

ENERGY-SAVING ELECTRIC STEAMING DEVICE CONTAINING HEAT RECOVERY SYSTEM

Technical Field

- 5 [0001] The present invention relates to the field of food processing technologies, and particularly to an energy-saving electric steaming device containing a heat recovery system.

Technical Background

- 10 [0002] An electric steaming device, such as an electric steaming boiler or an electric steaming cabinet, is a kitchen appliance which is developed on the basis of the traditional wooden steamer, aluminum steamer, bamboo steamer, etc., and is used for directly steaming a variety of foods using the principle of generating steam by electricity, and the electric steaming device is very common in people's daily life and applied widely in kitchens, canteens, restaurants, and a variety of food processing enterprises.
- 15 [0003] Relying on its own buoyancy, the steam in the electric steaming device is accumulated at the top of a steaming chamber body so that the top housing of the steaming device generally has a very high temperature; also, the top housing is generally exposed to the atmosphere, thus not only resulting in an energy waste, but also bringing some dangers to the operator.

20 Summary of the Invention

- [0004] An object of the present invention is to provide an energy-saving electric steaming device containing a heat recovery system, which can fully recollect and utilize the energy of steam accumulated at the top of the steaming chamber body, thus improving operational safety of the operator.
- 25 [0005] To achieve this object, the present invention employs the following technical solutions.
- [0006] An energy-saving electric steaming device containing a heat recovery system includes a heating chamber, a steaming chamber body, an upper heat recovery chamber, where the heating chamber is located below and communicated with the steaming chamber body, the upper heat recovery chamber is located above the steaming chamber body in such a manner that
- 30 the bottom of the upper heat recovery chamber is attached to the top of the steaming chamber body, the steam inlet of the upper heat recovery chamber is connected with the steam outlet of the steaming chamber body, and a heat storage medium is provided within the upper heat recovery chamber.

[0007] Preferably, water is used as the heat storage medium, and the upper heat recovery chamber is provided with a tap-water inlet and a hot-water outlet.

[0008] The device further includes a lower heat recovery chamber, where the top of the lower heat recovery chamber is attached to the bottom of the heating chamber; the hot-water outlet of the upper heat recovery chamber is connected with the hot-water inlet of the lower heat recovery chamber, and the lower heat recovery chamber is communicated with the heating chamber.

[0009] Preferably, the hot-water outlet of the lower heat recovery chamber is connected with the hot-water inlet of the heating chamber.

[0010] Preferably, the upper heat recovery chamber is provided with a steam outlet which is located close to the tap-water inlet and connected with the low-temperature steam inlet of the lower heat recovery chamber.

[0011] Preferably, the upper heat recovery chamber is provided with a steam outlet which is located close to the tap-water inlet and connected with the inlet of the steaming chamber body.

[0012] The heat storage medium is stored in a serpentine pipe which is coiled within the upper heat recovery chamber; and the inlet and the outlet of the serpentine pipe are connected with the tap-water inlet and the hot-water outlet of the upper heat recovery chamber, respectively. The serpentine pipe is made of stainless steel and is provided with stainless steel fins. The upper recovery chamber is provided with intermediate separators, preferably two or more intermediate separators. The intermediate separator, which is adaptively arranged at the bending portion of the serpentine pipe, is configured to guide the steam. A gap, which is present between only one end of the intermediate separator and the upper heat recovery chamber, is used to accommodate the bending portion of the serpentine pipe, and the gaps with respect to adjacent intermediate separators are located at opposite sides in relation to each other, corresponding to the bending portion of the serpentine pipe.

[0013] A thermal insulation layer is disposed outside of the upper heat recovery chamber and the lower heat recovery chamber, and is preferably formed by a polyurethane foam layer.

[0014] The steam recollected by the upper heat recovery chamber contains overheated steam.

[0015] An electric heating plate with a certain height in the vertical direction is disposed at the lower part of the heating chamber; for the purpose of heating, water is added into the heating chamber such that the lower part of the electric heating plate is immersed therein, but the upper part of the electric heating plate extends from the surface of the water. The lower part of the electric heating plate is used to heat the water within the heating chamber to generate normal saturated steam above the water; the upper part of the electric heating plate is used to heat the

normal saturated steam to generate the overheated steam; both the normal saturated steam and the overheated steam may heat foods in the steaming chamber body; the process of generating the normal saturated steam includes generating the steam from the water during boiling thereof; due to fluctuating of the water surface during the boiling of the water, the middle and/or upper
5 part of the electric heating plate alternately heats the normal saturated steam and the boiling water.

[0016] Beneficial effects of the present invention are in that an energy-saving electric steaming device containing a heat recovery system includes a heating chamber, a steaming chamber body, an upper heat recovery chamber, where the heating chamber is located below
10 and communicated with the steaming chamber body, the upper heat recovery chamber is located above the steaming chamber body in such a manner that the bottom of the upper heat recovery chamber is attached to the top of the steaming chamber body, the steam inlet of the upper heat recovery chamber is connected with the steam outlet of the steaming chamber body, and a heat storage medium is provided within the upper heat recovery chamber. When the steam is
15 accumulated relying on its own buoyancy at the top of the steaming chamber body, the heat of the steam can be transferred to the heat storage medium within the upper heat recovery chamber; alternatively, the steam may flow into the upper heat recovery chamber via the steam outlet of the steaming chamber body, to transfer the heat to the heat storage medium. When the heat storage medium within the heat recovery chamber reaches a certain temperature, it is equivalent
20 to that an additional heating source is provided at the top of the steaming chamber body, thus both the recovery and utilization of the steam power can be achieved, while improving the operational safety of the operator.

Description of Drawings

[0017] To more clearly and effectively illustrate the technical solutions in the embodiments of the present invention, the accompanying drawings to be used in the embodiments are briefly introduced. It is apparent that the drawings in the following description show just some
25 embodiments of the present invention. Based on these drawings, other drawings can also be made by those skilled in the art without creative work.

[0018] Figure 1 is a schematic diagram showing the structure of an energy-saving electric steaming device containing a heat recovery system according to an embodiment of the present invention;
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[0019] Figure 2 is a schematic diagram showing the structure of an upper heat recovery chamber of the energy-saving electric steaming device containing the heat recovery system of

the present invention;

[0020] Figure 3 is a schematic diagram showing the structure of an electric heating plate of the energy-saving electric steaming device containing the heat recovery system of the present invention;

5 **[0021]** Figure 4 is a schematic diagram showing the heat transfer coefficient versus the overheat degree of the electric heating plate in the process of heating the liquid; and

[0022] Figure 5 is a schematic diagram showing the structure of an energy-saving electric steaming device containing a heat recovery system according to another embodiment of the present invention.

10 **[0023]** Reference numeral list:

[0024] 1: Heating chamber; 2: Steaming chamber body;
3: Upper heat recovery chamber; 4: Serpentine pipe; 5: Stainless steel fin;
6: Intermediate separator; 7: Electric heating plate;
8: Lower heat recovery chamber.

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Detailed description of the Preferred Embodiment

[0025] The accompanying drawings to be used in the embodiments are briefly introduced in order to more clearly and effectively illustrate the technical solutions of an energy-saving electric steaming device containing a heat recovery system of the present invention. It is
20 apparent that the drawings in the following description illustrate just some embodiments of the present invention. Based on these drawings, other drawings can also be made by those skilled in the art without creative work.

[0026] The technical solutions of the present invention will be illustrated below through specific embodiments and in conjunction with Figures 1 to 5.

25 **[0027]** [A first embodiment]

[0028] An energy-saving electric steaming device containing a heat recovery system includes a heating chamber 1, a steaming chamber body 2, an upper heat recovery chamber 3, where the heating chamber 1 is located below and communicated with the steaming chamber body 2, the upper heat recovery chamber 3 is located above the steaming chamber body 2 in such a manner
30 that the bottom of the upper heat recovery chamber 3 is attached to the top of the steaming chamber body 2, the steam inlet of the upper heat recovery chamber 3 is connected with the steam outlet of the steaming chamber body 2, and a heat storage medium is provided within the upper heat recovery chamber 3.

[0029] When the steam is accumulated relying on its own buoyancy at the top of the steaming chamber body 2, the heat of the steam can be transferred to the heat storage medium within the heat recovery medium 3; alternatively, the steam may flow into the upper heat recovery chamber 3 via the steam outlet of the steaming chamber body 2, to transfer the heat to the heat storage medium. When the heat storage medium within the heat recovery chamber 3 reaches a certain temperature, it is equivalent to that an additional heating source is provided at the top of the steaming chamber body 2, thus both the recovery and utilization of the steam power can be achieved, while the temperature at the top of the heat recovery chamber 3 will not be excessive, thus improving the operational safety of the operator.

10 **[0030]** [A second embodiment]

[0031] An energy-saving electric steaming device containing a heat recovery system includes a heating chamber 1, a steaming chamber body 2, an upper heat recovery chamber 3, where the heating chamber 1 is located below and communicated with the steaming chamber body 2, the upper heat recovery chamber 3 is located above the steaming chamber body 2 in such a manner that the bottom of the upper heat recovery chamber 3 is attached to the top of the steaming chamber body 2, the steam inlet of the upper heat recovery chamber 3 is connected with the steam outlet of the steaming chamber body 2, and a heat storage medium is provided within the upper heat recovery chamber 3.

20 **[0032]** In the present embodiment, water is used as the heat storage medium, and the upper heat recovery chamber 3 is provided with a tap-water inlet and a hot-water outlet. The hot-water outlet of the upper heat recovery chamber 3 is connected with the hot-water inlet of the heating chamber 1. The water, which serves as the source of the steam, is cheap and can store a plenty of heat, further, the hot water can also flow into the heating chamber 1 for the secondary use. The upper heat recovery chamber 3 is also provided with a steam outlet, which is located close to the tap-water inlet and connected with the inlet of the steaming chamber body 2. The steam with a lower temperature can be discharged and recollected by the steam outlet of the upper heat recovery chamber 3, so as to improve the heating efficiency of the electric steaming device.

30 **[0033]** In the present embodiment, the heat storage medium is stored in a serpentine pipe 4 which is coiled within the upper heat recovery chamber 3; and the inlet and the outlet of the serpentine pipe 4 are connected with the tap-water inlet and the hot-water outlet of the upper heat recovery chamber 3, respectively. The serpentine pipe 4 improves the space utilization of the upper heat recovery chamber 3, to further improve the efficiency of the electric steaming device.

[0034] The serpentine pipe 4 is made of stainless steel and provided with stainless steel fins 5.

The stainless steel material can ensure that the water in the electric steaming device is always in a clean and pollution-free state.

5 [0035] The upper recovery chamber 3 is provided with intermediate separators 6, preferably two intermediate separators 6. A gap is present between only one end of the intermediate separator 6 and the upper heat recovery chamber 3, and the gaps with respect to adjacent intermediate separators 6 are located at opposite sides in relation to each other. The intermediate separator 6, which is arranged at the bending portion of the serpentine pipe 4 that is accommodated at the gap between the intermediate separator 6 and the upper heat recovery chamber 3, is configured to guide the steam, thus accelerating the speed of steam circulation and improving the heating efficiency of the electric steaming device.

[0036] A thermal insulation layer, which is preferably a polyurethane foam layer, is disposed outside of the upper heat recovery chamber 3. The presence of the thermal insulation layer can improve the operational safety and improve the heat recovery rate of the electric steaming device.

15 [0037] The steam recollected by the upper heat recovery chamber 3 contains overheated steam, which may be used for processing foods so that the processed foods have a low nutrient loss, a low fat content, and a delicious taste.

[0038] The overall electric steaming device forms a steam flowing system, in which the steam flow is completed based on its own buoyancy and pressure, and the heat energy loss is low due to low heat emission from the electric steaming device to the outside, so that the power can be saved by two-thirds or more as compared to other devices having the same power with the electric steaming device. Particularly, if power of 32KW is required by the other devices to complete a task, power of 10KW is required by the inventive electric steaming device to complete the same task.

25 [0039] [A three embodiment]

[0040] An energy-saving electric steaming device containing a heat recovery system includes a heating chamber 1, a steaming chamber body 2, an upper heat recovery chamber 3, where the heating chamber 1 is located below and communicated with the steaming chamber body 2, the upper heat recovery chamber 3 is located above the steaming chamber body 2 in such a manner that the bottom of the upper heat recovery chamber 3 is attached to the top of the steaming chamber body 2, the steam inlet of the upper heat recovery chamber 3 is connected with the steam outlet of the steaming chamber body 2, and a heat storage medium is provided within the upper heat recovery chamber 3.

[0041] The steam inlet of the upper heat recovery chamber 3 is connected with the steam

outlet of the steaming chamber body 2, which is located at the top of the steaming chamber body 2 and below the upper heat recovery chamber 3. Based on its own pressure and buoyancy, the steam accumulated at the top of the steaming chamber body 2 can flow into the upper recovery chamber 3, thus the design is optimal.

5 **[0042]** In the present embodiment, water is used as the heat storage medium, and the upper heat recovery chamber 3 is provided with a tap-water inlet and a hot-water outlet. The upper heat recovery chamber 3 is also provided with a steam outlet which is located close to the hot-water outlet and connected with the inlet of the steaming chamber body 2. The steam with lower temperature can be discharged and recollected by the steam outlet of the upper heat
10 recovery chamber 3, so as to improve the heating efficiency of the electric steaming device.

[0043] In the present embodiment, a lower heat recovery chamber 8 is also included. The top of the lower heat recovery chamber 8 is attached to the bottom of the heating chamber 1; the hot-water outlet of the upper heat recovery chamber 3 is connected with the hot-water inlet of the lower heat recovery chamber 8; and the lower heat recovery chamber 8 is communicated
15 with the heating chamber 1 in that the hot-water outlet of the lower heat recovery chamber 8 is connected with the hot-water inlet of the heating chamber 1. The water with a low-temperature stored in the upper heat recovery chamber 3 absorbs the waste heat of the steam from the steaming chamber body 2 and thus is converted to hot water, which is in turn stored by the lower heat recovery chamber 8, or flows into the heating chamber 1 via the lower heat recovery
20 chamber 8.

[0044] The upper heat recovery chamber 3 recollets the steam accumulated at the top of the steaming chamber body 2 and stores the heat energy thereof in the heat recovery medium, and the heat energy is allowed to flow into the heating chamber 1 via the lower heat recovery chamber 8, so that the waste heat of the steam can be reused; the lower heat recovery chamber 8
25 absorbs the energy dissipated at the bottom of the heating chamber 1, stores the energy recollected by the upper heat recovery chamber 3, and stores the energy of the low-temperature steam which is released from the upper heat recovery chamber 3; in this way, the overall electric steaming device has a high energy utilization and a low energy loss; while the temperature at the top of the device is reduced, thus improving the operational safety.

30 **[0045]** In the present embodiment, the steam outlet of the upper heat recovery chamber 3 is also connected with the low-temperature steam inlet of the lower heat recovery chamber 8. After fully recolleting the heat energy of the steam, the upper heat recovery chamber 3 discharges the low-temperature steam into the lower heat recovery chamber 8, and the energy of the low-temperature steam is absorbed by the low temperature water stored in the lower heat

recovery chamber 8, thus further improving the energy utilization of the overall electric steaming device. In this way, the waste heat of the steam can be reused, thus further improving the energy utilization and reducing the energy consumption; while the temperature at the top of the electric steaming device is reduced, thus improving the operational safety. In the present embodiment, the heat storage medium is stored in a serpentine pipe 4 which is coiled within the upper heat recovery chamber 3; and the inlet and the outlet of the serpentine pipe 4 are connected with the tap-water inlet and the hot-water outlet of the upper heat recovery chamber 3, respectively. The serpentine pipe 4 is made of stainless steel and provided with stainless steel fins 5.

[0046] The upper recovery chamber 3 is provided with intermediate separators 6, preferably three intermediate separators 6. A gap is present between only one end of the intermediate separator 6 and the upper heat recovery chamber 3, and the gaps with respect to adjacent intermediate separators 6 are located at opposite sides in relation to each other. The intermediate separator 6, which is provided at the bending portion of the serpentine pipe 4 accommodated at the gap between the intermediate separator 6 and the upper heat recovery chamber 3, is configured to guide the steam, thus accelerating the speed of the steam circulation, and improving the heating efficiency of the electric steaming device. The upper heat recovery chamber 3 is separated by the upper intermediate separator 6 into a plurality of heat-exchanging spaces. In order to increase the number of heat-exchanging spaces, four or more intermediate separators 6 may be present.

[0047] A thermal insulation layer, which is preferably a polyurethane foam layer, is disposed outside of the upper heat recovery chamber 3. The presence of the thermal insulation layer can improve the operational safety and improve the heat recovery rate of the electric steaming device.

[0048] The steam recollected by the upper heat recovery chamber 3 contains overheated steam, which may be used for processing foods so that the processed foods have a low nutrient loss, a low fat content, and a delicious taste.

[0049] In the present embodiment, an electric heating plate 7 with a certain height in the vertical direction is disposed at the lower part of the heating chamber 1; for the purpose of heating, water is added into the heating chamber 1 such that the lower part of the electric heating plate 7 is immersed therein, but the upper part of the electric heating plate 7 extends from the surface of the water.

[0050] The lower part of the electric heating plate 7 is used to heat the water within the heating chamber 1 to generate normal saturated steam above the water; the upper part of the

electric heating plate 7 is used to heat the normal saturated steam to generate the overheated steam; both the normal saturated steam and the overheated steam may heat foods in the steaming chamber body 2; when the water is boiling, the middle and/or upper part of the electric heating plate 7 alternately heats the normal saturated steam and the boiling water during the boiling of the water.

[0051] The middle and/or upper part of the electric heating plate 7 alternately heats the normal saturated steam and the boiling water during the boiling of the water, and the heat exchange state of the middle and/or upper part of the electric heating plate 7 is close to the critical point between the nucleate boiling and the transition boiling, resulting in fast heat transfer and a high heat exchange efficiency. Since the middle and/or upper part of the electric heating plate 7 is above the water surface and the lower part thereof is below the water surface, the overheat degree of the overheated steam is controlled to be within a relatively small range due to the heat transfer, so that the temperature of the overheated steam is generally in a range from 106°C to 135°C, thus the processed food is delicious. In view of the continuously generated overheated steam in this case, the use of the upper heat recovery chamber 3 becomes extremely necessary. Thus, the heat energy is reused continuously in the overall electric steaming device, and overheated steam with a small overheat degree is continuously generated.

[0052] The overall electric steaming device forms a steam flowing system, in which the steam flow is completed based on its own buoyancy and pressure, and the heat energy loss is low due to low heat emission from the electric steaming device to the outside, so that the power can be saved by three-fourths or more as compared to other devices having the same power with the electric steaming device. Particularly, if power of 30 KW is required by the other devices to complete a task, power of 7 KW is required by the inventive electric steaming device to complete the same task.

[0053] As mentioned above, the middle and/or upper part of the electric heating plate 7 alternately heats the normal saturated steam and the boiling water during boiling of the water, particularly, the saturated steam and the boiling water are alternatively heated by the middle and/or upper part of the electric heating plate 7 due to the fluctuating of the water surface during boiling of the water, therefore, the normal saturated steam and the boiling water are alternately heated.

[0054] As mentioned above, the heat exchange state of the middle and/or upper part of the electric heating plate 7 is close to the critical point between the nucleate boiling and the transition boiling, particularly as follows:

[0055] as shown in Figure 4, the following four phases occur along with the changes of the

overheat degree in the process of heating water, and the four phases are that: 1) when the overheat degree is small, the heat exchange is conducted in a manner of the natural convection; 2) as the overheat degree increases, the bubbles are increasingly generated, so that the heat exchange is intensive and gets into the nucleate boiling state; 3) bubbles are excessively generated to form a gas film which covers the heated surface, so that the heat exchange effect becomes worsen, and this phase will last until the heat transfer coefficient is the minimal; and 4) the heat exchange is conducted in a film state, that is, when a stable gas film layer is formed, the heat exchange effect becomes better, but the temperature of the heating device is easy to be out of control, which may result in an equipment damage. With the heating method provided by the present invention, the upper part of the electric heating plate 7 is away from the water and thus has a high overheat degree; the lower part of the electric heating plate 7 is immersed in the water and thus substantially will not be overheated; and the transition region between the lower part and the upper part of the electric heating plate 7 has a relatively modest overheat degree; the saturated steam and the boiling water are alternatively heated by the middle and/or upper part of the electric heating plate 7 due to the fluctuating of the water surface during boiling of the water, and the overheat degree is controlled to be within a relatively small range, so that the heat transfer state can be well controlled close to the critical point between the nucleate boiling and the transition boiling.

[0056] The technical principles of the present invention are described as above in conjunction with the specific embodiments. However, the above description is only intended to explain the principles of the present invention, but not construed in any way as limiting the scope of protection of the present invention. Based on the explanation herein, other implementations of the present invention may occur to those skilled in the art without any creative work, and all these implementations should fall into the scope of the present invention.

CLAIMS

1. An energy-saving electric steaming device containing a heat recovery system comprises a heating chamber (1), a steaming chamber body (2), where the heating chamber (1) is located below and communicated with the steaming chamber body (2), wherein the device further comprises an upper heat recovery chamber (3) provided with a serpentine pipe (4), the upper heat recovery chamber (3) is located above the steaming chamber body (2) in such a manner that the bottom of the upper heat recovery chamber (3) is attached to the top of the steaming chamber body (2), the steam inlet of the upper heat recovery chamber (3) is connected with the steam outlet of the steaming chamber body (2), and a heat storage medium is provided within the upper heat recovery chamber (3) in such a manner that the serpentine pipe (4) is directly heated by steam in the upper heat recovery chamber (3);

wherein the device further comprises a lower heat recovery chamber (8), where the top of the lower heat recovery chamber (8) is attached to the bottom of the heating chamber (1); a hot-water outlet of the upper heat recovery chamber (3) is connected with a hot-water inlet of the lower heat recovery chamber (8), and the lower heat recovery chamber (8) is communicated with the heating chamber (1).

2. The device of claim 1, wherein water is used as the heat storage medium, and the upper heat recovery chamber (3) is provided with a tap-water inlet.

3. The device of claim 1, wherein the upper heat recovery chamber (3) is provided with a steam outlet which is located close to the tap-water inlet and connected with the low-temperature steam inlet of the lower heat recovery chamber (8).

4. The device of claim 1, wherein the upper heat recovery chamber (3) is provided with a steam outlet which is located close to the tap-water inlet and connected with the inlet of the steaming chamber body (2).

5. The device of claim 2, wherein the water is stored in the serpentine pipe (4) which is coiled within the upper heat recovery chamber (3); and the inlet and the outlet of the serpentine pipe (4) are respectively connected with the tap-water inlet and the hot-water

outlet of the upper heat recovery chamber.

6. The device of claim 5, wherein the serpentine pipe (4) is made of stainless steel and provided with stainless steel fins (5).

7. The device of claim 6, wherein the upper recovery chamber (3) is provided with intermediate separators (6), preferably two or more intermediate separators; a gap is present between only one end of the intermediate separator (6) and the upper heat recovery chamber (3), and the gaps with respect to adjacent intermediate separators (6) are located at opposite sides in relation to each other.

8. The device of claim 1, wherein a thermal insulation layer is disposed outside of the upper heat recovery chamber (3) and the steam recollected by the upper heat recovery chamber (3) contains overheated steam.

9. The device of claim 8, wherein an electric heating plate (7) with a certain height in the vertical direction is disposed at the lower part of the heating chamber (1); for the purpose of heating, water is added into the heating chamber (1) such that the lower part of the electric heating plate (7) is immersed therein, but the upper part of the electric heating plate (7) extends from the surface of the water.