Lesson 15
General points of consideration for designing dairy plant

15. 1 Introduction

Dairy industry in India is growing at fast rate and as such, there is need for Scientific Layout and Planning with a view to have model studies by dairy designers, engineers and architects. The term 'Dairying' has been bifurcated into two branches, namely Dairy Husbandry and Dairy Technology. Under the purview of dairy husbandry comes animal breeding, care, health, nutrition of animals, animal housing, clean and safe production of milk, i.e., mulching animals in good sanitary conditions. In some organized sectors, milk collection and chilling before milk is transported for processi9ng at dairy factory also forms an activity of dairy husbandry.

The Dairy Technology commences with processing of milk at dairy plant for market milk and various dairy products. The dairy plant layout and design means designing a layout plan for dairy factory, i.e. layout of various sections in dairy building, equipment layout, laying of dairy machines in each section for economical and efficient movement of men and material in the plant. It will deal with all items which are needed for planning and layout of dairy factory, with direct application to fundamental topics, such as location, selection of site for dairy plant, building materials, specific requirement of each section including service sections. It will also touch the practical need of prospective entrepreneurs aspiring to set up a dairy plant. Management and planning of layout of indirectly related sections, such as office and administration block will also find place in this presentation. The treatment of subject matter is descriptive and lucid so that students, teachers and dairy professionals can imbibe the topics discussed easily. Many illustration and diagrams have been given to make the subject crystal clear. Thorough study of the text book will not deprive the learner of various definitions of milk and milk products, terminology of various processing and technical terms as are commonly spelled in dairy technology and engineering.

Milk and milk products, however, impose certain requirements which do not occur elsewhere in food or other industries. These special requirements affect the structure and the layout of the building, the provision and distribution of services and the choice of site. The products of dairy industry – milk for liquid consumption, yoghurt, curd (dahi), cream, butter, ghee and similar products, cheese, milk powder and so on – are foods which play a fundamental part in human nutrition. In any country, therefore, it is in the nation's interest that milk and milk products be available to everyone at the lowest possible rate. The margin of profit which the dairy entrepreneur can expect is limited. Therefore, every possible economy in capital outlay on building and plant should be sought. Planning must be done wisely to make best use of the labor employed and to keep operating costs to a minimum. Materials and method used in building must be such as to give the longest practical life with the minimum of maintenance, in spite of working conditions which are often relatively severe from both the mechanical and chemical points of view. It should also be seen that most of the repairs, alterations or extensions could be done without stopping the production. These characteristics demand closest attention during planning.

There is need for highest standard of hygiene. Milk is most suitable medium for the growth of microorganisms; therefore, every possible measure should be taken to reduce the possibility of contamination, especially after processing. Failure to maintain adequate control of hygiene will spoil the product, it may not keep well or its flavor may change. This will pose problem to sell the product. A good layout design and use of proper materials and techniques make great contribution towards hygiene. Proper cleaning and maintenance of plant and building is essential, so that, there is no contamination. Care should be taken to provide adequate natural and

artificial lighting. Every possible effort should be made to ensure that the building and the site will be pleasant to look at. The architect can provide a good landscape and an attractive outlook. The welfare of the employees must be kept in view. Canteen facilities are essential. Housing for key workers must be provided near the plant at reasonable distance, so that they can reach in time in emergency.

To sum up, dairy plant layout needs careful thought and planning keeping in view manufacture of the products and their commercial aspects.

15.2 Increased safety and improved working conditions

Good plant layout incorporates safety into the plant by eliminating hazards at work stations, in materials handling, storage activities, maintenance operations and the like. Man hour losses can be cut down to minimum. Reduction in losses of capital equipment and materials is another result of "built in" safety in the layout. The provision of a good physical plant environment improves the overall working conditions. Increased employee moral tends to reduce production costs and helps develop a stable operating force.

15.3 Perishable nature of milk

Milk by its nature is perishable. The following three factors contribute to its being perishable;

(a) Contamination with bacteria

(b) Warm temperatures, and

(c) Prolonged time before cooling or processing

In practice, none of these factors can be eliminated completely, so if any one is accentuated, the life of milk will decrease. Therefore, every effort must be made to minimize these factors on the farm, during collection at milk plant and during distribution to consumers. At the farm, the aim must be to cool the milk as soon as possible often milking. Freshly drawn milk has bacteriostatic property, i.e. it contains substances which resist the growth of bacteria for several hours. However, there is a substantial bacterial population. Ideally, the milk should be chilled to 4 ^{o}C within two hours after milking. If for any reason this can not be done at farm, quick transport of milk to the plant is essential.

If milk can be stored conveniently at the farm or local collecting depot at low temperature, the organization of transport to milk processing plant is simplified to greater extent by transporting bulk quantity in insulated tankers. The type, size and number of vehicles necessary are, therefore determined not only by the usual factors such as distance or nature of roads but also by the condition of milk production. This applies to cream also. In some cases, the milk may be separated at the farm and only the cream, i.e., milk containing 5 to 30 per cent fat is sent to plant for manufacturing butter or ghee.

15.4 Flexibility

Management should lay stress upon maximum flexibility in production facilities and distribution methods consistent with low cost operations. Production facilities and layout can be designed to attain flexibility and adaptability to meet changing economic and technological conditions. To combat regular fluctuations in the supplies of milk available to processing plant throughout the year, flexibility in the plant layout is essential. Flexibility is necessary since market conditions for the sale of finished products attain flexibility in production changes of the product, and technological advances must be anticipated so that plant equipment does not become obsolete. The amount of production flexibility depends on such factors as the nature of the products, the kind of production facilities can in part be attained by initially selecting universal and standard types of machines, which can perform a variety of operations, such as Tri-process machine used for cream separation,

clarification and standardization of milk. Layout flexibility can also be attained by incorporating into the layout as much as possible the process-layout arrangement whenever it is consistent with low cost operations.

Allowance for increases in capacity can be anticipated in a layout by properly arranging production departments and selecting the type of building that can be expanded at low cost. Sound layout engineering attains low cost flexibility in the kind of operations performed and an ease in the increase of output capacity which may be required for the future.

Good plant layout achieves a floor arrangement that contributes in a number of ways to low-cost production planning and control. Materials control can be more easily attained in a well designed plant layout. A steady amount of production capacity is facilitated an idleness of machinery and man is reduced to minimum. The net result is facilitation of dispatching activities on operating floor. Deliveries toi customers on short notices are easily attained.

15.5 Modes of transportation of milk

A mode of transportation of milk depends on type of area, type of transportation available and local road conditions. Table 15.1 shows different types of mode of transport used for procurement of milk, for optimum load conditions and distance.

Table 15.1. Various modes of transportation of milk to dairy plant along with optimum load and distance.

Mode	Optimum load (kg)	Optimum distance (km)
Head load	15 to 25	3 to 8
Shouldering	Up to 30-	3 to 6
Animal (Ponies, Horses, Donkeys)	80	6 to 10
Bullock cart	300 to 400	10 to 12
Tongas	200 to 300	12
Bicycles	40 or more	15
Cycle rikshaw	100 to 150	10
Boat (for crossing rivers)	50 to 200	2 to 8
Auto-rikshaws	250 to 500	15
Motor truck	3 tonnes	15
Railway wagon	11 tonnes	100 or more
Road tanker	5 tonnes	100 or more
Rail tanker	5 tonnes	100 or more

The milk is usually brought to dairy plant either by Road or Rail Transport through cans or tankers. Plus points of these means are given below:

Table 15.2. Mode of transport and their corresponding advantage.

Mode of transport	Advantage
Road	Loading and unloading conveniently done at godowns of sellers and buyers. Cheaper than rail over short distances. Less time consuming.
Rail	Cheaper than road over long distances. Large quantity of milk can be handled at a time.
Can	Small quantity of milk can be handled.
Tanker	Faster mode of transport. Low cost. Better temperature control. Less risk of contamination. Time and labour saving. Low investment in cans. Saving in detergents.

15.6 Milk procurement and reception at dairy plant

In most of the countries, milk production is carried out in rural areas from where it is transported to milk processing plant, and thereafter for distribution to consumers through local depots or milk parlours. Under Indian conditions, milk has to be regularly collected and transported twice a day (morning and evening).

The usual methods of milk collection and reception at dairy plant are:

Milk procurement through individual producers: In this milk is brought to the dairy plant by the individual producers in their own vessels any type. This is possible for those producers who are located nearby milk processing dairy.

Milk collected through co-operative organizations: Here, co-operative societies form an organization which is responsible for uninterrupted supply of milk to the dairy plant. Supply of milk can also be effected by single co-operative society formed by milk producers. This is beneficial to the producers as there is no middle man to share the profit.

Milk procured through contractors: There is less return to the milk producers, as milk contractor will keep his share in the profit.

Milk reception from milk collection cum chilling centers: This method is generally possible and is prevalent in organized sectors, and dairy corporations in India.

Milk is collected at various milk collection centers from nearby villages in 40 litre cans usually belonging to the organization. The milk is weighted, tested for fat content and kept ready to be dispatched to the milk chilling center, where milk cans are emptied, washed through can washer and sent back to milk collection centers for next day collection of milk. Route plan linking villages, milk collecting centers and chilling center is shown in Fig. 1.1. On arrival at milk chilling center, the milk is weighed chilled and transported to milk processing dairy plant through Insulated Road Mill Tankers or Rail Tankers. The important equipment for reception of milk at milk processing plant are

(i) Can conveyor (ii) milk weigh tank

(iii)weighing scale (iv) dump tank with cover

(v)can washer (vi)drip saver

(vii)milk pump (sanitary type) (viii)surface/plate chiller

(ix)refrigeration unit (suitable capacity), and (x)milk testing laboratory

The milk as soon as it is received at plant, it is weighed, dumped into the dump tar (weigh tank) and has to be chilled before it is stored for processing. This has to be done in quick succession through equipment well planned and installed at milk reception dock and receiving room. If the milk is received in bulk through tankers, the arrangement has to be made for quick transfer of milk through milk pumps installed at milk reception dock to milk storage tanks. The milk received in the evening may be chilled and the stored for processing next day. This all will need careful planning of layout of equipment at milk reception dock and milk receiving room. Roads leading to milk reception dock and dispatch dock have to be planned in such a manner so as to avoid traffic congestion inside the factory or road blockage.

15.7 Contamination and its prevention

Milk coming from its source to milk plant for processing is prone to contamination as it passes through different stages, hands and environmental conditions. Unless proper precautions are taken, outbreaks of milk-borne diseases can occur anywhere anytime especially if raw milk is consumed as such. Diseases which are know to be transmissible through milk are given hereunder together with the manner in which they may enter the milk.

Infection of milk directly from the cows: These diseases are essentially bovine. The causative organisms enter the milk through the mammary glands or through contamination, and may cause a diseased condition in persons who consume the milk. Bovine tuberculosis or fever can occur.

Infection from man to cow and to milk: These diseases are essentially human, but can become established in cow's udders, e.g., septic sore throat, scarlet fever, diptheria etc.

Direct contamination of milk by human beings: These are human diseases, the pathogenic organisms of which enter the milk through contaminated milk bottles or other utensils, water supply, insects and dust, e.g. typhoid or paratyphoid fever, dysentery or diarrhoea etc.

For human consumption, milk must be clean and safe. The sanitation of milk supply can be safeguard in two ways.

(a) Production and handling of raw milk. It should be done in such a way, so as to prevent its contamination by pathogenic organisms. This will require ((a)ensuring the health of dairy cattle by various control measures, (b) safeguarding health of employees by regular medical check ups, (c) protection of water supply from contamination by organisms, (d) straining the milk through milk strainer for any dirt straw etc.

(b) Pasteurization of milk. This will kill all pathogenic organisms and avoid any post-pasteurization contamination.

There are many factors which help in preventing contamination, such as design of equipment, effectiveness of cleaning and sterilization, methods of handling and design layout of building, particularly internal finishes. The end products of processing plant are liquid milk in various forms, cream, butter, cheese, milk powder, ghee, etc., each item is produced to meet consumers requirement. In all these conservation processes, highly perishable raw material is given longer life. Although the various processes are different, but they are similar in sense that they control development of bacteria. It is, therefore, recommended to keep the raw material well separated from the processed products. The isolation of dirty bottle reception and bottle washing from pasteurized milk bottling, storage and dispatch is one of the example of this. Similarly, pipelines for raw milk must be completely separate from those carrying processed milk. Every section of the plant must be independent and self contained as far as possible. For instance, many varieties of cheese involve the growth of

molds to give their characteristic flavour, whereas the presence of mold in butter would damage it. Most of dairy products quickly absorb flavours not only from one another, but also from any strong smelling contaminants such as oil, ammonia, paint or kerosene.

Table: 15.3. Sources of contamination and control methods.

Interior of the udder	1. Check for mastitis. 2. Discard foremilk.
Exterior of the cow udder and flanks	1. Wash and wipe udder. 2. Clip the udder and flanks. 3. Dry milking. 4. Use small top milk pail
Bard air and dust	Keep milk covered.
Files and insects	1. Eliminate breeding places. 2. Fly control with fly sprays, if traps, meshed door etc.
The milker	1. Clean habit 2. Dry milking
Utensils	Clean, sanitize and dry before use.

15.8 Cleaning and sterilization

The dairy industry is somewhat different from other industries so far as hygiene is concerned, and is comparable with medical practice. Every detail of equipment and building design must have medical rather than industrial approach. Every item of equipment which comes into contact with milk must be cleaned thoroughly and sterilized every day. Anything less than this will quickly lead to problems. In hot climate, the problem is intensified. Once trouble starts, it may quickly spoil large portion of the production it may then take several days to control the situation.

With milk pasteurization, daily cleaning may not be sufficient. Where the plant has to operate for more than five hours at a time, it will be necessary to stop for an intermediate cleaning and sterilizing operation. The reason for this is deposit of milk solids heating surfaces, which causes loss of heat transfer efficiency. Dairy equipment, therefore, must be designed so that it can be easily and thoroughly cleaned. Crevices and small internal radii must be avoid. The equipment may be dismantled and thoroughly cleaned. The material used must be corrosion proof. The building should fulfil high standards of sanitation. Every possible effort must be made to eliminate dust and insects. Floors, walls and ceiling finishes must be such that they can be easily cleaned, thus reducing the contamination. Neat and clean dairy is liked by everyone and also makes a good business.

****** ☺ ******

Lesson 16
Different types of layouts

16.1 Introduction:

Planning is the way of proceeding or scheme of arrangement for executing any work or project. Planning a layout for a dairy calls for careful thinking. Designing a dairy plant layout is a joint venture of Architects, Dairy Managers, Dairy Engineers and Administrators, because it is an overall managerial function. The ideas of several technocrats are sought and future requirements are estimated as accurately as possible. The anticipated capacity in 10 years, products to be manufactured, types of packages, methods of distribution, material handling, loading out facilities and office space are the examples of items to be kept in view while planning layout. The plant layout engineering function is to achieve an efficient plant layout through the utilization of logical, well through procedure.

Top management policies affect the plant layout as policies determine the plant layout objectives and scope of plant activities. The layout engineer must have a clean and complete understanding of those top management policies, that have a bearing on plant layout objectives. A knowledge of managerial policy with respect to the future volume of production and the size of business firm is of particular importance to dairy plant layout engineer, because it will point to the need for providing for future expansion or contraction in the layout. Included in expansion programmes are management decision with respect to the addition of new or related lines of products. A plant layout should be so planned and arranged, that the needed capacity to produce new or related products can be added at low cost, with minimum of plant revision and interruption of production schedules.

A good layout must improve or facilitate production operations, minimize material handling maintain flexibility of the operation for alteration and expansion, minimize investment in equipment, make economical use of floor area, promote effective utilization of the labor force and provide for employee convenience and comfort.

Many companies engage an architect to draw up a plant of an attractive design and consult dairy equipment manufacturers for ideas regarding latest machinery. The common mistake lies in making too large or too small a plant. The size of dairy plant is a matter of consideration and prudence. It has often been found unwise and erroneous to construct a very large building in as much as it may not be paying especially in new business. Many concern have faced bankruptcy due to overhead cost on massive construction.

16.2 Principles of dairy layout

As far as possible dairy layout engineers should try to incorporate the following principles in layout, which, in turn, will help in having an economical and efficient dairy plant. It is often seen that the dairy designer or layout engineer is not in a happy position because he is always confronted with one or the other layout planning problem, which makes him unable to apply all the principles described hereunder:

1. The milk route should be as short as possible. This will minimize the cost of pipe length and save time in cleaning.

2. Reception and dispatch platforms must be arranged in relation to plant in such a way that congestion of transport vehicles is avoided.

3. A small dairy handling milk up to 20,000 liters/day may have reception and dispatch at one dock as there will not be much rush of vehicles. In large dairies, this separation is essential. Generally milk reception and dispatch

of washed cans is one side (because washed cans are reloaded on the same vehicle and returned to milk producers) and dirty bottle reception is on the other side.

4. Where space is available, single storey building is most suited. The plan may have a rectangular shape with roads on all sides.

5. The floor level of milk reception and dispatch docks and of all rooms concerned with milk cans and bottles should be at the same height above the ground level suited to vehicles. However, the weigh tank and raw milk pump should be at a lower level in order to have a convenient tipping height. A well or pit must be constructed for the weigh tank and raw milk pump.

6. The raw milk storage tank and pasteurized milk balance tank may be mounted on a staging in order to save floor space and to provide a gravity head to fillers.

7. If it is desired to have a refrigeration compressor room and boiler house in the same building, the floor level of these rooms should be at part with ground level. This gives extra height to boiler and affords a study foundation to compressor.

8. Laboratory should have easy approach to processing room, reception room and filling room.

9. Separate apartments should be assigned for offices.

10. Boiler should be located near the place where steam is required.

11. Refrigeration machinery room should be near the process room and cold store.

12. Security and watch and ward offices should be located near gate.

16.3 Operational layouts

Operational layouts describe operations which take place in processing or manufacture of any item. All operations involved are represented diagrammatically in chronological way, i.e., sequence-wise-what comes next on the paper like any flow diagram which can be easily understood by a layman. There is no restriction in showing pictorial views or three dimensional layouts. For instance, an operational layout of a butter making factory will differ from that of ice cream making plant as two have different operations to achieve end product.

These layouts are usually drawn to impress upon management board which may comprise of professional and non-professional members for quick understanding of the proposed project.

16.4 Typical layouts for different types of product sections of dairy plant:

Typical layouts are prepared for different types of product manufacturing in the dairy plant. The layout should be functional to facilitate each unit operation involved in product manufacturing. Fig. 16.1, 16.2, 16.3, 16.4, 16.5, 16.6, 16.7, 16.8, 16.9, 16.10, 16.11, 16.12 and 16.13 shows typical layout of different product manufacturing sections, integrated product plant and service block.

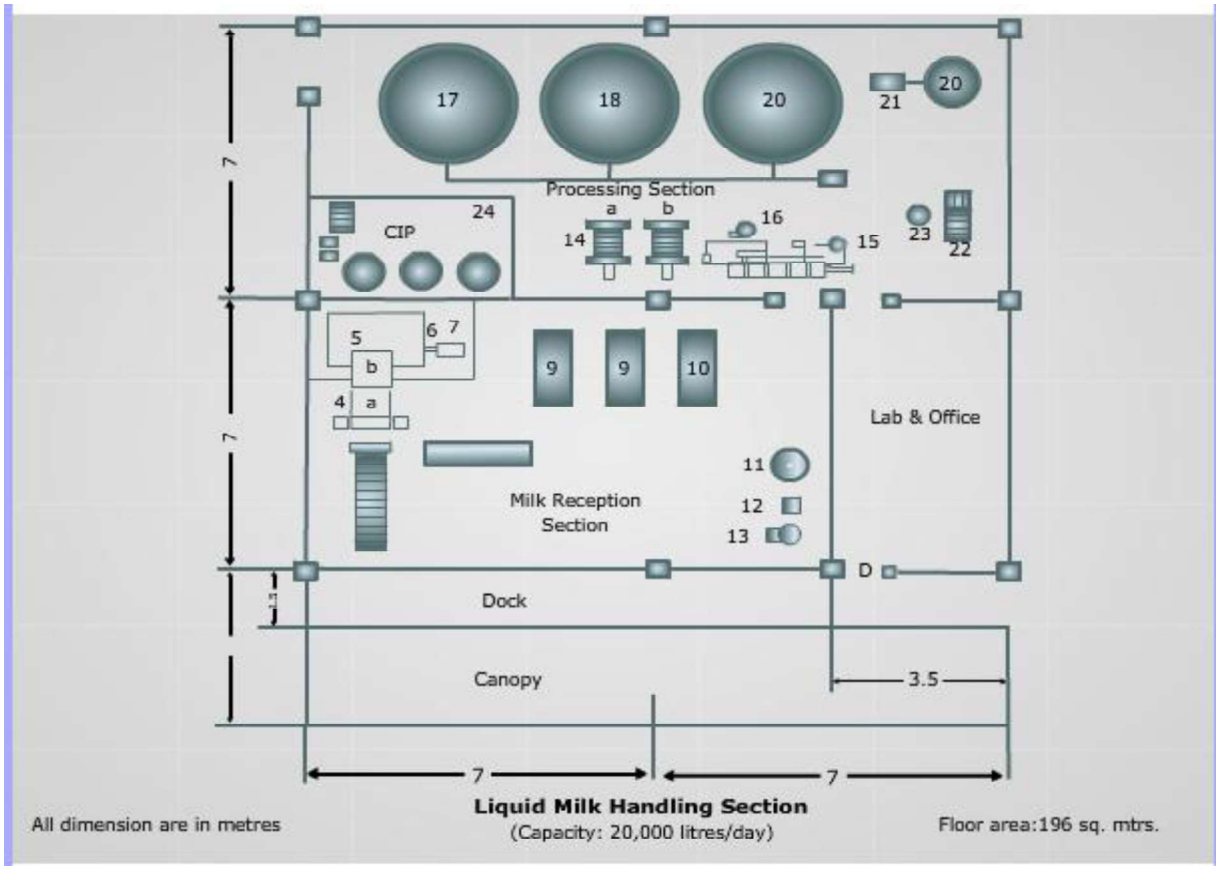

Fig. 16.1 Liquid Milk Handling Section

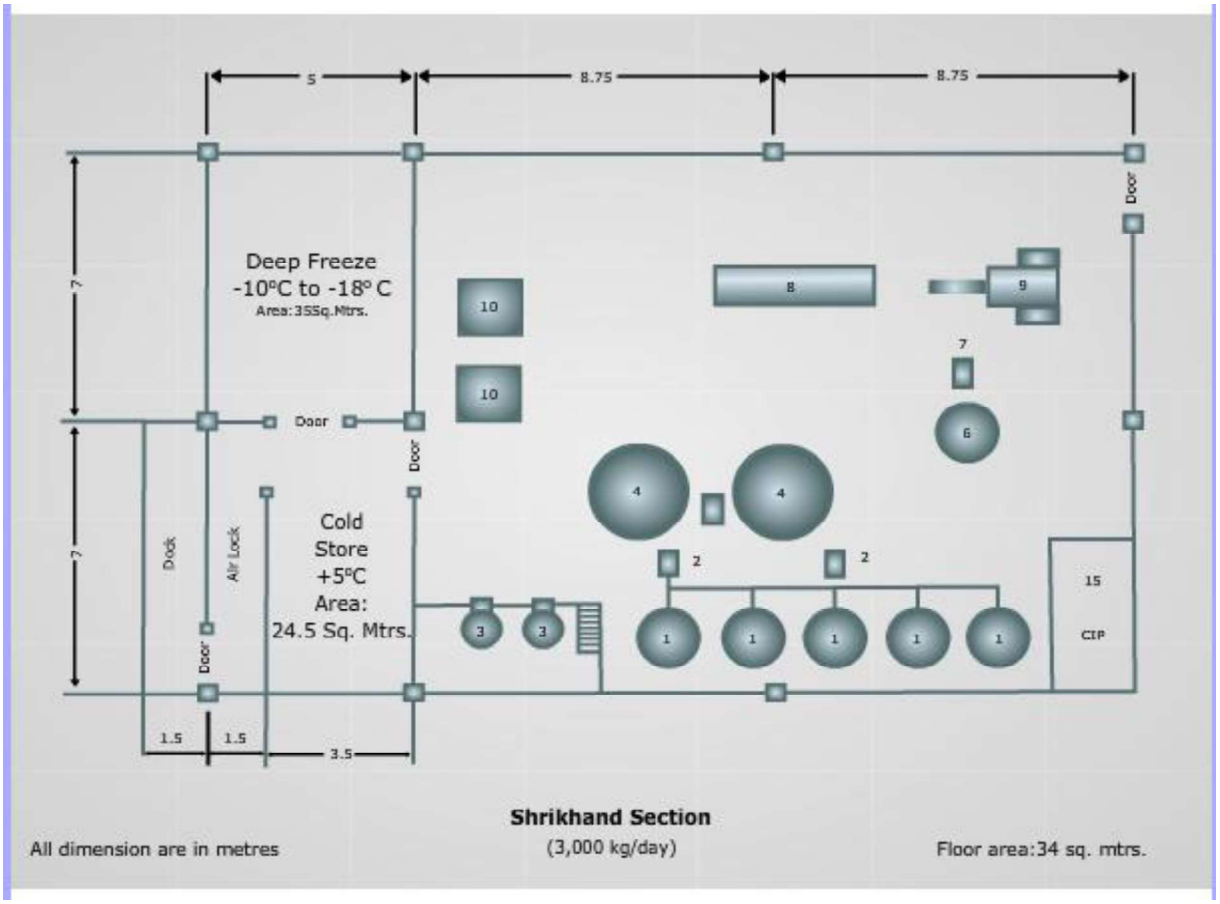

Fig. 16.2 Shrikhand Section

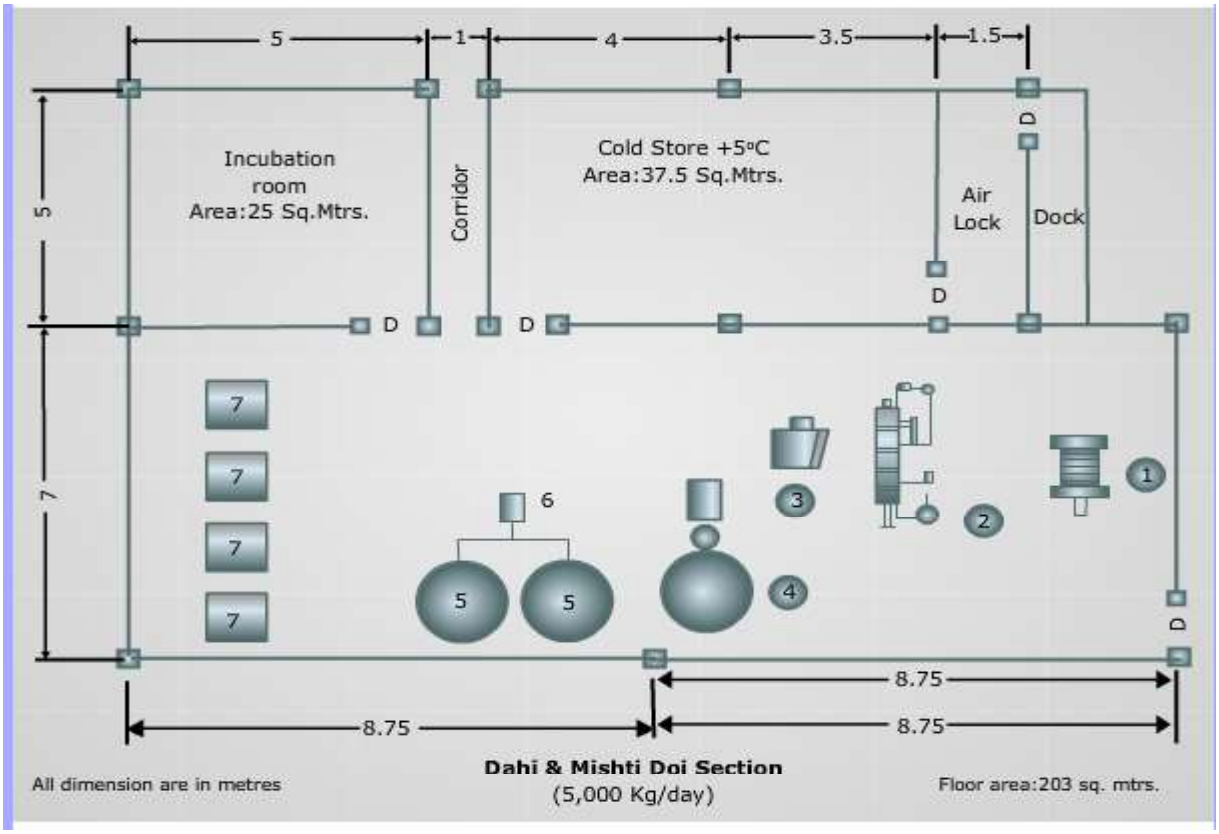

Fig. 16.3 Dahi & Mishti dahi section

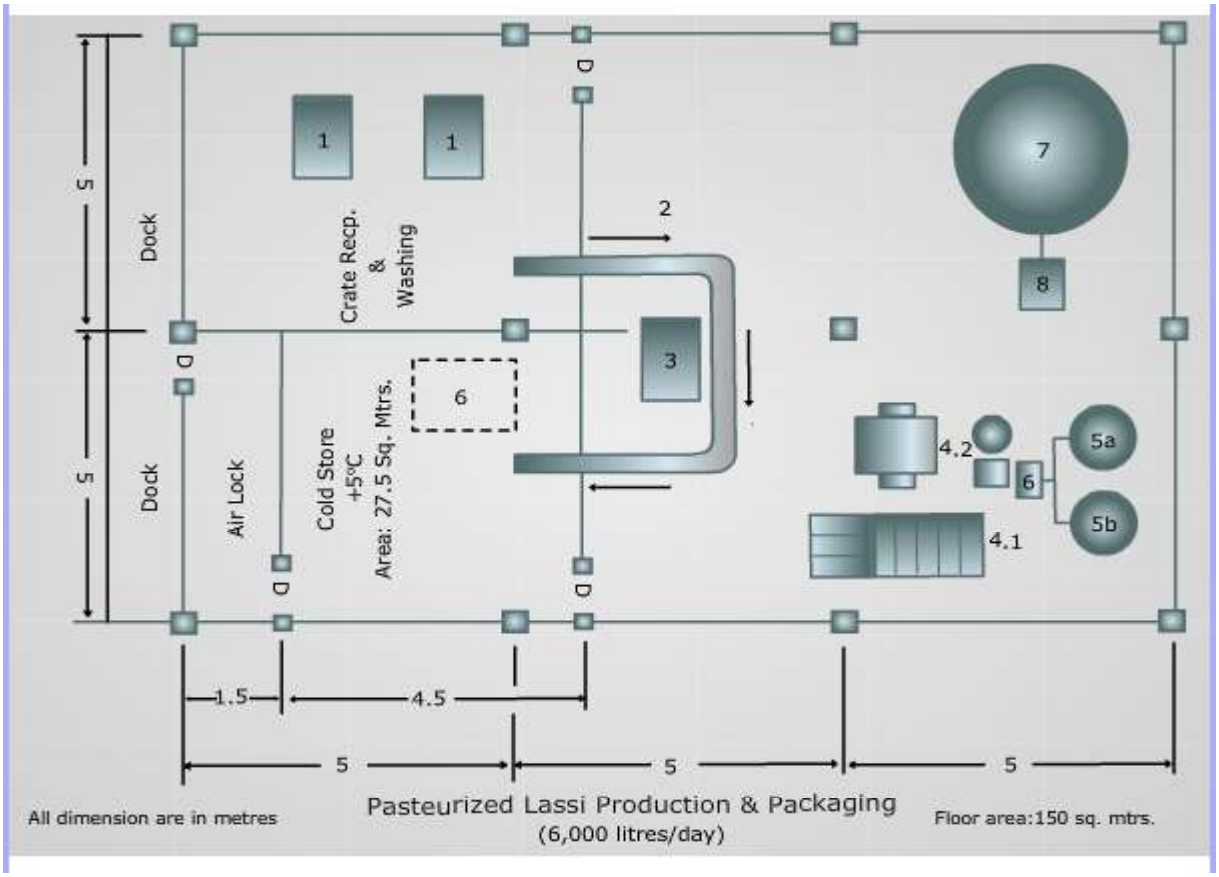

Fig. 16.4 Pasteurized Lassi Production & Packaging

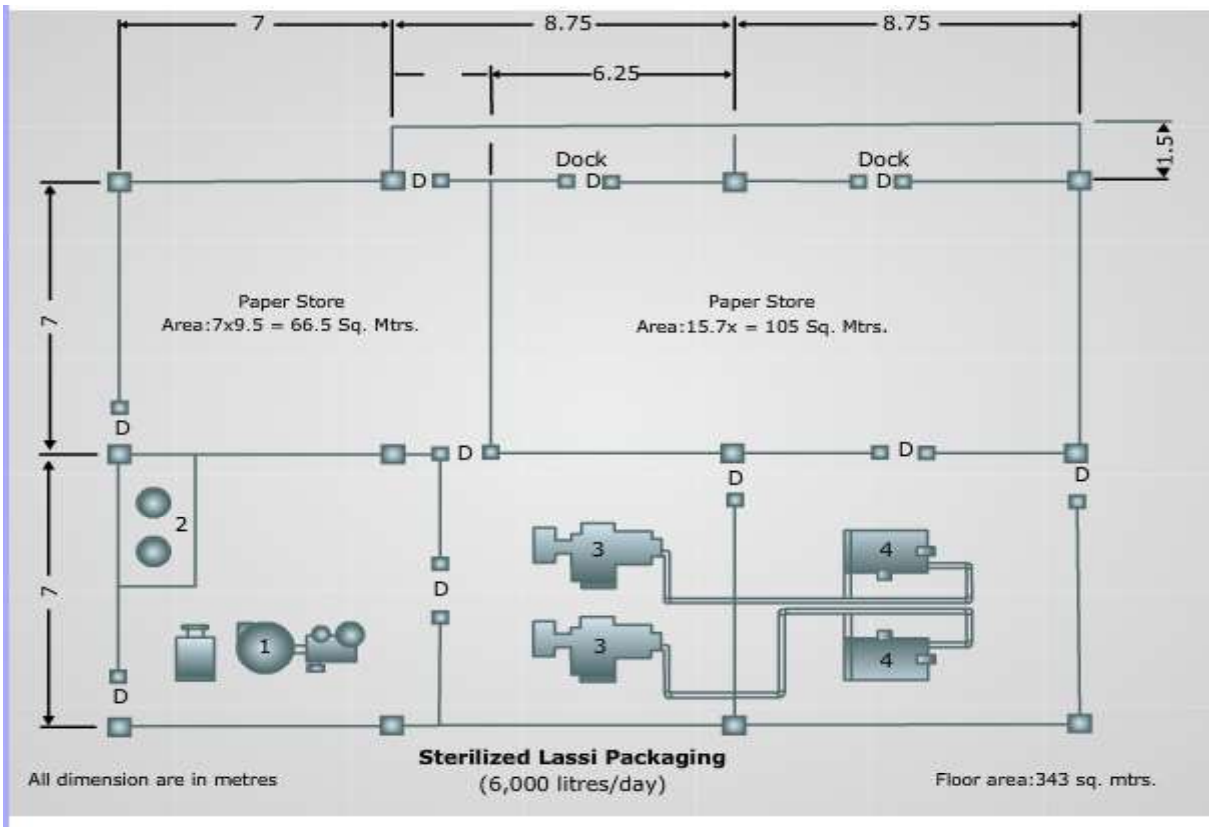

Fig. 16.5 Sterilized Lassi Packaging

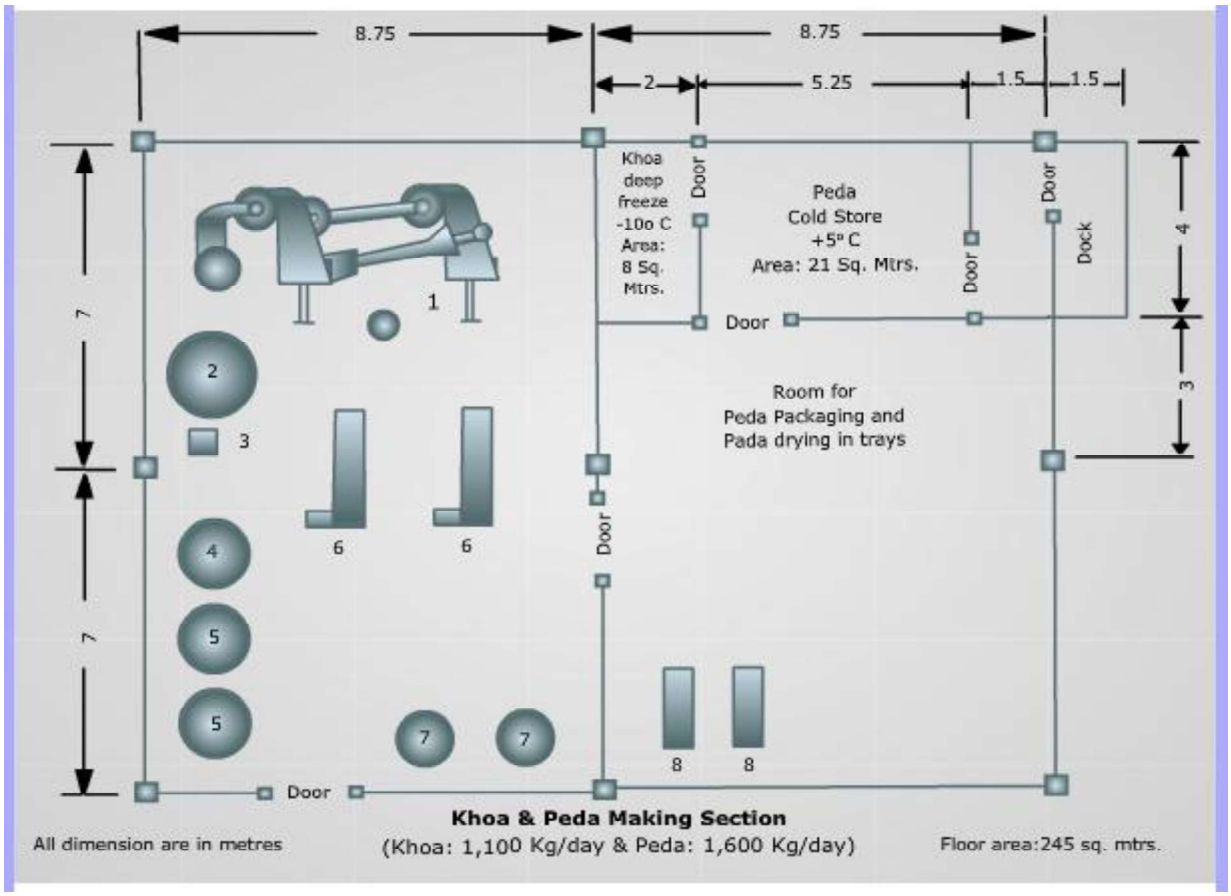

Fig. 16.6 Khoa & Peda Making Section

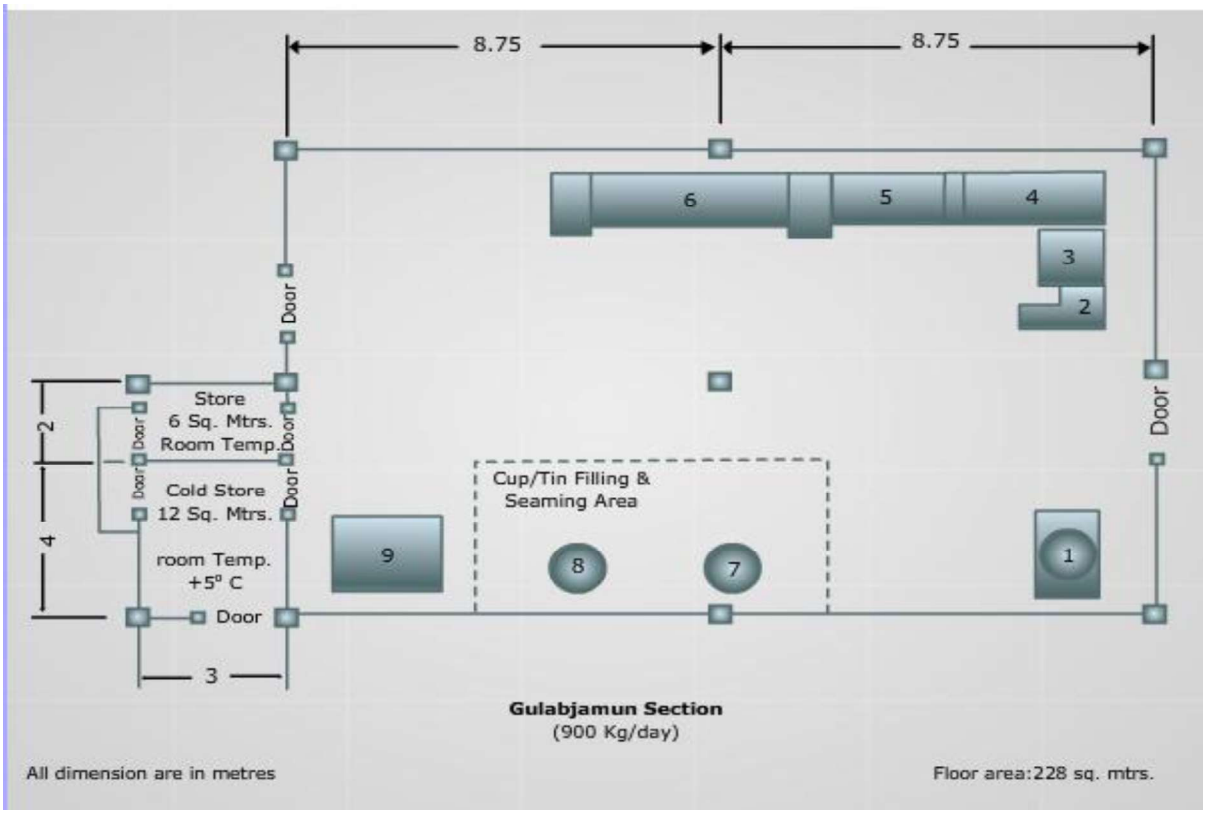

Fig. 16.7 Gulabjamun Section

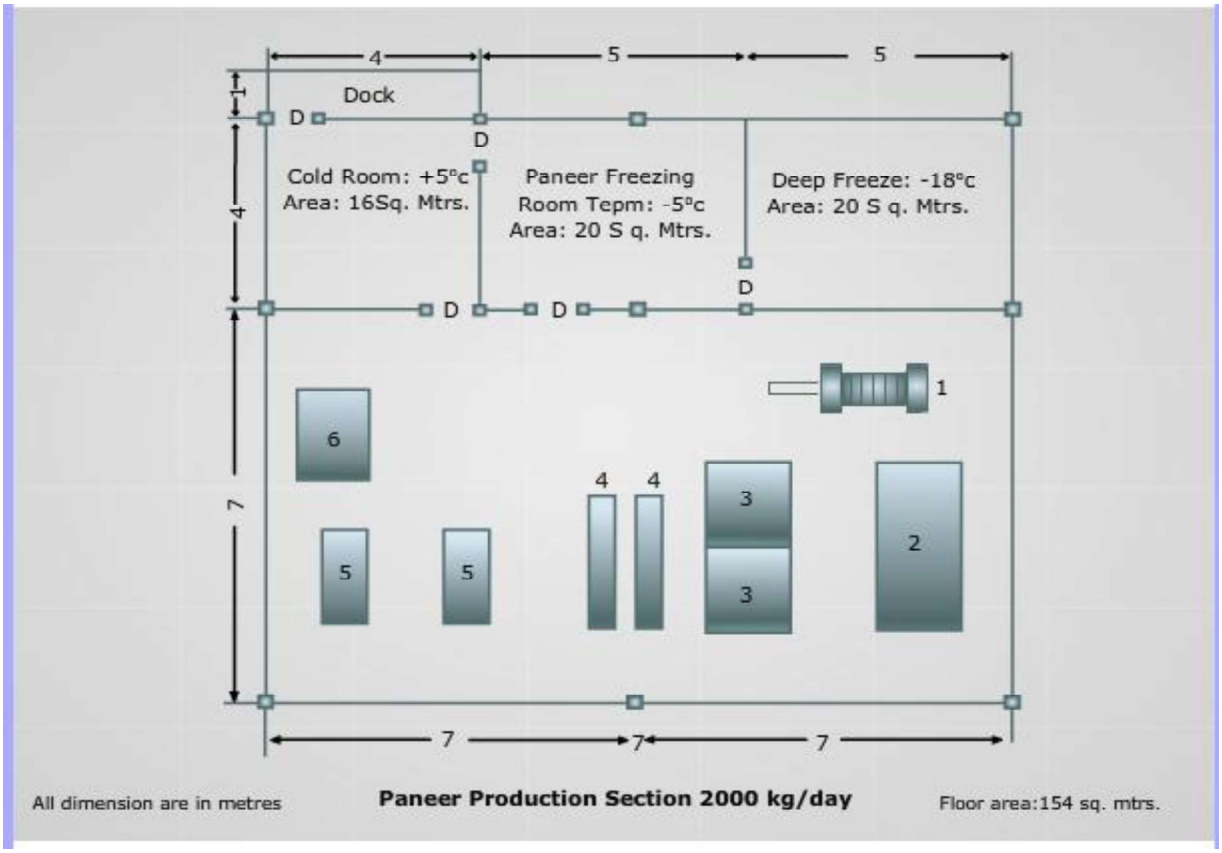

Fig. 16.8 Paneer Production Section

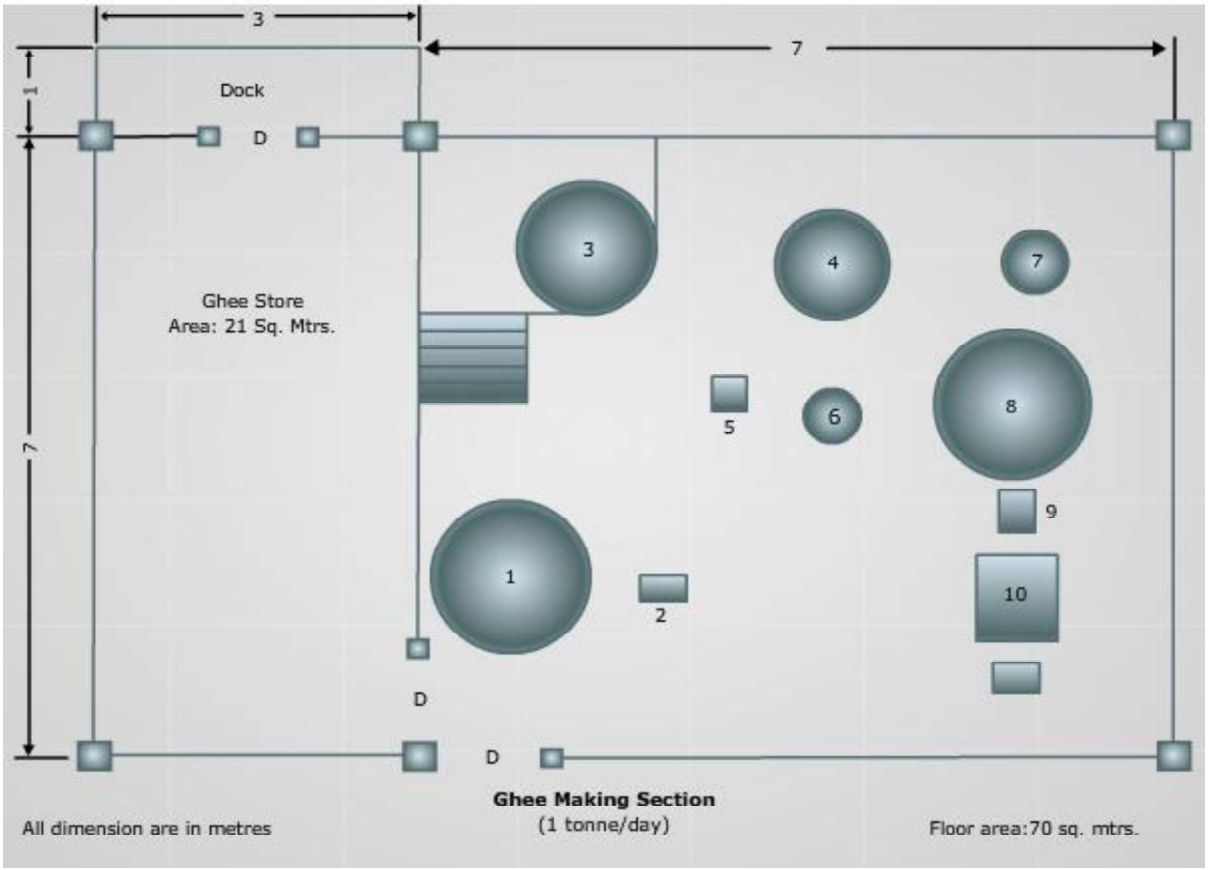

Fig. 16.9 Ghee making section

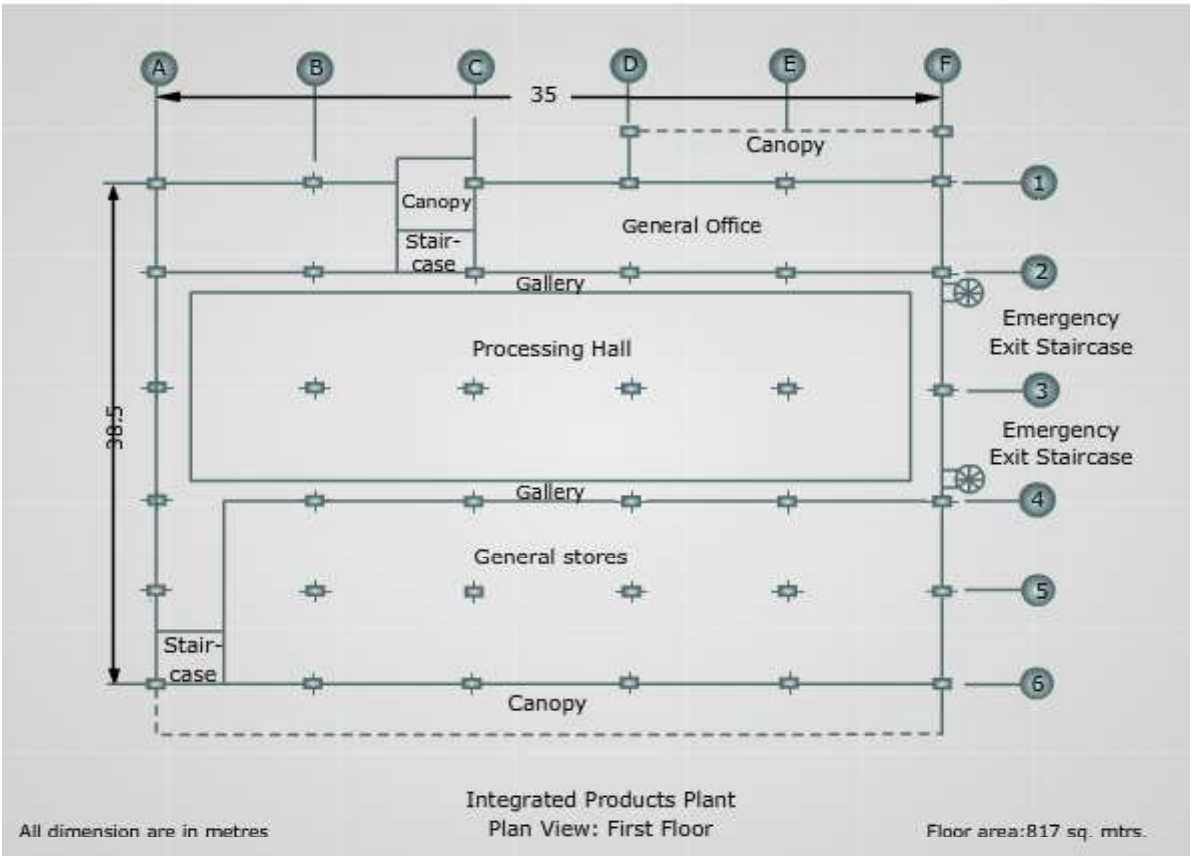

Fig. 16.10 Integrated product plant

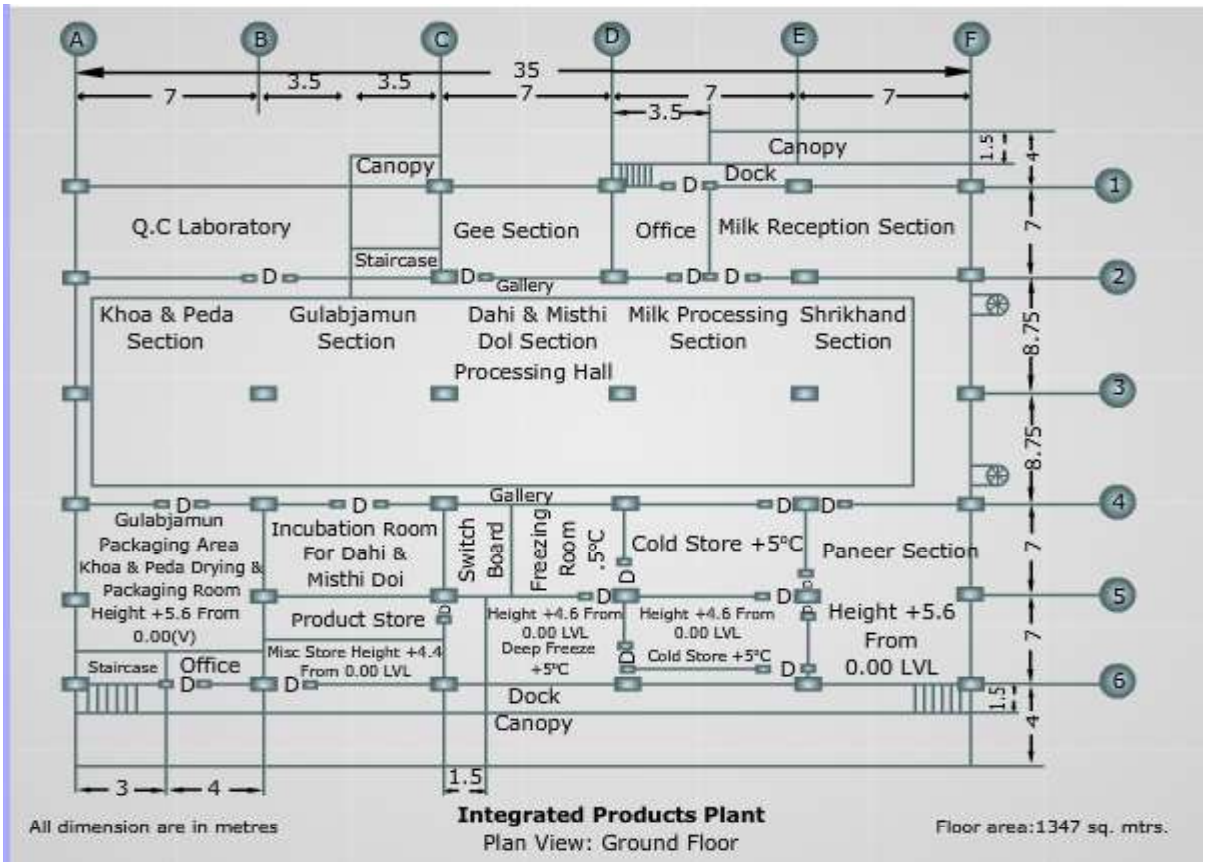

Fig. 16.11 Integrated product plant

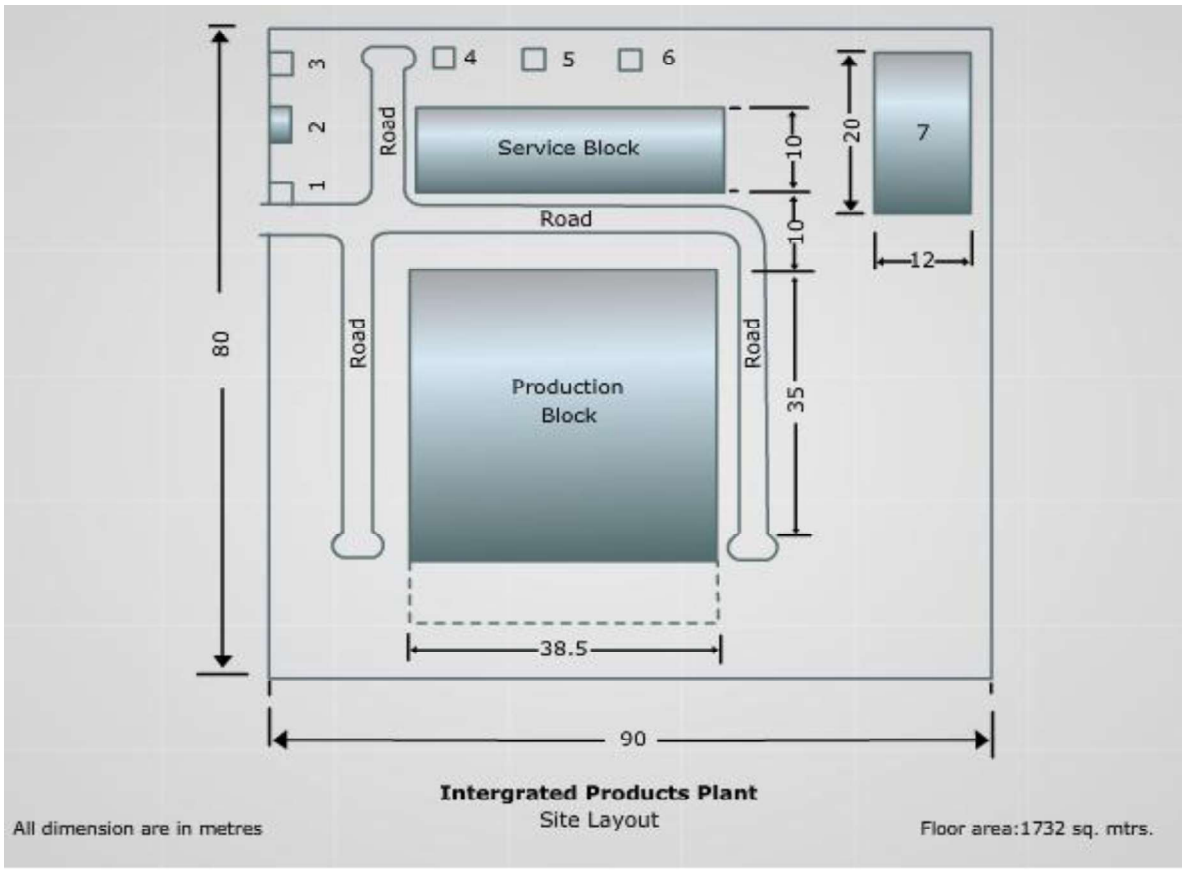

Fig. 16.12 Integrated product plant(Site layout)

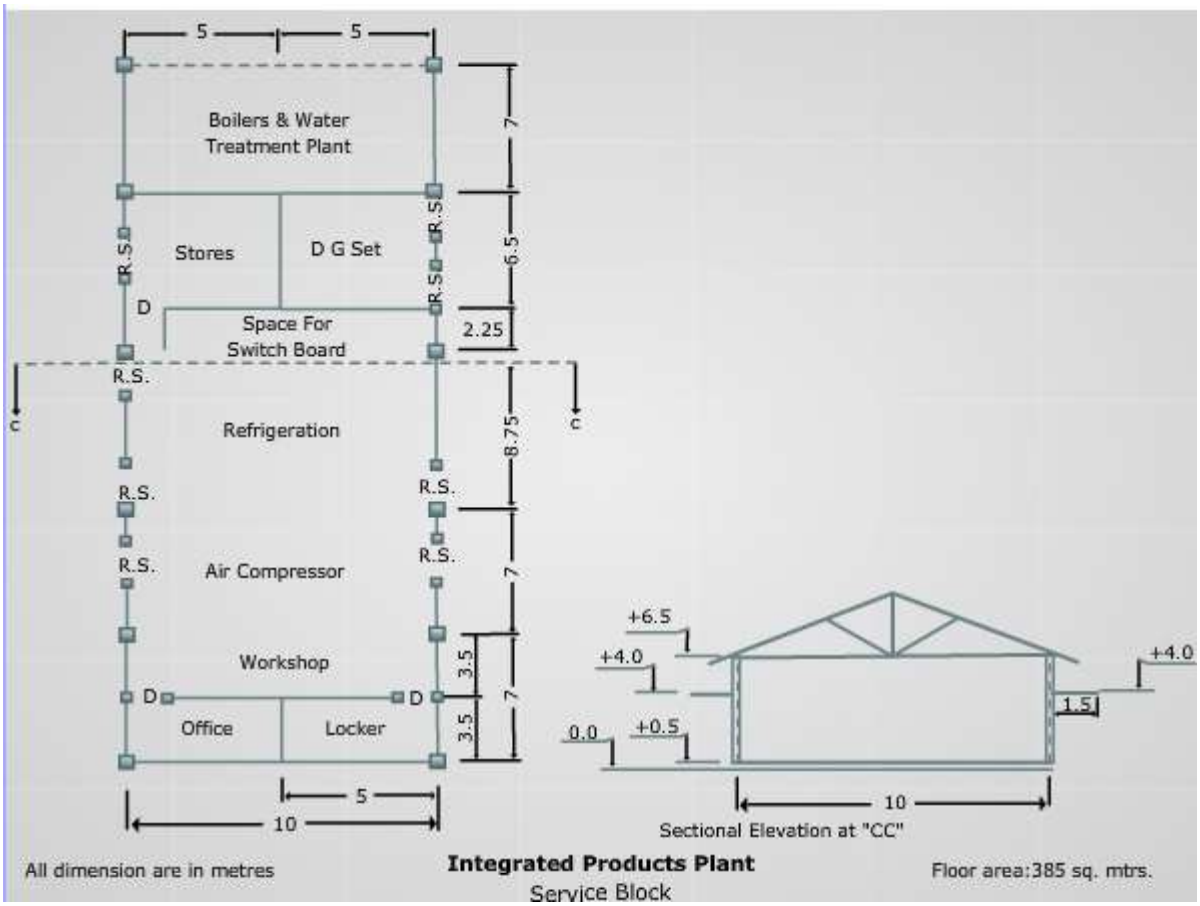

Fig. 16.13 Integrated product plant(Service Block)

****** ☺ ******

Lesson 17
Single or multilevel design

17.1 Introduction:

Single or multi level design of dairy plant is decided based on its capacity, type of products manufactured and provision for future expansion. The single story concept is used where plenty of land is available at cheaper rate, but if land is costly then multi level concept is used. In multi level dairy plant concept of super structure on beams and columns is used to have better strength and to facilitate future expansion. Multi level concept is also used for drying plants. In multi level dairy plants heavy machineries are generally installed at ground level and if required to be installed at other place then it should be provided by pillars up to ground level to transfer vibrations and impact load likely to come on it.

17.2 Selection of single or multi level building

The number of floors to be provided in the building obviously affects the planning of various sections and the area required. In considering this, it should be remembered as a general principle that it is preferable to keep heavy goods at one level and that liquids are easily pumped to high level and can flow back by gravity.

If the depth of the external drainage system, the nature of the site and the condition of the ground are suitable, a basement for the supply and distribution of services should be considered. Such an arrangement allows short, direct connections to the process equipment on the ground floor and eliminates the necessity for housing service pipes in the process room.

For small plants specializing in only one product, and where floor space required is relatively small, it is almost always cheaper to build in one level, this may also be the case for large single product plant. In other cases provided conditions permit, basement to house services will generally be an advantage.

The number of floors above ground which the plant should have depends to some extent on the scale and nature of the process, but mainly on the number of product ot be manufactured. However, small plants are generally of single storey even if several products are made. Only the storage tanks are at first floor level.

For medium size plant dealing with one or two products such as bottled milk and butter, it is more practicable to have the main sections on the same level. Only the tank room needs to be placed on an upper floor, partly to reduce length of the piping and also to avoid pumping treated with to the bottled machines. If the plant specializes in more than two products than the floor space required would be so large that it should be more economical to construct a two storey building. Some types of equipment require two storey operation, for example continuous sterilizers and spray driers.

Which sections are to be located on the various floors is a matter of practical business administration and the deciding factors include the extent of production and the transport of goods. It is assumed that the plant has a service basement which can also provide storage for packing materials and other commodities, as well as housing operational equipment.