It is an optical operating cost such as charging of truck batteries, etc. This is required for efficient working of the system and to improve the productivity. It also increases the life of equipment.

ix. **License cost:** The equipment which is to be provided by license such as ,heavy trucks, etc. The licensing cost has to be borne by the firm to operate the trucks.

x. Interest on investment cost: When a firm is not in a position to purchase the equipment then, it has to be taken on a loan. In such cases the interest has to be borne by the firm.

xi. **Rent of space:** The cost of space rented or if equipment is hired for rent comes under this category. Example: Rent of garage space for parking.

xii. **Probable salvage cost:** This cost arises when the equipment is break down and is to be scrapped. This scrapping value should be as high as possible.

HOW COST OF MATERIAL HANDLING DECREASES BY IMPROVING THE MATERIAL HANDLING TECHNIQUES:

i. Better utilization of space.

ii. Reducing material handling labour

iii. Minimizing the damage of material during material handling.

iv. Material handling should not be handled by skilled or semi-skilled labour.

v. Reduction in process storage

vi Indirect labour expenses should be minimized on activities such as quality control, storage inspection, shipping, tool room, repairing, etc.

vii. Increasing the rate of production.

viii. Decreasing the inventory.

ix. Minimizing the cost on packing and other protective devices.

i. **Load utilization:** In load unitization, material handling must consider a fundamental principle which states that the economy (earnings) of material handling is directly influenced by the size of load handled. Put simply, it is directly proportional to the number of trips ie., as the number of trips increases, more number of labour is required to unload it which in turn increases the cost of stacking. Hence, an entire process can be made economical by reducing the number of trips for materials handling one of the best method is by consolidating the small packages to form a single load which is termed as load unitization. pelletization and containerization are used for the accomplishment of a unit load.

- **Pelletization**: A pallet or a skid is a wooden platform usually used for stacking goods during transportation and storage. It is highly economically to keep the manufactured goods in the form of stocks until the order fulfillment requires bulk breaking . pelletization is also useful in optimal utilization of space optimal utilization space and load unitization.

- **Containerization:** Basically, containers are used for consistent handling of materials and load unitization. Containers are secured and waterproofed large boxes, in which goods are safely placed for transportations and storage. This ability of containers facilities the forms to storage goods even in open yard without making use of ordinary warehouse

- **Space layout:** As the cost of warehouse is mainly influenced by the location of stocks in warehouses, firm need to maintain a proper balanced between the two, while designing the internal arrangement of warehouses.

- **. Layout for storage:** While designing a warehouse 'configuration' plays a vital role. If goods are available in large amount for storage, extensive care needs to be taken for their arrangement which is time consuming step. In a warehouse where turnover is low, wide and deep storage are suitable where stocking may be as high as ceiling height with narrow aisles. However, this layout may not be suitable in case of increased turnover which requires wide aisles and decreased altitude of stocks.

- **TRAINING PROGRAMME FOR SAFETY OF MATERIAL HANDLING EMPLOYEES**
- Proper material lifting techniques for manual handling.
- The employees must be aware of different equipments available for material handling.
- Proper terminology of different equipments.
- The various operating procedures for different types of material handling equipments.
- Listing of different codes with respect to the corresponding equipment.
- Different rules and regulation pertaining to specific types of material handling equipment.
- Inspection of the equipment at regular interval.
- Proper work practice for handling and the use of safety devices.
- Use of appropriate material handling equipment for its suitable task.
- General maintenance procedures and requirements

- **DIFFERENT ACCIDENTS ENCOUNTERED BY FORK LIFT TRUCK**
- i. Loads being dropped/pushed onto employees.
- ii. Overturning of trucks.
- iii. Collision with static elements or knocking them on other employees.
- iv. Employees being hit by the FLT
- v. Trapping injuries.

- **Causes of Accidents by Forklift Truck**
- Operators fault.
- Instability of load caused by shift in the centre of gravity.
- Using trucks for unsuitable premises.
- Lack of clear visibility.
- Due to insufficient skills of drivers and other employees working in the regions where FLT is being used.
- Due to poor communication among employees working in that area.
- Due to improper layout and markings on the premises.
- Inadequate ventilation and battery charging.
- Lack of maintenance of FLT
- using FLT for unsuited tasks.
- Due to over speed of trucks with heavy loads.

ERGONOMICS OF MATERIAL HANDLING EQUIPMENTS

- Ergonomics: Ergonomics is defined as the science which deals with the study of work. It is also concerned with the design of working systems. Ergonomics relates or involves the man, machine and environment in order to increase the efficiency and productivity of the system.

PRINCIPLES INVOLVED IN ERGONOMICS FOR DESIGNING WORK SYSTEM.

- work task
- work equipment
- work process
- work space
- work environment
- work stress
- work strain
- Work fatigue.