Chapter 5

PASTEURIZATION OF MILK

(Objectives of pasteurization, Pasteurization requirements for milk, Methods and equipment for long hold batch type pasteurization, HTST pasteurization, UHT pasteurization)

Pasteurization is the process of heating the product to a predetermined temperature and holding it until all or nearly all objectionable microorganisms, which may be present, are killed. (This was developed by Louis Pasteur, 1960)

Objectives of pasteurization

- To make the product safe for human consumption by destroying the pathogenic organism, which may be present.
- Improves preservation quality by destroying almost all spoilage organisms.
- Helps to retain good flavor over a longer period of time.

Pasteurization requirements for milk

Pasteurization by heating and time treatments are a compromise among bacterial killing along with a number of other factors such as taste, phosphate inactivation, cream line reduction, etc. The target microorganism for milk processing is Micobacterium tuberculosis (TB germ). The following Table 5.1 shows how the pasteurization process has been standardized considering these factors. Accordingly, the methods of pasteurization can be given as in Table 5.2.

Table 5.1. Standardization of pasteurization requirements for milk

Requirement	30 min	15 sec
Kill TB germ	138°F	158°F
Phosphate inactivation	142°F	160°F
Pasteurization requirement	145°F (63°C)	161°F (72°C)
Creamline reduction	146°F	162°F

Table 5.2. Methods of pasteurization for milk

Methods	Treatment
Long hold batch type / Vat pasteurization	63°C-30 min
High temperature short time (HTST) pasteurization	72°C-15 s

Ultra high temperature (UHT) pasteurization	88°C-3 s

However, the time and temperature combination maintained in a dairy plant may vary from the above Table values depending on the initial microbial load and other considerations.

LONG HOLD OR VAT PASTEURIZATION

The long hold or vat pasteurization is a batch type method where the pasteurization is carried out at 63°C for 30 min. The basic operations involved in a vat pasteurizer are given in Fig. 5.1.

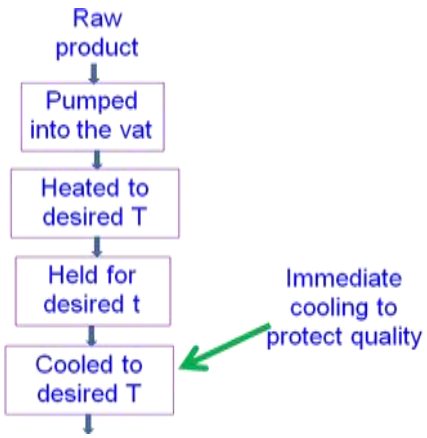

Fig. 5.1 Basic operations in a vat pasteuriser

Types of vat pasteurizers (Classification based on flow of heating medium)

1. Spray type
2. Flooded type
3. High velocity flooded type

General requirements

The following are the requirements for a successful batch pasteurization process.

- Rapid heating: Generally the circulation of heating medium is started as soon as filling of the vat is begun, thus shortening the heating time.
- Immediate cooling: In some designs the cold water is circulated over the outside of the inner lines as soon as the holding period is completed, so a part of cooling can be done in the vat itself.
- Heating medium should be only a few degrees warmer than milk to prevent formation of milk stones on heating surfaces and cause minimum injury to cream line or flavour.
- ***Agitation*.** Agitation of milk within a certain degree helps in improving the heat transfer.
    - Agitation is easier in case of hot fluid than cold ones.
    - Agitation should not develop foam and it should not injure the cream line.
    - Viscosity of the fluid greatly affects the type of agitator.

- Less viscous materials require small diameter high speed agitator. Highly viscous materials require slow speed large surface blade type agitators.

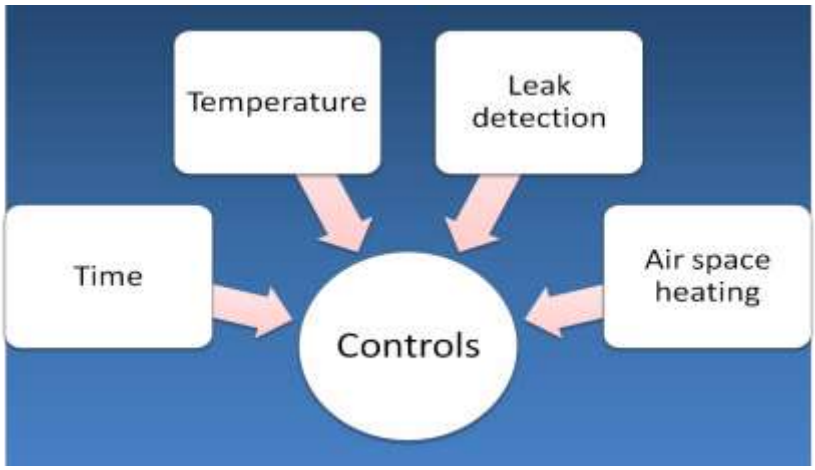

Fig. 5.2 Pasteurizer Controls

For vat pasteurizers, an electric or air operated control can be connected with a timing clock so that the heat is shut off when the proper milk temperature has been reached and a bell rings when the proper length of holding time has elapsed. Also temperature of heating water can be controlled during the holding period.

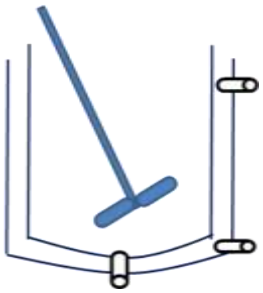

Fig. 5.3 Schematic representation of a long hold batch type pasteurizer

Advantages

- Well suited for small plants, low volume products
- Variety of products can be handled.
- Well suited for cultured products such as bottle milk, sour cream, etc.
- Simple controls
- Low installation cost

Disadvantages

- Batch type
- Slow process
- As the controls are mostly manual, it requires constant attention.
- Both heating and cooling are relatively expensive (as we do not have heat regeneration).

HTST PASTEURIZATION

High temperature short time pasteurisers are usually continuous flow systems using heat exchangers. Generally plate type heat exchangers with regenerative heating, heating and cooling systems are used.

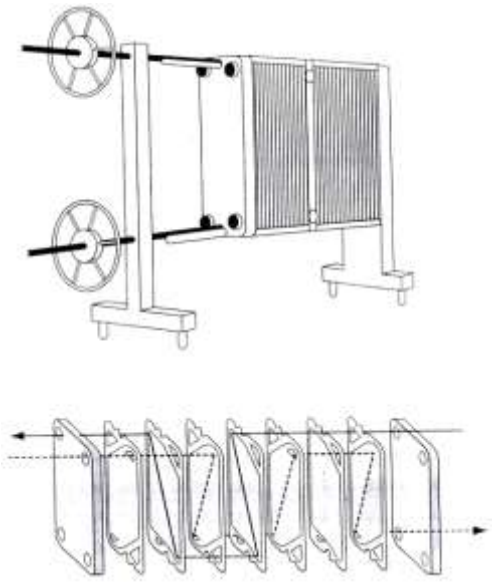

Fig. 5.4 Plate heat exchanger

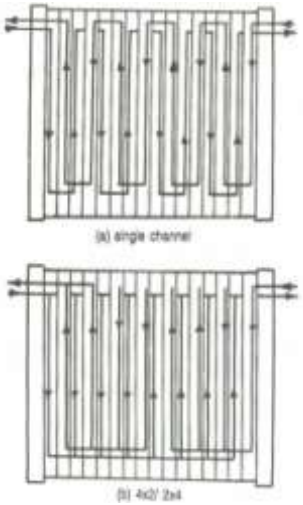

Fig. 5.5 Flow pattern in plate heat exchangers

Fig. 5.6 Types of plates used in plate type heat exchanger

Basic components of HTST pasteurization system

The HTST pasteurization process and its basic components are shown in Fig. 5.7. First from a constant level tank, milk is pumped by a booster pump into a heat exchanger to heat it with the help of pasteurized milk to about 60°C. As the pasteurized milk is used for heating the raw milk and there is no external heating source, we call that a regenerative heater. The regenerator reduces the actual heat requirement for pasteurization and hence is very important for the overall cost effectiveness of the system. Then the milk enters into the heater where the temperature of milk is raised to the actual pasteurization temperature. The milk then passes through the holder, where the milk temperature is maintained for the specific time so that pasteurization is completed. Then the pasteurized milk goes to the regenerator so that it gives away some heat to the raw milk. It is also simultaneously cooled so that the refrigeration requirement is reduced. After the regenerator, the pasteurized milk goes to a chiller, where the milk temperature is reduced to about 4-5°C.

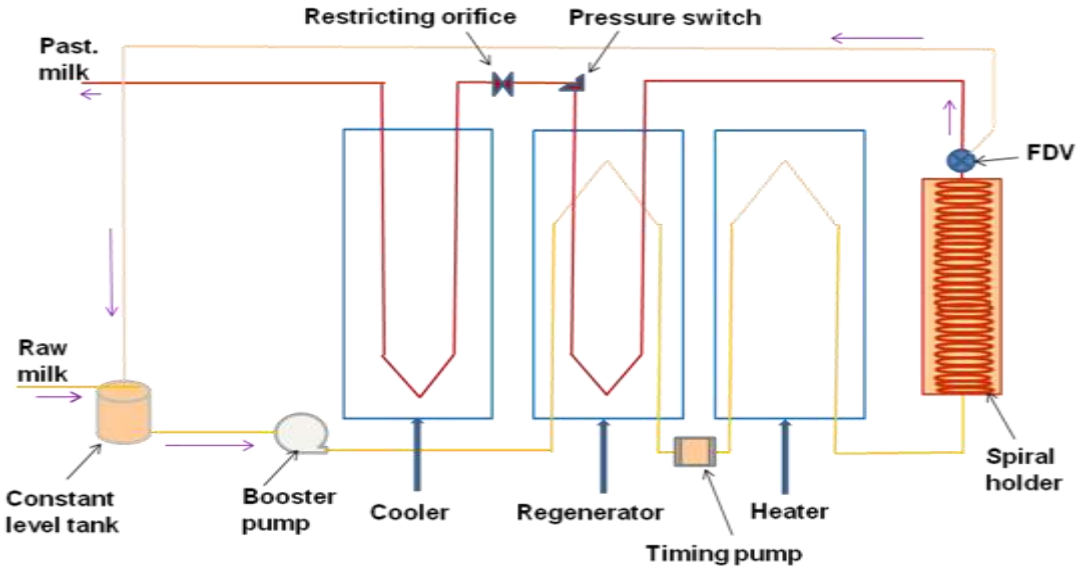

Fig. 5.7 HTST pasteurization process

Fig. 5.8 A HTST pasteurizer

For HTST pasteurization, the following controls are very important.

- Flow rate
- Temperature
- Pressure

Control for flow rate

- The flow rate is regulated by a metering or timing pump
- A positive displacement pump of rotary or piston type is used.
- Often variable speed drives are used to change the rate of flow when desired.
- Pump must be sized and perfectly driven such that flow rate does not exceed the actual, i.e. the holding time is not below legal minimum.

Control for temperature

- Control of temperature includes means for maintaining a uniform product temperature at or above the legal minimum at a safe value.
- It should divert the flow back to the system if the temperature at the end of holder is below legal minimum.
- Usually a safety thermal limit recording controller is used. (It makes a continuous record of the temperature and marks the time when the flow diversion valve operates.)

Control for pressure

The pressure control is important in the following three sections.

- In the regenerators
- In the flow diversion valve
- In the diverted milk lines (for homogenization, etc.)

Pressure related problem in the regenerator

The different causes and effects of pressure related issues in a pasteurization system are given in Fig. 5.9. As it can be seen, the centrifugal booster pump takes care of the pressure related problems in the regenerator. Besides, there are three more devices as the timing pump, pressure switch and the restrictor, the functions of which are given below.

- Timing pump: It assures that the pasteurized product side is always under higher pressure than the raw side in the regenerator.
- Pressure switch: It will allow the pump to run only when the pressure in pasteurized side is at least 1 psi more than the raw side.
- Restrictor: It is an additional device to satisfy the minimum 1 psi difference if the cooler section does not produce enough back pressure on the pasteurized side.

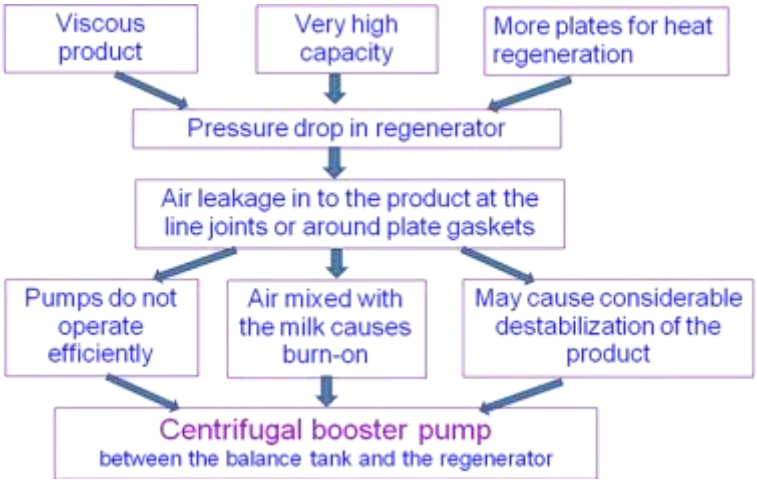

Fig. 5.9 Use of booster pump in a pasteurization system

Pressure management in the flow diversion valve

- The thermal limit recorder not only makes a record of the temperature of the milk, but also indicates, records and controls the action of the flow diversion valve.

Pressure management in diverted milk line

- The other pressure management is needed on the diverted milk line, since it may affect the holding time during diversion.
- If the holding time during diverted flow is shorter than that in forward flow, a restricting orifice should be placed in the divert line.

Main parts of HTST pasteurizer

Now that we have discussed the process and the controls required during the process, we can write down the main parts of HTST pasteurizer as follows.

- Constant level tank
- Regenerator
- Booster pump

- Timing pump
- Heater
- Holder
- Flow diversion valve
- Pressure switch
- Restricting orifice
- Cooler

Important accessories

- Leak detector valves at all inlet and outlet pipes.
- Air space heaters (Air space heating is done by introducing steam above the level of the product).

Advantages of HTST pasteurization

- Uniform treatment.
- Temperature is regulated at close limits and overheating is prevented.
- Economical than batch systems (due to regenerative heating).

Disadvantages

- The system is complicated.
- Not portable.
- Installation cost is more.

ULTRA HIGH TEMPERATURE (UHT) PASTEURIZATION

As we have discussed previously, the UHT pasteurization process involves heating the milk at a temperature of 88°C for 3 sec. The equipment is much the same as the HTST units and the controls are also similar, but the operating temperature is higher. The holder is much smaller for smaller pasteurizing time.

Advantages

- Better texture of milk due to short holding time
- Greater bacterial destruction is possible.

When UHT treatment is needed for greater bacterial destruction or its beneficial effect on the body and texture of ice cream, then the treatment may be given following regular pasteurization.

Pasteurization and homogenization

- Since nearly all fluid milk and ice cream mix etc. are homogenized, homogenizers are integrated to the continuous pasteurization process.
- As the homogenization temperature must be at least 60°C, the homogenizer must be located either between the regenerator and heater or after the heater.

- The equipment, when installed, should not reduce the holding time below the legal minimum either when they are operating or when they are at rest.
- The capacity of the homogenizer can seldom be synchronized exactly with the timing pump unless a vented cover or other relief valve is employed, and then the pump operates at slightly greater capacity than the homogenizer.
- The usual practice now a day is to use homogenizer having 3-8% greater capacity than the maximum flow rate of the system. They are equipped with a recirculation, by-pass loop from the discharge line to the suction feed line.
- Here the timing pump regulates the flow rate of the system at all the times.

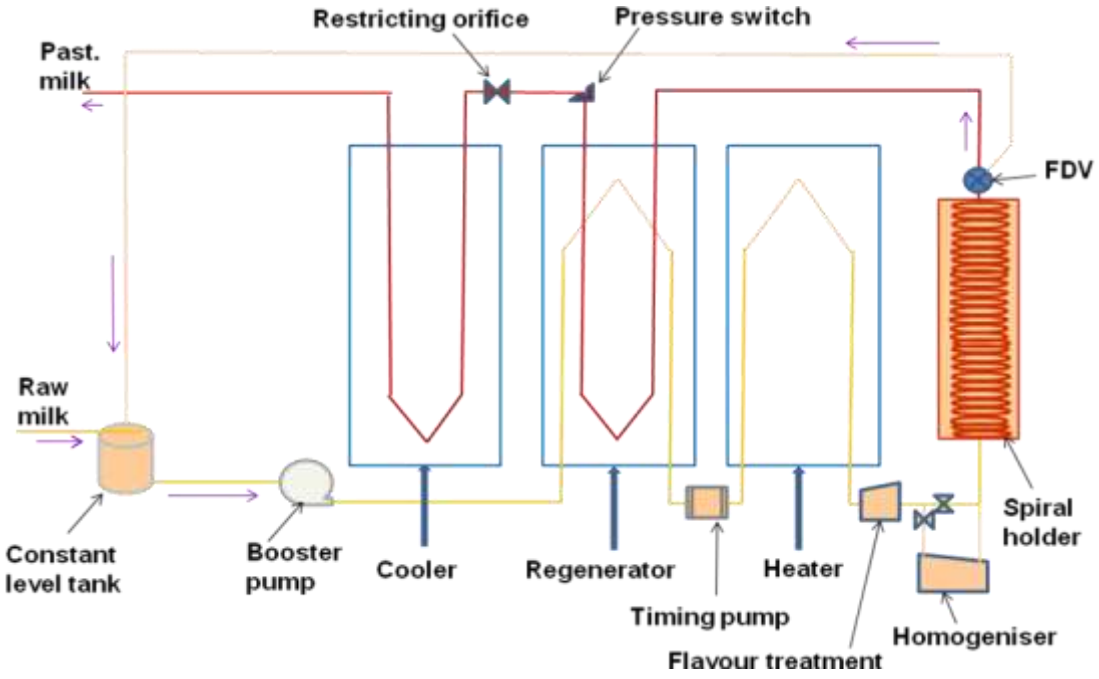

Fig. 5.10 Homogenizer incorporated in HTST pasteurization system

Like homogenizers, clarifiers and separators may also be integrated into the lines of HTST and UHT systems.

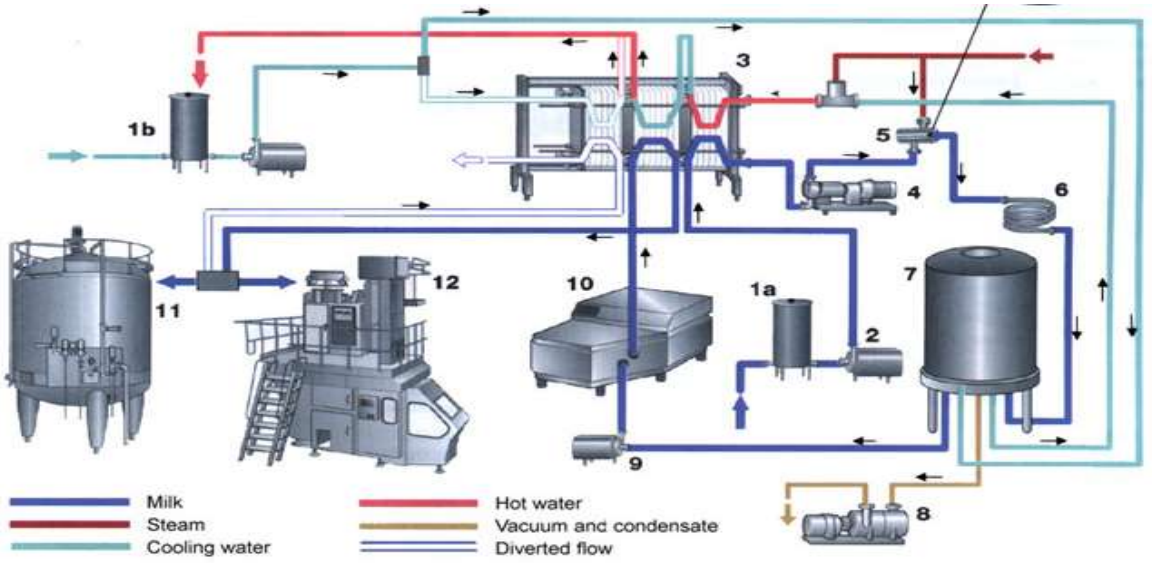

Fig. 5.11 UHT process with heating by direct steam injection combined with plate HE

(1a: Balance tank milk, 1b: Balance tank water, 2: Feed pump, 3: Plate heat exchanger, 4: Positive pump, 5: Steam injection head, 6: Holding tube, 7: Expansion chamber, 8: Vacuum pump, 9: Centrifugal pump, 10: Aseptic homogenizer, 11: Aseptic tank, 12: Aseptic filling)

Uperization (Ultra-pasteurization)

This is another method of pasteurization and the unit operations involved in the process are given in Fig. 5.12.

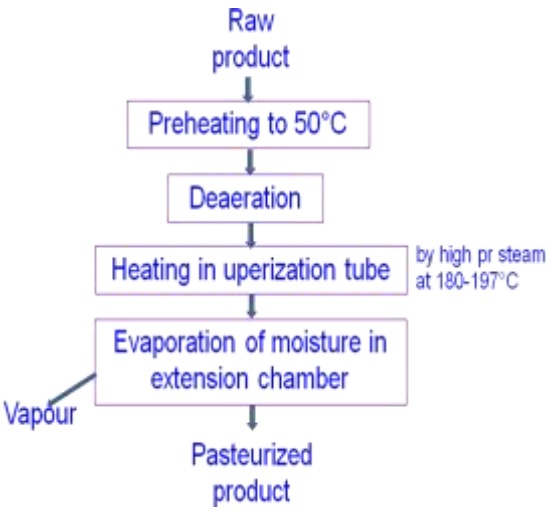

Fig. 5.12 Uperization process

The process involves heating the milk with high pressure steam at 180-197°C. The milk is heated to 150°C for less than 1 sec to obtain the desired effect of pasteurization.

Vacreation

- The process of heat treatment under vacuum in stainless steel chamber is known as vacreation.
- Vacreation is normally done for cream used in manufacture of butter.

The purpose of vacreation is to

- Kill bacteria,
- Inactivate enzyme,
- Remove undesirable odors and flavors,
- Deaeration to expel dissolved air and finely dispersed bubbles.

The system consists of a product feed pump, steam pressure controller, a temperature-recorder controller, vacuum controller, milk inlet controller, concentration ratio controller. The equipment is called 'Vacreator' (trade name adopted from Protech engineering, NZ).

Care and maintenance of pasteurizing equipment

- Keep all surfaces clean
- Routine preventive maintenance and adjust controls
- Proper care and lubrication of gasket
- Lubrication of motor, pump and other necessary equipments
- Thermometers and control equipments should be checked for accuracy. Replace if out of tolerance.

Flavor treating system of milk

The milk may contain flavors, which are mainly as follows.

- Flavor which is made of volatile component
- Weed and feed flavor

When it is desired to remove flavor, the following methods are adopted.

- Aeration
- Vacuum flashing or distillation
- Steam injection followed by vacuum washing

The volatile substances can be removed by aeration. The fat and soluble flavors are removed by steam washing method.

Types of flavor treating equipment

Vacuum alone type

- Deaeration with no vaporization of the product
- Vaporizing unit

Steam vacuum unit

- Temperature control steam supply type
- Excess steam supply type / steam washing

The vaporizing unit is placed immediately after the flow diversion valve.

CHECK YOUR PROGRESS

1. Explain the differences between blanching, pasteurization and sterilization.
2. Explain the basis of selection of temperature and time for pasteurization.
3. What are the different methods of vat pasteurization? Explain the specific care to be taken during batch type pasteurization with a mention of the pasteuriser controls.
4. What are the relative advantages and disadvantages of batch pasteurisers over continuous pasteurisers?
5. Draw the flow chart of HTST pasteurization system and explain the flow process.
6. How the temperature, flow rate and pressure are controlled in HTST pasteurisers?
7. Mention the different component of an HTST pasteuriser and explain the function of each component.
8. What are the relative advantages and disadvantages of HTST pasteurisers over batch pasteurisers?
9. Write a short note on UHT pasteurization.
10. What type of heat exchangers are used in UHT pasteurization systems? Explain briefly the working principle of those heat exchangers.
11. Mention the special cares needed if you want to incorporate a homogeniser in the HTST system.