Chapter 5

Cream Separation

Introduction

To learn about cream separation and centrifugal separators

Principle

Before the invention of separators, cream was separated by keeping milk in a vessel until the cream floated to the top and could be skimmed off by hand. This method was time consuming, caused souring of milk, allowed partial removal of cream and thus was not suitable for industrial application. Therefore centrifugal separators are used for cream separation (Fig.5.1).

Centrifugation separation is based on Stoke's law which relates various factors for determining particle terminal

Fig.5.1. Centrifugal cream separator

velocity. In case of sedimentation, terminal velocity is also known as settling or sedimentation velocity. The Stoke's law is defined by the following equation:

$$v_t = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} gR^2$$ ——— equ (i)

Where,

v_s = Particle terminal velocity
[Particle will move vertically downwards if $\rho_p > \rho_f$, upwards if $\rho_p < \rho_f$]

ρ_p = Density of particle (kg/m^3)

ρ_f = Density of fluid (kg/m^3)

μ = Fluid viscosity (Ns/m^2)

R = Radius of the particle (m)

g = Acceleration due to gravity (m/s^2)

In case of fat separation, Stoke's equation is given as:

$$v_s = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} gR^2$$ ——— equ (ii)

v_s = Fat separation velocity

ρ_p = Density of milk plasma (kg/m^3)

ρ_f = Density of fat globule (kg/m^3)

μ = Milk plasma viscosity (Ns/m^2)

R = Radius of the fat globule (m)

g = Acceleration due to gravity (m/s^2)

if d = fat globule diameter then equ (ii) can be rewritten as:

$$v_s = \frac{1}{18}\frac{(\rho_p - \rho_f)}{\mu} gd^2$$ ——— equ (iii)

Or,

$$v_s \propto \frac{(\rho_p - \rho_f)}{\mu} d^2$$ ——— equ (iv)

It can be inferred that velocity of fat separation will increases with:

- Increasing fat globule diameter
- Increasing difference between milk plasma and fat density
- Decreasing milk plasma viscosity

For centrifugal separation of fat globules, the separation velocity is given by the equation:

$$V = \frac{1}{18}\frac{(\rho_p - \rho_f)}{\mu} d^2 . R\omega^2$$ ——— equ (v)

Where,

R = Distance between fat globule and axis of rotation of centrifuge

ω = Angular velocity

Centrifugal separators are widely used in the dairy industry. Cream separators work on the principle of centrifugal separation. Some of the applications of centrifugal separation in dairy processing units are as follows:

- Clarification: Removal of impurities and foreign objects like straw, curd particles etc from raw milk
- Skimming: Removal of cream from milk
- Standardization: Adjusting the fat content of milk and milk products to desired level
- Bactofugation: Removal of bacteria from milk
- To recover fat from buttermilk or whey
- Whey clarification
- Quarg separation

Equipment

The core component of centrifugal separator is conical discs which are stacked one over the other. There are about 120 or more conical discs having an angle of 45 to 60 degrees. The discs are separated by separation channels. The gap between two consecutive disc is in the rage of 0.5 to 2.0 mm. The milk enters at the base of disc stack inside the rapidly revolving bowl of the separator. The speed of rotation of separator bowl can vary from 2000 rpm to 20,000 rpm depending on the capacity. The discs are provided with

distribution holes (Fig.5.2). The distribution holes are positioned one above the other making channel for the ascending liquid (Fig.5.3). Due to the centrifugal force the light phase moves towards the axis of rotation and the heavy phase towards the bowl wall (Fig.5.4). The milk plasma has higher specific gravity (1.036) than that of fat (0.9). During centrifugation, plasma is thrown towards the outer periphery and channelized into skim milk out let. The lighter phase i.e. cream is channelized towards the axis and is pumped out through cream outlet by pairing disc (Fig.5.5). Paring disc is used to pump cream or skim milk towards the outlet.

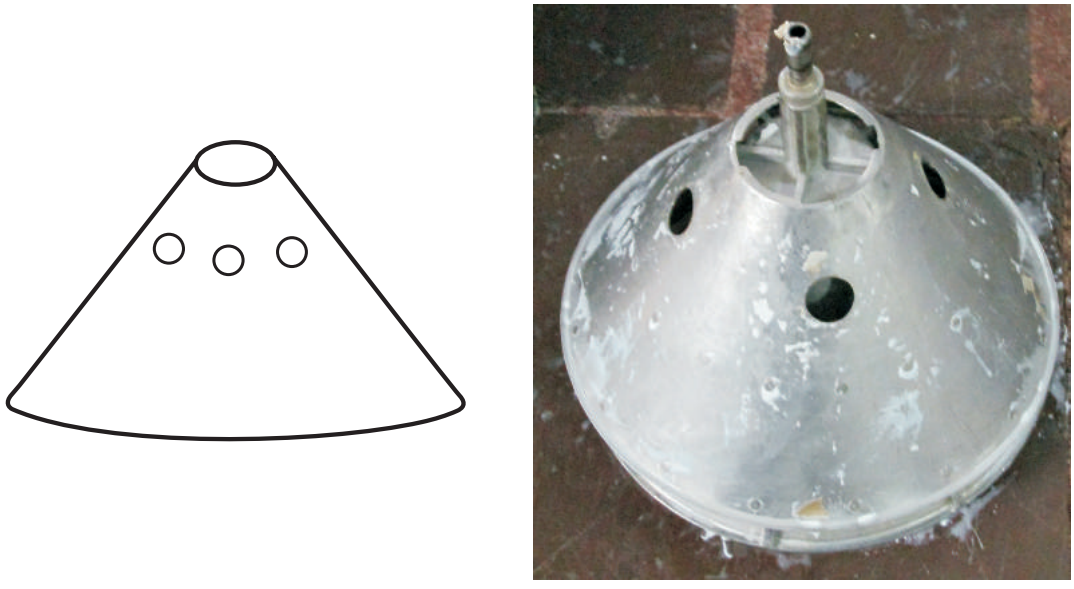

Fig.5.2. Disc of cream separator

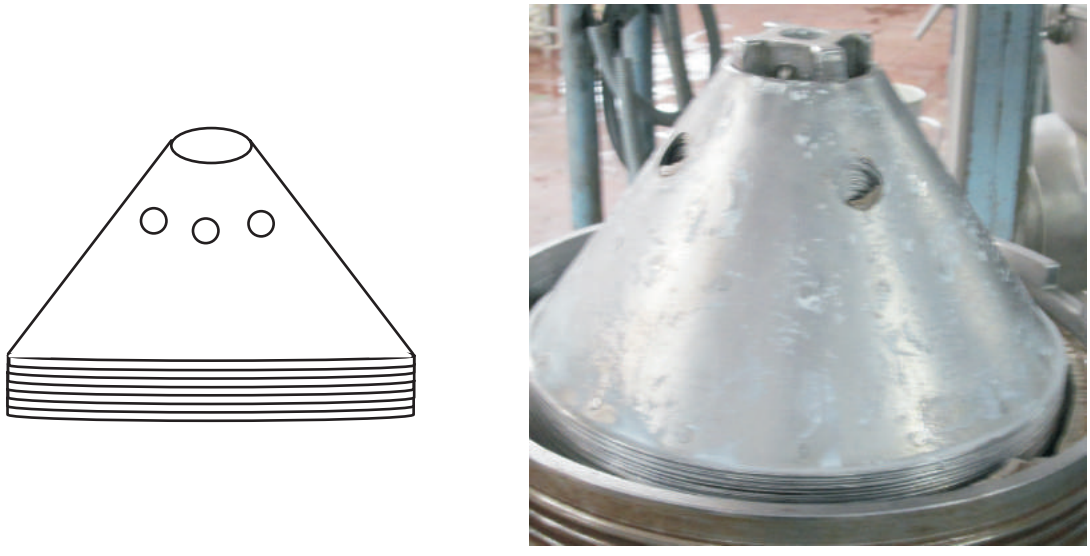

Fig. 5.3. Stacking of discs

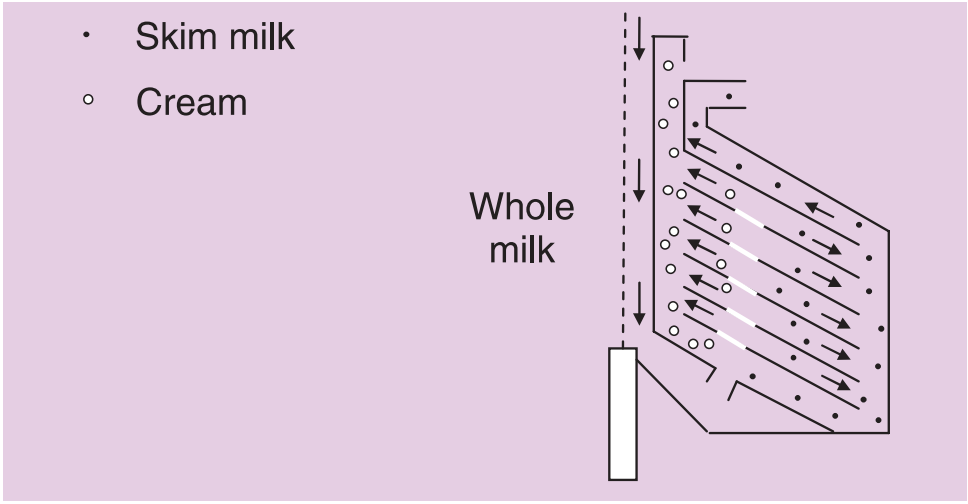

Fig.5.4. Separation of milk plasma and fat in a disc bowl centrifuge

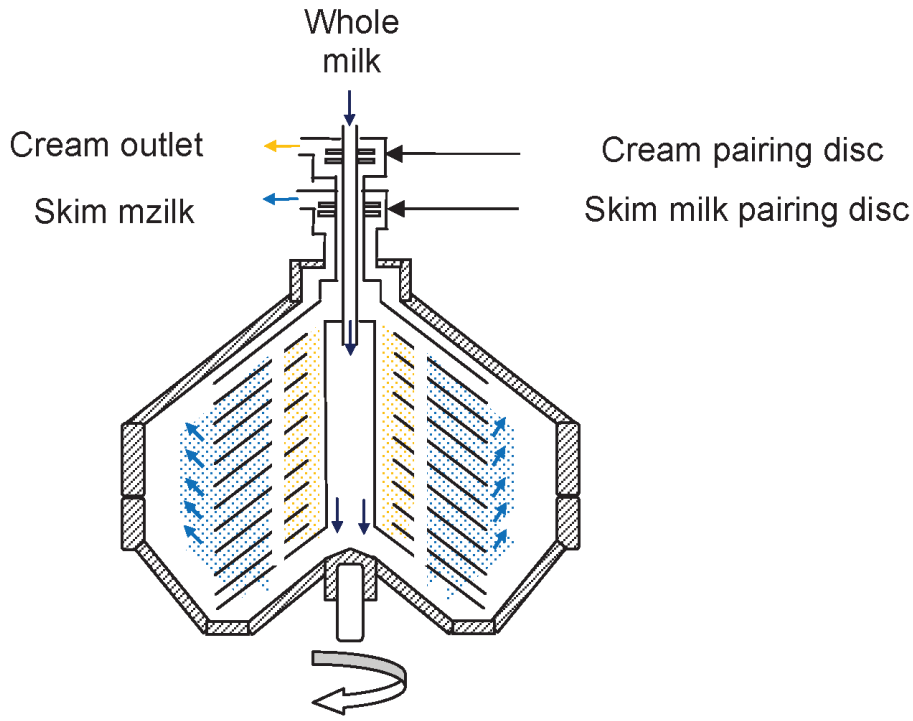

Fig.5.5. Centrifugal cream separator

The capacity of the cream separator is in terms of skimming and standardization. During skimming entire cream from the whole milk is separated by the cream separation. The fat content in skimmed milk may be as low as 0.04-0.05%. In standardization the operating parameters of cream separator is set to obtain milk of a desired fat content. Since more energy is required for skimming, therefore skimming capacity is always less than the standardization capacity. Cream separators can be operated at a lower capacity than rated capacity by lowering the rpm.

Classification of Cream Separator

According to Temperature

- **Warm separator:** The optimum milk temperature for fat separation is 52 to 55°C, as the dynamic viscosity of the milk is virtually stable in this temperature range. Higher temperature above this range will cause protein precipitation, which is undesirable.
- **Cold separator:** For cold separation operating temperature is between 4 and 20 °C. Cold separation method has lower energy consumption and prevents growth of microorganism.

According to Milk Feed

- **Top feed:** Provision of whole milk inlet is from the top of the centrifuge bowl (Fig.5.6).
- **Bottom feed:** Milk is fed at the bottom of bowl through the hollow spindle (Fig.5.7).

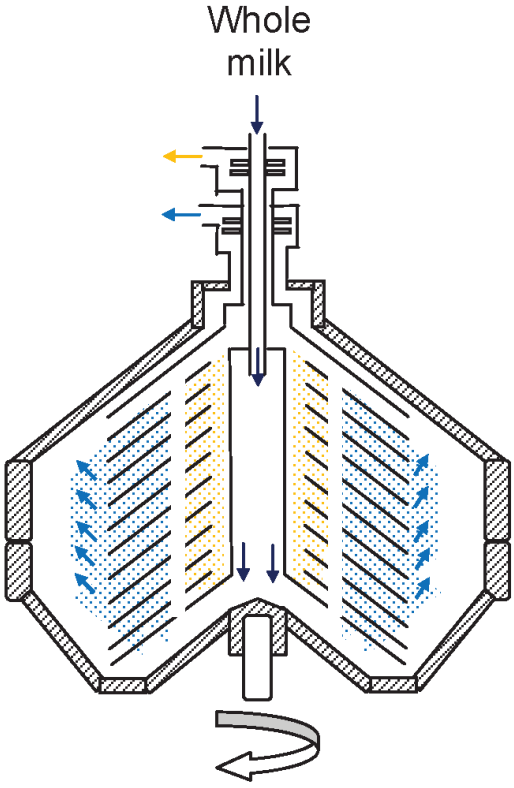

Fig.5.6. Top feed cream separator

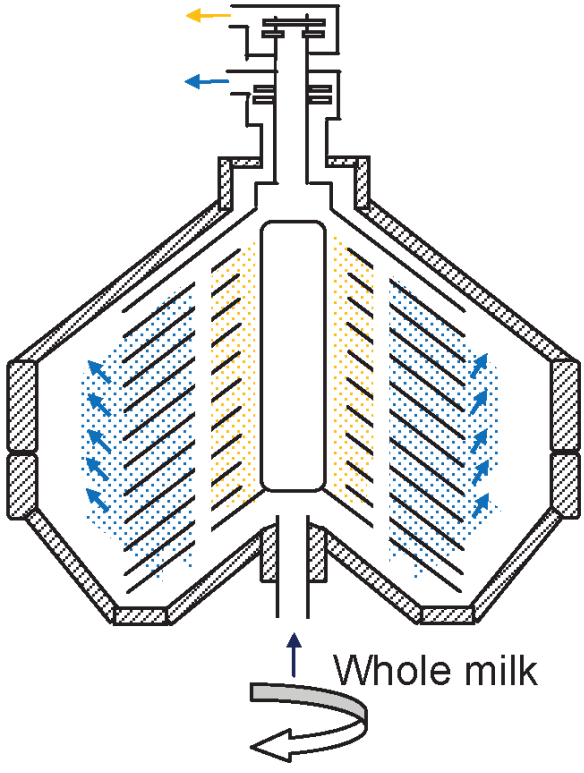

Fig.5.7. Bottom feed cream separator

Efficiency

The performance of a cream separator is evaluated by the degree of cream separation from the whole milk. Degree of cream separation (E) is given as:

$$E = \frac{Fat\ content\ of\ \ the\ \ cream}{Fat\ Content\ of\ the\ whole\ milk}$$

Suggested Reading

http://creamseparatorgallery.webs.com/articles.htm

REVIEW QUESTIONS

1. What is the primary purpose of cream separation?
2. Briefly describe principle of cream separation?
3. With a neat diagram explain working of cream separator.
4. Give classification of cream separator