UNIT 13 SITE SELECTION AND LAYOUT

Structure

13.0 OBJECTIVES

After studying this unit, you should be able to:

- understand the importance of proper plant layout for efficient and optimum working environment;
- describe the general guidelines for layout of a fruits and vegetables processing plant; and
- explain various steps that can be taken for maintenance of clean working environment and workers' safety in a fruit and vegetable processing plant.

13.1 INTRODUCTION

In this unit we shall study about the various aspects of plant layout, which is nothing but the arrangement of different facilities and equipment in a plant. It begins with the importance of proper plant layout followed with the general principles of a plant layout. We will also discuss how a proper plant layout helps in saving of manpower and energy, and maintaining efficient and optimum working environment. And as you know, all of these parameters lead to the maximisation of profits.

This unit also covers different considerations for maintenance of clean working environment and safety of workers, which are very important for the survival of any industry. You will be able to comprehend that the working environment of the food processing plant and ultimate sustainability of the plant do not depend only on the plant operation management; rather a major part of it is

also dependent on the plant layout, design and installation of different equipment and the safety measures. You will also know about the guidelines for placement of different equipment and other facilities in a fruit and vegetable processing plant.

13.2 SITE SELECTION

Suppose you want to establish a mango processing industry in a particular area, what type of questions would immediately come to your mind?

The first set of questions you would ask yourself is:

- Is sufficient quantity of good quality raw material available in the locality, or what will be the transportation cost for bringing raw material from another locality to the proposed processing site?
- Whether the auxiliary facilities such as electricity, water, labour, etc. are available in the locality?
- Is there any other associated problem for establishment of industry in the particular place?

The answers to all these questions should be favourable. These are some of the factors, which affect the site selection for any type of manufacturing industry. In fact many such factors have an effect on the site selection for any industry. If we don't give a realistic consideration to all these factors, we may face problems in running the industry in future.

In general, a proper site for a fruits and vegetables processing plant should have the following features.

- Adequate quantities of good quality raw materials should available in the nearby locality, because fruits and vegetables are highly perishable and deteriorate in very long distance transport.
- The fruits and vegetables processing plant requires a huge amount of water for processing, cleaning and other operations. Hence the area should have a good source of quality water supply, or a permanent water source should be created for the purpose.
- The environment should be as far as possible clean and free from debris and dust. The site should be at a considerable distance from other industrial factories, which may affect adversely the quality of processed product by spreading smoke, disagreeable odours, etc.
- There should not be any problem for availability of electrical power in the area. A standby generator will help in maintaining operation during power failures.
- There should exist proper transport facilities for the movement of raw materials and finished products.
- There should be easy availability of labour in the area.
- There should also be facilities for disposal of the waste, as this is becoming a matter of growing concern these days.
- There should be scope for future orderly expansion of the factory.

After we have selected an area or region for locating the plant, the next job is to select a specific site. The final site selection requires a careful scrutiny of experts. We should shortlist some probable sites and test their soil condition. If the soil doesn't have good bearing capacity, there will be more investment on foundation costs. Good natural drainage is another desirable feature. If the site is located near a stream or other body of water, we should check the flood history. In addition, consultation with officials of the neighbouring plants on the various nature of locations in the area and attitude of the local community is also helpful for deciding a suitable location for the plant.

13.3 IMPORTANCE OF PROPER PLANT LAYOUT

13.3.1 What is Plant Layout?

We may consider any food processing operation as a transformation process. In a fruit and vegetable processing plant, the raw materials (raw fruits and vegetables) are transformed into finished product (processed fruits and vegetables) by a series of operations, whose sequence and numbers are specified for the input. For example, the sequence of operations that are carried out in an onion dehydration plant, can be shown as in Figure 13.1.

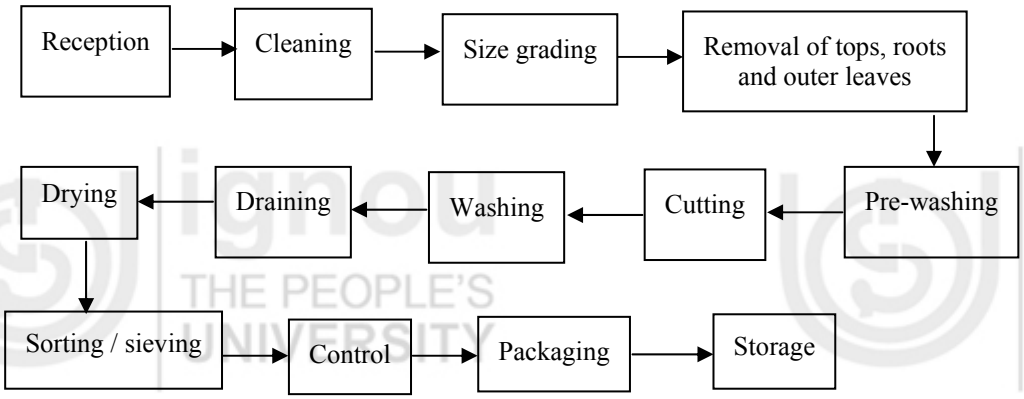

Figure 13.1: Processing of dehydrated onions

We can not change the sequence of these operations as per our desire. In this case, after receiving, the dust and dirt sticking to the surface of the onion bulbs must be cleaned first. Then the bulbs should be graded for size, then the tops and roots be removed, and so on. Therefore, for efficient utilisation of energy, labour (these are the other inputs than the raw materials), and of course money, the cleaning section should be kept adjacent to the receiving section followed by the grading section, and so on.

Now, suppose we place the size grader between the receiving yard and the cleaning section or the drying section between the packaging section and storage section, what do you think will happen? It will unnecessarily increase the materials handling cost and time, and reduce overall performance. In addition, it will also cause collision between the workers and wastage of manpower and energy. Hence, we should arrange the work areas, equipment and auxiliary facilities judiciously in the processing plant such that the operation will be economical and the employees will feel safe and satisfying.

Thus, the arrangement of the different facilities and equipment in a food processing plant plays an important role in the overall viability of the project. This physical arrangement of the industrial facilities is known as **plant layout**. The arrangement also includes the space needed for material movement, storage, indirect labour and all other supporting activities, or services, as well as for operating equipment and personnel.

13.3.2 Advantages of Good Plant Layout

In general, a good plant layout will permit simple and forward movement for the product and containers through the plant. Let us take a simple example.

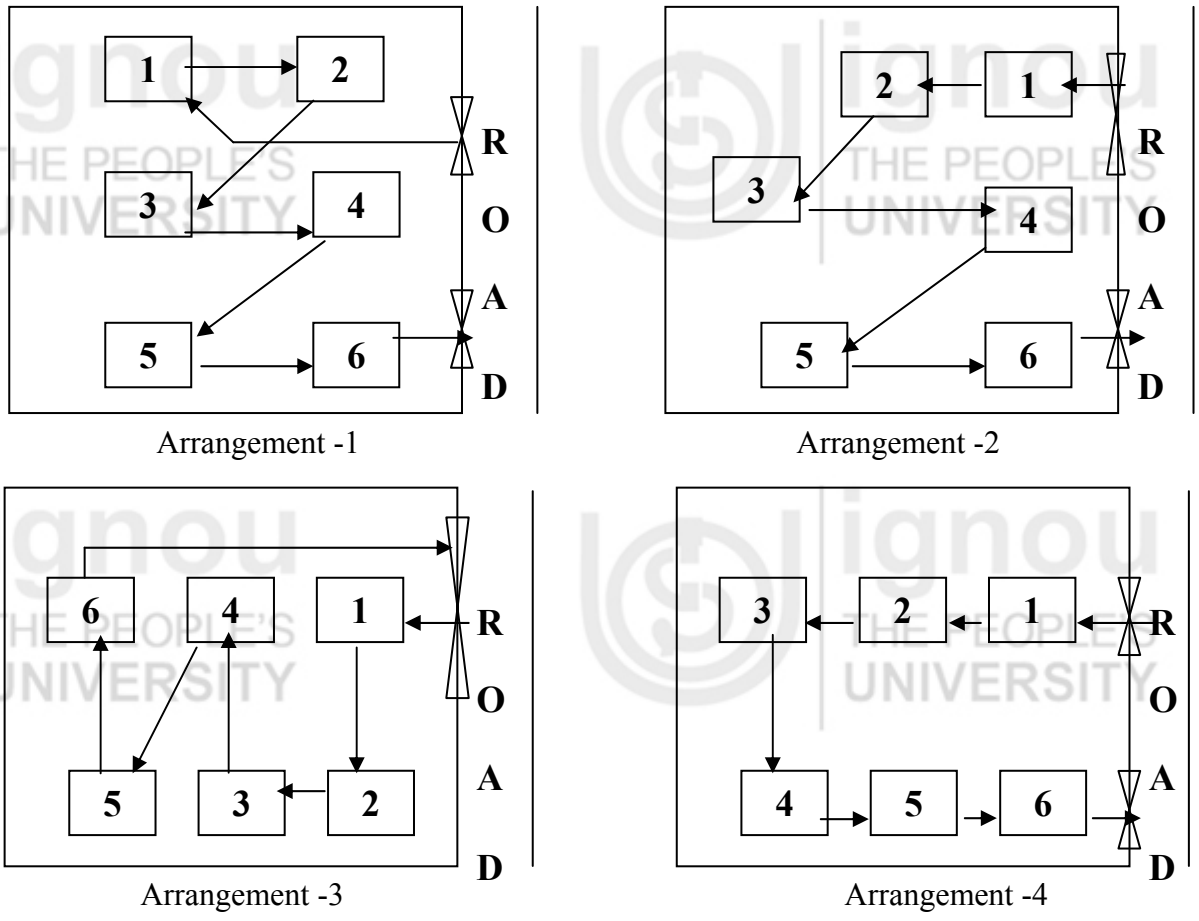

Figure 13.2: Understanding what plant layout means

In Figure 13.2, we have shown you some equipment in boxes, in which the numbers show the sequence of operations. Say, the first operation (may be cleaning) will be done by the Equipment-1, the second operation by Equipment 2 and so on. The Equipment 6 does the packing and then the product has to be taken out of the factory. I have shown you four possible arrangements for these equipment. Which pattern or arrangement do you think will be the best to reduce the cost of operation and improve performance?

Obviously Arrangement No. 4 will be the most ideal one. Remember, we are yet to learn the general guidelines for a good plant layout. However, you will definitely agree that if the machines are not properly arranged, as in the cases 1, 2 or 3, the total material movement inside the plant is unnecessarily

increased. Besides, there is also crossing of the flow paths, which would interrupt a smooth operation.

The sequence of operations is one of the major criteria, but not the only criteria for designing plant layout, which we will discuss later in the unit. But as we are discussing about the advantages of a good plant layout, we wee that a proper plant layout helps us in reducing cost of operation, which is very important for survival of any industry.

A good plant layout, in general, has the following advantages.

- Saving in floor space;
- Better utilisation of machine and man power, and services;
- Reduced material handling, thus saving in labour and cost, less production delays;
- Reduced inventory in process, thus saving in investment and working capital;
- Increased output/ production per unit time, labour, money and energy; and
- Easier and better supervision.

In addition to the above, a properly designed layout helps to maintain proper sanitation and safety standards in a plant. It reduces confusion between different sections of workers, and improves moral of the workers. All these factors directly affect the output. Careful layout planning can identify and remedy bottlenecks and trouble spots before the plant is built, and thus prevents troubles later.

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the major factors for selection of site for a fruits and vegetables processing plant?

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2. What are the main advantages of a good plant layout?

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13.4 GENERAL PLANT LAYOUT

In this section, we will discuss about the different requirements and general guidelines for a good plant layout. As we go on discussing the general

guidelines, you will discover that a careful planning is very essential for the health of any industry, and in particular the industries processing fruits and vegetables.

13.4.1 Requirements/Factors in Planning Layouts

As we have already discussed, the basic objectives of a good plant layout are smooth operation and reduced cost in handling and processing. Further good layout must include arrangement of specified areas for processing, storage and handling in efficient coordination. This should also consider the following factors.

- ***Proper placement of equipment and conveying machines –*** All the equipment and conveying machines should be arranged in proper coordination depending on the flow sequence and characteristics of equipment. Depending on requirements, the layout can be single level, multi storied, or combined designs.

- ***Economic distribution of services*** – The layout, in addition to proper placement of important equipment, should also have provision for efficient and economic distribution of water, process steam, power, and gas, etc. The distribution lines for these utilities should not interrupt the normal working of the people.

- ***Suitable use of floor and elevation space –*** This will depend on the type of food processing plant and the special facilities and equipment used for the system.

- ***New site development or addition to a previously developed site*** – If we want to plan the plant on a site, which already has some installed equipment, office rooms and storage godowns, etc., then the layout should consider these amenities. Our objectives will be to see that minimum alterations or modifications are made to the existing facilities without affecting the overall objective of the layout.

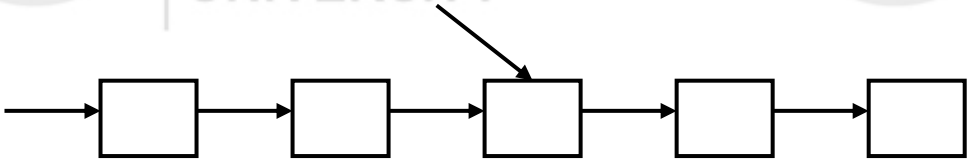
- ***Future expansion –*** The layout should have sufficient provision for future expansion. Suppose at this stage we are interested in a 1 tph (tonne per hour) dehydration plant for ginger. But after some years, we want to increase the capacity to 4 tph or want to prepare dehydrated onion and garlic from the same plant. It requires installation of some more equipment. We will also need more space for godown and processing operations. In that case, we will be in trouble if the present arrangement doesn't have sufficient provision for expansion. Another alternative is to install a completely new plant in another location. It will involve some unnecessary cost and further it will also be difficult to manage two plants at two different locations. To overcome such type of difficulties, the layout should have provision for future expansion.

- ***Waste disposal problems*** – The layout should have adequate provision for disposal of solid, liquid and gaseous wastes. Or else, the project may not be even passed by the pollution control authorities.

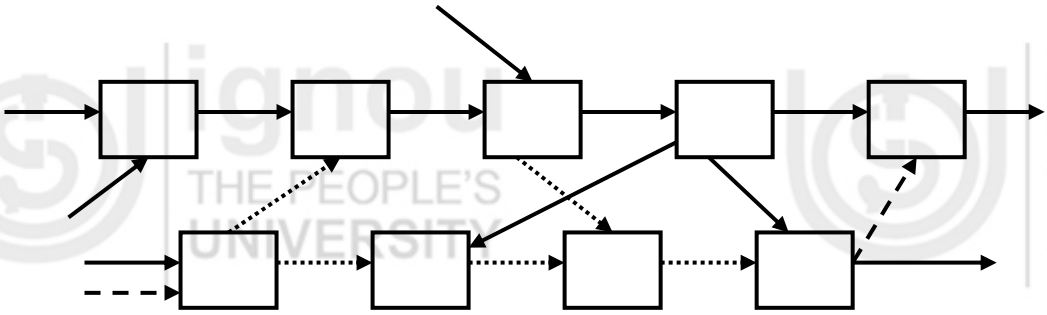
- ***Safety considerations*** **–** We should keep the equipment or areas having chances of hazards like fire or explosion away from normal working of the people. For example, we should isolate the boiler room.
- ***Other factors*** **–** The building code requirement, weather conditions like extreme high or low temperatures, maximum wind speed in the area, etc. are some other factors which need to be considered during planning the layout.

13.4.2 Types of Layouts

There are generally two types of product flow in food processing industry, namely, **line flow process** and **intermittent flow process.** In the line flow process, the product flows from one operation to the next in a prescribed sequence as in the preparation of homogenised and pasteurised milk in an automatic dairy plant. The individual work tasks are closely coupled. There may be side flows, which impinge on this line, but they are integrated to achieve a smooth flow. In an intermittent flow process the production is carried out in batches at intermittent intervals. In this case, we can organise the equipment and labour into different work centres by similar types of skill or equipment. The product can be sent to any of the work centres as per requirement. For example, in a mango processing plant, the mango slices can be sent to a dehydrator for preparing dried mango slices or sent to the canning section for getting canned mango slices, or may be filled with syrup and frozen to prepare frozen mango slices. Similarly mango pulp can be processed in different work centres to get frozen mango pulp, mango squash, mango nectar, mango bar, mango powder or mango cereal flakes. Or, say the particular squash manufacturing section can be used for different commodities like mango, pineapple, lime or watermelon at different times. This often results in a jumbled pattern of flow. The volume of product handling can be changed easily in this type of flow.



LINE FLOW- PRODUCT FORM OF LAYOUT



INTERMITTENT FLOW-PROCESS FORM OF LAYOUT

Figure 13.3: Product form and process form of layout

Based on the above classification of flow processes, the layouts also differ. The intermittent process is also known as a **process form of layout** as similar equipment and processing operations are grouped together. It is also known as

'layout by function'. The line flow is also called a **product form of layout** because various process equipment, and labour skills are put into sequence according to the way the product is made.

When a product lacks standardisation or the volume of product is low, the intermittent operation is economical and involves least risk. If an industry produces high volume of one or a few products, then layout by product or flow-line layout can be used. The equipment are placed in sequence, either on a straight line, or in shapes like U, L or convoluted or serpentine shape. As the raw material is processed, some products and by-products may move away from the principal direction of the flow.

Many modifications to above flow patterns are possible. A **hybrid layout** is one, where some portions may be layout by process and some portions by product. Generally the small food processing plants have process form of layout, whereas bigger industries have hybrid layouts.

Another type of classification of layout is single level, multi-storey or combined layout.

13.4.3 General Guidelines for Layout of a Fruit and Vegetable Processing Plant

After obtaining some idea on the factors affecting the layout planning and the different types of layout plans, in this section, we will give a closer look at different aspects of layout of a fruit and vegetable processing plant.

Layout of different sections / buildings

After a complete study of the requirements of the plant, the selection of the building or buildings must be considered. The building should be designed around the process, not a beautiful structure into which the process must fit.

Different products may each have their own processing room or area, or they may be housed in a single room with different allocated area. The primary rooms should be planned larger than necessary, for possible future expansions. We should keep in mind that the height is also equally important as the floor space requirement for layout planning.

The office room needs to be accessible to suppliers, customers and visitors. In large plants it can be kept at the main entrance as a separate building. The office accommodation should also contain a reception room and a demonstration room for study groups, etc. For small plants such offices are contained in the main building. The main laboratory can be conveniently put on an upper floor of the administrative building or next to the office room so that manager can easily control both administrative and technical services.

Reception and dispatch rooms should be situated on the ground floor having good access to main gate. The reception platform should be at a height to suit the vehicles concerned. In small plants loading and unloading, and conveying within the plant are done manually, In large plants, if mechanical conveyors or hydraulic conveyors are to be used, then the conveying section has to be planned simultaneously with the reception section.

Storage facilities for raw materials and intermediate and finished products may be located either in isolated areas or in adjoining areas. While considering for storage, the amount of handling involved for carrying the materials from reception to the storage section or from the storage to the processing section should be considered. However, sometimes storage of materials in adjoining areas to reduce materials handling may create problem for future expansion of the plant. Hazardous materials, if stored in large quantities, should be isolated.

Areas involving dust, dirt, oil and fumes, which may contaminate the products must be separated from processing or storage areas. The boiler room, fuel store, repair shop, compressor rooms are such types of areas.

The orientation of prevailing winds, the polluting potential of the air, topography of the site and access to roads must be considered when fixing the position of different rooms. Direct exposure of certain areas of the plant to the summer sun may be undesirable.

Layout of equipment

The information on exact space needed for installation of each equipment is very important for planning. The design and capacity of equipment will determine the floor space. Manufacturers normally give the dimensions of their equipment including floor space required. Besides, there should be adequate space for convenience in operation and maintenance, while still practising economy of floor space and good housekeeping in the plant. Allowances for working space should be five times the floor space occupied by the equipment. Floor area for dry store and office spaces should each be 25% of the plant floor area. The floor areas should also include space for possible additional equipment.

The equipment that need frequent servicing needs special care. There should be space for lowering the overhead equipment for maintenance. Besides, it is not wise to fit the equipment too closely in a building. A slightly larger building that appears unnecessary will cost little more than the one that is crowded, but this will help in maintenance of proper sanitation, safety and comfort of the operators.

We must consider the relative levels of several pieces of equipment and their accessories before placement. For gravity flow, the materials are first lifted to a higher level, and hence, a multi-storey layout is often necessary. The cost of mechanical transportation is greatly reduced in single storey plant.

In most of the cases, a group of operations are carried out simultaneously, for example, in a canning plant the can filling, exhausting, and can closing are such type of operations. So we can group the necessary equipment in proper sequence in a single room. It helps us in division of operating labour so that some specialised operators can be trained to attend all equipment of the group.

Suppose at any point of time we need to bypass a machine or a section, then the plant layout should be such that it allows that with minimum of alterations.

Layout of materials handling equipment

As we have discussed previously, considerations for materials handling should accompany the equipment and buildings layout. Suppose the materials are to be carried by crates on a chain conveyor from the receiving yard to storage, then the layout should have provision for that, in addition to working space for the labourers. Wherever possible, we should take advantage of the topography of the site location. The working surface of the conveyor must be at a height to facilitate the operations, which may be involved.

Lay out of service facilities

The important service facilities for any type of food processing plant are water, steam, power, electricity, gas and air. Proper placement of the distribution lines for the above services help in ease of operation, orderliness, and reduction in costs of maintenance. For example, we must not lay any pipe on the floor or up to a height of 7 ft level, where the operator is expected to move during the work. Chaotic arrangement of piping invites chaotic operation of the plant.

The service lines should be as short as possible to reduce capital investment and running costs. In small plants it is practicable to provide accommodation for steam production, refrigeration and electricity within the main building. In large plants, this is often not possible, and the service rooms are grouped in a separate building. The switch room may be as central as possible, to economise in wiring. In large plants more than one switch room may be necessary. The generator room should be adjacent to the switch room.

The boiler house must provide accommodation for the steam boilers and auxiliary equipment, such as feed water tank, feed water treatment plant etc. The type and capacity of the boilers greatly influence the space required. A working space of 1-2 m should be allowed between boilers and other equipment or wall of the building to give access for maintenance. The space in front of boiler must be much higher than this for cleaning of flue tubes and their replacement. The room or house for the boiler is usually separated from the main plant building in compliance with legal requirements.

The refrigeration machinery should be grouped in one room, but if separate compressor(s) are used for direct refrigeration, they must be placed close to the room, which they cool. Longer service lines need more cost of refrigerant required to charge the system, and thus higher will be the running costs.

Layout of waste disposal system

The disposal of wastes, which include liquors, fumes, dusts and gases, need special attention. The wastes should not affect the local community. If the wastes are not disposed properly, they will attract local dissatisfaction and prosecution by law, which will harm the unit in long run. The special equipment installed for ventilation, fume elimination, and drainage should not interfere with the flow of materials in process.

Other considerations

We should locate the windows / doors/ ventilators to allow maximum possible thermal circulation of air. Proper orientation of the buildings in respect to the solar position and prevailing wind direction is also important.

The local and national safety and fire code requirements are important factors while arranging the equipment and buildings in a plant. Different fire protection devices must be incorporated to protect costly plant investment and reduce insurance rates.

Existing or possible future rail roads and roads adjacent to the plant should be considered for placing the layout of building and auxiliary facilities. There should be proper access to all parts of the plant. Sufficient free space should be kept in the initial planning for future expansion.

13.4.4 Steps of Layout Planning

The steps involved in layout development are as follows:

First we have to decide the process and the type of layout design. The factors affecting process selection are capital, market conditions, labour, management, raw materials and viability of technology. As mentioned before, a complete understanding of the different unit operations involved in the process is essential. Layout has to be done for individual sections, and for individual equipment inside each section.

Then the preparation of the product flow charts is the next step in planning. The product flow chart shows 'how the product is processed', in addition to the transportation and storage activity. An example of a simple flow chart is shown in Figure 13.4 for manufacture of tomato sauce.

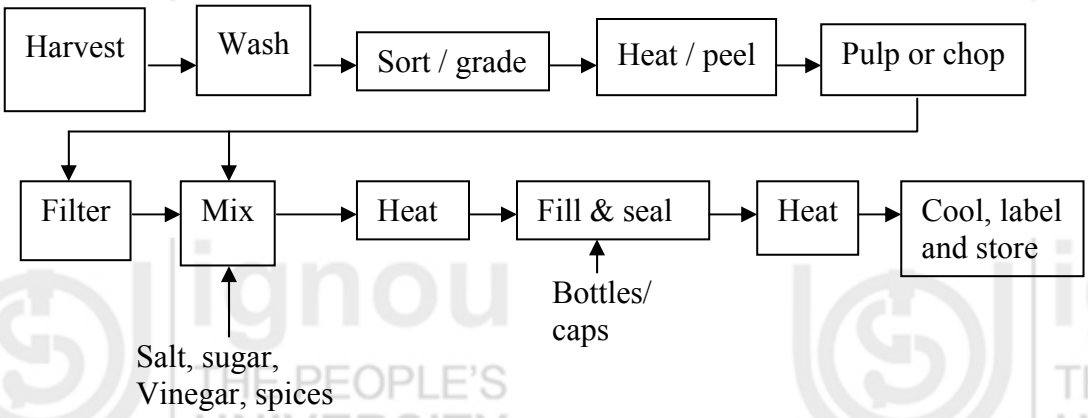


Figure 13.4: Product flow chart for tomato sauce

After preparing the product flow chart, we have to decide the principal equipment; the flow lines are then converted to machine lines. The designer must have a complete knowledge on the space requirements for individual pieces of equipment, for processing, storage of products and by-products, and for the working of people. At a later stage of process planning, the make or capacity of certain item may be changed when the particular details of the equipment become fully available, or we find better equipment during the planning process.

As the layout design develops it should be drawn on paper. After appropriate revisions, detailed drawings can be made to show the exact location of equipment and distances. Scale drawings are widely used in layout planning. We arrange the basic blocks or sections and arrange them in plot plans. Thus, the shape and extent of any area/section is described and the interrelationship between each area is shown. This is also known as 'Unit area concept' of planning.

Two dimensional scaled templates or small cutouts of unit areas and equipment within each area are placed on crosshatched scale paper. After repeated investigations and with different combinations/alterations, a basic plot plan is prepared with detailed two-dimensional diagrams, and is shown in a series of drawings.

Three dimensional scale models prepared from blocks of wood and cardboard give a better representation than the two-dimensional drawings. In bigger models, the piping and utilities can be shown. Now-a-days softwares are available for layout planning of process facilities using computers.

13.4.5 Example of Plant Layout

In Figure 13.5, we have shown you a typical example of fruit processing plant layout. Check how the raw materials receiving and storage and processed product storage are isolated from each other. See that the raw material enters

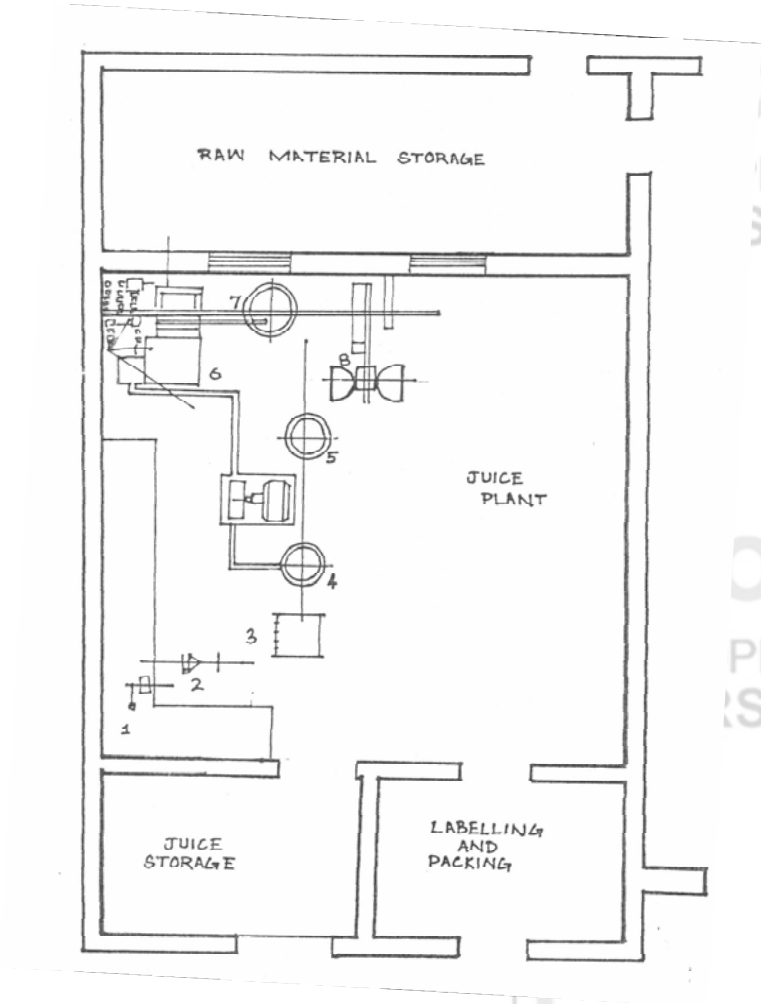


Figure 13.5: Layout plan of a fruit juice plant: 1) Capsular, 2) Corker, 3) Filler, 4) Syrup agitator, 5) Syrup maker, 6) Pulping M/C, 7) Pump, and 8) Pulp extractor

the processing room from one side and exits from the other. In the processing section, all the equipment are arranged in sequence so as to avoid criss-crossing of the flow lines. Besides, also observe that sufficient working space is kept in the processing room, which will avoid collision between workers and avoid accidents, and also help in maintenance of the equipment. Many arrangements or alternate layouts are possible for this kind of plant. But the basic features that we have studied in the previous section should be carefully incorporated in the system for optimum working conditions.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What is the basic objective of a good plant layout?

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2. Why considerations for future expansion is important during designing of a plant layout?

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3. What are the different types of plant layouts?

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4. What are the advantages of 3-dimensional scale models over two-dimensional representations?

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13.5 ANALYSIS OF MAN AND MATERIAL MOVEMENT

In a fruit and vegetable processing plant, in addition to the cost of raw material and its processing, the other major costs involved are the cost of labour,

storage, transport and distribution. Hence we must try to minimise the material handling cost as well as employee travelling time, which also affect the viability of the project. Similarly, mechanical handling equipment consume a lot of power and by generously planning the layout, a considerable saving is possible with this aspect.

The total cost involved in a plant for transportation can be expressed as follows:

$$C = \sum_{i=1}^{N} \sum_{j=1}^{N} T_{ij} C_{ij} D_{ij}$$

where C = Total cost

T_{ij} = Trips between section i and section j

C_{ij} = Costs per unit distance per trip travelled from i to j

D_{ij} = Distance from i to j

N = Number of sections

Here C can be considered in rupees or time units to accommodate materials handling or travelling time criteria. The trips between any two sections will depend on the quantity of materials handled, and hence, once the plant capacity is decided, the number of trips between sections becomes apparently constant. The cost per trip is regulated by the labour rates or power utilised in the conveying machines, and for the purpose of this analysis, may be assumed constant. Hence to minimise the total cost due to man and material movement, the sections need to be arranged in such a manner that the distance travelled by the people or product between the time it enters the processing plant till the time it is dispatched will be minimum. The same approach can be thought of the movement between equipment in a particular room or department. In other words, our objective will be to find out particular D_{ij} combinations for minimising C.

Generally we proceed as follows:

- Determine the number of trips between each pair of sections per unit time such as a day, week, month or year, and with this information draw the ***trips matrix***.
- Ascertain the costs of material handling per unit of distance and draw the ***cost matrix***.
- Draw the ***distance matrix*** with the knowledge of distance between each pair of sections. These distances will depend on layout chosen.
- Compute the total materials handling cost per each pair of sections with the help of above three matrices.

The following example of Figure 13.6 will help you understand how this can be done.

Let us take the example of a small food processing plant, which has only five sections. In the first matrix, I have shown the number of trips required per

week between each pair of section for a fixed quantity of raw material (Figure 13.6). Say for example, there will be 23 trips between sections 2 and 3, and 26 trips between sections 3 and 5.

I have put the costs of material handling per unit of distance between each pair of sections in the 2nd matrix. Subsequently on the basis of the layout plan, I found the distance between each pair of sections, and substituted the values in distance matrix.

It will be interesting for you to see that the **total cost matrix** is computed by multiplying the corresponding figures in the trips matrix, cost matrix and the distance matrix. Observe in Figure 13.6 that for sections 2 to 4 the cost of materials handling is (22)(23)(5) = Rs. 2530. After I have calculated all costs, I added all cells in the total cost matrix to get the total cost as, C = Rs. 38561 per week. This completes the evaluation of the equation for a particular layout plan.

Sections	1	2	3	4	5
1		24	25	27	24
2			23	22	24
3				25	26
4					27
5					

Trips matrix

Sections	1	2	3	4	5
1		32	23	34	42
2			30	23	21
3				18	23
4					20
5					

Cost matrix

Sections	1	2	3	4	5
1		5	7	8	4
2			6	5	4
3				7	8
4					5
5					

Distance matrix

Sections	1	2	3	4	5
1		3840	4025	7344	4032
2			4140	2530	2016
3				3150	4784
4					2700
5					

Total cost matrix

Figure 13.6: Computation of total cost of man and material movement for a layout plan

After this step, we may think of improvements by exchanging pairs of sections, and recalculating the total cost again. Alternate combinations of the locations, i.e. every possible layout are evaluated to find out the optimal solution.

In the above example of Figure 13.6, we have only 5 sections, and hence, we have only 4! combinations, i.e. only 24 arrangements are possible. However, as the number of sections increases the possible combinations would increase. For example with a plant having 8 sections the number of possible combinations will be 7! or 5040. You calculate yourself what will be the possible combinations for a plant having 20 sections. In such cases the use of a computer becomes inevitable.

13.6 MAINTENANCE OF CLEAN WORKING ENVIRONMENT

Cleanliness is very essential in any food processing establishment. It aims at protecting the food safety as well as improving and maintaining the quality of food. It is also the key to good health and efficient work. It is not only the responsibility of the plant manager to take care of sanitation aspects during operation, but proper layout, suitable placement of equipment, proper construction of building, doors, windows, selection of building materials etc. are also vital in maintaining a clean working environment during the plant operation. What do you do to remove bad gases or odours during cooking? The answer will be to switch on the exhaust fan or open the windows. But if the kitchen has no provision of exhaust fan/ventilator or windows, then what shall you do? It is the fault of planning the kitchen that the cook will suffer.

So, we should think about sanitation from the preparation stage of building plan. Provision of built-in sanitation in the construction design as well as in every piece of equipment, fittings, fixtures and utilities help us in maintaining a clean working environment. If the work area is not properly planned, the employee may tend to overlook hygienic practices while handling food. For example, if the wash basin is at a considerable distance from the working table, the worker may tend to skip proper washing of hands when required. There should be sufficient space to provide convenience and comfort to workers.

While selecting a site, we must have taken care that the area should be at a considerable distance from other industries, which might cause pollution. But after selecting the site also, we must be very careful for maintenance of clean environment within the industry and its vicinity. As discussed previously, we should isolate the areas/equipment producing dust, fumes, etc., so that they would not pollute the other working places. The processed food area should be kept away from the raw food area, receiving and cleaning sections. For example, if ginger or turmeric is collected directly from the field, then the washing operation should be carried out in a separate room or in an open yard away from the main room. The drying yard should not be kept near to the road or dusty areas. We should install the grinding mills or cyclones collecting powders in a separate room, or else, it will make the whole environment dusty. In the ceiling if there are exposed beams or girders of iron or reinforced concrete, they would harbour dust and dirt. These dust and dirt get into the plant atmosphere and contaminate both equipment and products. The best ceiling is therefore one with a plain smooth horizontal surface. Light fixtures embedded or inset into the ceiling are more sanitary than the suspended ones. Windows must be properly constructed and maintained to provide adequate light and ventilation. The panes, frames, and screens must be easily and regularly cleaned. The doors and windows must be fly and rodent proof.

Smooth surfaces on the floor and glazed surfaces on the walls up to a height of at least 150-200 cm are satisfactory from sanitation point of view. Drains with proper slope should be provided in all rooms to carry away the liquid wastes promptly from the main working areas. Suitable slope of the floor helps easy cleaning. Garbage dumps and stagnant water in the vicinity encourage breeding of rodents, flies and mosquitoes, and hence should be at a considerable distance from the working areas.

13.7 WORKERS' SAFETY

Safety of workers is one of the prime concerns of any type of industry, and as mentioned in the preceding section, safety considerations start even from the stage of layout planning. Some of the important points that can be considered for workers' safety during designing of a food processing plant are as follows:

- There should be adequate space around all working equipment including those used for material handling to avoid collision between workers and the equipment and between workers themselves. This is more important for equipment, which need frequent servicing.
- The foundation and structure of the floor must be capable of supporting equipment, especially large storage tanks, work load and traffic.
- In the processing plant, fruit juices may fall on the floor throughout the processing area. If the floors have pores, cracks, joints then these get deposited on the floor and ferment to produce acid. The acids react chemically with the floor materials, corroding and damaging the floor. Hence, all parts of the food processing plant should have suitable acid resistant floors. The floors should also be able to tolerate physical abuse and thermal shock.
- The surface of the floors must not be slippery. However, rough surfaces are not preferred as they are difficult to clean; hence we should give a suitable slope to the floor for proper drainage. The design of the drains must permit quick flow of effluent. Drains should be covered with grills or perforated grate, which are inset and level with the floor. This allows normal traffic across a floor area without interference by the drains.
- We should assure proper lighting to all parts of the plant. The areas where there is more chance of water pouring onto the floors or the moist areas need special attention.
- The dangerous and moving parts of the machines need to be fenced. The places where the persons are likely to fall as dangerous pits, sumps, openings in floor, etc. should also be fenced. There should be provision for suitable safety devices in the moving machines so that they can stop immediately if any problem occurs.
- During operation, untrained and unskilled workers must not be allowed to operate any machine or equipment.
- There should be provision of emergency doors for escape in case of fire, necessary fire fighting equipment and training to workers.
- Proper maintenance measures should be taken for each and every machine and periodic routine checkups are essential to avoid accidents.

Safety is a matter of concern for all directly or indirectly involved in the industry, and small cares taken for maintenance of a better work place and during operation can help prevent major accidents and improve the performance of the food processing plant.

13.8 REGULATIONS AND STANDARDS

The Factories Act, 1948 is applicable to all types of food processing industries. The main objectives of the Factory Act are (i) to regulate working conditions in factories; and (ii) to ensure that basic minimum requirements of safety, health and welfare of the factory workers are provided. Besides, the Act envisages regulating the working hours, leave, holidays, overtime, employment of children, women and young persons, etc. The revision of the Act in 1987 included rules for use and handling of hazardous substances and procedures for setting up hazardous industries. The State Governments are empowered to make the rules for ensuring the administration of the provisions of the Act in their respective states. The occupier of a factory is required to get prior approval of the State Govt. for the site on which the factory has to be situated. The Chief Inspector of Factories is responsible for the approval. The occupier of the factory is also required to get the factory registered for obtaining a license for operating it and send a notice of occupation to the Chief Inspector of Factories, at least 15 days before it begins to occupy the factory.

Some important aspects of the Act as regards to health, safety and layout aspects are as follows:

1. Maintain all places of work in a condition that is safe and without risks to health.
2. Make arrangements for ensuring safety and absence of risks to health in connection with the use, handling, storage and transport of articles and substances.
3. Fencing of all dangerous and moving parts of the machinery while in motion or use.
4. Providing sufficient space for workers to operate self-acting machines; encasing and guarding of all machinery installed in the factory and every set of screw, bolt, spindle, wheel or pinion so as to prevent danger
5. Taking necessary steps to ensure that the maximum safe working peripheral speed of every revolving machine, etc. and the maximum safe working pressure of any pressure plant are not exceeded.
6. Keeping floors stairs, steps, free from obstructions and slippery substances and providing with substantial handrails, wherever necessary.
7. Providing suitable striking gear or such device for the movement of driving belts of any transmission machinery and proper locking of device which can shift inadvertently from ‘off’ to ‘on’ position.
8. Ensure that workers do not overcrowd the workplace. There should be a provision of minimum space of 14.2 m^3 per worker in a new factory and 9.9 m^3 per worker in an existing factory. Suitable provisions for lighting, drinking water, latrines, urinals and spittoons are also covered under the Act.

Besides, as I have mentioned previously, there are specific standards for ergonomical considerations for design of equipment or arrangement of workspace. Some more standards related to maintenance of clean working environment come under the Pollution Control Laws.

Check Your Progress Exercise 3

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. How does the analysis of man and material movement help in layout planning of a food processing industry?

   ……

   ……

   ……

   ……

2. What is the need to have enough working space around the equipment?

   ……

   ……

   ……

   ……

3. Write True / False:

   a) In a fruit and vegetable processing plant, the processed food area and raw food area should be kept close to each other.

   b) The drying yard should be kept close to the roads.

   c) The floors of a food processing room should be made rough to avoid slipping of the workers.

13.9 LET US SUM UP

In this unit, we have studied the various aspects of site selection and layout of a fruit and vegetable processing plant. We began with the factors affecting site selection and plant layout and then discussed the general considerations for a food plant layout. We discussed some rules for layout of different buildings, equipment, service facilities and waste disposal systems. We also studied the different steps involved in a layout planning process. How the analysis of man and materials movement, cleanliness and safety affect the plant layout are also discussed here. The unit has acquainted you with the general principles of site selection and plant layout, which are the primary steps in planning any type of industry.

13.10 KEY WORDS

Plant layout : Physical arrangement of the industrial facilities

Line flow process : When the product flows from one operation to the next in a prescribed sequence

Intermittent flow process : When the production is carried out in batches at intermittent intervals. We can organise the equipment and labour into different work centres by similar types of skill or equipment

Process form of layout : The intermittent process is also known as process form of layout as similar equipment and processing operations are grouped together.

Product layout : The line flow is also called a product layout because various process equipment, and labour skills are put into sequence according to the way the product is made.

13.11 SELF TEST FOR THE COMPLETE UNIT/ ASSIGNMENT

1. Describe the different guidelines for layout of different buildings in a food processing plant?

2. Describe the different guidelines for layout of different equipment in a food processing plant?

3. Explain the different steps that can be taken during layout planning for maintenance of clean working environment and workers' safety?

13.12 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. The major factors for selection of site for a fruits and vegetables processing plant are availability of raw material and good quality water, good surroundings, availability of electrical power, good transport facilities, easy availability of labour, facilities for disposal of wastes and scope for future expansion.

2. A good plant layout has the following advantages: saving in floor space, better utilisation of machine, manpower and services, reduced material handling, reduced inventory in process, increased output/ production per unit time, labour, money and energy, easier and better supervision

Check Your Progress Exercise 2

1. The basic objectives of a good plant layout are smooth operation and reduced cost in handling and processing.

2. If during the preparation stage of a plant layout, possible future expansion is not considered, we will face problems in expanding our industry or business, either by addition of new products or by increasing the capacity.

3. The layouts can be process form of layout and product layout. Also hybrid layouts, which are a combination of the above two are possible. The layout can also be classified as single level, multi-storey or combined layout.

4. Three dimensional scale models give a better representation of relative positions of different equipments and spaces than the two-dimensional drawings. In bigger models, the piping and utilities can be shown, which give idea on the actual work area that will be available.

Check Your Progress Exercise 3

1. The analysis of man-material movement helps to select a layout among many possible alternatives, which will reduce the total cost of movement and materials handling within the plant. This helps in minimising the cost of operation of food processing industry.

2. There should be adequate space around equipment to avoid collision between workers and the equipment and between the workers themselves. This will also help in servicing of the equipment.

3. a) False
   b) False
   c) False

13.13 SOME USEFUL BOOKS

1. Reed, R. (1961). Plant layout-Factors, Principles and Techniques. Richard D. Irwin, Inc. Illinois.

2. Vilbrandt, F.C., Dryden, C.E. (1959). Chemical Engineering Plant Design. 4th Edition, McGraw Hill Tokyo.