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Market milk industry---
Processing of the market milk (part 1)

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Milk is one of the most precious natural materials and has been a basic component of human food for long time. It is one of the oldest foods and at the same time the most important one. Milk is the most nutritious food and considered as most complete food. It contains all the nutrients required for the growth of any living organism. The milk obtained from cow or buffalo when presented in the form that can be salable is termed as market milk. The milk obtained from the animal is termed as raw milk. The milk then undergoes various stages of processing before it reaches the consumer in the form of liquid milk. This episode deals market milk under the following subheadings.

Collection of milk
Reception, platform testing
Stages of milk processing
- Filtration
- Homogenization
- Pasteurization

Description and working of
- Clarifier
- Cream separator
- Homogenizer and
- Plate heat exchange

Collection of milk: Milk is the most perishable food which needs to be collected and stored in chilled conditions (i.e. below 5^0C) to retain its original quality for longer period. In India, milk is collected in cooperative system which works on 3 tier system. i.e, Society,Union and Federation. The collection centers at villages forms the societies. The milk unisons in a geographical state forms Federation. i.e. the societies are controlled by unions and they are monitored by the Federation. The society is formed at village level where the farmers can give the milk to the society. The milk is collected from the farmers and the quantity is measured. A

sample of milk is taken out for testing the quality of milk for its fat and solids- not – fat (SNF) content.
The payment is made to the farmer based on the fat and SNF content of the milk that he/she has given to the society. The milk is collected twice a day (morning and evening). Milk is collected from the societies and transported to the chilling center for chilling of milk, where it is further processed. Thus milk reaches the chilling center within few hours of milking.
At the chilling center or milk processing center, the milk is tested for organoleptic qualities and platform tests are conducted to check the presence of adulterants and/or preservatives. The detection of adulterants and preservative are done by simple and instant chemical tests which qualitatively show the absence or presence of the additives. The common additives that are tested are sugar, starch and urea while the common preservatives those are tested are sodium bicarbonate and hydrogen peroxide.

Platform Tests: the milk which is free from dust and other materials is smelled to judge its freshness. Doubtfulmilkfrom the can is taken into a test tube (about 5 ml) and heated over a flame to boil. If any flakes are seen in the boiled milk, the milk is said to be positive for Clot – On - Boiling (COB) test. This indicates that the milk is old, has become sour and unfit for processing. Such milk will be rejected for processing. Milk is tested chemically for the presence of neutralizer to confirm its presence. Similarly milk is tested for presence of any additives like starch, sugar, urea or any other additives. The milk containing additives and neutralizers will be rejected for processing.

Stages of Milk Processing:

Filtration: the milk after organoleptic and platform tests, is filtered through muslin cloth and online filters to remove all visible extraneous matter present in raw milk. To remove the invisible extraneous particles, clarifiers are used which works on the centrifugal force. The design and principle of operation of clarifier is similar to the cream separator which is explained later. The main difference between clarifier and cream separator are: the clarifier will have only one out let for clarified milk while the cream separator will have two outlets, one for cream and another for skim milk. The clarifiers work at lower RPM compared to cream separators and the separating discs are smaller in clarifier to house more amount of sludge.

Chilling: After receiving the milk,it is filtered using filter cloth and is immediately chilled to less than 5^0C. The microorganisms grow well at room temperature and bring about undesirable changes in milk and also make the milk sour within a short

period of 2 to 3 hours. The chilling of milk to less than 5^0C controls the growth of microorganism and thus helps in retaining the freshness of milk for longer period (i.e. more than 18 – 20 hours).

There are various methods of chilling the milk. For small quantities, the bulk milk coolers and can coolers are used. In bulk milk coolers, the fresh raw milk is poured into a double jacketed vat and the refrigerant or chilled water is circulated between the jackets and the milk is kept agitated at very slow RPM till the temperature of the raw milk reaches below 5^0C. The milk is chilled to less than 5^0C in about an hour. This type of cooler is used when the quantity of milk chilled is about 5000 litres. If the quantity of milk to be chilled is about 1000 litres, generally can coolers is suggested. In this type of coolers, the cans with milk is immersed in chilled water tanks where the chilled water temperature is maintained at less than 4^0C.For more than 5000 litres, plate heat exchangers are used. In plate heat exchangers the milk is instantly chilled to desired temperature.

After chilling, the milk is pumped into insulated storage tanks. The milk is then standardized to desired fat and milk solids not fat (SNF) levels to the legal standards before it is pasteurized. The legal standard for market milk is given in **Table 1**. The fat in milk is reduced to desired level by separation of milk. The storage tank capacities varies from 10,000 litres to 1,50,000 litres.The storage tanks are equipped with thermometer, agitator, manhole for cleaning the tanks manually, and view glass to know the volume of the milk stored.

Standardization of milk:

The representative sample of the milk from the storage tank is taken and the fat and SNF content is estimated. Then, fat and SNF content in the milk is adjusted to desired level by using Pearson Square method. The fat and SNF is adjusted to supply uniform quality of milk to the consumers throughout the year and mainly to meet the legal standards.

Plate Heat Exchangers: A popular heat exchanger for fluid of low viscosity, such as milk is the plate heat exchanger, where heating or cooling fluids flow through passages between alternate plates, while the milk to be heated or chilled flow through the remaining passages of alternate plates. The heating or cooling medium and the milk are pumped in opposite directions for efficient heat transfer. The PHEs are generally used in chilling units and continuous type pasteurizers (High Temperature Short Time pasteurizers). The main advantages of PHEs are: high energy efficient, occupies less space, compact and simple, easily cleanable by cleaning-in-place system, capacity can be increased by addition of plates, and hygiene and sanitary method of processing. The gaps between the plates are

packed with gaskets to avoid leakage of the milk and the heating/cooling medium. The plates are corrugated to increase the surface area for heat exchanger and provide turbulent flow of the milk. The turbulent motion of milk helps in bringing every particle of milk to the surface so that they are instantly heated or chilled. The diagram of PHE and flowof milk and the heating/cooling medium is shown in Fig 1.

Cream separation: The raw milk that is received from villages will have varied percentage of fat and SNF. The fat content of the milk has to be at standard level as per the legal standards **(Table 1).** The excess fat present in the milk has to be removed. The fat is removed instantly from the milk by using cream separator. The cream separator works on the principle of centrifugal force. Centrifugation may be defined as a unit operation involving the separation of immiscible materials by the application of centrifugal force. The difference in density of fat (0.930) and skim milk (milk without fat component) (1.030) is taken into advantage for separating these two components of milk. In a centrifugal separator, milk is separated in disc type centrifugal machines that employ force from 5 to 10 thousand times that of gravity.The cream separator has two main parts i.e. separating bowl and driving mechanism which make the bowl to rotate at a fixed speedwhich may vary from 5000 to 10,000 rpm. The design of the centrifugal cream separator is shown in **fig.2 and fig 3**.

The milk will enter the interior of the bowl from the central tube to the bottom of the rotating bowl into the distributor. Under the influence of the centrifugal force the lighter fat globules travels inwards towards the axis of the centrifugal (center) of the rotation and the heavy phase i.e, skim milk moves outwards towards the wall of the bowl.

The fat along with a small portion of milk called cream is collected through the cream outlet similarly, the milk without fat (called skim milk) from the gap of the discs is collected at the end of the discs moves upwards and above the top disc and collected from another outlet called skim milk outlet. Thus, the flow of cream and skim milk is separated by the neck of the top disc. All the fat that is present in raw milk is separated into cream and the skim milk will have only traces of the fat that escapes the centrifugal force during separation.The maximum fat content in well operated cream separator will be less than 0.1%. The cream separator is said to be efficient when the fat content in the skim milk is less than 0.05%.

Conditions for separating milk are:

The temperature of milk should be between 35 to 40^0C

The flow of milk into the bowl should be uniform

The flow should be smooth and there should not be any vibration during operation.

The cream separator should be switched on atleast 4 to 5 minutes before feeding the milk into the bowl to attain the maximum speed of bowl rotation

The milk is forewarmed to about 35 - 40^{0}C before it is fed into the cream separator so that all the fat in the milk will be in liquid form and the difference between the densities of milk fat and skim milk will be maximum. the density of milk fat is 0.93 while that of skim milk is 1.030. The difference in the densities is made use in separation of milk fat in the form of cream by using centrifugal force which makes the fat move towards the axis of rotation, accumulates and collected separately. The skim milk which is heavier than milk fat move away from the axis towards the periphery of the rotating bowl and collected separately as skim milk having no or traces of milk fat in it.

Pasteurization: Pasteurization is a process of heating every particle of milk to a specific temperature for a specific period and immediately chilling to less than 5^{0}C so as to make the milk safe for consumption. The primary purpose of pasteurization is to kill all the microorganisms capable of causing diseases (pathogenic bacteria). The *mycobacterium tuberculosis* is taken as indicator pathogenic bacteria for checking the efficiency of the pasteurization since it is the most resistant pathogen that is likely to present in the raw milk. The time-temperature combination for pasteurization of milk is fixed on the destruction of *Mycobacterium tuberculosis* and *Coxillaburnetii*. These pathogenic bacteria are destroyed at temperature-combination of 60^{0}C for 15 min or 70^{0}C for 12 to 13 seconds.

There are two types of pasteurization:

Holding method: Low Temperature and Long Time (LTLT) type - wherein milk is heated to 63^{0}C for 30 minutes

Continuous method: High Temperature Short Time (HTST) type - where in milk is heated to 72^{0}C for 15 seconds

Holding method: In this method, the milk is heated or cooled in batches. The milk is taken in double jacketed vat and the milk is heated to 63 - 65^{0}C by circulating hot water in the jacket, and held at that temperature for 30 minutes. The milk is finally cooled to 5^{0}C by circulating chilled water in the jacket. In some vats the heating and cooling of milk is done by using PHEs which is more efficient than circulating method. The batch type pasteurizer is shown in **fig. 4.**

Continuous method: This type of pasteurization involves high temperature short time (HTST) process in which the milk is heated to a minimum temperature of 72^0C with a holding period of just 16 seconds before it is cooled to less than 5^0C.

The raw milk first enters a balance provided with a float valve which controls the flow of milk into the pasteurizing unit. A centrifugal milk pump pumps the milk into the regeneration section PHE where the chilled raw milk passes in alternate gaps in the PHE. Then the milk enters the final heating section where the milk is heated to final temperature of 72^0C. After heating, the milk passes through a holding tube where the milk is held at the temperature for 16 seconds. The length of the holding tube is such that the hot milk takes 16 seconds to travel through the tube. At the end of the tube a unit is fixed which is called Flow Diversion Valve (FDV) which diverts the milk back to the float balance tank if the milk temperature is below 72^0C. If the milk temperature is above 72^0C, then milk is allowed to flow forward to the regeneration section where the chilled raw milk is flowing alternate gaps of the PHE. Here the outgoing hot milk is cooled to around 50^0C by the chilled milk which is flowing in alternate gaps. The chilled milk which is heated to around 55^0C before the raw milk enters the final heating section. The partially cooled pasteurized milk then enters into another PHE where the milk is cooled to room temperature by using tap water in the PHE. Finally, the milk enters the chilled section of PHE where the milk is cooled to less than 5^0C.The flow of milk in HTST pasteurizer is shown in **fig 5 and 6**

The advantages of batch type pasteurizers:They are convenient for low volume handling of milk, low investment, easy to clean and can be handled by semiskilled personnel.
The disadvantages: They are not hygienic in operation, chances for post processing contamination, low energy efficient, not suitable for high volume milk processing, more time consuming and occupies large floor area. The batch type pasteurizers cannot be synchronized with other operations such as online cream separation and homogenization.

To check the efficiency of desired heat treatment given to milk, the presence of enzyme alkaline phosphatase is tested.This enzyme gets inactivated at the temperature just above the pasteurization temperature. Hence, if the phosphatase test answers positive, it indicates that the milk has not attained the temperature required for destruction of this enzyme which in turn indicates the incomplete destruction of the pathogen and inefficient pasteurization. After pasteurization milk should be immediately chilled to less than 5^0C.

Principle of phosphatase test: raw milk contains phosphatase enzyme. It is destroyed at the temperature necessary for efficient pasteurization. But when milk containing phosphatase enzyme is incubated with p-nitro-phenyl disodium orthophosphate, the liberated para-nitro-phenol gives a yellow colour under alkaline conditions of the test. The colour is the measure of the phosphatase content of the milk. If the phosphatase enzyme is destroyed during efficient pasteurization, the milk does not turn yellow.

Homogenization: Homogenization is the process of breaking the fat globules so that the fat does not separate during storage at cold temperature. The size of fat globules in milk ranges from 2 to 20µ. The bigger fat globules have the tendency to rise to the top when kept undisturbed. During homogenization, the bigger fat globules brakes down to small size of less than 2µ,so they do not raise to the surface during storage. Before homogenization, it is mandatory to heat the milk to at least 60^0C to bring all the fat into liquid phase and mainly to inactivate the native lipase enzyme which otherwise hydrolyze the fat and results in off flavour development in milk. The milk is homogenized in two stage homogenizer. In first stage the milk is homogenized at 2500 psi pressure and second stage at 500 psi. This is because, after first stage of homogenization, the broken fat globules have the tendency to clump together to form loose cluster similar to grape cluster. In second stage these clusters are disintegrated to distribute the broken fat globules uniformly in the milk matrix. The principle of homogenization of milk is shown in **fig 7.**

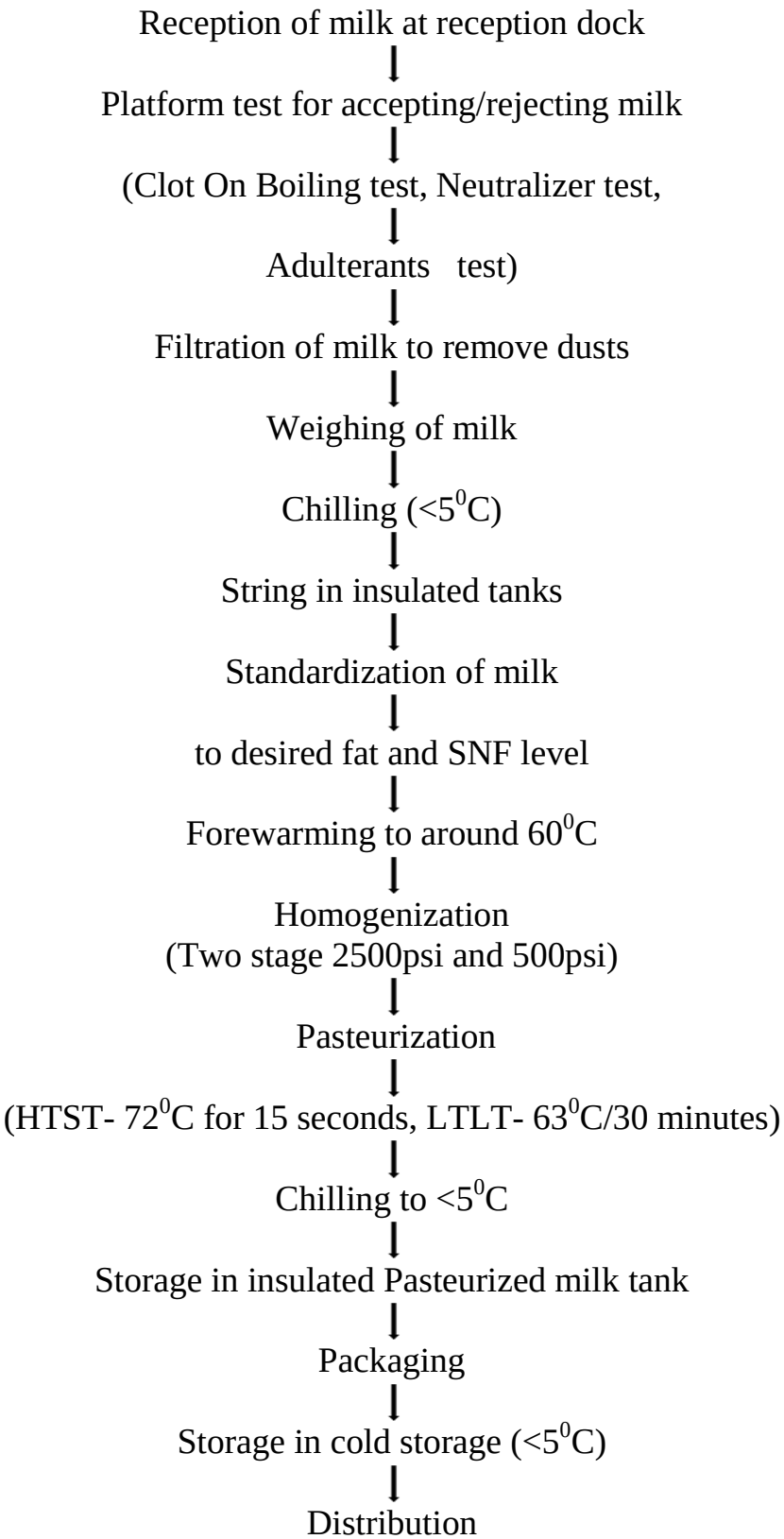
Packaging of milk: The pasteurized milk is generally packed in polyethylene pouches in 500 ml and one litre capacity. They are filled in form-fill-seal machines wherein the roll of polyethylene film is fed into the machine. The machine will form the pouch, fill the pouch with preset volume of liquid (i.e. milk) and seals & cuts the pouch after filling from the next pouch.

The packed milk is collected in plastic crates and stacked in cold store till it is dispatched for distribution.

Conclusion

Milk is one of the most nutritious and essential commodity. Most of the Indian population being vegetarian depends on milk and milk based products on daily basis. Milk processing plays crucial role in the shelf life of the milk. Milk has to be standardized as per the FSSAI standards before marketed, based on the type of milk. Pasteurization and homogenization of the milk is important to ensure the quality of milk during storage and till it reaches to the consumer.

Flow Diagram 1: Flow Chart for milk processing



Flow Diagram 2: Flow of milk in HTST pasteurizer

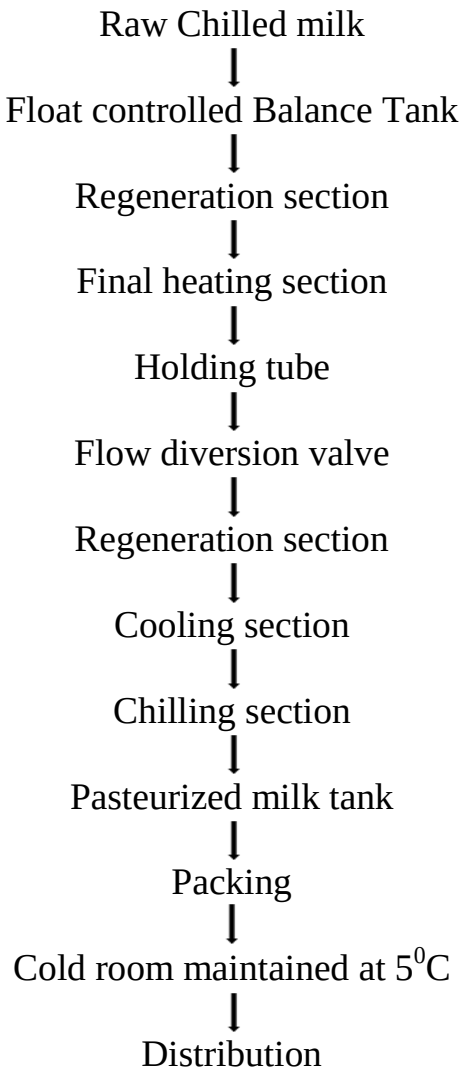


Table 1; FSSAI standards for different variants of milk to be sold in market

Type of milk	Milk fat (%)	Milk SNF (%)
Skim milk	Max 0.5	Min 8.7
Double toned milk	Min 1.5	Min 9.0
Toned milk	Min 3.0	Min 8.5
Recombined milk	Min 3.0	Min 8.5
Standardized milk	Min 4.5	Min 8.5
Cow milk	Min 3.5 (in Karnataka,	Min 8.5
Buffalo milk	Min 5.0 (in Karnataka	Min 9.0

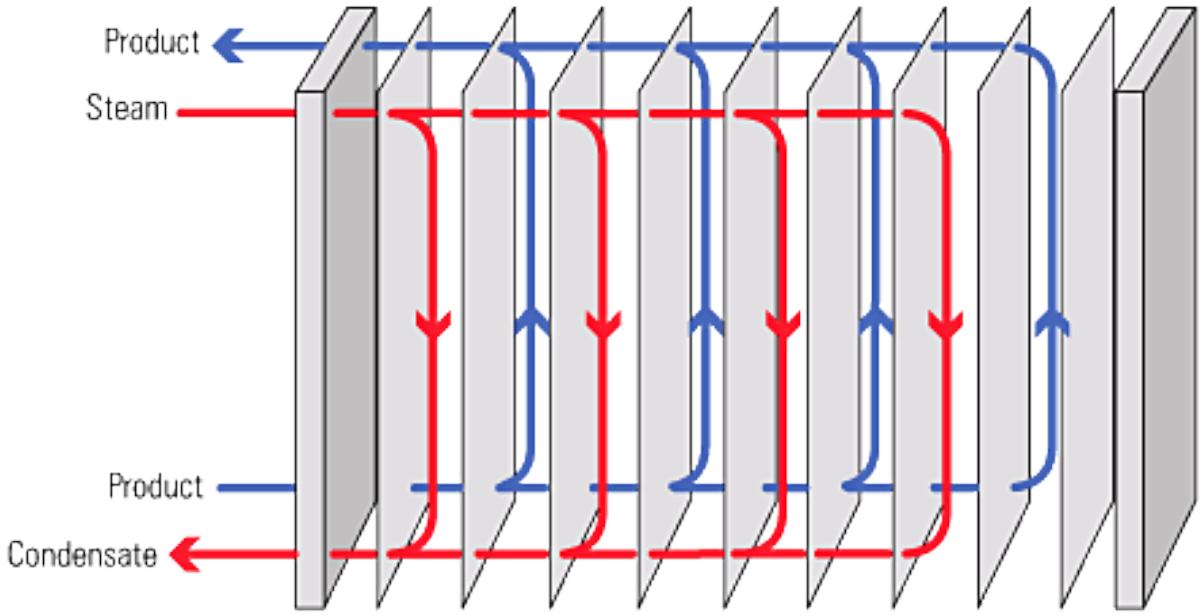


Fig 1. Design of Plate Heat Exchanger

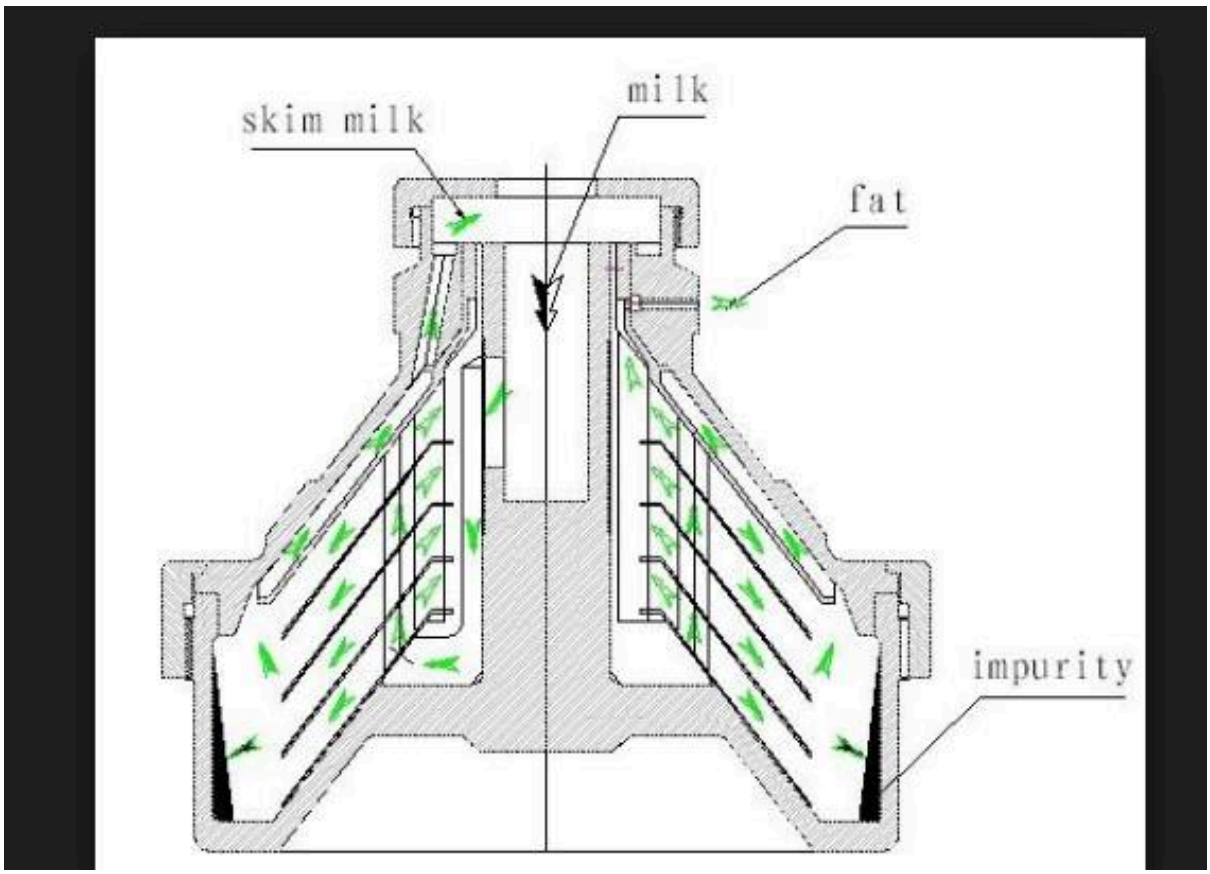


Fig 2. Assembly of cream separator bowl

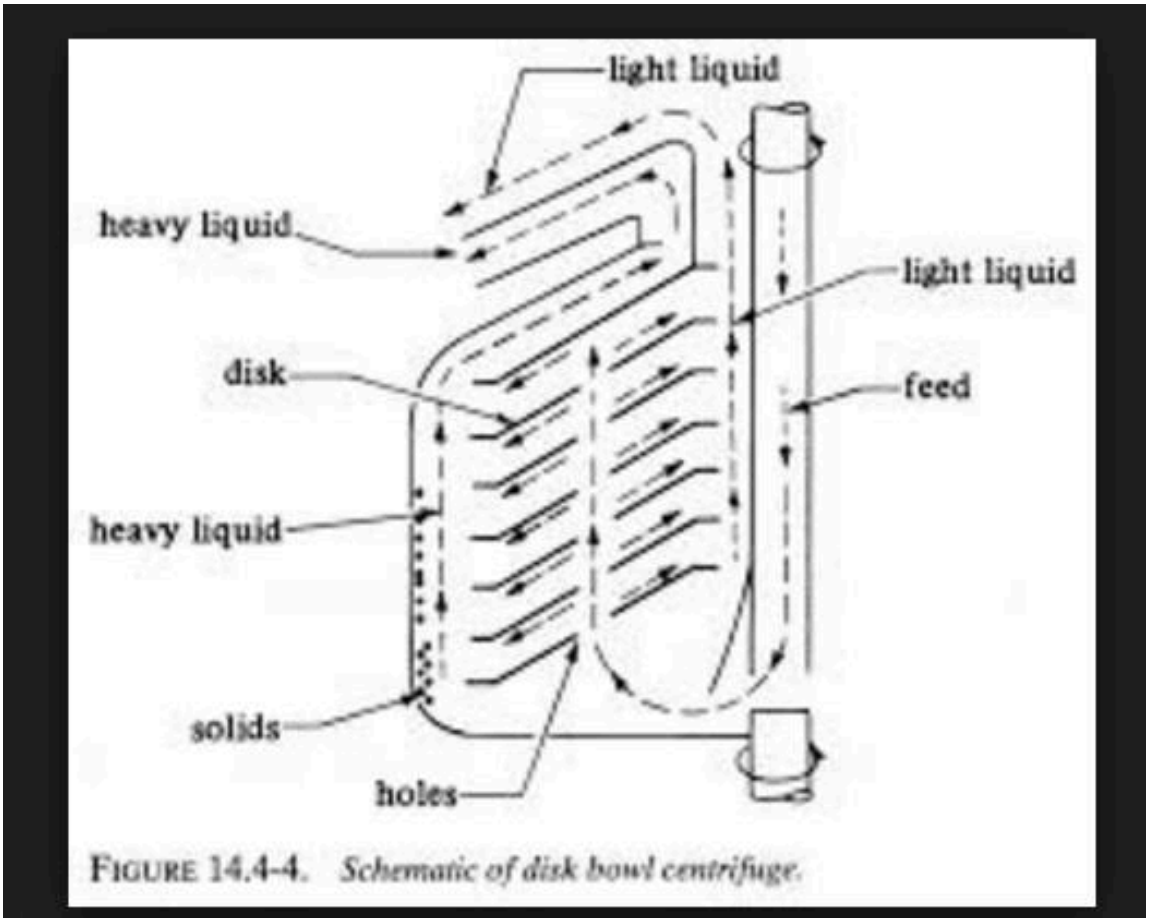
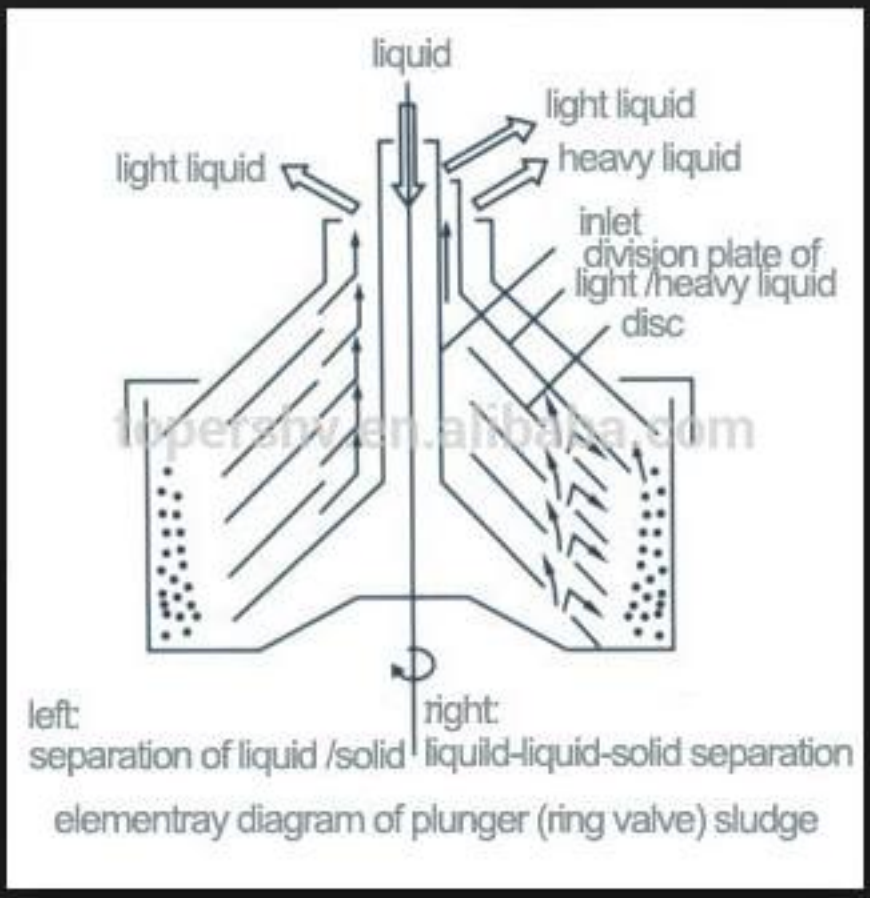
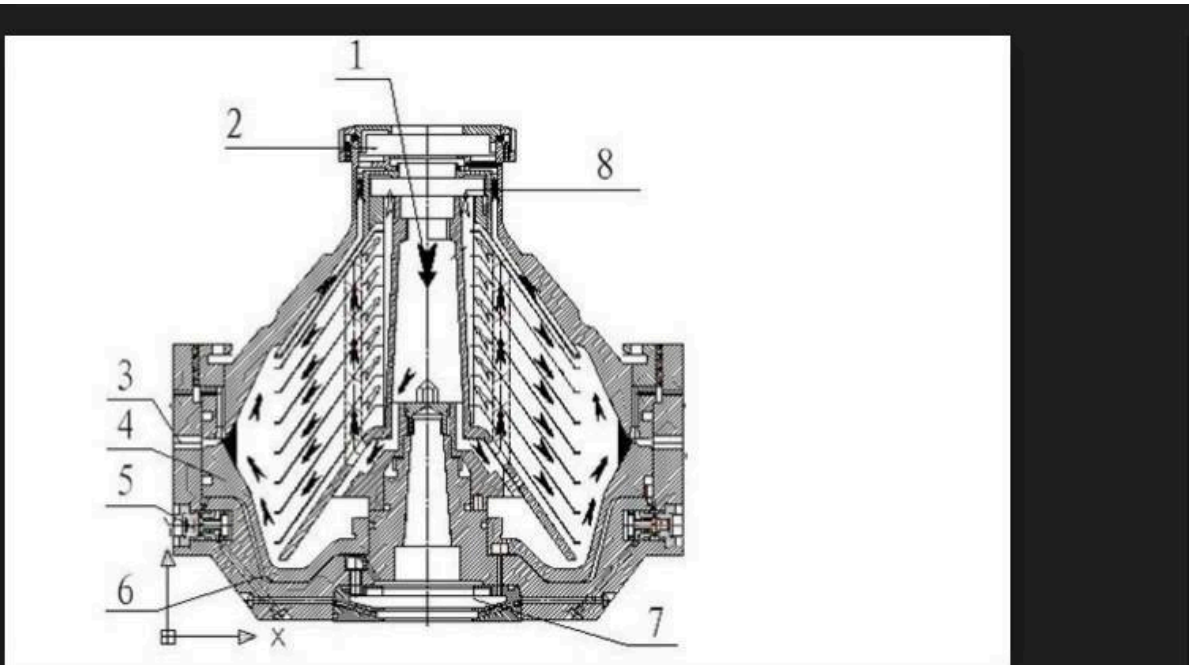


FIGURE 14.4-4. *Schematic of disk bowl centrifuge.*

Fig. 3. Flow of milk and separation of cream and skim milk



elementray diagram of plunger (ring valve) sludge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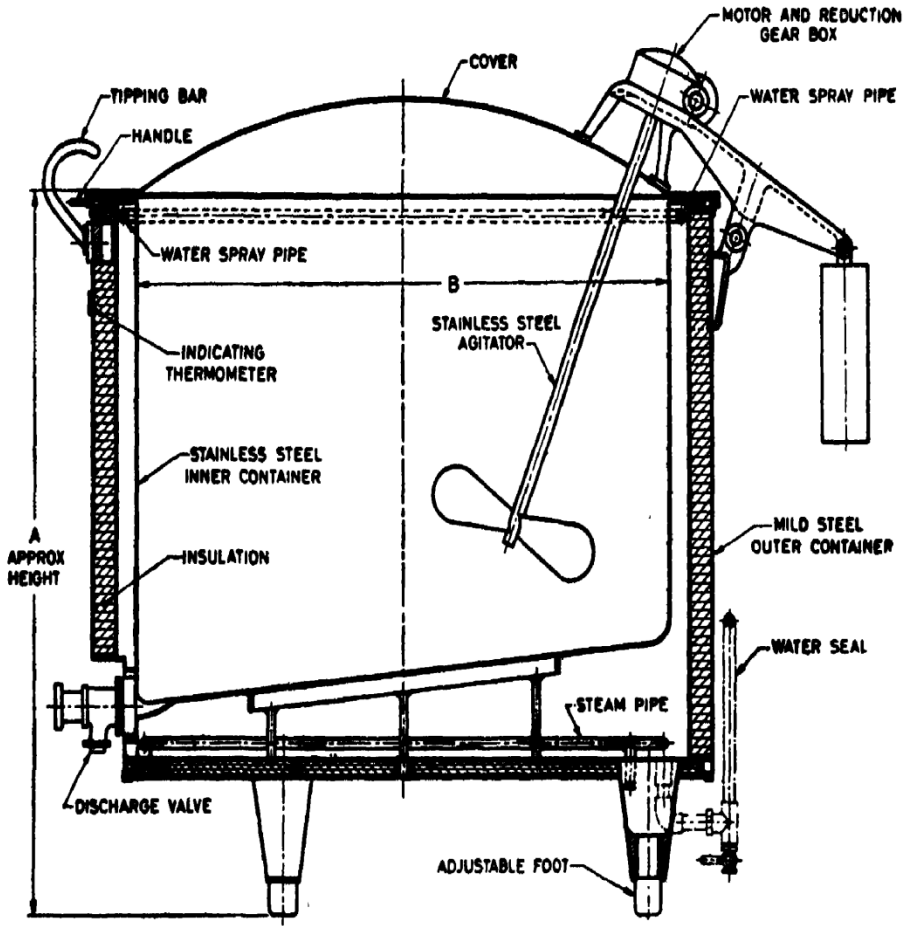

Fig 4. Batch type milk pasteurizer

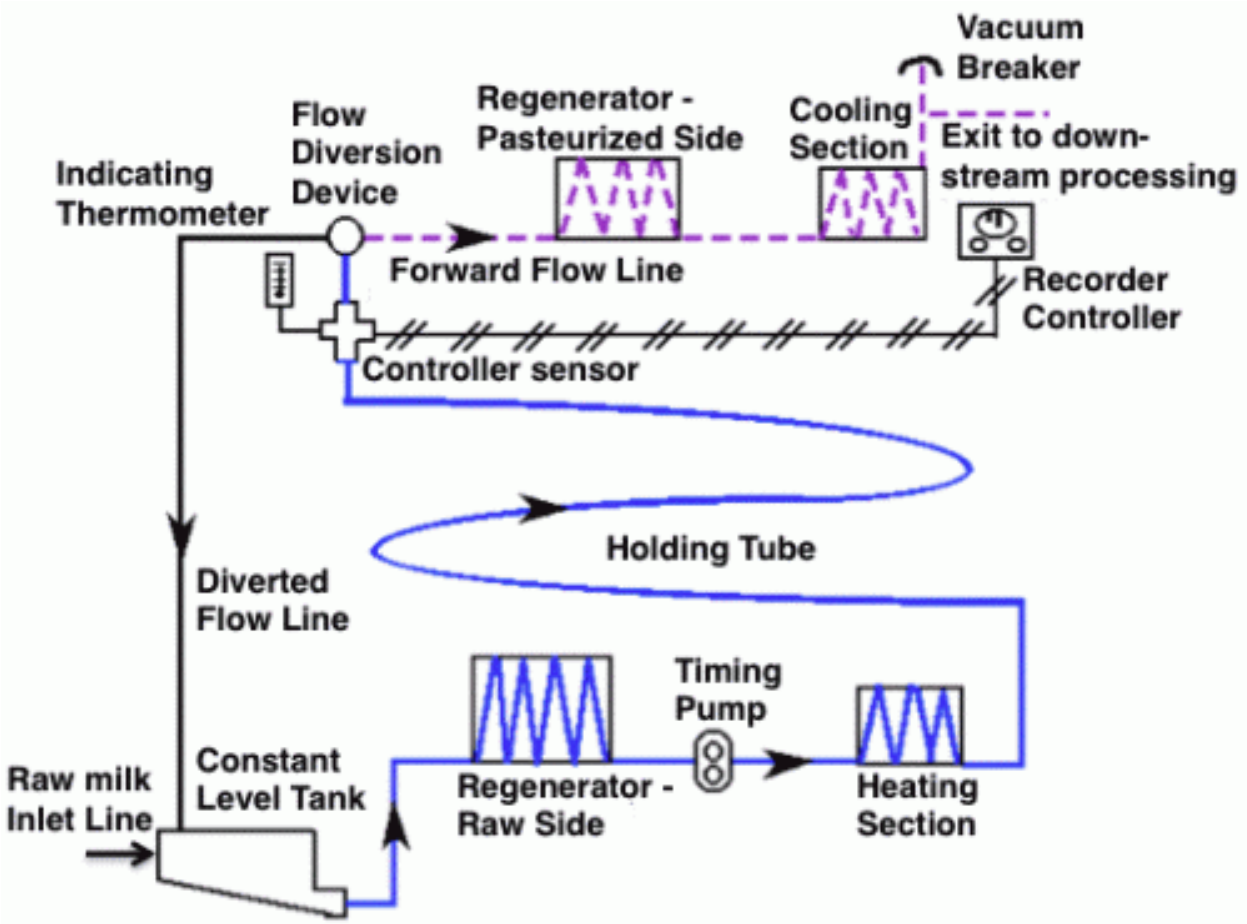

fig 5. Flow of milk through pasteurizer

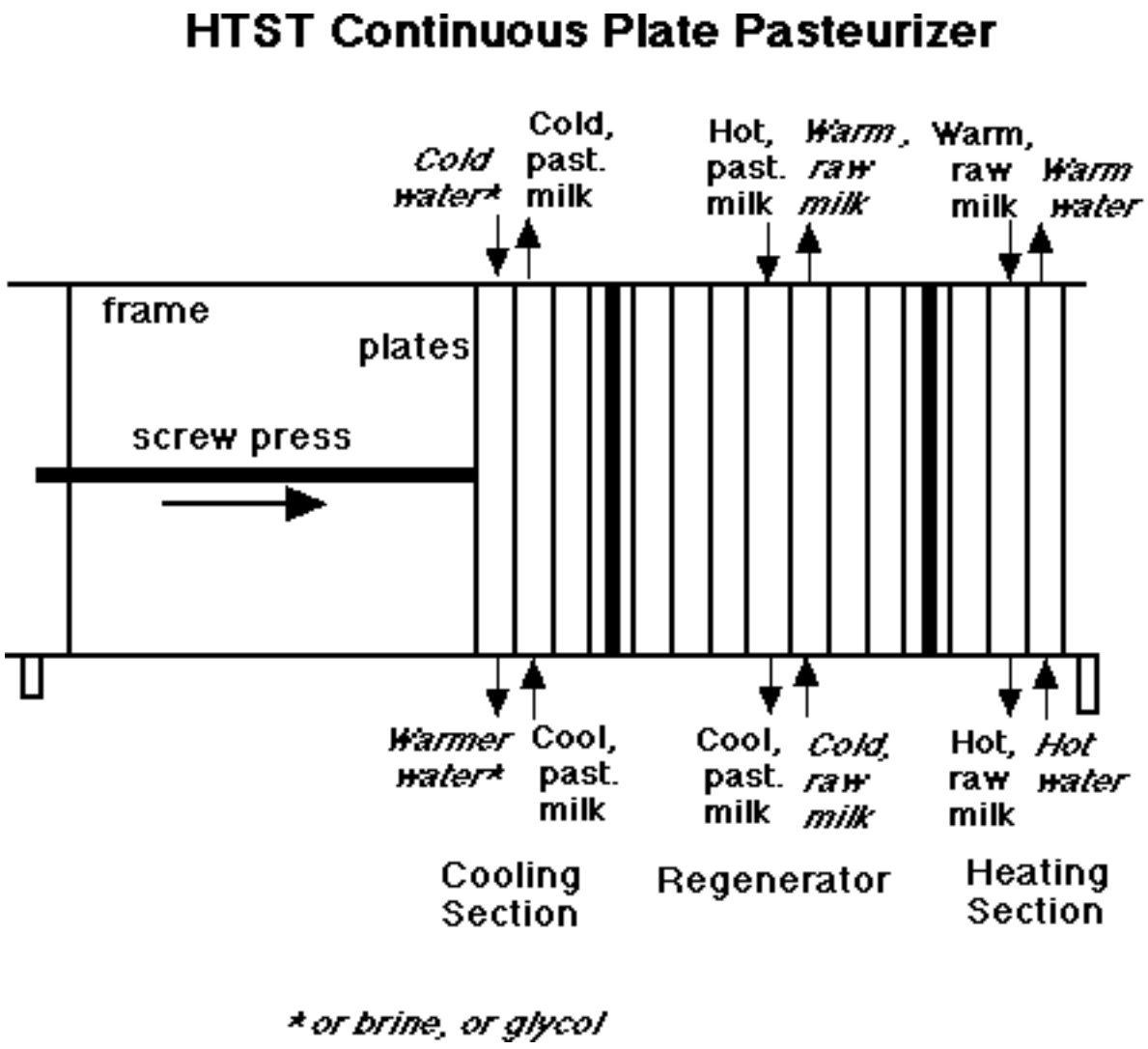

Fig 6. HTST Continuous pasteurizer

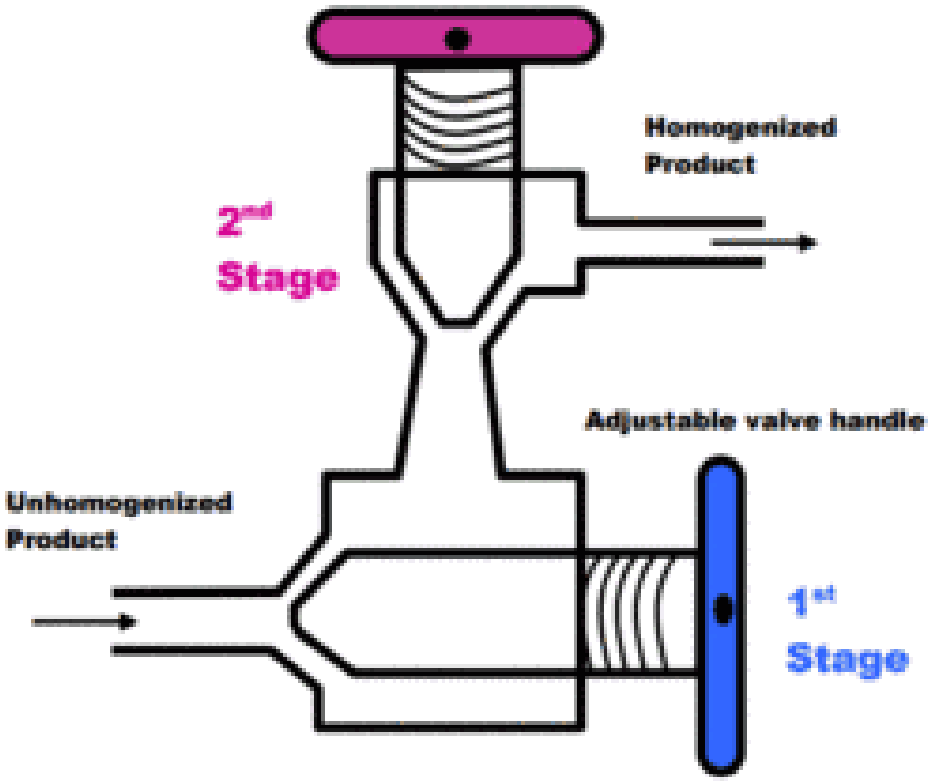

Fig 7. Homogenization principle