Chapter 7

HOMOGENIZATION OF MILK

(What is homogenization, Homogenizer, Operational parameters during homogenization)

What is homogenization of milk

Homogenized milk is that which has been treated in such a manner as to ensure break up of the fat globules to such an extent that after 48 hours of storage, no visible cream separation occurs on the milk in a quart bottle, or, proportionate volumes in containers of other sizes does not differ by more than 10% from the fat percentage of the remaining milk as determined after through mixing.

To achieve this, we should have the fat globules in small and uniform sizes.

The process of breaking up the fat globules to very small sizes in order to prevent cream formation is known as homogenization. The equipment used for the same is known as homogeniser.

The fat globules present in normal milk vary from 0.1 to 3 or 4 microns depending upon the breed of cows and various other factors. By homogenization, we break up the fat globules to below 2 micron sizes.

Homogenization of milk also serves the following purposes.

- Prevents cream formation.
- Increases milk viscosity, it gives richer appearance to tea or coffee.
- Fat globules do not rise readily and there is no necessity for agitating the milk before serving.
- Prevents churning of fat during rough handling or excessive agitation.
- Reduces curd tension, i.e. forms a soft curd when homogenized milk is coagulated, i.e. milk becomes more palatable due to brighter appearance, heavier body and richer flavor.
- Milk becomes more digestible partly because of the smaller fat globules and partly because of the lower curd tension. The homogenized milk can be recommended for infants.
- Reduces the chances of separation of fat during the manufacture of evaporated milk and ice-cream, it gives a smoother texture of the product.
- Homogenizer can be used to prepare reconstituted milk by mixing butter oil or butter with skim milk.
- The milk becomes less susceptible to oxidized flavor development.

However, if we are interested in recovery of fat, then homogenized milk should not be taken. Fat recovery from homogenized milk is difficult.

Four different forms of fat globules in milk

- Single globules unattached.
- Clusters, consisting of two or more globules loosely attached.
- Clumps, consisting of two or more globules tightly clumped together so that the individual appearance of the globules is almost lost.
- Churned or butter particles in which the individual globules have lost their identity.

A homogenizer should break up all the clusters, clumps and butter particles present in un-homogenized milk.

THE HOMOGENIZER

The homogeniser consists of a high pressure pump fitted with a minute orifice having an adjustable opening through which fluids are forced at a very high pressure. Thus the fat globules are reduced in size.

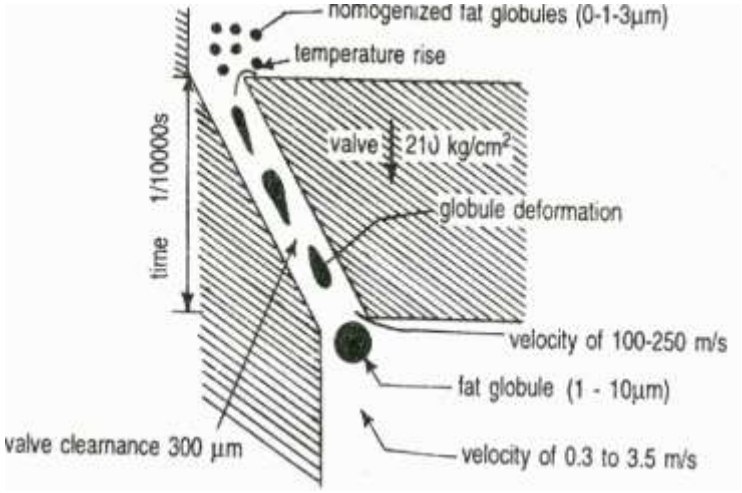


Fig. 7.1 Working principle of a homogenizer

In actual practice most valves employ a combination of three principles (Fig. 7.2). The homogenization can occur due to shear or due to disruption. The shearing action occurs among the fact globules and in the narrow opening through which the milk is forced to pass. The disruption occurs at the breaker ring and also due to sudden pressure drop as the fluid leaves the valve.

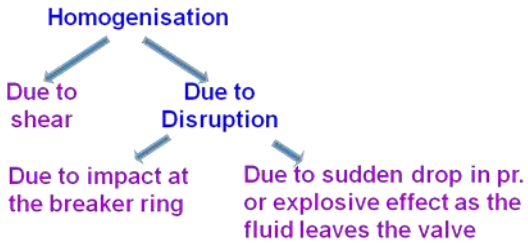


Fig. 7.2 Types of forces acting during homogenization

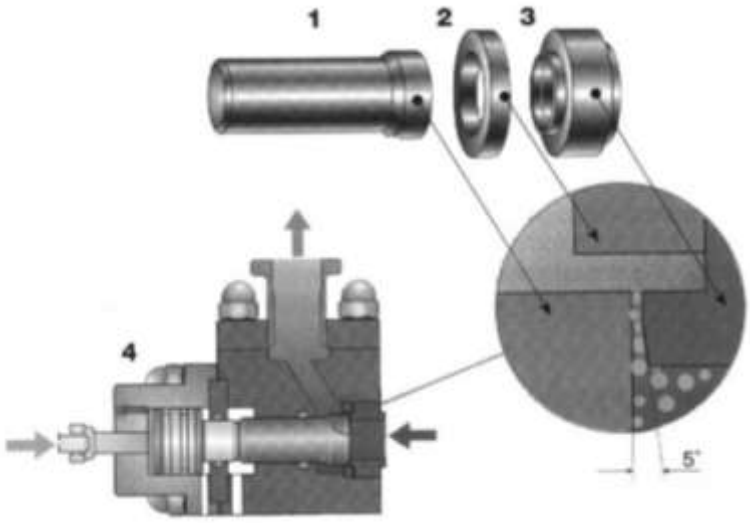
Proper dispersion is equally important.

- Some homogenizers may give excellent break up, but the dispersion is very poor, resulting in excessive clustering and clumping and even churning.
- This cause the development of excessive viscosity, which sometimes makes the product very difficult to pump or cool.

In addition to other factors, the size and shape of the orifices are also affected by the volume of milk to be handled per unit time and by the viscosity of product.

Main components of a homogenizer

The main parts of a homogenizer are shown in Figs. 7.3 and 7.4.



1. Forcer 2. Impact ring 3. Seat 4. Hydraulic actuator

Fig. 7.3 Components of a single-stage homogenization device

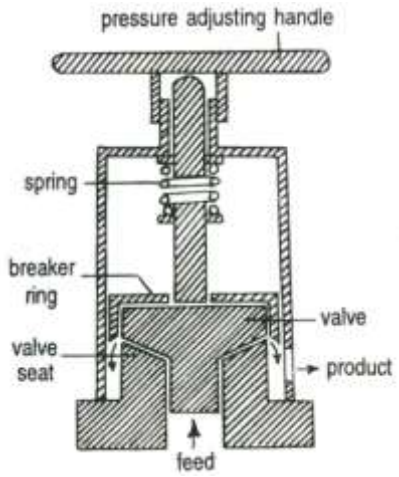


Fig. 7.4 Main components of a homogenizer

As can be seen from the above figures, the main components of a homogenizer are: pump, homogenizing valve, breaker ring, tension spring and the valve sheet.

Homogenizing valve

- The homogenizing valve is the heart of the homogenizer.
- This may be of different shapes and sizes.
- Most valves are of poppet type, which have a breaker ring so that the fluid strikes the inner surface of the breaker ring perpendicularly as it leaves the orifice formed by the conical shaped valve and seat.
- The valve is held by a heavy spring having adjustable tension. As the fluid pressure comes against it, the valve rises few thousandth of an inch to form a narrow annular opening (orifice).

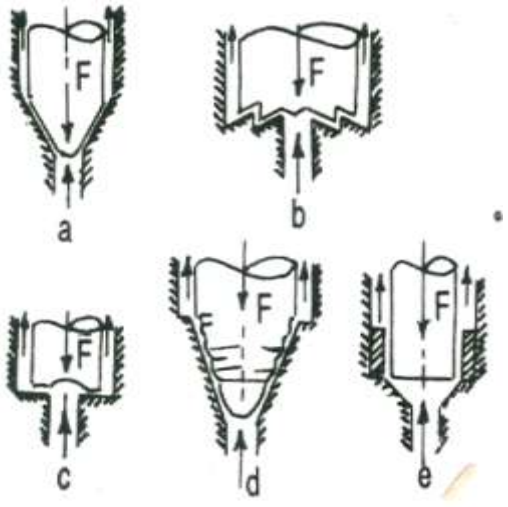


Fig. 7.5 Types of homogenizing valves

- The valve parts are subjected to extreme abrasion because of the high velocity and pressure of the fluid as it passes through the valve. So they must be constructed of extremely tough and wear resistant hard metals such as stellite.
- The valve size must be suited to the capacity of the machine. Larger valves cause excessive clustering and too small valves may not give proper break up.
- Any slight grooving due to wear and tear may reduce the effectiveness. Hence, two valves are used in series, which is called a two stage homogeniser. A two stage homogenizer is shown in Fig. 7.6.
- The principal advantage of the two stage method is that it improves dispersion of fat globules and is useful in controlling viscosity of cream and ice cream mix.

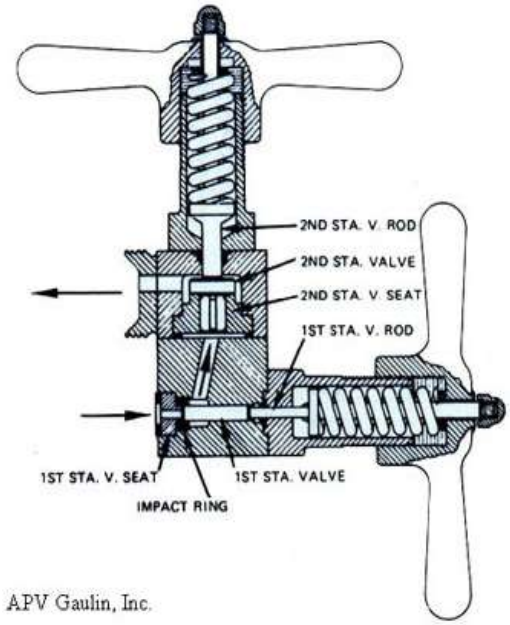


Fig. 7.6 A two stage homogenizer

Homogenizing pump

The homogenizing pump imparts the desired pressure required for homogenization. Table 7.1 gives an understanding on the effect of homogenization pressure on fat globules break up.

Table 7.1 Effect of homogenization pressure on fat globules break up

Pressure (psi)	Range of size of fat globules micron	Average size of fat globules in micron
500	1 to 14	2.39
1,000	1 to 7	1.68
1,500	1 to 4	1.40
2,000	1 to 3	1.08

2,500	1 to 2.5	0.99
3,000	0.5 to 2	0.76

- As can be seen from the table, the homogenization of milk should be carried at 2000 to 3000 psi (136-204 kg/cm²) pressure.
- For milk with up to 6% fat content, usually 136-170 kg/cm² (2000-2500 psi) in a single stage is sufficient.
- Higher pressure may increase the tendency for the milk to curdle when cooked, due to the increased destabilizing effect on the milk proteins.
- For products with more than 6% fat, 2-stage homogenization is needed to prevent fat clumping: 136-170 kg/cm² at the first stage and 34 kg/cm² at the second.
- New modern valves use low pressure, even 1/3rd less than that of conventional valves and furthermore they maintain efficiency without frequent valve grinding, since the wearing out (the wire valve) is replaced every day.

The homogenizer is always required to maintain steady pressure because

- The shearing effect of the valve changes with the velocity of the fluid and, for a certain valve, shearing effect can be acceptable only at a given velocity.
- With fluctuating pressure, the velocity will fluctuate, thus causing irregular results, non-uniform products and thereby decreasing the efficiency.
- A single plunger pump will develop pulsating pressure, and hence it is very common to have 3-plunger positive displacement pump, or, triplex pump for the purpose.
- The overlapping of strokes tends to give a reasonably uniform pressure (there is about 20% pressure variation).

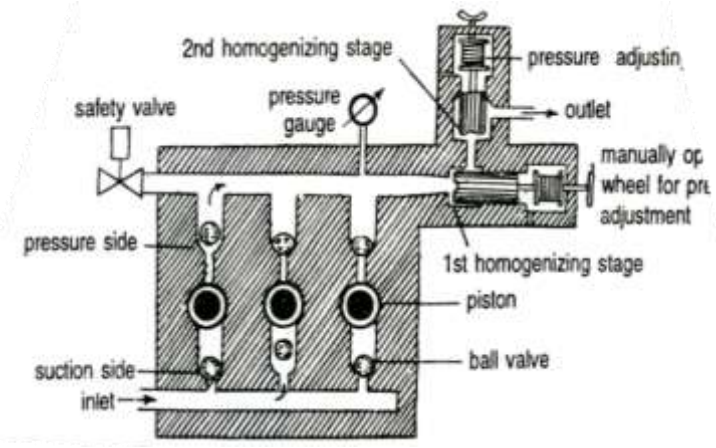


Fig. 7.7 Typical two stage homogenizer with 3-plunger pump

Temperature during homogenization

The following points are important in this context.

- The melting point of fat is 33°C.
- For inactivation of lipase, we require 55°C.

- The viscosity of milk during homogenization should also be optimum.
- Therefore, to inactivate the enzyme lipase and to reduce the tension between globules, the milk is heated to 65-70°C for homogenization.

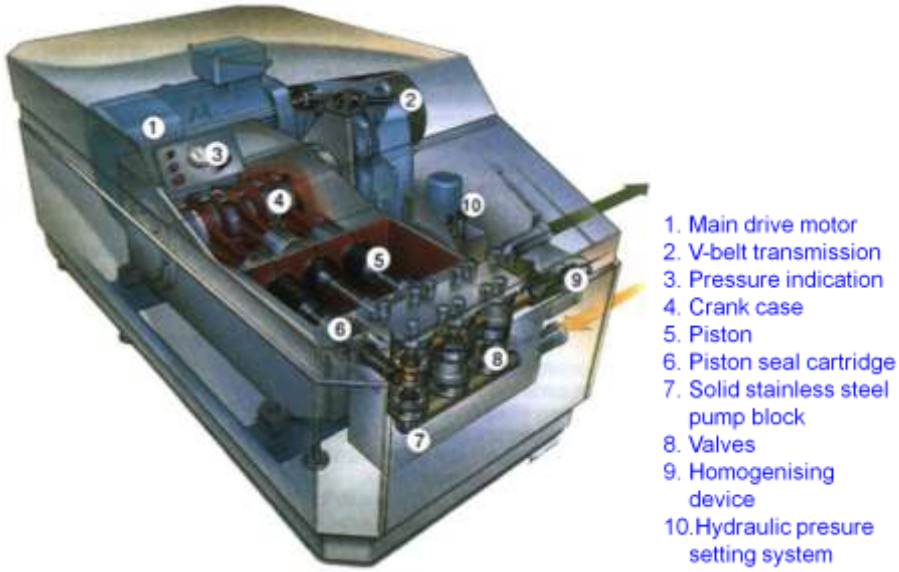


Fig. 7. A homogenizer showing different components

Effect of different operational parameters during homogenization

- High temperature homogenization causes reduced clustering, reduced viscosity, and better break up of fat globules.
- Low temp (50-55°C) homogenization reduces break up and offers more resistance to flow.
- Increase in pressure causes finer break up of fat globules, increases tendency to form clusters or clumps.
- Irregular pulsating pressure reduces efficiency.
- High temperature and pressure cause excessive casein destabilization.
- High acidity causes more viscosity, and tends to form clusters or clumps.
- Homogenization efficiency may be reduced if the produce is not held at proper temperature for 30 min.
- Minute imperfections in the homogenizing valve allow large globules to slip through and thereby prevent effective homogenization.
- The fat globules are surrounded by a membrane of about 10 µm thick consisting of approximate 48% protein, 33 % phospholipids and 19% water.
- When the fat globules are reduced to smaller sizes in a homogenizer, new membranes are automatically formed, provided the membrane material does not become limiting.
- The requirement of membrane material becomes high when the fat globules are reduced to very small sizes.

- In certain situations, e.g. for the preparation of the reconstitution of milk from skim milk powder and butter oil, some amount of fresh milk is required. The fresh milk supplies the desired amount of phospholipids to the new membranes, which are formed during the homogenization of butter oil.

Judging the efficiency of homogenization

- One of the best methods is to examine a sample under a high power microscope and to note and analyze the size of the fat globules.
- The product is accepted as homogenized if 85% of the fat globules are less than 2 µm size.

Care and maintenance of homogenizers

- The suction and discharge pipes need to be kept in good condition otherwise the homogenizer will pulsate badly, yielding an inferior product.
- The homogenizing valve, being the heart of the machine, must be kept smooth. When the valve or the seat shows grooves on the wearing surface, they should be returned to the factory for resurfacing of the valve and seat.
- Care should be exercised to keep the suction line as short as possible.
- All joints should be carefully finished to eliminate any possibility of air leakage.
- In installations where suction lines are longer than 5 m, it is recommended that a feeding pump be installed.

CHECK YOUR PROGRESS

1. Define homogenized milk.
2. State the advantages of homogenization of milk.
3. What are the four different forms of fat globules in milk?
4. Explain the different parts of the homogenizer with suitable figures and also state their functions.
5. What are the pressure and temperature maintained during homogenization of milk? Why only those values?
6. Explain the effect of different operational parameters during homogenization.