CC: 11 UNIT 2 – FOOD ENGINEERING.

DESIGN OF FOOD PLANTS

Plant design is very important in a food processing industry. Productivity or production of processed food at least cost in an industry depends on the plant layout. Several types of plant layout can be made while establishing a food industry and the type of layout depends on the food materials to processed. Let us see the detailed consideration in establishment of a food processing industry.

The following aspects will be described in detail:

I. Definition.
II. Introduction.
III. Considerations for Site location.
IV. What is plant lay out.
V. Objectives of Plant layout.
VI. Classifications of layout.

I. Definition:

Plant layout is defined as physical arrangement of men, materials and machines to achieve the proposed productivity.

in the words of Mallick and Manddeau, “Plant layout is a Flour plan for determining and arranging the designed machinery and equipment of a plant, whether established or contemplated, in the best place , to permit the quickest flow of material, at the lowest cost and with minimal handling in processing the product, from the receipt of raw material to the shipment of finished product”

II. Introduction:

Food processing is an emerging area which adds to the economic growth of the country. Most of the food produced in the country is consumed fresh and a small quantity of the food material is processed. Processed food not only adds value to the produce, but also increase the shelf life of the product thereby helping the farmer

with reduced uncertainty. The fundamental intent of food processing is of three fold; a) to provide a safe and hygienic food to the consumer, b) to increase the shelf life of the food material by adopting scientific method of processing, c) to help the farmer with better returns for the produce. In order to deal with the above requirements, it is essential to interface food processing with a food engineer. Food engineer has a great deal of challenge to integrate the food (biological) materials with that of the food processing machinery with varied degree of uncertainty (processing and control variables) both of food materials and the processing machinery. A few decades back, the design of food processing plant was more empirical and with little scientific information. International labour organization (ILO) had brought out clear guide lines for establishment of factory. The Government of India formulated the factory act in the year 1948 and the act clearly states the requirement of different aspects involved from construction, plant layout, safety of men and machinery, operation and maintenance of the factory.

With increased market/consumer awareness in terms of food safety, hygiene, and presentation of food, the manufacturer has a great deal of responsibility to meet the demands of the market. Information such as the nutritional facts, national standards, date of manufacture, date of expiry, bar coding of internal details have become mandatory for the manufacturers to print on the packaged food. A few manufacturers have indicated even the manufacturing/plant details such as HACCP (Hazard Analysis and critical control points) compliant, NABL (National Accreditation Board for testing and calibration of Laboratories) accredited laboratory, technology from a research institute and so on. These are essential to enhance the consumer confidence to accept these packaged foods available in the market.

III. Considerations for Site location:

Food processing engineer has the responsibility of selection and execution of the food processing plant and identification of the location for establishment is very important. The location of the plant is based on several factors, which include;

1. Soil condition of the proposed plant (whether the location is earth quake prone).

2. Raw material/materials availability for the rated capacity of the plant and also the plan for disposal of the by products from the plant.
3. Availability of utilities such as electricity, water, fuel etc.
4. Flexibility of the proposed plant to adapt to different raw materials.
5. Availability of the technically skilled labour for the operation and maintenance of the plant and machinery.
6. Methods for the waste disposal and treatment of effluents.
7. Logistics for the transportation of the raw materials and finished products from and to, To the market place.
8. Government policies prevailing in the area.

Let us study the above points in detail:

1. Soil condition of the proposed plant: A detailed data must be obtained from the concerned department (meteorological department) to understand the nature of the soil. The data will indicate whether, the region is prone for earth quakes or land slides etc. In case the topography of the land is such that, a gradient available in the site, it can be used for the benefit of material handling. Most of the food processing plants involves huge amount of water for cleaning (material and machine) during different unit operations and the gradient will help in free flow from location to location and finally to the waste treatment plant.

2. Availability of raw materials: Food processing activity is usually season dependent and raw materials are harvested in a particular period. The processing activity has to be carefully timed to meet the availability and normally the availability of the raw materials would range from 3 ~ 5 months in a year. The selection of the plant machinery must be flexible to handle the wide variety of raw materials. For example, orange processing equipments can be used for processing pineapple or for bottling of water in off season. Flexible layout of plant and machinery will make the venture to be economically viable.

3. Utilities: Utilities such as water, electricity, fuels and waste treatment plant are the most important, as they are the back bone of any industry. Food engineer must plan for the required quantity of above utilities based on the proposed capacity of the food processing plant. Since the biological materials are being processed in food processing, great care is needed for disposal of solid and liquid waste. (to be dumped at a distance so as to avoid cross contamination).

4. **Flexibility of the proposed plant:** Food processing is aimed at value addition to the agri materials and is seasonal in nature. The selection of the machinery must be able to handle a wide variety of raw materials during the year. Say for example processing line of orange and pineapple are similar (with slight change in order of process line and few machinery) and utilization of the plant and machinery can be extended/adapted.

5. Availability of technically skilled labour for operation and maintenance: The success of any industry would depend on technically skilled labour. Food processing operations are too sensitive and time dependent. Operation and maintenance of food processing plant and machinery are important for continual operation of a food processing plant and technically trained labour play an important role.

6. Methods for treatment of effluents and waste disposal: Waste disposal is an important activity in a food processing plant. In view of the increased concern about environment, awareness of disposal of industrial solid, liquid and gaseous wastes is important. It is mandatory to obtain the clearance from the pollution control board for starting the food processing industry and also to subject the industry for audit by pollution control board.

7. Logistics for transportation of raw materials and finished products from and to, to the market place: Availability of raw materials is key for the success of the food processing industry and also the distance through which the raw materials are to be transported. With the increasing cost of fuel, cost of

transportation of raw materials, finished goods, waste disposal add significantly add to the final cost of the product. Encouraging the nearby farmers to grow the raw materials required for the industry is desirable and mutually beneficial.

8. **Government policies prevailing in the area: F**ood processing industry has taken importance at the national level. A separate ministry has been established to show the importance of the sector. Encouragement for establishment of startups in food processing sector has taken a lead. Several concessions has been given by the state and central governments, such as tax holidays, concessional land, subsidies on plant and machinery, guidance for patent filing, are a few to mention.

IV. What is plant lay out:

Plant layout is an important pre-requisite for efficient operations of a food processing plant. It is defined as physical arrangement of men, materials and machines to achieve the proposed productivity.

in the words of Mallick and Manddeau, “Plant layout is a Flour plan for determining and arranging the designed machinery and equipment of a plant, whether established or contemplated, in the best place , to permit the quickest flow of material, at the lowest cost and with minimal handling in processing the product, from the receipt of raw material to the shipment of finished product”

V. Objectives of plant layout.

The main object of the plant lay out is to increase productivity; namely to produce the maximum at the lowest cost. It can be achieved through proper planning and execution. Properly planned plant layout aims at achieving the following objectives

1. Streamline the flow of materials through the plant.
2. Facilitate the manufacturing process.
3. Maintain high turnover of in-process inventory.
4. Minimize materials handling and cost escalation.

5. Effective utilization of men, equipment and space.
6. To make effective utilization of cubic space.
7. Flexibility of manufacturing operations and arrangements.
8. To have minimum materials handling.
9. Convenience and safety of workers in and around work place.
10. To reduced work in progress materials.
11. Reduce bottlenecks in movement of materials.
12. Minimize the possibilities of accidents.
13. Minimize investment in equipments.
14. To minimize overall production time.
15. Plan for future expansions.
16. To facilitate the organizational structure.

The objective of the plant layout has been explained by Shubin and Madeheim as; “Its objective is to combine labour with the physical properties of a plant (machinery, plant services, and handling equipments) in such a manner that the greatest output of high quality goods and services, manufactured at the lowest unit cost of production and distribution, will result”.

VI. Classifications of layout.

Plant layout can be classified into the following four categories.

A. Process layout.
B. Product layout.
C. Combination layout.
D. Fixed position layout.

A. Process layout: it is defined as the one where in the material is moved from one machine/equipment to the other. The arrangement of the machine/equipment are not in order and are placed on availability of space and is as shown in figure - 1. Based on the nature of unit operations, the materials shifts from equipment to equipment.

Following are the advantages and disadvantages of the process layout:

Advantages:

I. The processing quantity of the materials can be controlled as required.
II. The overhead costs are low.
III. Since the operations are specific, the material movement is known.
IV. Food materials of similar nature and properties can be handled easily.
V. Changes in output and production volumes can be altered.
VI. Supervision is more effective and specialized.
VII. Breakdown of one or more machine does not affect the production.
VIII. There is flexibility for expansion of plant.

Disadvantages:

I. In process layout, material handling involved is more.
II. No orderly movement of materials.
III. Need technically qualified labour for operation of the equipment.
IV. Needs special skill of the operator.
V. Handle limited quantities of materials.
VI. Operation is not continuous.
VII. Productivity is low.

B. **Product layout:** It is defined as the one where in the material is moved from one machine/equipment to the other sequentially. Dedicated plants are established (wherein the machine/equipment are arranged systematically) for processing a particular product. Based on the nature of physical operations, the machines are arranged sequentially and food materials automatically move from equipment to equipment and is as shown in figure - 2. Movement of food material is purely automatic and through material handling equipments such as conveyors, cranes etc.

Following are the advantages and disadvantages of the product layout:

Advantages:

I. Processing quantity of the plant is fixed based on the capacity.
II. The overhead costs are high as the plant is for continuous operation.
III. Material movement is by automatic material handling equipments.
IV. Capacity of the plant is fixed.
V. Machineries are specific and the operation of the plant is automatic.
VI. Plant and machinery are fixed and flexibility is not possible.

Disadvantages:

I. In product layout, material handling equipments are essential.
II. Orderly movement of materials is a must.
III. Need less technically qualified labour for operation of the equipments.
IV. Special skill of the operator is not essential.
V. Handle predetermined quantities of materials.
VI. Since operation is continuous, large amount of materials is needed for processing.
VII. Not suitable for a multiple products in large volumes.

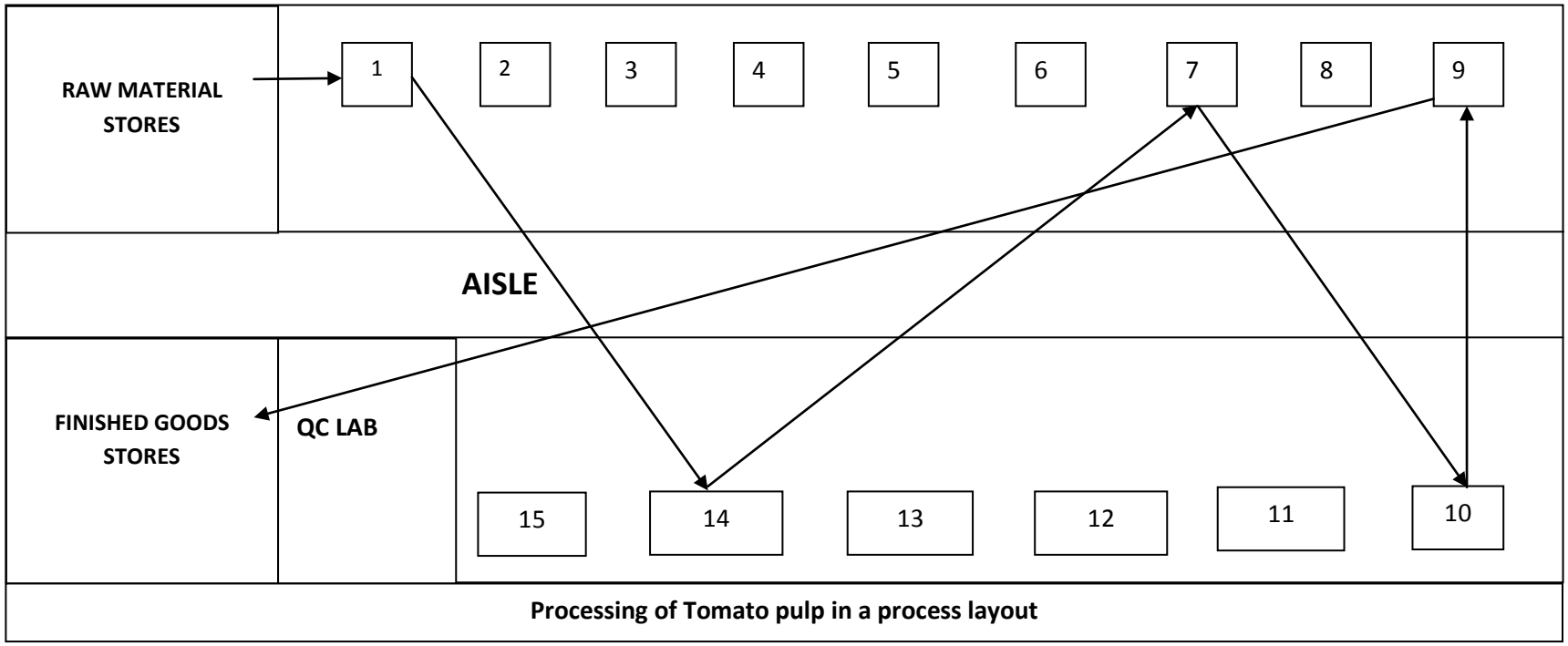
C. Combination layout: is the one where in the product mix in a processing plant are varied and the plant layout has a combination of process and product layout and is as shown in Figure - 3. For example manufacture of different sizes of gears.

D. Fixed layout: is the one where in the men, materials, equipments are moved to the site of fabrication and is as shown in Figure -4. For example manufacture of ship in a ship yard.

7. Summary:

The main aim of the industry is to produce large volumes of processed food materials hygienically at very competitive price. In order to achieve this, several factors such as availability of the raw materials at low cost, utility (such as water, electricity, fuel etc), skilled labor, logistics, plant layout contribute to the productivity (production at low cost). With the increased awareness of environment, pollution of air, water and solid waste disposal has gained importance. The trend of the modern industry is to have an integrated approach so that the industry would give out zero waste (solid, liquid and gaseous wastes). Selection of the location of the food industry plays a very important role. Location must take into consideration of nearness of availability of raw materials, skilled labor, market for the sale of the finished goods, utility etc. Plant layout for a food industry will either be a product or a process layout.

Figure – 1, showing a process layout for food processing.



Legend:

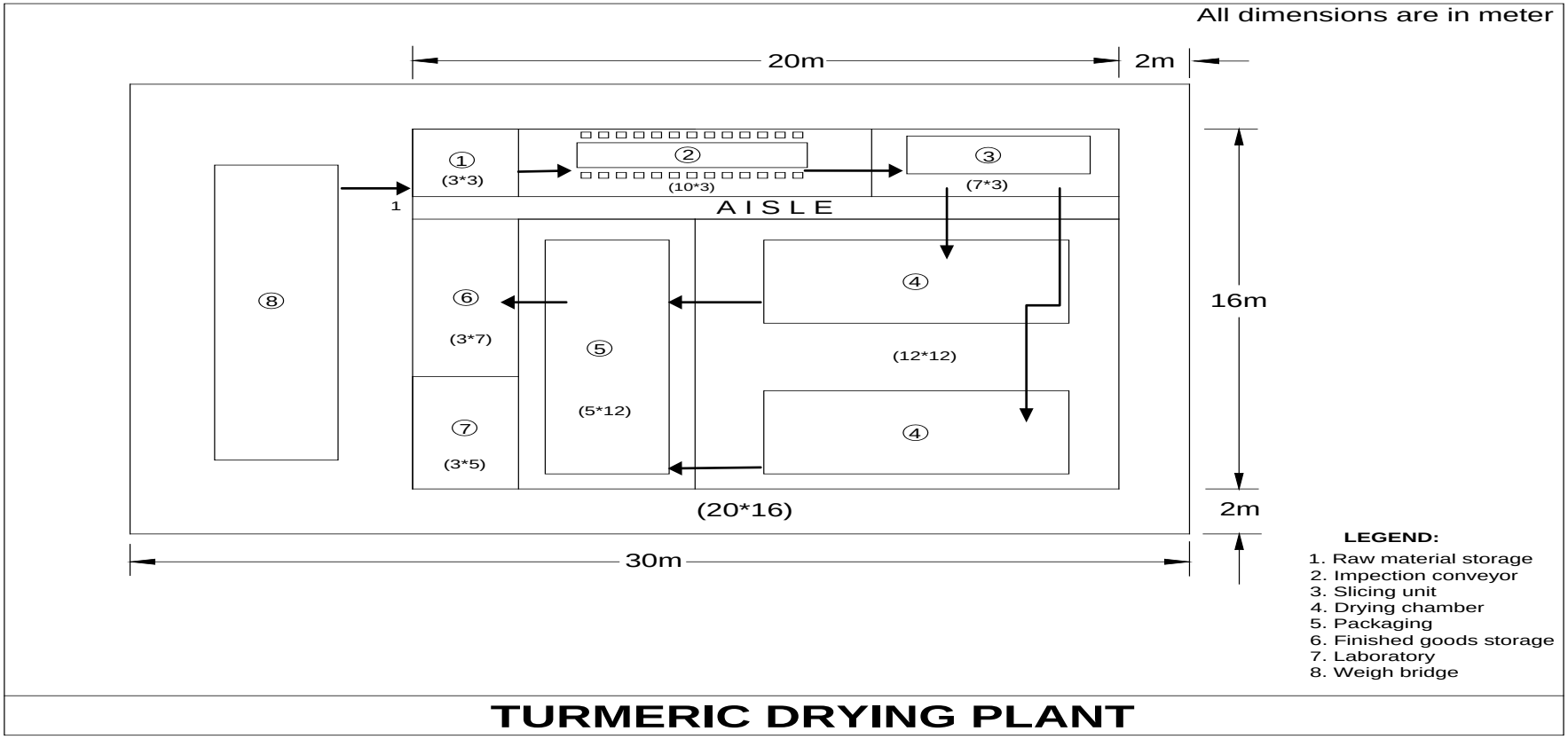
→ MATERIAL MOVEMENT

1 – 15 PROCESSING EQUIPMENTS

In the above process layout diagram, it can be seen that the food material moves from raw material stores to equipment number 1 and to equipment 14 to equipment 7 and to 10 further to equipment 9 and then to the finished goods stores.

Figure - 1

Figure – 2, showing a product layout for food processing.



Legend:

→ MATERIAL MOVEMENT

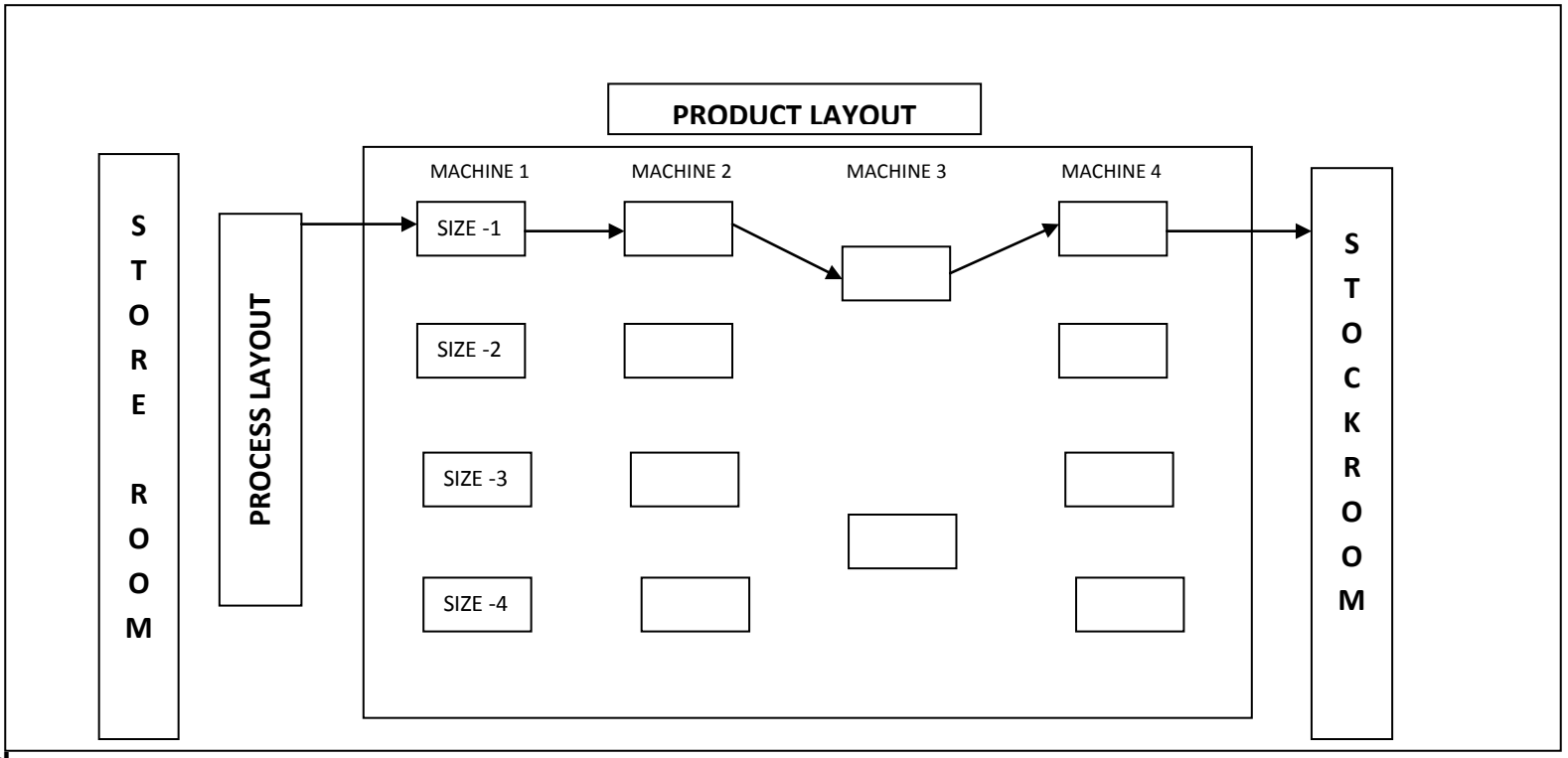
1 – 5 PROCESSING EQUIPMENTS

The material movement is from equipment 1 to 6 in a sequential pattern.

Figure - 2

3. Combination layout: is the one where in the product mix in a processing plant are varied and the plant layout has a combination of process and product layout. For example manufacture of different sizes of gears.

Figure – 3, showing a combination layout



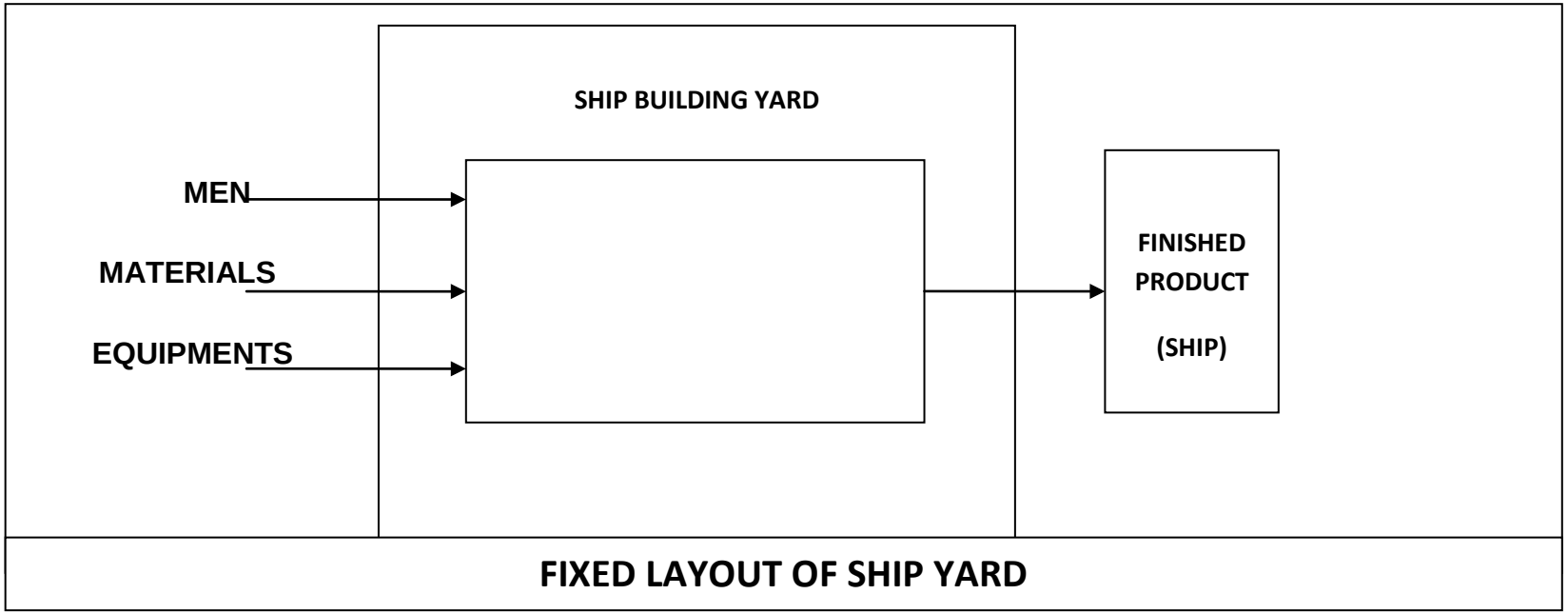
Legend:

→ MATERIAL MOVEMENT

Figure - 3

4. Fixed layout: is the one where in the men, materials, equipments are moved to the site of fabrication. For example manufacture of ship in a ship yard.

Figure – 4, showing a fixed layout



Legend:

→ MOVEMENT

Figure – 4