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A liquid heating module, a device comprising said module and a process for heating liquid.

5 The present invention concerns a liquid heating module for use in a hot beverage machine. The invention concerns further a device comprising said module and a process for the heating of a liquid.

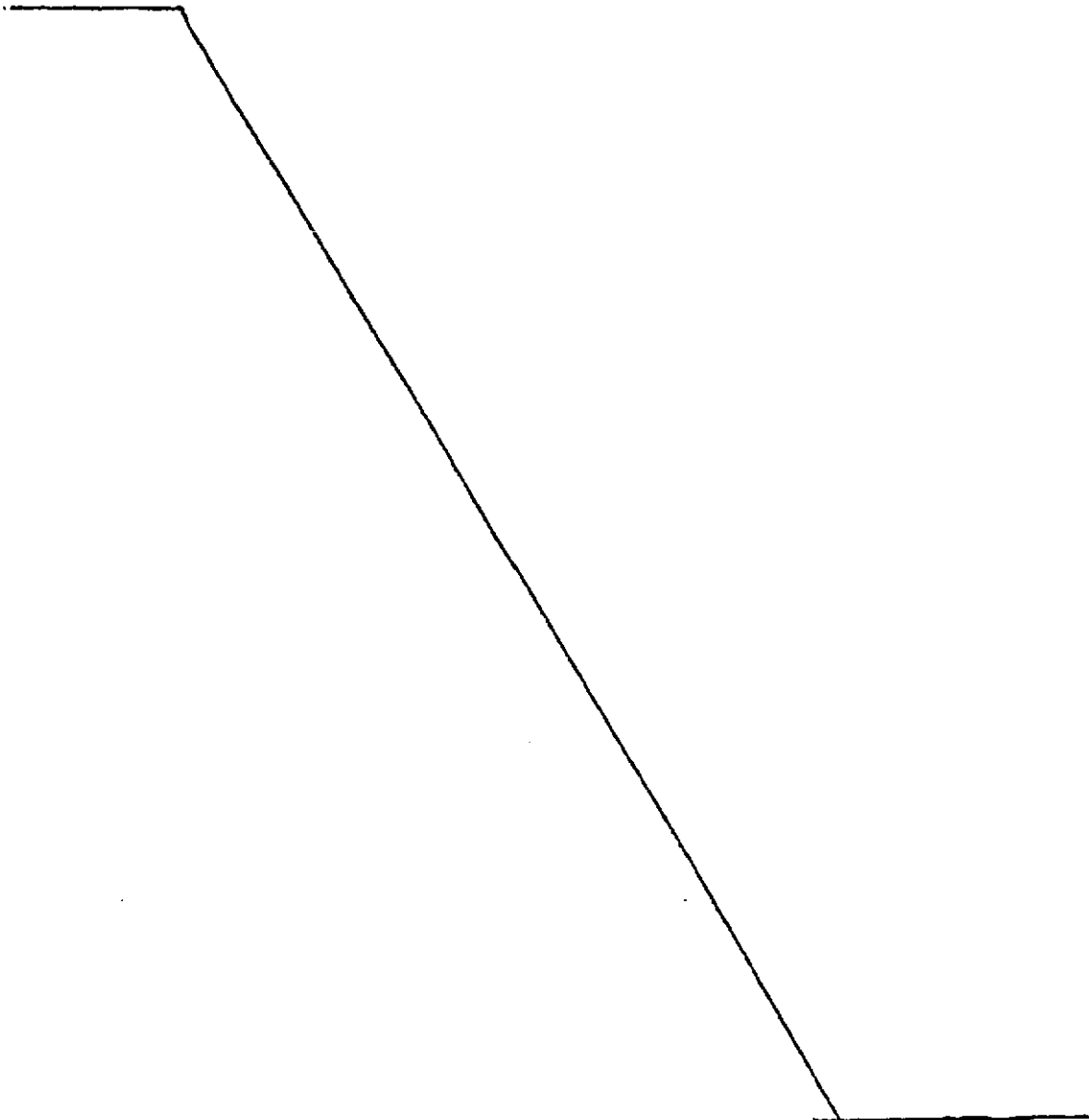
10 In the area of coffee machines, it is already known to have a thermoblock-heater in the machine, wherein said heater is permanently under power and allows hot water to be obtained at the moment when the consumer decides to operate the machine for preparing a coffee. The  
15 problems with this solution are following : first, there is a temperature inconsistency, that is, it is not possible to have a temperature of water permanently in a specific range, like between 85 and 90 °C. This has a negative influence on the quality of the obtained  
20 coffee. Secondly, the block-heater used is very heavy, which is not convenient when the coffee machine has to be moved. Thirdly, there is an energy inefficiency, because of the lost of energy during all the time the machine is under power.

25 It is also possible to have at least two heating devices along the pipe where the water is flowing. For example, DE Patent 4038462, NL Patent 8101610 and FR Patent 2685187 consider this type of solution : the first  
30 heating part providing a preheating of the water and the second part a heating at the required temperature. These types of solutions consider two separated heaters, which are placed at different places of the pipe. The problem with this type of solution is that the device is not  
35 compact, takes more place and is more energy consuming.

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5 The aim of the present invention is to minimize all the above mentioned problems. The present invention allows to provide the consumer a system of heating with a very accurate range of temperature, without a machine all the time under power, with a very light heating device, said device taking less place.

10 The present invention concerns a liquid heating module for use in a hot beverage machine, which comprises  
- a hollow tube of metallic material,



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- at least one electrical resistor on a first part of the outside of the tube for preheating liquid flowing through said hollow tube and
- at least one other electrical resistor on a second part of the outside of the tube for temperature adjustment of the liquid flowing through the tube.

The liquid which has to be heated in the module of the invention is not critical and can be any type of liquid. Preferably, the liquid heated is water, for example for preparing tea, coffee or other types of beverages. It is also possible to heat milk, for example for the preparation of cocoa beverages. The generation of steam can also be considered, for example for heating directly water in a cup or for foaming milk. The use of the heating module can be considered for small machines, like coffee machines or bigger machines, like vending machines.

Concerning the electrical resistor for the first part of the tube, in the case of a coffee machine, one or two resistors are present, in the case of a vending machine, it is possible to have 1 to 5 resistors. Concerning the electrical resistors for the second part of the tube, the same number of resistors applies as for the first electrical resistor. More preferably, only one resistor is used.

The material for the hollow tube is a metal. Preferably, the tube is made of stainless steel. The size of the tube can vary, depending on the type of use. For example, if it is used for a coffee machine, it can have a diameter of about 6 to 20 mm and a length of about 100 to 200 mm. The thickness of the tube is around 1 to 4 mm. In the case of use in a vending machine, the tube has a diameter of about 30 to 50 mm and a length of about 200 to 400 mm. The thickness of the tube is the same as before.

The ratio of the length of the hollow tube to the diameter of said tube is comprised between about 5 and about 40.

5 The heating module according to the invention comprises further a cylindrical insert, which is disposed inside the hollow tube, along its entire length and substantially along its axis of symmetry. The fact that an insert is present enhances heat transfer from the tube surface to the  
10 liquid with the heating element under power. This allows a good transfer of energy and a quick heating of the water. The insert is made of plastics or metallic material, which is food grade and could be of a good thermal conductivity. The insert is preferably made of copper or teflon (tetra-  
15 fluoro-ethylene). The ratio of the diameter of the hollow tube to the diameter of the insert is comprised between 2 and 5. It is possible to have either a fixed insert or an insert, which can be rotated along its axis of symmetry. In the case of a rotating insert, said insert is connected  
20 with a rotating wheel of a flowmeter disposed at the lower part of the insert and so it can be powered by the flowing cold water, which flows in a tangent angle on to the flowmeter propeller. The rotatable cylindrical insert comprises a metal wire brush. These metal brush bundles are  
25 integrated through the insert in a longitudinal plane (on one side only or on two symmetric sides of the insert) or on a spiral way, for example 1 or 2 spirals. They are built only in the insert part inside the hollow tube. The brush should be of proper mechanical tensile and strength so that  
30 it can descale the inner tube surface. Both the brush bundle ends should be slightly contacted with the inside surface of the tube at 90° C. The whole bundles should be designed to push water upwards when it is powered to rotate by the flowmeter propeller.

The insert can also be a hollow object, which will introduce a reversed flow of part of the hot water to mix with the cold water and so to enhance water mixing when the water is heated.

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The electrical resistors of the tube are made in a form selected from the group consisting of wires and thick-film. The thick-film technology is known in the electronic area and is now used for the manufacture of resistors. The technology uses conductive inks (like paste) over a substrate of quartz, metal, alumina or beryllium oxide. As said before, it is preferably a metallic substrate.

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The hollow tube comprises further at least one other electrical resistor for the temperature control. This resistor is disposed at the inlet or outlet of the cold/hot water from the tube.

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The electrical resistors have a power density of up to 30 to 70 Watt/cm<sup>2</sup>. This power density of the resistors allows a very quick increase of the temperature of the water from the room temperature to around 85-90 °C. In order to have a good insulation of the hollow tube, it is preferred to have an enamel painting on the outside of said tube under the resistors. The thickness of this painting is normally comprised between 100 and 300 microns. Finally, the electrical resistors of the hollow tube are covered with an electrically non conductive material, for example a plastic. This insulation can be either a tube or a layer of a non conductive material.

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The liquid heating module of the invention is used as a part of a machine for the heating of a liquid for the preparation of a beverage. The present invention concerns further a device for the heating of a liquid comprising

- a water supply,

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- a pump for supplying said water to
- a liquid heating module as described before, wherein all the three elements are in fluid communication ,
- a channel for the exit of heated liquid, either on a substance to be extracted or in a mixer to mix said heated liquid with a powder.

In the system of the invention, the tube is either horizontally or vertically disposed. The tube is preferably vertically disposed.

The liquid heating module is part of a coffee machine or another similar machine based on the extraction of a substance, like coffee or tea. In this case, it is possible to have either directly the substance to be extracted, like a bed of coffee, and then an espresso machine, or the substance to be extracted in already prepared cartridges or capsules, like those object of the European patents No. 512'468 and 602'203.

According to a second embodiment, the device of the invention is used for vending machines, that is a machine where the consumer has directly the cup of tea, of coffee or of cocoa, wherein the heated liquid is mixed just before being delivered in a cup with the corresponding powder.

The device of the invention integrates also other usual elements present normally in coffee or vending machines, like a valve, a temperature control, a flowmeter.

The present invention concerns finally a process for heating a liquid, wherein said liquid is fed through the liquid heating module as described before at a flow range comprised from 150 to 1000 ml/min and brought to a temperature of about 85 to 90 °C in 3 to 10 seconds and wherein the electrical resistor on the first part of the

tube is permanently connected to power and the electrical resistor on the second part of the tube is connected to power and not connected to power according to a certain frequency depending on the required end temperature.

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It is possible according to the process of the invention to heat in a few seconds from the room temperature to 85-90 °C the water, without the need of having the machine permanently switched on. The heating of the electrical

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resistors only occurs when the consumer ask for a coffee.

The first electrical resistor, for example increases the temperature of the water from 20 to around 60 °C, and the second group of electrical resistor only needs to increase

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from 60 to 85 °C. Therefore, you do not need to have permanently a heating on this second electrical resistor.

In this case, the electrical resistor on the second part of the tube is connected to power during about 50 to 100 % of the time at full power.

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The second resistor is turned on and off in a percentage of time so that the outlet temperature is correct, in case of variation of electrical line voltage and flow rate. The wattage of this group of resistor is in such values that the on/off adjustment will not generate flickers.

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In the case of the first embodiment of the device of the invention, that is a coffee machine, the flow rate of the water to be heated is comprised between 150 and 300 ml/min.

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In the case of a vending machine, the flow rate of water is comprised between 300 and 1000 ml/min.

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As already said before, it is useful to have a control of the temperature of the heated water. In this case, the temperature of the liquid at the exit of the tube is measured, so that if the temperature is too high the electrical resistor on the second part of the tube is

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stopped and if the temperature of the liquid is not high enough, this electrical resistor continues to be connected to power.

5 The invention is now described in more detail in relation with the drawings, wherein

Fig. 1 represents a schematic view of the liquid heating module of the invention,

10 Fig.2 represents a schematic view of a coffee machine comprising the module of figure 1 and

Fig. 3 represents a schematic view of a vending machine comprising the module of figure 1.

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The heating module (1) comprises a hollow tube (2) made of stainless steel, a cylindrical insert (3) made of plastic (Teflon), a first electrical resistor (4) on the first part of the tube and a second electrical resistor (5) on the  
20 second part of the tube. Both of these electrical resistors are made of a thick-film and are connected to the power (11,12). The direction of the flow of water in the hollow tube is given by arrows A and B. The hollow tube is vertically installed to minimize air or steam accumulation  
25 inside the tube. Both ends of the insert are fixed on the cold water cap (6) and on the hot water cap (7). The insert (3) is connected to the rotating wheel of the flowmeter (8) and so it can be powered by the flowing cold water and rotates according to arrow C. A resistor (9) is furthermore  
30 disposed at the end of the hollow tube for measuring and controlling the temperature of the hot water leaving the module. Metal brush bundles (10) are built on the insert inside the hollow tube. A dielectric insulation (13), like enamel is painted on the tube under the resistors. For  
35 avoiding a too high loss of energy and guaranteeing a better safety an insulation (14) covers the resistors on

the entire height of the hollow tube. A free space (15) is provided into the hot water cap (7) for the buffering and the collecting of generated steam and separated air.

5 The liquid heating module operates as follows: when the consumer decides to prepare a beverage, both resistors (4,5) are under power. Resistor (4) remains permanently under power during the flowing of water through the hollow tube, whereas resistor (5) is switched on and switched off  
10 according to a certain frequency based on the remained required demand of energy to reach the final temperature of water necessary for the preparation of coffee. For example, resistor (4) allows an increase of temperature from 20 to 65 °C and the second resistor (5) has then only to provide  
15 the energy for increasing the water temperature from 65 to 85 °C. Because of the flowing of the water, the flowmeter (8) rotates and drives with it the insert (3). The metallic brush (10) on the insert avoids any deposit of calcium on the inside of the hollow tube.

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Figure 2 gives an embodiment of the use of module (1) in a coffee machine. The machine comprises a cold water tank (16) connected through a pipe (17) to a pump (18) delivering the cold water to the heating module (1). At the  
25 exit of the module (1), the hot water flows through a conduit (19) and arrives on a cartridge (20) containing roast and ground coffee. This cartridge is a sealed cartridge opening under pressure according to the EP patent No. 512'468. The ready to drink coffee flows in a cup (21).  
30 The coffee machine can integrate further elements, like a valve, electronic controls.

Figure 3 gives a second embodiment of the use of module (1) in a vending machine. The cold water of the tank (22) flows  
35 through a pipe (24) with the help of a pump (23) in the heating module (1). At the exit of said module, the water

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reaches a temperature of around 85 °C and flows through conduit (25) to a mixer (26). Simultaneously with the arrival of hot water, powder, like coffee powder is fed in the mixer from a powder storage (27) through a screw or  
5 auger (28) and said powder is mixed with the hot water and delivered in a cup (29). As already said before, the present machine can also integrate further elements normally present in such kinds of machines.

- 10 The specification is now made in relation with a specific example related with a heating module for a coffee machine.

#### Example

- 15 A stainless steel hollow tube having a diameter of 12mm with a length of 160 mm is used. The insert is made of plastic and has a diameter of 4 mm and the same length as the hollow tube. The resistors (4) and (5) have each a power of 600 Watts. The tube must support a pressure of  
20 max. 20 bar. The water flows with a flow rate of 200 ml/min. The required temperature is reached within 7 sec. And the second resistor is on during 60 % of the time. With this heating module, the temperature is very constant with the time and has only variation around 2 °C.

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## Claims

- 1) A liquid heating module for use in a hot beverage machine, which comprises
  - 5 - a hollow tube (2) of metallic material,
  - at least one electrical resistor (4) on a first part of the outside of the tube for preheating liquid flowing through said hollow tube and
  - at least one other electrical resistor (5) on a second  
10 part of the outside of the tube for temperature adjustment of the liquid flowing through the tube.
- 2) A liquid heating module according to claim 1 comprising  
15 further a cylindrical insert (3), which is disposed inside the hollow tube (2), along its entire length and substantially along its axis of symmetry.
- 3) A liquid heating module according to claims 1 or 2,  
20 wherein the cylindrical insert (3) is of plastics or metallic material.
- 4) A liquid heating module according to any of claims 1 or 3, wherein the hollow tube (2) is of stainless steel.
- 25 5) A liquid heating module according to any of claims 1 to 4, wherein the ratio of the length to the diameter of the tube (2) is comprised between about 5 and about 40.
- 6) A liquid heating module according to any of the claims 1  
30 to 5, wherein the outside of the hollow tube (2) comprises at least one further electrical resistor for the temperature measurement and control.
- 7) A liquid heating module according to any of the claims 1  
35 to 6, wherein the insert (3) is fixed or can be rotated along its axis of symmetry.

8) A liquid heating module according to claim 7, wherein the insert (3) is rotated because of its connection with a rotating wheel of a flowmeter (8) disposed at the lower part of said insert.

9) A liquid heating module according to any of claims 1 to 8, wherein the different electrical resistors (4, 5) of the tube are made in a form selected from the group consisting of wires, thick-film.

10) A liquid heating module according to claims 8 or 9, wherein the rotatable cylindrical insert (3) comprises a metal wire brush (10).

11) A liquid heating module according to any of claims 1 to 10, wherein all of the electrical resistors (4, 5) have a power density of up to 30 to 70 Watt/cm<sup>2</sup>.

12) A liquid heating module according to any of claims 1 to 11, wherein the hollow tube (2) comprises enamel painting (13) on its outside under the resistors.

13) A liquid heating module according to any of claims 1 to 12, wherein the electrical resistors (4, 5) are covered or insulated with an electrically non conductive material (14).

14) A device for the heating of a liquid comprising

- a water supply (16),
- a pump (18) for supplying said water to
- a liquid heating module according to any of claims 1 to 13, wherein all the three elements are in fluid communication ,

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- a channel (19, 25) for the exit of heated liquid, either on a substance to be extracted or in a mixer to mix said heated liquid with a powder.

- 5 15) A process for heating a liquid, wherein said liquid is fed through the liquid heating module according to any of claims 1 to 13 at a flow range comprised from 150 to 1000 ml/min and brought to a temperature of about 85 to 90 °C in 3 to 10 seconds and wherein the electrical resistor on
- 10 the first part of the tube is permanently connected to power and the electrical resistor on the second part of the tube is connected to power and not connected to power according to a certain frequency depending on the required end temperature.
- 15 16) A process according to claim 15, wherein the electrical resistor on the second part of the tube is connected to power during about 50 to 100 % of the time at full power.
- 20 17) A process according to any of claims 15 or 16, wherein the flow rate is comprised between 150 and 300 ml/min for a coffee machine and between 300 and 1000 ml/min for a vending machine.
- 25 18) A process according to any of claims 15 to 17, wherein the temperature of the liquid at the exit of the tube is measured, so that if the temperature is too high the electrical resistor on the second part of the tube is
- 30 stopped and if the temperature of the liquid is not high enough, this electrical resistor continues to be connected to power.