

SUPERHEATED STEAM GENERATING DEVICE AND COOKING DEVICE

TECHNICAL FIELD

5 [0001] The techniques disclosed herein relate to a superheated steam generating device and a cooking device.

BACKGROUND ART

10 [0002] Superheated steam generating devices have been known that generate superheated steam (also called superheated water vapor) by heating mist generated from water (e.g., see Patent Document 1). This configuration can generate superheated steam at a lower energy than, e.g., a configuration in which superheated steam is generated by heating water steam generated by boiling water. Specifically, in this superheated steam generating device, mist generated by a mist generating unit installed in a water tank moves to a superheating unit through an upper opening of the water tank and is heated by a heater installed in the superheating unit to generate superheated steam. For example, oxidation of food materials can be suppressed by supplying superheated steam into a heating chamber in which food materials are arranged to perform hypoxic treatment on the food materials.

20 CITATION LIST

PATENT LITERATURE

[0003] Patent Document 1: Japanese Unexamined Patent Application Publication No. 2007-205705

25 SUMMARY OF INVENTION

TECHNICAL PROBLEM

30 [0004] Mist is just a fine liquid, heavier than air. For this reason, the amount of mist moving from the upper opening of the water tank to the superheating unit is relatively small compared to the amount of mist generated by the mist generating unit, and as a result, the amount of superheated steam generated in the superheating unit might be insufficient. If the amount of the generated superheated steam is insufficient, there arise problems such as the inability to suppress the oxidation of food materials due to insufficient supply of superheated steam to the heating chamber.

[0005] The preset specification discloses techniques capable of solving the aforementioned problems.

SOLUTION TO PROBLEM

5 [0006] The techniques disclosed herein can be implemented, e.g., in the following forms.

[0007] (1) A superheated steam generating device disclosed herein includes: a mist generating unit that generates mist from liquid; a flow path unit having an upward flow path extending from an inlet side into which mist generated by the mist
10 generating unit enters toward an outlet side located higher than the inlet; an air flow generating unit that generates updraft from the inlet to the outlet in the upward flow path; and a superheated steam generating heater that is arranged in the upward flow path and heats the mist flowing into the upward flow path to generate superheated steam.

15 [0008] In this superheated steam generating device, the mist generated by the mist generating unit moves upward in the updraft generated in the upward flow path, and becomes superheated steam by being heated by the superheated steam generating heater. That is, the mist and the superheated steam generated from the mist (saturated water vapor may be included depending on conditions such as the amount of mist
20 generated, heat generation temperature, and updraft velocity) go up against gravity by the updraft in the upward flow path to move toward the outlet side while maintaining a relatively high concentration (density). Thus, the superheated steam generating device can increase the amount of superheated steam generated per unit time compared with the configuration which heats mist moving in a flow path extending in
25 a horizontal direction.

[0009] (2) The superheated steam generating device may further include: a storage unit having an internal space where the mist generated by the mist generating unit is supplied, wherein the flow path unit may be arranged in the internal space and includes an inner pipe having a lower side opening to the internal space and an upper
30 side opening to the outside of the storage unit, at least a part of the superheated steam generating heater may be arranged in the inner pipe, and the air flow generating unit may include an outer pipe that is arranged in the inner space, surrounds the inner pipe, and has upper and lower sides that are both open in the inner space, thereby being configured to generate the updraft in the inner pipe by the pressure difference due to

the temperature difference between the inside and outside of the inner pipe caused by the heating of the superheated steam generating heater. In this superheated steam generating device, updraft is generated in the inner pipe by the pressure difference due to the temperature difference between the inner pipe and the outer pipe caused by the heating of the superheated steam generating heater. As a result, the amount of superheated steam generated per unit time can be increased while suppressing the energy loss caused by the temperature drop in the inner pipe caused by air or the like compared with the configuration in which air or the like is directly supplied into the upward flow path to generate the updraft.

[0010] (3) In the superheated steam generating device, at least a part of the superheated steam generating heater may be a rod-shaped body extending in the axial direction of the inner pipe, and a metal body may be arranged between the superheated steam generating heater and an inner wall of the inner pipe. According to this superheated steam generating device, in the inner pipe (in the upward flow path), the updraft flows further upward while colliding with the heated metal body. Therefore, the mist and saturated steam (wet steam, dry steam) contained in this updraft can be efficiently heated by the heated metal body to further increase the amount of superheated steam generated per unit time.

[0011] (4) In the superheated steam generating device, at least a part of the superheated steam generating heater may be rod-shaped body extending from the lower side of the inner pipe toward the inside of the inner pipe. This superheated steam generating device can heat a large amount of mist existing on the lower side of the inner pipe to generate superheated steam and draw it into the inner pipe efficiently compared with a configuration in which the superheated steam generating heater is not located on the lower side of the inner pipe.

[0012] (5) The superheated steam generating device may further include: a secondary heating unit arranged outside the storage unit and provided with a delivery flow path communicating with the inner pipe and a discharge port opening to the outside from the delivery flow path, and the superheated steam generating heater may include a primary heater arranged in the inner pipe and a secondary heater arranged in the delivery flow path and having a heating temperature lower than the primary heater. This superheated steam generating device can increase the amount of superheated steam generated per unit time while reducing the temperature on the discharge side of

superheated steam compared with the configuration in which the superheated steam generating heater is a single heater.

[0013] (6) In the superheated steam generating device, the mist generating unit may include a tank for containing liquid, an ultrasonic vibrator arranged in the liquid of the tank, and an air injection unit for injecting air into the tank and capable of changing the air flow rate of the air. This superheated steam generating device can adjust the amount of superheated steam generated per unit time by changing the flow rate of the air supplied by the air injection unit to the tank.

[0014] (7) A cooking device disclosed herein is a cooking device that applies heat treatment to food materials, including: the superheated steam generating device according to any one of claims 1 to 6; a cooking unit having a heating chamber to which superheated steam generated by the superheated steam generating device is supplied; and a cooking heater for heating food materials arranged in the heating chamber. This cooking device can supply a large amount of superheated steam to the heating chamber from the superheated steam generating device to apply heat treatment to food materials in an atmosphere with a high concentration of superheated steam.

[0015] (8) In the cooking device, the superheated steam generating device may be configured to output superheated steam toward an opposing wall including at least one of a ceiling wall and a side wall constituting the heating chamber, and the shape of the opposing wall may be a curved shape that allows superheated steam to recirculate in the heating chamber. This cooking device can apply heat treatment to food materials in an atmosphere with a high concentration of superheated steam while suppressing the application of pressure caused by superheated steam to the food materials.

[0016] (9) In the cooking device, the cooking unit may be configured such that the heating chamber opens to the outside through an inlet and an outlet, respectively, and the cooking device may further include a conveyance unit that conveys food materials from the inlet to the outlet. This cooking device can apply heat treatment to food materials in an atmosphere with a high concentration of superheated steam even in a configuration with a so-called tunnel-type heating chamber.

BRIEF DESCRIPTION OF DRAWINGS

[0017] FIG. 1 is a perspective view schematically illustrating a configuration of a cooking device 10 in an embodiment.

FIG. 2 is an explanatory view illustrating the cross-sectional configuration of the cooking device 10 taken along line II-II in FIG. 1.

5 FIG. 3 is a perspective view schematically illustrating a configuration of a superheated steam generating device 100.

FIG. 4 is a perspective view schematically illustrating a top configuration of the superheated steam generating device 100.

10 FIG. 5 is an explanatory view illustrating the cross-sectional configuration of the superheated steam generating device 100 taken along line V-V in FIG. 3.

DESCRIPTION OF EMBODIMENTS

[0018] A. EMBODIMENT:

A-1. BASIC CONFIGURATION OF COOKING DEVICE 10:

15 FIG. 1 is a perspective view schematically illustrating a configuration of a cooking device 10 in an embodiment, and FIG. 2 is an explanatory view illustrating the cross-sectional configuration of the cooking device 10 taken along line II-II in FIG. 1. FIG. 2 shows the X1 portion in the cooking device 10 in an enlarged view. Each figure shows the XYZ axes orthogonal to each other to define the directions. In
20 this specification, for convenience, the Z-axis direction is assumed to be the upper-lower direction of the cooking device 10, the Y-axis direction is assumed to be the conveyance direction of the conveyance unit 40 described later, and the X-axis direction is assumed to be the conveyance width direction. The same applies to FIG. 3 and subsequent drawings.

25 [0019] The cooking device 10 supplies superheated steam G3 into the heating chamber S1 having an inlet 36 and an outlet 37 to make the inside of the heating chamber S1 a highly concentrated superheated steam atmosphere in which the volume fraction of the superheated steam G3 is high, while applying heat treatment to a large quantity of food materials sequentially conveyed into the heating chamber S1.

30 [0020] As shown in FIGS. 1 and 2, the cooking device 10 includes a trestle 20, a cooking unit 30, a conveyance unit 40, a control unit 22, and a superheated steam generating device 100.

[0021] The trestle 20 is equipped with a frame 24, a plurality of legs 25, and a shelf plate 26. The frame 24 is a rectangular frame extending in a predetermined horizontal

direction (conveyance direction Y in FIG. 1). Each leg 25 extends downward from each corner of the frame 24. The shelf plate 26 is a rectangular plate-like body parallel in the horizontal direction, and is fixed to the plurality of legs 25 at a position lower than the frame 24. The control unit 22 is arranged in an installation space formed
5 between the frame 24 and the shelf plate 26.

[0022] The cooking unit 30 is provided with a cooking chamber cover 32. The cooking chamber cover 32 is arranged on the trestle 20. A heating chamber S1 is formed inside the cooking chamber cover 32. The heating chamber S1 is a tunnel-type furnace opened on both front and rear sides in the conveyance direction Y.

10 [0023] Specifically, the cooking chamber cover 32 has a ceiling wall 33, an inlet-side wall 34, and an outlet-side wall 35. The ceiling wall 33 is a rectangular plate-like body parallel in the horizontal direction and extending in the conveyance direction Y, and is positioned above the frame 24 of the trestle 20. The inlet-side wall 34 is located between the trestle 20 and the ceiling wall 33 on the inlet side in the conveyance direction (positive Y-axis direction side in FIG. 1). The inlet 36 is formed in the inlet-side wall 34 (see FIG. 2). The outlet-side wall 35 is located between the trestle 20 and the ceiling wall 33 on the outlet side in the conveyance direction (negative Y-axis direction side in FIG. 1). The outlet 37 is formed in the outlet-side wall 35. Thus, in
15 the cooking unit 30, the heating chamber S1 opens to the outside through the inlet 36 and the outlet 37, respectively.

20 [0024] The conveyance unit 40 is provided to penetrate the heating chamber S1 and is a conveyor that sequentially conveys a plurality of food materials (not shown) from the inlet 36 to the outlet 37. The conveyance unit 40 is provided with a driving unit 44, a driven unit 46, and a belt 48 (see FIG. 1). The driving unit 44 is arranged on the outlet 37 side and includes a driving roller and a motor. The driven unit 46 is arranged on the inlet 36 side and has a driven roller. The belt 48 is an endless mesh belt composed of, e.g., a metal (e.g., stainless steel) mesh material and is installed between the driving roller and the driven roller. When the conveyance unit 40 is activated, a plurality of food materials arranged on the belt 48 are carried into the heating chamber S1 through the inlet 36, move in the heating chamber S1 at a prescribed speed, and are carried out to the outside through the outlet 37.

30 [0025] The heating chamber S1 is divided into multiple zones (e.g., four zones) arranged in the conveyance direction Y, and each zone is provided with an upper heater 164 and a lower heater 166. The upper heater 164 is arranged on the upper side

of the belt 48 (conveyance unit 40), and the lower heater 166 is arranged on the lower side of the belt 48. In the present embodiment, temperatures of the upper heater 164 and the lower heater 166 provided in each zone can be individually controlled. In addition, the superheated steam generating devices 100 are provided for each zone.

5 The upper heater 164 and the lower heater 166 are examples of the cooking heater in the claims.

[0026] A-2. CONFIGURATION OF SUPERHEATED STEAM GENERATING DEVICE 100:

FIG. 3 is a perspective view schematically illustrating a configuration of the superheated steam generating device 100, and FIG. 4 is a perspective view schematically illustrating a top configuration of the superheated steam generating device 100. In FIG. 4, the X2 portion in the superheated steam generating device 100 is shown in an enlarged view. FIG. 5 is an explanatory view illustrating the cross-sectional configuration of the superheated steam generating device 100 taken along line V-V in Figure 3.

[0027] As shown in FIGS. 3 to 5, the superheated steam generating device 100 includes a mist generating unit 110, a mist heating unit 120, and a secondary heating unit 130.

[0028] The mist generating unit 110 is a device for generating mist G1 from liquid W (e.g., water). The mist G1 is a foggy liquid (droplets) and can be, e.g., fine particles of liquid with a diameter of 10 micrometers or less suspended in the atmosphere. The mist generating unit 110 is equipped with a tank 112, an ultrasonic vibrator 114, and an airflow fan 116. A storage chamber S2 is formed inside the tank 112, and liquid W is stored in the storage chamber S2 (see FIG. 3 and FIG. 5). The ultrasonic vibrator 114 is arranged in the liquid W contained in the tank 112, and the mist G1 is generated from the liquid W with the vibration of the ultrasonic vibrator 114 (see FIG. 5). In the present embodiment, as shown in FIGS. 3 and 4, the tank 112 (storage chamber S2) is a box-like body that is long in a predetermined direction (conveyance direction Y in FIG. 1) when viewed in the vertical direction, and two ultrasonic vibrators 114 are arranged in the tank 112 so as to be aligned in the conveyance direction Y.

[0029] A mist outlet 113 is formed at the top of the tank 112, and the mist G1 generated in the tank 112 is discharged to the outside of the tank 112 via the mist outlet 113. The space above the liquid W in the tank 112 has a relatively small

volume to be filled with the generated mist G1. The airflow fan 116 is provided, e.g., on a side wall of the tank 112 and injects air F1 (outside air) into the space above the liquid W in the tank 112 (see FIG. 5). The airflow fan 116 is, e.g., a sirocco fan. The rotational speed (flow rate) of the airflow fan 116 can be controlled by the control unit 22 described above, and the amount of the air F1 injected into the tank 112 per unit time (hereinafter referred to as "air flow rate") can be changed by changing the rotational speed of the fan. The higher the air flow rate, the greater the amount of the mist G1 discharged from the tank 112 to the mist heating unit 120 side per unit time.

[0030] The mist heating unit 120 is provided with a mist retention unit 121, a double pipe 150, and a mist heater 160. The mist retention unit 121 has a retention chamber S3 formed therein. The mist retention unit 121 is formed of, e.g., a heat insulating material. A mist supply port 122 is formed at the bottom of the retention chamber S3, and the mist supply port 122 is connected to the mist outlet 113 of the tank 112 through a connecting pipe 140. Therefore, the mist G1 generated by the mist generating unit 110 is supplied to the retention chamber S3 and retained (circulated by convection) in the retention chamber S3. In the present embodiment, as shown in FIG. 4, the mist retention unit 121 (retention chamber S3) is a box-like body that is narrower in the conveyance direction Y than the tank 112 and longer in the conveyance width direction X when viewed in the vertical direction Z, and is positioned at the center with respect to the two ultrasonic vibrators 114. With such a configuration, approximately the same amount of the mist G1 generated by each of the two ultrasonic vibrators 114 is collected through the connecting pipe 140 and supplied to the retention chamber S3. The mist retention unit 121 is an example of the storage unit in the claims, and the retention chamber S3 is an example of the internal space in the claims.

[0031] The double pipe 150 is arranged to extend in the vertical direction Z in the retention chamber S3. When viewed in the vertical direction Z, the double pipe 150 is arranged at a position different from the mist supply port 122 (see FIGS. 3 and 4). The double pipe 150 has a double pipe structure with an outer pipe 152 and an inner pipe 154. The outer pipe 152 is a tubular body that extends linearly in the vertical direction. The outer pipe 152 is cylindrical in shape, but may be rectangular or otherwise. The upper end of the outer pipe 152 opens to the retention chamber S3 at a position lower than the ceiling wall of the retention chamber S3 (see FIGS. 3 and 5). On the outer peripheral surface of the lower end of the outer pipe 152, a mist introduction port 156

is formed. The mist introduction port 156 is formed on the side of the mist supply port 122 in the outer peripheral surface of the lower end of the outer pipe 152. The outer peripheral surface of the lower end of the outer pipe 152 opposite to the mist supply port 122 extends to the bottom surface of the retention chamber S3 and is not open.

5 Therefore, the mist G1 supplied to the mist outlet 113 flows efficiently into the double pipe 150 through the mist introduction port 156.

[0032] The inner pipe 154 is a tubular body that extends linearly in the vertical direction. The inner pipe 154 is cylindrical in shape, but may be rectangular or otherwise. The inner pipe 154 is arranged coaxially with the outer pipe 152 on the inner circumferential side of the outer pipe 152. Between the outer pipe 152 and the inner pipe 154, a sub-flow path R2 is formed that communicates from the lower end side to the upper end side of the outer pipe 152. The upper end of the inner pipe 154 penetrates the ceiling wall of the retention chamber S3 and projects to the outside of the mist retention unit 121. The space between the outer peripheral surface of the inner pipe 154 and the ceiling surface of the retention chamber S3 is sealed. The lower end of the inner pipe 154 is arranged at a position higher than the mist introduction port 156 of the outer pipe 152. The inner pipe 154 is an example of the flow path unit in the claims, the lower end opening of the inner pipe 154 is an example of the inlet in the claims, and the upper end opening of the inner pipe 154 is an example of the outlet in the claims. The outer pipe 152 and the inner pipe 154 are formed of metal (such as stainless steel), for example.

[0033] The mist heater 160 is arranged in a space on the inner periphery side of the inner pipe 154 (hereinafter referred to as "upward flow path S4"). The mist heater 160 is a rod-shaped heating element extending in the vertical direction Z (axial direction of the inner pipe 154), and the outer diameter of the mist heater 160 is smaller than the inner diameter of the inner pipe 154. Therefore, a main flow path R1 communicating from the lower end side to the upper end side of the outer pipe 152 is formed between the inner wall of the inner pipe 154 and the mist heater 160. The mist heater 160 extends from the lower side of the inner pipe 154 toward the inside of the inner pipe 154. Specifically, the mist heater 160 extends to a position where it is exposed from the mist introduction port 156. Furthermore, the mist heater 160 extends to the bottom surface of the retention chamber S3. The position of the upper end of the mist heater 160 is lower than the position of the upper end of the outer pipe 152. The outer pipe 152 and the mist heater 160 are examples of the air flow generating

unit in the claims, and the mist heater 160 is an example of the primary heater in the claims.

[0034] A metal body is arranged between the inner wall of the inner pipe 154 and the outer peripheral surface of the mist heater 160. The length of the metal body in the vertical direction Z is shorter than the length of the mist heater 160 in the vertical direction Z. The metal body is, e.g., a lump of metal formed by a metal with high thermal conductivity. Specifically, the metal body is a plurality of metal spheres 170. The metal spheres 170 are arranged in a circumferentially spaced manner to surround the mist heater 160. Each metal sphere 170 is supported by a support member (not shown) while exposing its spherical surface in the main flow path R1. It is preferable that at least a surface of each metal sphere 170 on the inlet side of the inner pipe 154 is exposed. The shape of the metal sphere 170 is not limited to a spherical shape but may be cylindrical or the like, or comprehensively speaking, the metal sphere 170 may have spherical or curved shape.

[0035] The secondary heating unit 130 is arranged outside the mist retention unit 121. The secondary heating unit 130 includes a heat conducting unit 312 and a secondary heater 162. The heat conducting unit 312 as a whole extends in the conveyance width direction X, and is cylindrical with a delivery flow path S5 formed therein. The base end side of the heat conducting unit 312 is connected to the upper end of the inner pipe 154 through a connecting pipe 142, and the tip side of the heat conducting unit 312 is arranged in the heating chamber S1 of the cooking unit 30 (see FIG. 2). The tip side of the heat conducting unit 312 is bent toward the ceiling wall 38 constituting the heating chamber S1, and on the tip side of the heat conducting unit 312, a discharge port 133, which opens from the delivery flow path S5 to the heating chamber S1, opens toward the ceiling wall 38.

[0036] The secondary heater 162 is arranged in the delivery flow path S5 of the heat conducting unit 312. The secondary heater 162 is a rod-shaped heating element extending in the conveyance width direction X, and the outer diameter of the secondary heater 162 is smaller than the inner diameter of the heat conducting unit 312. Therefore, between the inner wall of the heat conducting unit 312 and the secondary heater 162, there is formed a flow path communicating from the base end side to the tip side of the secondary heater 162. The mist heater 160 and the secondary heater 162 are examples of the superheated steam generating heater in the claims.

[0037] The superheated steam generating device 100 is provided with three fixing members 101, and the mist generating unit 110 and the mist heating unit 120 are fixed relative to the trestle 20 and the cooking unit 30 at the outside of the heating chamber S1 (one side in the conveyance width direction X) through the fixing members 101.

5 [0038] As shown in FIG. 2, the shape of the ceiling wall 38 toward which the discharge port 133 of the heat conducting unit 312 directs is a curved shape for recirculating the superheated steam G3 into the heating chamber S1. Specifically, the ceiling wall 38 is provided with a heat leveling plate 39 having an arc-shaped surface that opens downward when viewed in the horizontal direction (e.g., in the conveyance
10 direction Y). The surface of the heat leveling plate 39 is mirrored.

[0039] A-3. OPERATION OF COOKING DEVICE 10:

When the cooking device 10 is activated, the control unit 22 controls each part of the cooking device 10. For example, the superheated steam generating device 100 generates the superheated steam G3 in the heating chamber S1 of the cooking unit 30.
15 Specifically, as shown in FIG. 5, the mist G1 is generated from the liquid W stored in the tank 112 by the vibration of the ultrasonic vibrator 114. The temperatures of the liquid W and the mist G1 are, e.g., 30 °C or more and 40 °C or less. The control unit 22 can adjust the amount of the mist G1 generated per unit time by changing the vibration frequency of the ultrasonic vibrator 114. The generated mist G1 moves into
20 the retention chamber S3 of the mist heating unit 120 through the connecting pipe 140 while filling the space above the liquid W in the storage chamber S2 of the tank 112.

[0040] The air F1 injected into the storage chamber S2 by the airflow fan 116 provided in the tank 112 generates an air current flowing into the retention chamber S3 through the connecting pipe 140 while being circulated in the storage chamber S2.

25 The mist G1 generated in the storage chamber S2 flows efficiently into the retention chamber S3 by the air flow of the air F1. Here, the flow path cross-section (XY cross section) of the connecting pipe 140 is narrower than either the XY cross section of the storage chamber S2 or the XY cross section of the retention chamber S3. Thus, by providing the connecting pipe 140 between the storage chamber S2 and the retention
30 chamber S3 to narrow the flow path area, the semi-superheated steam G2 described later heated in the retention chamber S3 is prevented from flowing back into the storage chamber S2. This prevents, e.g., the failure of the ultrasonic vibrator 114 due to the rise in the temperature of the liquid W in the tank 112 caused by the backflow of the semi-superheated steam G2.

[0041] The mist G1 flowing into the retention chamber S3 is circulated (retained) in the retention chamber S3. The mist G1 circulating in the retention chamber S3 is drawn into the main flow path R1 by updraft F2 generated in the inner pipe 154 of the double pipe 150 and heated by the mist heater 160, thereby generating the semi-superheated steam G2. The semi-superheated steam G2 has a volume fraction of superheated steam lower than the superheated steam G3 described below, and also contains more saturated steam (wet steam, dry steam) and the mist G1. The heating temperature of the mist heater 160 is, e.g., 450 °C or more and 550 °C or less, and the temperature of the semi-superheated steam G2 is, e.g., 100 °C or more and 200 °C or less.

[0042] Specifically, when the mist heater 160 is heated, the updraft F2 is generated in the upward flow path S4 of the inner pipe 154 by the pressure difference due to the temperature difference between the main flow path R1 around the mist heater 160 and the space above the main flow path R1 (the mist heater 160).

[0043] In addition, the sub-flow path R2 is formed by surrounding the inner pipe 154 with the outer pipe 152, which further enhances the momentum of the updraft F2. The reasons behind this are not clear, but the following are possible. That is, a temperature difference occurs between the main flow path R1 on the inner periphery side of the inner pipe 154 and the sub-flow path R2 on the outer periphery side, and a pressure difference occurs due to the temperature difference. It is presumed that the Venturi effect in the relatively high-pressure main flow path R1 enhances the momentum of the updraft F2.

[0044] When the updraft F2 is generated in the inner pipe 154 of the double pipe 150, the mist G1 retained in the retention chamber S3, especially near the bottom where the density of the mist G1 is high, is drawn into the main flow path R1 from the mist introduction port 156. The drawn mist G1 is heated by the mist heater 160, which generates the semi-superheated steam G2. Because the semi-superheated steam G2 goes up against gravity by the updraft F2 to move toward the secondary heating unit 130 while maintaining a relatively high concentration (density: volume fraction of the semi-superheated steam G2 per unit volume).

[0045] The semi-superheated steam G2 moved to the side of the secondary heating unit 130 is heated by the secondary heater 162 while moving through the delivery flow path S5 so that the superheated steam G3 is generated. The superheated steam G3 has a higher volume fraction of superheated steam than the semi-superheated

steam G2 and contains almost no saturated steam (wet steam, dry steam) or the mist G1. The heat generation temperature of the secondary heater 162 is lower than that of the mist heater 160, e.g., 350 °C or more and 450 °C or less, and the temperature of the superheated steam G3 is 330 °C or more and 370 °C or less. Keeping the heat
5 generation temperature of the secondary heater 162 as low as possible can suppress the baking of food materials in the heating chamber S1 by the secondary heater 162.

[0046] The generated superheated steam G3 is discharged from the discharge port 133 of the heat conducting unit 312 toward the ceiling wall 38, and recirculates in the retention chamber S3 by the heat leveling plate 39 and filled uniformly in the
10 retention chamber S3. Here, as described above, the heating chamber S1 is a tunnel-type furnace opened to the outside through the inlet 36 and the outlet 37, and the superheated steam G3 supplied into the heating chamber S1 flows out to the outside.

However, since the amount of the superheated steam G3 generated per unit time is large in the superheated steam generating device 100, the inside of the heating
15 chamber S1 can be maintained in a highly concentrated superheated steam atmosphere with a high volume fraction of superheated steam. In addition, since the superheated steam G3 is not jetted directly to the food materials, the application of pressure by the superheated steam G3 to the food materials can be suppressed.

[0047] After the conveyance unit 40 is activated, food materials are sequentially
20 placed on the belt 48, and the upper heater 164 and the lower heater 166 are heated. Then, the multiple food materials are sequentially carried into the heating chamber S1 of the highly concentrated superheated steam atmosphere, and heated and baked by the upper heater 164 and the lower heater 166. In a highly concentrated superheated steam atmosphere, a large amount of the superheated steam G3 adheres to the surface
25 of the food and easily penetrates the inside of the food. For this reason, the surface of the food and the inside of the food are heated in a hypoxic state, and as a result, the whole food can be evenly baked from the surface to the inside while suppressing the oxidation of the food.

[0048] As described above, the control unit 22 is configured to control temperature
30 and on-off of each heater 160, 162, 164, and 166, airflow of the airflow fan 116, and vibration frequency of the ultrasonic vibrator 114. Therefore, control of changing at least one of the temperatures of the heaters 160 and 162, the airflow of the airflow fan 116, and the vibration frequency of the ultrasonic vibrator 114 can adjust the amount of the mist G1 generated per unit time, and the proportion of the superheated steam in

the semi-superheated steam G2 or the superheated steam G3. Thus, it is possible to adjust the amount of the mist G1 generated in the heating chamber S1 to a desired amount. Furthermore, the control unit 22 can individually control temperature and on-off of each heater 160, 162, 164, and 166, airflow of the airflow fan 116, and vibration frequency of the ultrasonic vibrator 114 for each zone. In other words, the control unit 22 can change or switch the heating temperature and on-off of each heater, superheated steam quantity, and the like zone by zone.

[0049] A-4. Effect of the present embodiment:

As described above, in the superheated steam generating device 100 of the present embodiment, the mist G1 generated by the mist generating unit 110 goes up in the upward flow path S4 by the updraft F2 generated in the upward flow path S4, and is heated by the mist heater 160 to become the semi-superheated steam G2. Then, the semi-superheated steam G2 goes up against gravity by the updraft F2 in the upward flow path S4 to move toward the outlet side while maintaining a relatively high concentration (density). With this configuration, the present embodiment can increase the amount of the superheated steam G3 (semi-superheated steam G2) generated per unit time compared with the configuration which heats mist moving in a flow path extending in a horizontal direction.

[0050] In the present embodiment, the updraft F2 is generated in the inner pipe by the pressure difference due to the temperature difference between the inner pipe 154 and the outer pipe caused by the heating of the mist heater 160. As a result, the amount of the superheated steam G3 (semi-superheated steam G2) generated per unit time can be increased while suppressing the energy loss caused by the temperature drop in the inner pipe 154 caused by air or the like, compared with a configuration in which air or the like is directly supplied into the upward flow path to generate the updraft.

[0051] The mist heater 160 is a rod-shaped body extending in the axial direction of the inner pipe 154, and the metal spheres 170 are arranged between the mist heater 160 and the inner wall of the inner pipe 154. In the inner pipe 154 (in the upward flow path S4), the updraft F2 flows further upward while colliding with the heated metal spheres 170. Therefore, the semi-superheated steam G2 contained in this updraft F2 can be efficiently heated by the heated metal spheres 170 to further increase the amount of the superheated steam G3 (semi-superheated steam G2) generated per unit time. Moreover, by providing the metal spheres 170, the mist G1 can be effectively

heated to generate the semi-superheated steam G2 while reducing the length in the vertical direction Z of the mist heater 160.

[0052] The mist heater 160 is rod-shaped body extending from the lower side of the inner pipe 154 toward the inside of the inner pipe 154. As a result, compared with the configuration in which the mist heater 160 is not located on the lower side of the inner pipe 154, a larger amount of the mist G1 existing on the lower side of the inner pipe 154 can be heated to generate the semi-superheated steam G2 and the generated semi-superheated steam G2 can be efficiently drawn into the inner pipe 154.

[0053] Thus, the mist heater 160 and the secondary heater 162 the heating temperature of which is lower than that of the mist heater 160 are provided as a superheated steam generating heater, and the superheated steam G3 is generated from the mist G1 by multi-stage heating. As a result, compared with a configuration in which the superheated steam generating heater is a single heater, the amount of the superheated steam G3 generated per unit time can be increased while reducing the temperature on the discharge side of the superheated steam G3.

[0054] The amount of the superheated steam G3 generated per unit time can be adjusted by changing the air flow rate per unit time of the air F1 supplied from the airflow fan 116 into the tank 112.

[0055] B. Modifications:

The techniques disclosed herein are not limited to the above-described embodiment and can be modified in various forms without departing from the gist of the invention, including the following modifications.

[0056] The configuration of the cooking device 10 and the superheated steam generating device 100 in the above embodiment is only an example and can be variously modified. For example, in the above embodiment, the inner pipe 154 (upward flow path S4) extending in the vertical direction Z is exemplified as the flow path unit (upward flow path), but this may be an inner pipe extending in an oblique direction inclined with regard to the vertical direction Z. In addition, the flow path unit (upward flow path) is not limited to a straight line but may be curved. In addition, the flow path unit may have a part extending in the horizontal direction on at least one of both sides of the upward flow path. In other words, the flow path unit may have any configuration as long as it has an upward flow path extending from the inlet side into which the mist enters toward the outlet side located higher than the inlet.

[0057] In the above embodiment, the tunnel-type heating chamber S1, which opens to the outside via the inlet 36 and the outlet 37, is exemplified as the heating chamber, but at least one of the inlet 36 and the outlet 37 may not be provided. In addition, the heating chamber may have multiple, e.g., three or more openings.

5 [0058] In the above embodiment, the heating chamber S1 of the cooking device 10 is divided into multiple zones, and the superheated steam generating device 100 and the heaters 164 and 166 are arranged in each zone, but the heating chamber S1 may not be divided into multiple zones, and the heating chamber may have one superheated steam generating device 100, one upper heater 164, and one lower heater 166. In the
10 above embodiment, the upper heater 164 and the lower heater 166 are exemplified as the cooking heaters, but only one of the upper heater 164 and the lower heater 166 may be provided.

[0059] In the above embodiment, the storage chamber S2 of the tank 112 and the retention chamber S3 of the mist retention unit 121 are connected through the
15 connecting pipe 140 with a relatively small flow path cross-section, but the storage chamber S2 and the retention chamber S3 may be integrated without the connecting pipe 140. Although the tank 112 is positioned below the mist retention unit 121 in the above embodiment, the position is not limited thereto, e.g., the tank 112 may be positioned on a side of the mist retention unit 121.

20 [0060] In the above embodiment, a sirocco fan is exemplified as the air injection unit, but other airflow fans such as a propeller fan may be used. In addition, an air tank with an adjustment valve capable of ejecting air and adjusting the amount of ejection may be connected to the tank 112. In addition, the mist generating unit 110 may be configured without the airflow fan 116. The mist generating unit 110 may also have
25 one ultrasonic vibrator 114 or three or more ultrasonic vibrators 114.

[0061] In the above embodiment, the double pipe 150 is arranged at a position different from the mist supply port 122 when viewed in the vertical direction Z (see FIG. 4). This configuration can draw a large amount of the mist G1 into the double pipe 150 by sufficiently retaining the mist G1 while suppressing the momentum of the
30 air F1 flowing from the mist generating unit 110 in the retention chamber S3 of the mist heating unit 120. However, in the above embodiment, the double pipe 150 may be arranged at the same position as the mist supply port 122 when viewed in the vertical direction Z.

[0062] The outer pipe 152 may be omitted from the above embodiment. Even with such a configuration, updraft can be generated in the inner pipe 154 by the temperature difference between inside and outside of the inner pipe 154 due to the heating of the mist heater 160 or by the air F1 from the airflow fan 116. In this case, the airflow fan 116 is an example of the air flow generating unit in the claims. The air flow generating unit may be configured to generate updraft in the inner pipe 154 by, e.g., partially narrowing the flow path cross-section of the inner pipe 154.

[0063] In the above embodiment, one or more discharge ports may be formed in the side wall of the heat conducting unit 312 of the secondary heating unit 130. In addition, the discharge port 133 of the heat conducting unit 312 may open toward the side wall constituting the heating chamber S1, and the heat leveling plate 39 may be formed on the side wall. The discharge port 133 of the heat conducting unit 312 may be directed toward food materials (the conveyance unit 40).

[0064] In the above embodiment, the superheated steam G3 is generated from the mist G1 by heating in two stages with two heaters (mist heater 160, secondary heater 162) as the superheated steam generating heater, but the present invention is not limited to this, and the superheated steam G3 may be generated from the mist G1 by heating in multiple stages with multiple (three or more) heaters. Alternatively, the superheated steam generating heater may a single heater, and the superheated steam G3 may be generated from the mist G1 by heating of this single heater. For example, the secondary heating unit 130 may be omitted from the above embodiment, and the superheated steam G3 may be generated from the mist G1 only by the heat generated by the mist heater 160.

[0065] The material of each member in the above embodiment is only an example and can be variously modified.

[0066] For example, the tank 112 in the above embodiment may store chlorine, and by operating the mist generating unit 110 with each heater 160, 162, 164, and 166 turned off under the control of the control unit 22, the chlorine mist can be supplied to the heating chamber S1 for sterilization treatment.

REFERENCE SIGNS LIST

[0067] 10: cooking device, 20: trestle, 22: control unit, 24: frame, 25: leg, 26: shelf plate, 30: cooking unit, 32: cooking chamber cover, 33, 38: ceiling wall, 34: inlet-side wall, 35: outlet-side wall, 36: inlet, 37: outlet, 39: heat leveling plate, 40: conveyance unit, 44: driving unit, 46: driven unit, 48: belt, 100: superheated steam generating

device, 101: fixing member, 110: mist generating unit, 112: tank, 113: mist outlet,
114: ultrasonic vibrator, 116: airflow fan, 120: mist heating unit, 121: mist retention
unit, 122: mist supply port, 130: secondary heating unit, 133: discharge port, 140,142:
connecting pipe, 150: double pipe, 152: outer pipe, 154: inner pipe, 156: mist
5 introduction port, 160: mist heater, 162: secondary heater, 164: upper heater, 166:
lower heater, 170: metal sphere, 312: heat conducting unit, F1: air, F2: updraft, G1:
mist, G2: semi-superheated steam, G3: superheated steam, R1: main flow path, R2:
sub-flow path, S1: heating chamber, S2: storage chamber, S3: retention chamber, S4:
upward flow path, S5: delivery flow path, W: liquid

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CLAIMS

1. A superheated steam generating device, comprising:
 - a mist generating unit that generates mist from liquid;
 - 5 a flow path unit having an upward flow path extending from an inlet side into which mist generated by the mist generating unit enters toward an outlet side located higher than the inlet;
 - an air flow generating unit that generates updraft from the inlet to the outlet in the upward flow path; and
 - 10 a superheated steam generating heater that is arranged in the upward flow path and heats the mist flowing into the upward flow path to generate superheated steam.
2. The superheated steam generating device according to claim 1, further comprising:
 - 15 a storage unit having an internal space where the mist generated by the mist generating unit is supplied,
 - wherein the flow path unit is arranged in the internal space and includes an inner pipe having a lower side opening to the internal space and an upper side opening to the outside of the storage unit,
 - 20 wherein at least a part of the superheated steam generating heater is arranged in the inner pipe, and
 - wherein the air flow generating unit includes an outer pipe that is arranged in the inner space, surrounds the inner pipe, and has upper and lower sides that are both open in the inner space, thereby being configured to generate the updraft in the inner
 - 25 pipe by the pressure difference due to the temperature difference between the inside and outside of the inner pipe caused by the heating of the superheated steam generating heater.
3. The superheated steam generating device according to claim 2,
 - 30 wherein at least a part of the superheated steam generating heater is a rod-shaped body extending in the axial direction of the inner pipe, and
 - wherein a metal body is arranged between the superheated steam generating heater and an inner wall of the inner pipe.

4. The superheated steam generating device according to claim 2 or 3,
wherein at least a part of the superheated steam generating heater is rod-shaped body extending from the lower side of the inner pipe toward the inside of the inner pipe.

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5. The superheated steam generating device according to any one of claims 2 to 4, further comprising:

a secondary heating unit arranged outside the storage unit and provided with a delivery flow path communicating with the inner pipe and a discharge port opening to the outside from the delivery flow path,

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wherein the superheated steam generating heater includes a primary heater arranged in the inner pipe and a secondary heater arranged in the delivery flow path and having a heating temperature lower than the primary heater.

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6. The superheated steam generating device according to any one of claims 1 to 5, wherein the mist generating unit includes a tank for containing liquid, an ultrasonic vibrator arranged in the liquid of the tank, and an air injection unit for injecting air into the tank and capable of changing the air flow rate of the air.

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7. A cooking device that applies heat treatment to food materials, comprising:
the superheated steam generating device according to any one of claims 1 to 6;
a cooking unit having a heating chamber to which superheated steam generated by the superheated steam generating device is supplied; and
a cooking heater for heating food materials arranged in the heating chamber.

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8. The cooking device according to claim 7,
wherein the superheated steam generating device is configured to output superheated steam toward an opposing wall including at least one of a ceiling wall and a side wall constituting the heating chamber, and

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wherein the shape of the opposing wall is a curved shape that allows superheated steam to recirculate in the heating chamber.

9. The cooking device according to claim 7 or 8,

wherein the cooking unit is configured such that the heating chamber opens to the outside through an inlet and an outlet, respectively, and

the cooking device further comprises a conveyance unit that conveys food materials from the inlet to the outlet.