UNIT 8 FACILITIES PLANNING

Objectives

After studying this unit, you should be able to understand the :

- meaning of capacity planning & its need:
- facility planning and its objectives:
- the layout planning & its type;
- the development of the process layout and approaches for product layout.

Structures

8.1 WHAT IS FACILITY PLANNING

Facility planning exercise determines how an activity's tangible fixed assets best support achieving the activity's objectives. In developing a layout for a system producing goods or services, we seek the optimum allocation of space to the components of the system. More specifically we try to determine the best arrangement of facilities and equipment capable of satisfying anticipated demand (quantity, quality and timing) at lowest cost. This is the phase when all the elements of the process are integrated and therefore special care should be taken to create an environment conductive to high productivity and the satisfaction of social and psychological needs of all the people at work. Facility Planning is also known under other names such as Lay out Planning, Plant Layout, Facilities Design, Facilities Planning etc.

8.2 NEED FOR FACILITY PLANNING

Following questions bring out facility planning opportunities:

i) What impact does facilities planning have on handling and maintenance costs?

   It has been estimated that between 20 and 50 per cent of the total operating expenses within manufacturing are attributed to material handling. It is generally agreed that effective facilities planning can reduce these costs by at least 10 to 30%. Also good layout provides easy access to equipment maintenance and repair, thus reducing downtimes and maintenance costs.

ii) In what do organisations invest the majority of their capital and how convertible is their capital once invested?

iii) What impact does facilities planning have on a facility's capability to adapt to change and satisfy future requirements?

Since a particular solution to a layout problem is very costly and difficult to change. it is desirable to maintain adequate flexibility to make it possible for the system to adapt to changes. Economic considerations force a constant re-evaluation and re-organisation of the existing systems, personnel and equipment. New machines and new processes render older models and methods obsolele. Changes that are constantly taking place in production methods, better equipment and materials render it impossible for companies to retain their old facilities and layouts without severely damaging their competitive position in the market place. To sum up, changes in level of demand, design of product(s) or services and in technology often result in layout adjustments that can be achieved only with flexibility the existing configuration.

iv) What impact does facilities planning have on employee morale and how does employee morale affect operating costs?

The layout design must assure every employee safe, healthy and comfortable working environment. Due consideration must be given to health and safety norms Specified in factory act by eliminating or minimizing possible hazardous conditions in the place of employment. Any equipment or process that may create hazards to workers' health and safety must be located in areas where the potential for employee contact is minimal. A well designed layout, besides minimising losses in both money and manpower resulting from industrial accidents; provides a working environment that leads to a better utilisation of the all important human resource.

8.3 FACILITY PLANNING-OBJECTIVES

Facilities planning is a. continuing activity in any organisation that plans to keep abreast of developments in the field. The problem presents a challenge to management because of the complex interactions of several key factors and the difficulty in assessing their impact on system performance. Although the methods available fall short of comprehensive approach, they can provide good solutions to several layout sub-problems through general guidelines, principles and techniques. Therefore rather than seeking an optimum solution to the complete layout problem, the analyst relies on experience, good judgement and some quantitative techniques to produce a satisfactory overall solution. Facilities planning thus, although becoming more scientific, continues to rely greatly on the experience of planners.

It may not be realistic or feasible to state one precise objective for any facility planning exercise or the same objectives for all the facility planning exercises. Some typical objectives considered while developing layouts are listed below. Their order of importance depends-on the specific problem under consideration.

i) Support organisation's mission through improved material handling_ materials control, and good house keeping.

ii) Effectively utilise people, equipment, space and energy.

iii) Minimise capital investment.

iv) Be flexible and promote ease of maintenance.

v) Provide for employee safety and job satisfaction.

These objectives can be restated as characteristics of good layout.

Is it time for relayout study?

Many a time layouts are originally designed efficiently. As the organisation grows and ' changes to accommodate a changing environment, the layout becomes less and less efficient. This forces the need for a relayout exercise.

Following are some indicators pointing towards a relayout study (which can be _restated as the characteristics of a poor layout):

- Congestion in aisles and storage areas and poor utilization of space
- Excessive in process inventory and excessive work flow distances

- Continual production bottlenecks in some locations and simultaneous idle facilities elsewhere
- Skilled workers doing excessive unskilled work
- Long operation cycles and delivery delays
- Worker anxiety and strain
- Accidents or near accidents
- Obvious lack of production control
- General feeling of confusion with employees often spending time in locating products, components, materials, tools etc.

The main purpose of relayout studies is generally to maximise the profitability or . efficiency of operations. Other purposes include minimising safety or health hazards, facilitating crucial staff interaction, freeing up bottleneck operations, "and minimising interference, noise or distractions between different operational areas.

Activity A

Do you propose the relayout of your factory facility location give the reasons for that.

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8.4 TYPES OF LAYOUTS

Process or Functional Layout

A process layout is the arrangement of facilities and equipments in groups according to function performed. Different orders follow different paths through the system, depending on their special processing requirements.

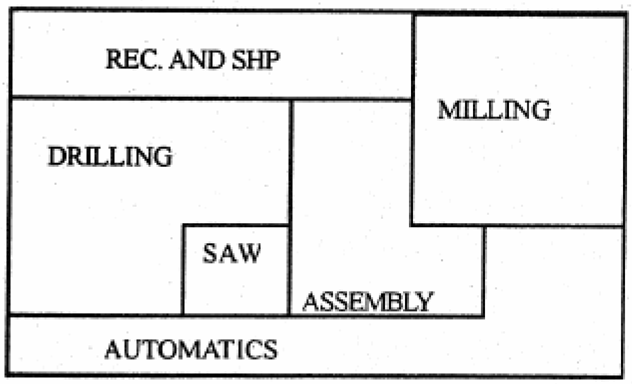

Fig.8.1: Process Layout

This grouping, in a process layout. results in departments like drilling, milling, sawing turning, painting, receiving and shipping etc. It may be noted that there is no loss in efficiency (in the context of operation) if machines used to convert materials into products are located long distance apart. The problem is about the loss of time, wasted effort and cost of moving materials. This grouping of machines by function (Fig. 8.1) is characteristic of job shops and batch type production facilities.

8.4.1 Product or Line Layout

A product layout is an arrangement of facilities and equipment in the same sequence as that of the operations needed to complete each unit of the product or the service offered. Successive units follow the same path through the system. (Fig. 8.2)

Examples of such layouts, which are characteristic of mass or continuous production, may be found in such industries as cement manufacturing*, oil refining*, machining of engine cylinder blocks, crankshafts, domestic appliances, automobile assembly and mass production of similar hard discrete items. In contrast to process layouts, product layouts are not flexible since they are specifically designed for making or assembling a single product.

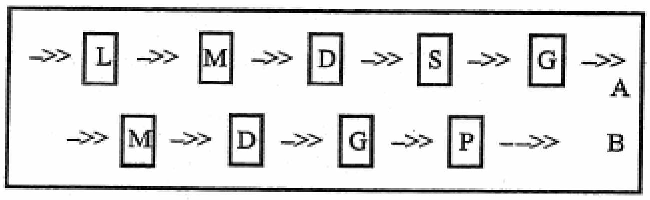

Fig. 8.2: Product Layout

8.4.2 Fixed Position Layout

A fixed position layout is the arrangement of facilities and equipment so that resources needed in the form of workers, equipment, materials etc. flow to the item being produced or serviced.

This type of layout (Fig. 8.3) is characteristic of such jobs as assembling large steam turbines, ship building, bus body building etc. Unlike the previously discussed layouts, this requires both people and machines to be brought to the product being made or assembled.

This selection of a fixed position layout is often dictated by the complexity, the size or some other unique feature of the task performed. The size and weight of a ship or jumbo jet do not allow any alternatives. Similarly the maintenance of a steel mill, a power plant, or a building dictate that resources be moved to the place where the work must be performed.

The crucial aspect in the application of this type of layout is the requirement for effective scheduling, coordination and control of the productive activities involved and the resources used in the process (project scheduling).

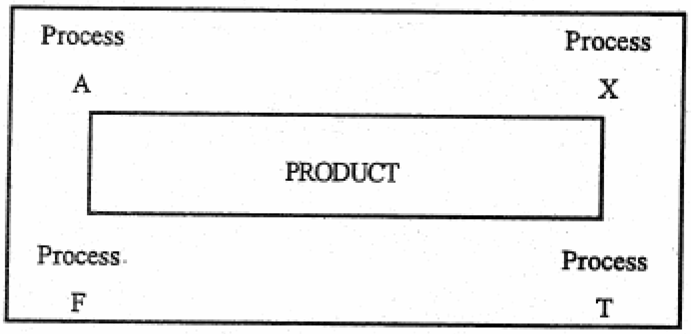

Fig. 8.3: Fixed Position Layout

8.4.3 Combination Layout

Very often a combination of layouts is used. Typically, a process layout is combined with a product layout. For example, in refrigerator manufacturing, a process-oriented layout is used to produce various parts (i.e. metal forming, welding, heat treatment). For the final assembly of the refrigerator, all these functions-are placed in a product-oriented layout.

Activity B

What relationships exist between the layout and location decisions"

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* The design of such systems is technology dependent and no flexibility or choice exists in the design from the point of view of facility design. We therefore restrict our discussion here to manual flow lines used for mass production of discrete items.

8.5 PRODUCT VERSUS PROCESS LAYOUT

Relative Advantages of Product Layout

i) Lower total material handling cost

ii) Lower total production time

iii) Less work-in-process

iv) Greater incentive for groups of workers to raise level of performance and greater possibility of group incentive pay plans with broader coverage.

v) Less floor area required per unit of production.

vi) Simpler production control; fewer controls & records needed, lower accounting cost.

Relative Advantages of Process Layout

i) Less duplication of equipment and hence lower total investment in equipment.

ii) Greater flexibility of production. Flexibility with respect to accommodating

- design changes,
- production volume changes, and
- new products and new machines.

iii) Capability to handle breakdown of equipment by transferring the work to other machines.

iv) Better and more efficient supervision possible through specialisation.

v) Greater incentive to efficient individual workers:

When to use Product and Process Layouts?

Product Layout

i) One or few standard products.

ii) Large volume of production of each item over a considerable period of time.

iii) Possiblity of carrying out effective motion and time studies and setting accurate standards.

iv) When there is a scope for getting good labour & equipment balance.

v) Minimum of inspection required during processing.

vi) Minimum of very heavy equipment or equipment requiring special features (isolation from general production areas etc.)

vii) Little or no occasion to use some machines for more than one operation.

Process Layout

i) Many types cir styles of products, or emphasis on special orders.

ii) Relatively Ion Column o production of individual items.

iii) Adequate motion and time studies difficult or impossible to make.

iv) Difficult to achieve good labour and equipment balance.

v) Many inspections required during a sequence of operations.

Activity C

Give examples of organisations that have Predominantly Product, process and fixed position layout.

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Activity D

Consider a layout decision which has been made in your residence on at work. How was the decision made? What were the important factors?

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8.6 DEVELOPING THE PROCESS LAYOUT

In order to realise the maxinuun potential of a new layout a systematic plan oral tack must be followed. The final layout can be no better than the data upon which it is based. To assure collection and analysis of the necessary supporting data, the following steps are required in planning for and preparing the layout.

i) Analyse the product or products to be produced - this includes having available or developing the following

a) Complete design drawings or assembly sketches from which a complete list of parts can be developed.

b) The parts list which established those parts to be manufactured and/or purchased and which must be provided for in the general plant area under consideration.

c) Assembly charts indicating the sequence by which the parts are combined into subassemblies and assemblies. The assembly chart eventually provided the basin for arrangement of the production and assembly line patterns on the final layout

ii) Determine the process required to manufacture the product

a) Route sheets and operation sheets must be obtained or developed for each manufactured part and assembly. For layout purposes only the sequence of operations is required at this time. This sequence must, however, be complete. Operation combinations and equipment selections should is best accomplished at the time of preparing the layout charts and specific selections should be delayed until that time.

b) Operation process charts arc prepared following the preparation of the route sheets to provide a means of combining the assembly charts and route sheet data in a single graphic form, at the same time incorporating inspect ion operations necessary to assure maintenance of quality and to prevent further expenditure of time rind money on non acceptable parts. By study of the operation process charts the most logical location of the inspections in the process can be determined.

iii) Prepare layout planning charts

The layout planning chart is the most important single phase of the entire layout process. This chart serves as the medium for first tabulating and then combining the various factors to be provided in the final layout for production of the product. it incorporates the following:

a) Flow process showing all operations, moves, storages and inspections in sequence.

b) Standard limes for each operation obtained from lime study or predetermined time standards:

c) Machine selection.

d) Manpower requirements for the production activity.

e) Machine balance and Manpower balance.

f) Material handling loads, methods and equipment requirements.

In completing the layout planning chart, full review and analysis is required at each step. If this is done, the layout of the manufacturing area is primarily a problem of convert ing the layout planning chart data to the physical plant area. In order to do this, the following problems must be looked into.

iv) Determine the work stations

Layouts must be developed taking into consideration machine. operator. materials and service area requirements. This is best accomplished by use of man and machine and/or operation clans and scaled work station sketches.

v) Analyse storage area requirements

This should be studied bon h as to size and location relative to production activities. It must be kept in mind that a minimum of three storage problems exist for the complete process and for individual operations.

a) Storage of material or parts awaiting processing (Raw material storage).

b) In-process storage and

c) Finished goods storage. Minimum storage area requirements should be determined prior to starting the actual layout.

vi) Establish minimum aisle widths

Clearance around the various pieces of equipment and departments should be determined before starting the layout. Aisle widths will be primarily dependent upon materials handling methods and equipment. work station clearance requirements and pedestrian traffic.

With this data, the layout for the production area can be prepared. However, this alone dries not make the total plant and we must therefore consider four more requirements as fawns (steps: 7 - lit):

vii) Establish office requirements

These will depend upon the scope of operational activities to be included in the facilities.

viii) Consider personnel facilities and services

Allow for such items as first aid, lunch and refreshment centres. lockers, rest rooms, ingress & egress, and parking.

ix) Survey plant services

Include utilities waste disposal maintenance, heating and ventilation.

x) Provide for further expansion

This may include provisions for addition of new product line, or increase sales demand for present products.

Activity E

Critically evaluate the process adopted into manufacture the product / services in your organisation.

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8.7 CONVENTIONAL APPROACH FOR DEVELOPING PROCESS LAYOUT

The right solution to the plant layout problem is important for following reasons:

Savings resulting from material handling costs (amounting to 311- 75 per cent of the cost of the product in different industries)

Need for having to live for long time with a poorly laid out plant. Once a layout decision is implemented. it is not ordinarily possible to make changes. Decision will have a long term influence on the ; productivity. Besides, if safely is also in jeopardy'. t here it ill be added problems of frequent accidents, lack of motivation of workers absentism etc

Due consideration must therefore be given to (i) the determination of relative location of the various production departments within the plant area and (ii) the arrangement of equipment and facilities within each of the departments. Besides production departments. it is necessary to locate and arrange other sections like warehouses, tool rooms, maintenance areas, power generation, compressed air, food services, wash rooms & toilets, health and recreational facilities, offices etc.

Space requirements for the above facilities depend on several factors. Production departments take into account space for housing the machines, movement of operators and material handling equipment, in-coming, in-process and finished material storage, tools and auxiliary equipment etc. Space requirements for certain other facilities could depend on factors like type of manufacturing activity, number of employees in the plant.

Methods employed for developing layouts range from totally subjective ones to completely objective ones making use of computer support. At one end, we have a layout man moving a few machine templates on a board representing the factory area and deciding the location and orientation of templates on the board based on his 'feel'. At the other end of the spectrum, we have the number cruncher trying to develop the optimal layout, examining several configurations against some specified measure of effectiveness. Needless to say that the latter procedure involves collection of a lot of data to be used in a model developed with several assumptions made to keep the problem tractable.

We are not considering the desirability or otherwise of selecting a model from this spectrum at the present moment. It can be clearly seen that the desire in all these models is to establish smooth movement of materials resulting in lower handling costs. This requires the knowledge of material handling relationship between the different departments besides the area requirements of the departments.

Material flow between departments often represents the desired closeness that. the layout man feels, should exist between departments. This is depicted by means of a Relationship Chart (Rel-Chart). Other considerations affecting the proximity relationship between departments include convenience, safety, communication needs, use of same personnel in two or more departments (or machines) etc.

The standard codes used to represent closeness relationship between departments in descending order are A, E, I, 0 and U. In addition, there is a code X to describe the undesirability of having two activities close together eg. the out patient department and the intensive care unit in a Hospital. A procedure for the construction of a Rel-Chart based on flow of material is presented below:

Given below is the procedure to develop the From - To' Chart. Table 8.1: Proposed Production Plan

	Sequence of	Production per week
1	A C - D - F	500
2	B-A-C-D-F	1000
3-	E-B-C-A-F	300

The sequence of operations along with weekly demand for the product is given in Table 1 for a firm producing three products

Table 8.2: Flow Chart

	TO					
FROM	A	B	C	D	E	F
A		500				300
		1000				
B	1000	300				
C	300		500			
			1000			
D						500
						1000
E	300					
F						

This Chart is developed by noting the flow between departments to the next in their defined sequence.

Table 8.3: From to Chart						
TO						
FROM	A	B	C	D	E	F
A	-	1000	1800			300
B		-	300		300	
C			-	1500		
D				-		1500
E					-	
F						-

The flows between the departments are now collected to produce a from-to chart. The entries show the total now between any two departments. This data is now converted to generate the Relationship (Rel) Chart

Table 8.3: From to Chart						
TO						
FROM	A	B	C	D	E	F
A	-	E	A	U	U	O
B		-	O	U	O	U
C			-	A	U	U
D					U	A
E					-	U
F						-

The strong flow between Departments A & C, C & D and D & F is assigned an `A' relationship. Departments A & B with a flow of 1000 units are given the 'E' relationship. A-F, B-C and B-E with a flow of 300 are given rating 0. The rating U is given where there is no flow.

Table 8.5: Relationship Chart Symbols

Closeness Rating	Vowel Letter	Number Value
Absolutely Necessary	A	4
Especially Important	E	3
Important	1	2
Ordinary Closeness OK	O	1
Unimportant	U	0
Not Desirable	X	-1

Let us now consider the conventional approach to layout development in some detail with the help of an example. Problem is to find out an arrangement for the eight departments of a-factory given the following information.

Space Requirements			
Sl.No. Department		Area(square feet)	Blocks
1. Production	(PR)	48(1(1	12
2 Warehouse	(WA)	3050	8
3. Office	(OF)	24W	6
4. Toolroom	(TR)	'1150	3
5. Food Service	(FS)	750	2
6. Maintenance	(MT)	1(XX)	2
7. Locker room "	(LR)	600	2
8. Shipping and Receiving	(SR)	19(X1	5
	Scale-40:1		Total 40

It is necessary to determine (lie appropriate block size. Smaller block sizes permit flexibility concerning relative location of the departments by permitting flexibility in the shape of the Department to be located. This finally-may help in realising the much desired regular overall shape. However there is the possibility of extreme` deformation of the individual department shapes. Such distorted department shapes may not permit accommodation of all the facilities of the department to be located in them although numericaly the total area provided is sufficient. On the other hand larger block sizes cause difficulty in the realisation of an overall regular shape for all the departments taken together. This is because of the lack of flexibility in changing the individual department shapes.

Relationship -Chart given below is developed based on the procedure described in the previous section.

	PR	WA.	OF	TR	FS	MT	LR	SR
PR	-	A	E	A	E	A	E	E
WA			O	O	U	O	U	A
OF				U	O	O	U	O
TR.					O	A	U	U
FS'						U	U	U
MT							U	0
1R							-	U
SR								-

The next step is to develop a pictorial representation of the Rel-Chart. Here the work centres are represented by nodes and the number of lines connecting any two nodes wilt show the desired closeness with which the activities should exist in the layout. Larger the number of lines connecting the two nodes greater is the need for keeping them adjacent. The undesirability of keeping any two activities side by side is indicated by a zig zag line connecting them in the nodal diagram.

The nodal representation begins by placing the most connected department in the centre. (This can be found out by either inspection-of the From-To chart or by quantifying the data in Rd-chart by assigning proper weightages to the letter relationships). Next node to appear adjacent will represent the department that has largest material handling relationship with the already placed department. All the departments are thus entered till the completed nodal diagram emerges. The nodes are now connected by lines depicting the relationship between them.

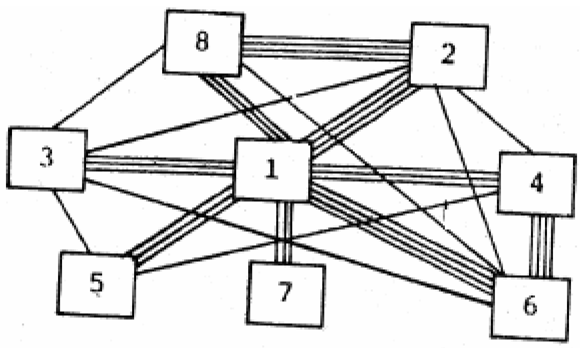

Fig. 8.4: Initial Nodal Representation

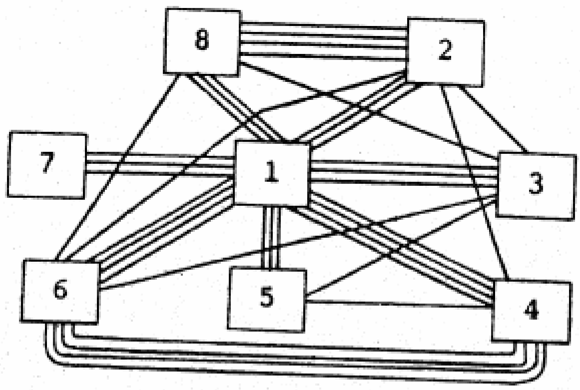

Fig.8.5: Improved Nodal Representation

The ideal nodal representation has any two departments having handling relationship adjacent. Since realising this is not possible, attempt will be made to get a good nodal representation which will have the fewest lines crossing least number of departments. This is done by moving the nodes on a trial and error basis and examining the connecting lines. ,

The templates representing the departments (Fig. 8.6) can now replace the nodes in the grid. The grid representation should be used as a starting point for developing the size and shape of the templates for the individual departments. Grid is only an approximation of the required area. It will be frequently required to enlarge or reduce the grid to meet the exact specifications. The templates above should be laid out according to the grid selected.

The resulting layout (Fig. 8.7) will be irregular in shape and requires modification. Modifying the layout is basically on a trial and error basis; but since the grid has already approximated the layout, the task should be a simple one, requiring only minor adjustments (small adjustments in departments 2 and 6 results in the following final layout. (fig. 8.8).

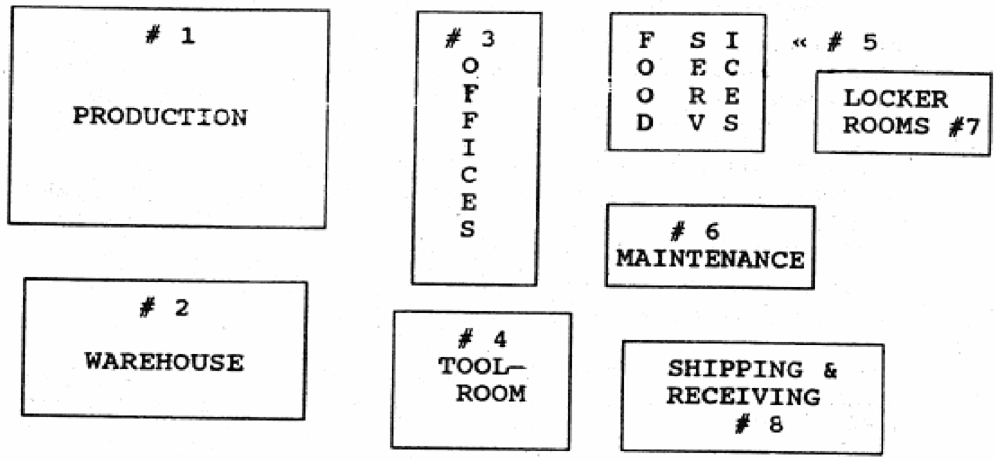

Fig. 8.6: Departmental Templates

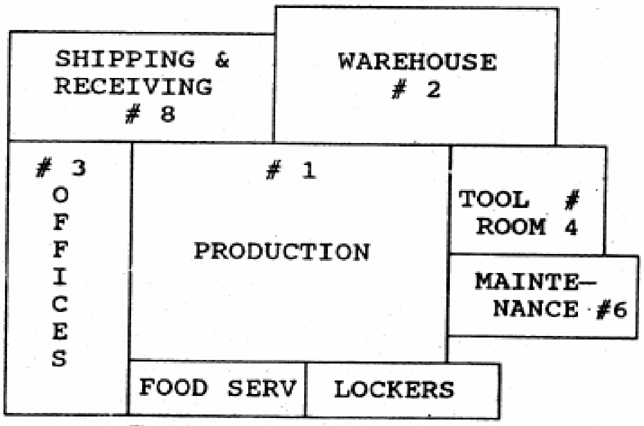

Fig. 8.7: Layout with Irregular Boundary

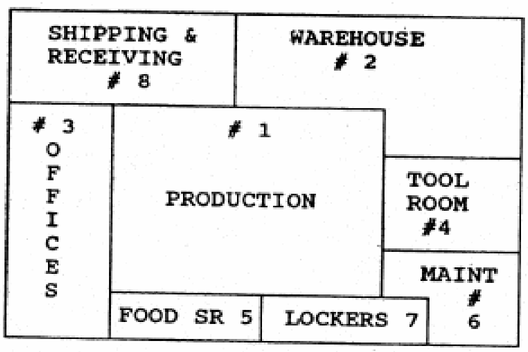

Fig. 8.8: Final Layout

8.8 CONVENTIONAL APPROACH FOR DEVELOPING PRODUCT LAYOUT

Product layouts are suitable for mass production of discrete items. Henry Ford used the assembly line systems for mass production of automobiles early in the 20th Century.

Product layouts are used to achieve smooth flow of large volume of highly standardized products that require standardized (repetitive) processing operations. The arrangement of facilities is known as production line or assembly line.

The main issue in design of product layouts is line balancing. The total assembly work is broken down into a number of elemental tasks that can be performed quickly and routinely by relatively less skilled workers on the line. The process of deciding how to assign tasks to work stations on the line is referred to as line balancing. The objective of line balancing is to obtain task groupings that represent approximately equal time requirements. This minimizes idle tittle along the line. Idle time occurs only if work station times are not equal.

Perfect balance would lead to smooth flow of work. But it is very difficult to achieve perfect balance because of the inability to obtain task groupings that have same durations. Also there may be some restrictions such as fixed location of some work stations, precedence - requirements of operations etc. Further, it may not be feasible to combine certain tasks.

The cycle time (amount of time each work station has. to complete its set of tasks before the product moves to the next station), determines the output rate for the line. For example, if a line has a cycle time of 6 minutes, completed items should come out of the line at the rate of 10 per hour. Consider the following example:

Assembly of a certain product consists of eleven operations. The operation times and precedence requirements are given in the table below: (Table 8.6)

Table 8.6: List of Operations

Operation Number	Duration	Immediate Preceding Operation(s)
1	0.4	-
2	0.7	-
3	0.5	1,2
4	0.4	3
5	0.4	-
6	0.2	4,5
7	0.1	6
8	0.3	7
9	0.4	-
10	0.5	8,9
11	0.6	10
Total 4.8 minutes		

The precedence diagram for the 11-operation problem is shown below

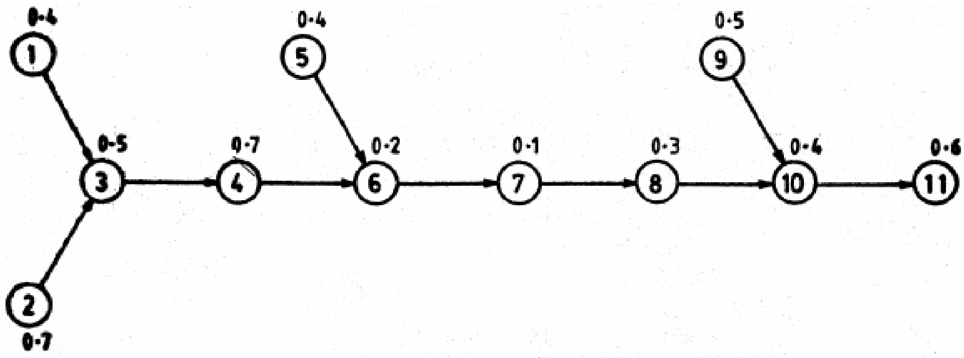

Fig. 8.9: Precedence Diagram

(The numbers inside the circle indicate Operation Number. The values at the top of each circle indicate the operation time)

Further data for the problem are as follows:

Desired output = 6500 units/week

The company operates for 5 days per week, three shifts per day, at 90 per cent efficiency. Thus .9 x 8 = 7.2 hours are available per shift.

$$\text{Required cycle time} = \frac{\text{6500 units/week}}{\text{(5days/week) x (3 shifts/day) x (7.2 hrs/shift) x (60 minutes/hr)}}$$

$$= 1.00\text{minutes}$$

The problem is to assign operations to workstations on the line without violating precedence relations and without exceeding the cycle time of 1.0 minutes.

The procedure is as follows:

Start with station 1 and find out which operations can be assigned to station 1. Assign the operation with the largest time first. Go on assigning operations to the station without exceeding the cycle time and without violating the constrints. Continue in this way until all operations are assigned The assignment of operations to the stations is given in 'Fable 8:7.

Table 8.7: Assignment of Operation

Station	Operations assigned	Station time	Idle time
1	2	.7	.3
2	1,3	.9	1
3	4	.7	.3
4	5,6,7,8	1:0	0
5.	9,10	.9	1
6	11	.6	.4
	Total	4.8 Min	1.2 Min

For Station 2, we could assign elements 1, 5 or 9 each having same duration. However, we broke the tie by picking the smallest operation number:

The line efficiency is computed as

$$\text{Line efficiency} = \frac{\text{Sum of all operation times x 100}}{\text{(Number of Stations) (Cycle time)}} \frac{4.8 \times 100}{(60)(1.0)} = 0.08 \times 100 = 80\%$$

Balance Delay = (1- .8) x 100 = 20%

The above example presents some of the basic issues of line balancing compared to ^{no}w real life situations. The example problem is rather simple. Hence the line balancing problem is rather a complex one because of large number of alternatives for grouping of tasks. This combinatorial complexity has necessiated the development of heuristic approaches since the heuristic approaches reduce the number of alternatives to be considered. The heuristic approaches do not guarantee optimum solutions, but they provide reasonably good solutions with lesser amount of effort.

Some of the heuristic rules used in practice are:

1) **Largest candidate** rule: assign tasks to stations, largest tasks first and continue until all tasks have been assigned. This rule was used for the example problem mentioned above:

2) **Positional weight:** assign tasks according to positional weight, which is the sum of a task's time and the times of all its following tasks.

3) Assign tasks in order of most number of following tasks.

8.9 SUMMARY

Layout decisions play an important role in design of productive system.

One of the main design aspects refers to the type of manufacturing: intermittent or continuous. Intermittent processing is needed for a wide range of products/services. whereas continuous processing is characterised by high volume of one or few similar products or ser^{v}ices. Product layouts arc used for continuous processing. whereas process layouts are used for intermittent processing.

Process layout design centres around relative location of different facilities, whereas line balancing is the main design issue in product layout. Although layout decisions are traditionally associated with manufacturing situations. they can equally Well be applied to service systems. For example process layouts are found in offices hospitals, and product layouts are found in cafetarias. Real life layout problems possess a large number of alternatives which are practically impossible to examine. Hence heuristic approaches, aided by computers are used to solve layout problems. These solutions are quite satisfactory. A number of computer-aided layout packages are available for solving such problems with less effort.

8.10 SELF-ASSESSMENT EXERCISES

1) To what extent do the quantitative layout models consider behavioural factors?
2) Compare the manual and quantitative models for process layout design. What are time advantages of each kind of model?
3) Compare differences in design strategics for developing an initial layout design (for a new facility) and for developing a revised layout design (for an existing facility).
4) Some would contend that employees should not have major voice in layout design. Other argue that the design process should be discuss the issues.
5) Seven areas will receive incoming parts from a factory's receiving dock, which can Ike located at either position A or position B in the facility. The number of loads per month is shown in parentheses. The distances to A and B are given in brackets. Which position is best, A or B ?

A	1 (90)	B
2 (60) [A:1: B:2]	3 (30)	4 (50) [A:2: B:1]
5 (40) [A:2: B:2]	6 (90)	7 (70) [A:2: B:2]

6) A manager is trying to determine the best layout of her office. The following information has been collected on the average number of trips per day by carious types of persons from and to their own offices. It is; also know a that executive our paid $ 200 per day, staff people arc paid 1 110 per day, and secretaries are paid $ 70 per day. The manager would like to minimise the cost of lost time due lo trips between various locations in the office.

Department	Executives	From /to trips per day Secretaries	Staff
A. Mail Room	0	40	10
B. Secretarial office	10	0	20
C. Conference Room	30	10	20
D. Coffee Room	30	30	20
E. Executive Offices	0	40	40
F. Staff Office	20	30	0

Assume that a trip between adjacent offices takes 5 minutes travelling time in both directions irate trip is between non adjacent offices the traveller must more in rectangular directions along the hallways between offices. Thus the travelling times for the layout shown are given below:

Executive E	Mail A
Secretarial B	Conference room C
Coffee D	Staff F

Travel time (min)

	A	B	C	D	E	F
A		10	10	15	5	15
B			5	10	10	10
C				10	10	10
D					15	5
E						15
F						

a) Evaluate the total of this layout plan.

b) Develop a layout plan with lower cost.

c) What additional factors other than travel cost might be important in this problem?

7) The university library is considering a new location for department 6, the book purchase processing department. Library staff would like to exchange location of department 6 and department 2 (2 being the social science reference stall).

Give estimates as shown, what would be the impact of this change? Do you have a better recommendation? If so, show your work to support your recommendation.

Monthly book loads

Department	2	3	4	5	6
1	500	0	200	100	0
2		0	0	0	0
3			50	150	0
4				0	100
5					0

Current Layout

1	2	3
6	4	4

8) Load shipments among work contents A through L, tentatively located as shown, are given in the Table.

Annual loads (in units)

	To				
Frotn	D	G	H	I	J
A	300	600	-		200
C	600	300	200		400
E	100	-	-		500

Layout (tentative)

A	B	C	D
E	F	G	H
I	J	K	L

a) Assuming transportation cost of $1/distance Unit for each load, find the good layout.

b) Suppose the cost is $4/distance unit for each load from work center E and $I /distance unit for each load from A and C. find a good layout.

9) A toy company: Electro-Play, inc, is interested in balancing a production line that will manufacture an electronic football game to compete with the successful pocket calculator-size model mattel. Tasks ask times and precedence requirements arc given in the Table.

Task	Task Time (Seconds)	Required predecessors	Task	Task time (Seconds)	Requned predecessor
A	40	none	G	10	C
B	20	A	H	I0	E.
C	15	B	I	10	E
D	60	none	J	5	L.G.H.I
E	20	D	K	10	J
F	10	C			

a) Construct a sequence diagram fear the tasks.

b) To balance the line with a 60 second cycle tin^{g}e, x1•hat is the theoretical minimum number of stations required°? A Seven-four day is worked.

c) Balance the line with the longest operation time (LOT) mile, balancing to a 60-second cycle tin^{g}e.

10) An enterprising college student has received a contract to deliver 300 submarine sandwitches per day to a cafeteria. The student experts to assemble these sandwitches, on an assembly line using the following times and precedence relationships.

Task	Description	Seconds	Precedences
A	Spread book buns (butler)	25	
B	Put on Lettuce	15	A
C	Put on meat	13	A
D	Put on cheese	15	A
E	Put on tomato	12	A
F	Wrap finished sandwitch	20	A,B,C,D,E

a) For a 40 second cycle time, balance the assuming tin^{g}e using the least -naunbcr-of- predecessors rule. How many stations are required and what operations are assigned to each?

b) What is the minimum number or stations for a 40-second cycle time! What is the efficieny of the balance obtained in pant 'a'? how long will it take to produce the 300 sandwitches a day?

c) Suggest alternative wars to-organise the assemble of these sandwitches wising file same amount of labour which method do you prefer?.

8.11 FURTHER READINGS

1) Grant lreson (1952). Factory Planning & Plant Layout, Prentice Hall.
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9) Stevenson. W J (1990), production operation Management , R D Irwin