although any suitable method of heating the liquid may be implemented. The warmed liquid can then be returned to the vessel 202 via a warmed liquid inlet 242. Similarly, the cooling loop 244 shown in FIG. 6 includes a pump 246 for circulating liquid withdrawn from a second liquid outlet 248 of the vessel 202 to a cooler 250, wherein the liquid is cooled. It should be appreciated that in certain implementations, the vessel 202 may include only one outlet such that the liquid outlet 238 associated with the heating loop 234 and the liquid outlet 248 associated with the cooling loop are one in the same. In such implementations, further components for diverting fluid to the heating loop 234 and the cooling loop 244 may be included downstream of the common outlet. In one specific example, the cooler 250 cools the liquid via indirect heat exchange with cooling water or other cold heat transfer fluid, although any suitable method of cooling the liquid may be implemented. The resulting cooled liquid can be returned to the vessel 202 via a cooled liquid inlet 252. As generally shown in FIG. 6, the warmed liquid inlet 242 and the cooled liquid inlet 252 may be located near opposite ends of the vessel 202, but are generally configured to facilitate introduction of warmed or cooled liquid into the same vessel including the microwave launchers. Thus, the vessel 202 may preheat using warm water, pasteurize or sterilize using warm water and microwave energy, hold using warm water, and cool using cool water, in one possible example.

[0081] In certain implementations, the heating loop 234 may generally be operated during the preheating, heating, and, when applicable, holding steps of the pasteurization or sterilization process, while the cooling loop 244 may be operated mainly during the cooling step. However, the absolute and relative flow rates and/or temperatures of the warmed and cooled liquid may be adjusted at any time during any step of the process in order to control the temperature of the liquid surrounding the articles.

[0082] In some cases, heating systems in accordance with the present disclosure may further include one or more nozzles for discharging jets of pressurized fluid toward articles within the vessel during at least a portion of the preheating, heating, holding (if applicable), or cooling steps of the process. For example, FIG. 7 is an additional schematic illustration of the heating system 200 and, in particular a longitudinal cross-section of the vessel 202. As shown in FIG. 7, the heating system 200 may include a fluid discharge system including a plurality of nozzles 254A–H coupled to and adapted to discharge fluid into the vessel 202.

[0083] The nozzles 254A–H may be arranged in any suitable configuration and, in some cases, may be located at one or more areas along the perimeter of the vessel 202. Although shown in FIG. 7 section as being located at the top and bottom portions of the vessel 202, it should be

CLAIMS

1. A method for pasteurizing or sterilizing a plurality of articles in an electromagnetic radiation heating system, the method comprising:

(a) pasteurizing or sterilizing a first group of articles in a first processing vessel, in which the pasteurizing or sterilizing includes preheating the first group of articles with a first warming liquid, heating the first group of articles using electromagnetic radiation energy, and cooling the first group of articles with a first cooling liquid;

(b) attaching a second processing vessel to the first processing vessel to form a combined processing unit; and

(c) pasteurizing or sterilizing a second group of articles in the combined processing unit, in which the pasteurizing or sterilizing includes preheating the second group of articles with a second warming liquid, heating the second group of articles using electromagnetic radiation energy, and cooling the second group of articles with a second cooling liquid different from the first cooling liquid,

in which, during the pasteurizing or sterilizing of step (c), at least a portion of the heating is performed in the first processing vessel and at least a portion of at least one of the preheating and the cooling is performed in the second processing vessel.

2. A method according to Claim 1, in which:

the attaching of step (b) includes attaching the second processing vessel to one end of the first processing vessel and attaching a third processing vessel to an opposite end of the first processing vessel and

during the pasteurizing or sterilizing of step (c), at least a portion of the heating is performed in the first processing vessel, at least a portion of the preheating is performed in the second processing vessel, and at least a portion of the cooling is performed in the third processing vessel.

3. A method according to Claim 1, in which the first processing vessel comprises a first end segment, a second end segment, and at least one launcher segment between the first and second end segments, in which the launcher segment comprises pairs of launchers that

discharge the electromagnetic radiation energy into the first processing vessel during the heating.

4. A method according to Claim 3, in which the first and second end segments do not include any launchers.

5. A method according to Claim 1, further comprising:

prior to the pasteurizing or sterilizing of step (a), loading the first group of articles in a first carrier and pasteurizing or sterilizing the first group of articles in the first carrier in step (a); and

prior to the pasteurizing or sterilizing of step (c), loading the second group of articles into a second carrier and pasteurizing or sterilizing the second group of articles in the second carrier.

6. A method according to Claim 1, in which the first processing vessel is at least partially filled with a liquid during at least a portion of the heating of steps (a) and (c).

7. A method according to Claim 1, in which the pressure surrounding the first group of articles during each of the preheating, the heating, and the cooling of step (a) is within 10 psig of each of the other of the preheating, the heating, and the cooling of step (a).

8. An electromagnetic heating system for pasteurizing or sterilizing a plurality of articles, the system comprising:

a processing vessel for receiving a carrier loaded with a plurality of articles, in which the processing vessel comprises:

a first end;

a second end spaced apart from the first end defining a chamber therebetween, at least one of the first and the second ends of the processing vessel including an opening configured for at least one of introducing the carrier into and removing the carrier out of the processing vessel,

a warm liquid inlet for introducing a warmed liquid into the chamber;

a cool liquid inlet for introducing a cooled liquid into the chamber;

a convey line for passing the carrier through at least a portion of the chamber; and

two launchers for discharging electromagnetic energy into the chamber,

in which the processing vessel is configured to be a liquid-filled vessel for each of preheating the articles, heating the articles with electromagnetic energy, and cooling the articles

in which the processing vessel is configured to be coupled to an additional vessel and, when coupled to the additional vessel, to disable at least one of preheating and cooling functions of the processing vessel.

9. A system according to Claim 8, in which the launchers are two of a plurality of launchers for discharging electromagnetic energy into the chamber, the plurality of launchers including more than two launchers.

10. A system according to Claim 8, in which the launchers are located on the same side of the processing vessel.

11. A system according to Claim 8, in which the launchers are located on opposite sides of the processing vessel.

12. A system according to Claim 8, in which the processing vessel further comprises a plurality of nozzles for discharging jets of pressurized liquid into the chamber during at least one of the preheating and the cooling.

13. A system according to Claim 8, in which the convey line is configured to transport the articles in opposite first and second horizontal convey directions.

14. A system according to Claim 8, in which:

the processing vessel comprises a first end segment, a second end segment opposite the first end segment, and a launcher segment between the first end segment and the second end segment,

the first end segment is configured to carry out a portion of the preheating,

the second end segment is configured to carry out a portion of the cooling, and

the launcher segment is configured to carry out a portion of the heating.

15. A system according to Claim 8, in which the processing vessel includes at least two launcher segments.

16. A method of heating a plurality of articles comprising:

conveying the plurality of articles through each of a first processing vessel and a second processing vessel, in which:

the first processing vessel includes each of a first preheating zone, a heating zone subsequent to the first preheating zone, and a first cooling zone subsequent to the heating zone, and

the second processing vessel includes one of a second preheating zone and a second cooling zone;

preheating the articles in one of the first preheating zone and the second preheating zone by exposing the articles to a warmed liquid;

while the articles are in the heating zone, directing electromagnetic energy from a plurality of launchers coupled to the first processing vessel into the first processing vessel to heat the articles; and

cooling the articles in one of the first cooling zone and the second cooling zone.

17. A method according to Claim 16, in which:

the second processing vessel is coupled to the first processing vessel upstream of the first processing vessel such that the second processing vessel is isolatable from the first processing vessel,

the second processing vessel includes a second preheating zone, and

the step of preheating the articles is performed in the second processing vessel.

18. A method according to Claim 16, in which:

the second processing vessel is coupled to the first processing vessel downstream of the first processing vessel such that the second processing vessel is isolatable from the first processing vessel,

the second processing vessel includes a second cooling zone, and

the step of cooling the articles is performed in the second processing vessel.

19. A method according to Claim 16 further comprising conveying the plurality of articles through a third processing vessel, in which:

the second processing vessel is coupled to the first processing vessel upstream of the first processing vessel such that the second processing vessel is isolatable from the first processing vessel,

the second processing vessel includes a second preheating zone, and

the step of preheating the articles is performed in the second processing vessel.

the third processing vessel is coupled to the first processing vessel downstream of the first processing vessel such that the third processing vessel is isolatable from the first processing vessel,

the third processing vessel includes a second cooling zone, and

the step of cooling the articles is performed in the third processing vessel.