NEW HIGH-TEMPERATURE PASTEURIZATION PROCESSES—INSTRUMENTATION AND CONTROL[1]

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During the past few years, there has been an interest in the pasteurization of milk and milk products at higher temperatures without a measured holding time. This interest has been advanced by the development of equipment which is capable of heating milk and milk products very rapidly to temperatures above 190° F. without "burn-on" of milk solids. Along with this have come reports that higher temperatures provide some definite advantages to the dairy industry. Tobias (*1*) points out that ice-cream mix has improved body and texture when pasteurized at 240° F. in equipment capable of rapid heating. He also mentions that processing other types of dairy products at higher temperatures presents possibilities of greater bacterial destruction and, therefore, better keeping qualities.

The pasteurization of milk and milk products imposes exacting requirements on a process. It must be capable of destroying the causative agents of those diseases which may be transmitted through milk, and it must be such that controls may be applied which will assure uniform and adequate treatment of every particle of the product being pasteurized. Obviously, temperatures above 190° F. require considerably less time for the destruction of pathogenic microorganisms than the 15 seconds current standards specify for conventional high-temperature, short-time pasteurization, but research from which the HTST standards were derived does not provide an adequate basis for determining the time necessary for proper pasteurization in the 190° F. range. However, the prospects of simpler operation and improvement in some product characteristics have stimulated several research projects relating to the extent of holding time necessary for pasteurization when temperatures above 190° F. are used.

Two avenues of study were open to the investigators. First, they might follow the classic method employed by Rosenau, North, Park, and other early investigators, namely, to determine the combination of time and temperature which is necessary to destroy milkborne pathogens. Second, on the assumption that the current standards for pasteurization provide adequate margins for safety, they could determine the time at given temperatures which is necessary to provide the same degree of bacterial destruction as is furnished by present pasteurization methods.

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The second consideration in evaluating a pasteurization process is the ability of the equipment to maintain adequate time and temperature during all phases of operation. Much of the bacterial destruction in these processes takes place during the heat-up period, and the design of the equipment should be such that all of the product being processed is heated at a uniform rate. In addition, automatic controls are needed which will guard against even momentary departures from safe-process conditions. Much of the early criticism of continuous-flow pasteurization was generated from scepticism that the equipment and control de-

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vices then available would assure a completely safe product.

UNIFORMITY OF HEATING

Commercial equipment now available for pasteurization at temperatures above 190° F. have features which tend toward a high degree of uniformity in product heating. One such pasteurizer heats by gravitational fall of the product through steam under vacuum. Controls are provided which assure that a more than adequate quantity of steam is present for heating the product to proper process temperature whenever a product is being introduced in the chamber. Since the product is homogeneous, the most likely possibility for variance in heating rate and final temperature would occur when conditions permitted the product to fall in different-sized streams. Tracy, Pedrick, and Lingle (2) studied this aspect of the problem and reported that this type of equipment would pasteurize satisfactorily even though the distributor which divides the product into fine streams might be plugged or removed.

Other pasteurizers now being used for pasteurization at temperatures above 190° F. heat by exchange through a metal barrier. In order to achieve the high heating rate necessary, these heaters are designed to provide high surface volume ratios, and to use a high heating-medium product-temperature differential. Consequently, high velocities are necessary to prevent burn-on of milk solids and impaired heat exchange. These high velocities result in a degree of turbulence which is conducive to uniform heating of the product.

TEMPERATURE CONTROL

Temperature controls on pasteurizers which operate at temperatures above 190° F. must fulfill the same basic functions as those used on conventional HTST equipment; namely, a control to maintain a reasonably uniform product temperature and, more important from the public-health viewpoint, a control to prevent the passage of subtemperature product. In providing the latter type of control, it becomes necessary to consider the rate at which the temperature can drop under adverse conditions in relation to the reaction time of control instruments.

Existing specifications for thermometric lag and reaction time of flow stops are predicated on observations of their effectiveness when used on conventional HTST equipment. The adequacy of these specifications to accommodate the needs when higher temperatures and shorter holding times are used, is subject to some question. In practice, manufacturers have been providing more sensitive or different types of controls for use with these process conditions.

It was obvious that the flow-diversion value could not be utilized on the pasteurizer which heats by direct contact of the product with steam. First, product transport is by entrainment in a vapor stream, and the passage in which the valve should be located is larger than could be accommodated by existing flow-diversion valves. Second, the passage is under negative pressure, and a diversion line would have to terminate in a chamber of higher vacuum if diverted flow was to occur. Third, the rate of product transport is so rapid that an impracticable response time would be necessary if forward flow of subtemperature product was to be prevented.

In view of these considerations, controls were developed which went beyond temperature *per se* and which were applied to the operating components which govern heating and product flow. The product is introduced in this equipment by means of a pump, and the functional manifestation of all the control instruments is the control of pump operation. Since the negative pressure within the first chamber could result in some flow without the pump in operation, a spring-loaded valve is also provided at the inlet to the pasteurizer, to prevent entrance of product when the pump is not operating.

The control system is composed of three interlocks with the infeed pump: (a) a temperature-sensitive element in the passage between the first and second chambers permits pump operation only when temperatures above 194° F. are registered; (b) the quantity of steam supplied for product heating is so regulated by a fixed orifice that, when a predetermined pressure (35 lbs.) is maintained between the orifice and the cut-off valve, there will be adequate steam for product heating; and (c) a pressure switch located at this point permits pump operation only when sufficient pressure is present. A third element in the control system is more closely identified with proper operation and with product composition than with the maintenance of adequate pasteurization conditions. This control consists of a vacuum switch located in the condenser which will stop the infeed pump unless sufficient vacuum is present for proper functioning of the pasteurizer.

Equipment which heats by means of exchange through a metal barrier is not subject to the same limitations on the use of a flow-diversion device as those noted above. In this equipment, the product is under pressure and fitting sizes are adaptable to standard valves. However, one problem has resulted from the desire of the industry to use temperatures in excess of the boiling point when pasteurizing ice-cream mix; namely, that the sealing of the diversion and leak-escape ports on the valve, although adequate in lower temperature ranges, has not proven entirely satisfactory in this application. At the present time, such valves are usually modified to prevent excessive leakage at these points.

In commercial installations, the response of the valve to temperature change is more rapid than that of flow stops employed on conventional HTST equipment. The control instrument has been designed with a substantially shorter lag, and the speed of the driving mechanism of the valve has been increased by use of higher spring tension and air pressure. Field observations indicate that response of such devices is sufficiently rapid to prevent the passage of subtemperature product.

Time Control

Time, as a regulated factor, assumes less importance than when lower temperatures are employed. This is due, principally, to the difference that exists in the contribution of the heat-up period to the total lethality of these processes. When milk is processed at 143° F. and heating is reasonably rapid, the lethal effect of the heat-up period is negligible as compared to that of the ensuing 30-minute holding period. However, when temperatures above 190° F. are employed, the heat-up period in commercial equipment appears to provide the conditions of time and temperature necessary for pasteurization of milk and milk products without further holding time.

This should not be construed as instantaneous pasteurization. Each pasteurizer now available requires an increment of time to bring product to process temperature and back below the lethal range. The evident fact is that it is not necessary for the product to be held at one temperature for a given interval in order for microorganisms to be destroyed.

Time control in the higher temperature ranges may differ in concept from time control in conventional HTST pasteurization. The conditions of time and temperature for conventional HTST systems are established in the definition of the process, and pasteurizers are built and operated to conform to these specifications. In the higher temperature ranges, individual processes have been accepted by regulatory authorities on the basis of specific studies showing their ability to destroy microorganisms at a given temperature. Here, the problem of time control is one of assuring that the time during which lethal temperature was applied during test conditions will be met or exceeded during all phases of operation.

Need for a time control on a given pasteurizer will depend substantially on whether it is possible to heat any product to the pasteurization temperature at a faster rate than that used to establish the acceptability of the process. If the time of product transport through the equipment is independent of operating variations, or if it is so interrelated to the control of temperature that sufficient time is always assured when adequate temperature is provided, a time control as a separate entity becomes unnecessary.

The latter situation exists in the pasteurizer which heats by product exposure to steam under vacuum. In this equipment, the transport time of product through the equipment is governed by the amount of steam introduced, the presence of a proper operating vacuum, both of which are controlled, and gravity. Tracy, *et al*, in the study cited above, considered the effect of varying the steam supply and the amount of vacuum, and reported no loss of pasteurization effectiveness within a range where the temperature control would permit continued operation. Accordingly, there appears to be no need for a separate time control on this pasteurizer.

In other types of equipment in which product heating is achieved by exchange through a metal barrier, there exist greater possibilities for variation in the heating rate. While there is a theoretical maximum rate beyond which the product would not reach the proper process temperature, the effectiveness of this maximum heating rate for the destruction of bacteria is not normally established during test conditions. Further, units of different capacity or of modified design might well be expected to provide different heating rates.

In view of these potentials for varying the heating rate, it may prove simpler for all concerned to provide a short, supplemental holding period which will assure a sufficient time for pasteurization at all possible flow rates through such equipment.

Indicating and Recording Instruments

Up to this point only the functional aspects of instrumentation have been considered. However, it is axiomatic in milk sanitation that a variable which requires control should also be measurable. Accordingly, there is need for indicating instruments and in some instances recording devices. In the preceding discussion, situations have been described in which steam pressure and vacuum have been interlocked by switches to the infeed pump to provide proper operating conditions during pasteurization. It appears logical to expect suitable gauges to be provided at the same point, in order that both the operator and the sanitarian can test for proper operation.

Measurement and recording of temperature are an established procedure with all pasteurization processes. These newer methods present a need for instruments which operate in different ranges and possibly with greater speed. The desire of the industry to process certain products at temperatures well above that required for pasteurization and to have such temperatures recorded, has presented a problem to instrument manufacturers in providing accuracy at both ranges. Recording thermometers which utilize a separate pen for each range may be necessary to fill this need. The scales needed on such instruments are of about the same type as those now specified for conventional HTST equipment. The difference will rest with the focal point for accuracy and readability which, in these processes, should be the temperature which is established for their use as pasteurizers.

SUMMARY

Pasteurization of milk products at temperatures above 190° F. with only momentary holding is now being performed commercially in equipment designed for rapid product heating. In such processes, most of the lethal effect occurs during the heat-up period and all factors which contribute to the maintenance of both heating rates and final temperature must be considered in providing process controls. Equipment now being offered commercially incorporates design features and supplementary controls which appear adequate to assure properly processed products.

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