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ORIGINAL ARTICLE

A Mini Review on Working Mechanism, Standard Operating Procedure (SOP) and Preventative Maintenance of Low Temperature – Long Term (LTLT) Milk Pasteurizer

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ABSTRACT – A small-scaled batch Low Temperature- Long Term (LTLT) pasteurizer is one of many types of pasteurizers that is being utilized in food-based industries particularly in dairies. It has a capacity of heating up the milk and holding the temperature for a certain amount of time to kill pathogenic microorganisms. The instantaneous heat up is caused by heat exchangers either in the form of plates or metal coils depending on the machine. The coil is circulated within the jacket of the tank where it heats up and holds the temperature. Hot water circulation will be in continuous movement around the milk to heat it up and maintain the desired temperature. After certain period, the efficiency of LTLT pasteurizer starts declining due to cumulated issues. Decline in efficiency will affect the output of the machine too. Instantaneous heat exchanges, leaking, unstable pressure and electrical problem degrades the machine over period if it is not complying with Standard Operating Procedure (SOP) and a proper Preventative Maintenance (PM) plan. The SOP and PM will increase the machine's lifespan and maintain a good efficiency rate for longer period. This mini review paper will compile the possible PM plan and establish a sustainable SOP for the LTLT Pasteurizer.

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INTRODUCTION

The dairy sector in agricultural industry has been consistently on an uptrend as the demand can't be reached. In 2019, global milk production (81% cow milk, 15% buffalo milk, and 4% goat, sheep, and camel milk combined) increased by 1.3% to approximately 852 Mt. India, the world's largest milk producer, increased production by 4.2% to 192 Mt, but this had little impact on the global dairy market because India trades only marginal quantities of milk and dairy products [1]. The demand of dairy is justified with the consumption per capita where the least consumption of dairy is from Asia, and slowly progressing [1].

The dairy demand justifies that the raw material and machines procurement is going to be high too. Intense production from dairy producers and by-product manufacturers needs standardized machines. A Low Temperature-Short Term (LTST) pasteurizer is a promising product for manufacturers to standardize the quality of their raw material. Raw milk consists of dangerous microorganisms such as Staphylococcus aureus, Salmonella spp., Listeria monocytogenes, Escherichia coli O157:H7 and Campylobacter which may affect human health [2]. This pasteurizer machine kills harmful pathogens by instantaneous heat spike [3]. Besides killing of pathogen pasteurization of milk increase shelf life of the milk, enhances the taste and quality of the processed milk and legal requirements of it [4].

There are multiple types of pasteurizers such as Low Temperature – Long Term Pasteurizer (LTLT), Higher temperature- Short Time Pasteurizer (HTST), Ultra High Temperature Pasteurizer (UHT) and Ultra Pasteurizer (UP) [5]. Each processing method has its own purpose. LTLT and HTST Pasteurizer function is to increase shelf life and safety for human consumption, destroy all pathogens and spoilage-causing microorganisms [6]. HTST Pasteurizer is very efficient as the milk temperature is immediately raised to 72˚C at 15 seconds but it may have an impact on vitamin fortification [6]. LTLT Pasteurizer raises the temperature to 63˚C and hold onto the temperature for 30 minutes [7]. The risk of bacteria multiplication that cause foodborne illness in milk is minimized and the lifespan of the product is extended [8]. UHT is heated in extensive environment to provide a lifespan of the milk for several months depending on processing parameters, storage conditions (time and temperature) and type of packaging [9].

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ADVANTAGES AND DISADVANTAGES OF LTLT PASTEURIZER

There are many types of pasteurizers in the market and there are many reasons why the LTLT Pasteurizer was chosen for this review paper. Both LTLT Pasteurizer and HTST Pasteurizer are well adopted in dairy operative system as both reduce the bacterial colonies [10]. However, there are a few specified advantages for LTLT Pasteurizer:

1) Versatile machine with adjustable temperatures.
2) Made of sanitary stainless steel for easy cleaning and hygiene
3) Easy to operate. It comes with a programmable timer and electronic control panel.
4) Suitable for small scale processors.
5) Initial investment will be low.
6) Least floor space is used.
7) Suitable to make by-products as this process modifies the milk composition.

This LTLT Pasteurizer is very straight forward and easily accessible for users. The pasteurizer's sustainability complies with a proper Standard Operating Procedure (SOP) and periodic maintenance plan. However, there are also certain disadvantages with LTLT pasteurizer compared to HTST Pasteurizer.

The disadvantages are as follows: -

1) The extended holding process in heat changes the milk protein structure and taste.
2) Takes longer time to process compared to HTST pasteurizer.
3) Cooling element of the LTLT pasteurizer comes separate and detached from the system.

Despite the disadvantages, this machine is the most suitable for small-scale dairy processors. Marketing this machine in the market intensely will eventually boost the industry because small-scaled dairy processors are the majority in the sector.

WORKING MECHANISM OF LTLT MILK PASTEURIZER

An LTLT milk pasteurizer (as in Figure 1) consists of a collection tank, centrifugal pump, heat coils, regeneration, filter, flow direction valve, control panel, heating panels, milk revolver, and automatic controller set device [11]. LTLT Milk Pasteurizer will be able to process with limited input of milk depending on the machine capacity. It starts with the heating tank. The milk is poured in the heating tank upfront. A revolver is also attached in the collection tank to stir the milk consistently for even heat spread. Upon pouring the desired volume of milk, the control panel is regulated for the desired temperature for pasteurization. The temperature can be set via control panel. After regulation of temperature is set to 72˚C, the control valve should be opened. This control valve allows the water to be pumped from supply into the plate heat exchangers in the control panel and to the jacket of heating tank. Normal water will be heated in the process before entering the heating tank, where milk is being stored. A heating coil is placed inside and around the heating tank, specifically called jacket, where the hot water will be circulated. This method only heats up the tank and not directly in contact with the milk. The heat exchange term can be classified as conductive heating. Conductive heating occurs when the heat from heated water in pasteurizer's external jacket is transmitted to the thin wall of internal jacket resulting in a relatively large temperature gradient in the radial direction [12]. Correlating with the LTLT machine, the heat is transmitted from the hot water to the jacket before reaching the milk.

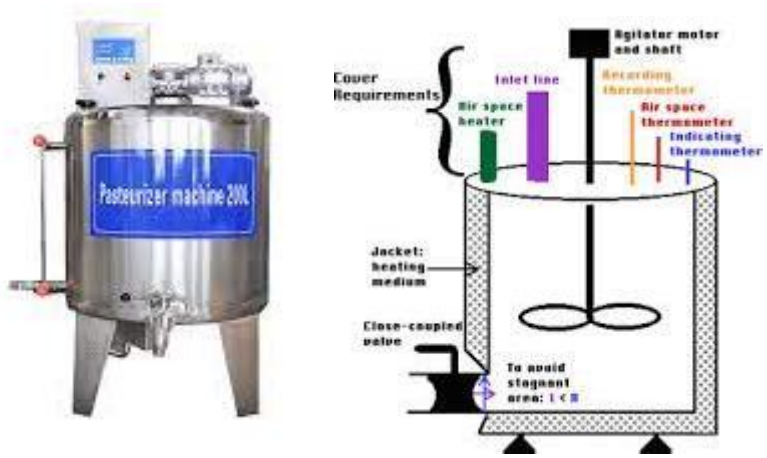

Figure 1. LTLT milk pasteurizer.

While heating, the revolver in the heating tank will be constantly stirred for even spread of heat throughout the milk. This is to prevent the milk from getting burnt and increase its quality. The control panel cuts off the heating operation automatically when the 72˚C is achieved. The hot water will be reverted externally from the system by regulating the flow control valves. The temperature is held constant for 30 minutes. The heat-induced reactions in the bulk of the milk can be classified into five groups: microorganism destruction, enzyme inactivation, protein denaturation, nutrient loss, and the formation of new components. Most reactions are described by a single irreversible reaction step [13]. However, it is safe to consume this product as heat-treated milk is without a doubt the best compromise between safety and chemical-nutritional and organoleptic quality [14]. Pasteurization will only be completed when the cooling down process is involved. The milk is cooled down to 4˚C to further kill pathogens and slow the multiplication of psychotropic bacteria in milk which contributes mainly to milk spoilage [15]. The cooling element for this machine is installed separately where the milk travels from the heating tank to the cooling tank, From the cooling tank, there will be an outlet where the milk is filtered and flushed out before the next operation.

STANDARD OPERATING PROCEDURE (SOP) OF LTLT MILK PASTEURIZER

The best suggestion for efficient operation of LTLT Milk Pasteurizer is to comply with the regulated Standard Operating Procedure (SOP) for sustainability of the product. The SOP will cover pre, during and post operation of the pasteurizer.

Pre-operation SOP:

1) Test the milk for coagulation by using alcohol test, there should be no coagulation before the milk enters the pasteurizer.
2) The milk collection tank, tank outlet and revolvers should be sterilized with hot water to prevent any sort of contamination.
3) The valve should be checked for the flow of the hot water to enter the jacket of the machine.
4) The control panel is made sure in default settings before operation.
5) Any possible damage or leaking on the machine must be checked before operation begins.
6) Any remaining water must be drained before operation.

During operation SOP:

1) Make sure the control panel is in default specifications.
2) The temperature is set in the control panel and automatic cut-off will be executed.
3) The flow valves of hot water into the jacket of the machine are opened according to direction.
4) The revolver in the collection tank is turned on for even heating.
5) The operation must be made sure that there are no leakages in the system. If there are any, the operation must be stopped immediately.

Post-operation SOP:

1) The control panel must check if the desired temperature is achieved.
2) The valve also should be regulated once the temperature is cut off.
3) The milk must be totally flushed out of the collection tank.
4) Upon flushing, the whole tank should be sterilized again with Potassium Hydroxide powder.

5) The control panel must be reset before and turned off.
6) The revolver is also made sure stopped and turned off.

Besides pre, during and post operation, there is a specified Standard Operating Procedure (SOP) for cleaning as well. Cleaning is an essential process of LTLT Pasteurizer to avoid contamination which causes developments of various fermentative bacteria which reduces the shelf life of milk. Thus, proper cleaning and sterilization is needed to maintain the quality of the product.

Cleaning of the LTLT Pasteurizer

1) For cleaning of the pasteurizer, distilled water must be used instead of tap water which is infused with chlorine water.
2) The milk collection tank of the LTLT pasteurizer must be cleaned initially with room temperature distilled water to remove heavy contaminations before sterilizing.
3) After cleaning with room temperature distilled water, the collection tank must be sterilized with 80˚C temperature distilled water for further killing of pathogens.
4) Potassium Permanganate must be used to clean with the hot water for further reduction of bacterial load.
5) The knob, or better known as the output of the pasteurizer, must be cleaned using the bottle brush.
6) The thread of the knob must be sterilized using Potassium Permanganate too.
7) The outside of the tank and control panel must be wiped with Ethanol to avoid bacterial growth through milk strains.

MAINTENANCE PLAN

The variable preventive maintenance has a marginally significant effect on production achievement. This means that improving preventive maintenance performance will influence or increase production achievement [16]. This is to ensure that the machine can sustain for a longer period in efficient condition. Besides, preventative maintenance plans reduce the risks of breakdown and reduction in the amount of corrective maintenance that needs to be done. Preventative maintenance is also essential for maintaining food security for people and ensure there is no disease spread.

Preventative maintenance of LTLT pasteurizer covers few serial aspects such as inspections, lubrication, adjustments, testing and replacing worn parts of the machine. These aspects can be divided into 2 categories, where the first would be frequent maintenance and another would be tentative maintenance. Inspection and lubrication would be done frequently and tentatively or during any emergencies, lubrication, adjustments, testing and replacing of worn parts will be done.

Preventative maintenance also must be planned well with the appointed authorities (employees or third party) who know well about the machine. LTLT pasteurizer can still be maintained by employees due to lack of complexity of the machine. However, complex industrial graded LTLT pasteurizers require eligible authority who specialize with the machine for commissioning. All specific parts must be specified and detailed during the scheduled maintenance. 2 of the major components require strict maintenance plans as the whole system relies on the mechanism, which is the motor and electric control panel.

Motor

Figure 2. Motor of pasteurizer agitator

1) Visual inspection must be made.
2) Brush and commutator inspection must be performed.
3) The motor winding test must be conducted.
4) The bearing must be checked if they are still in good quality.
5) Vibration tests must be conducted if necessary.
6) Documentation and report writing on actions taken.
7) Complete overhaul is suggested to be done once a year.

Electric Control Panel

Figure 3. Electric control panel of pasteurizer

1) The environment must be checked to see if they are suitable for the electronic program boards. Ensure the humidity, temperature, and other factors.
2) The debris, dust and buildups must be cleared to prevent downtime and avoid catastrophic short circuits.
3) Clean and replace the filters for better air flow.
4) The connections are made sure tightened.
5) The LED battery indicator must be checked.
6) EMI (Electromagnetic Interference) must be checked on the surroundings of the machine for maximum efficiency.

Preventative maintenance should be done periodically to keep the machine running without major disruption. Preventative maintenance should also be included in SOP as a tentative plan.

CONCLUSION

LTLT (Low Temperature- Long Time) pasteurizer conclusively provides an added advantage to the sector and benefits the industry. The easy operative module of the machine is an added advantage to dairy producers and processors for sustainability of the business. LTLT pasteurizer is still affordable depending on the processing capacity. The machine continuously degrades along time but with correct Standard Operating Procedure (SOP) and periodic maintenance plan will increase the lifespan of the machine. Besides lifespan, the efficiency of the machine can be maintained as it is very vital to maintain the quality of perishable item. Despite milk, this machine is explored in other sectors as well such as fruit juice manufacturing plant, sauce lant, dips plant, jam plant and syrup plant.

A correct SOP before, during and after the operating process will ensure that the machine is not mishandled. This will prevent the machine for human errors and provide a systematic procedure handling the machine. Sustainability and efficiency can be maintained for the machine. Periodic maintenance plans usually happen post processing on a scheduled timeline. This will ensure the machine does not break down by cumulated problems. The scheduled time for the machine will ensure the parts are aligned well, provide proper lubrication, wiring assessment and cleaning of internal parts with chemicals. Preventative maintenance provides assurance of a lasting operation. Conclusively, a proper SOP has to be established according to the LTLT machine specifications and provide periodic preventative maintenance for the machine for sustainable production.

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