

MCE 527- MANUFACTURING TECHNOLOGY

MANUFACTURING PROCESSES AND PLANT LAYOUT

INTRODUCTION

Manufacturing is the backbone of any industrialized nation. It is important to know the various manufacturing processes, materials being processed, tools and equipment for manufacturing different components or products with optimal process plan using proper precautions and specified safety rules to avoid accidents. The basic requirements of workshop activities in terms of man, machine, material, methods, money and other infrastructure facilities needed to be positioned properly for optimal shop layouts or plant layout and other support services effectively adjusted or located in the industry or plant within a well planned manufacturing organization.

The complete understanding of basic manufacturing processes and workshop technology is highly difficult for anyone to claim expertise over it. The study deals with several aspects of workshops practices also for imparting the basic working knowledge of the different engineering materials, tools, equipment, manufacturing processes etc. It also describes and demonstrates the use of different hand tools (measuring, marking, holding and supporting tools, cutting etc), equipment, machinery and various method of manufacturing that facilitate shaping or forming the different raw materials into suitable usable forms.

WHAT IS MANUFACTURING?

Manufacturing is derived from the Latin word “manufactus”, means “made by hand”. It involves making products from raw material by using various processes, by making use of hand tools, machinery or even computers. It is therefore a study of the processes required to make parts and to assemble them in machines. The study of manufacturing reveals those parameters which can be most efficiently being influenced to increase production and raise its accuracy.

WHAT IS PRODUCTION PROCESS?

It is the process followed in plant for converting semi-finished products or raw materials into finished products. The art of converting raw materials into finished goods with application of different types of tools, equipment, machine tools, manufacturing set ups and manufacturing processes, is known as production process. In general, there are three basic types of production system which are:

1. Job production
2. Batch production
3. Mass production

Hence, manufacturing process is that part of the production process which is directly concerned with the change of form or dimensions of the part being produced. It does not include the transportation, handling or storage of parts, as they are not directly concerned with the changes into the form or dimensions of the part produced.

CLASSIFICATIONS OF MANUFACTURING PROCESSES

1. **Primary shaping processes:** involve the manufacturing of a product from an amorphous material. Some of the important primary shaping processes is: Casting, Powder metallurgy, Plastic technology, Gas cutting, Bending and Forging.
2. **Secondary or machining processes:** Some of the common secondary or machining processes are- Turning, Threading, Knurling, Milling, Drilling, Boring, Planning, Shaping, Slotting, Sawing, Broaching, Hobbing, Grinding, Gear cutting, Thread cutting etc
3. **Metal forming processes:** They are classified into hot working processes such as Forging, Rolling, Hot spinning, Extrusion, Hot drawing and cold working processes such as cold forging, cold rolling, cold heading, cold drawing, wire drawing, sheet metal working processes such as piercing, punching, notching, coining, squeezing, bending etc.
4. **Joining processes:** Some common and important joining processes are- welding, brazing, soldering, riveting, screwing, press fitting, sintering, adhesive bonding, shrink fitting, explosive welding, keys and cotters joints, coupling, nut and bolts joints.
5. **Surface finishing processes:** Some of the commonly used are: Honing, lapping, polishing, deburring, electroplating, painting, metal spraying, sand blasting, etc
6. **Processes effecting change in properties:** A few of such processes are: Annealing, normalizing, hardening, case hardening, flame hardening, tempering, age hardening etc.

PLANT LAYOUT

In manufacturing organization, a job to be manufactured spends most of the time in moving and waiting. For reduction of this moving and waiting time of jobs/parts, it is necessary to have proper layout and proper scheduling procedure. Plant layout specifies the position of the overall arrangement of the various facilities such as equipment, materials, manpower, materials handling, service facilities, and passage required to facilitate efficient operation of production system of the plant within the area of the site selected previously. Shop layout in manufacturing plant also forms an integral part of the factory planning or plant layout. Plant layout begins with the design of the position of the factory building and goes up to the location and movement of a work table of the machine. All manufacturing facilities such as equipment, raw materials, machinery, tools, fixtures, manpower, etc., are given proper place in each shop of the manufacturing plant. Plant layout of an industrial organization plays an important role in scientific management and is defined as:

“Plant layout is such a systematic and efficient functional arrangement of various departments, machines, tools, equipment and other support services of an industrial organization that will facilitate the smooth processing of the proposed or undertaken product in the most effective, most efficient and most economical manner in the minimum possible time.”

Plant layout of an industrial organization comprises of all the aspects connected with the industrial enterprise, viz., grounds, buildings, machinery, equipment, departments, methods of manufacturing, factory services, material handling, flow of production, working conditions, hygiene, labour and

shipment of goods, etc. it does not necessarily mean planning a new enterprise only. However, it also involves minor improvements in the existing layout, expansion of the existing plant, re-layout of the existing plant and layout of a new proposed plant.

NECESSITY OF PLANT LAYOUT

The necessity for planning a plant layout may arise due to the one of the following reasons:

1. Setting up a new plant
2. Change in the design of a product. This may result in change in the manufacturing operations or sequence of operations.
3. Expansion of existing department(s).
4. Relocation of existing department(s).
5. Addition of new department(s).
6. Addition of new product to the existing facilities.
7. Replacement of existing machines/equipment by modern and more efficient machines/equipment.
8. Improving the existing plant layout.

IMPORTANCE OF PLANT LAYOUT

1. It avoids congestion and underutilization of plant site.
2. It minimizes material/part handling and movement.
3. Minimizes work in progress inventory
4. Minimizes workers movements and hence worker fatigue.
5. Ensure convenience and safety of workers.
6. Improves quality of production.
7. Minimizes cost of production.
8. Ensure optimum utilization of plant facilities.
9. Ensures efficient control over the various production processes.
10. Smooth and continuous flow of production or manufacturing work with least possible bottlenecks and congestion points.

OBJECTIVES OF PLANT LAYOUT

1. It should provide overall satisfaction to all concerned.
2. It should reduce the part and material handling costs.
3. It should provide for workers convenience, and better working conditions.
4. It should promote job satisfaction.
5. It should promote safety.
6. It should provide high work in progress turnover.
7. It should reduce inventory.
8. It should assist supervision and reduce manufacturing time.
9. It should help in effective utilization of employees, machines and services.

10. It should utilize the plant site effectively, that is, no congestion and underutilization.
11. It should simplify control of production.
12. It should increase operator output and reduce fatigue.
13. It should reduce production delays and hence increasing productivity.
14. It should be flexible so that it is easier to expand and diversify.

MERITS OF A GOOD PLANT LAYOUT

The main advantages of a good plant layout involve effective and economical utilization of entire floor space of the plant, increased rate of production, reduced men and machine hours per unit of production, reduced material handling, minimal production delays, effective utilization of men, machinery, material and other factory support services, reduced overall production time, elimination of large amount of paper work, significant reduction in the indirect expenses, considerable reduction in inventory work for material, promote effective supervision, facilitate easy flow of men, tools and material, promote flexibility in arrangement to suit the future changes, promotes better planning and effective control, facilitates better and easier maintenance of plant and machinery, provides safer and healthier working conditions thereby improving the morale of the workmen, provides the material as well as psychological satisfaction to the workers and enhance overall efficiency of the plant.

TYPES OF PLANT LAYOUT

In fulfilling the objectives of a good layout as per yearly product requirement and product types, the layouts are classified into four major categories namely fixed or position layout, line or product layout, process or functional layout and combination or group layout. Each kind of layouts is explained with respective advantages, disadvantages and application as under.

1. Fixed or Position Layout

Fixed or position layout is also known as project layout. A typical fixed layout is shown in Fig.1.1. In this type of layout, the major part of an assembly or material remains at a fixed position. All its accessories, auxiliary material, machinery, equipment needed, tools required and the labor are brought to the fixed site to work. Thus, the product by virtue of its bulk or weight remains at one location. Therefore the location of the major assembly, semi assembly component and material is not disturbed till the product is ready for dispatch. This layout is suitable when one or a few pieces of an item are to be manufactured and material forming or treating operation requires only tools or simple machines. This layout is highly preferable when the cost of moving the major piece of material is high and the responsibility of product quality by one skilled workman or group of skilled workers is expected. This type of layout is mainly adopted for extremely large items manufactured in very small quantity such as ships, aeroplanes, boilers, reactors etc. The main advantage of this layout is the minimum movement of men, material, and tooling during manufacturing process. This layout is high flexible as the type of product and the related processes can be easily changed without any change in the layout. The advantage and disadvantage of this type of layout is discussed below:

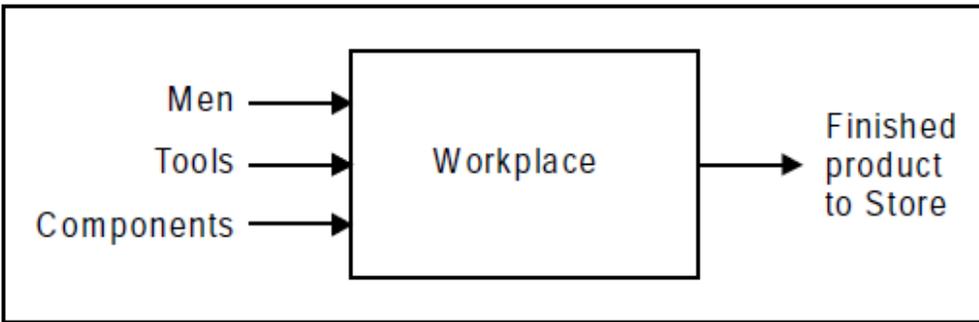


Fig. 1.1 Typical project layout

Advantages

Its main advantages are—

- Layout is highly flexible for varieties of products having intermittent demand as the type of product and the related processes can be easily altered without any change in the layout.
- There is a minimum movement of men, material, and tooling during manufacturing process.
- The material is drastically reduced.
- Highly skilled operators are required to complete the work at one point and responsibility for quality is fixed on one person or the assembly crew.
- Every personnel of manufacturing team is responsible for quality work for manufacturing the product.

Disadvantages

The major disadvantages of this layout are:

- The cost of equipment handling is very high.
- Labors and equipment are difficult to utilize fully.
- It is limited to large items only.

Applications

This type of layout is mostly adopted for extremely large items manufactured in very small quantity such as ships, aeroplanes, aircraft, locomotive, ship assembly shops, shipyards, boilers, reactors etc.

2. Process or Functional Layout

A typical process or functional layout is shown in Fig. 1.2. In this type of layout arrangements of similar machines, production facilities and manufacturing operations are grouped together according to their functions. Machine tools of one kind are positioned together so that all the similar operations are performed always at the same place e.g. all the lathes may be grouped together for all kinds of turning and threading operations, all drilling machines in one area for carrying out drilling work, all tapping machines in one area for carrying out tapping work, all milling machines in one area for carrying out milling work all buffing and polishing machines at one place for carrying out surface finishing work, and so on. This type of layout is normally preferred for the industries involved in job order type of production and manufacturing and/or maintenance activities of non- repetitive type. This layout needs not to have to be changed every time of the product or component changes. Also the breakdown of any machine does not affect the production. This type of layout is highly suitable for batch production.

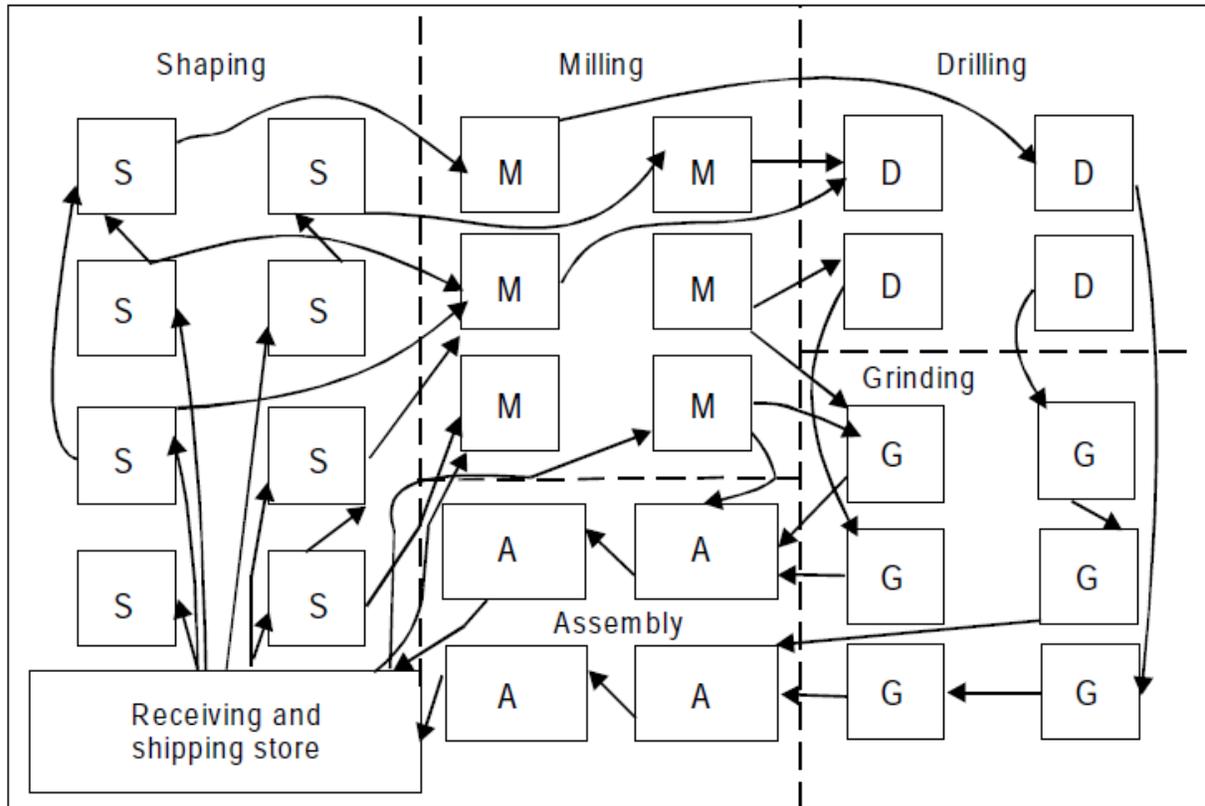


Fig. 1.2 Typical functional layout

Advantages

The major advantages of this layout are:

- There exists a wide flexibility regarding allotment of work to equipment and workers.
- There is a better utilization of the available equipment.
- Comparatively less numbers of machines are needed in this layout and hence thus reducing capital investment.
- There is an improved product quality, because the supervisors and workers attend to one type of machines and operations.
- Varieties of jobs coming as different job orders thus make the work more interesting for the workers.
- Workers in one section are not affected by the nature of the operations carried out in another section. For example, a lathe operator is not affected by the rays of the welding as the two sections are quite separate.

Disadvantages

The major disadvantages of this layout are:

- This layout requires more space in comparison to line or product layout for the same amount of production.
- Production control becomes relatively difficult in this layout.
- Raw material has to travel more which increases material handling and the associated costs.

- This layout requires more efficient co-ordination and inspections.
- Increased material handling cost due to more movement of process raw material to various paths
- More material in process remains in queue for further operations.
- Requires large in-process inventory.
- Completion of same product takes more time.

Application

1. This layout is used for batch or moderate production.
2. It specifies path for group technology.

3. Line or Product Layout: In this layout, the machines, equipment, and work centres are arranged in a straight line or curved line, in the order in which they have to be used, that is, according to the sequence of operations needed to manufacture a product. To justify the product layout, the product must be standardized and manufactured in large quantities. Hence, it is a system best suited for mass production and ensures smooth flow of materials and reduced materials handling. Breakdown of any machine in the line in this layout may result in even stoppage of production. For examples automobile assembly lines, bottling plants and so on. The raw material enters at one end of the line and moves from one machine to another in the line without back-tracking or cross-movements and finally the end product leaves from the other end of the line. It is normally applied in assembly work.

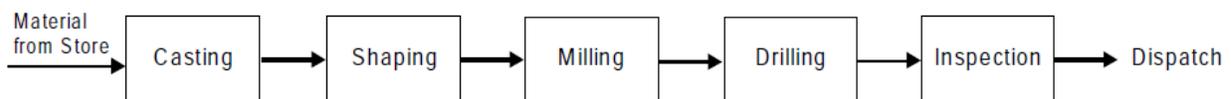


Fig. 1.3 Typical line layout

Advantages

Its main advantages are—

- It involves smooth and continuous work flow.
- It may require less skilled workers
- It helps in reducing inventory.
- Production time is reduced in this layout.
- Better coordination, simple production planning and control are achieved in this layout.
- For the same amount of production, less space requirements for this layout.
- Overall processing time of product is very less.
- This layout involves automatic material handling, lesser material movements and hence leads to minimum possible cost of manufacturing.

Disadvantages

The major disadvantages of this layout as compared with process layout are—

- It is very difficult to increase production beyond the capacities of the production lines.
- When single inspector has to look after many machines, inspection becomes difficult
- This layout is very less flexible for product change.
- The rate or pace rate of working depends upon the output rate of the slowest machine and hence leading to excessive idle time for other machines if the production line is not adequately balanced.
- Machines being put up along the line, more machines of each type have to be installed for keeping a few as stand by, because if on machine in the line fails, it may lead to shut down of the complete production line. That is why the line or product layout involves heavy capital investments.

Applications

It is used in assembly work.

4. Combination Layout

Fig. 1.4 shows a typical combination type of layout for manufacturing different sizes of crank shafts. It is also known as group layout. A combination of process and product layouts combines the advantages of both types of layouts. Most of the manufacturing sections are arranged in process layout with manufacturing lines occurring here and there scattered wherever the conditions permit. These days, the most of manufacturing industries have adopted this kind of layout. In this type of layout, a set of machinery or equipment is grouped together in a section, and so on, so that each set or group of machines or equipment is used to perform similar operations to produce a family of components. A combination layout is possible where an item is being made in different types and sizes.

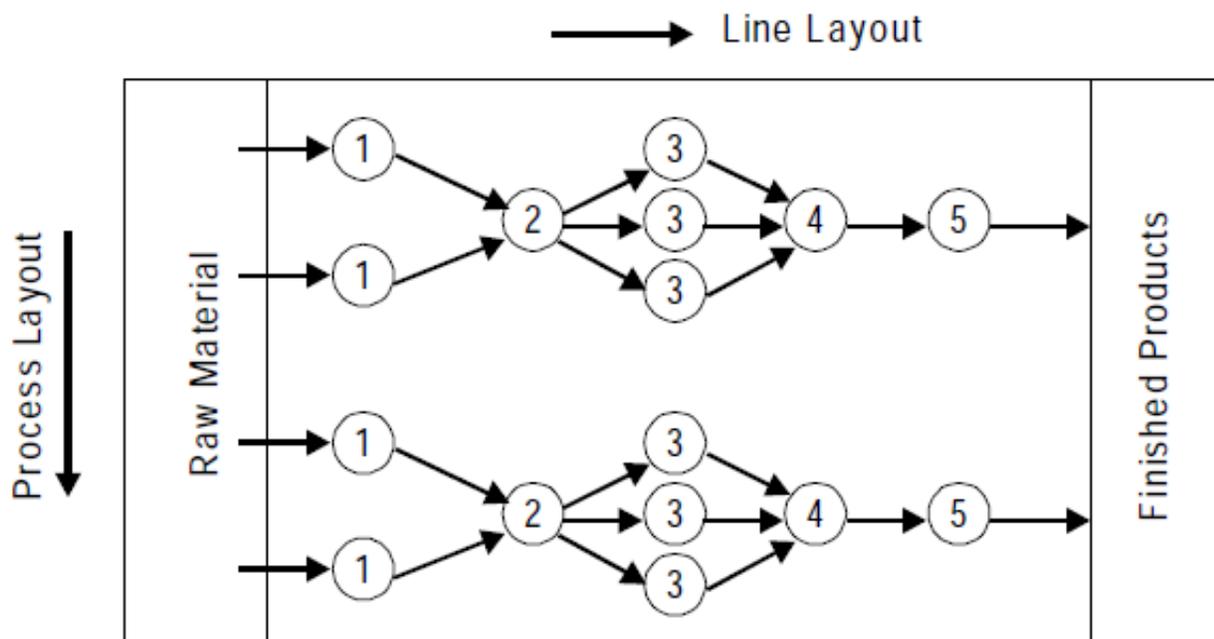


Fig. 1.4 Typical combination layout

In such cases, machinery and manufacturing equipment are arranged in a process layout but a group of number of similar machines is then arranged in a sequence to manufacture various types and sizes of products. In this layout, it is noted that, no matter the product varies in size and type, the sequence of operations remain same or similar. This layout is suitable when similar activities are performed together thereby avoiding wasteful time in changing from one unrelated activity to the next. It focuses on avoiding unnecessary duplication of an effort. It is preferable for storing and retrieving information changing related to recurring problems thereby reducing the search in understanding information and eliminating the need to solve the problem again. It is also useful when a number of items are produced in same sequence but none of the items are to be produced in bulk and thus no item justifies for an individual and independent production line. There are some advantages, disadvantages and application of this layout which are given as under:

Advantages

The advantages of this type of layout are:

- Reduction in cost of machine set-up time and material handling of metals.
- Elimination of excess work-in-process inventory which subsequently allows the reduction in lot size.
- Simplification of production planning functions, etc.

Disadvantages

The major disadvantages of this layout are:

- Change of the existing layout is time consuming and costly.
- Inclusion of new components in the existing component requires thorough analysis.
- Change of input component mix may likely to change complete layout structure.
- Change of batch size may change number of machines.

Application

Manufacturing circular metal saws, hacksaw, wooden saw, files and crank shaft.

COMPARISON OF LINE OR PRODUCT LAYOUT AND PROCESS OR FUNCTIONAL LAYOUT

S/N	Line or Product Layout	Process or Functional Layout
1.	In line or product layout, similar machines are arranged according to the sequence of operations required for manufacturing the product.	In process or functional layout, similar machines are arranged in one location for manufacturing the product.
2.	It leads to transfer lines.	It leads to group technology
3.	It is meant for mass production and extremely less job variety	It is meant for moderate production and more job variety
4.	Work flow is smooth in this layout	Work flow is not smooth in this layout
5.	Job movement is very less.	Job movement is comparatively more
6.	Full automation in material handling is	Automation in material handling is not

	possible in this layout	effective in this layout
7.	Machine utilization is poor in this layout	Machinery utilization is better in this layout.
8.	Capital investment required is more in this layout	Capital investment required is comparatively less in this layout
10.	Breakdown of one machine affects greatly in this layout	Breakdown of one machine does not affect so much in this layout
11.	Production planning and control is easy	Production planning and control is comparatively difficult
12.	Less skilled workers are required Comparatively	More skilled workers are required
13.	Space required for same amount of production is less	Space required for same amount of production is comparatively more
14.	Monotony in working is more because jobs are repetitive in nature in this layout	Monotony in working is less because jobs are non-repetitive in this layout
15.	It is used in mass production or assembly work	It is used in job order production or maintenance work of non-repetitive type

TYPES OF FLOW PATTERN

Flow pattern means the path followed by the work through the plant, starting from raw material up to finished product. As each plant layout is unique, there is no best way to layout of a flow pattern. However, the flow pattern should be such that it:

- i. Minimizes material handling
- ii. Minimizes back-tracking and cross movement of work.
- iii. Maximizes floor space utilization.
- iv. Results in most flexible layout.

There are six basic flow patterns:

1. **Straight line:** Most suited for product layout.
2. **L-Flow:** Similar to straight line but economizes on floor spaces.
3. **U-Shaped:** The raw materials enter and the finished products leave the plant at the same end. This pattern results in better space utilization and easier inspection.
4. **S-Flow:** Still better space utilization and simpler inspection. However the material enters the plant at one end and the finished products leave the plant from the other end. It is normally used when production line is very long.
5. **Circular or O-Flow:** Easier supervision and minimum back-tracking of work. This flow is suited where the operations are carried out on rotary tables or where the starting point and the finishing point are the same, for example, mechanized foundry.
6. **Convolutd:** This pattern has the same characteristics as the S-Flow pattern.

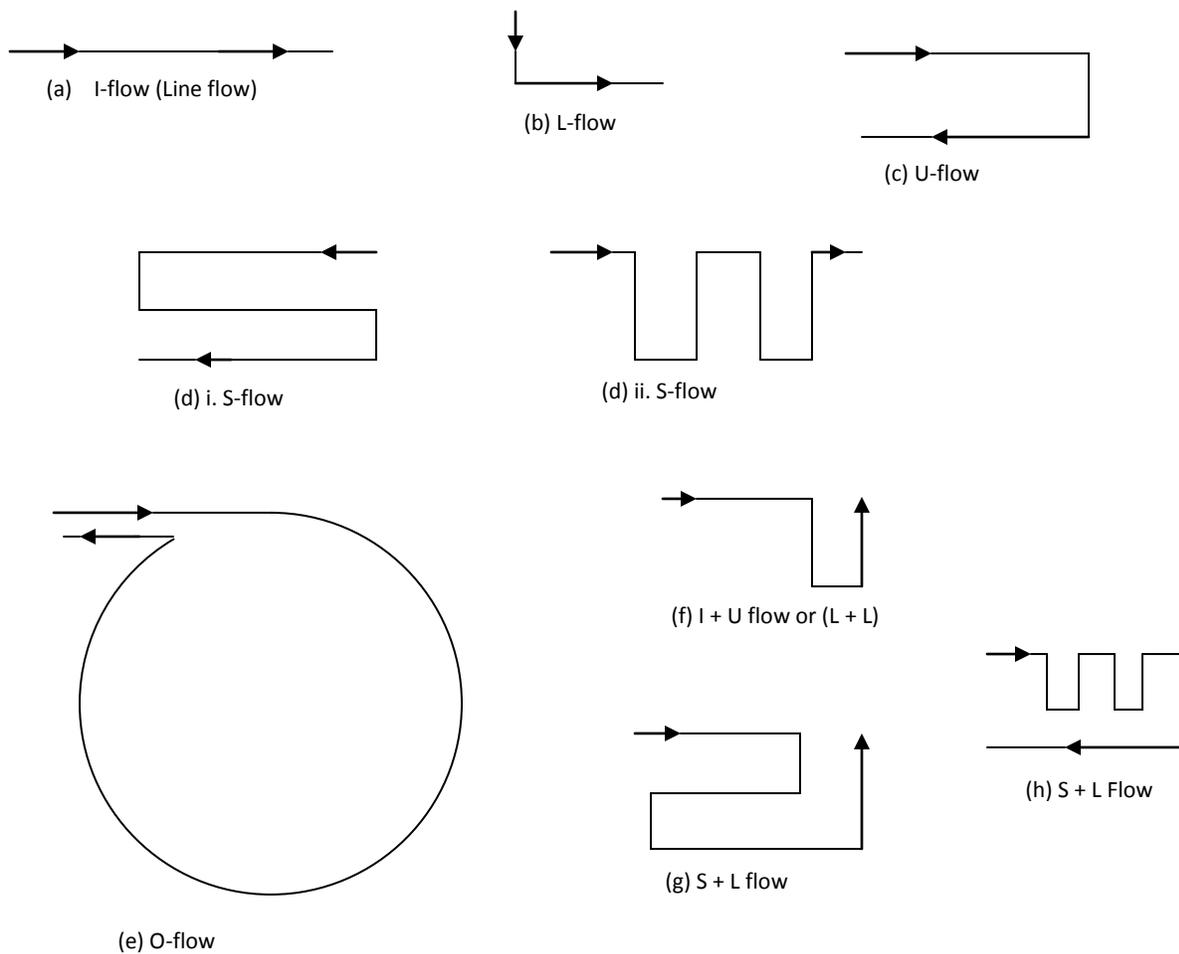


Figure: Basic Horizontal flow pattern

PRINCIPLES OF PLANT LAYOUT

1. Principle of minimum distance or movement
2. Principle of flow
3. Principle of cubic space
4. Principle of satisfaction and safety
5. Principle of flexibility
6. Principle of overall integration
7. Principle of minimum investment

STEPS IN PLANT LAYOUT PLANNING

Guiding fundamentals:

1. Plan the whole and then the details.
2. Plan the ideal and then the practical
3. Follow the cycle of layout development and overlap the phases.

4. Plan the process and machinery around the material requirement.
5. Plan the layout around the process and the machinery/equipment.
6. Plan the building around the layout.
7. Plan with the aid of clear visualization.
8. Plan with the help of others
9. Check the layout.
10. Sell the layout.

REVIEW QUESTIONS

1. What is manufacturing?
2. What is production process?
3. What is manufacturing processes?
4. How do you classify the manufacturing processes?
5. Define plant layout
6. What is the necessity of plant layout?
7. Enumerate the objectives of plant layout
8. Discuss the importance of plant layout planning
9. Discuss the four types of plant layouts and state their advantages and disadvantages
10. Discuss the principles of plant layout
11. What is flow pattern? Discuss the flow pattern used in plant layouts.