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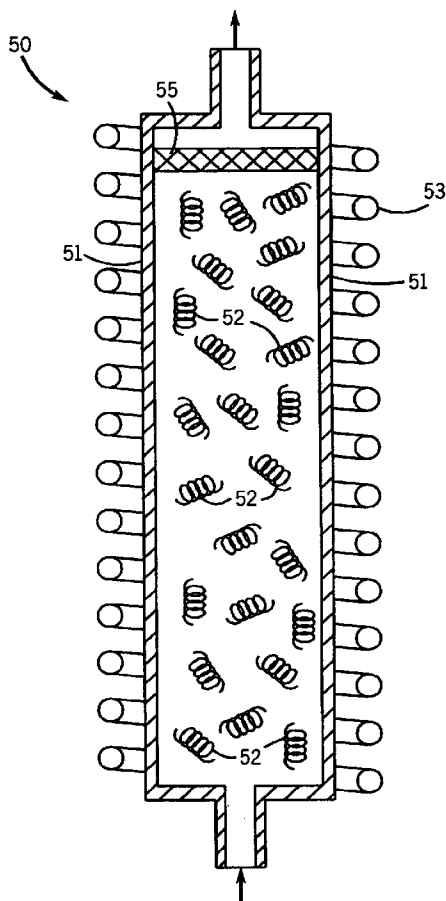
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(54) Title: IMPROVED INDUCTION HEATER



(57) Abstract: A heating system and method for heating fluids are provided. The heating system includes an enclosure with an inlet and outlet for fluid flow, an induction coil, thermal transmitters placed in the enclosure, and a power source for the induction coil. In one preferred embodiment, the fuel processing system includes a heating system that is at least partially filled with thermal transmitters which receive electromagnetic energy and generate heat within the heating system.



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TITLE: **IMPROVED INDUCTION HEATER**

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Cross Reference to Related Applications

[0001] This application claims the benefit of prior U.S. provisional application Serial No. 60/779247 filed on March 2, 2006 which is hereby incorporated by reference in its entirety.

Background

[0002] The present invention relates to a method and apparatus for heating fluids, particularly to a method and apparatus for heating fluids by way of induction heating.

[0003] Various types of fluid heating systems are employed in the domestic, commercial, and industrial heating of fluids. There are batch heated systems (i.e. fluid-tank heaters) and there are continuous heated systems (i.e. tankless fluid heaters). Both of these heating systems may be electrically heated and/or they may be gas-fired heated. However, these fluid heating systems can be inefficient, costly, and may not produce an effective residence time when heating the fluid.

[0004] Information relevant to attempts to address these problems can be found in U.S. Patent Nos. 6,175,689; 6,240,250; and 6,574,426. However, each one of these suffers from the fact that they all utilize electrical resistance as the heating means. Electrical resistance heating may be inefficient, costly, and may have a longer residence time compared to induction heating.

[0005] In view of the foregoing, it is apparent that a need still exists for an improved process for heating fluids.

Summary

[0006] The present invention is directed to a system and method for heating fluids in which induction heating is employed in an efficient manner to heat a fluid. The heating of fluids by way of induction heating can result in the effective and rapid heating of fluids which can be very advantageous for many fluid heating applications. The induction fluid heating system comprises:

(a) an enclosure having an inlet for receiving fluid and an outlet for fluid to exit

said enclosure;

(b) at least one induction coil at least partially surrounding said enclosure;

(c) at least one thermal transmitter placed within said enclosure wherein said at least one thermal transmitter receives electromagnetic energy from said at least one least one induction coil; and

(d) at least one power supply for supplying current to said at least one induction coil to heat said thermal transmitter wherein said heating system is used for heating fluids.

[0007] The features of this invention will be apparent from the following description.

Brief Description of the Drawings

[0008] Figure 1 is a schematic diagram of a preferred embodiment of the present invention.

Detailed Description of the Preferred Embodiments

[0009] As noted above, the present invention relates to a system and method for heating fluids in which induction heating is employed in an efficient manner to provide for an effective fluid heater.

[0010] “Fluid” is herein defined as one or more substances, as a liquid or gas, that is capable of flowing and that changes its shape at a steady rate when acted upon by a force tending to change its shape.

[0011] FIG. 1 illustrates a preferred embodiment of the present invention. In this preferred embodiment, inductively heated system 50 is used for heating fluids to a desired temperature. The desired temperature will be dependent on the type of operation in which the heating system is used. In addition, the design of the heating system can be modified to be used in almost any system in which fluids are heated.

[0012] The preferred embodiment of the heating system 50 depicted in FIG. 1 shows an enclosure 51, thermal transmitters 52, induction coil 53, and filter 55. The filter on this heating system is optional.

[0013] The fields of use of the design depicted in FIG. 1 can include any uses or operations wherein it is desired to heat a fluid stream to a desired temperature. For example, this technology can be utilized in such applications that include but

are not limited to, an on-demand hot water heater for personal or industrial use, a steam generator, a pre-heater, a heat exchanger, a scrubber or absorption unit, a reactor or any like device wherein it is desired to efficiently and quickly heat a fluid.

[0014] In this embodiment, enclosure 51 would be made of a substantially non-electrically conductive material. Preferably enclosure 51 is substantially made of a ceramic material or a composite thereof. Enclosure 51 is preferably at least partially surrounded by at least one induction coil 53 whereby induction heating is employed to heat a fluid to a desired temperature. The desired material used to build the enclosure will be substantially invisible to the electromagnetic energy generated by the induction coil 53 so that the electromagnetic energy may penetrate the enclosure to heat the thermal transmitters 52 discussed below in more detail.

[0015] In a preferred embodiment, enclosure 51 is filled with thermal transmitters 52 which include, but are not limited to, geometric structures substantially made of a material that has a high electrical resistivity, a high melting point, and a thermal conductivity. Thermal transmitters 52 receive electromagnetic energy from induction coil 53 which preferably surrounds each individual enclosure 51. Preferably, the induced electromagnetic energy is transmitted at an effective frequency that allows the energy to substantially penetrate enclosure 51 wherein the induction energy transmits substantially throughout the volume of thermal transmitters 52 so that the temperature of the thermal transmitters 52 may be as uniform as possible. As thermal transmitters 52 absorb the induced electromagnetic energy, thermal transmitters 52 are heated to an effective

temperature that is sufficient to heat the fluid. The operating temperatures of the thermal transmitters 52 will depend entirely on the desired temperature of the outlet temperature of the fluid. The heating properties of the thermal transmitters 52 are attributable to their specific electrical conductivity and resistivity characteristics.

[0016] Thermal transmitters 52 can be any suitable shape and size that will fit enclosure 51. It is preferred that the thermal transmitters 52 be of a cork screw shape about one inch in diameter and about three inches in length. It is also preferred that the thermal transmitters will be placed into the heating system 50 in random order. Other shapes of thermal transmitters 52 that may be utilized in the heating system may include but are not limited to: (a) rasching rings; (b) Pall rings; (c) Berl saddles; and (d) Intalox saddles, which are all conventional shapes for tower packings.

[0017] In another preferred embodiment, thermal transmitters 52 may be of a structured packing design wherein the structured packing will be comprised of an ordered geometry rather than a random packing configuration. This embodiment will also include a combination of structured and random packing configuration as it would be obvious to one skilled in the art to combine these two configurations.

[0018] Preferably, the thermal transmitters 52 will have an electrical resistance higher than about 100 $\mu\text{ohm-cm}$ at 1800°F and a thermal conductivity higher than about 195 BTU-in/ft²-hr-°F at 1800°F. The melting point of thermal transmitters 52 is preferably higher than the operating temperature of inductively heated system 50 and most preferably about 50°F higher than the operating

temperature of inductively heated system 50. In addition, the preferred melting point of thermal transmitters 52 is higher than about 1000°F, the more preferred is higher than about 1500°F, and the most preferred is higher than about 2000°F.

[0019] The preferred material for thermal transmitters 52 is silicone carbide or a composite thereof. In addition, it is preferred that the material for thermal transmitters 52 be comprised of a substantially non-magnetizable material. It should be understood, however, that any other materials that meet the above referenced melting point, thermal conductivity, and electrical resistivity can be used for constructing thermal transmitters 52. Thermal transmitters 52 may be of sufficient quantity and shape to disturb the flowing fluids sufficiently to knock out any entrained solid particles carried by the fluid stream thus acting as a particulate scrubber.

[0020] In another preferred embodiment, heating system 50 can be operated in parallel with at least one additional heating system. In addition, although not shown in any of the figures, heating system 50 can be operated with at least one additional heating system placed in series with heating system 50.

[0021] In a preferred embodiment, a filter 55 is installed at about the outlet of the enclosure 51. This filter is purely optional and the heating system can be operated without the filter 55. This filter 55 is preferably made of materials which are compatible with or the same as thermal transmitters 52 wherein filter 55 will have an electrical resistance higher than about 100 $\mu\text{ohm-cm}$ at 1800°F and a thermal conductivity higher than about 195 BTU-in/ft²-hr-°F at 1800°F. The melting point of filter 55 is preferably higher than the operating temperature of

inductively heated system 50 and most preferably about 50°F higher than the operating temperature of induction heating system. Filter 55 will also preferably be comprised of a honeycomb structure capable of screening out at least a portion of any particulates that may have passed through induction heating system. Filter 55 may also be comprised of any effective structure that is suitable for screening out such particulates.

[0022] In another preferred embodiment of the present invention, thermal transmitters 52 could be coated or impregnated with a catalyst to help drive various chemical reactions, including but not limited to an endothermic steam reforming reaction. In a reactive environment, it would be preferable to place a filter 55 in the heating system to capture any particulate. The inductively heated filter 55 could provide enough heat to cause the particulate to further react and exit the system. The filter would prevent particulates from entering a downstream process.

[0023] Insofar as the description above and the accompanying drawings disclose any additional subject matter that is not within the scope of the claims below, the inventions are not dedicated to the public and the right to file one or more applications to claim such additional inventions is reserved.

[0024] There are of course other alternate embodiments which are obvious from the foregoing descriptions of the invention, which are intended to be included within the scope of the invention, as defined by the following claims.

Claims:**What is claimed is:****1. A heating system comprising:**

an enclosure having an inlet for receiving fluid and an outlet for fluid to exit said enclosure;

at least one induction coil at least partially surrounding said enclosure;

at least one thermal transmitter placed within said enclosure wherein said at least one thermal transmitter receives electromagnetic energy from said at least one induction coil; and

at least one power supply for supplying current to said at least one induction coil to heat said at least one thermal transmitter wherein said heating system is used for heating fluids.

2. The heating system of claim 1 wherein said enclosure comprises a substantially non-electrically conductive material.

3. The heating system of claim 1 wherein said enclosure comprises a ceramic material or a composite thereof.

4. The heating system of claim 1 wherein said at least one thermal transmitter comprises a material having an electrical resistance higher than about 100 $\mu\text{ohm-cm}$ at 1800 °F.

5. The heating system of claim 4 wherein said thermal transmitter is comprised of a non-magnetizable material.

6. The heating system of claim 1 wherein said thermal transmitter comprises silicon carbide or a composite thereof.

7. The heating system of claim 1 further comprising a filter installed within said enclosure but of a location at about said outlet of said enclosure.

8. A heating system comprising:

an enclosure having an inlet for receiving fluid and an outlet for fluid to exit said enclosure wherein said enclosure is comprised of a substantially non-electrically conductive material;

at least one induction coil at least partially surrounding said enclosure;

at least one thermal transmitter placed within said enclosure wherein said at least one thermal transmitter receives electromagnetic energy from said at least one induction coil and wherein said thermal transmitter is comprised of a material

having an electrical resistance higher than about 100 $\mu\text{ohm-cm}$ at 1800°F wherein said

material is also non-magnetizable; and

at least one power supply for supplying current to said at least one induction coil to heat said at least one thermal transmitter;

wherein said heating system is used for heating fluid streams.

9. A heating system comprising:

an enclosure having an inlet for receiving fluid and an outlet for fluid to exit said enclosure wherein said enclosure is comprised of a substantially non-electrically

conductive material;

at least one induction coil at least partially surrounding said enclosure;

at least one thermal transmitter placed within said enclosure wherein said at least one thermal transmitter receives electromagnetic energy from said at least one induction coil and wherein said thermal transmitter is comprised of a material having an electrical resistance higher than about 100 $\mu\text{ohm-cm}$ at 1800°F wherein said material is also non-magnetizable and wherein said thermal transmitters are coated or impregnated with a catalyst; and

at least one power supply for supplying current to said at least one induction coil to heat said at least one thermal transmitter;

wherein said heating system is used for heating fluid streams.

10. A method of heating fluids comprising the steps of:

- a) charging fluid into an enclosure wherein said enclosure is made of substantially non-electrically conductive material;
- b) heating said fluid in said enclosure to a desired temperature;
- c) providing at least one thermal transmitter within said enclosure wherein said thermal transmitter is made of a substantially non-magnetizable material; and
- d) heating said enclosure with said at least one induction coil.

11. The method of claim 9 wherein said enclosure is made of a ceramic material or a composite thereof.

12. The method of claim 9 wherein said thermal transmitter is made of silicon carbide or a composite thereof.

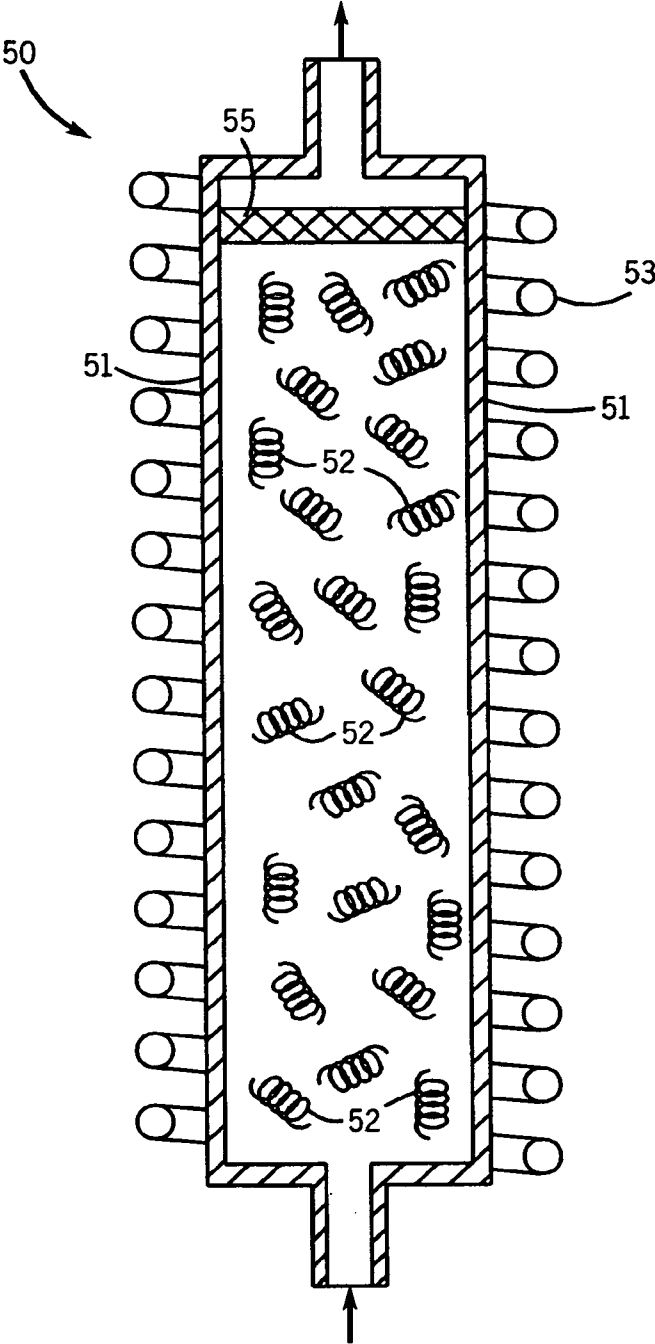


FIG. 1