
UNIT 4 DAIRY PLANT DESIGN AND LAYOUT

Structure

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4.0 OBJECTIVES

After reading this unit we will be able to:

- 1 explain issues and concepts in design and layout of dairy plants, including various facilities, sections and equipment; and
- 1 describe food hygiene and sanitary requirements to satisfy GMP, MMPO and Codex criteria.

4.1 INTRODUCTION

Milk processing plants, converting raw milk into processed milk and /or milk products are usually termed as dairy plant or simply dairies. Numbers of unit operations are carried out to transform raw milk into value added finished products, employing all sorts of resources like raw ingredients, utilities (water, air, electricity, refrigeration, steam and waste treatment etc.), plant - machinery and human resource. All these resources are housed in one or more buildings located in campus. In order to optimize the economy of interactions between these housings and various resources, the various factors need to be considered in the planning stage. A good planning, therefore, helps in smooth flow of resources towards

effective operations to create hygienic atmosphere during production at one hand and economy of operation and value addition on the other.

In our country less than 15% of total milk production is processed in dairy plant in organized sector. Rest is either consumed at home or used in unorganized production centers like sweet makers. Most of the plants are underutilized. Especially during lean period the capacity utilization goes further down. Operation of unnecessary larger size plants and equipment becomes uneconomical due to more expenses for their operation along with other overheads, which depends on size and capacity of the plant and equipments. In this way, improperly design dairy plants require higher investment and working capital. Therefore, various factors that are relevant to design and layout of dairy plant, must be looked into.

4.2 CLASSIFICATION OF DAIRY PLANT

Precisely looking at the basic production features and core operations, dairy plants could be categorized as liquid milk processing plants, products manufacturing plants or combination of these two (Composite Dairy Plants).

- a) **Liquid milk Processing Plant:** In such dairy plant raw milk received at dock, is chilled, processed (pasteurized) and packed for sale. These plant directly procure milk from identified milk sheds or other sources. This type of plant has low value addition but the liquidity of money is very high. The liquidity is better because payment for raw milk is done after 7 or 10 days, whereas realization is either in advance or on the same day. Secondly, the realization money is circulated on daily basis creating an edge for low requirement of working capital.
- b) **Product Manufacturing Dairy Plants:** Raw milk is transformed into value added milk and milk products by employing suitable technologies and using proper equipment. Manufacture of value added products improve the profitability of the overall milk business. Other advantage lies in the conversion of perishable milk into long shelf life products. This aspect has high impact due to perishable and seasonal nature of milk production. Long shelf life products are also suitable for distant marketing.
- c) **Composite Dairy Plant:** Most of the dairy plants do have facilities for processing and packing of liquid milk and milk products. In this way, dairy plant can be benefited for high liquidity along with the advantage of increased shelf life and value addition. Such milk plants are more viable and sustainable.

4.3 PLANNING CONSIDERATIONS FOR DAIRY PLANT

Planning for dairy plant should consider following aspects:

- a) Forecasting for milk business with regards to milk procurement and marketing;
- b) Market analysis for product demand;
- c) Availability & requirement of land, topography to suit disposal of waste and communication;

- d) Analysis for requirement and availability of water; and
- e) No objection from municipal, pollution and aviation authorities.

Depending upon the status of above-mentioned factors, dairy plant of desired capacity could be designed for processing and production of selected products. Accordingly full considerations is to be given for selection of plant location, design and layout.

4.4 SITE LOCATION

The criterion, which has foremost operational importance, is minimum cost for procurement, production and distribution. Other essential factors which should favour the location include topography, shape and size of site, availability of water, power and fuel and, climatic conditions. However due to increased pollution and industrialization, all sites are not permitted for industrial work. Some states or central government give incentive for development of certain industry on specified locations. Therefore, all such points to be analyzed judiciously for finding out the best location.

4.5 ESTIMATION OF CAPACITY

Successful design of dairy plant largely depends on selection of facilities and equipment for appropriate handling of the various resources involved in the manufacturing of products. Therefore, one of the foremost step would be to estimate the capacity of a dairy and, ear- mark production of various products with capacity. Other requirements like equipment, utilities, structure and manpower will be function of the estimated capacity of dairy. Generally following main factors are taken into consideration:

- a. Milk shed area and its potentiality,
- b. Future possibility of expansion,
- c. Nearby dairy plant, its distance and expansion possibilities,
- d. Productivity of animals and future aspects affecting milk production,
- e. Connectivity of villages, possibilities for milk procurement and expected development,
- f. Social tendencies for milk business,
- g. Allied occupation of farmers and extent of their sustainability,
- h. Government policies for augmenting milk production,
- i. Change in life style, purchasing power of consumers and nutritional awareness among people.

4.6 SELECTION OF PLANT EQUIPMENTS

Some of the important points for deciding equipments are detailed below:

- a) Finalize the production technology,
- b) Find out number of equipments with their capacities,
- c) Finalize production line. Some plants have process sequence, whereas others are specific to products. Production line would be finalized according to the multiple use of processes and requirement of products having provision to get maximum benefits,
- d) Look at the cleaning and sanitary provision to allow maintenance, cleaning, disinfection, monitoring and inspection.
- e) The material of construction should be non-reactive, non-toxic and of food grade quality specially that coming in the direct contact of milk. It should be able to withstand heat treatment processes like heating and cooling. Materials of heat transferring equipment should be good heat conductors.
- f) Wherever necessary, equipment should have provision for controlling and monitoring of temperatures, humidity, airflow and other parameters which, otherwise would be considered as detrimental to food safety.
- g) Space requirement for equipment should be analyzed.
- h) Utility requirements associated with the product and equipment.
- i) Spacing between adjacent equipment and service pipelines to facilitate maintenance.
- j) Develop flow diagram to identify sequence of operations and flow of materials.
- k) Consider the housing requirement for each product and equipment. Some products need to be manufactured in controlled atmosphere and need proper building, whereas others manufactured within the equipment kept in open. Similarly some of the equipment requires proper housing and others need open air for their efficient operation.

In dairy industry you will find lot of examples to observe the above situations. For examples, ammonia condenser used in the refrigeration plant needs to be kept in open for maximum dissipation of heat, whereas milk vats need to be placed in the sanitary place with complete enclosure. While visiting a dairy plant one can have notice of such aspects.

- a) Find out economy of material handling by using natural or gravity flow.
- b) Find out operation economy by proper location of section or equipment. In other words, we should not place openings of low temperature or cold room directly facing to west if frequent openings are to be in the second half of the day. Similarly, openings or doors of high hygiene production area should not open towards the unhygienic area, without safety measure like air curtain or anti-room.

After giving full considerations to above aspects, next planning step would be to design establishment for production and other facilities.

Check Your Progress-1

1. What are the main planning consideration for a dairy plant?

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2. Name main Factors which influence dairy plant capacity.

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3. Write any five major factors for selection of dairy equipment.

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4.7 DESIGN OF ESTABLISHMENT

Manufacturing norms for Milk and milk products are covered under Essential Commodity Act like Prevention of Food Adulteration (FPA) and Milk and Milk Product Order (MMPO). After globalization under World Trade Organization (WTO) agreement, the manufacturing conditions can be looked with more stringent CODEX Food hygiene guidelines. Now with implementation of Food Safety and standards bill 2006 all food produces including milk products will have to meet its guidelines.

Depending upon the nature of the operations, and the risks associated with them, premises, equipment and facilities should be located, designed and constructed to ensure that:

- a) Contamination is minimized to safe level;
- b) Permits appropriate maintenance, cleaning and disinfections and minimize air borne contamination;
- c) Surfaces and materials, in particular those in contact with food, are non-toxic and if necessary suitable for easy cleaning.
- d) Where appropriate, suitable facilities are available for temperature, humidity and other controls; and
- e) Effective protection against pest access and harborage.

Attention to good hygienic design and construction, appropriate location, and the provision of adequate facilities, is necessary to enable hazards to be effectively controlled. In this context, each aspect of dairy is discussed below:

i. Location

Suitable location for the establishment and equipment should include following considerations:

a) Establishments

- 1 To prevent potential sources of contamination to food.
- 1 No food establishment should be located in the hazard prone site.
- 1 Location should be away from environmentally polluted area that can contaminate food, such as, flooded, waste and infestations of pest prone area

b) Equipment

- 1 Equipment should be properly located to permit adequate maintenance and cleaning.
- 1 The location facilitates good hygienic practices and effective monitoring.

ii. Premises and Rooms

Suitable consideration should be given depending upon requirement and nature of equipment:

a) Design and Layout: Where appropriate /applicable, the internal design and layout of food establishments should permit good food hygienic practices including protection against cross-contamination during manufacturing and storage.

b) Internal Structure and Fittings: structures within dairy establishment should be soundly built of durable materials and be easy to maintain, clean and /or disinfect. To achieve this, the surfaces of wall, ceiling and floor should be impervious and of non- food toxic materials. The surfaces should be smooth and allow proper removing of water, dirt and germs. The material of facilities or fittings coming in the direct contact of milk should be non-reactive type.

c) Temporary /Mobile premises and vending machines:

- 1 Premises and structures like stalls, mobile sales and street vending points as temporary housing should be sited, designed and constructed to avoid, as far as reasonably practicable, contaminating food and harbouring pests.

iii. Equipment and Containers

The design and construction of equipment and Containers handling milk and milk products should be given adequate consideration for cleaning, disinfecting and preventing food contamination. The contact surfaces should be made of materials with no toxic effect in the intended use of food. Design of equipment should facilitate easy movement and capability of disassembling to allow maintenance,

cleaning, disinfecting, monitoring and inspecting pest. Other important requirement of processing equipment is to withstand processing condition without affecting food safety aspect. The equipment should have provision and capability for monitoring and control of process parameters. Containers for waste, by-products and inedible or dangerous substances should have specific identification, safe design and placement at appropriate location. Required safeguard should be made to prevent cross contamination from these containers or their contents.

iv. Design of Facilities

Dairy plant has to be provided with required facilities for water supply, drainage /waste disposal, cleaning system, personal hygiene, toilets, humidity, air and temperature control, lighting and storage of various materials. These are discussed below:

- a) **Water Supply:** An adequate and potable water supply with appropriate storage, distribution and temperature control, should be available whenever necessary to ensure the safety and suitability of food. Supply and storage line for non-potable water should be separate with proper identification. This requires proper selection of source of supply, pumping, storage and treatment units.
- b) **Drainage and disposal system:** Adequate sanitary condition in and around plant can be maintained by proper arrangement for types of drains with cleaning and dis-infection arrangement. Slope of floor and drains is of equal importance to let-out the spillage and washings.
- c) **Cleaning:** Cleaning of plant premises and equipment should have provision in the planning stage itself. Proper clearance and facilities need to be considered. When manual cleaning is either not possible or less effective, then alternative methods like cleaning –in-place should be employed.
- d) **Facilities for Personnel Hygiene:** In order to prevent cross contamination from machine and materials to man and vice versa, required arrangements should be thought for necessary equipment, space and water supply. Good dairy plants have provisions of cloth changing and hand washing and drying. Other requirement relates to minimizing human contact with product. For this, most of the works are done by equipment and tools like trolley and shovel etc.
- e) **Temperature Control:** Most of the dairy operations are temperature dependent. Heating, cooling or holding at certain temperature is required to obtain product of good microbial quality, flavor and texture. For this steam supply unit, refrigeration unit and temperature recording, monitoring and controlling mechanism are provided.
- f) **Air Supply System:** Adequate air supply system should include compressor, inter-cooler, oil separator, air filters and drier /humidity controller. Air pipe line is provided to meet operation requirements of agitation, oxidation, control and / or conveying function. If air comes in direct contact of product, then its proper hygienic quality should be ensured.
- g) **Lighting:** Design should consider availability of adequate natural light. However provision of artificial light needs to be made according to the requirement of operation. A minimum illumination requirement in lumen per square meter for functions like reception, processing, cleaning is approximately 500 to 600,

monitoring places like weighing, equipment with gauges, filling & inspection, laboratory and accounting is approx. 1000 and for common places like corridor and utility section is 200 to 300.

- h) Storage:** Adequate facilities should be provided for the storage of food, ingredients and non-food chemicals (e.g. cleaning materials, lubricant fuels). Appropriate, food storage facilities should be designed and constructed to permit adequate cleaning and maintenance, avoid pest access and harbourage, enable food to be effectively protected from contamination, and provide proper environment that minimizes the deterioration. Storage of edible, non-edible and hazardous materials should be separate.

v. Space Consideration

Space requirement for facilities and equipment varies from make to make and model to model for a given capacity. Functional areas or rooms in a plant must not be crowded or sized far larger than necessary. Therefore, the structure and civil arrangement is made precisely, one has to either select specific model /make process /product line or has to approximate the requirements. In the first type of arrangement, selected supplier may be requested to detail the space requirement. However, the planning of a dairy is done in advance before selection of a particular equipment /model or manufactures; hence, for effective planning , one has to depend on certain guidelines, which are given below for general purpose:

1. For a medium size milk plant, the area should be 2 to 3 sq.m per 100 litres of milk, whereas for small plant of less than 10000 Lit.per day, space requirement will be approximately 6 to 7 sq.m per 100 lit. milk.
2. Approximately 75000 lit milk can be stored in 200 sq.meter area cold store.
3. Approx. 50 kg ghee or butter can be stored per sq.meter area.
4. 750 Kg milk powder in 25 kg bags would require approx. one sq.meter storage space.
5. Dry storage area should constitute approx. 25% of the total plant area.
6. Refrigeration and steam boilers each requires approx. one fifth sq.m per 100 lits milk
7. Processing area should be five times the size of equipments
8. At-least one meter space is considered good between two equipment.
9. If floor area available is insufficient, then vertical type of storage tanks /vessels should be preferred. Now for storage of chilled water, insulated silos are becoming popular, which requires less space and can be installed outside of plant. Similarly, milk storage tank can be kept outside of the constructed building.
10. While considering the requirement of hardening room, a minimum of five days production would be required.
11. Milk reception, storage tank and product sections require approximately 10% of the plant area. CIP, Laboratory, personal hygiene and rest room etc.

require approx. 2 to 3 %, whereas processing, packaging and cold store would require 15 to 20% of the plant area.

4.8 PLANT LAYOUT

Dairy functions and equipments require number of considerations. Therefore, best match of these considerations would give optimum layout to allow smooth plant operations without hindrance and cross contamination at economical cost. While finalizing the layout plan, future expansion of facilities and product line also need to be kept in mind. The ideal layout permits production of new product or modification in production system at the least possible expense and interruption in production schedule.

Good plant layout has short pipeline, least number of bends. As far as possible, sequencing of equipment should follow the process layout. Plant machinery should be placed apart at sufficient distance to allow movement for cleaning, operation and monitoring. Minimum holding of product during production is another aspect of consideration. Least possible stock of intermediary or in-process and finished item should be present on the production floor. The premises should allow use of the material handling equipment. Development of good layout should fulfill following objectives:

- a. Improve or facilitate production operation,
- b. Minimize material handling,
- c. Have flexibility of operation for alterations and expansions,
- d. Minimize investment in equipment,
- e. Economize use of floor area,
- f. Make labour utilization effective,
- g. Make effective utilization of by-products,
- h. Provide convenience and comfort for employees,
- i. Ensure proper cleaning, operation and monitoring of processes, and
- j. Prevent cross contamination.

The above points can be planned according to the type of layout. In multi purpose production system, product layout is preferred, whereas specialized production needs process oriented layout. Depending upon the requirement and nature of production, each function should have their optimized layout. All such individual layouts then be integrated to provide comprehensive dairy plant layout meeting the above mentioned objectives.

Your answer should include the following points:

Check Your Progress - 2

1. What is expected from a good design of establishment, Give main five objectives?

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2. Write any five major factors for selection of dairy equipment.

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3. What do you understand by plant layout?

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4.9 LET US SUM UP

Dairy plants employ varieties of plant equipments depending upon operations for manufacturing of milks and milk products. Some of the crucial factors like Perishable nature of milk, requirement of hygienic production, fluctuation in milk procurement and marketing and heavy initial investments need thorough consideration. While meeting all the production requirements, plant can be designed to result smooth operations, quality products and flexibility for modification at the least expense. The use of available local and natural resources also economize the profitability of dairy plants. Optimal benefits from regulatory and commercial provisions should also be incorporated in the design process.

4.10 KEY WORDS

- Design** : To make preliminary sketches of; plan or to plan and workout something creativity, device.
- Layout** : The manner in which anything is laidout, arrangement.
- Location** : An area marked off for a specific purpose.
- Plant** : The equipment machinery building etc. of a factory or the apparatus for certain mechanical operation.
- Dairy** : A commercial establishment that processes and distributes milk and milk products.

Premises	: The property so mentioned.
Equipment	: Machinery used for processing operations. Whatever one is equipped with, supplies, furnishes, apparatus etc.
Machinery	: Any means by which some thing is kept in action or a desired result is obtained.
Facilities	: Processing supports required or the means by which something can be done.
Storage	: Keeping of items or products in appropriate environment.
Establishment	: Plant premises required for housing all the plant activities including plant & machinery.
Milk-shed	: Area identified for milk procurement
Procurement	: Collection of milk
Milk Products	: Preparations from milk that are required for the consumption of dairy or consumers.
Food hygiene	: All measures necessary to ensure the safety, soundness and wholesomeness of food.
Cleaning	: The removal of soil, food residues, dirt, grease or other objectionable materials
Hygienic	: Promoting health, sanitary.
Container	: A thing for containing something, box, can , jar, vessel etc.

4.11 SOME USEFUL BOOKS

Arthur W.Farrall, 967, Engineering for Dairy and Food Products, Wiley Eastern Private Limited South Extension, New Delhi-3

BIS, New Delhi 11002. IS 15000:1998, Food Hygiene – General principles - Code of practice (second Revision),

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4.12 ANSWERS TO CHECK YOUR PROGRESS

Your answers should include the following points.

Check Your Progress – 1

1. Main planning considerations include:

- 1 Estimation for future trend in milk procurement and marketing
- 1 Market analysis for product mix and demand
- 1 Availability & requirement of land, road and other communication
- 1 Requirement and availability of water
- 1 Suitability of business with respect to profitability, statutory and legal norm.

2. Following factors mainly influence plant capacity estimation:

- 1 Milk shed area with respect to its potentiality
- 1 Future possibility of expansion
- 1 Nearby dairy plant, its distance and future expansion possibilities,
- 1 Productivity of animals and status of future strategies.
- 1 Connectivity of villages and expected development in the area.
- 1 Social habits and consumption pattern in the milk shed area.
- 1 Allied occupations of farmers, extent of their sustainability,
- 1 Government policies for augmenting milk production,
- 1 Change in life style, purchasing power of consumers and nutritional awareness among people

3. Following five are among major factors needs to be considered while selected dairy plant equipment:

1. Type of production line, process sequence and nature of lay-out process or product.
2. The cleaning and sanitary provision and requirements.

3. The material of construction to suit the product and production
4. Provision for controlling and monitoring of facilities like temperatures, humidity, airflow and other parameters, which can be considered as detrimental to food safety.
5. Space requirement for equipment and availability.

Check Your Progress - 2

1. Five main objectives that a properly designed establishment should fulfill include followings?
 - 1 Contamination is minimized to safe level and effective protection against pest access and harborage
 - 1 Permits appropriate maintenance, cleaning and disinfection and minimise air borne contamination;
 - 1 Surfaces and materials, in particular those in contact with food, are non-toxic and if necessary suitable for easy cleaning.
 - 1 Where appropriate, suitable facilities are available for temperature, humidity and other controls; and
 - 1 Ensure productivity of operations.
2. A good layout should fulfill following objectives:
 - 1 Improve or facilitate production operation,
 - 1 Minimize material handling,
 - 1 Have flexibility of operation for alterations and expansions,
 - 1 Minimize investment in equipment,
 - 1 Economize use of floor area,
 - 1 Make labour utilization effective,
 - 1 Make effective utilization of by-products,
 - 1 Provide convenience and comfort for employees,
 - 1 Ensure proper cleaning, operation and monitoring of processes, and
 - 1 Prevent cross contamination.