A tankless heater includes at least one non-metallic tube, at least one heating layer on or adjacent an external or internal surface of the tube, and a controller to generate a signal to be applied to the heating layer. The signal from the controller is applied through one or more electrodes coupled to the heating layer, and the heating layer generates heat in response to the signal. The heat is then transferred to a liquid flowing through, a gel located within, or a solid inside of the tube to heat the liquid, gel, or solid to certain temperature range, which may or may not be predetermined. Or, the heat is transferred to a liquid, a gel or a solid around the tube to heat the liquid, gel or solid to certain temperature, which may or may not be predetermined. In a multiple-tube configuration, the tubes may be independently selected and may have different temperature ranges. Also, according to one arrangement, no heating element is included inside any of the tubes.
NON-METAL ELECTRIC HEATING SYSTEM AND METHOD, AND TANKLESS WATER HEATER USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority under 35 USC §119 (e) to provisional U.S. Patent Application Ser. No. 61/223, 962, filed on Jul. 8, 2010, the content of which is incorporated herein by reference.

BACKGROUND

[0002] 1. Field

[0003] One or more embodiments disclosed herein relate to heaters.

[0004] 2. Background

[0005] Tankless water heaters have been developed in recent years and are known by a variety of names, including instantaneous, combination or “combi” boilers, continuous flow, inline, flash, or on-demand water heaters. This type of water heater is gaining in popularity mainly for space-saving and energy efficiency reasons. These advantages are achieved by heating water as it flows through the unit.

[0006] As a practical matter, tankless water heaters may be installed throughout a household at various points-of-use (POU) or at a centralized location. They also can be used alone or in combination with a centrally located water heater. In some cases, larger tankless models may be used to provide the hot water requirements for an entire house. Whether installed at one or multiple POUs, tankless water heaters provide a continuous flow of hot water and energy savings compared with tank-type heaters, which are only able to provide a finite supply of hot water limited by tank size and hot water recovery rates.

[0007] For all of the advantages they provide, tankless water heaters on the market today suffer from significant disadvantages. First, there is a delay between when water flow starts and when a flow detector activates one or more heating elements. This causes cold water to flow before hot water. The flow of cold water under these circumstances is undesirable and is particularly noticeable when a hot water faucet is repeatedly turned on and off by a user.

[0008] Second, when activated, tankless water heaters tend to heat idle water in surrounding pipes through the process of convection. Also, tankless water heaters only heat water upon demand so that idle water in the piping is cold. Thus, there is a more apparent “flow delay” for hot water to reach a distant faucet.

[0009] Third, because tankless water heaters are inactive when hot water is not being used, they may be incompatible with hot water recirculation systems unless an expansion tank is added.

[0010] Fourth, tankless water heaters often have minimum flow requirements before the heater is activated. This can create in a gap between the temperature of cold water and the coolest warm temperature that can be achieved with a hot-and-cold water mix. This gap can produce undesirable effects to the user.

[0011] Moreover, unlike tank-type heaters, the hot water temperature from a conventional tankless water heater is inversely proportional to the rate of water flow. In other words, the faster the flow, the less time water spends in the heating element. As a result, a certain range of desirable hot water temperatures may not be achievable or achieving a desired temperature with precision may be difficult to control. For example, in certain situations mixing hot and cold water to just the “right” temperature using a single-lever faucet (e.g., while taking a shower) may take a lot of practice to master. A user may therefore consider installing a temperature compensating valve under these circumstances, which can increase costs.

[0012] In addition to the foregoing disadvantages, installing a conventional tankless water heating system may be expensive, particularly in retro-fit applications. Also, tankless heaters have demonstrated certain inefficiencies and safety problems that need improvement.

[0013] Tankless and other forms of water heaters are also disadvantageous in terms of their metallic heating elements. These elements tend to corrode over time, thereby necessitating their replacement over relatively short periods of time. This can be especially burdensome to homeowners in terms of cost and convenience. Also, conventional water heaters that use metallic heating elements have proven to be inefficient, unmanageable, or both, for many applications.

[0014] In view of the foregoing considerations, there is a need in the art for a more efficient and effective heating system and method capable, for example, of not only heating water more quickly than conventional systems and methods but also with greater efficiency, precision, and safety. A need also exists for a heating system and method of the aforementioned type which is more durable, longer-lasting, and cost-efficient compared with those that use metallic heating elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1A shows one embodiment of a non-metallic heating element, and FIG. 1B shows a cross-section of the element in FIG. 1A.

[0016] FIG. 2 shows one embodiment of a tankless water heater that uses one or more non-metallic heating elements such as shown in FIGS. 1A and 1B.

[0017] FIG. 3 shows a second embodiment of a tankless water heater.

[0018] FIG. 4 shows a third embodiment of a tankless water heater.

DETAILED DESCRIPTION

[0019] One or more embodiments herein are directed to systems and methods for instantaneously generating heat in any one of a variety of residential, commercial, industrial, or medical applications. The heat is generated using one or more non-metallic heating elements which prove to be safer, more efficient, and more cost effective than their metallic counterparts over the lifetime of the equipment.

[0020] According to one illustrative application, the heating system and method may be applied to heating water, for example, for a user’s faucet, shower, appliance, or other device. In another application, the liquids different from water such as a gel may be heated. In still another application, the air or a solid may be heated. Moreover, because non-metallic heating elements are used, the embodiments disclosed herein require less power due to no efficiency or capacity decay, making them suitable for use in virtually any application that requires heat. Other types of metallic heating elements may build up lime scale over time, which reduces heating elements ability to heat water.
FIG. 1A shows one embodiment of a heating element having an electric heating layer 1 disposed on a non-metallic tube 2. The heating layer may be in the form of a coating, film, or layer which generates heat when a voltage or other electrical signal is applied. The coating, film, or layer may be applied directly to the exterior surface of the tube or an interior surface of non-metallic tube. Such a coating, film, or layer may be made from electric heating membrane material agglutinated onto or embedded or burned into the exterior or interior surface of the non-metallic tube or otherwise applied to the tube surface. Examples of this material include carbon fiber, nylon, conductive polyimides, conductive indium-tin oxide (ITO), kapton, and polymer thick-film inks that are screen printed onto a substrate.

When a signal is applied to this material by electrodes 3 and 4, heat is generated based on electrical resistance. The heat passes through the tube wall to heat a medium disposed therein to a desired temperature. For many residential applications, a temperature of between 20°C and 100°C may be sufficient. For other, commercial applications, a range of between 20°C and 500°C may be more suitable.

The medium inside the tube to be heated may be air or another gas, water, or another liquid, gel, or even a solid. The size and quantity of electric heating material and the amount of voltage applied thereto (as well as other electrical properties such as frequency) may be varied or set to generate a predetermined amount of heat (e.g., temperature) and/or heating response time for the intended application.

FIG. 1B shows a sectional view of the heating element to FIG. 1A. In this view, the medium 5 is shown as water passing through the tube at a predetermined rate. Because the heating layer is able to provide instantaneous heating, the water is immediately heated as a result of the signal applied through the electrodes. As a safety precaution, insulating material (not shown) may be mounted proximate the heating layer.

The non-metallic tube 1 may be made of quartz, glass, or ceramic or another material capable of withstanding heat. The use of a non-metallic tube is highly desirable for many applications in order to prevent corrosion which occurs in more traditional heaters that use metallic heating elements. The thickness of the tube walls is preferably set to be strong enough to withstand breakage as a result of shock or other sudden forces, but thin enough to rapidly transfer heat from the heating layer to medium 5. The thickness range may, for example, lie in the range of between 5 to 10 mm for many applications. Of course, in other applications, a different thickness range may be used.

The electrodes 4 and 5 may be attached to the heating layer using any one of a variety of connections including but not limited to lead wires, conductive terminals, and metallic traces. The signal generator connected to the electrodes generates signals at a predetermined voltage, frequency, and/or current to heat the medium inside the tube to the intended temperature, or temperature range.

FIG. 2 shows one embodiment of a tankless water heater which uses one or more heating tubes such as shown in FIGS. 1A and 1B. The tankless water heater includes a heating section 10, a power source 11, one or more sets of terminals 12, and a controller 13, all of which are supported within a housing 20. The power source may include a transformer for providing power to the controller, and the terminals are coupled to transfer the signals generated by the controller to the heating section at a predetermined voltage, current, and/or frequency set based on the operational requirements of the heater and the temperature to be achieved by application of the heat.

The heating section contains a predetermined number of heating tubes for heating water. In this illustrative embodiment, two heating tubes 40 and 50 are used to provide heated water, for example, to different appliances in a house. A different number of tubes may be used in other embodiments.

The heating tubes are held between upper and lower mounting sections 21 and 22 in a fixed position. The mounting sections not only provide structural support for the tubes, but also include a water path between the tubes or electrodes for electrically connecting the heating layers of the tubes to different sets of terminals 12.

To help secure the tubes between the mounting sections, one or more support rods 23 are provided adjacent the tubes. Also, a number of sealing components are provided to seal the tubes from leaks, both along their lengths and also at the interface points. The sealing components may, for example, be made of a pressurized silicon polymer or other suitable sealing material sustainable to, for example, over 3.0 MPa water pressure.

The heating tubes are coupled to different water pipes. In this two-tube configuration, tube 40 is coupled to an inlet water pipe 41 and tube 50 is coupled to inlet water pipe 51. Water passing through tubes 40 and 50 then exit through exit pipes 42 and 52, respectively. The exit pipes carry the water to different destinations that have heating demands, e.g., dishwasher and clothes washer. As mentioned, the interface points between the heating tubes and their corresponding inlet and outlet pipes are provided with sealing members to protect against leaks. The sealing members may be made from nylon or another polymer-based material.

The controller 13 generates signals at one or more predetermined voltages, currents, and/or frequencies to the heating layers of the tubes. The signals are applied to the electrodes of the tubes through the different sets of terminals 12. If the heating tubes are to heat water to different temperatures, then the controller signals will be proportionately different.

Moreover, in a multiple-tube configuration such as shown in FIG. 2, the tubes may be identically made or may be different. If different, the heating layer on the tubes may be different to provide different heating temperature ranges. For example, one tube may heat water to a first temperature range suitable for one type of appliance or faucet, and the other tube may heat water to a second temperature range greater than the first temperature range suitable for another type of appliance or application. This two-temperature range configuration of the tankless water heater may be especially desirable for commercial applications where heated water in vastly different temperature ranges (e.g., a first range of 20°C to 100°C, and a second range of 20°C to 500°C may be required).

In addition to the foregoing features, insulation may be provided at various points within the heating section 10 to protect the components therein. This insulation may be especially desirable at a location between the tubes, to prevent a high-temperature range tube from adversely affecting a low-temperature range tube. Insulation may also be provided between the tubes and interior walls of the heating section.

Additional electrical components may be provided, for example, in the form of relays and/or timers to control the timing of when heated water is to be supplied, optionally, a silicon-controlled rectifier to control power and voltage requirements of the heating section, flow sensors to detect the rate of water flow at various positions relative to the heating tubes, a temperature sensor to form part of a protection circuit to prevent overheating, power regulators, water leakage protection circuits to detect water escaping from the tubes and/or
heating section housing, and dry heat protection circuits. A ground for the electrical circuits may be provided, for example, in the form of a connection to one or more of the inlet or outlet water pipes.

[0036] In addition, a heating element box or other means of protection may also be included to protect the heating element from physical damage. Thermal insulation material may enhance the thermal efficiency of the equipment. These features may also protect the heating elements from being exposed when the unit is opened.

[0037] A control board may be included to protect the control boards or circuits used for the heating tubes, for example, by preventing a high-voltage section of the system from being exposed when the unit is opened.

[0038] An outside jack may be included to meet visual design requirements. The controller and other circuits may also be equipped with or interfaced to one or more control panels and/or buttons to allow a user to adjust power, temperature, and/or other settings related to heating. The controller may modify the signals (e.g., voltage, current, or frequency) applied to the heating layer(s) of the tube(s) in accordance with the adjustments made through the control panel or buttons.

[0039] The embodiments of the non-metal water heater described herein may have one or more of the following advantages. The non-metal tubes have higher sustainability to voltage than metal heating elements. Also, the non-metal tubes do not scale; have excellent insulation properties and therefore are safer. The tubes also will not age for over many years, have a pure resistance load, heat up quickly, have high thermo efficiency, and long lifetime.

[0040] In addition, the non-metallic heating element of the tubes in an electric water heater application demonstrate resistance to corrosion and are expected to have reduced power requirements and improved operational stability compared with their metallic counterparts.

[0041] FIG. 3 shows another embodiment of a tankless water heater which has a single heating tube 150 in a substantially U-shaped configuration. In this embodiment, different sections 160 and 170 of the tube are used to heat water from inlet pipe 180 before being discharged through outlet pipe 190. Using this two-section, single-tube configuration, water from the inlet pipe may be heated for a longer period of time. Moreover, the different tubes may be individually controlled based on signals from the controller to effect heating at different stages and/or at different temperatures.

[0042] In other embodiments, a different number of heating tubes may be used from the tubes shown in FIGS. 2 and 3. Varying the number of heating tubes may have the effect of varying power capacity of the heating elements. Depending on the capacity required for a particular application, three or more heating tubes may be group together for purposes of generating heated water for discharge through a same or different outlet pipes. Also, the multiple heating tubes may be selectively and independently activated in order to satisfy heating requirements for a particular application.

[0043] FIG. 4 shows another embodiment of a tankless water heater which uses multiple heating tubes 210 and 220 to heat water from a single inlet pipe 230. The heated water is then combined and passed through a single outlet pipe 240. In this embodiment, the heating tubes are independently and selectively activated based on signals from the controller to effect heating at different temperatures.

[0044] For example, the controller may supply signals to only heating tube 210 to heat the water to within a low-temperature range. In this case, signals are not supplied to heating tube 220. The controller may then supply signals to both heating tubes 210 and 220, to thereby activate both tubes to heat the water to within a high-temperature range. If the heating tubes have different heating material or heating capabilities, the controller may supply signals to only heating tube 220 to heat the water to a middle temperature range.

[0045] When the water is to be heated using only one tube, a three-way electronically controlled valve 240 may be located downstream of an inlet of the inlet pipe to shut off flow of water to a tube when the other tube is only to be selected for heating. Signals for controlling the configuration of the valve may be generated from the controller.

[0046] In accordance with another embodiment, a water heating system which uses a tank to hold a supply of water may be provided. This system may use one or more non-metallic heating tubes disposed within the tank to heat the supply of water. Alternatively, one or more inlet pipes as previously discussed may carry a flow of water stored in the tank to one or more heating tubes with or without a water pump. Such a system may, thus, correspond to a tank-based water heating system where the heating elements are located outside of the tank.

[0047] In accordance with any one of the aforementioned embodiments, one or more intervening layers may be included between heating layer 1 and non-metallic tube 2. These layers may include, for example, an insulating layer, a sensing layer, a protective layer, an electrode layer or any combination thereof.

[0048] In addition, one or more layers may be formed over heating layer 1 including, for example, an insulating layer to prevent the heat generated by the heating layer from dissipating or escaping, a heat reflective layer to focus and/or redirect heating generated by layer 1 towards the tube to provide improved transfer of heat, a protective layer to prevent against damage from outside forces and/or to prevent the heat generated for one tube from migrating to another adjacent tube.

[0049] Also, in the foregoing embodiments which use multiple tubes, the tubes are shown to be substantially parallel to one another. However, in other embodiments, the tubes may, for example, be independently selected and perpendicular or otherwise angled relative to one another to meet the needs of a particular application and/or inlet pipe/outlet pipe configuration.

[0050] In accordance with another embodiment, a heating system using one or more non-metallic tubes may be provided to heat a gelatin-type material. The heated gelatin (as well as the water or liquids heated by the other embodiments described herein) may be used for a variety of home, commercial, industrial, or medical uses. Alternatively, blood, chemicals, or other substances may be heated in other embodiments.

[0051] In accordance with one or more embodiments described herein, all the heating elements of the heating tubes are located outside of the tube, e.g., on or adjacent an external surface of each tube. None of the heating elements are included inside the tube. This is beneficial in that if heating elements were included inside the tubes, then those elements over time would corrode or otherwise require replacement, thereby limiting the useful life of the entire system or increasing the maintenance costs thereof. In an alternative embodiment, a heating element may be included inside of the tube to provide extra heating if necessary.

[0052] Any reference to “one embodiment,” “an embodiment,” “example embodiment,” etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of such phrases in various places in the specification are not necessarily all referring to
the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments. Moreover, the features of any one embodiment may be combined with the features of the other embodiments.

Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

What is claimed is:

1. A tankless heater comprising:
at least one non-metallic tube;
at least one heating layer on or adjacent the tube; and
a controller to generate a signal to be applied to the heating layer, wherein:
the signal is applied through electrodes coupled to the heating layer;
the heating layer generates heat in response to the signal, said heat transferred to a liquid flowing through or around the tube to heat the liquid to within a first temperature range, and
the heating layer is on or adjacent an external or internal surface of the non-metallic tube and no heating element is included on another surface of the non-metallic tube in contact with the liquid.

2. The tankless heater of claim 1, wherein the non-metallic tube is made of a material that includes at least one of quartz, glass, ceramic, polymer or a synthetic material.

3. The tankless heater of claim 1, wherein the heating layer includes a coating applied to the external or interior surface of the tube.

4. The tankless heater of claim 3, wherein the film is made of a conductive material.

5. The tankless heater of claim 4, wherein the film is made from conductive polyimides, conductive indium-tin-oxide (ITO), tin oxide, kapton, polymer inks or a combination thereof.

6. The tankless heater of claim 1, wherein the liquid is water, chemicals, blood, or gels.

7. The tankless heater of claim 1, wherein the controller adjusts the signal to change a temperature of the liquid based on control information generated from a control panel, buttons, sensors, or a combination thereof.

8. The tankless heater of claim 1, wherein the non-metallic tube has:
a first section including a first heating layer,
a second section including a second heating layer, and
a third section between the first and second section, wherein the second section is oriented in a direction different from at least one of the first or third sections.

9. The tankless heater of claim 8, wherein the second section does not include a heating layer.

10. The tankless heater of claim 8, wherein the first section and third section are substantially parallel and the second section is substantially perpendicular to the first section and third section.

11. The tankless heater of claim 1, further comprising:
a plurality of non-metallic tubes; and
a plurality of heating layers on or adjacent respective ones of the tubes,
wherein the controller independently selects different combinations of the non-metallic tubes based on signals applied to electrodes attached to respective ones of the non-metallic tubes.

12. The tankless heater of claim 11, wherein:
the heating layers on or adjacent the tubes are made of different materials, and
the tubes heat liquid to within different temperature ranges based on said different materials.

13. The tankless heater of claim 11, wherein:
the controller generates different signals for respective ones of the tubes, said different signals causing the tubes to heat liquid to within different temperature ranges.

14. The tankless heater of claim 11, wherein the controller selects one of the non-metallic tubes by sending a signal to said one tube and does not select another one of the tubes by not sending a signal to the tube.

15. The tankless heater of claim 11, wherein the plurality of non-metallic tubes are coupled to different inlet pipes.

16. The tankless heater of claim 15, wherein the plurality of non-metallic tubes are coupled to different outlet pipes to provide heated water to different destinations.

17. The tankless heater of claim 15, wherein the plurality of non-metallic tubes are coupled to a same outlet pipe.

18. The tankless heater of claim 15, wherein:
the plurality of non-metallic tubes are coupled to a same inlet pipe, and
a valve blocks a flow of liquid from the inlet pipe into a first tube when the controller selects a second tube for heating the liquid and does not select the first tube.

19. The tankless heater of claim 18, wherein the valve is controlled based on a signal from the controller.

20. A heater comprising:
at least one non-metallic tube;
at least one heating layer on or adjacent the tube; and
a controller to generate a signal to be applied to the heating layer, wherein:
the signal is applied through electrodes coupled to the heating layer;
the heating layer generates heat in response to the signal, said heat transferred to a gel in the tube to heat the gel to within a first temperature range, and
the heating layer is on or adjacent an external surface of the non-metallic tube and no heating element is included inside the non-metallic tube in contact with the gel.

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