Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

This invention relates to a machine for the homogenisation and thermal treatment of liquid and semi-liquid food products such as, for example, ice creams, whipped cream, creams, chocolate, yogurt and the like.

It should be noted that machines for the homogenisation and thermal treatment of liquid and semi-liquid food products such as, for example, ice creams, whipped cream, creams, chocolate, yogurt and the like are machines which perform operations such as heating (intended, for example, to facilitate mixing of the ingredients of the mixture), pasteurization (in the typical sense of thermal treatment), homogenisation (that is to say, preventing and/or delaying the natural tendency of the substances in the mixture to separate), aging (that is to say, allowing the product to rest at a suitable temperature) and storage (that is, keeping the product at a low temperature until used).

Known in the prior art are many machines for the homogenisation and thermal treatment of liquid and semi-liquid food products such as ice creams, whipped cream, creams, chocolate, yogurt and the like, comprising a containment tank having on the bottom of it a vessel pump for circulating the mixture and equipped with an electrical heater and a cooling circuit.

As described in document GB2031292A, in machines of this kind, the vessel pump causes the mixture to circulate inside the tank and at the same time also heats and then cools the mixture itself.

More specifically, when the pump blade comes into operation, the mixture in the tank is drawn into the pump vessel and then returned to the tank, thereby stirring and blending the mixture.

When the electrical heater is activated, the mixture circulating through the pump is subjected to heating characterised by high heat exchange coefficients. Generally speaking, when the mixture reaches the desired temperature (whether for low, medium or high pasteurisation), the heater is switched off and the cooling circuit switched on until the mixture reaches a steady state at the aging or storage temperature (a low temperature around 2° to 6°C).

The electric heater usually consists of an electrical heating element mounted in the wall of the pump and/or of the tank and heated by the Joule effect.

The cooling circuit, on the other hand, consists of the evaporator of a cooling system coiled around the pump liner and/or the side wall of the tank. The prior art machines described briefly above have several disadvantages.

Mounting the electric heater on the bottom of the vessel pump or on the side wall of the tank does not guarantee optimum transmission of heat to the mixture circulating in the pump. Heating the mixture may therefore take a very long time since the operating temperature of the heating element cannot be raised too much (without the risk of locally overheating the mixture).

It is also extremely difficult to control the local temperature of the heating elements and to prevent the formation of hot spots (leading to local overheating and burning of the mixture).

Further, it has proved extremely complex to mount the electric heating element in the same way as the evaporator of the cooling circuit because the surface available for heat exchange is not large enough for both. Moreover, since a complete thermal treatment cycle comprises heating, holding the temperature, cooling and again holding the temperature, it is necessary to strike a compromise which optimizes both steps of heating and cooling.

Moreover, again in connection with this aspect, in the transient from heating and/or holding the temperature to cooling, the process is significantly slowed by the thermal inertia of the heating elements and of the mass of mixture, delaying the treatment of the food mixture.

Lastly, the above machines consume large amounts of electricity, thus increasing machine running costs considerably. It is also known from the prior art document EP0088351A1 which describes electrical apparatus for the preparation of food, particularly for cooling and/or refrigerating while simultaneous mixing and/or homogenizing, foodstuffs that comprises a refrigerating unit, in conditions of thermal exchange with a container, that provide the cooling and the heating of the container by reversing the refrigerating cycle.

In this context, the technical purpose which forms the basis of this invention is to propose a homogenisation, thermal treatment and pasteurisation machine which overcomes the above mentioned disadvantages of the prior art.

More specifically, this invention has for an aim to provide a pasteurisation machine capable of heating the mixture uniformly and effectively.

Another aim of the invention is to provide a homogenisation, thermal treatment and pasteurisation machine having limited running costs.

The technical purpose indicated and the aims specified are substantially achieved by a machine comprising the technical features described in one or more of the accompanying claims.

Further features and advantages of the invention are more apparent in the detailed description below, with reference to a preferred, non-limiting embodiment of a machine for the homogenisation and thermal treatment of liquid and semi-liquid food products, illustrated in the accompanying drawings, in which:

- Figure 1 is a schematic representation of a machine according to this invention for the homogenisation and thermal treatment of liquid and semi-liquid food products;
- Figure 2 is a perspective view, with some parts cut away in order to better illustrate others, of a detail from Figure 1;
- Figure 3 shows a graph representing an operating parameter of the machine of Figure 1; and
- Figure 4 schematically represents a detail of the machine of Figure 1.

[0019] With reference to the accompanying drawings, the numeral 1 denotes in its entirety a machine for the homogenisation and thermal treatment of liquid and semi-liquid food products such as, for example ice creams, whipped cream, creams, chocolate, yogurt and the like.

[0020] The machine 1 comprises a containment tank 2 for the mixture and a centrifugal pump 3 put in fluid communication with the bottom of the containment tank 2 for drawing mixture from the tank and putting it back into the tank.

[0021] Heating and cooling means 4 operate at the pump 3 for heating and cooling the mixture in transit in the pump 3.

[0022] The heating and cooling means 4 comprise a thermal machine with reversible thermodynamic cycle.

[0023] The thermal machine with reversible thermodynamic cycle operates according to a transcritical thermodynamic cycle and uses carbon dioxide (CO2) as refrigerant.

[0024] In other words, the thermal machine with reversible thermodynamic cycle can operate either as a heat pump or as a cooling machine depending on the direction of the transcritical thermodynamic cycle. The basic difference between carbon dioxide and traditional refrigerants such as, for example, HFC (R-134a and R-404A) and hydrocarbons is the critical temperature value which, for carbon dioxide, is 31°C.

[0025] Thus, in a traditional vapour compression cycle, the transfer of heat to the surrounding environment (that is to say, to the food mixture when the machine operates as a heat pump) does not entail condensation of carbon dioxide but its gradual cooling until obtaining a dense gas phase.

[0026] A thermal machine with reversible thermodynamic carbon dioxide cycle does not therefore contemplate a condenser but a dense gas refrigerator, known as gas-cooler.

[0027] The corresponding thermodynamic cycle is referred to as transcritical because it occurs between two isobars, the first of which (at the inlet to the compressor and hence at the outlet from the evaporator) at a pressure lower than the critical value, and the other at a pressure higher than the critical value (at the outlet from the compressor and into the gas-cooler).

[0028] Advantageously, the thermal machine comprises a pipe 5 coiled around a containment body 6 holding the centrifugal pump 3.

[0029] The pipe 5 operates as an evaporator when the cooling means are activated and as a gas-cooler when the heating means are activated.

[0030] The carbon dioxide in the pipe 5 flows in countercurrent with respect to the flow of the mixture in the pump 3.

[0031] In other words, the pipe 5 heats the mixture flowing through the pump 3 when the thermal machine is working as a heat pump, and the selfsame pipe 5 cools the mixture flowing through the pump 3 when the thermal machine is working with a thermodynamic cycle which is the reverse of that of the heat pump (that is to say, when it is working as a cooling machine).

[0032] In an alternative embodiment (not illustrated) the pipe 5 is substituted with a direct exchange evaporator integral with the containment body 6 of the centrifugal pump 3.

[0033] This evaporator works by direct expansion when the cooling means are activated and as a gas-cooler when the heating means are activated.

[0034] In other words, the purpose of the evaporator is exactly the same as that of the pipe 5 and thus, all the functions performed by the pipe 5 are performed by the evaporator.

[0035] When the thermal machine 4 operates as a cooling machine, work is supplied to extract heat from the mixture and transfer it, increased by the thermal equivalent of the work done, to the outside environment.

[0036] Basically, a superheated vapour compression machine consists of a compressor, an evaporator, a condenser (or gas-cooler in the case of CO2) and an expansion element (consisting, for example, of a capillary tube or a thermostatic valve). During the operating cycle, the refrigerant, according to the invention carbon dioxide, is compressed and brought to gas-cooler inlet pressure.

[0037] The refrigerant in the gas-cooler cools down at a constant pressure until reaching a dense gas phase transferring heat to the surrounding environment. It should be noted that at this stage the carbon dioxide does not undergo any phase change.

[0038] In other words, the refrigerant does not condense but undergoes dense gas cooling.

[0039] Next, by a lamination effect, the carbon dioxide undergoes adiabatic expansion from the second pressure to the first.

[0040] The refrigerant then enters the evaporator (consisting of the pipe 5), absorbing heat from the mixture in transit through the pump 3, thus completing the thermodynamic cycle with a step of isobaric heating.

[0041] When the thermal machine operates as a heat pump, that is to say, when the mixture in transit through the pump has to be heated, the thermodynamic cycle described above is performed in reverse.

[0042] That way, the transfer of heat to the mixture in transit through the centrifugal pump 3 occurs in the pipe 5 acting as a gas-cooler.

[0043] It should also be noted that the heat pump provides more thermal energy (that is, heat transferred to the mixture to be heated) than the electrical energy used by the compressor since it absorbs heat from the outside environment.

[0044] That way, the mixture in transit through the pump is heated in a much more energy efficient manner.
than if it were heated using Joule effect electrical heating elements (in which the thermal energy transferred is less than the electrical energy used).

It should also be noted that the substantial amount of energy (that is to say, the maximum mechanical work that can be extracted from the system when it is brought to a state of equilibrium with a reference environment) made available when the hot gas is cooled in the gas-cooler is partly recovered by the heated food mixture, allowing the machine 4 to obtain an efficiency level comparable with or greater than machines of the same kind operating with traditional refrigerants such as, for example, R-134a and R-404A.

The shape of the hypercritical isobars for carbon dioxide show that transcritical cycles operating with this refrigerant are optimal for heat pumps used for heating a flow of fluid with large fluid temperature variations.

The above may be inferred from Figure 3 which shows the temperature profiles of carbon dioxide at a pressure of 120 bar (unbroken line) and a water flow heated in countercurrent (dashed line) in the gas-cooler from 15° to 84°C (the temperature values are shown on the y-axis).

As may be noticed from the graph, the two curves are very well matched, demonstrating the better efficiency in heating the liquid mixture compared to a machine which uses a traditional refrigerant. In effect, the same graph also shows the temperature profile (decidedly less favourable) in the condenser of a heat pump which uses R-134a for the same process (dotted line).

Structurally, the pump 3 is directly connected to the bottom of the tank 2 (see Figure 1) and comprises an intake opening (not illustrated) located at the top of the pump 3 and at least one delivery opening 7 located in a lower portion of the pump 3.

The delivery opening 7 makes the heated or cooled mixture circulate in the tank 2.

The heat pump is controlled automatically by selecting the thermal cycle - for example, type of pasteurisation required (high, low or medium) - in such a way that the thermodynamic cycle for heating the mixture is set at the correct temperature for the necessary length of time (depending also on the quantity of mixture to be treated).

When pasteurisation is over, the heat pump, for example, starts the thermodynamic cycle by which the thermodynamic cycle for heating the mixture is set at the correct temperature for the necessary length of time (depending also on the quantity of mixture to be treated).

Preferably, the driving magnet 10 lies in a housing which is defined by the fixed element 12 and which is hermetically separated from the zone of the pump 3 through which the mixture passes.

Further, the fixed element 12 has fitted to it an impeller 13 which rotates about the fixed element 12 to generate a pressure head.

The impeller 13 is integral with the driven magnet 11 in such a way as to be rotationally driven by the rotation of the driven magnet 11.

The containment body 6 of the centrifugal pump 3 comprises two annular walls 14 made of a material with high thermal conductivity, such as aluminium. The pipe 5 is placed in the gap between the two annular walls.

To guarantee the correct operation of the machine 1, the latter comprises a device 15 for washing the centrifugal pump 3 and the containment tank 2 (Figure 4).

The washing device 15 comprises a connection 16 to a source 17 of washing liquid.

The connection 16 comprises a conduit T and a pump 18 for drawing the washing liquid from the source 17.

The source 17 is a tank containing water and/or a sanitising liquid or, alternatively, it may be the water mains.

The washing device 15 also comprises a heater 19, for example a boiler, for the washing liquid, for producing superheated steam.

The heater is connected to the conduit T which extends as far as the pump 3 (passing through the boiler), forming a circuit for channelling the liquid and/or the superheated steam into the centrifugal pump 3.

The washing device 15 is equipped with control means 20 comprising a central processing unit which in turn comprises timing means and means for regulating the temperature of the heater 19.

In use, when the machine 1 does not have any food mixture in it, a first step is activated which comprises heating the washing liquid while keeping it in the liquid
state and then conveying it into the pump 3 through the conduit T. During this step, the pump 3 is on and makes the washing liquid circulate both in the pump and in the tank 2. At the end of this step, the pump 3 is switched off and the washing liquid is fed into the pump itself. At the end of the second step in the cycle, the heater 19 heats the washing liquid to produce superheated steam which is fed through the conduit T into the centrifugal pump 3 (which, during this step, is off). That way, the machine 1 is fully and thoroughly sanitised.

The steps described above can be repeated as required.

The invention can be modified and adapted in several ways without thereby departing from the scope of the claims.

**Claims**

1. A machine for the homogenisation and thermal treatment of liquid and semi-liquid food products, for example ice creams, whipped cream, creams, chocolate, yogurt and the like, comprising a containment tank (2) for the mixture and a centrifugal pump (3) put in fluid communication with the bottom of the containment tank (2) for drawing mixture from the tank (2) and putting it back into the tank, heating and cooling means (4) acting at the pump (3) for heating and cooling the mixture in transit in the pump (3), the heating and cooling means (4) comprising a thermal machine with reversible thermodynamic cycle, characterised in that the thermal machine with reversible thermodynamic cycle uses carbon dioxide as refrigerant.

2. The machine according to claim 1, wherein the thermal machine operates according to a transcritical thermodynamic cycle.

3. The machine according to claim 1 or 2, wherein the thermal machine comprises a pipe (5) wound around a containment body (6) of the centrifugal pump (3); the pipe (5) operating as an evaporator when the cooling means are activated and operating as a gas-cooler when the heating means are activated.

4. The machine according to claim 1 or 2, wherein the thermal machine comprises a direct exchange evaporator which is integral with the containment body (6) of the centrifugal pump (3); the evaporator operating with direct expansion when the cooling means are activated and operating as a gas-cooler when the heating means are activated.

5. The machine according to claim 3, wherein the operating fluid passing through the pipe (5) operates with a countercurrent flow relative to the mixture passing through the centrifugal pump (3).

6. The machine according to any of the foregoing claims, wherein the pump (3) is directly connected to the bottom of the tank (2) and comprises an intake opening located at the top of the pump (3) and at least one delivery opening (7) located in a lower portion of the pump (3).

7. The machine according to any of the foregoing claims, wherein the centrifugal pump (3) is of the magnetic drive type.

8. The machine according to claim 6, wherein the pump (3) comprises an electric motor (8) connected to a driving shaft (9); a driving magnet (10) which is rotatably driven by the driving shaft (9); a driven magnet (11) being operatively associated with the driving magnet (10) and rotatably driven by the latter; an impeller (13) rotatably driven by the driven magnet (11).

9. The machine according to claim 8, wherein the pump (3) comprises a fixed unit (12) integral with a containment body (6) of the pump (3) on which the impeller (13) is rotatably fitted; the fixed unit (12) physically separating the driven magnet (11) from the driving magnet (10).

10. The machine according to any of the foregoing claims, comprising a device (15) for washing the centrifugal pump (3) and the containment tank (2).

11. The machine according to claim 10, wherein the washing device (15) comprises a connection (16) to a source (17) of washing liquid, a heater device (19) for the washing liquid, for producing superheated steam, a circuit for conveying the washing liquid and/or the superheated steam inside the centrifugal pump (3) and/or the containment tank (2).

**Patentansprüche**

1. Maschine zur Homogenisierung und Wärmebehandlung von flüssigen und halbflüssigen Lebensmittelprodukten, zum Beispiel Speiseeis, Schlagsahne, Cremes, Schokolade, Joghurt und ähnlichen, umfassend einen Behälter (2) zur Aufnahme der Mischung und eine Kreiselpumpe (3), die in Fluidverbindung mit dem Boden des Aufnahmebehälters (2) zur Entnahme der Mischung aus dem Behälter (2) und zur Rückgabe in den Behälter steht, Erhitzungs- und Kühlmittel (4), die an der Pumpe (3) wirken, um die durch die Pumpe (3) laufende Mischung zu erhitzen und zu kühlen, wobei die Erhitzungs- und Kühlmittel (4) eine Wärmomaschine mit reversiblen, thermodynamischem Kreisprozess umfassen, dadurch gekennzeichnet, dass die Wärmemaschine mit reversiblen, thermodynami-
schem Kreisprozess als Kältemittel Kohlendioxid verwendet.

2. Maschine nach Anspruch 1, wobei die Wärmemaschine gemäß einem transkritischen, thermodynamischem Kreisprozess arbeitet.

3. Maschine nach Anspruch 1 oder 2, wobei die Wärmemaschine ein Rohr (5) umfasst, das um einen Aufnahmekörper (6) der Kreiselpumpe (3) gewickelt ist; wobei das Rohr (5) als ein Verdampfer arbeitet, wenn die Kühlmittel aktiviert sind, und als ein Gaskühler arbeitet, wenn die Erhitzungsmittel aktiviert sind.

4. Maschine nach Anspruch 1 oder 2, wobei die Wärmemaschine einen Verdampfer mit direkter Verdampfung umfasst, der einstckig mit dem Aufnahmekörper (6) der Kreiselpumpe (3) verbunden ist; wobei der Verdampfer mit direkter Verdampfung arbeitet, wenn die Kühlmittel aktiviert sind, und als ein Gaskühler arbeitet, wenn die Erhitzungsmittel aktiviert sind.

5. Maschine nach Anspruch 3, wobei das durch das Rohr (5) hindurchlaufende Arbeitsfluid relativ zur durch die Kreiselpumpe (3) hindurchlaufenden Mischung mit einem Gegenstrom arbeitet.

6. Maschine nach einem der vorangehenden Ansprüche, wobei die Pumpe (3) direkt mit dem Boden des Behälters (2) verbunden ist und eine Einlassöffnung, die sich an der Oberseite der Pumpe (3) befindet, und mindestens eine Auslassöffnung (7), die sich in einem unteren Abschnitt der Pumpe (3) befindet, umfasst.

7. Maschine nach einem der vorangehenden Ansprüche, wobei die Kreiselpumpe (3) vom magnetgetriebenen Typ ist.

8. Maschine nach Anspruch 6, wobei die Pumpe (3) einem mit einer Antriebswelle (9) verbundenen Elektromotor (8) und einem drehbar von der Antriebswelle (9) angetriebenen Antriebsmagneten (10); wobei ein angetriebener Magnet (11) mit dem Antriebsmagneten (10) verbunden ist und von diesem drehbar angetrieben wird; ein drehbar vom angetriebenen Magneten (11) angetriebenes Laufrad (13) umfasst.

9. Maschine nach Anspruch 8, wobei die Pumpe (3) eine einstckig mit einem Aufnahmekörper (6) der Pumpe (3) verbundene fixierte Einheit (12) umfasst, auf die das Laufrad (13) drehbar aufgesetzt ist; wobei die fixierte Einheit (12) den angetriebenen Magneten (11) physisch vom Antriebsmagneten (10) trennt.

10. Maschine nach einem der vorangehenden Ansprüche, umfassend eine Vorrichtung (15) zum Spülen der Kreiselpumpe (3) und des Aufnahmebehälters (2).

11. Maschine nach Anspruch 10, wobei die Spülvorrichtung (15) eine Verbindung (16) mit einer Quelle (17) Spülfüssigkeit, eine Heizvorrichtung (19) für die Spülfüssigkeit zum Produzieren von Heißdampf, einen Kreis zum Leiten der Spülfüssigkeit und/oder des Heißdampfes in die Kreiselpumpe (3) und/oder den Aufnahmebehälter (2) umfasst.

Revendications

1. Machine pour l’homogénéisation et le traitement thermique de produits alimentaires liquides et semi-liquides, comme par exemple des crèmes glacées, de la crème fouettée, des crèmes, du chocolat, du yaourt et des produits similaires, comprenant une cuve de logement (2) pour le mélange et une pompe centrifuge (3) mise en communication fluidique avec une base de la cuve de logement (2) pour aspirer le mélange de la cuve (2) et pour le réinjecter dans la cuve, des moyens de chauffage et de refroidissement (4) agissant au niveau de la pompe (3) pour chauffer et refroidir le mélange lorsqu’il transite par la pompe (3), les moyens de chauffage et de refroidissement (4) comprenant une machine thermique disposant d’un cycle thermodynamique réversible, caractérisée en ce que la machine thermique dispose d’un cycle thermodynamique réversible emploie du dioxyde de carbone comme fluide frigorigène.

2. Machine selon la revendication 1, dans laquelle la machine thermique fonctionne selon un cycle thermodynamique transcritique.

3. Machine selon les revendications 1 ou 2, dans laquelle la machine thermique comprend un conduit (5) enroulé autour d’un corps de logement (6) de la pompe centrifuge (3) ; le conduit (5) fonctionnant comme un évaporateur lorsque les moyens de refroidissement sont activés et fonctionnant comme un refroidisseur de gaz lorsque les moyens de chauffage sont activés.

4. Machine selon les revendications 1 ou 2, dans laquelle la machine thermique comprend un évaporateur à expansion directe étant solidaire du corps de logement (6) de la pompe centrifuge (3) ; l’évaporateur fonctionnant avec une expansion directe lorsque les moyens de refroidissement sont activés et fonctionnant comme un refroidisseur de gaz lorsque les moyens de chauffage sont activés.
5. Machine selon la revendication 3, dans laquelle le fluide de commande passant par le conduit (5) opère avec un débit à contre-courant par rapport au mélange passant par la pompe centrifuge (3).

6. Machine selon l’une quelconque des revendications précédentes, dans laquelle la pompe (3) est directement reliée à la base de la cuve (2) et comprend une ouverture d’admission située au sommet de la pompe (3) et au moins une ouverture d’évacuation (7) située dans une partie inférieure de la pompe (3).

7. Machine selon l’une quelconque des revendications précédentes, dans laquelle la pompe centrifuge (3) est à entraînement magnétique.

8. Machine selon la revendication 6, dans laquelle la pompe (3) comprend un moteur électrique (8) relié à un arbre d’entraînement (9) ; un aimant d’entraînement (10) étant entraîné en rotation par l’arbre d’entraînement (9) ; un aimant entraîné (11) étant fonctionnellement associé à l’aimant d’entraînement (10) et entraîné en rotation par ce dernier ; un rotor (13) entraîné en rotation par l’aimant entraîné (11).

9. Machine selon la revendication 8, dans laquelle la pompe (3) comprend une unité fixe (12) solidaire du corps de logement (6) de la pompe (3) sur laquelle le rotor (13) est ajusté de façon rotative ; l’unité fixe (12) séparant physiquement l’aimant entraîné (11) de l’aimant d’entraînement (10).

10. Machine selon l’une quelconque des revendications précédentes, comprenant un dispositif (15) permettant de laver la pompe centrifuge (3) et la cuve de logement (2).

11. Machine selon la revendication 10, dans laquelle le dispositif de lavage (15) comprend un raccordement (16) à une source (17) de liquide de lavage, un dispositif de chauffage (19) destiné au liquide de lavage pour produire de la vapeur surchauffée, un circuit pour acheminer le liquide de lavage et/ou la vapeur surchauffée à l’intérieur de la pompe centrifuge (3) et/ou de la cuve de logement (2).
REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 2031292 A [0004]
- EP 0088351 A1 [0013]