Title: PRODUCT TREATMENT APPARATUS

Abstract: A milk pasteuriser (200) has a heat regenerator having two heat exchanger sections (202, 104). Water is circulated round fluid flow path (216) by a water pump (214), which path as fluid flow paths in the regeneration section (204). Raw milk is passed through the heat exchanger section (104) to be heat treated in stream section (108), passed into a holding tube (103) to be fully pasteurised, into the heat exchanger section (202) to a chiller section (102). The water in the circulation loop (216) transfers heat from the pasteurised milk passing through heat exchanger section (104). A food-safe colorant is present in the water in the circulation loop which, if it leaks into the product, is detected by an optical sensor (218). The controller (220) responds by operating a divert valve (222) to direct the treated product away from a batch tank to disposal tank. This provides for continuous heat exchanger leak monitoring during normal operation of pasteurisation of milk.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
PRODUCT TREATMENT APPARATUS

Background of the Invention

1. Technical Field of the Invention

This invention relates to product treatment apparatus and methods of their use in particular to such an apparatus which includes a heat exchanger assembly having a regenerator.

2. Description of the Related Art

Pasteurisers used in the food, dairy and beverage process industries are an example of such a product treatment apparatus which includes a product path along which product is passed for heat treatment. Heating and cooling media are passed through separate circuits in close heat-exchange relationship with the product path via a number of heat exchange plates. Modern pasteurisers of this kind are known as HTST (High Temperature, Short Time) pasteurisers.

An example of a prior art pasteuriser is shown schematically in Figure 1, this example being a dairy machine. The pasteuriser 100 has four heat exchanger sections namely a chiller section 102, a regeneration section 104, a hot product section 106 and a steam section 108, constituting a heat exchanger assembly.

The flow of milk from when it first enters the pasteuriser 100 as raw milk to its exit from the pasteuriser 100 as a finished, pasteurised product is as follows. The milk enters the regeneration section 104 at an input 110 and exits at an output 112. The milk then enters the hot product section 106 at an input 114 and exits an output 116. The milk then is passed through a holding tube 103 where the milk has a dwell time sufficient to pasteurise the milk to the required heat/time regulations. The milk then enters the regeneration section
104 at an input 118 and exits at an output 120. The milk then enters the chiller section 102 at an input 122 and exits at an output 124.

Steam is introduced into the steam section 108 at an input 126 and steam condensate exits at an output 128. Water is circulated in a circulation loop 129 by a hot water pump 130 into the steam section at an input 132 and to exit at an output 134, then enter the hot product section 106 at an input 136 and to exit at an output 138 and back to the hot water pump 130.

Cold water is passed through the chiller section 102 by introducing the cold water to an input 132 to an exit 134, for example as a part of a refrigerated circulation loop.

Within each of the heat exchanger sections 102, 104, 106 and 108, the flow paths shown diagrammatically between distinct pairs of inputs and output indicate, in the usual way, physically separate fluid flow paths both which are in intimate heat relationship to allow ready heater transfer from the hotter to the colder fluid in the respective fluid flow paths.

The pasteuriser 100 operates as follows. Steam is continuously passed through the steam section 108. Water is continuously circulated by the hot water pump 130 through the steam section 108 (where it is heated by the steam) and the hot product section 106 (where it heats up the milk). Cold water is passed through the chiller section 102 (where it cools the milk after pasteurisation). Raw milk is passed through the regeneration section 104 where it is partially heated by the hot pasteurised milk, through the product heating section 106 where it is fully heated by the circulating hot water, through the holding tube 103 into the regeneration section 104 where the hot milk is partially cooled by incoming raw milk, and finally through the chiller section where the milk is cooled by the cold water also passing through the chiller section 102.

From time to time, leaks can develop between the fluid flow paths of a heat exchanger. Such leaks can be very costly, not only because the contaminated product must be discarded but also due to the cost of finding and rectifying the leak. Present maintenance techniques involve shut down of the
plant, dismantling of the pasteuriser, detailed examination and testing of the individual heat exchange plates using mechanical and/or chemical tests, careful cleaning of the components, re-assembly with new seals, pressure and leak testing, and recommissioning of the re-assembled pasteuriser. Such a procedure results in considerable lost production time whilst the equipment is out of commission and is extremely labour intensive. It also necessitates the cost of new seals. In addition, there is a substantial risk that further leaks can inadvertently be introduced during the re-building process due to plates cracking as the machine is tightened up.

An alternative approach is to disconnect the intact heat exchangers from the interconnecting pipework and connect them to a test rig in which a fluid with a tracer material is passed around one fluid flow path of a heat exchanger section whilst another fluid passed round the other fluid path of the same heat exchanger section is tested for leakage of the tracer material from the one fluid path to the other. This requires a high concentration of the tracer material to provide sufficient sensitivity to detect very small leaks. It is known to test a heat exchanger section not used for product processing for leaks in a similar way during use of the heat exchanger when cross-contamination of the tracer is acceptable, for example when sea water is used to cool a closed water coolant loop in a nuclear reactor, the conductivity of the water in the conductivity of the water in the reactor loop can be monitored to detect a leak of salt water into the coolant water. Also some products themselves can be detected if they pass through defects and contaminate the coolant, for example sulphuric acid coolers. Here the cooling water is monitored for increasing conductivity (or decreasing pH), this indicates a leak.

However, this approach is not possible for the entirety of the prior art product treatment apparatus of Figure 1 as the product, in this particular example milk, is passed along both fluid paths of the regeneration section 104.

The present invention seeks to provide a heat exchanger having a regeneration section, and a method of operating such a heat exchanger,
capable of detecting leakage of at least the regeneration section during processing of a product, particularly one destined for human consumption.

Accordingly there is provided a product treatment apparatus including a heat exchanger assembly having a regenerator which includes two heat exchanger sections each heat exchanger section including a first and a second fluid flow path in intimate heat exchanger relationship, the first fluid flow paths of the two heat exchanger sections forming part of a circulation fluid flow path which contains a regeneration fluid, the regeneration fluid including a food-safe tracer material, the apparatus further including a sensor arranged to detect the presence of the tracer material in the product after treatment by the apparatus.

The applicant has realised that in the case of some products destined for human consumption it is be possible to use a tracer material, if it is food-safe, whose presence can be detected in the product if a leak occurs and whose presence in the food product up to a concentration detectable by a sensor is acceptable.

The product treatment apparatus may include a product flow control assembly, including the sensor, which is arranged to direct a product exiting the heat exchanger assembly to a selected destination dependent on whether or not any tracer material is detected in the treated product. The sensor may be monitored to provide alternative or additional actions, including visual or audio alarms, or closing down of the apparatus.

The sensor may be one that is capable of detecting an optical characteristic of the tracer material.

The tracer material may be a food colorant or other food-safe material with some physical property detectable in the product.

The product treatment may further include a product heating heat exchanger section, and a product cooling heat exchanger section.

The product treatment apparatus may be, for example, a milk pasteurising apparatus and including a holding section or tube in which heated milk will dwell before entering the regenerator for cooling.
The tracer material may be present in all heat exchanger fluid flow paths which are in intimate heat exchanger relationship with a fluid flow path along which the product is arranged to flow.

The present invention also encompasses a method of treating a product with a product treatment apparatus of the present invention including:

a) circulating the regeneration fluid round the circulation fluid path; while

b) passing the product to be treated successively through one of the heat exchanger sections of the regenerator, through a treatment flow path, through the second heat exchanger section of the regenerator, out of the heat exchanger assembly and past the sensor.

The method may include directing the product exiting the heat exchanger assembly to a selected destination dependent on whether or not any tracer material is detected in the treated product.

3. Brief Description of the Drawings

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings of which:

Figure 1 is a schematic diagram of a prior art product treatment apparatus; and

Figure 2 is a schematic diagram of a product treatment apparatus according to the present invention.

Detailed Description and Embodiments of the Invention

The prior art product treatment apparatus of Figure 1 has already been described. A product treatment apparatus 200 according to the present invention is shown in Figure 2, with the same components as the prior heat exchanger assembly of Figure 1 being denoted by the same reference numeral.

In this embodiment there is a regeneration section 204 which is partly as
the regeneration section 104 of the Figure 1 assembly but to which a further heat exchanger section 202 has been added, to form the combined regeneration section 204.

The heat exchanger section 202 has an input 206 in fluid communication with an output 208 and another input 210 in fluid communication with an output 212. The output 208 is coupled to the input 122 and the output 212 is coupled to the input 120. The input 210 of heat exchanger section 202 and the output of heat exchanger section 104 are connected to a pump 214 to form a closed circulation loop 216. This form of combined regenerator section 204 is known in the prior art.

The pasteurised milk from the holding tube 103 is passed to input 206 from where it travels to the output 124 of the chiller section 102. A colour sensor 218 detects the colour of the milk exiting the heat exchanger assembly 200 and provides a signal representative of the value of a preselected colour component of the product to a controller 220. Dependent on the signal from the colour sensor 218, the controller controls a diverter valve 222 to direct the milk flow to a batch tank (not shown) or a disposal tank (not shown).

The water in the circulation loop is dyed with a food safe colorant, for example cochineal, as is the water in circulation loop 129 and the cold water passing through the chiller heat exchanger section 102.

The pasteuriser 200 heats the raw milk by the hot product section 106 and steam section 108 and the heated milk is passed to the holding tube 103 as described with reference to the prior art embodiment of Figure 1. Similarly, the partially cooled pasteurised milk from the regeneration section 204 is cooled by the chiller section 102 as in the prior art embodiment of Figure 1. The regeneration is now effected by the hot pasteurised milk transferring heat to the water in circulation loop 216 in regeneration section 202 and the water in the circulation loop 216 passes heat to the incoming raw milk in regeneration section 104.

If a leak should start between the fluid flow paths within any of the heat
exchanger sections 102, 202, 104 or 106, red dye in the water passing through that heat exchanger section will pass into the milk to be detected by the sensor 218. When the sensor 218 detects a significant change in the colour content of the milk corresponding to the dye colour, the controller 220 operates to Switch over the divert valve to direct the milk to a disposal or holding tank and any other desired control function, eg stopping milk processing, alerting operating personnel and activating alarms.

The various components useful to construct a heat exchanger assembly of Figure 2 are all readily available commercial items. The invention has been illustrated by the milk pasteuriser 200 in which the tracer material is a food-safe dye. It should be appreciated the invention is not limited to such a use of the inventive heat exchanger assembly but to any product processing system in which heat regeneration between treated product and untreated product (whether the treated product is the hotter or colder of the two) and leakage between the untreated and treated product must be detected. Other food-safe tracer materials may be used which are detectable in the product being processed.

The indirect heat regeneration of the present invention, in the illustrated embodiment the heat transfer from the heated pasteurised milk to the colder incoming raw milk by the intermediary agent of the water in circulation loop 216, compared to the direct regeneration of the prior art assembly of Figure 1 provides a reduced thermal efficiency of regeneration, approximately 60-80% rather than 80-90%, increased installation costs due to the need for an additional pump, heat exchanger plates, power consumption of the additional pump and increased space requirement. However, these embodiments of the present invention provide the advantages of continuous contamination detection during uninterrupted product processing.
CLAIMS

1. A product treatment apparatus including a heat exchanger assembly having a regenerator which includes two heat exchanger sections, each heat exchanger section including a first and a second fluid flow path in intimate heat exchanger relationship, the first fluid flow paths of the two heat exchanger sections forming part of a circulation fluid flow path which contains a regeneration fluid, the regeneration fluid including a food-safe tracer material, the apparatus further including a sensor arranged to detect the presence of the tracer material in the product after treatment by the apparatus.

2. A product treatment apparatus as claimed in claim 1, including a product flow control assembly, including the sensor which is arranged to direct a product exiting the heat exchanger assembly to a selected destination dependent on whether or not any tracer material is detected in the treated product.

3. A product treatment apparatus as claimed in claim 1, in which the sensor is capable of detecting an optical characteristic of the tracer material.

4. A product treatment apparatus as claimed in claim 3, in which the tracer material is a food safe dye or colorant.

5. A product treatment apparatus as claimed in claim 1, and further including one or more product heating heat exchanger sections, and one or more product cooling heat exchanger sections.

6. A product treatment apparatus as claimed in claim 5, being pasteurising or sterilizing apparatus and including a holding section or tube in which heat treated milk dwells before entering the regenerator for cooling.

7. A product treatment apparatus as claimed in claim 1, in which the tracer material is present in all heat exchanger fluid flow paths which are in intimate heat exchange relationship with a fluid flow path along which the product is arranged to flow.

8. A product treatment apparatus substantially as hereinbefore described with reference to Figure 2 of the drawings.
9. A method of treating a product with the product treatment apparatus of claim 1 including:
   a) circulating the regeneration fluid round the circulation fluid path; while
   b) passing the product to be treated successively through one of the heat
      exchanger sections of the regenerator, through a treatment flow path, through
      the second heat exchanger section of the regenerator, out of the heat
      exchanger assembly and past the sensor.
10. A method as claimed in claim 9, including directing the product exiting the
    heat exchanger assembly to a selected destination dependent on whether or not
    any tracer material is detected in the treated product.
11. A method as claimed in claim 10, in which the sensor detects an optical
    property of the tracer material.
12. A method as claimed in claim 9, in which the tracer material is a food
    safe dye or colorant.
13. A method as claimed in claim 9, in which the product is a foodstuff,
    beverage or pharmaceutical product.
14. A method as claimed in claim 13, in which the product is passed to a
    holding section or tube after heat treatment and before entering the regenerator.
15. A method as claimed in claim 9, in which tracer material is passed along
    all heat exchanger fluid flow paths which are in intimate heat exchange
    relationship with a fluid flow path along which the product is arranged to flow.
16. A method as claimed in claim 1, in which the product is also passed
    through one or more product heating heat exchanger sections, and one or more
    product cooling heat exchanger sections.
17. A method of treating a product substantially as hereinbefore described
    with reference to Figure 2 of the drawings.