# UNIT 4 FACILITIES LAYOUT AND MATERIALS HANDLING

**Objectives**

After going through this unit, you should be able to

- Appreciate different types of layout problem, become familiar with the basic types of plant layouts and the factors to be considered for layout design and comprehend the procedure for designing the layouts in a systematic manner
- Understand different kinds of tools that can be used for the analysis of material flow and activities in a plant, realise how the space is estimated and allocated for different work centres and the facilities and know the use of computerised techniques for designing the layouts.
- Learn how to evaluate, specify, present and implement a layout,identify the factors that should be considered in the selection of material handling system, become familiar with different types of material handling equipments used in plant design and appreciate the integrated approach to layout planning and material handling system design and the role of automation in plant design.

**Structure**

## 4.1 INTRODUCTION

**Importance and Function**

Facilities layout refers to an optimum arrangement of different facilities including man, machine, equipment, material etc. Since a layout once implemented cannot be easily changed and costs of such a change are substantial, the facilities layout is a strategic decision. A poor layout will result in continuous losses in terms of higher efforts for material handling, more scrap and rework, poor space utilisation etc. Hence, need to analyse and design a sound plant layout can hardly be over emphasised. It is a crucial function that has to be performed both at the time of initial design of any facility, and during its growth, development and diversification.

The problem of plant layout should be seen in relation to overall plant design which includes many other functions such as product design, sales planning, selection of the production process, plant size, plant location, buildings, diversification etc. The layout problem occurs because of many developments including:

- change in product design
- introduction of new product
- obsolescence of facilities
- changes in demand
- market changes
- competitive cost reduction
- frequent accidents
- adoption of new safety standards
- decision to build a new plant

Plant layout problem is defined by Moore (1962) as follows:

**"Plant layout is a plan of, or the act of planning, an optimum arrangement of facilities, including personnel, operating equipment, storage space, materials- handling equipment, and all other supporting services, along with the design of the best structure to contain these facilities."**

**Objectives and Advantages**

Some of the important **objectives of a good plant layout** are as follows:

i) Overall simplification of production process in terms of equipment utilisation, minimisation of delays, reducing manufacturing time, and better provisions for maintenance.

ii) Overall integration of man, materials, machinery, supporting activities and any other considerations in a way that result in the best compromise.

iii) Minimisation of material handling cost by suitably placing the facilities in the best flow sequence.

iv) Saving in floor space, effective space utilisation and less congestion/ confusion.

v) Increased output and reduced inventories-in-process.

vi) Better supervision and control.

vii) Worker convenience, improved morale and worker satisfaction.

viii) Better working environment, safety of employees and reduced hazards.

ix) Minimisation of waste and higher productivity

x) Avoid unnecessary capital investment

xi) Higher flexibility and adaptability to changing conditions.

**Types of Layout Problems**

The facilities layout problems can be classified according to the types of facility under consideration e.g.

i) Manufacturing Plants

ii) Commercial facilities, e.g., shops, offices, Bank etc.

iii) Service facilities, e.g., Hospitals, Post Offices etc.

iv) Residential facilities, e.g., houses, apartments etc.

v) Cities, townships

vi) Recreational facilities, e.g. parks. theatres etc.

According to the nature of layout problem, it can be categorised into four types as follows:

- Planning a completely new facility
- Expanding or relocating an existing facility
- Rearrangement of existing layout
- Minor modifications in present layout

**Flow Patterns**

According to the principle of flow, the layout plan arranges the work area for each operation, or process so as to have an overall smooth flow through the production/service facility. The basic types of flow patterns that are employed in designing the layouts are I-flow, L-flow, U-flow, 0-flow, S-flow as shown in Figure 1. These are briefly explained below:

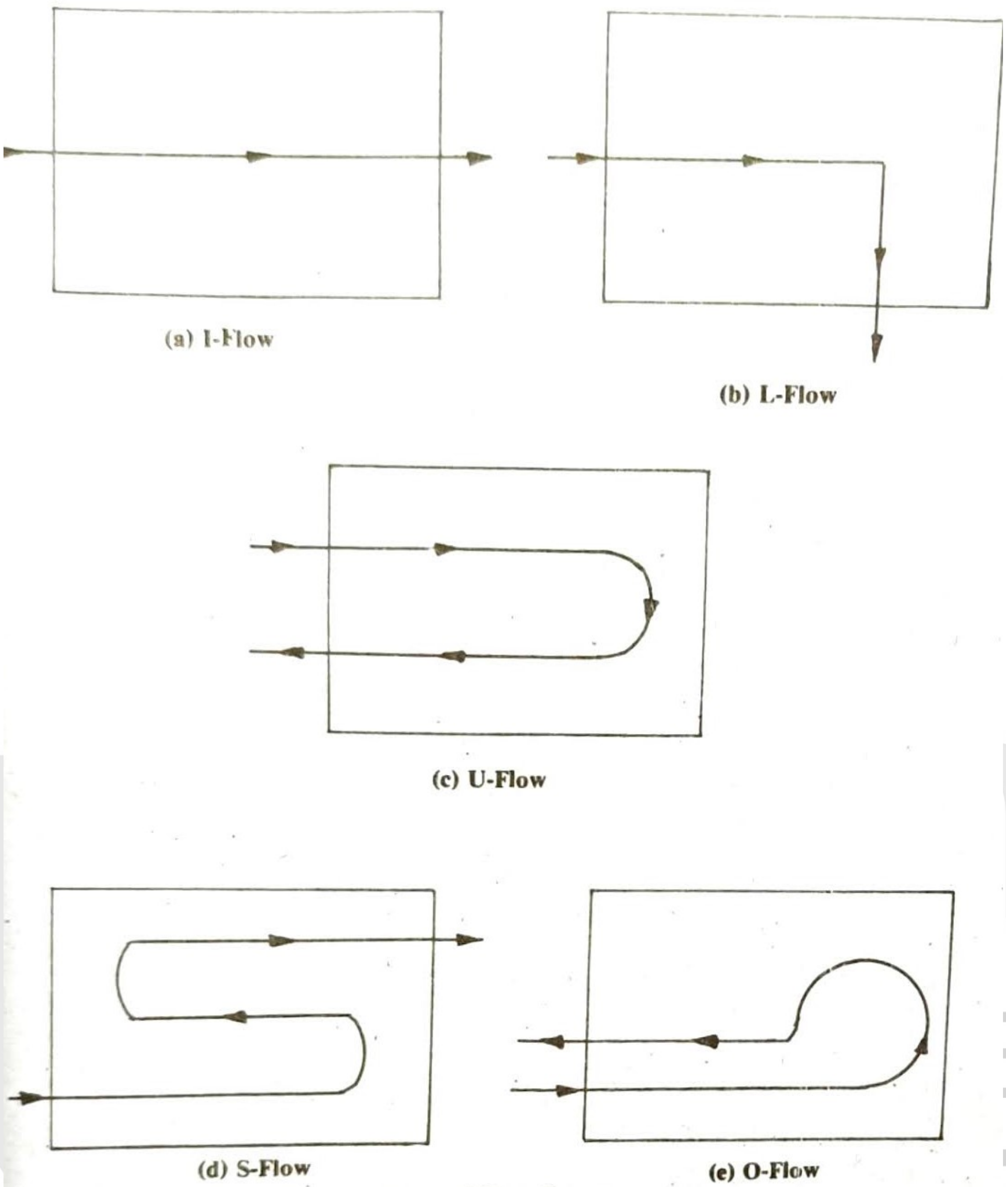



Figure I Flow Pattern

I- Flow: separate receiving and shipping area

L-Flow: when straight line flow chart to be accommodated.

U-Flow: very popular as a combination of receiving and shipping.

O-Flow: when it is desired to terminate the flow near where it is originated.

Serpentine or S-Flow: when the production line is long and zigzagging on the production floor is required.

## 4.2 BASIC TYPES OF PLANT LAYOUTS

Depending upon the focus of layout design there are five basic or classical types of layouts. Most of the practical layouts are a suitable combination of these basic types to match the requirements of activities and flow. The basic types of the layouts are:

**A) Product or Line Layout (B) Process or functional Layout (C) Cellular or Group Layout (D) Project or Fixed Position Layout**

### A) Product or Line Layout

This type of layout is developed for product focused systems. In this type of layout only one product, or one type of product, is produced in a given area. In case of product being assembled, this type of layout is popularly known as an 'assembly line'

The work centres are organised in the sequence of operations. The raw material enters at one end of the line and goes from one operation to another rapidly with minimum of work-in-process storage and material handling. A typical product layout is shown in Figure II (a).

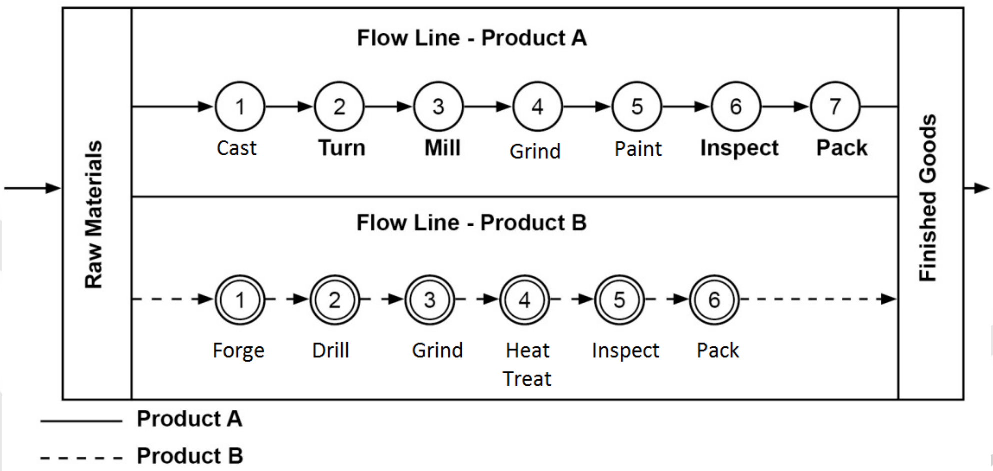



**Fig II (a) Product or Line Layout**

The decision to organise the facilities on a product or line basis is dependent upon a number of factors and has many consequences which should be carefully weighed. Following conditions favour the decision to go for a product focused layout.

i) High volume of production for adequate equipment utilisation.

ii) Standardisation of product and part interchangeability.

iii) Reasonably stable product demand.

iv) Uninterrupted supply of material.

The major problem in designing the product-focused systems is to decide the cycle time and the sub-division of work which is properly balanced (popularly known as line balancing).

Some of the major advantages of this type of layout are:

i) Reduction in material handling.

ii) Less work-in-process

iii) Better utilisation and specialisation of labour

iv) Reduced congestion and smooth flow

v) Effective supervision and control.

**(B) Process or Functional Layout**

This type of layout is developed for process focused systems. The processing units are tandardi by functions into departments on the assumption that. Certain skills and facilities are available in each department. Similar equipments and operations are grouped together, e.g., milling, foundry, drilling, plating, heat treatment etc. A typical process layout is shown in Figure II (b)

The use of process-focused systems is very wide both in manufacturing and other service facilities such as hospitals, large offices and municipal services etc.

The functional layout is more suited for low-volumes of production (batch production) and particularly when the product is not tandardized. It is economical when flexibility is the basic system requirement. The flexibility may be in terms of the

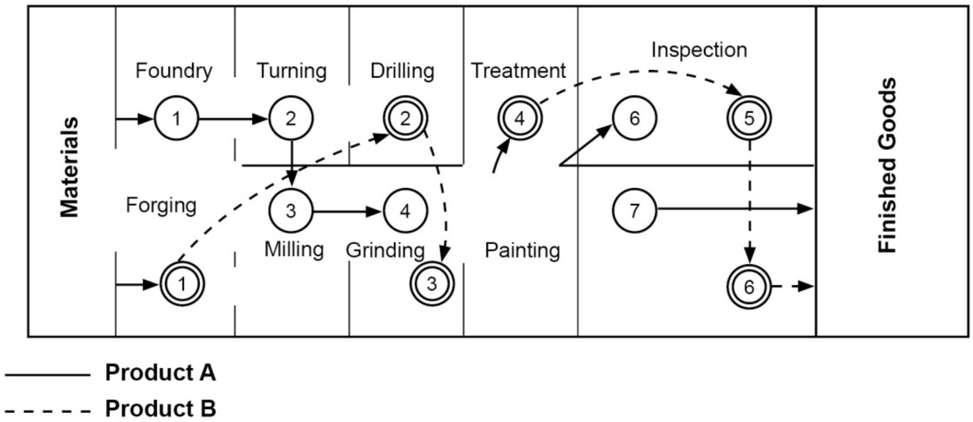



**Fig II (b)- Process Layout**

routes through the system, volume of each order, and the processing requirements of the 'items.

The major advantages of a process layout are:

i) Better machine utilisation

ii) Higher flexibility

iii) Greater incentive to individual worker

iv) More continuity of production in unforeseen conditions like breakdown, shortages, absenteeism etc.

**(C) Cellular or Group Layout**

It is a special type of functional layout in which the facilities are clubbed together into cells. This is suitable for systems designed to use the concepts, principles and approaches of group technology'. Such a layout offers the advantages of mass production with high degree of flexibility. We can employ high degree of automation even if the number of products are more with flexible requirements. In such a system the facilities are grouped into cells which are able to perform similar type of functions for a group of products. A typical cellular layout is shown in Figure II (c).

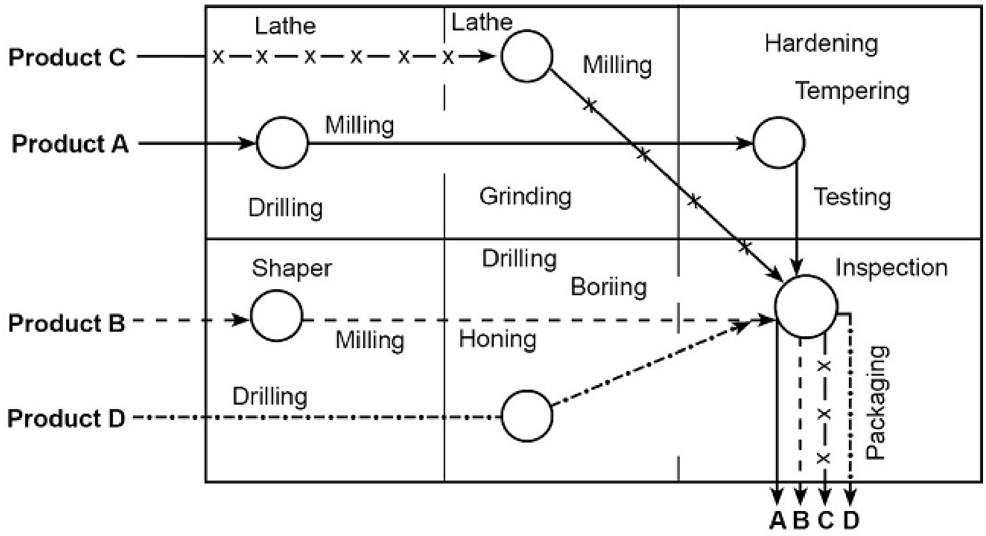



**Fig : II (c) Cellular layout**

### Job-shop Layout

It is a layout for a very general flexible system that is processing job production. The preparation of such a layout is dependent on the analysis of the possible populations of orders and is a relatively, complex affair.

### Project or Fixed Position Layout

This is the layout for project type systems in which the major component is kept at a fixed position and all other materials, components, tools, machines, and workers etc. are brought and assembly or fabrication is carried out. This type of layout is now not used very commonly as the machines required for manufacturing work are big and complicated. The fixed position layout is used only when it is difficult to move the big and major components and fabrication is to be carried out. A typical example is- production of ships.

Some of the major advantages of fixed position layout are as follows:

i) The handling requirements for major unit are minimised.

ii) Flexible with reference to the changes in product design.

iii) High adaptability to the variety of product and intermittent demand.

iv) The responsibility for quality can be pin-pointed.

v) The capital investment is minimum.

A typical fixed position layout is shown in Figure II (d).

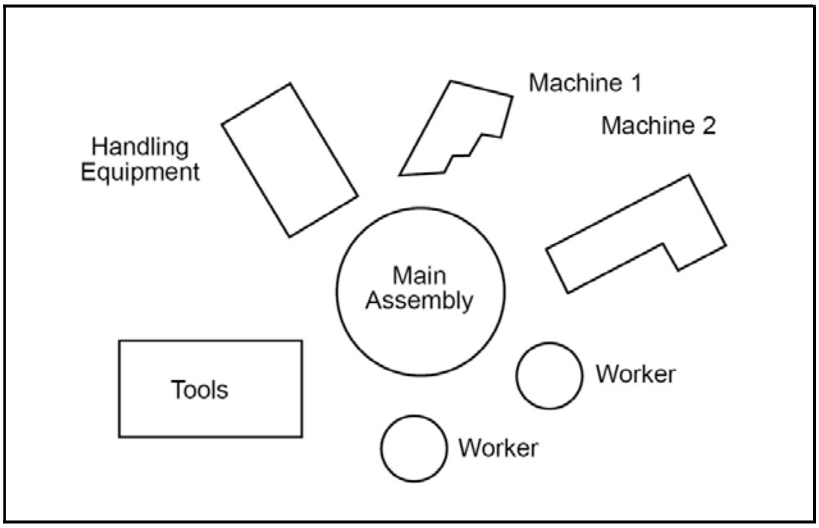



Figure II (d) Fixed position layout

The fixed position layout is used ideally for a project situation i.e. for one product of a different type. As the quantity increases the production operations can be broken down into different work centres and material can be allowed to move rather than the machines and a process layout is preferred. With further increase in volume i.e. with mass production the advantages of production line can be better derived and a product layout is desirable. The break-even analysis comprising the production volume of the three basic layouts i.e., product, process and fixed position layout is shown in Figure III.

Fig II: Breakeven point analysis of Basic types of Layout

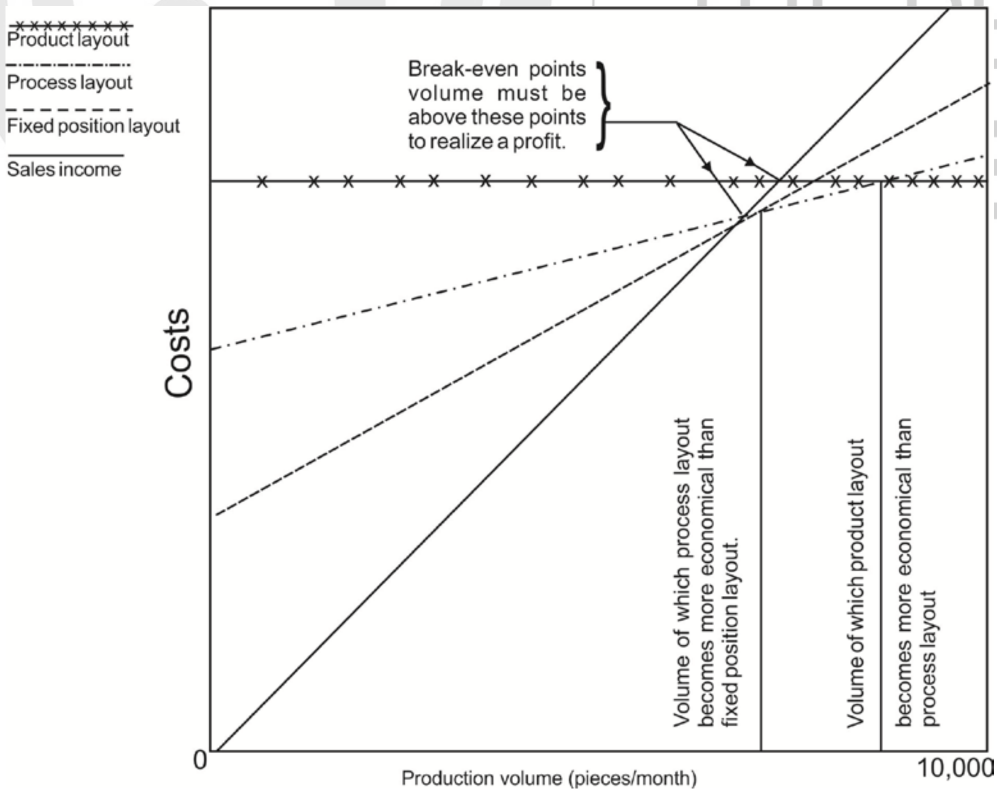



**Fig. III Break-even Point Analysis of Basic Types of Layouts**

## 4.3 PLANT LAYOUT FACTORS

The design of any layout is governed by a number of factors and the best layout is the one that optimises all the factors. As discussed by Muther (1955) the factors influencing any layout are categorised into the following eight groups:

i) The material factor: Includes design, variety, quantity, the necessary operations, and their sequence.

ii) The man factor: Includes direct workers, supervision and service help, safety and manpower utilisation.

iii) The machinery factor: Includes the process, producing equipment and tools and their utilisation.

iv) The movement factor: Includes inter and intradepartmental transport and handling at the various operations, storages and inspections, the materials handling equipments.

v) The waiting factor: Includes permanent and temporary storages and delays and their locations.

vi) The service factors: Include service relating to employee facilities such as parking lot, locker rooms, toilets and waiting rooms etc. service relating to materials in terms of quality, production control, scheduling, despatching, waste control; and service relating to machinery such as maintenance.

vii) The building factor: Includes outside and inside building features and utility distribution and equipment.

viii) The change factor: Includes versatility, flexibility and expansion.

Each of the above mentioned factors comprise a number of features and the layout engineer must review these in the light of his problem. Usually the layout design process is a compromise of these various considerations to meet the overall objectives in the best possible manner.

## 4.4 LAYOUT DESIGN PROCEDURE

The overall layout design procedure can be considered to be composed of four phases viz., Phase I Location

Phase II General Overall Layout

Phase III Detailed layout

Phase IV Installation

Some important guidelines that help in the layout design are:

i) Plan from whole to details

ii) First plan the ideal and then move to the practical aspects

iii) Material requirements should be central to the planning of process and machinery.

iv) Modify the process and machinery by different factors to plan the layout.

Though there is always an overlap in the different phases of layout design the major steps that have to be followed in the layout design are outlined as follows:

i) Statement of the problem in terms of its objective, scope and factors to be considered.

ii) Collection of basic data on sales forecasts, production volumes, production schedules, part lists, operations to be performed, work measurement, existing layouts and building drawings etc.

iii) Analysis of data and its presentation in the form of various charts.

iv) Designing the production process

v) Planning the material flow pattern and developing the overall material handling plan.

vi) Calculation of equipment requirements and work centres

vii) Planning of individual work centres

viii) Selection of material handling equipment

ix) Determining storage requirements

x) Designing activity relationships

xi) Planning of auxiliary and service facilities

xii) Calculation of space requirements and allocation of activity areas

xiii) Development of Plot Plan

xiv) Development of Block Plan

xv) Development of detailed layouts in terms of steps (vii) to (xi)

xvi) Evaluation, modification and checking of layouts

xvii) Installation of layouts

xviii) Follow up.

The S.L.P. (Systematic Layout Planning) procedure as presented by Francis and White (1974) is shown in Figure IV. We see that once the appropriate information is gathered, a flow analysis can be combined with an activity analysis to develop the relationship diagram. Space considerations when combined with the relationship diagram lead to the construction of the space relationship diagram. Based on the space relationship diagram, modifying considerations and practical limitations, a number of alternative layouts are designed and evaluated.

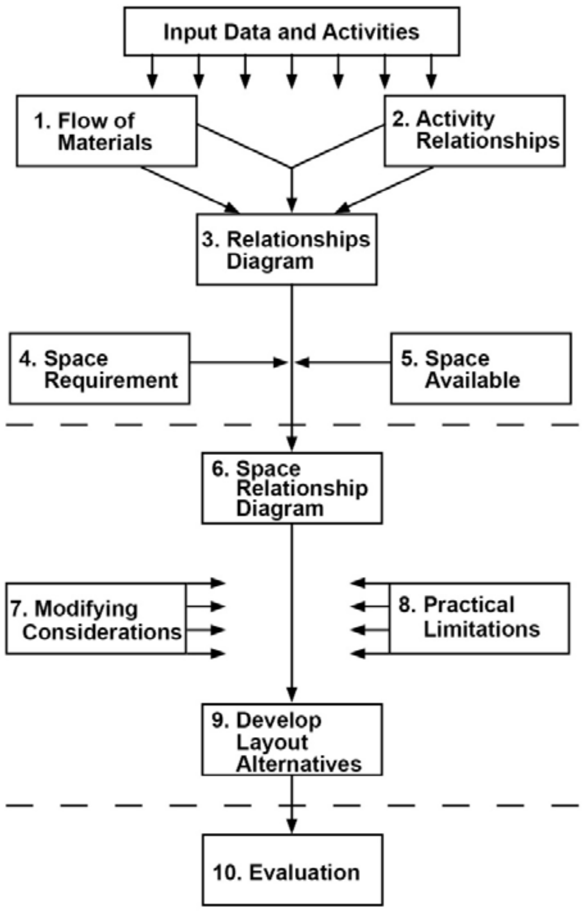



**Fig IV- Systematic Layout Planning Procedure**

## 4.5 FLOW AND ACTIVITY ANALYSIS

### Data Collection

The development of any layout is dependent on the quality and quantity of facts that we have about the various factors influencing it. The data collection phase is not a one time effort but an ongoing function. The data for overall plan is to be collected at initial stages whereas the data for detailed layouts may be obtained at a later stage.

The facts have to be obtained regarding various materials and processes, the flow routing and sequencing, space requirements, and different activities and relationships. The information required about the materials and processes is listed in Table 1. We will now discuss some of the tools and techniques that help in the layout analysis..

Table 1
Information Required about Materials and Processes

| | Data Required | Source of Data |
|---|---|---|
| Product Specifications | Product size, weight and shape Quality requirements Special properties | Product engineering, quality control inspection |
| Production Volume | Number of different items (product mix) Quantity of each item per unit time Variation in output Variation in demand | Sales department, market research, production planning |
| Component Parts | Performance times for all operations Variation in performance times Sequence of fabrication Operations Sequence of assembly Operations Types of machinery required | Production Planning, time study department |

Source: Moore, J.M. 1970. *Plant Layout and Design*. The Macmillan Company: New York.

### Process Charts

There are many types of process charts that can be developed. The most commonly used ones are operation process charts and Flow Process Charts. ,

**Operation Process Chart:** This is a graphic representation that describes the different operations (O) and inspection (☐) in a sequential manner including information regarding time and location etc.

xix) **Flow Process Chart:** The arrangement of facilities in a production process govern the flow of product and vice-versa. Thus the analysis of flow should be carried out closely when formulating a plant layout proposal. The flow process chart summarises the flow and activity of a component/man through a process or procedure in terms of sequence of operation, transportation, inspection, delay and storage. It includes the information about time required and distance moved. A sample flow process chart is shown in Figure V.

### Flow -Diagram

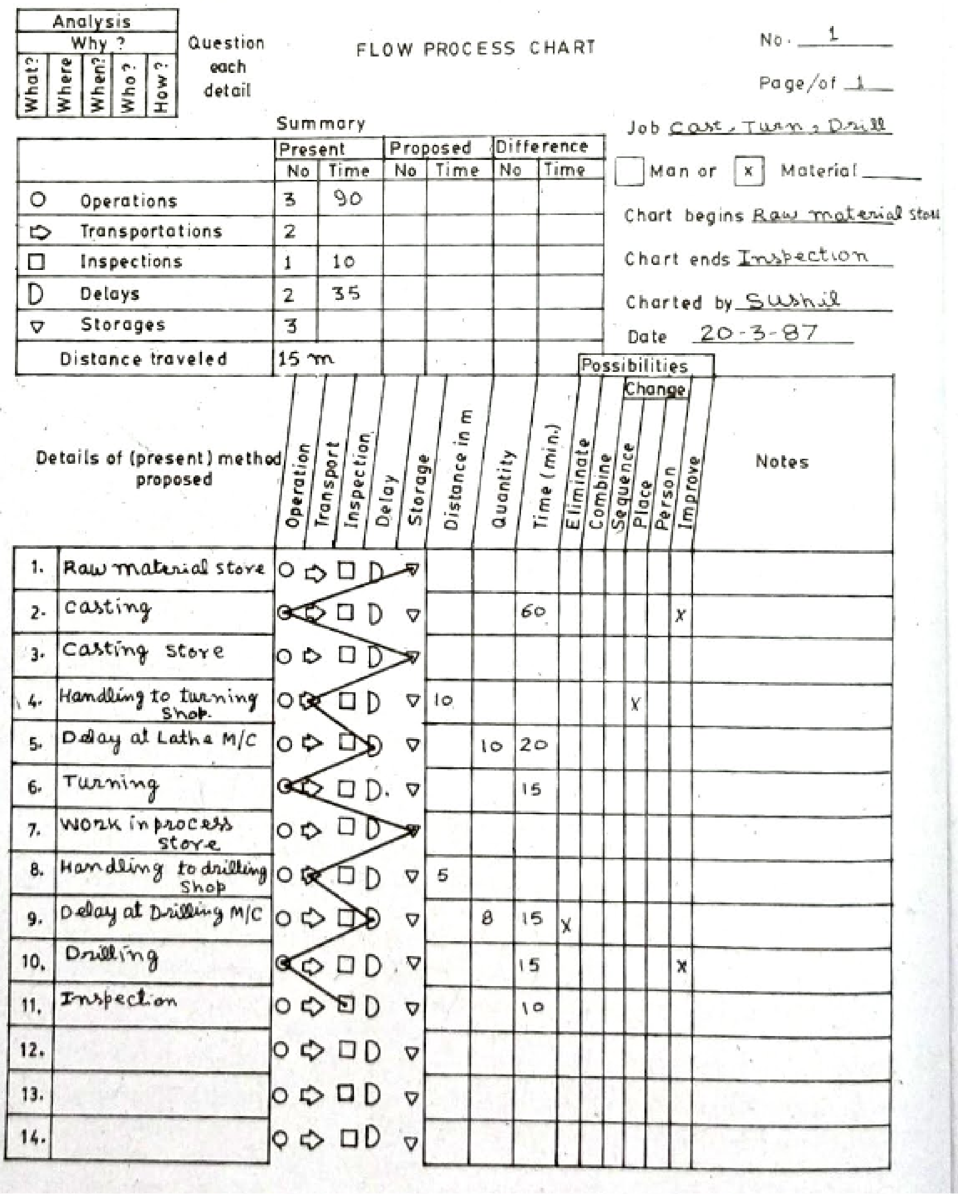
It is a sketch of the layout which shows the location of all activities appearing on a flow process chart. The path of movement of material or man is traced on the flow diagram. The different activities are given by process chart symbols with a number. This gives an idea about the overall flow through the plant in a pictorial manner.

Any back tracking or crisis crossing of the flow can be pin-pointed and the layout engineer can redesign the layout for a smoother flow by minimising these wasteful flows. If necessary a three dimensional flow diagram can be developed, particularly in case of multi-storeyed buildings. This helps in the activity relationship diagram which when superimposed by space relationship results in block plan.

## Travel Chart

It is also known as **From-To Chart.**

This chart is helpful in analysing the overall material flow. It indicates the distance and number of moves between different pairs of departments taken as origin and destination. The travel chart is helpful in the process type layout design; but in product layout, it is not important. It indicates the relationship between different departments in terms of material interaction. Attempts should be made in layout design to put those departments close to each other which have high level of material interaction so as to minimise the materials handling requirements provided other objectives are also satisfied. In most of the practical situations, it may be difficult to achieve the theoretical optimum, but the closest possible solution to the optimum. should be approached.



FLOW PROCESS CHART

| Analysis | | | | | |
|---|---|---|---|---|---|
| Why ? | | | | | Question each detail |
| What? | Where | When? | Who ? | How ? | |

No. 1
Page/of 1
Job Cast, Turn, Drill
☐ Man or ☒ Material
Chart begins Raw material store
Chart ends Inspection
Charted by Sushil
Date 20-3-87

Summary

| | Present | | Proposed | | Difference | |
|---|---|---|---|---|---|---|
| | No | Time | No | Time | No | Time |
| ○ Operations | 3 | 90 | | | | |
| ⇨ Transportations | 2 | | | | | |
| □ Inspections | 1 | 10 | | | | |
| D Delays | 2 | 35 | | | | |
| ▽ Storages | 3 | | | | | |
| Distance traveled | 15 m | | | | | |

| | Details of (present) method proposed | Operation | Transport | Inspection | Delay | Storage | Distance in m | Quantity | Time (min.) | Possibilities: Eliminate | Combine | Change: Sequence | Place | Person | Improve | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Raw material store | ○ | ⇨ | □ | D | ▽ | | | | | | | | | | |
| 2. | casting | ○ | ⇨ | □ | D | ▽ | | | 60 | | | | | | x | |
| 3. | Casting store | ○ | ⇨ | □ | D | ▽ | | | | | | | | | | |
| 4. | Handling to turning Shop. | ○ | ⇨ | □ | D | ▽ | 10 | | | | | | X | | | |
| 5. | Delay at Lathe M/C | ○ | ⇨ | □ | D | ▽ | | 10 | 20 | | | | | | | |
| 6. | Turning | ○ | ⇨ | □ | D | ▽ | | | 15 | | | | | | | |
| 7. | Work in process store | ○ | ⇨ | □ | D | ▽ | | | | | | | | | | |
| 8. | Handling to drilling Shop | ○ | ⇨ | □ | D | ▽ | 5 | | | | | | | | | |
| 9. | Delay at Drilling M/C | ○ | ⇨ | □ | D | ▽ | | 8 | 15 | X | | | | | | |
| 10. | Drilling | ○ | ⇨ | □ | D | ▽ | | | 15 | | | | | | x | |
| 11. | Inspection | ○ | ⇨ | □ | D | ▽ | | | 10 | | | | | | | |
| 12. | | ○ | ⇨ | □ | D | ▽ | | | | | | | | | | |
| 13. | | ○ | ⇨ | □ | D | ▽ | | | | | | | | | | |
| 14. | | ○ | ⇨ | □ | D | ▽ | | | | | | | | | | |

**Figure V: Flow Process Chart Summaries The Flow and All Activity of A Component Through its Manufacturing Process**

The travel chart summarises the data on material handling in compact matrix form, which is amenable to computer applications also. Further, the information regarding the bulk of material handled, mode of material handling and material handling equipment etc. may also be listed to make it more informative.

The following example will explain the travel chart.[Fig VI(a to d)]

Existing plant layout showing the locations of various departments (A to F) is given in the Fig VI (a)

| | | |
|---|---|---|
| A | B | C |
| D | E | F |

Fig VI (a) First step: (Existing Layout)

**2nd Step :** Movements from A to B are 20,B to A 10, B to C 15, A to F 25, C to D 30,D to C 50,D to F 40,E to F 10 and F to E 15

**3rd Step :** A square Grid is drawn and the various movements are marked Fig VI (b)

**4th Step :** Fig VI(c) is simplified by combining movements like A to B (20) and B to A (10) which involve same distance and ,therefore, total movement.

$B \rightleftarrows A = 20 + 10 = 30$

| From / To | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| A | | 10 | | | | |
| B | 20 | | | | | |
| C | | 15 | | 50 | | |
| D | | | 30 | | | |
| E | | | | | | 15 |
| F | 25 | | | 40 | 10 | |

**Fig. vi(b)**

| From / To | A | B | C | D | E |
|---|---|---|---|---|---|
| A | | | | | |
| B | 30 | | | | |
| C | | 15 | | | |
| D | | | 80 | | |
| E | | | | | |
| F | 25 | | | 40 | 25 |

**Fig. VI(c)**

This Simplified Travel Chart (see Fig VI (c)) shows the movement as follows

$A \rightleftarrows B = 30$
$B \rightleftarrows C = 15$
$C \rightleftarrows D = 80$
$A \rightleftarrows F = 25$
$D \rightleftarrows F = 40$
$E \rightleftarrows F = 25$

According to these figures maximum number of movements are between departments C and D, Hence in the plant layout these two departments should be side by side. The next lesser number of movements are between D and F, hence D and F should also lie closer to each other and so on.As a result the existing plant layout can be modified as shown in Figure VI (d)

| | | |
|---|---|---|
| C | D | A |
| E | F | B |

**Fig VI(d) Modified Layout**

Departement C and D (80), D and F (40), A and B (30), A and F (25), E and F (25) are closure to each other whereas B and C which have minimum number of movements (i.e 15) between them, are away from each other

Some of the important advantages and uses of travel chart are:

i) It helps in analysing the material movement

ii) It aids in determining activity locations

iii) It alternates flow patterns and layouts can be compared

iv) It shows relationship of different activities in terms of volume of movement.

v) It depicts quantitative relationships which can be used for computerised analysis and OR applications.

**REL CHART.** This is known as 'Relationship Chart' which indicates the relationship between pairs of departments in terms of closeness depending upon the activities of the departments as A-Absolutely essential, E-Essential, I-Important, O-Ordinary, U-Unimportant and X-Undesirable. A typical Rel Chart is shown in Fig VII.

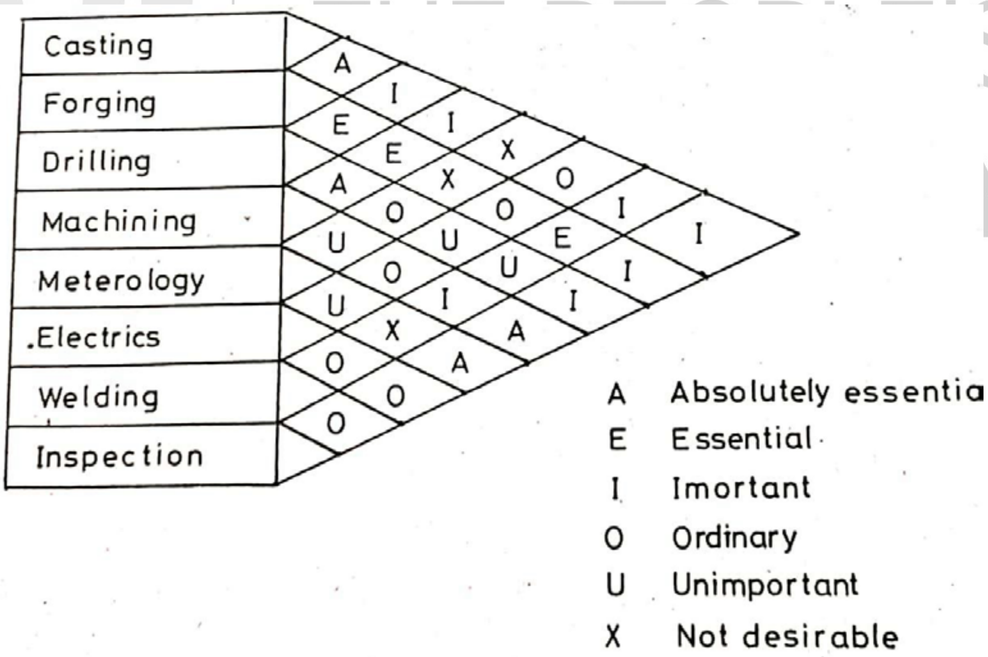
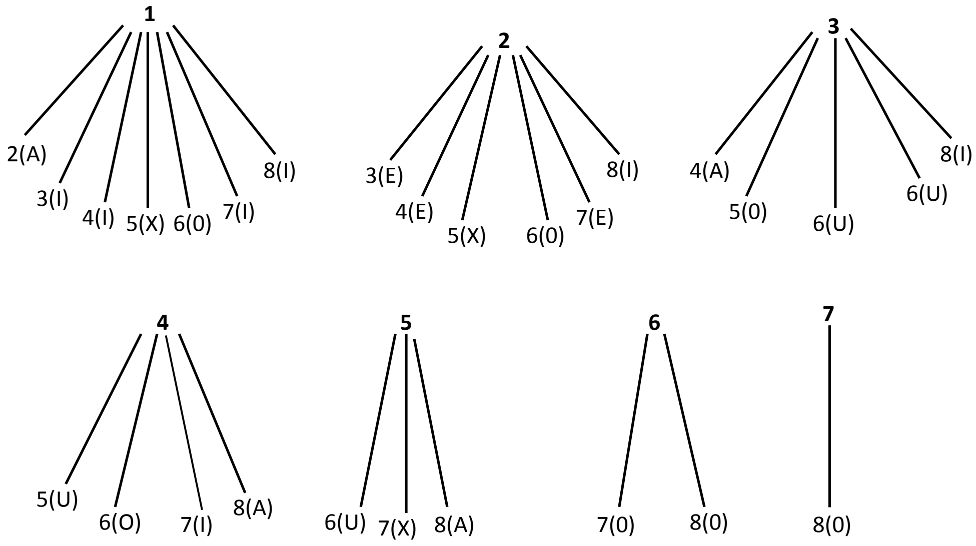
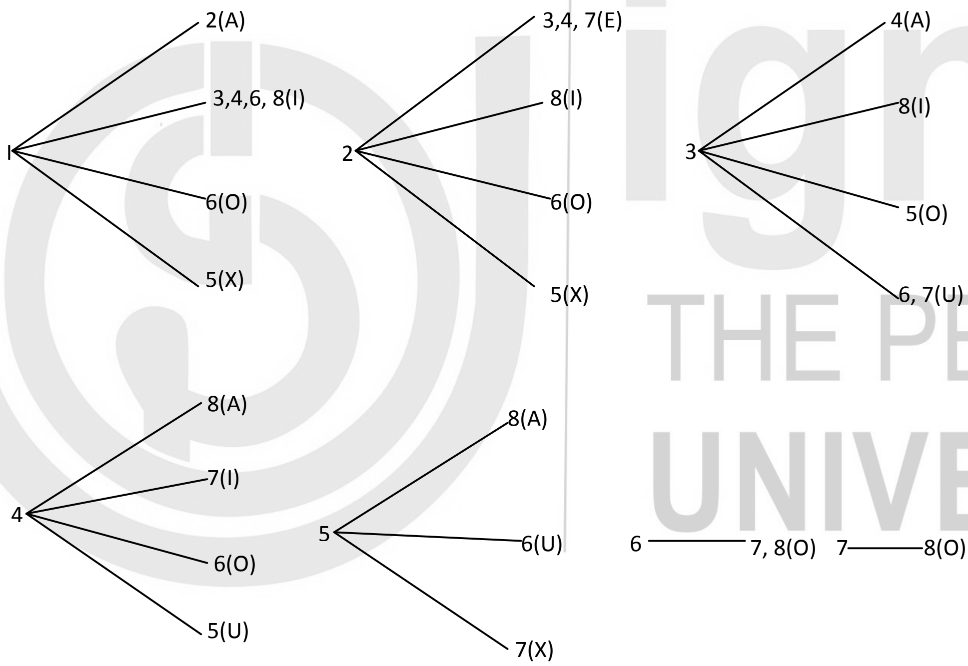



**Fig VII: REL Chart**

For the given nearness diagram expressing the proximity requirements, we can attempt to arrange the work centres into a suitable 2×4 or 4×2 grid. Shown below is the method of construction of the proximity grid (The method is self-explanatory).




**Step 1.** Show the various work centres with their nearness with respect to other work centres in an exploded form as shown above.






**Step 2.** Next show the nearness of other centres with their attributes of proximity (A, E, I, O, U, X) with respect to work stations 1, 2, 3, 4, 5, 6. 7, 8 as shown above.

| | | | |
|---|---|---|---|
| 1 | 2 | 7 | 6 |
| 3 | 4 | 8 | 5 |

Or

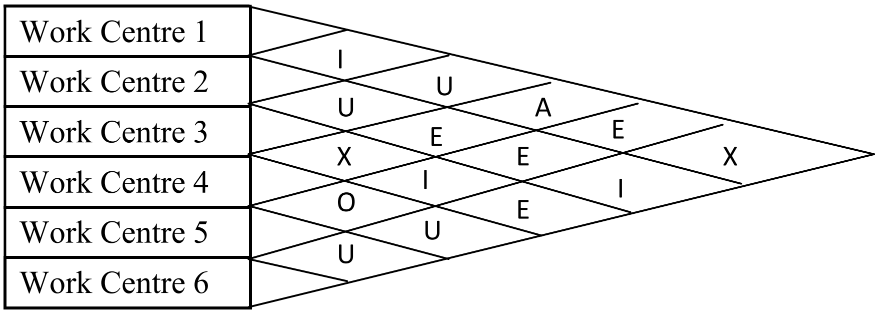
| | |
|---|---|
| 1 | 3 |
| 2 | 4 |
| 7 | 8 |
| 6 | 5 |

Arrangement of work centres in 2 x 4 or 4 x 2 grid.

**Step 3:** Finally arrange the various work centres in the proximity grid of 2×4 or 4×2 as shown above

**Example 4.1:** Given the following nearness diagram expressing the proximity requirements.

Arrange the work centres into a suitable 2×3 or 3×2 grid. The symbols A,E,I,O,U,X have their usual meaning.




**Solution**

| | | |
|---|---|---|
| 2 | 1 | 3 |
| 5 | 4 | 6 |

2 × 3 grid

or

| | |
|---|---|
| 2 | 5 |
| 1 | 4 |
| 3 | 6 |

3 × 2 grid

**Application of Quantitative Techniques**

The techniques of Operations Research can be applied to quantitatively analyse the layout problems, particularly. in terms of material flow. Some of the important techniques that have been applied by different researchers in the field of layout planning are as follows:

i) Linear Programming

ii) Transportation Algorithm

iii) Transhipment Problem

iv) Assignment Problem

v) Travelling Salesman Problem

vi) Dynamic.Programming

vii) Queueing Theory

viii) Simulation.

Linear Programming is used when there is a linear objective function which is to be maximised/minimised subject lo certain linear constraints. In the layout design the objective is to minimise the Materials handling. 'Transportation and assignment problems are special cases of Linear Programming. Further, to meet the multiple objectives of layout planning attempts have also been made to apply **Goal Programming** as a technique of Multi-criteria Decision-making. These operations research techniques are discussed in other course.

## 4.6 SPACE DETERMINATION AND 'AREA ALLOCATION

In the layout planning process the space is allocated to different activities. The requirement of space by a facility bears a close relationship to equipment, material, personnel and activities. Two major methods that are being used for space calculations are space based on present layout and production centre method.

### Space Based on Present Layout

This approach is suitable when the proposed layout is to be developed for an existing product. While determining the space, consideration should be given to space required for the following:

- operating equipment
- storage
- service facilities,
- operators

Allowance must be made for space between machines for operator movement, work in-process, access of materials handlers and maintenance personnel etc.

### Production Centre Method

The space for each production centre is determined including the space for machines, tool cabinets, worked and unworked parts, access to the aisle and maintenance. In this method actual arrangement of equipment is considered for space calculation. The departmental space is calculated by multiplying it with the number of production centres in that department.

### Work Place Layout

The details of the arrangements at a work centre is to be provided in terms of the machines and auxiliary equipment, operator, tools, materials and auxiliary services. The procedure for work place design is as follows:

i) Determination of direction of overall flow

ii) Determination of the desired direction of flow at work place

iii) Determination of the items contained in a work place

iv) Sketching the arrangement of these items

v) Specifying the sources of material and direction of flow

vi) Indicating the destination of material

vii) Method of waste disposal specified

viii) Sketching the material handling equipment

ix) Checking the arrangements against the principles of motion economy

x) Marking of distances between items

xi) Recording the layout on scale

xii) Indicate method of operation on chart,

**Area Allocation**

The activity relationships and space requirements are integrated to allocate the areas which forms the basis for detailed layout planning. There are a number of factors that should be considered for area allocation, some important ones are:

i) Area should be allocated for expansion purposes. The allocation of expansion area depends upon the type of flow pattern i.e. straight line, U-flow and 0-flow etc.

ii) Area allocation to maintain flexibility in layout.

iii) Maximum use of third dimension

iv) Area allocation for point of use storage and centralised storage

v) Area allocation for aisles

vi) Consideration of column spacing.

## 4.7 COMPUTERISED LAYOUT PLANNING

A recent trend has been the development of computer programme to assist the layout planner in generating alternative layout designs. Computerised layout planning can improve the search of the layout design process by quickly generating a large number of alternative layouts.

Computer programmes are generally either construction programmes or improvement programmes:

| | |
|---|---|
| i) Construction programmes<br><br>(Successive selection and placement of activities) | CORELAP (Computerised Relationship Layout Planning)<br><br>ALDEP (Automated Layout Design Programme) |
| ii) Improvements programmes | CRAFT<br>(Computerised Relative Allocation of Facilities Techniques) |

A complete existing layout is required initially and locations of department are inter-changed to improve the layout design.

Both ALDEP and CORELAP are concerned with the construction of a layout based on the closeness ratings given by the REL chart.

CRAFT is concerned. with the minimisation of a linear function of the movement between departments. Typically CRAFT employs an improvement procedure to obtain a layout design based on the objective of minimising material handling costs.

**CORELAP (computerised Relationship layout Planning)**

It begins by calculating which of the activities in the layout is the busiest or most related. The sums of each activity's closeness relationships with all other activities are compared and the activity with the highest total closeness relationship (TCR) count is selected and located first in the layout matrix. This activity is named **Winner**. Next, an activity which must be close to the winner is selected and placed as adjacent as possible to winner: This activity is denoted as A (closeness absolutely necessary) and is named **Victor.** A search of winner's remaining relationships for more A-related victors is then made. These are placed, again, as close to each other as possible. If no more A's can be found, the victors become potential winners and their relationships are searched for A's. If an A is found, the victor becomes the new winner, and the procedure is repeated. When no A's are found, the same procedure is repeated for E's (closeness Especially important), I's (closeness important), and 0's (Ordinary closeness o.k.) until all activities have been placed in the layout. CORELAP also puts a value on the U (closeness Unimportant) and X (closeness not desirable) relationship.

**ALDEP (Automated layout Design Programme)**

It uses a preference table of relationship values in matrix form to calculate the scores of a series of randomly generated layouts. If for example, activities 11 and 19 are adjacent, the value of the relationship between the two would be added to that layout's score. A modified random selection technique is used to generate alternate layouts. The first activity is selected and located at random. Next, the relationship data are searched to find an activity with a high relationship to the first activity. This activity is placed adjacent to the first. If none is found, a second activity is selected at random and placed next to the first. This procedure is continued until all activities are placed. The entire procedure is repeated to generate another layout. The analyst specifies the number of layouts wanted which must satisfy a minimum score.

**CRAFT(computerised Relative Allocation of Facilities Techniques)**

It is the only one which uses flow of materials data as the sole basis for development of closeness relationships. Material flow, in terms of some unit of measurement (pounds per day, in terms of skid-loads per week), between each pair of activity areas, forms the matrix to the programme.

A second set of input data allows the user to enter cost of moving in terms of cost per unit moved per unit distance. In many cases this cost input is unavailable or inadequate, in which case it can be neutralised by entering 1.0 for all costs in the matrix.

Space requirements are the third set of input data for CRAFT. These take the form of an initial or an existing layout. For new area layouts, hest guess or even completely random layouts can be used. In any case, activity identification numbers, in a quantity approximate to their space requirements, are entered in an overall area of close proximity. The location of any activity can be fixed in the overall area through control cards. CRAFT limits the number of activities involved in the layout to 40.

## 4.8 EVALUATION, SPECIFICATION, PRESENTATION AND IMPLEMENTATION

**Plot Plan**

It is a diagrammatic representation of the building outline, showing its location on the property, the location of external transportation facilities and other items such as tanks, storage areas and parking lots etc. It can be used as a key or master drawing for locating separate detailed drawings of the layout. The plot plan is presented in the form of a drawing or as a scaled model.

**Block Plan**

A block plan is a diagrammatic representation showing internal partitions of departments, columns and area allocation but not machinery, equipment and facilities. This is usually presented in the form of drawings and is used as a reference or master for detailed layouts of different departments. This shows the area allocations for aisles and column spacing etc.

**Detailed Layout**

It is a diagrammatic representation of the arrangement of equipment operator and materials along with the arrangement of supporting activities. The detailed layout can be constructed by utilising any one of the following methods

- drafting or sketching
- templates
- models

A **template** is a scaled representation of a physical object in a layout may be of a machine, workman, material handling equipment, work-in-process and storage etc.

Models are three dimensional representations of the physical objects which give depth to the layout and make it more presentable.

These templates and models may be prepared from cardboard, paper, sheet metal, plastic or wood and may be black and white or coloured. These may be attached to the backing material by using various fastening devices such as glue, staples, rubber cement, thumbtacks and magnetism etc.

**Checking the Layout**

The layout finally developed should be checked for

- overall integration
- minimum distance moved
- smooth flow of the product

- space utilisation
- employee satisfaction and safety
- flexibility

The flexibility should be introduced in building and services by providing unobstructed floor area and in equipment by mounting them on wheels or skids.

**Evaluation of Layout**

The evaluation may be done of an existing layout or of an alternative layout. The basis for evaluating the layout might include:

i) the objectives of layout planning

ii) cost comparison with other alternatives

iii) return on investment

iv) intangible factors which must be evaluated on the basis of judgment.

v) productivity evaluation

vi) space evaluation

vii) ranking

viii) pilot plant

ix) sequence demand-straight line-considering the sequence of operations on a variety of parts.

x) Factors analysis by weighing various factors according to their importance.

The optimising evaluation can also be done by using Operations Research Techniques such as

- Linear Programming
- Line Balancing
- Level Curve Concept

Mathematical models express the effectiveness of layout as a function of a set of variables which can be evaluated. Some other mathematical techniques of evaluation are:

- Monte Carlo Method
- Queuing Theory
- Engineering Economy
- Analogues

These are not discussed in details here.

**Installation of Layout**

The layout is presented in the following ways:

i) The Visual presentation of the layout itself, supplementary details and facts and supplementary charts and displays.

ii) An Oral report

iii) A Written report

When the final layout is approved it is installed in a number of phase, and it is needed to prepare

- detailed drawings
- precise specifications of production and materials handling equipment
- detailed listing of all equipment and utility requirements
- actual plans and schedule of construction and installation.

The techniques of project management such as CPM/PERT may be used for planning and monitoring the progress of the layout installation.

## 4.9 MATERIALS HANDLING SYSTEMS

We have discussed in previous sections the analysis of material flow and the design of layout based on it. We have referred to the selection of material handling equipment and area allocation for it. Materials handling is the art and science involving the movement, packaging and storing of substances in any form.**Material Handling is a system which forms the various factors of movement, tranfer, warehousing, in-process handling and shipping into one independent cycle considering the most economical solution for the respective plant**. In this section we will discuss about the objectives of the material handling system design, basic types of material handling systems and the procedure for the design and selection of material handling system while developing a plant layout.

**Objectives and Functions**

In order to perform the activities of materials handling the basic goal is to minimise the production costs. This general objective can be further subdivided into specific objectives as follows:

i) To reduce the costs by decreasing inventories, minimising the distance to be handled and increasing productivity.

ii) To increase the production capacity by smoothing the work flow.

iii) To minimise the waste during handling

iv) To improve distribution through better location of facilities and improved routing.

v) To increase the equipment and space utilisation.

vi) To improve the working conditions.

vii) To improve the customer service.

The analysis of materials handling requirements can be carried out by using travel charts and other quantitative techniques as outlined in section 4.5.

The basic materials handling function has to answer a number of questions as follows:

i) Why do this at all? Justifying the necessity of material handling.

ii) What material is to be handled? Giving the type (unit, bulk etc.), characteristics (shape, dimension etc.) and quantity.

iii) Where and when? Specifying the move in terms of source and destination, logistics, characteristics (distance, frequency, speed and sequence etc.) and type (transporting, conveying and positioning etc.)

iv) How? And Who? Specifying the method in terms of the handling unit (load support, container, weight, number etc.), equipment, manpower, and physical restrictions (column spacing, aisle width and congestion etc.)

**Basic Materials Handling Systems**

The different material handling systems can be classified according to the type of equipment used, material handled, method used or the function performed.

**Equipment-Oriented Systems:** Depending upon the type of equipment used, there are several systems.

i) Overhead systems

ii) Conveyer systems

iii) Tractor-trailor system

iv) Fork-lift truck and pallet system

v) Industrial truck systems

vi) Underground systems.

**Material Oriented Systems:** These may be of the following types.

i) Unit handling systems

ii) Bulk handling systems

iii) Liquid handling systems

A unit load consists of a number of items so arranged that it can be picked up and moved as a single entity such as a box, bale, roll etc. Such a system is more flexible and requires less investment.

**Method Oriented Systems:** According to the method of handling and method of production, the material handling systems can be:

i) manual systems

ii) mechanised or automated systems

iii) job-shop handling systems, or

iv) mass-production handling systems

**Function Oriented Systems:** The systems can be defined according to the material handling function performed as follows:

i) Transportation systems

ii) Conveying systems

iii) Transferring systems

iv) Elevating systems

**Selection and Design of Handling System**

The selection and design of the material handling system should be done alongside the development of the layout as each one affects each other. Hence, an integrated approach to the design process is usable. A computerised technique known as COFAD (Computerised Facilities Design) has been developed for integrated handling system and layout design. The steps to be followed in the selection and design of handling systems are as follows:

i) Identification of system

ii) Review of design criteria and objectives of the handling system

iii) Data collection regarding flow pattern and flow requirements

iv) Identification of activity relationships

v) Determining space requirement and establishing material flow pattern

vi) Analysis of material and building characteristics

vii) Preliminary selection of basic handling system and generation of alternatives considering feasibility of mechanisation and equipment capabilities

viii) Evaluation of alternatives with respect to optimal material flow, utilising gravity, minimum cost, flexibility, ease of maintenance, capacity utilisation and other objectives of the system design considering various tangible and intangible factors

ix) Selection of the best suited alternative and checking it for compatibility

x) Specification of the system

xi) Procurement of the equipment and implementation of the system

## 4.10 MATERIALS HANDLING EQUIPMENT

After the simplification of the handling method the selection of equipment is important with respect to the different objectives of speed, efficiency-cost etc. There are both the manual and powered kind of handling equipments. Some of the typical handling equipments arc shown in Figure VIII. Apple (1982) (Apple James M-plant Layout and Material Handling- New York. James

Wiley and Sons-1982) has classified the handling equipments into four basic types, viz., conveyers, cranes and hoists, trucks, and auxiliary equipment.

**Conveyers**

These are gravity or powered devices commonly used for moving uniform loads from point to point over fixed paths, where the primary function is conveying. Commonly used equipment under this category are:

i) Belt Conveyer

ii) Roller Conveyer

iii) Chain Conveyer

iv) Bucket Conveyer

v) Trolley Conveyer

vi) Screw Conveyer

vii) Pipeline Conveyer

viii) Vibratory Conveyer

ix) Chute.

**Cranes, Elevators and Hoists**

These are overhead devices used for moving varying loads intermittently between points within an area, fixed by the supporting and binding rails, where the primary function is transferring or elevating. Some common examples are:

i) Overhead travelling crane

ii) Gantry crane

iii) Jib crane

iv) Elevators

v) Hoists

vi) Stacker crane

vii) Winches

viii) Monorail

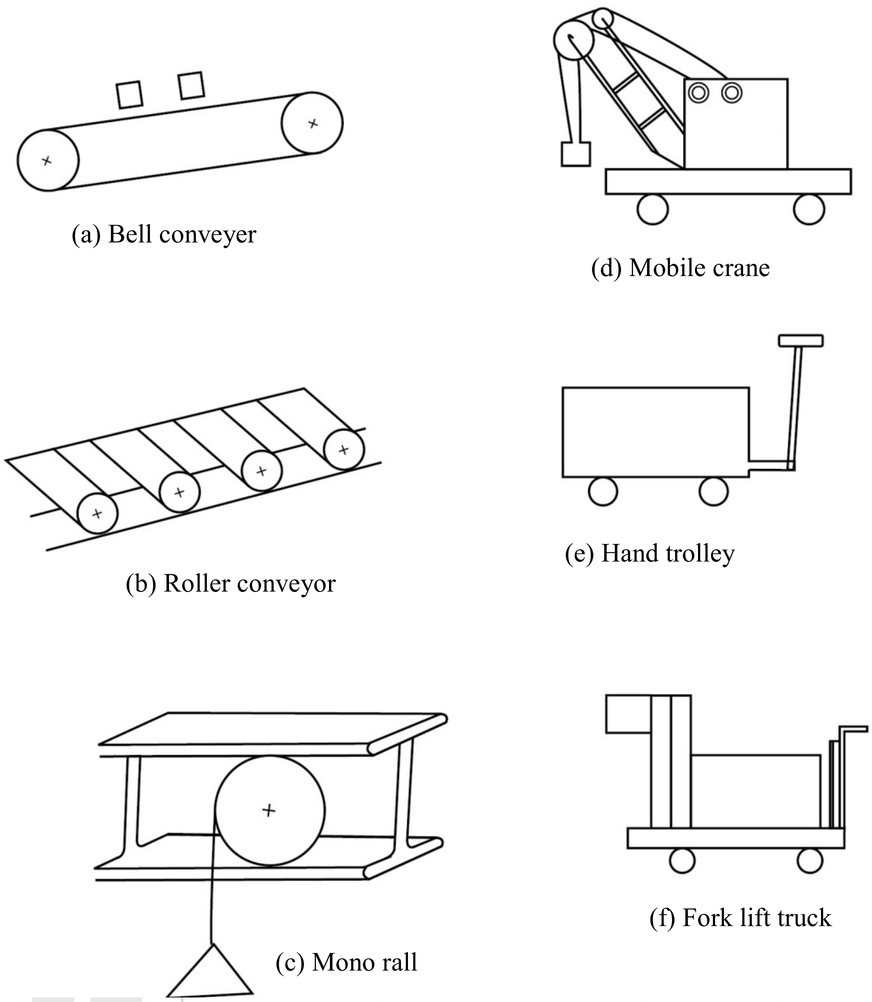



**Fig. VIII: Material Handling Equipment**

## Industrial Trucks and Vehicles

These are hand operated or powered vehicles used for movement of uniform or mixed loads intermittently over various paths having suitable running surfaces and clearances where the primary function is manoeuvering or transporting. These include:

i) Fork lift truck

ii) Platform truck

iii) lndustrial tractors and traitors

iv) lndustrial cars

v) Walkie truck

vi) Two-wheeled hand truck or trolley

vii) Hand stacker

**Auxiliary Equipment**

These are devices or attachments used with handling equipment to make their use more effective and versatile. Some common examples are:

i) Ramps

ii) Positioners

iii) Pallets and skids

iv) Pallet loader and unloader

v) Lift truck attachments

vi) Dock boards and levelers

vii) Containers

viii) Below the hook devices

ix) Weighing equipment

## 4.11 SUMMARY

1n this unit we have discussed different types of layout problems. The basic types of plant layouts have been identified as product layout, process layout, job shop layout, cellular layout and fixed position layout. The factors to be considered in designing plant layout are outlined as man, material, machine, movement or flow, service facilities, building and flexibility.

The tools and techniques for analysing the flow of materials and the activities have been discussed. Some important tools are, flow process chart, flow diagram, travel chart, REL chart etc. By making use of these tools a systematic layout planning procedure has been discussed starting from the development of plot plan to detailed work place layout. The use of computers in layout planning has been highlighted and computerised techniques named as CORELAP, ALDEP and CRAFT have been outlined. The art of presentation and implementation of the layout has been briefly dealt with. The selection of materials handling system has been presented along with the important types of materials handling equipments. The important concepts in automation in layout and materials handling have been touched upon.

## 4.12 KEY WORDS

**ALDEP:** Automated Layout Design Programme

**Block Plan:** A diagrammatic representation showing internal partitions of departments, columns and area allocation but not machinery, equipment or facilities.

**CORELAP:** Computerised Relationship Layout Planning

**CRAFT:** Computerised Relative Allocation of Facilities Technique.

**Facility:** Any production, operation or service unit is termed as facility, e.g. plant, stores, bank, hospital, machine, equipment and service centre etc.

**Flow Diagram: A** sketch of the layout which shows the location of all activities appearing on a flow process chart.

**Flow Process Chart:** 1t summarises the flow and activity of a component/man through a process or procedure in terms of sequence of operation, transportation, inspection, delay and storage.

**Materials Handling:** It is the art and science involving the movement, packaging and storing of substances in any form.

**Plant Layout: A** plan or the act of planning, an optimum arrangement of industrial facilities including operating equipment, personnel, storage space, materials handling equipment and all other supporting services, along with the design of the best structure to contain these facilities.

**Plot Plan: A** diagrammatic representation of the building outline, showing its location on the property, the location of external transportation facilities and other items such as tanks, storage areas and parking lots etc.

**Process Layout:** Also known as functional layout groups together the facilities according to process or function in a department.

**Product Layout:.** Also known as line layout is an arrangement of facilities according to the product; suitable for one type of product.

**REL Chart:** It indicates the relationship between pairs of departments in terms of closeness rating dependent upon the activities of the department as absolutely essential, essential, important, ordinary, unimportant or not desirable.

**SLP:** Systematic Layout Planning.

**Template:** A scaled representation of a physical object in a layout may be of a machine, workman, materials handling equipment, work in process, and storage etc.

**Travel Chart:** It indicates the distance and number of moves between different departments, taken as origin and destination.

## 4.13 SELF-ASSESSMENT EXERCISES

1) Enumerate the basic types of plant layouts. Haw does a cellular layout differ from a process layout?

2) What are the different factors that should be considered for designing a plant layout?

3) Prepare a flow chart for overhauling the engine of an automobile.

4) What is the significance of travel charts in layout design? Prepare a travel chart for a hypothetical engineering concern with five functional departments, i.e foundry, forging, machining, welding and inspection (you may assume your own data). Given this travel chart proceed to find the locations of different departments.

5) How can the relationships of different departments be considered in preparing a layout? Prepare a REL chart for the different departments of a typical hospital.

6) What is Systematic Layout Planning?

7) What are the different factors that you will consider in determining the space requirement of a particular facility? Allocate the areas to different departments considered in exercise 4 and develop a block plan.

8) Outline the basic logic used in CORELAP, ALDEP and CRAFT. Can the layout generated by these computerised techniques be directly implemented?

9) How will you specify and present a layout developed for the purposes of implementation?

10) What is the importance of materials handling in designing a layout? How will you go about selecting the materials handling system?

11) What are the different kinds of materials handling equipments used? is a totally automated materials handling system desirable in a job shop?

## 4.14 FURTHER READINGS

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