Chapter 3

PROCESS FLOW CHARTS AND PLANT LAYOUT

(Flow chart, Different unit operations in milk processing with the help of flow charts, Know how to draw the flow charts and plant layouts)

FLOW CHART

A flow chart is a representation of sequence of operations in a processing plant or in a process. For example, if we want to prepare dried vegetables, the sequence of operations will be sorting, washing, peeling, slicing and then drying either under sun or in a mechanical dryer. But we may also think of blanching of the vegetable or treat with sulphur dioxide depending on the characteristics of the commodity and product. Thus if we prepare a flow chart of these processes, the flow chart may look somewhat like as in Fig. 3.1.

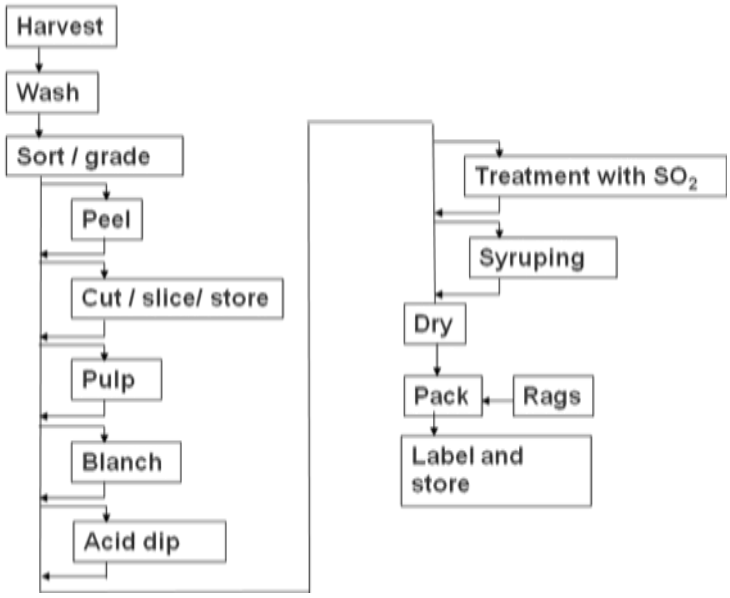

Fig. 3.1 Flow chart for vegetable dehydration

For preparation of a flow chart, first of all we have to know the sequence of operations. Or in other words, we can know the proper sequence of operations and better understand the process, if we have a flow chart of the process. We can also know the critical control points and we also know where to improve.

The flow chart also helps in identifying each unit operation in the process which helps in proper selection of equipment and better management of man and machines. For example, the type of equipment that will be required for the preparation of dehydrated vegetables will be as follows.

Equipment required for vegetable dehydration

- Wash tanks or special washers
- Knives, peelers, small peeling machines
- Fruit and vegetable choppers, cutters, slicing and dicing machines
- Pulpers, liquidizers, steamers, or at a large scale, pulper-finishers
- Boiling pan, heat source, wire basket or steamer
- Weighing scales or scoops, sulfuring cabinet or food grade plastic tank
- Weighing scales or scoops, boiling pan, heater, food-grade tank, muslin cloth filter
- Sun-drying, solar dryer, any type of suitable dryer
- Electric heat sealer for plastic bags

So now we have understood that the flow charts are very important for understanding and monitoring a process. In this section, we will discuss how the flow charts are prepared for some common milk processing operations. In fact this will also help you in understanding the methods of preparation of these specific products.

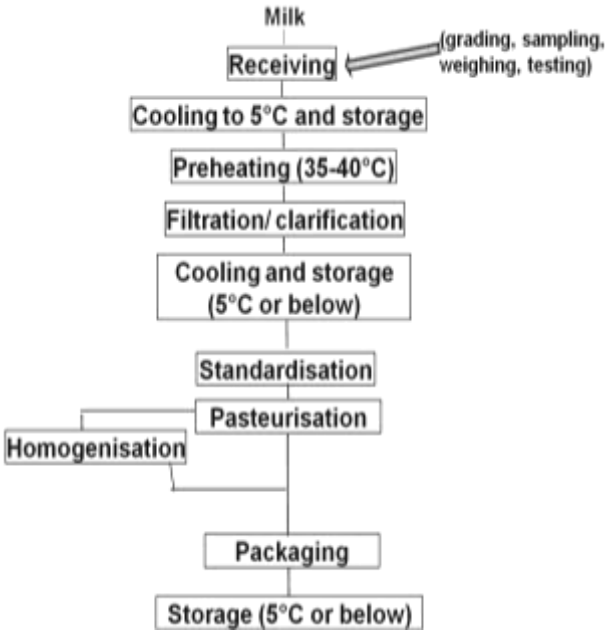

Fig. 3.2 Flow chart for preparation of pasteurized milk

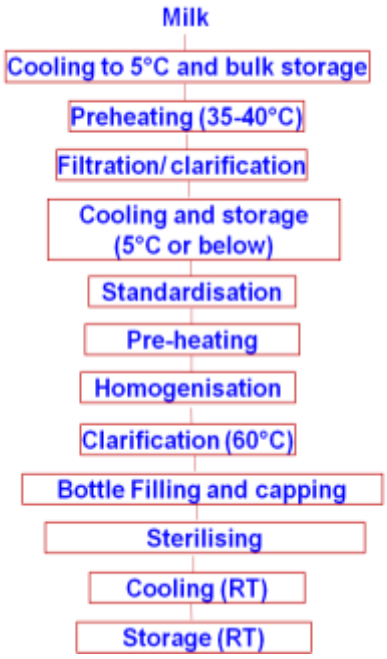

Fig. 3.3 Flow chart for preparation of sterilised milk (In-bottle sterilization)

Fig. 3.4 Flow chart for preparation of flavoured milk

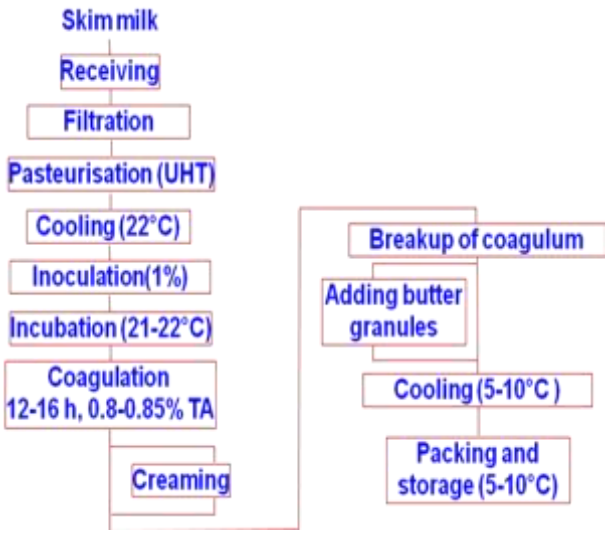

Fig. 3.5 Flow chart for preparation of butter milk

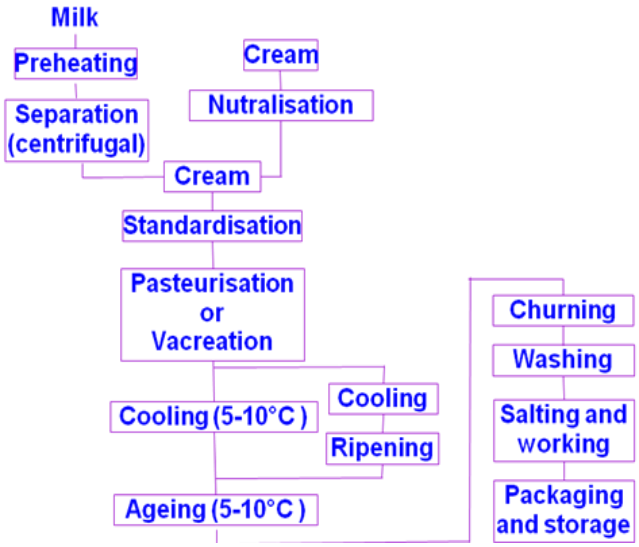

Fig. 3.6 Flow chart for preparation of butter

Fig. 3.7 Flow chart for preparation of ice cream

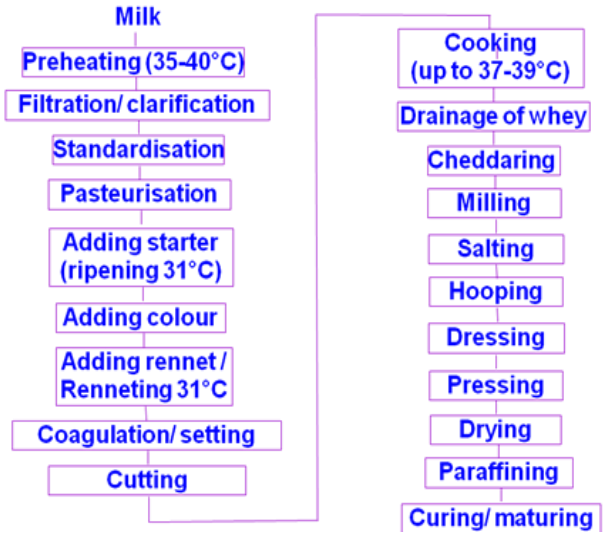

Fig. 3.8 Flow chart for preparation of cheddar cheese

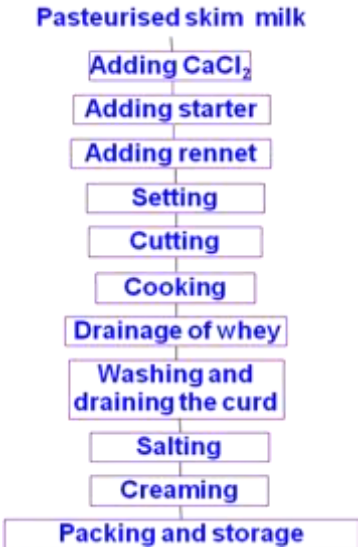

Fig. 3.9 Flow chart for preparation of cottage cheese

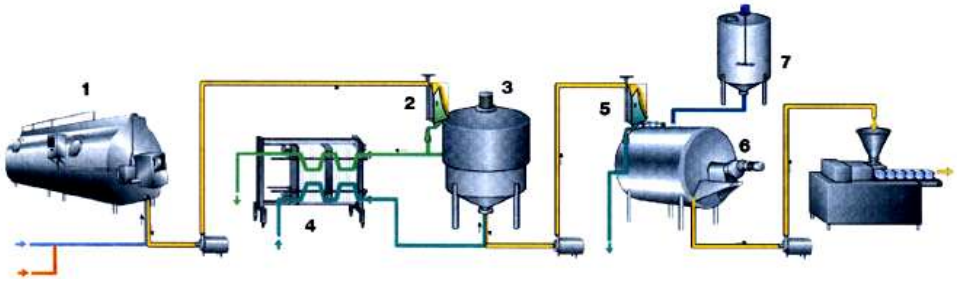

Fig. 3.10 Equipment flow chart for preparation of cottage cheese

Curd
Skimmilk
Starter
Whey
Wash water
Dressing

1 Cheese vat
2 Whey strainer
3 Cooling and washing tank
4 Plate heat exchanger
5 Water drainer
6 Creamer
7 Dressing tank
8 Filling machine

Fig. 3.11 Flow chart for preparation of evaporated milk

PLANT LAYOUT

Plant layout is the arrangement of equipment/ machines/ facilities in a plant for the efficient functioning of the whole system with a view to maximize the profit.

We may consider any food processing operation as a transformation process. In a fruits and vegetables 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 Fig. 3.12.

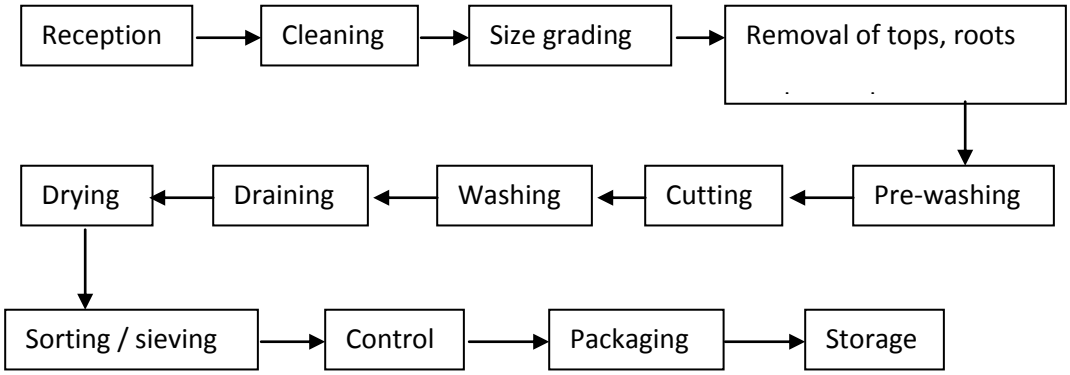

Fig. 3.12: Preparation of dehydrated onion

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 utilization of energy, labor (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 labor and all other supporting activities, or services, as well as for operating equipment and personnel.

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.

In Fig. 3.13, I 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?

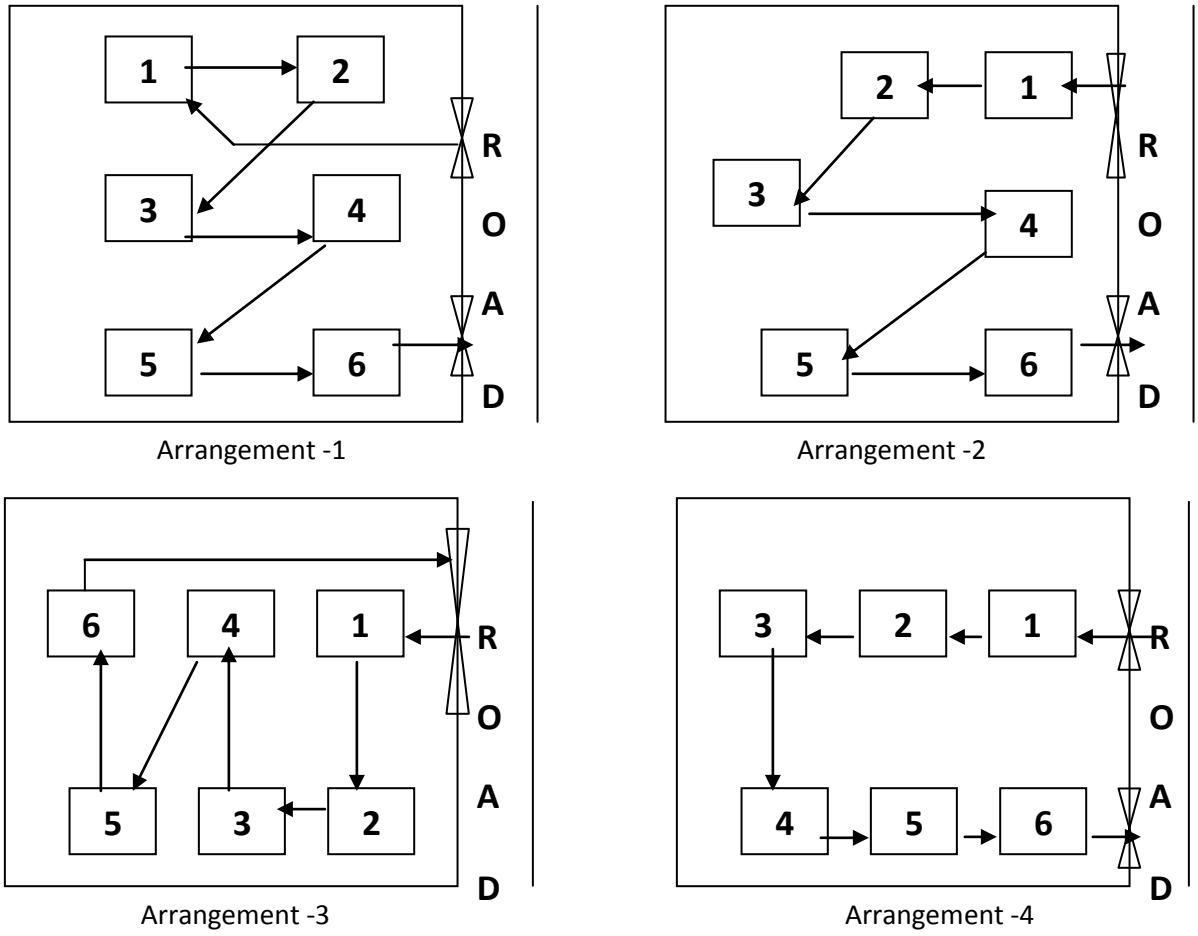

Fig. 3.13 Understanding what plant layout means

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 utilization of machine and man power, and services;
- Reduced material handling, thus saving in labor and cost, less production delays;
- Reduced inventory in process, thus saving in investment and working capital;
- Increased output/ production per unit time, labor, 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.

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. Good layout must also 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 (tonnes 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 go down 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 sped in the area, etc. are some other factors which need to be considered during planning the layout.

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 homogenized 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 organize the equipment and labor into different work centers by similar types of skill or equipment. The product can be sent to any of the work centers 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 centers 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.

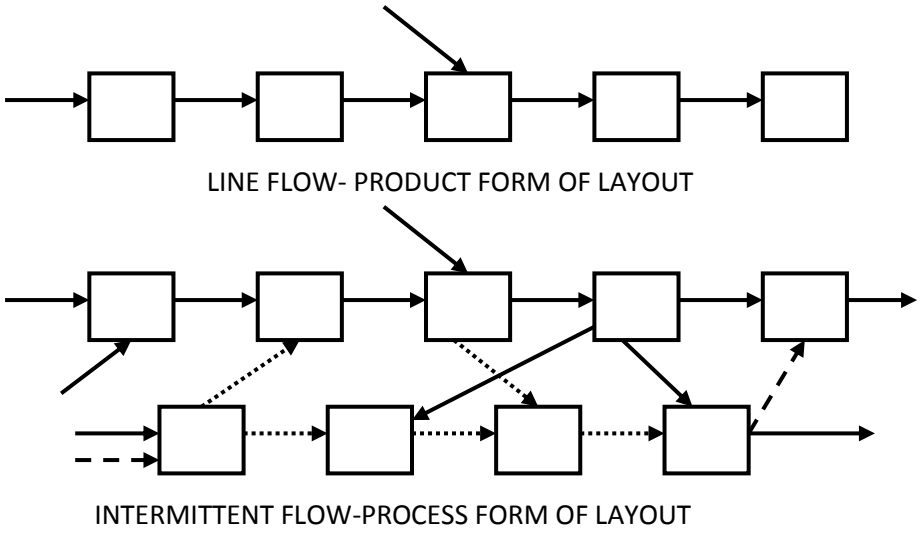

Fig. 3.14 Product form and process form of layout

- 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 labor skills are put into sequence according to the way the product is made.

- When a product lacks standardization 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.

On the basis of the above two representative layouts have been given in Fig. 3.15 and 3.16. You will be visiting a dairy plant during this course and you will have to draw the layout plan of all the equipment and utilities in the plant. You will also have to carefully report whether the layout has taken into consideration all minute things and whether some modifications are needed in the layout of the plant.

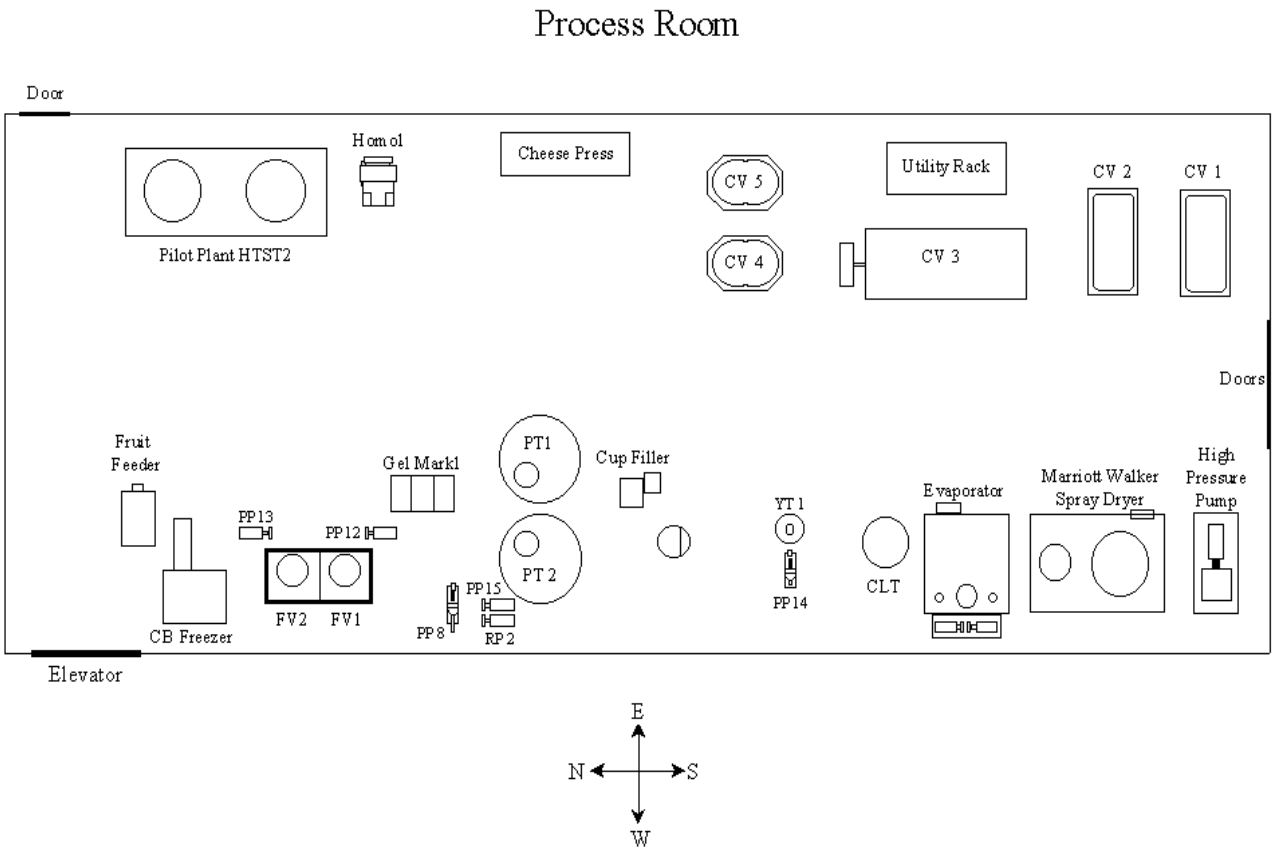

Fig. 3.15 An example of a plant layout

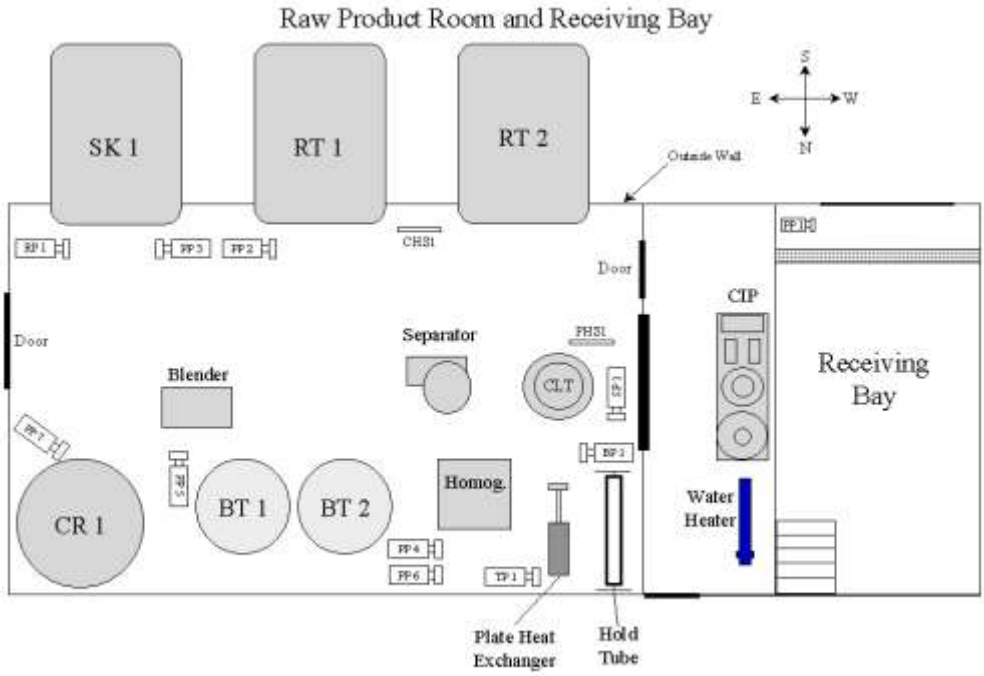

Fig. 3.16 An example of a plant layout

CHECK YOUR PROGRESS

1. Draw the layout of any dried vegetables manufacturing plant producing 100 kg product per day.
2. Draw the layout of a dairy plant that you have visited in your locality and give your critical comments about its layout modification.

The answers to the above questions should include the following.

- Flow chart
- Assumptions about capacity utilization, storage or raw and processed materials, etc.
- Type of equipment necessary
- Planning of equipment installation area
- Layout
- Your comments/analysis