5

FACILITIES LAYOUT AND MATERIAL HANDLING

(A) Introduction

A factory is a place where all the industrial activities are housed. After the selection of the factory site, the factory building is constructed at the selected site. The problem of arrangement of various departments inside the factory building arises only after the availability of the floor area covered by the walls and roofs forming the factory building. It should be noted that, though the problem of factory and plant layout arises only after the building facilities have been made available, they are considered along with the construction of the factory building. Certain specific requirements of the administrative departments and the characteristics of the production processes and plant services have a direct bearing on the construction of the factory building. Thus both factory building and factory layout are considered simultaneously. The architectural design and the exterior view of the factory is considered with the technical requirements of various departments. The emphasis is given to the technical aspects rather than the aesthetic considerations.

Factors like owned or hired building, new construction or readymade building, single story or multi-story building have a considerable effect on the decision of the arrangements of various departments inside the factory. A distinction between the factory layout and the plant layout should be noted carefully. The factory layout is a broad consideration and it decides about the housing of all the activities inside the factory. Generally the activities are divided into the following groups:

(1) Office area in which the administrative departments are housed;

(2) Plant area which houses the following activities:

(*i*) Production departments,

(*ii*) Services departments,

(*a*) Technical Services — like receiving departments
store-room,
stock-room,
tool-room,
inspection department,
power house or boiler room
material-handling equipment,
shipping department etc.
and

(*b*) Personal Services — like parking area,
time-keeper's office,
canteen and lunch-room,
recreation room,
toilets etc.

In relation to factory layout, plant layout is a narrow consideration and concentrates on the arrangements of production and service departments along with the location and sequence of machines and equipment.

(B) Ideal Plant Layout

Plant layout is the overall arrangement of the production processes, store-room, stock-room, tool-room, material handling equipment, aisles, racks and sub-stores, employee services and all other accessories required for facilitating the production in the factory. As it encompasses production and service facilities and provides for the most effective utilization of the men, materials and machines constituting the process, it is a master blueprint for co-ordinating all operations performed inside the factory.

According to *F. G. Moore,* "A good layout is one which allows materials rapidly and directly for processing. This reduces transport handling, clerical and other costs down per unit, space requirements are minimized and it reduces idle machine and idle man time.".

(C) Objectives of an Ideal Plant Layout

A good plant layout strives to attain the following objectives:

(1) Minimization of material handling.

(2) Elimination of bottle-necks through balancing of plant capacities.

(3) High material turnover through shorter operating cycle.

(4) Effective utilization of installed capacity so that the returns on the investments may be maximized.

(5) Effective utilization of cubic space of the factory area.

(6) Effective utilization of man-power resources through elimination of idle time.

(7) Elimination, improvement or confinement of objectionable operations e.g., operations with bad odour, vibrating operations etc.

(8) Elimination of physical efforts required of operative workers.

(9) Avoidance of industrial accidents.

(10) Better working conditions for the employees like lighting, ventilation, control of noise and vibrations etc.

(11) Decency and orderliness inside the plant area.

(12) Better customer services through cheaper and better product supplies according to the delivery promises.

(D) Factors Affecting the Plant Layout Decision

The decision of the plant layout is affected by the following factors:

(1) Type of production: The layout for an engineering unit will be quite different from that of a flour factory.

(2) Production System: The plant layout in a continuous production system will be totally different from that under the intermittent production system.

(3) Scale of production: The plant layout and material handling equipment in the large-scale organization will be different from that in the small-scale manufacturing activity.

(4) Type of machines: The use of single-purpose and multipurpose machines substantially affects the plant layout. Similarly noisy and vibrating machines require special attention in the plant layout decision.

(5) Type of building facilities: The plant layout in a single-story building will be different from that in a multi-story building.

(6) Availability of total floor area: The allocation of space for machines, work-benches, sub-stores, aisles, etc, is made on the basis of the available floor area. Use of overhead space is made in case of shortage of space.

(7) Possibility of future expansion: Plant layout is made in the light of the future requirements and installation of additional facilities.

(8) Arrangement of material handling equipment: The plant layout and the material handling services are closely related and the latter has a decisive effect on the arrangement of production process and plant services.

(E) Material Flow System

Men, machines and materials are the three basic inputs in the manufacturing processes. Generally men and machines tend to remain static while the materials move from one work station to another for the purpose of processing. The raw-materials pass through various paths till they are converted into finished products. The pattern of movement of materials inside the plant area is prescribed under different types of floor systems. The pattern of material flow is an important consideration in the plan layout decision because good layout aims at minimizing the flow of materials. The pattern of the flow of the materials is largely decided by the type of layout. In the product layout, the material flow is short and smooth, while in the process layout it is long and involves many complexities. The flow pattern of the material is closely related to the type of the material handling equipment and the cost of material handling. It also decides the need for temporary storing, spots of bottlenecks or rushing. The operating cycle period has a close relation with the flow pattern of materials.

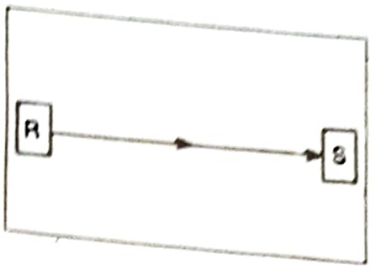
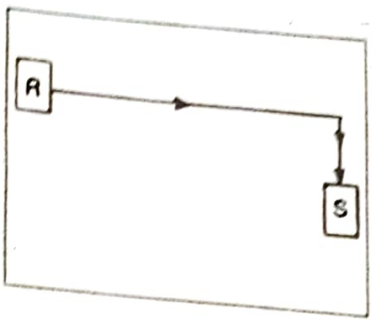
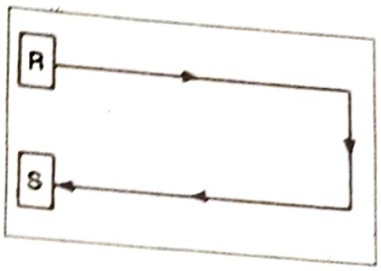
The flow pattern of the materials helps in eliminating bottlenecks, rushing, back-tracking and ensures good supervision and control. It also helps in minimizing the material

handling cost, effective utilization of plant capacity, reduction in the operating cycle and resultantly profitable returns on the investments.

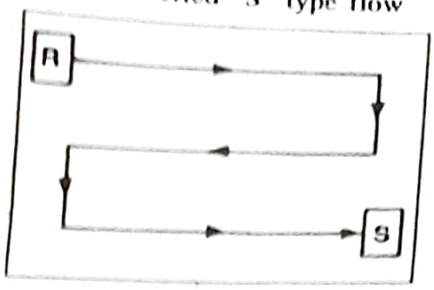
The materials flow system is broadly divided into two on the basis of the nature of the availability of floor space as under:

(1) Horizontal flow system, (2) Vertical flow system.

(1) Horizontal Flow System: The horizontal flow systems are devised in the single story building when the flat floor area is available. The starting point is the "receiving" (R) of raw-materials and the terminal point is the "shipment" (S) of finished goods. In between these two points, the materials move from one work station to another for the purpose of processing. The horizontal flow system is denoted by the alphabetic letters as under:

Flow System	Characteristics
(i) "I" type flow:  Fig. 5.1	*(i)* Shortest route *(ii)* Must have roads on both sides. *(iii)* Plant area has long lengths but short width. *(iv)* Difficulty in returning empty containers. *(v)* Absence of rushing of outside transportation. *(vi)* Unsuitable for longer production lines.
(ii) "L" type flow  Fig. 5.2	— same as "I" type flow —
(iii) "U" type flow  Fig. 5.3	*(i)* One side road link will be required. *(ii)* Less difficulty in returning the empty containers. *(iii)* Possibility of rushing of outside transportation. *(iv)* Suitable for longer production lines. *(v)* Requires square-like floor area.

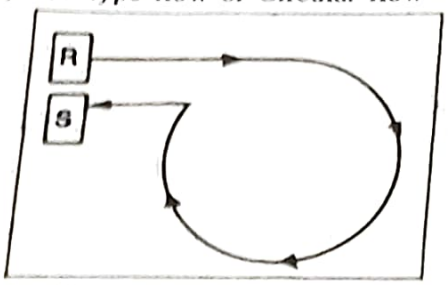
(*iv*) "S" or inverted "S" type flow



(*i*) Requires roads on both sides
(*ii*) Absence of rushing of outside transportation.
(*iii*) Requires square-like floor area
(*iv*) Difficulty in returning empty containers.
(*v*) Suitable for longer production lines.

Fig. 5.4

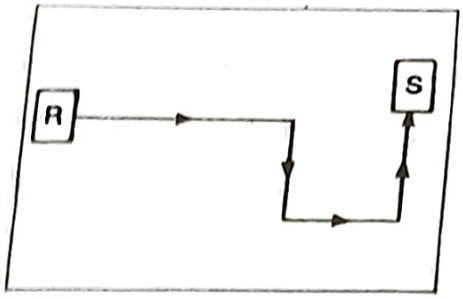
(*v*) "O" type flow or Circular flow



(*i*) One side road facility is required.
(*ii*) Heavy rush of outside transportation.
(*iii*) Ease in returning empty containers.
(*iv*) Requires square-like floor area.
(*v*) Suitable for longer production line.

Fig. 5.5

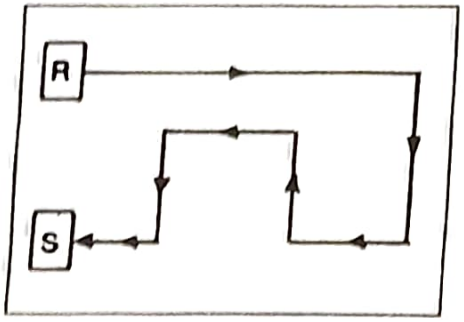
(*vi*) Combination of "I" and "U" type flow



Combined characteristics of "I" and "U" type flow

Fig. 5.6

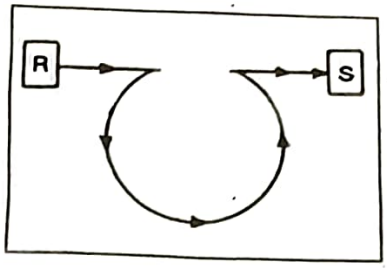
(*vii*) Combination of "I" and "S" type flow



Combined characteristics of "I" and "S" type flow.

Fig. 5.7

(*vii*) Combination of "I" and "O" type flow



Combined characteristics of "I" and "O" type flow.

Fig. 5.8

(2) Vertical Flow System: The vertical flow system arises in case of multi-story buildings. Multi-story building are used where limited land area is available and the processing is done on light materials with the help of light machines. The advantages of gravity flow can be tapped, however, it first requires the availability of materials at the top floor.

Certain important vertical flow system are as under:

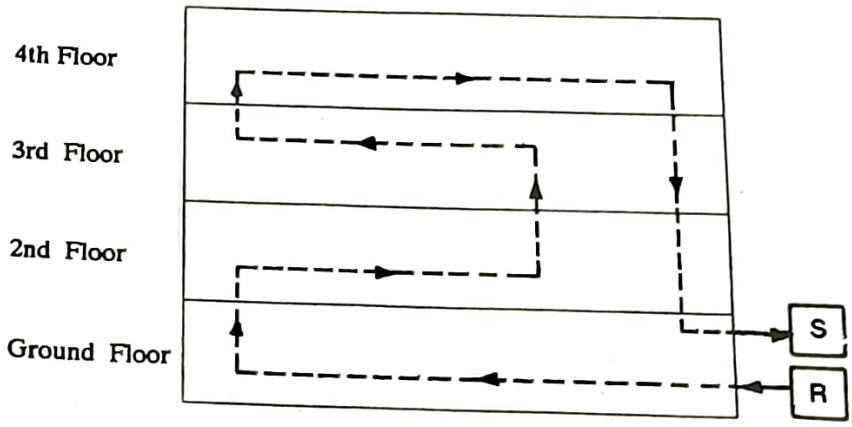


Fig. 5.9

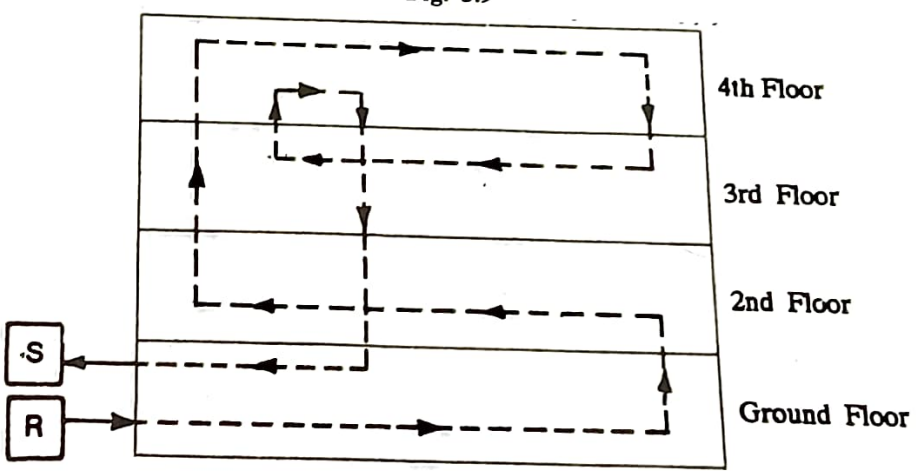


Fig . 5.10

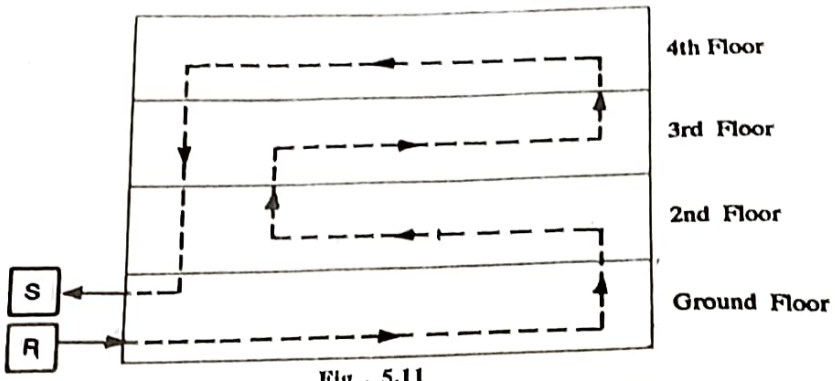


Fig . 5.11

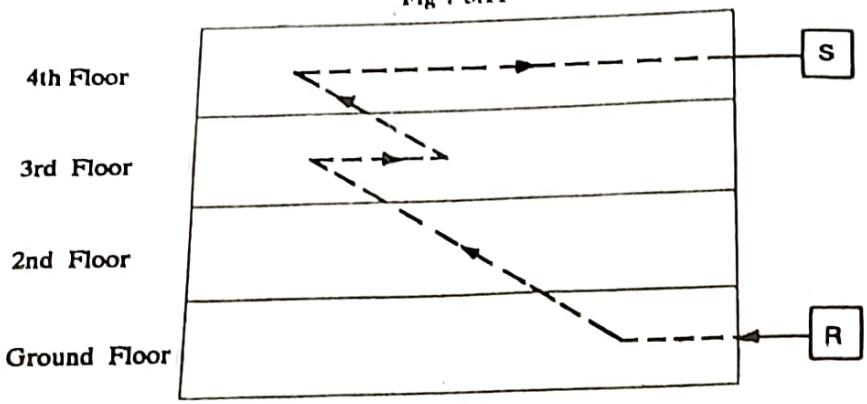


Fig . 5.12

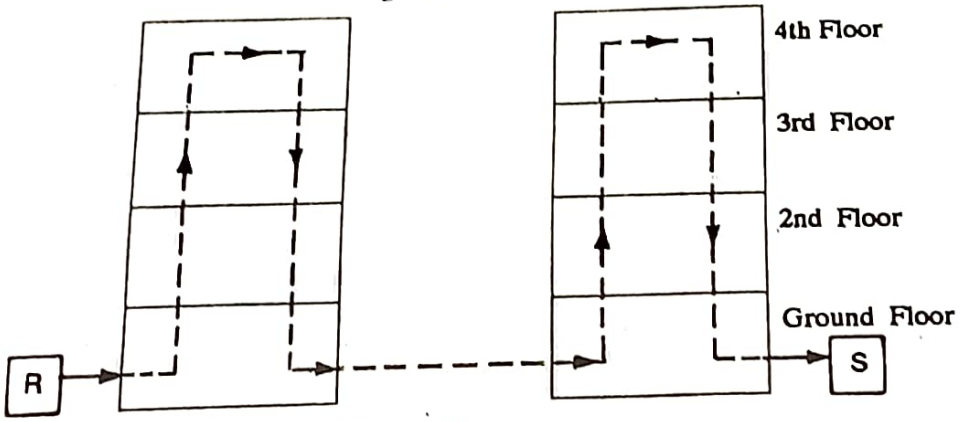


Fig . 5.13

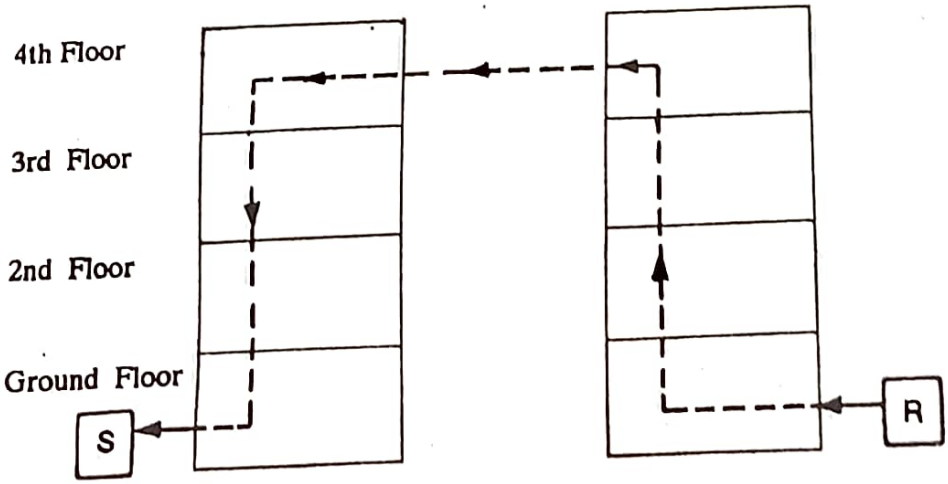


Fig . 5.14

(F) Types of Plant Layout

The following are the popular types of plant layout:

(1) Process layout (2) Product layout (3) Combined layout (4) Static product layout or Project layout (5) Cellular layout (6) Job Shop layout. Each layout is explained in brief in the following paragraphs:

(1) Process layout: It is also called functinal layout. All machines performing similar type of operations are grouped at one location in the process layout. e.g., all lathes, milling machines, cutting machines etc. in the engineering shop will be clustered in their like groups. Thus all forging will be done in one area and all the lathes will be placed in another area. In this layout, several products may share a machine to make its full use. The sequential arrangement of the machine-group is generally, but not necessarily made on the basis of labour operations. In this type of layout, the process rather than the product has a dominating role. The product is given secondary consideration and is moved for the purpose of operations to the process section with like machines stationed at a particular point. This type of process is more suitable to job order type of production. In such production the operations differ from product to product. So, it is desirable to arrange the machines on the basis of process rather than on the products.

The typical arrangement of the machines in the process layout will be as under:

Product 'A'and Product 'B' with their differential sequence will be routed for the processing in the manner as shown in the following figure:

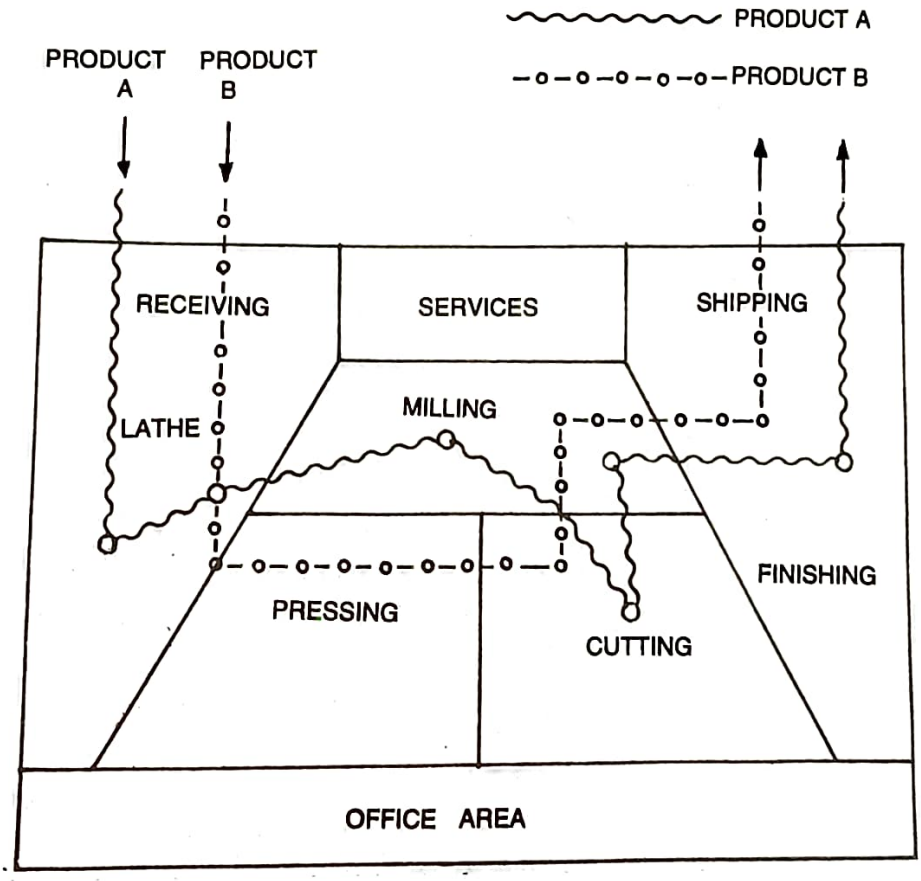


Fig. 5.15 Process Layout

Advantages: The process layout avails of the following advantages:

(*i*) Like product layout it eliminates the duplication of machines and enables the optimum use of installed capacity.

(*ii*) It facilitates the flexibility in production. It is more flexible than a line layout. Different products can be made without the changes in the arrangement of machine. The production capacity is not arranged in rigid sequence and fixed rated capacity with line balancing.

(*iii*) Like product layout, the break-down of one machine does not interrupt the entire production flow.

(*iv*) Specialization in supervision becomes possible.

(*v*) Individual incentive schemes can be developed.

Disadvantages: The following are the main disadvantages of the process layout:

(*i*) Due to lack of straight line sequence of production, it is impossible to maintain the line-balancing in production. So the problems of bottleneck and waiting and idle capacity arise.

(*ii*) The cost of material handling increases due to long-routing and back-tracking between the processes.

(*iii*) The processing time is prolonged which reduces the inventory turnover and increases the investments in inventories.

(*iv*) The inspection cost increases. Due to frequent changes in the machine set-up, inspection is required at each stage of the process.

(*v*) The cost of supervision increases due to specialist supervisors and more number of supervisors are required at each process unit.

(*vi*) The production planning and control becomes difficult due to complexities arising in routing, scheduling, despatching and follow-up.

(*vii*) It is not possible to implement the group incentive schemes on the basis of quantity of the products manufacturing.

(*viii*) More space is required for internal storing, reservoir of materials and provision for the expansion of the particular process section.

(2) Product layout: In this type of layout, the machines are arranged in the sequence as required by the particular product. All machines as required to balance the particular product line are arranged in a sequential line but not necessarily in the straight line. It is also known as "the product-line layout." In this layout, one product goes through all the machiines lined up, in the order required by its manufacture (Fig. 5.16). The best-known example of this type of layout is seen in motor-car production. To make this layout successful, the work-load on the various machines must be balanced. The process of getting even loading at each stage of production is called *line balancing.*

In this type of layout, the product is dominating over the process, in the sense that the product is given the primary importance and the process machine must remain present at a point where the product needs its services. Thus, unlike the process layout, the process is given secondary importance in relation to the product. Product layout is more suitable for continuous flow-production with few items of production. It does not require frequent

changes in machine set-up. The typical arrangement of the machines in the product with the separate independent product lines for the product 'A' and Product 'B' will be as shown in the following figure:

Advantages: The product layout is advantageous as under:

(*i*) Reduced material handling cost due to straight-line production flow.

(*ii*) Mechanisation of material handling is possible due to handling between fixed points.

(*iii*) Line balancing may eliminate bottlenecks and idle capacity.

(*iv*) Shorter operating cycle due to shorter and speedier movement of materials.

(*v*) Maximum utilization of machine and labour capacity through developing proper balance between them.

(*vi*) Effective control over production with reduced supervision by generalists supervisors. By reducing the manufacturing to simple steps we can often use less skilled labour.

(*vii*) Effective quality control with reduced inspection points. It does not require frequent changes in machine set-up.

(*viii*) Effective production planning and control. Unlike process layout, the routing, scheduling, despatching and follow-up are relatively easier.

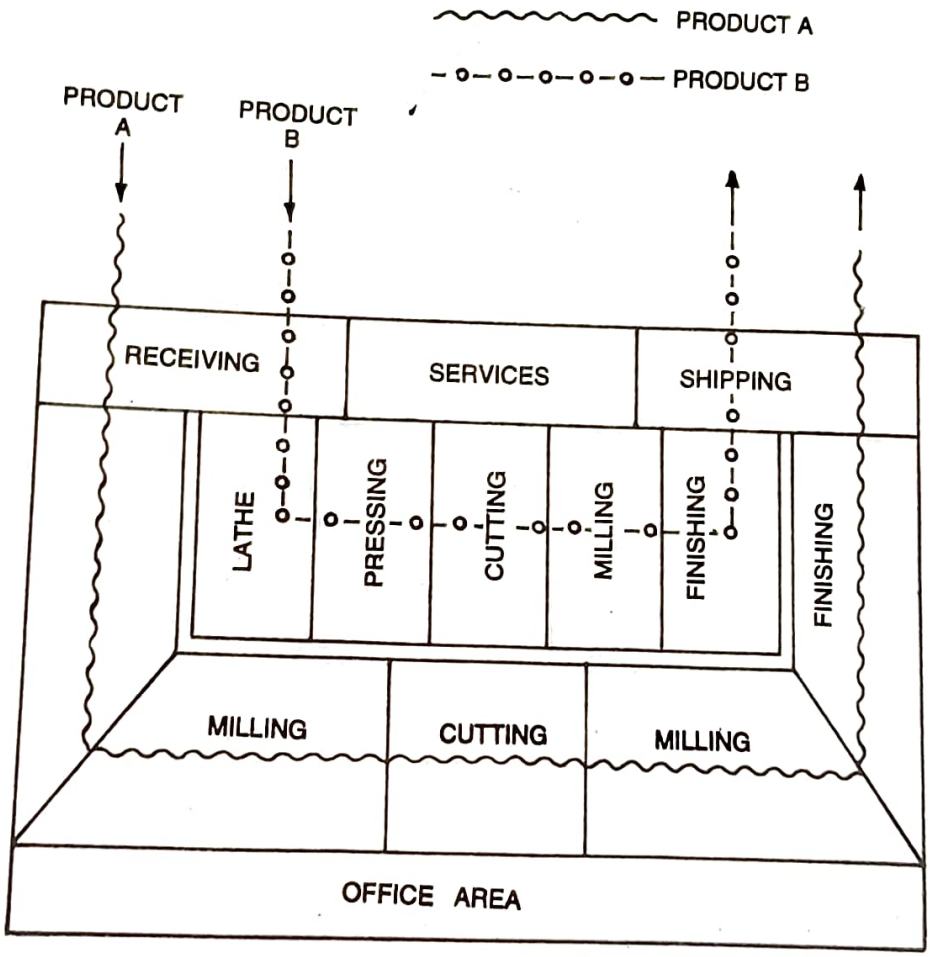


Fig. 5.16

(*ix*) Maximum use of space due to straight production flow and reduced need of interim storing.

(*x*) It facilitates the implementation of the group incentive schemes for the workers.

(*xi*) It is relatively easy to control.

Disadvantages: The following are the main disadvantages of the product layout:

(*i*) The duplication of machines and equipment necessitates the increased investments in them sometime resulting in idle capacity.

(*ii*) The production flow is regulated through the straight line sequence and fixed rated capacity, and thus makes it highly inflexible.

(*iii*) The break-down of one single machine in the line interrupts the entire production flow.

(*iv*) Unlike process layout, the benefits of specialized supervision is not possible.

(*v*) As the entire production is the result of the joint efforts of all operations in the line, it is difficult to implement individual incentive schemes.

(*vi*) They are less flexible than others. Any change in product requires re-balancing the line. If there is any trouble with one machine, the line goes out of balance.

(3) Mixed or Combined Layout: Generally pure process or pure layout is not found in practice. Both are mutually exclusive. A proper compromise reaping the benefits of both the layouts is possible to some extent. So efforts are made to have the combined layout incorporating the benefits of process and product layout. Combined layout is developed as under:

(*i*) Product layout for the main product with a process layout for joint or by-product tapping the idle capacity of product layout along with marginal investments required in process layout.

(*ii*) To diversify the production with a view to tap the idle capacity of the product layout. Products with complete negative correlation with the product-line can make the maximum use of idle capacity of the product layout.

(*iii*) In the product layout, some process may be segregated from the product-line, e.g. objectionable, hazardous, requiring special treatment and repetitive performance etc.

(4) Static Product Layout or Project Layout: The manufacturing operations require the movements of men, machines and materials. Generally few inputs tend to be static while the others are moving. In the product layout and process layout generally the machines have fixed installations and the operators are static in terms of their specified work-stations. It is only the materials which move from operation to operation for the purpose of processing. But where the product is large in size and heavy in weight, it tends to be static, e.g. ship building. In such a production system, the product remains static and the men and machines move performing the operations on the product. The production characteristics are sufficient enough to treat it as a separate type of layout, viz. static product layout.

(5) Cellular or Group Layout: Here an attempt is made to introduce some of the advantages of a line layout into a situation where pure line layout is not practicable. Here machines are placed in groups. Each machine group makes a family of parts which require

similar treatment. This layout lies between process layout and line layout. It is easier to control than a strictly process layout and has more flexibility than a line layout. These days there is a tendency to bring an element of flexibility into the manufacturing system as regards the batch size variations and the differing operations sequences. FMS — Flexible Manufacturing System was first installed in England in 1968. It employed group layout and is suitable for metal cutting, electronic assembly, IC manufacturing and testing etc. FMS is a mixture of traditional automation and state-of-the-art computer technology which essentially consist of a set of machine tooks performing production operations linked up with material handling system. All these are controlled by a central computer system. FMS has several patterns of CNS: computerized numerical control machines.

(1) Flexible Manufacturing Module (FMS)

(2) Flexible Manufacturing Cell (FMC)

(3) Flexible Manufacturing System (FMS)

(4) Flexible Manufacturing Line (FML).

The grouping into cells enable the performance of similar type of functions for a group of products.

(6) Job Shop Layout: Here there is processing of job production, and hence the system is very flexible. The layout depends upon the analysis of the universe of orders received and is a very complex affair.

(G) Plant Layout Factors

There are a host of factors that affect the plant layout. It is necessary to optimise these to have an ideal layout. The factors have been grouped into the following clusters:

(1) Manpower factors

(2) Machinery factors

(3) Movement factors

(4) Material factors

(5) Waiting factors

(6) Service factors

(7) Factory building factors

(8) Change related factors.

All these groups have a number of features which are borne in mind before attempting the layout. The ultimate layout design is a compromise amongst the diverse factors.

(H) Layout Design Procedure

The layout design moves from ideal to what is practical under the limitations given. The plan as a whole is made first, and details are added afterwards. The requirement of materials is central to all layout planning. The process and machinery may need modification in the light of the different factors affecting the layout plan. The following steps are followed in any layout plan:

(1) Determine the objectives. Determine the limitations.

(2) Collect the input data and study the activities involved. The input data may be about forecasts, work study, existing layout, charts etc.

(3) Determine the flow of materials and activity relationships and form a relationship diagram. This is subject to space available and space required. What we ultimately get is a space relationship diagram.

(4) The said space relationship diagram is modified in the light of various considerations and practical limitations.

(5) Several alternative layouts emerge as a result. They are then evaluated.

Flow and Activity Analysis

Data Collection: In order to design a sound layout plan, we require both qualitative and quantitative data about various factors affecting the plan like product attributes, output volume, and component parts. Data required is collected on a continuous basis through techniques like industrial engineering, quality control, marketing research, time and motion study etc. We need data regarding various materials and processes, flow and sequences, space required and activity relationships.

Process Charts: The most commonly used process charts are: (1) Operations Process Chart (2) Flow Process Chart.

(1) Operations process chart: It is a process chart which gives an overall picture by recording in sequence only the main operations (O) and inspections (□)

A specimen of an Operation Process Chart is given below in Fig. 5.17.

Reconditioning Brake Shoes
Operation Process Chart

METHOD: Present
CHARTED BY: D.M
DATE: 23 January 1997

LOCATION: Crossfield Garage
CHART BEGINS: Inspection pit
CHART ENDS: Road test

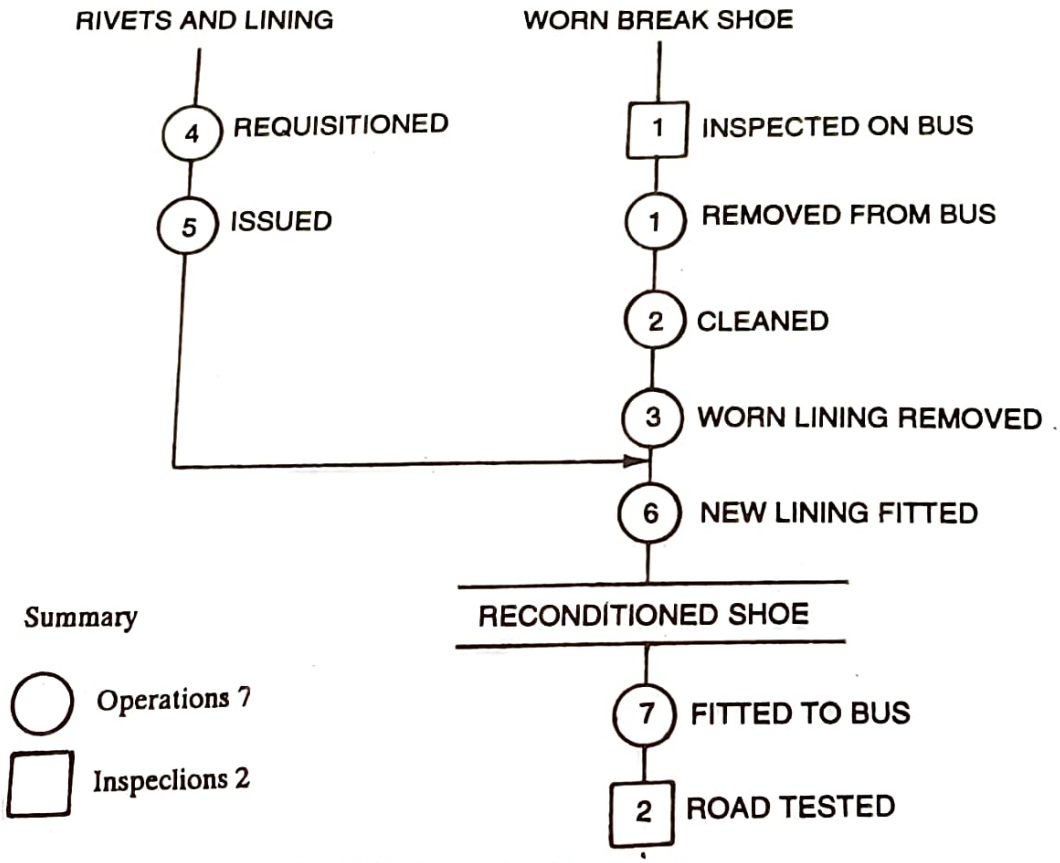


Fig. 5.17 Operation Process Chart