

Plant Layout

3.1 INTRODUCTION

Plant layout involves relative allocation of adequate spaces at the appropriate places for equipment, workers, materials other supporting activities and customers in service industries. The objective behind the arrangement of work areas is to produce most economically, to design service effectively and to provide safe and good physical environment for workers and customers. Thus, plant layout is an effective physical location or configuration of different departments, machines, equipment and services of an organization used to create product or provide service in efficient and economic manner.

It is the process of determining the systematic arrangement of facilities and equipment capable of satisfying and anticipating demand with respect to quantity, quality and timing at lowest cost. It requires meaningful integration of all the elements of conversion process, like men, machine and materials, conveniences and services. It plays an important role in creating an environment conducive to high productivity and satisfaction of social and psychological needs of people at work place.

In addition, it requires the knowledge of the constraints imposed by legal, technical or other factors for new facilities. Such knowledge is also required for existing buildings and other physical structures that form part of the production facilities and the transportation network to which it is integrated.

Thus, in the words of James Hundy, “Layout identically involves the allocation of space and the arrangement of equipment in such a manner that overall operation costs are minimized.” The cost takes into account the losses or gains, if any due to social and psychological needs, health and morale of people.

3.2 OBJECTIVES OF PLANT LAYOUT

A plant is an arrangement of production facilities and equipment. An ideal plant must result in economical production and provide safe and satisfying place to the users and workers. A good layout serves the following objectives:

1. Placing equipment in a position resulting in its maximum utilization.
2. Reducing congestion in the flow of materials or movement of workers through successive stages in the process.
3. Providing easy access to equipment for maintenance and repair.
4. Facilitating effective and easy supervision.
5. Minimising production delays.
6. Providing efficient and smooth flow of material within the plant.
7. Providing for fast and safe material handling.
8. Effective utilization of cubic space.
9. Providing comfortable and safe working environment.
10. Providing flexibility to allow minor changes as and when required.

3.3 FACTORS AFFECTING PLANT LAYOUT

The major factors which influence the nature of layout of plant in any type of production system are as follows:

3.3.1 Human Factor

It is the most important factor of production system. It arranges, coordinates and integrates physical infrastructure, machines, equipment and materials for effective conversion. Human factor is most critical as well as highly flexible element of production system which may decide about the facilities and their arrangements.

3.3.2 Nature of Material to be Used

Material takes three aspects during manufacturing. The incoming material is in raw form and has own shape and size. During process its form is changed and waste produced. The material in process has to move from machine to machine. The final product has a different form. The plant layout will have to be based on ease of handling and safety at each stage.

3.3.3 Machine—Their Types and Sizes

Machines, their types and sizes dictate the types of plant layout. Machines are required for processing of materials, testing and inspection. Some equipment are needed for repairs. All the machines are identified and then placed as per the requirement.

The first three factors, viz. human, material and machines are basics of physical facility.

3.3.4 Movement of Men and Material

It is related to movement of men, machines and materials, besides information flow for the purpose of effective communication within the industries and outside. This factor of plant layout is generally concerned with different types of movement in production system.

3.3.5 Building Layout

It is another important factor in the process of plant layout design as well as in the installation. Basically, plant building is a shell which houses the basic facility and other supporting services. It includes every factor inside as well as outside which is related to plant building design and building utility distribution system.

3.3.6 Service Factor

Several activities are carried out in a plant which indirectly contribute to production. Many of them require specialized equipment and machines which have to be moved on shop floor. These activities include:

- (i) Maintenance of plant.
- (ii) Quality control.
- (iii) Inspection of product.
- (iv) Control of wastage.
- (v) Scheduling.
- (vi) Material handling.
- (vii) Dispatching.
- (viii) Fire protection.
- (ix) Facilities for employees.

3.4 SIX BASIC PRINCIPLES OF PLANT LAYOUT

The six basic principles relating to plant layout are given below:

3.4.1 Integration Principle

All other things being equal, best layout is one which integrates men, materials and machines in the best possible manner.

3.4.2 Flow Principle

All other things being equal, best layout is one which provides for smooth and uninterrupted flow of men and materials.

3.4.3 Space Utilization Principle

All other things being equal, best layout is one which make best use of available cubic space.

3.4.4 Minimum Movement Principle

All other things being equal, best layout is one which results in minimum movement of men and material in the plant.

3.4.5 Safety and Comfort Principle

All other things being equal, best layout is safe and comfortable for employees working in plant.

3.4.6 Flexibility Principle

All other things being equal, best layout provides flexibility.

3.5 PLANT LAYOUT PROCEDURE

Plant layout exercise requires a systematic approach. The procedure requires the following steps:

3.5.1 Information Collection

The following data are to be collected:

- (i) Volume and rate of production.
- (ii) Production specifications and bill of materials.
- (iii) Process sheets indicating tools, equipments and methods.
- (iv) Flow process charts.
- (v) Standard time to complete the operation.

3.5.2 Analysis and Coordination

The information collected is used to decide the following:

- (i) The work force size and type.
- (ii) Number of work stations required.
- (iii) Types of equipment required.
- (iv) Storage and other space requirement.

3.5.3 Choice of Machinery and Equipment

The machinery and equipment needed for the production service is to be decided on the basis of following:

- (i) Number of components to be produced.
- (ii) Capacity of each equipment.
- (iii) Time in which a particular work order is completed.

3.5.4 Selection of Material Handling System

The selection is based on the following factors.

- (i) Material/products to be moved.
- (ii) Container in which it will be moved.
- (iii) Length of movement
- (iv) Speed of movement.

3.5.5 Sketching the Plant on the Plot

Building out line, roads, storage and service areas, etc. are marked on the available plot. It must be kept in mind that the orientation of plant should utilize maximum natural head, light and other weather conditions.

3.5.6 General Flow Pattern

The next step is laying out the details of shop areas as follows:

- (i) Machinery may be laid as per production process requirements, and plant building be constructed around the same.
- (ii) Flow pattern of materials should be such that the distance involved is least between the store and shipping department through the production centers. There should be minimum backtracking and bottleneck.
- (iii) Flow pattern may be analysed using operation process charts or flow process charts.

3.5.7 Individual Work Stations Design

Each work station is laid for achieving optimum performance of operations, material and space utilization and safety and comfort of employees.

3.5.8 Assembly of the Individual Work Station Layout

The total assembly is made in accordance with the general flow pattern and the building facilities.

3.5.9 Storage Space Required

Storage space can be calculated by knowing volume of each stored item, number of items to be kept in stores and the time for each item to be kept in store.

3.5.10 Preparation of Flow Diagrams for Work Stations

After making flow diagrams the work stations are allocated to their respective areas of the plan.

3.5.11 Planning and Locating Service Areas

Service areas such as offices, toilets, wash rooms, rest and lunch room, cafeteria, dispensaries, power generation area, parking areas etc. are planned and located appropriately.

3.5.12 Making Master Layout

Master layout is prepared using templets and models.

3.5.13 Checking Final Layout

The final layout is checked for the safe and economical material handling, adequate production and production control, plant building and its surroundings, service areas, employees safety and comfort, etc.

3.5.14 Approval of Layout

The finally checked layout has to be got officially approved from the concerned authorities.

3.6 BASIC TYPE OF PLANT LAYOUT

The layout is essentially an arrangement to facilitate the production process efficiently. It therefore, is classified as follows:

3.6.1. Fixed Position Layout

It is a type of layout where the job remains in a fixed position and all its accessories such as materials, machinery, equipment and workers, etc. are brought to workstations. Usually this is needed when the job is bulky and its transportation is not desirable or possible. Example of this type of layout occurs in heavy construction (dams, bridges, sky scrappers), shipbuilding, aircraft-assembly and railway wagon industry. It is shown in Fig. 3.1.

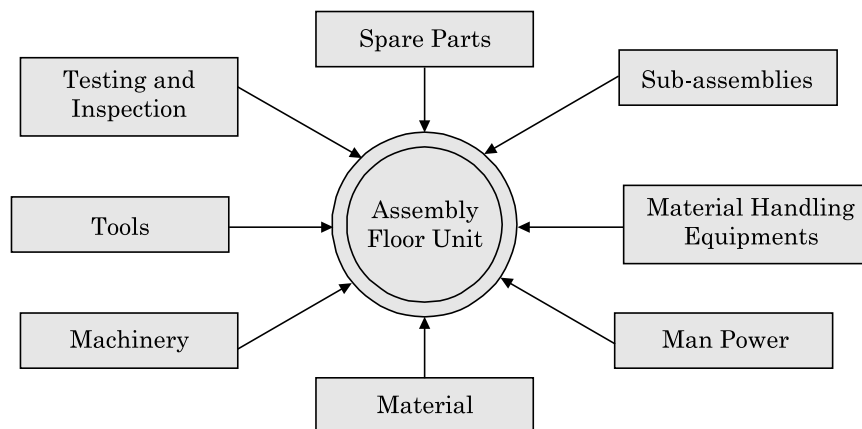


Fig. 3.1 Fixed Position Layout

Advantages:

1. Less material handling for bulky or heavy job.
2. Better utilization of available space.
3. Minimum movement of men during working.
4. Safe working condition for workers.
5. Flexible to change in the product design and its process.

Disadvantages:

1. The utilization of machines and men is less
2. Special purpose machines cannot be used, so the process is slow.
3. Inspection is difficult.
4. Production scheduling and control is difficult to automate.

3.6.2 Process Layout

A process layout is the arrangement of facilities and equipment in group according to the function performed. In this type of layout, similar types of machines or similar types of operations are grouped together and put in one department. For example, all grinding machines may be at one place, all drilling machines at another place and all turning machines at yet another place.

It means that all the machines have been arranged according to their functions. It is preferred for the industries engaged in job order type product. Examples of such layouts in manufacturing are machine shop, shoe making industries, garment industries, etc. and in service sector hospitals, universities, bank, etc. are the examples. They are organised so that their resources are grouped according to the different functions performed. This layout is also referred to as functional layout is shown in Fig. 3.2.

Advantages:

1. High utilization rates for human resource and equipment since disruption due to break-downs or lack of supplies tend to be localized and easily passed.
2. Better product quality, the foreman or supervisor and workers attended to one type of machine and operation.
3. Well-motivated work force due to the relative independence from an unpaced work flow, pride in the application of considerable skill and experience and considerable freedom for satisfying personal needs at work beyond the earning of wages.
4. Workers in one section are not affected by the nature of the operation carried out in other section.
5. Investment is lower in equipment due to the flexibility and interchangeability of general purpose machines.

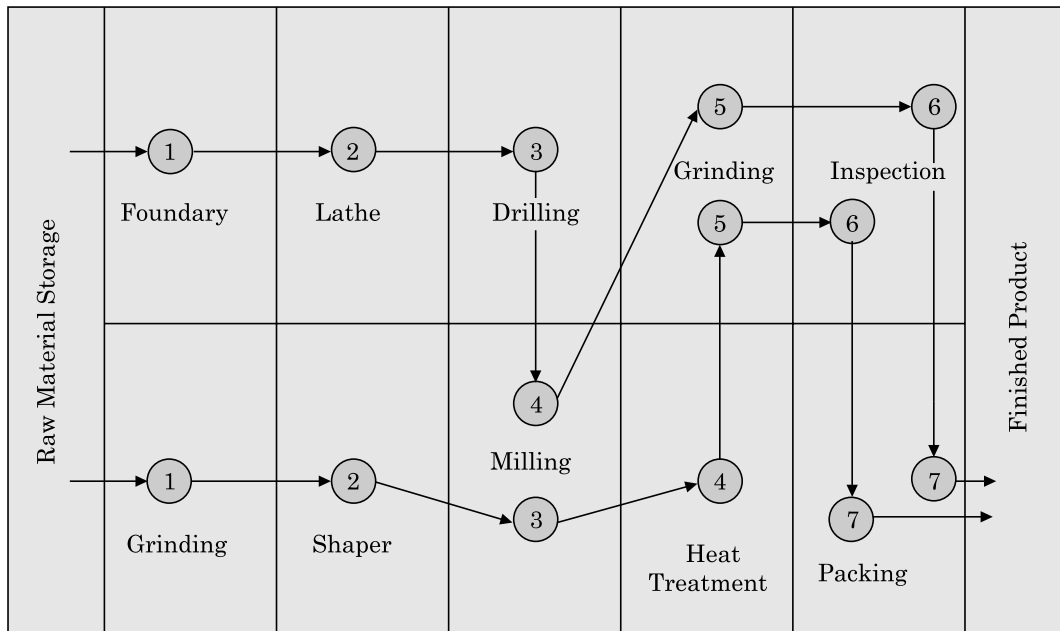


Fig. 3.2 *Process Layout*

6. Varieties of job due to different job orders makes the work more interesting for the workers.
7. Any breakdown of one machine does not affect production.

Disadvantages:

1. High production cost per unit due to the need for special setup and processing requirements.
2. Large in-process inventories are required.
3. More floor area are required for layout.
4. Production control is difficult.
5. It takes relatively long processing times.
6. Material handing process is difficult to be automated.
7. It needs flexible material-handling equipment (fork-lift trucks, cranes, etc.) to handle numerous product types, shapes and sizes with increased space requirement for travel routes and access to work stations.
8. Scheduling and control is complex since each order must be handled individually.

3.6.3 Product Layout

A product layout is the arrangement of facilities and equipment in the same sequence as that of the operations needed to complete each unit of the product or service offered. Successive units follow the same path through the system. This type of layout is very popular in mass production, where only one type of product is manufactured. Examples of product layout applications in the manufacturing are automobile parts industries, chemical industries, T.V. set manufacturing, refrigeration manufacturing, bottling plants, etc. Example in the service sector are cafeteria, insurance claim processing, procedure for issuing passport and driving licenses, etc. As the facilities in product layout are arranged in line as per the processing sequence, it is also referred to as line layout. Fig. 3.3 shows the product layout of a car manufacturing unit. The line need not be straight. It could be any curve to suit the available area.

Advantages:

1. Material handling time and costs can be reduced through the use of mechanized or automated devices (conveyors, chutes, etc.).
2. In-process inventory requirements are reduced due to smooth and relatively fast movement of units through the various processing stages.
3. Inspection of unit is easy.
4. Space utilization is increased due to the elimination or reduction of the need for in-process storage and for flexible materials handling equipment (fork-trucks, carts, etc.) which require special access to workstation.
5. Planning, scheduling and control of operations are simplified since these functions have largely been incorporated in the design of the production line. This significantly reduces the need for information processing and design-making.

Disadvantages:

1. Lack of flexibility is a key problem when the need for adjustment in the line to accommodate desired changes in the product characteristics. This often means higher capital investment is needed.
2. Duplication of identical special purpose equipment for different production lines often requires considerably higher investment than could be necessary if such equipment could be shared by similar products.
3. Breakdown of any one of the several machine on a production line usually forces idleness on the entire line, with costly delays, high maintenance cost or both.
4. All the machines cannot be used to their maximum capacity at a time.
5. Highly simplified and repetitive tasks and a fast production pace create serious psychological problems with the work force, expressed in the form of low morale and high absenteeism and worker turnover rates.
6. Trained workmen are required to operate special purpose machines.

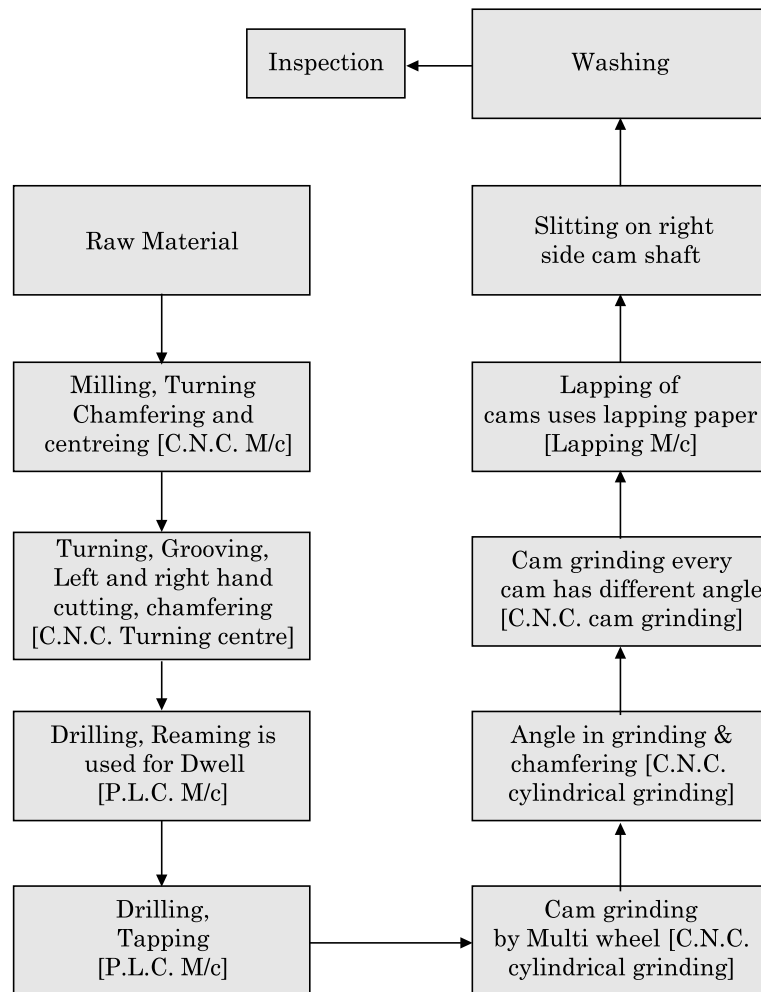


Fig. 3.3 *Product Layout*

3.6.4 Combination Layout

These days most of the manufacturing industries have adopted this type of layout. A combination of process and product layout combines the advantages of both type of layout. In this layout system, a set of machinery or equipment is grouped together in a section and each set of machines or equipment is used to perform similar kind of operations to produce a family of component. This layout is suitable where an item is being made in different

types and sizes. In such cases, machinery is organised in a process layout but the process grouping is then arranged in a sequence to manufacture various types and sizes of product. A sample combination for manufacturing forged crank shaft is shown in Fig. 3.4.

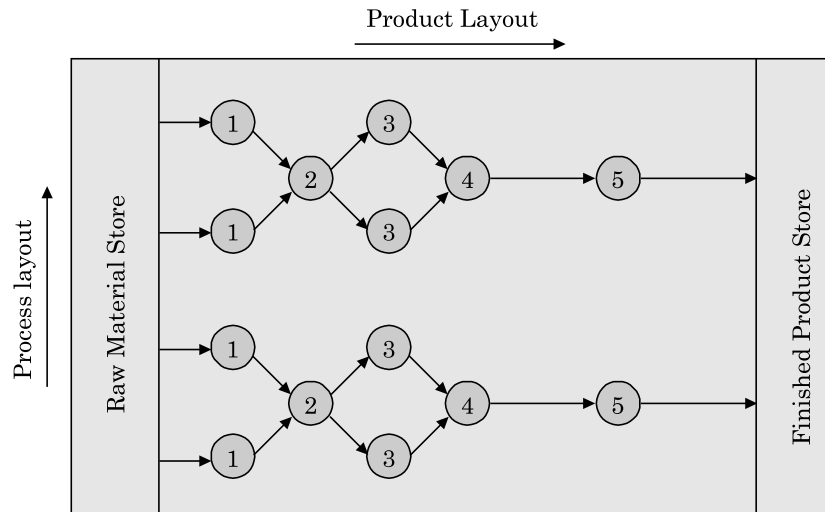


Fig. 3.4 *Combination Layout*

- | | |
|---------------------|-------------------|
| 1. Forging hammers | 2. Inspection |
| 3. Grinding | 4. Heat treatment |
| 5. Final inspection | |

Advantages

1. Production planning and control is easy.
2. Work flow is continuous and smooth.
3. Inspection is easier.
4. Less floor area is required.
5. Better utilization of machines is achieved.
6. Over all cost of production is less.
7. Material handling cost is low.

Disadvantages:

1. All machines cannot be used to their maximum capacity leading to poor facility utilization and higher capital cost.

2. Trained workers are required for this layout.
3. Routing and scheduling is difficult.
4. It needs more frequent inspection.

3.7 COMPARISON OF PROCESS AND PRODUCT LAYOUT

Table 3.1 shows the comparison between process layout and product layout.

Table 3.1 *Comparison of Process and Product Layouts*

	<i>Process Layout</i>	<i>Product Layout</i>
Nature	<ul style="list-style-type: none"> • All similar facilities grouped together. 	<ul style="list-style-type: none"> • Sequence of facilities derived from needs of product.
Application	<ul style="list-style-type: none"> • Low quantity production large range of products. 	<ul style="list-style-type: none"> • Large quantity production only a few products.
Characteristics	<ul style="list-style-type: none"> • Permits specialist supervision. • High volume of work in progress • High material handling cost. • Ease of provision of services. • Can tolerate breakdown. • Easy to incorporate inspection. • Individual Bonus possible. • Flexibility, variety and product change possible. • Maintenance easy. • Production control complex. • Production Planning simple. • Long production time. 	<ul style="list-style-type: none"> • Little specialized supervision required. • Minimum work in progress. • Minimum material handling cost. • Difficult to provide services. • Single breakdown stop all machines. • Difficult to incorporate inspection. • Group bonus. • Little variety possible. • Maintenance out of production hours. • Production control simple. • Production Planning complex. • Low production time.

Fig. 3.5 depicts the break-even analysis showing economic advantages of various types of layouts for same product at different output levels.

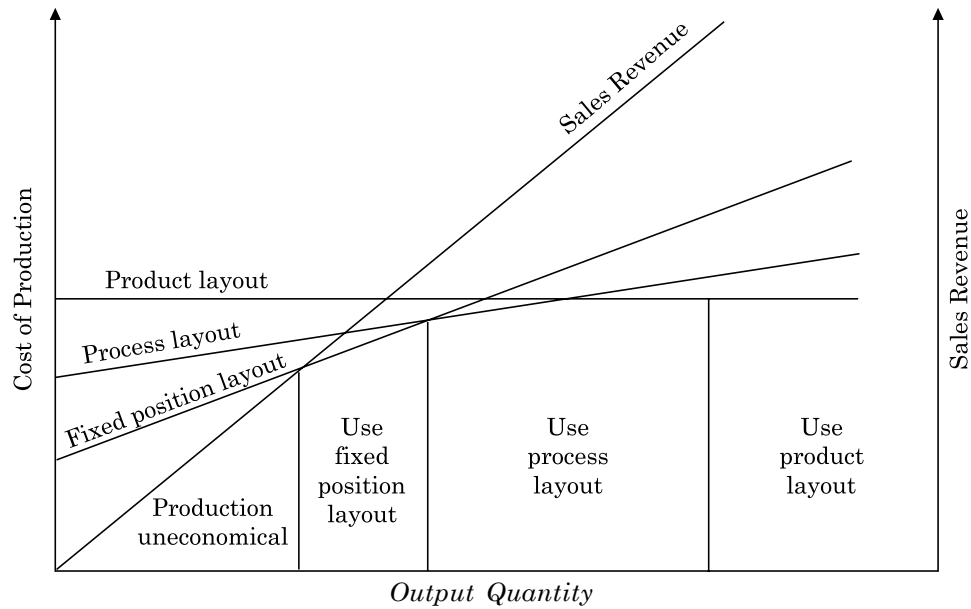


Fig. 3.5

3.8 PROCESS AND PRODUCT LAYOUT

Table 3.2 shows the summary of characteristics for fixed position, process and product layout.

Table 3.2 Summary of Characteristics for Fixed Position, Process and Product Layout

<i>Characteristic</i>	<i>Fixed Position Layout</i>	<i>Process Layout</i>	<i>Product Layout</i>
Product or service design production flow path	One of kind. Unit worked on remains stationary and resources flow to it as needed.	Unlimited in numbers and variable over time. Different orders follow different paths to comply with variable processing requirements.	Limited in number stable over time. Successive units follow same path with same sequence of required operations.
Human skills	Skilled personnel with well defined task assignment.	Skilled employees assigned jobs with considerable work content, responsible for work pace and result.	Semiskilled work force suitable for repetitive routine tasks; limited work content and some what uncontrolled work pace.

Contd...

<i>Characteristic</i>	<i>Fixed Position Layout</i>	<i>Process Layout</i>	<i>Product Layout</i>
Equipment	Mostly general purpose equipment needed to allow versatile employment.	General purpose machines for variety of similar operations restricted to low output rates.	Special purpose machines restricted to few specialized operations suited for high output rates.
Material handling	General purpose equipment needed to allow versatile employment job site requirements.	Variable material handling Loads and paths with need for more (carts, fork lifts trucks, etc.).	Fixed material handling Loads and paths with considerable mechanization (conveyors, chutes, etc.)
Resource utilization	Limited, due to the tight requirements for scheduling and coordination.	High due to equipment versatility and relative independence of work centers.	Limited due to need for duplication and vulnerability to breakdown for several components.
Inventory requirements	Low materials and supplies ordered as needed to meet schedule requirements.	Considerable, due to the Low turnover of materials and semifinished components.	Limited due to high turn-over of raw materials and work in process.
Cost relationships	Low fixed and high variable costs, due to specialized skills and materials needed.	Low to medium fixed costs and high variable costs due to specialized skills, high inventories and slow through put rates.	High fixed costs and low variable costs due to special purpose production and material handling equipments.

3. QUESTIONS

1. What do you understand by plant layout?
2. Identify the objectives of plant layout.
3. What are the advantages of good plant layout?
4. State the six basic principles of plant layout.
5. Describe briefly the steps involved in plant layout procedure.
6. Describe the various types of plant layout.
7. Distinguish between product and process layouts, their relative advantages, limitations and applications.
8. Identify the plant layout in which tools and resources move to the job and other in which the job moves from one station to another. In which case the cost of production will increase more steeply with output? Which will require general purpose equipment for machining and handling?