

## Field of the Invention

The present invention relates to steam thermal energy collection apparatus, such as steam heat energy recycling apparatus or steam heat  
5 energy recovery apparatus. The present invention also relates to food steamers.

## Background of the Invention

Steam is energy rich. Historically, steam has been used as a power source for driving the pistons of steam engines. With the advent of electrical  
10 power drives and internal combustion engines, steam engines are no longer a practical alternative as a power source.

On the other hand, steam is widely used for food processing both in western and oriental cooking nowadays, and food steaming is gaining increasing popularity as a healthy alternative cooking style. Healthy cooking  
15 apart, food cooked by steaming has a unique characteristic which is not found in food cooked in other ways. For example, many Chinese dim sums and fresh fishes are best cooked by steaming.

Food steamers are a type of cooking apparatus which is devised

specifically for food steaming. A conventional food steamer comprises a heated water pool for generating steam and as a steam source and a steaming chamber inside which food is placed. In use, steam generated by the heated water pool enters the bottom portion (or the base portion) of the steaming chamber, passes or rises through the food inside, and then exits from the top portion of the steaming chamber by natural convection. The steam moisturizes as well as heats and/or cooks the food inside the steaming chamber on passing through the steam chamber, thereby giving a unique character to the steamed food.

However, the heated steam usually passes through the steaming chamber of a food steamer in a relatively short period of time, and is then discharged or directly drained into the environment or the kitchen while containing a substantial amount of residual thermal energy. As result, the energy utilization efficiency rate of food steaming is relatively low and the discharged steam constitutes a pollutant to the environment.

### **Summary of the Invention**

According to the present invention, there is provided a steam heat energy collection or recovery apparatus comprising a steam chamber and a

steam heat energy collection device, wherein the steam chamber is arranged such that steam enters at a steam inlet and exits from a steam outlet, and the steam heat energy collection device is arranged to collect thermal energy from steam inside the steam chamber by contact thermal exchange; characterized

5 in that the steam chamber comprises a steam guide that is arranged to guide steam to travel inside the steam chamber between the steam inlet and the steam outlet at a direction away from vertical.

According to another aspect of the present invention, there is provided a steam heat energy collection or recovery apparatus comprising a steam

10 chamber and a steam heat energy collection device, wherein the steam chamber is arranged such that steam enters at a steam inlet and exits from a steam outlet, and that the steam heat energy collection device is arranged to collect or extract thermal energy from steam inside the steam chamber by contact thermal exchange, and the extracted or collected thermal energy is

15 stored in a thermal energy collection fluid; characterized in that, the thermal energy collection fluid is arranged to travel in a direction against the direction of movement of steam inside the steam chamber. Such a movement arrangement helps to maintain a larger temperature difference between the thermal energy

collection fluid and steam inside the steam chamber throughout the entire operating area of the steam heat energy collection device to promote thermal collection efficiency.

The steam guide may be shaped such that steam inside the steam  
5 chamber travelling from the steam inlet to the steam outlet travels at a speed that is lower than that due to natural upward convection.

As an example, the steam guide or the chamber may be arranged such that steam exiting the steam chamber leaves the steam outlet in a direction substantially orthogonal to the direction of entry at the steam inlet.

10 In an exemplary embodiment, the steam guide extends substantially horizontally between the steam inlet and the steam outlet.

A steam guide which is arranged to guide the steam to travel at a direction away from the vertical means and/or at a lower speed will have the effect of slowing down the speed of steam movement while the steam is moving  
15 under natural convection, thereby allowing more contact time between the residual energy containing steam and the thermal energy collection device for more effective thermal energy recovery.

The steam guide may incline slightly upwards from the steam inlet to the

steam outlet. This strikes a balance between smooth steam exit and good energy collection efficiency.

According to yet another aspect of the present invention, there is provided a food steamer comprising a steam heat energy collection or recovery apparatus described herein.

In an embodiment, the steamer comprises a heated water pool for steam generation and an enclosed food steaming chamber having a steam inlet and a steam outlet, the steam inlet being admitting steam generated by the heated water pool into the steam chamber, and the steam outlet being arranged to feed steam exiting from the food steaming chamber into the steam chamber of the steam heat energy recovery apparatus.

For example, a 29kW steamer according to the present invention uses 41 liters of water per hour, and 368 liters of hot water at 96°C could be generated using steam heat energy recovery and 40 liters of distilled water at 56 could be recovered.

### **Brief Description of the Drawings**

Preferred embodiments of the present invention will be explained by way of example with reference to the accompanying figures, in which:-

Figure 1 is a longitudinal cross-sectional view of a steam heat energy collector according to an embodiment of the present invention,

Figure 2 is a side view of the steam heat energy collector of Figure 1, and

5           Figure 3 is a food steamer according to another embodiment of the present invention.

### **Detailed Description of Preferred Embodiments**

A steam heat energy collector 10 illustrating an exemplary embodiment of a steam heat energy collection or recovery apparatus of the present invention is depicted in Figures 1 and 2. The steam heat energy collector comprises a steam chamber 100 and a thermal energy collection device 200 for extracting thermal energy from steam inside the steam chamber. The steam chamber is enclosed within a main housing 110 which comprises an inner housing 112 and an outer housing 114 which insulates the steam chamber and the inner housing from the environment. The outer housing surrounds the inner housing and is separated from the inner housing by a vacuumed air space 116 as an example of an insulating layer. The vacuum layer operates to preserve steam heat energy by

providing thermal insulation to reduce heat loss from the steam chamber to the environment. In addition, a steam inlet 120, a steam outlet 130 and a water outlet 140, which are in communication with the steam chamber, are also formed on the main housing. A valve 150 for vacuum suction is provided on the main housing to

5 permit suction and removal of air from the space between the inner and outer housing to maintain a good vacuum state.

The thermal energy collection device (or thermal exchanger in short) 200 comprises a conductive pipe as an example of a thermal exchange element 220 adapted for extracting thermal energy from steam inside the steam chamber

10 as well as cooling the steam. As the primary purpose of the conductive pipe is for extracting steam thermal energy, the conductive is also referred to as a thermal collection element or member herein. The conductive pipe is helically wound about a tubular or cylindrical core 240 to form a tubular or cylindrical thermal collection member. As shown in Figures 1 and 2, the thermal collection member

15 comprises a cylindrical or tubular wall which surrounds the internal core, while the wall is an ensemble of the helically wound pipe.

In order to ensure that steam in the steam chamber has a good probability of encountering the thermal exchanger to undergo thermal exchange,

the central portion of the internal core is blocked while leaving a gap between the baffle means and the pipe for steam passage to be explained below. As the probability of steam encountering the thermal exchange is substantially increased, the steam heat energy recovery efficiency is also noticeably enhanced. For

5 example, the central portion of the internal core may be blocked by a cylindrical blocking member 260 as an example of a baffle means or a blocking means. In the embodiment of Figures 1 & 2, the blocking member is co-axial or concentric with the thermal collection member such that a uniform gap is maintained between the blocking member and the thermal exchanger to promote a uniform

10 passage of steam through the thermal collection member to be explained below.

The pipe is made of a thermally conductive material such as copper, aluminum or stainless steel to promote high thermal exchange efficiency when in contact with steam inside the steam chamber. So that the thermal energy extracted by the thermal exchanger could be transferred outside the steam

15 chamber for utilization, a thermal energy collection fluid is continuously run through the thermal exchanger during operation. The thermal energy collection fluid could be a coolant such as water which is driven through the thermal exchanger by a pumping apparatus or a pumping arrangement. As shown in

Figure 1, the thermal exchanger comprises a thermal energy collection fluid inlet 222 and a thermal energy collection fluid outlet 224. During use, a thermal energy collection fluid at a low temperature (for example room temperature) is driven to enter the thermal exchanger at the thermal energy collection fluid and then pass

5 through the thermal exchanger. After passing through the helically wound pipe element, the thermal energy collection fluid (or water in this example) picks up thermal energy from the steam due to temperature difference and exits from the thermal energy collection fluid outlet at a substantially elevated temperature approaching that of the steam inside the steam chamber. The thermal energy of

10 the heated water exiting the helically wound pipe could then be re-used. At the same time, a significant portion of steam inside the steam chamber condenses after giving up thermal energy, and the condensed water could be re-utilized as drinking or cooking water. Thus this apparatus serves a dual function of re-utilizing the steam thermal energy as well as producing distilled water from the

15 steam. The un-condensed steam will then exit the thermal exchanger at the steam outlet. In this embodiment, it will be appreciated that the thermal energy collection fluid in the thermal exchanger travels against the direction of movement of steam inside the steam chamber. As shown in Figure 1, the thermal energy

collection fluid inlet and outlet are respectively proximal the steam outlet and the steam inlet of the steam chamber. This arrangement help to ensure that a large temperature difference is maintained throughout the length of the helically wound coiled pipe. More specifically, the lower temperature thermal energy collection

5 fluid will encounter the lower temperature steam at the steam exit, while the heated thermal energy collection fluid will encounter the higher temperature steam at the steam inlet.

In order to further enhance thermal exchange efficiency between the thermal collection member and the steam inside the steam chamber, a portion of

10 the steam chamber is arranged as a steam guide to guide steam coming in from the steam inlet to move in a direction away from the vertical or from the direction of movement due to natural convection. As depicted in Figure 1, the steam guide is substantially horizontal or orthogonal to the direction of natural convection of steam. Such an arrangement slows down the time of transit of steam through the

15 steam chamber and therefore increases the contact time for contact thermal exchange. In addition, the thermal collection member and the steam guide are substantially parallel or co-axial with a substantially uniformed gap maintained there-between to further maximize thermal exchange. The gap is preferably

about the same width as the pipe diameter.

Exemplary dimensions of a pipe could have a diameter of 5mm to 200mm, the pipe length could be around 0.5m to 100m, and the length of the thermal collection device could be between 0.3 to 50m.

- 5** The food steamer of Figure 3 illustrates an embodiment of a food steaming apparatus 20 according to the present invention. The food steamer comprises a heated water pool 30, a food steaming compartment 40, a hot water pipe system 50 and a distilled water pipe system 60 and a steam heat energy collection device 10 of Figures 1 and 2. The food steaming compartment
- 10** comprises perforated shelves for food steaming and includes a steam inlet 420 and a steam outlet 440. The steam inlet is at the base of the food steaming compartment and the steam outlet is at the top portion of the food steaming compartment. *The water pool may be heated by an electrical heater or a gas heater without loss of generality.*
- 15** In use, steam generated by the heated water pool enters the food steaming compartment by natural convection. The steam passes through the perforated shelves of the food steaming compartment, gives up heat and moisture to the foodstuff inside the food steaming compartment, and then leaves

the food steaming compartment through the steam outlet 440.

The steam outlet of the food steaming compartment 440 is connected to the steam inlet of the steam heat energy collector 120 such that steam exiting from the food steaming compartment will enter the steam heat energy collector

**5** for steam heat energy recycling. When the food steamer is in operation, cold (or room temperature) water is also supplied to the thermal exchanger through the cold water inlet and is then moved across the helically wound pipe to exit at the water outlet. At the same time, steam entering the steam chamber of the thermal energy collector is guides to move laterally towards the steam outlet, and the

**10** steam movement direction is opposite the water movement direction inside the pipe. On encountering the thermal exchanger, thermal energy contained in the steam is transferred to the water inside the conductive pipe due to temperature differences. As the direction of movement of the water is opposite that of the steam, there is always a large temperature difference along the length of the

**15** thermal exchanger for optimal thermal exchange efficiency across the entire length of the thermal exchanger. The horizontally disposed steam guide changes the direction of movement of steam from a vertical movement on entry to substantially horizontal movement. This slows down the speed of movement of

the steam and increases the contact time between the thermal exchanger and the steam inside the steam chamber. The heated water of the thermal exchanger then leaves the thermal exchanger at the water outlet and re-enters the heated water pool through a hot water piping system for more steam generation or for

5 other use. As the heated water could be at the temperature range of between 80°C -99°C, there is substantial energy saving for further steam generation. Furthermore, as the temperature of the steam at the downstream end of the steam chamber has dropped significantly to say, 40°C -85°C after giving up a substantial portion of its heat, the warm distilled water could be utilized for

10 drinking or beverage making. In the present embodiment, the distilled water is also returned into the heated water pool. Finally, residual steam at a substantially lowered temperature will be discharged from the food steamer.

In another embodiment, a plurality of food steamers is connected to the hot water pipe system and form a pool of food steamers to share the recovered

15 steam heat energy and water.

While the present invention has been explained with reference to the exemplary embodiments, it should be appreciated that the embodiments are for illustrations only and should not be used to limit the scope of the present invention.

For example, while vacuum insulation is used to insulate the space between the inner and outer housing of the steam chamber, the main housing could be insulated using other insulating cladding materials such as insulating cotton, ceramic fiber, or other insulating materials. Also, while the steam guide of Figures 5 1 & 2 is substantially cylindrical, the steam guide could have a rectangular, square, elliptical or other cross sectional shapes without loss of generality. Furthermore, while the steam guide is substantially horizontally disposed, it could be slightly inclined, for example, to expedite evacuation of distilled water from the steam chamber.

**CLAIMS:**

1. A steam heat energy collection or recovery apparatus comprising a steam chamber and a steam heat energy collection device, wherein the steam chamber is arranged such that steam enters at a steam inlet in the direction of natural upward convection and exits from a steam outlet, and that the steam heat energy collection device is arranged to collect or extract thermal energy from steam inside the steam chamber by contact thermal exchange; characterized in that, the steam chamber comprises a steam guide that is arranged to guide steam to travel inside the steam chamber between the steam inlet and the steam outlet at a direction away from vertical, wherein the steam guide is substantially horizontal or orthogonal to the natural upward convection of steam, and wherein the steam heat energy collection device and the steam guide are substantially parallel or co-axial with a substantially uniform gap maintained there-between to further maximize thermal exchange.
2. A steam heat energy collection or recovery apparatus comprising a steam chamber and a steam heat energy collection device, wherein the steam chamber is arranged such that steam enters at a steam inlet in the direction of natural upward convection and exits from a steam outlet, and that the steam heat energy collection device is arranged to collect or extract thermal energy from steam inside the steam chamber by contact thermal exchange, and the extracted or collected thermal energy is stored in a thermal energy collection fluid; characterized in that, the thermal energy collection fluid is arranged to travel in a direction against the direction of movement of steam inside the steam chamber, wherein the steam chamber is arranged as a steam guide which is substantially horizontal or orthogonal to the natural upward convection of steam, and wherein the steam heat energy collection device and the steam guide are substantially parallel or co-axial with a

substantially uniformed gap maintained there-between to further maximize thermal exchange.

3. An apparatus according to Claims 1 or 2, wherein the steam guide is shaped such that steam inside the steam chamber travelling from the steam inlet to the steam outlet travels at a speed lower than that due to natural upward convection.
4. An apparatus according to any of preceding Claims, wherein the steam guide extends substantially horizontally between the steam inlet and the steam outlet.
5. An apparatus according to any of the preceding Claims, wherein the steam guide inclines slightly upwards from the steam inlet to the steam outlet.
6. An apparatus according to any of the preceding Claims, wherein the chamber is arranged such that steam exiting the steam chamber leaves the steam outlet in a direction substantially orthogonal to the direction of entry at the steam inlet.
7. An apparatus according to any of the preceding Claims, further comprising a distilled water outlet, the distilled water outlet being proximal the steam outlet.
8. An apparatus according to any of the preceding Claims, further comprising an insulated outer housing, the insulated housing being arranged to surround the steam chamber and mitigate heat loss from the steam chamber to the environment.
9. An apparatus according to any of the preceding Claims, wherein the steam heat energy collection device comprises at least one thermal

collection pipe, the thermal collection pipe being helically wound and forming part of a closed circulation system arranged to circulate a thermal collection medium, wherein the substantially uniform gap formed between the heat energy collection device and the steam guide is substantially the same width as the pipe diameter.

10. An apparatus according to Claim 9, wherein the helically wound thermal collection pipe collectively forms an internal core, the central portion of the internal core being blocked or baffled such that steam passing through the internal core is forced to pass through the unblocked or the un-baffled portion of the internal core during operation.
11. An apparatus according to Claims 9 or 10, wherein the thermal collection medium is arranged to travel against the direction of movement of the steam.
12. An apparatus according to any of Claims 9 to 11, wherein the thermal collection medium is water.
13. A food steamer comprising a steam heat energy collection or recovery apparatus according to any of the preceding Claims.
14. A food steamer according to Claim 13, wherein the steamer comprises a heated water pool for steam generation and an enclosed food steaming chamber having a steam inlet and a steam outlet, the steam inlet being admitting steam generated by the heated water pool into the steam chamber, and the steam outlet being arranged to feed steam exiting from the food steaming chamber into the steam chamber of the steam heat energy recovery apparatus.
15. A food steamer according to Claims 13 or 14, wherein the thermal collection medium is water and the food steamer comprises a heated

water pool for steam generation, the thermal collection medium being returned to the heated water pool as hot water for steam generation.

16. A food steamer according to any of Claims 13 to 15, wherein distilled water produced due to condensation of the steam in the steam chamber by the thermal energy collection device is returned to the heated water pool.