

Lesson 1.

Types of Dairies and Perishable nature of milk

1.1 Introduction

Since India is the leading country in milk production in the world at a fast rate, it has been lead to a need of very scientific layout and planning for the dairies being set up by the dairy designers, engineers and architects. In some organized sectors, milk collection and chilling of milk is done, before it is transported for processing at dairy factory. 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 plant. 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.

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, cream, butter, ghee and similar products, cheese, milk powder and so on- are foods which play a fundamental part in human nutrition. Materials and methods 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 point 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 a need for highest standard of hygiene. Milk is most suitable medium for the growth of microorganism, therefore every possible measure should be taken to reduce the possibility of contamination, especially after processing. A good layout design and use of proper materials and techniques make great contribution towards hygiene. The dairy layout needs careful thought and planning keeping in view manufacture of the products and their commercial aspects.

1.3 Perishable nature of milk

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

- (i) Contamination with bacteria due to widely dispersed and unhygienic collection methods
- (ii) Warm temperatures of tropical climate
- (iii) 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 minimise these factors on the farm, during collection at milk plant and during distribution to consumers. At the farm, the aim must be to cool milk as soon as possible after milking. Ideally, the milk should be chilled to 4°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.

When the milk is drawn from the udder of the milch animals (cows, buffaloes, goat, sheep, etc.), the quality of milk is almost sterile. The milk has its own anti-microbial system present which is active till 2 to 3 hours of milking. The components in milk such as lacto-peroxidase system, immunoglobulins, lactoferrin, etc. have the anti-microbial effect. The perishable nature of milk comes into picture with the contamination from air, human, and milking utensils. The temperature of milk during milking is equal to body temperature i.e., 37°C. The milk being very rich in nutrients such as carbohydrates, fats, proteins, minerals, vitamins and water, becomes good media for the growth of micro-organisms. So the milk should be immediately sent to the dairies within 2 or 3 hours of milking, before it gets sour. If the dairy is very far away from the milk collection area, it should be chilled to below 10°C in the bulk milk coolers at the farm level (village co-operatives and/or chilling centres) so that the microbial activity is inactivated.

1.2 Types of Dairies:

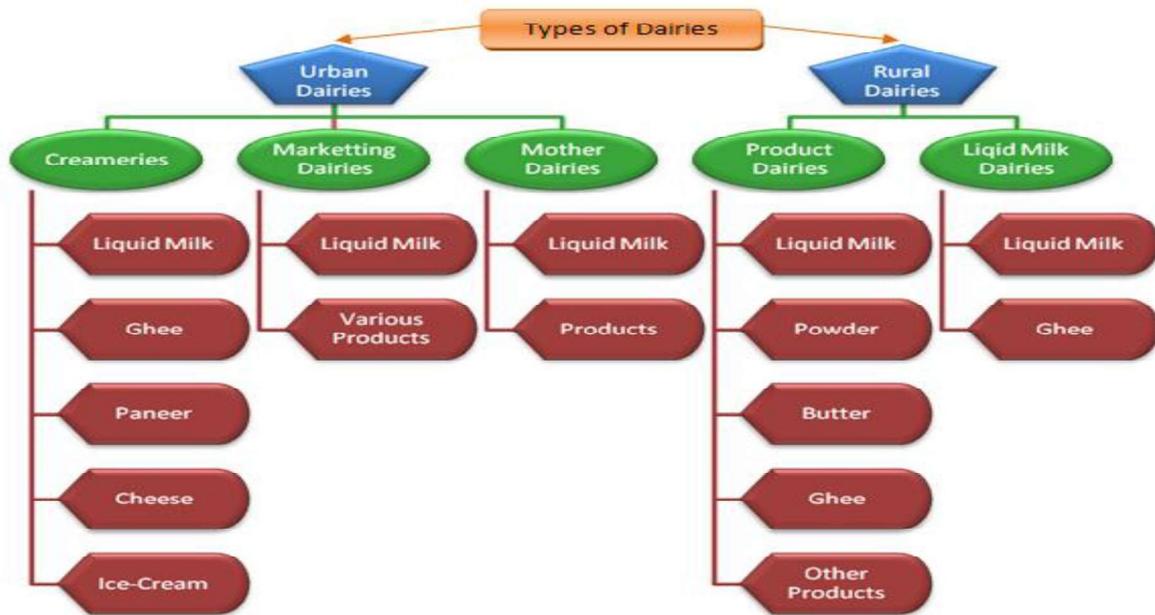


Fig. 1.1 Types of dairies



Lesson 2.

Importance of Dairy Plant Design

2.1 Introduction:

Dairy Plant design, involves the estimation of capacity, process scheduling and proper layout so as to achieve the objective of handling milk at the least cost and greatest safety. However, the dairy industry and the plant design has to meet certain special requirements and need to be focused on these. The following are the few aspects that make the dairy industry as a unique one.

Special Characteristics of Dairy Industry:

1. Perishable nature of milk: Milk is one of the most perishable of the agricultural commodities, and has only few hours of shelf life unless it is chilled and processed. Hence, the TIME factor is the most important aspect to be involved in the dairy plant design and lay out
2. Milk is an essential commodity. It provides nutrition especially to children and aged. Hence the dairy industry has a high profile in the society, and its functioning is very essential to the well being of the society.
3. Seasonal nature: The dairy industry has to deal with availability of raw milk fluctuations depending on the season. It is available in certain months, called Flush season when most of the calving and green fodder is available. During summer months, when milk availability dips due to most of the animals coming to end of their lactation period. Hence, OVER CAPACITY is the factor to be considered in plant design and layout, as the plant is to meet the peak procurement of the flush season, while in the remaining months it is having excess capacity. Also flexibility of the plant design and layout has to be considered.
4. Milk is a food item, which has to be consumed, especially by children and old people. Hence, PLANT HYGIENE is the important factor in plant layout and design.
5. Effluent disposal of dairy plant is essential as the volume and BOD value of the dairy effluent is high. Sufficient planning is required to handle this high volume of effluent to be handled by Effluent Treatment Plant (ETP).
6. Dairy Industry has to meet the various legal aspects and mandatory requirements. It has to meet the Industrial act, Labor act, Boiler act, Pollution control act. It also has to meet the HACCP and FSSAI guidelines.

2.2 Importance and economics of plant design:

The products of dairy industry i.e., liquid milk, yoghurt, curds/dahi, cream, butter, ghee, ice-creams, cheese, milk powders, shrikhand, traditional Indian dairy products etc. are foods which are very important for human nutrition. Therefore, it is very necessary that the milk and milk products should be available to everyone at the lowest possible rate. Also the profit margin that the dairy entrepreneur expects is limited. Therefore, the capital outlay of the building and plant should be economical. 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 maintenance, in spite of working conditions which are often relatively severe from both mechanical and chemical points of view. It should also be without stopping the production.

To extend the shelf-life some techniques like quick heating, quick cooling, acidification etc. are applied and also various advanced packaging techniques are used. The Dairy Technology starts with milk processing till the final products such as market milk and conversion into various products. So the subject Dairy Plant Design and Layout is the designing of layout plan for a dairy plant, i.e., layout for different sections in the dairy building, equipment layout, laying of dairy machines in such a manner that it allows efficient and economical movement of men and material in the plant in each section. The subject contains several applications of fundamental topics, such as locations site selection, building materials, specific requirements of each section including service sections.

2.3 Legal and commercial aspects of plant design:

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 to meet the requirement of Labor act. Ultimately, the dairy plant layout requires careful thought and planning keeping in view manufacture of the products and their commercial aspects. A sound layout engineering contains allowance for increase in capacity by arranging the production departments and selecting the type of building that can be expanded at low cost. It should be easy to increase the output capacity which may be required in the future. A floor arrangement that contributes to the low cost production planning and control are achieved in good plant layout. Material control and steady amount of production capacity can be easily attained with minimum idleness of machinery and man. Finally leading to the delivery of products in short notices can be achieved.

Safety and good working conditions are very necessary in a proper plant layout. Minimized hazards at the working stations, in material handling, storage, maintenance operations and so on are features of good plant layout. Minimum man hour losses, reduction in capital equipment and material losses incorporate improved working conditions. Increased employee moral tends to reduce production costs and helps develop a stable operating force.

In planning the building, several important factors have to be studied in detail before the plant could be developed to the stage of construction. The size of the building and the floor space to be provided depend upon the processes and choice of appropriate steps, numbers and associated equipment to be accommodated and the most important factor of rearrangement of facilities in the initially built building and provision for expansion of the building without costly modifications. A high degree of sanitation is necessary to ensure protection from contamination, odours, chemicals, organisms, etc. This includes the interior and exterior of the building and sanitary conditions of the environment. Simple pleasing design with high utility value without undue importance to architectural factors is necessary.

Civil Engineering aspects of plant design : The type and methods of use of civil construction is evolving day by day. New materials are being developed to meet specific requirements of industries. The planning of civil construction is very much related now to meet the requirements of HACCP and FSSAI acts, which are more stringent in nature. Structural modules of RCC Columns and beams gives good flexibility in the location of the equipment and layout of service lines. The height of the ceiling is another important factor. Plain smooth surface of the underside of the ceiling with embedded fixtures for lighting and pipe supports, etc. , into the ceiling is best.

2.4 Advantages of a good plant layout

1. A good layout reduces
 - a. the effort in normal material handling of a worker
 - b. cost of handling by direct labor and hence increased productivity per man hour and
 - c. indirect manufacturing cost by decreasing spoilage under difficult handling situation
2. It uses only essential space required and eliminate congestion and accident, permits flexibility for methods improvement and future expansion besides making supervision easier.
3. It also facilitates scheduling and despatching operation.



Lesson 3.

Milk Procurement

3.1 Introduction:

The wide range of milk procurement methods and handling has an affect on the plant design and layout. The method of milk procurement is also changing over the years. The recent trend of Bulk Milk Cooling at village clusters is altogether eliminating the procurement of milk by cans at the Dairy plants.

Lack of attention during procurement, processing and storage leads to decrease in the milk shelf-life. Quick chilling of milk should be done during the procurement if the dairy is far away from the Dairy Processing Plant and such milk is to be transported in bulk in insulated tankers to the dairies. In India, milk production is carried out in rural areas from where it is transported to milk processing plant. Thereafter distribution to consumers is done through depots and/or milk parlours.

3.2 Milk procurement:

In most of the countries, milk production is carried out in rural areas from where it is transported to milk processing plant. 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:

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

(ii) 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 affected by single co-operative society formed by milk producers. This is beneficial to the producers as there is no middle man to share profit.

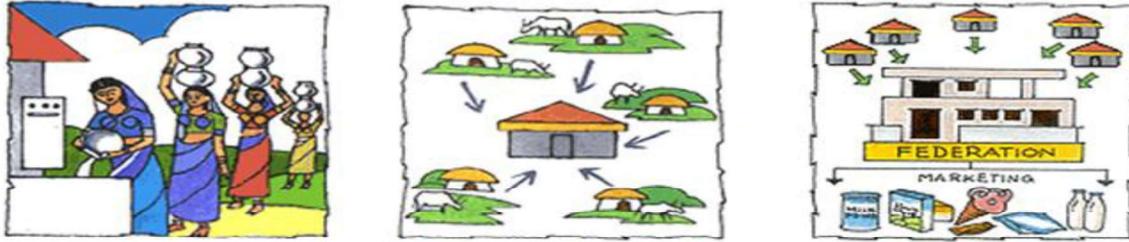
(iii) Milk procured through contractors: In this method the contractor supplying milk to the dairy plant collects the milk from producers at a cheaper rate and transports the milk to the dairy. Therefore, there is less return to the milk producers, as milk contractor will keep his share in the profit.

(iv) Milk reception from milk collection cum chilling centres: This method is generally possible and is prevalent in organized sectors, and dairy operations in India.

Milk is collected at various milk collection centres from nearby villages in 40 litre cans usually belonging to the organization. The milk is weighed, tested for fat content and kept ready to be dispatched to the milk chilling centre. From collection centre milk is picked up in an open truck and brought to milk chilling centre or dairy plant, where milk cans are emptied, washed through can washer and sent back to milk collection centres for next day collection of milk.

3.3 Three tier structure of 'Anand Pattern'

The Anand pattern for collection of milk, processing and marketing of milk and milk product is very popular for co-operative structure in Gujarat, and few other states. Fig. 3.1 shows three tier system of 'Anand Pattern'.



(i) The village level society, (ii) The district union, (iii) The state federation

Fig. 3.1 Three tier structure of 'Anand Pattern'

i) The Village Society

An Anand Pattern village dairy cooperative society (DCS) is formed by milk producers. Any milk producer can become a DCS member by buying a share and committing to sell milk only to the society. Each DCS has a milk collection centre where members supply milk every day. Each member's milk is tested for quality with payments based on the percentage of fat and SNF. At the end of each year, a portion of the DCS profits is used to pay each member a patronage bonus based on the quantity of milk poured.

ii) The District Union

A District Cooperative Milk Producers' Union is owned by dairy cooperative societies. The Union buys all the societies' milk, then processes and markets fluid milk and products. Most Unions also provide a range of inputs and services to DCSs and their members: feed, veterinary care, artificial insemination to sustain the growth of milk production and the cooperatives' business. Union staff train and provide consulting services to support DCS leaders and staff.

iii) The State Federation

The cooperative milk producers' unions in a state form a State Federation which is responsible for marketing the fluid milk and products of member unions. Some federations also manufacture feed and support other union activities.

The transportation of milk to milk collection centre by various methods has an important bearing on the quality and time constraints placed on the milk procurement.

Table. 3.1. Various modes of transportation of milk to collection centre

Mode	Optimum load (kg)	Optimum distance (km)
Head or shoulder load	5 to 10	2 to 5
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 rickshaw	100 to 150	10
Boat (for crossing rivers)	50 to 200	2 to 8



Lesson 4. Milk Reception

4.1 Introduction:

The objective of handling the milk as quickly as possible continues even at the milk reception, as the milk is still vulnerable to the spoilage, till it is chilled and taken into milk storage tank, and processed. The crucial stage of milk reception also involves the responsibility of checking the quantity, quality for acceptance, and the time management of handling many vehicles.

As mentioned earlier the timing is an important parameter while deciding about the mode of reception and transport. The load, distance to be covered and relative merits are given below in Table 4.1 and 4.2.

Table 4.1 Various modes of transportation of milk to the Dairy Plant:

Mode	Optimum load (kg)	Optimum distance (km)
Auto-rickshaws	250 to 500	15
Motor truck	3 tonnes	15
Road tanker	5 tonnes	100 or more
Rail tanker	5 tonnes	1000 or more

Table 4.2 Mode of transport and their corresponding advantage.

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

4.2 Reception at the Dock:

The milk as soon as it is received at plant, is weighed, dumped into the dump tank (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.

The reception of milk at the Raw Milk Reception Dock (RMRD) is done in three ways i.e., in cans, in milk tankers and combination of both. The type, size and number of vehicles can be determined by factors such as distance or nature of the roads and condition of milk production. In the chilling centres or BMCs, the milk is received only in cans (may be 40 lit or 20 lit capacity cans). In case of Marketing Dairies, the milk is received only in milk tankers where as in feeder dairies the milk is received in both cans as well as in tankers. The trend of establishing BMCs at village clusters has changed the mode of reception and monitoring of quality and quantity at Dairies.

There are some products that depend on the type of milk like cow and buffalo milk. Therefore, the reception dock may consists of two separate systems for cow milk reception and buffalo milk reception at chilling centres as well as in feeder dairy plants. In most of the dairy plants however, the milk is received as mixed milk.

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. All this 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.

4.2.1 Essential features of RMRD :

The RMRD dock should be of height suitable (usually 1.5 m) to receive milk from whatever mode of transport without spillage during unloading. For Milk tankers, the Tanker Bay must be spacious, suitable for washing and unloading at least two tankers at a time. The pump should be of 20,000 l/h capacity to unload faster. If the milk quantity is to be measured by weigh bridge, it should be properly calibrated and inspected periodically by local weights and measure authorities. If the quantity is to be measured by dip stick alone, then the tanker bay must be suitably leveled to avoid errors in measurement.

4.3 The important equipments for reception of milk processing plant on the RMRD are:

- Can conveyor: It should be of suitable type and length to transport easily the cans from the edge of the dock to the can tilting bar at the dump tank. The rate of reception and capacity of the dairy plant are also important in deciding about the type of can conveyor, like whether a Roller type or motorized chain conveyor.
- Milk weighing tank: The equipment involves a weigh bowl and dump tank. The capacity of weigh bowl should be able to weigh at least 4 cans, which may be an average quantity received from each village. Weigh bowl may be linked to indicate on a dial type of scale or through load cells in digital form of indication and recording
- Weighing scale: The weigh scale must at least be of 300 kg, so that the normal range of quantity of milk received from village is between 40 to 60% of the scale. The trend of digital indication through load cells are catching up, which has the advantage of recording as well as print out simultaneously, for easy monitoring and documentation. This is improving the confidence level between milk collection centres and dairy that is receiving the milk.
- Dump tank with cover: The capacity of Dump tank is at least twice the capacity of weigh bowl, so that while the milk quantity of one village is being weighed, the other quantity is being pumped out from dump tank to the

milk chiller. Recent trend is to link the level sensors and milk pump to get started and stopped when the milk level is high and low respectively.

- Drip saver: The drip saver must be of SS and should have drain leading to the dump tank, or to a separate can, which is emptied to dump tank from time to time.

- Can washer: The capacity of can washer should meet the rate of reception and dumping. Mostly Straight through can washers are chosen, and the empty can conveyor leads the washed cans to the dock or to the edge of RMRD to be loaded into vehicles.

- Milk pump: The milk pump used for pumping milk from dump tank to the plate chiller through in-line filter, should match the rate of reception. It is installed at a level lower than the dump tank and has flow control valve at the discharge side, The filter is sometimes located on the suction side to avoid threads, tags, etc connected with cans getting jammed into the pump impeller. The pump, in recent times is linked with control system to operate as per the level in the dump tank, to prevent overflow of dump tank or pump running dry by oversight of the operator.

- Plate chiller: The Plate chiller is usually of PHE type and used for chilling milk to 4°C. The Plate chiller is sized to meet the reception rate, and may sometimes be two in number, one each to receive milk by cans or road tankers. If the chiller is to receive milk from road tankers, the capacity is usually much larger, to meet the higher rate of reception to unload tanker rapidly.

- Raw milk silo: This is a vertical storage tank or a battery of storage tanks, that are specifically identified to store raw milk only. The silos can be located outside the processing hall, but connected to the hall through an opening called 'Alcove'. The operation of opening, closing of inlet and outlet valves, measuring the temperature, controlling the agitator etc are done from inside of the processing hall itself, though the silo is located outside. The tank overflow line will be positioned to inside of hall, so that the operator can know if the tank is full and overflowing.

- Milk testing laboratory: This is a preliminary testing laboratory, to perform so called Platform tests, like COB, acidity, turbidity, etc.

The Reception dock is essentially separated from the processing hall by partition doors, or walls, with fly proof devices like air curtains, or mesh doors. The trend now is to provide even the RMRD dock with provisions to prevent entry of flies and insects.

The crucial design calculations of the rate of dumping is illustrated by following example :

1. Milk to be received by Dairy Plant: 10,000 LPD
2. Milk to be received by AM and PM in the ratio of: 60:40
3. Milk to be received in the AM: $10,000 \times 0.60 = 6,000$ lts
4. Milk to be received in two hours
5. Milk reception per hour: $6,000 / 2 = 3000$ LPH

Hence the design of all the reception dock equipment will be to meet the above requirement of 3,000 LPH.