Unit IV – Topic VI

ULTRA-HIGH TEMPERATURE PROCESS

32.1 Introduction

It is a modern technique for milk sterilization. Long life or UHT milk originated at Switzerland in 1961. It has a long storage life and greater consumer acceptability than the conventional canned sterilized milk, in which the product suffers greater alterations in flavor, color and nutritional quality. While UHT processing is one way of producing sterilized milk, it is predated in terms of development and commercial application by in-container sterilization methods which also produce long-life products. In-container sterilization processes, in which milk is sterilized in either glass or high density polyethylene bottles, operate at lower temperatures than UHT processes, but for longer times. The process requires a minimum sterilization temperature of 100ºC for sufficient time to ensure that the product passes the turbidity test. The test is based on the confirmation of adequate heat treatment by the use of ammonium sulphate to precipitate milk proteins, including heat denatured whey proteins. In-container sterilization may be achieved either by batch processing, in which bottles of milk are heat treated in autoclaves or retorts, or by continuous processing where bottles of milk pass through a sterilizer. Two methods of continuous processing are common: the vertical tower or hydrostatic sterilizer and the horizontal sterilizer.

32.2 IDF Definition

A UHT product produced by UHT treatment is packaged in a sterile container under aseptic conditions. Typical temperature-time combination for UHT milk is 132°C for not less than 1 sec and for UHT cream 132°C for not less than 2s.

32.3 Advantages of UHT Milk

- UHT treated milk has definite advantage when the distance between producer and consumer is wide.
- UHT treated milk can be kept for several months without refrigeration, advantageous in warm summers.
- Temporary surpluses due to seasonal variations can be covered by subjecting milk to UHT treatment
- Manpower costs are saved
- Milk can be stored at home all the time. It can be readily available at distant locations and at all odd hours.

32.4 Disadvantages

- Flavor of UHT milk is dissimilar to pasteurized milk.
- Chances of formation of deposits within the system particularly in the direct steam system which causes extra operating cost
- Age gelation during storage.
- Higher cost of aseptic packaging
- Sometimes fat separation and sedimentation of insoluble particles may occur during storage.
- Nutritive value is much diminished as compared to pasteurized milk.
- It is expensive.

32.6 Types UHT Processing Plant

UHT processing plants can be divided into two principal types, using either direct or indirect heating

Difference between a pasteurizer and UHT plant

- Higher operating pressures are required in order to prevent the milk from boiling at the processing temperatures
- Homogenization step is essential to prevent fat separation during storage
- The plant needs to be sterilized down-stream of the holding tube prior to processing and maintain sterility throughout processing

32.6.2 Direct heating with steam injection

The milk flows through a pre-heater and a final heater, where it is heated to approximately 75 – 85°C. Pressure necessary for UHT heating (150°C corresponds to 4.76 bar) is applied by a pressure pump and the milk is intimately mixed with steam in the mixing chamber. The steam immediately condenses in the milk giving up its heat of vaporization and thus heating the milk. The amount of steam used must be such that immediately after mixing, both the milk and the condensate formed are heated to the sterilizing temperature. The mixture then flows through a holding tube (2-4s) which enters tangentially into the vacuum chamber. Close to the entry point, is an adjustable pressure retaining valve which maintains the saturated steam pressure corresponding to the sterilizing temperature. The hot mixture under pressure then expands and causes spontaneous cooling by evaporation. The vacuum is so maintained that exactly the same amount of water evaporates as is incorporated in the form of live steam. The steam released in vacuum chamber is used to preheat the incoming milk when the milk passes through an aseptic path pump, homogenizer and perhaps storage tank to aseptic packaging. The advantage of expansion cooling is that it removes undesirable odorous substances from milk. To maintain constant water content in UHT milk, it is required to maintain accurate temperature control of the milk entering the mixing chamber, in the holding tube and in the expansion chamber. The parameters that are controlled include the milk feed, the steam supply and the vacuum in the expansion chamber.

32.6.3 Milk into steam (Infusion)

The milk is homogenized and falls as a laminar free falling film into a steam pressure vessel, in which milk is heated to the UHT temperature, passes through a holding section and is cooled by expansion. In another method, the milk is atomized to fine droplets, injected into a steam pressure vessel via pressure jets. Milk droplets are more easily heated than a film. But the disadvantage is that the milk can also be sprayed onto the hot wall of the vessel which may allow the milk to leave the heater after holding time of very unequal durations.

32.6.4 Advantages

The product never comes in contact with a surface having a temperature above that of sterilization temperature. Therefore, the product retains excellent flavor.

32.6.5 Disadvantages

Difficulty to control the holding time exactly. The reason for this includes (i) droplets of milk are heated to sterilization temperature while falling through a steam chamber, (ii) the speed of milk droplets is bound to show variation, (iii) the infusion chamber must always contain a bottom layer of product introducing variation in holding time.

32.7 Indirect Heating Methods

32.7.1. Plate heat exchanger

The milk is pumped into the first heat exchanger where the temperature of milk is raised to about 75 or 85°C and it may or may not be admitted to a holding cell. In the holding cell, the product is kept for 30 seconds to 5 minutes at 80°C depending on the design. The reason for this holding cell is to reduce deposits which would otherwise form in the final heater of the equipment. From the holding cell, the product is sent to a homogenizer which functions as a positive pump and forces the product through the heating section.

The product enters a second holding cell where temperature regulation is done by a thermo-sensor by regulating the steam supply to the final heating section. The sterilizer is equipped with a flow diversion value. If the temperature drops below a preset value, the flow is diverted through a separate cooling section and back to the inlet balance tank.

Under normal production conditions, the product is cooled in a final cooler before leaving the plant. The cooling sections are regenerative type. Since whey proteins get denatured at high temperatures, deposits will always form in sterilizing equipments. In order to reduce the amount of deposits, a holding cell is introduced. In this way, the whey protein is carried through the equipment and scaling is diminished. The higher the air content in the product, more is the chance for deposits to form. The air content can be reduced by a de-aeration process and by the holding cell.

32.7.1.1 Advantages of plate heat exchanger

- High induced turbulence to the heating medium and heated product
- High heat transfer rate
- Low temperature difference between heating and heated fluids (low deposit formation)
- Low pressure drops in the product circuit
- Plates can be assembled to give a wide variety of heating and cooling sections.

32.7.1.2 Disadvantages

The gaskets set upper limits to the internal pressures that can be used with the heat exchanger.

32.7.2 Tubular heat exchanger (Stork) 3rd generation

The product is admitted via a balance tank and reaches the first homogenization head through the regenerative pre-heater and then the final heater. Final heater is designed to have lower energy consumption and ensures low temperature gradient between product and heating medium. For this, a triple tube heater in which steam passes through the centre and outer tubes surrounding the product, which flows through the middle tube. The advantage it offers is rapid heating of the product. Sterilization temperature (138°C) is reached here. After passing the first regenerative cooling section, the product is cooled down to about 75°C and reaches the second homogenization head. After passing the second regenerative cooling, the product is admitted to the final cooler where the temperature is brought down by means of water cooling to filling temperature. This arrangement gives almost twice the heat transfer of a single tube in a heating chamber. Inherent strength of tubes, much higher internal pressures can be withstood during the operation.

Stainless steel tubes do not cause induced turbulence in the product and natural turbulence resulting from high flow velocities is needed to give high heat transfer rates. Pressure drops through the heat exchanger and temperature differentials between heating and heated fluids are therefore higher than with plates.

32.7.3 Combined systems

These have plate heat exchangers in the lower temperature sections and tubular sections at the highest temperatures, where the internal pressures are also high.

32.7.4 Scraped surface heat exchangers

Scraped surface heat exchangers are suitable for viscous products where satisfactory heat transfer rates cannot be obtained by relying on an induced turbulence from conjugal plates or natural turbulence from high product velocities. The product flows axially inside a stainless steel cylinder, heated from the outside. A rotating shaft on the axis of the cylinder breaks down any stationary layer of viscous product and induces turbulence in the body of the fluid. Scraped surface heat exchangers operate with high differential temperatures between product and heating medium.

32.8 Electric Method

32.8.1 Indirect with electric heaters

The electricity heats the incandescence spiral resistance elements which are wound round quartz tubes through which the milk passes. The milk heated from 95 - 140°C using a combination of infra-red radiation and heat conduction through the quartz tubes. From the stand point of performance, this sterilizer is therefore simple to a conventional indirectly heated sterilizer.