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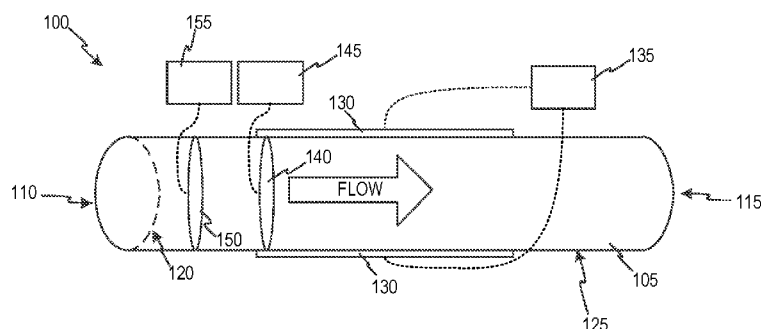


FIG. 1a

- (57) **Abstract:** Systems and articles of manufacture for minimizing corrosion in supercritical water gasification components are disclosed, as well as methods for their preparation and operation. The systems may include a nonconducting conduit that is configured to receive a fluid at a first end and transmit the fluid toward a second end thereof. The fluid may include a plurality of ions. The systems may further include a plurality of electrodes distributed about at least a portion of an outside surface of the nonconducting conduit and a power source electrically connected to the plurality of electrodes. The power source may be configured to apply an alternating current across the plurality of electrodes, and the alternating current may be effective to exert an electrophoretic force on the plurality of ions in the fluid.



CORROSION CONTROL FOR SUPERCRITICAL WATER GASIFICATION COMPONENTS

BACKGROUND

[0001] Supercritical water gasification of fuel, such as coal and the like, is of great interest in providing efficient and clean use of what may be otherwise dirty fuel. However, ions that are located within supercritical fluid and/or near-supercritical fluid are known for their corrosive properties, particularly in a run-up period to supercritical conditions. Thus, certain components that come in contact with the supercritical fluid have to be carefully selected to reduce or prevent corrosion.

[0002] Previous attempts to solve the problem have resulted in components that contain materials that may be potentially damaging to the fluid, components that are costly to implement, repair and/or maintain, components that do not successfully avoid becoming corroded, and/or the like.

SUMMARY

[0003] In an embodiment, a system for minimizing corrosion in supercritical water gasification components may include a nonconducting conduit that is configured to receive a fluid at a first end and transmit the fluid toward a second end thereof. The fluid may include a plurality of ions, and the nonconducting conduit may include an inside surface and an outside surface. The system may further include a plurality of electrodes distributed about at least a portion of the outside surface of the nonconducting conduit and a power source electrically connected to the plurality of electrodes. The power source may be configured to apply an alternating current across the plurality of electrodes, and the alternating current may be effective to exert an electrophoretic force on the plurality of ions in the fluid.

[0004] In an embodiment, a method of preparing a system for minimizing corrosion in supercritical water gasification components may include providing a nonconducting conduit configured to receive a fluid at a first end and transmit the fluid toward a second end thereof. The fluid may include a plurality of ions, and the nonconducting conduit may include an inside surface and an outside surface. The method may also include depositing a plurality of electrodes about at least a portion of the outside surface of the nonconducting conduit. The plurality of electrodes, when connected to a power source, may be configured to effect exertion of an electrophoretic force on the plurality of ions in the fluid.

[0005] In an embodiment, a method of minimizing corrosion in supercritical water gasification components may include providing a fluid into a nonconducting conduit configured to receive the fluid at a first end and transmit the fluid toward a second end thereof. The fluid may include a plurality of ions, and the nonconducting conduit may include an inside surface and an outside surface. The method may also include applying an alternating current through a plurality of electrodes disposed about at least a portion of the outside surface of the nonconducting conduit to generate and exert an electrophoretic force on the plurality of ions.

[0006] In an embodiment, a method of controlling ion concentration in a subcritical to supercritical process may include providing a subcritical fluid into a nonconducting conduit configured to receive the fluid at a first end and transmit the fluid toward a second end thereof. The fluid may include a plurality of ions, and the nonconducting conduit may include an inside surface and an outside surface. The method may also include causing the subcritical fluid to become supercritical and applying an alternating current through a plurality of electrodes disposed about at least a portion of the outside surface of the nonconducting conduit to generate and exert an electromotive force on

the plurality of ions to at least intermittently reduce a local concentration of ions at the inside surface.

[0007] In an embodiment, an article of manufacture that is resistant to corrosion may include a nonconducting supercritical water gasification conduit that is configured to receive a fluid at a first end and transmit the fluid toward a second end thereof. The fluid may include a plurality of ions, and the nonconducting supercritical water gasification conduit may include an inside surface and an outside surface. The article of manufacture may further include a plurality of electrodes distributed about at least a portion of the outside surface of the nonconducting supercritical water gasification conduit and a power source electrically connected to the plurality of electrodes. The power source may be configured to apply an alternating current across the plurality of electrodes, and the alternating current may be effective to exert an electrophoretic force on the plurality of ions in the fluid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1a depicts a detailed side view of a portion of a conduit according to an embodiment.

[0009] FIG. 1b depicts a cross-sectional view of a conduit according to an embodiment.

[0010] FIG. 2 depicts a detailed cross-sectional view of a conduit according to an embodiment.

[0011] FIG. 3 depicts a flow diagram for a method of preparing a system for minimizing corrosion in supercritical water gasification components according to an embodiment.

[0012] FIG. 4 depicts a flow diagram for a method of minimizing corrosion in supercritical water gasification components and for controlling ion concentration in a subcritical to supercritical process, according to various embodiments.

DETAILED DESCRIPTION

[0013] This disclosure is not limited to the particular systems, devices, and methods described, as these may vary. The terminology used in the description is for the purpose of describing the particular versions or embodiments only, and is not intended to limit the scope.

[0014] As used in this document, the singular forms “a,” “an,” and “the” include plural references unless the context clearly dictates otherwise. Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art. Nothing in this disclosure is to be construed as an admission that the embodiments described in this disclosure are not entitled to antedate such disclosure by virtue of prior invention. As used in this document, the term “comprising” means “including, but not limited to.”

[0015] The present disclosure relates generally to a system used for minimizing corrosion caused by ions dissolved in fluids under near-supercritical and/or supercritical conditions, as well as methods for operating and preparing the system. As a result of implementation of the systems and methods described herein, an effective and low cost way to transmit and store fluids containing ions under near-supercritical and/or supercritical conditions while reducing corrosion may result.

[0016] FIG. 1a depicts a side view of a system that may be used for minimizing corrosion in supercritical water gasification components according to an embodiment. Illustrative supercritical water gasification components may include, for example, a coal gasification system, a biomass gasification system, a waste gasification system, and/or the like. The system, generally designated **100**, may include a conduit **105** with a first end **110**, a second end **115**, an inside surface **120**, and an outside surface **125**. In some embodiments, a plurality of electrodes **130** may be attached to a portion of the outside surface **125** of the

conduit **105**. In some embodiments, the system **100** may also include at least a heater **140** and/or a pressurization apparatus **150**.

[0017] In various embodiments, the conduit **105** may generally be configured to receive objects at the first end **110** and transmit the objects toward the second end **115**. The objects are not limited in this disclosure and may include, for example, fluids, gases, solids, semisolid materials, supercritical fluids, near-supercritical fluids, light particles, sound waves, electrical waves, and/or the like. While the present disclosure relates generally to a fluid, those skilled in the art will recognize that any objects may be used without departing from the scope of this disclosure. In some embodiments, the fluid may include a supercritical fluid or a near-supercritical fluid among other elements. In other embodiments, the fluid may be a supercritical fluid. In other embodiments, the fluid may be a near-supercritical fluid. Illustrative supercritical fluids and/or near-supercritical fluids may include, for example and without limitation, an ionic slurry, water, coal, carbon dioxide, methane, ethane, propane, ethylene, propylene, methanol, ethanol, acetone, and the like, as well as combinations thereof. In some embodiments, an ion count in the supercritical fluid and/or near-supercritical fluid may increase by a factor of about 10^{11} to a factor of about 10^{14} in a run-up period from an original state to a supercritical and/or near-supercritical state. In some embodiments, the fluid may contain a plurality of ions dispersed therein. The ions may be particularly damaging to the inside surface **120** of the conduit **105**, causing the conduit to corrode. The systems and methods described herein may act to reduce or prevent corrosion of the conduit **105** caused by the plurality of ions.

[0018] In some embodiments, the conduit **105** may be a pipe, a channel, a tunnel, an electrical conduit, a duct, and/or the like. In some embodiments, the conduit **105** may be at least a portion of a supercritical water gasification reactor. In particular embodiments, the conduit **105** may be a feeder conduit that is operatively coupled to the supercritical water

gasification reactor. For example, the conduit **105** may provide supercritical fluid and/or near-supercritical fluid to the supercritical water gasification reactor, or may draw supercritical fluid and/or near-supercritical fluid from the supercritical water gasification reactor. In some embodiments, the conduit **105** may be a portion of, or operatively connected to, other elements of the supercritical water gasification reactor. Examples of other elements may include, but are not limited to, a reactor vessel, a pre-heater, a condenser, a pump, a heat exchanger, and/or the like.

[0019] In various embodiments, the conduit **105** may be made of a material that prevents the conduit from acting as a conductor for electricity, but does not shield electrophoretic forces, as will be described in greater detail herein. In some embodiments, the material used to construct the conduit **105** may withstand a temperature of at least about 600 K and a pressure of at least about 18 MPa. Specific examples of the temperature may include about 600 K, about 623 K, about 1000 K, about 1500 K, about 2000 K, and any value or range between any two of these values. Specific values of pressure may include about 18 MPa, about 20 MPa, about 22MPa, about 25 MPa, about 50 MPa, about 75 MPa, about 100 MPa, and any value or range between any two of these values. In some embodiments, the pressure may be from an area on the outside surface **125** of the conduit. In some embodiments, the pressure may be from an area on the inside surface **120** of the conduit. In some embodiments, the material may exhibit a tensile strength of at least about 25 MPa, a Young's modulus of at least about 15 GPa, and/or a flexural strength of at least about 25 MPa. Specific examples of the tensile strength may include about 25 MPa, about 50 MPa, about 75 MPa, about 100 MPa, about 200 MPa, and any value or range between any two of these values. Specific examples of the Young's modulus may include about 15 GPa, about 25 GPa, about 50 GPa, about 100 GPa, about 200 GPa, and any value or range between any two of these values. Specific examples of the flexural strength may include about 25 MPa,

about 50 MPa, about 100 MPa, about 200 MPa, and ranges between any two of these values. Examples of suitable materials may include, but are not limited to, ceramic matrix composites, stabilized alumina, stabilized zirconia, silicon carbide, a composite of silicon carbide fiber in a silicon carbide matrix, a composite of alumina fiber in an alumina matrix, and/or the like.

[0020] In various embodiments, the conduit **105** may have a cross-section of any size and shape. The shape may be regular or irregular, uniform or varying. In some embodiments, the conduit **105** may have a substantially circular cross-sectional shape. In particular embodiments, the conduit **105** may have a cross-sectional shape that is crescent shaped, elliptical shaped, oval shaped, semicircular shaped, round shaped, or the like. In some embodiments, the conduit **105** may have an internal radius of about 0.5 meters to about 100 meters. Specific examples of the internal radius may include about 0.5 meters, about 1 meter, about 5 meters, about 10 meters, about 25 meters, about 50 meters, about 75 meters, about 100 meters, and ranges between any two of these values.

[0021] In various embodiments, the system **100** may include a power source **135** that is electrically connected to the plurality of electrodes **130**. In some embodiments, the power source **135** may generally be configured to apply a current across the plurality of electrodes **130**. The current may be such that an electrophoretic force is effectively exerted, as will be described in greater detail herein. In particular embodiments, the current may be an alternating current (AC). An alternating current may be more suited for the present application than a direct current (DC), as will be described in greater detail herein. The power source **135** is not limited by this disclosure, and may generally be any power source that is capable of providing a current. Illustrative power sources may include, for example, a battery with an AC/DC converter, a capacitor, a solar cell, a fuel cell, a generator, and/or the like. In some embodiments, the power source **135** may be configured to provide a voltage of

about 1 V to about 100 kV across the plurality of electrodes **130**. Specific examples of the voltage provided by the power source **135** may include about 1 V, about 50 V, about 100 V, about 500 V, about 1 kV, about 10 kV, about 25 kV, about 50 kV, about 100 kV, and ranges between any two of these values. In some embodiments, the power source **135** may be configured to provide an electric power of at least about 9.5 kilowatts. In some embodiments, the power source **135** may be configured to provide an electric power of about 10 kilowatts to about 100 megawatts. Specific examples of the electric power provided by the power source **135** across the plurality of electrodes **130** may include about 9.5 kilowatts, about 10 kilowatts, about 50 kilowatts, about 100 kilowatts, about 500 kilowatts, about 1 megawatt, about 10 megawatts, about 25 megawatts, about 50 megawatts, about 100 megawatts, and ranges between any two of these values. In some embodiments, the power source **135** may be configured to apply the alternating current across the plurality of electrodes **130** at a frequency of about 10 Hz to about 100 kHz. In other embodiments, the power source **135** may be configured to apply the alternating current across the plurality of electrodes **130** at a frequency of about 100 Hz to about 1 kHz. Specific examples of the frequency of the alternating current provided by the power source **135** across the plurality of electrodes **130** may include about 10 Hz, about 50 Hz, about 100 Hz, about 500 Hz, about 1 kHz, about 10 kHz, about 50 kHz, about 100 kHz, and ranges between any two of these values.

[0022] In some embodiments, the plurality of electrodes **130** may be cylindrical. In some embodiments, the plurality of electrodes **130** may be hyperbolic. Other electrode shapes not specifically enumerated herein are also envisioned. For example, as depicted in FIG. 1b, the system **100** may have 4 hyperbolic electrodes **130**. In some embodiments, the plurality of electrodes **130** may be made from any composition capable of conducting

electricity, including, but not limited to, metals, metal alloys, non-metallic conductors, polymers, carbon-based compounds, and/or the like.

[0023] In various embodiments, the heater **140** may be coupled to the conduit **105**. In particular embodiments, the heater **140** may be thermally coupled to the conduit **105**. In some embodiments, the heater **140** may be configured to heat the fluid that is received and transmitted through the conduit **105**. The heater **140** may be any apparatus capable of raising the temperature of the fluid that is received and transmitted through the conduit **105**. Illustrative heaters may include, for example, electric heaters, dielectric heaters, ceramic heaters, superheaters, feed-water heaters, heat pumps, boilers, induction heaters, and/or the like. In some embodiments, the heater **140** may generally be made of one or more thermally conductive materials. Illustrative thermally conductive materials may include, for example, metals, metal alloys, metal oxides, polymers, carbon-based compounds, ceramic-based compounds, and/or the like.

[0024] In various embodiments, the heater **140** may be controlled by a first controller **145**. In some embodiments, the first controller **145** may contain at least a processor and a memory. The memory may store programming instructions that direct the processor to carry out various tasks as described herein. In some embodiments, the first controller **145** may be a standalone unit. In other embodiments, the first controller **145** may be integrated as a portion of another device, such as a computer, the heater **140**, the pressurization apparatus **150**, or the like. In some embodiments, the first controller **145** may provide signals to the heater **140** to cause the heater to heat the objects that are received and transmitted through the conduit **105**. In particular embodiments, the first controller **145** may provide signals to the heater **140** to heat a fluid above a critical temperature. The critical temperature may depend upon the composition and pressure of the fluid, among other things, and thus is not limited by this disclosure. However, some illustrative critical temperatures

may include about 33.2 K, about 126.3 K, about 154.6 K, about 190.9 K, about 304.19 K, about 309.6 K, about 584 K, about 623 K, about 647 K, about 927 K, and ranges between any two of these values. The first controller **145** may provide the signals via any method of transmission now known or later developed, including, but not limited to, wired transmission, wireless transmission, and/or the like. The heater **140** and/or the first controller **145** may incorporate one or more sensors, such as, for example, temperature sensors and/or the like to determine the temperature of the objects that are received and transmitted through the conduit **105**. By receiving one or more signals from the one or more sensors, the first controller **145** can determine whether the objects are in need of heating, calculate the settings that are necessary to heat the objects to an appropriate temperature, and transmit commands to the heater **140**. The commands may include, for example, a temperature at which the heater **140** can operate, an amount of time the heater can be turned on, shut off commands, and/or the like.

[0025] In various embodiments, the pressurization apparatus **150** may be coupled to the conduit **105**. In particular embodiments, the pressurization apparatus **150** may be in fluid communication with the conduit **105**. In some embodiments, the pressurization apparatus **150** may be configured to pressurize objects that are received and transmitted through the conduit **105**. The pressurization apparatus **150** may be any apparatus capable of raising the pressure of the objects that are received and transmitted through the conduit **105**. An illustrative pressurization apparatus may include, for example, a hermetically sealed compressor, a centrifugal compressor, a mixed-flow compressor, an axial flow compressor, a reciprocating compressor, a rotary compressor, a scroll compressor, a diaphragm compressor, a pump, and/or the like.

[0026] In various embodiments, the pressurization apparatus **150** may be controlled by a second controller **155**. In alternate embodiments, the pressurization apparatus

150 may be controlled by the first controller **145** where the first controller is configured to control both the pressurization apparatus and the heater **140** concurrently. In some embodiments, the second controller **155** may contain at least a processor and a memory. The memory may store programming instructions that direct the processor to carry out various tasks as described herein. In some embodiments, the second controller **155** may be a standalone unit. In other embodiments, the second controller **155** may be integrated as a portion of another device, such as a computer, the heater **140**, the pressurization apparatus **150**, or the like. In some embodiments, the second controller **155** may provide signals to the pressurization apparatus **150** to cause the pressurization apparatus to pressurize the objects that are received and transmitted through the conduit **105**. In particular embodiments, the second controller **155** may provide signals to the pressurization apparatus **150** to pressurize a fluid above a critical pressure. The critical pressure may depend upon the composition and temperature of the fluid, among other things, and thus is not limited by this disclosure. However, some illustrative critical pressures may include about 1.3 MPa, about 3.39 MPa, about 4.6 MPa, about 4.64 MPa, about 5.05 MPa, about 7.24 MPa, about 7.38 MPa, about 10.3 MPa, about 22.06 MPa, about 25 MPa, about 30 MPa, about 40 MPa, about 44 MPa, about 50 MPa, and ranges between any two of these values. The second controller **155** may provide the signals via any method of transmission now known or later developed, including, but not limited to, wired transmission, wireless transmission, and/or the like. The pressurization apparatus **150** and/or the second controller **155** may incorporate one or more sensors, such as, for example, pressure sensors and/or the like to determine the pressure of the objects that are received and transmitted through the conduit **105**. By receiving one or more signals from the one or more sensors, the second controller **155** can determine whether the objects are in need of pressurization, calculate the settings that are necessary to pressurize the objects to an appropriate pressure, and transmit commands to the pressurization apparatus

150. The commands may include, for example, a pressure at which the pressurization apparatus **150** should operate, an amount of time the pressurization apparatus must be turned on, shut off commands, and/or the like.

[0027] FIG. 2 depicts a detailed cross-sectional view of a conduit **205** according to an embodiment. In some embodiments, a plurality of electrodes **220** may be affixed to the outside surface **210** of the conduit **205**. When a current is applied through the plurality of electrodes, an electrophoretic force **225** may be generated. Specifically, the electrophoretic force **225** may act on the plurality of ions in the fluid that flows through the conduit **205**, effectively repelling the ions inward from the walls of the conduit **205**. In particular embodiments, the electrophoretic force **225** may be substantially directed in a radially inward direction with respect to a radius of the conduit **205**. Thus, the electrophoretic force **225** may flow from the electrodes **220** towards the center **230** of the conduit **205**, thereby forcing the plurality of ions in the fluid towards the center of the conduit. In some embodiments, the alternating current, when applied through the plurality of electrodes **220**, may cause the electrophoretic force **225** to reduce or prevent the ions from moving in a direction towards the inside surface **215** of the conduit **205**, thereby reducing or preventing at least a portion of the ions from coming into contact with at least a portion of the inside surface, while still permitting the ions to flow from the first end **110** (FIG. 1a) of the conduit towards the second end **115** (FIG. 1a).

[0028] In various embodiments, the reduced number of ions at or near at least a portion of the inside surface **215** of the conduit **205** may be relative to that of an untreated conduit that does not contain a plurality of electrodes and/or a current applied thereto, whereby a larger number of ions may be at or near at least a portion of the inside surface of the conduit. In some embodiments, the reduced number relative to an untreated conduit may be about 1/2 the number to about 1/500 the number. Specific examples of a reduced number

relative to an untreated conduit may be 1/2, 1/3, 1/4, 1/8, 1/10, 1/16, 1/24, 1/48, 1/96, 1/100, 1/200, 1/500, or any value or range between any two of these values.

[0029] In various embodiments, the electrophoretic force **225** may create a concentration gradient of ions within the conduit **205**. In some embodiments, the electrophoretic force **225** may intermittently create a concentration gradient of ions within the conduit **205**. In other embodiments, the electrophoretic force **225** may continuously create a concentration gradient of ions within the conduit **205**. In some embodiments, the electrophoretic force **225** may be strongest and most likely to repel ions near the inside surface **215** of the conduit **205**. In some embodiments, the electrophoretic force **225** may be weakest and least likely to repel ions near the center **230** of the conduit **205**. Thus, the concentration gradient of ions within the conduit **205** may range from few or no ions at or substantially near the inside surface **215** to a large population of ions at or substantially near the center **230**. As a result, the number of ions that come into contact with the inside surface **215** may be substantially reduced, which may reduce or prevent corrosion of the conduit **205** caused by the ions. In some embodiments, the concentration gradient of ions may increase at least 10-fold along the radially inward direction from the inside surface **215** of the conduit **205**. Thus, the concentration of ions at or near the center **230** may be at least 10 times the concentration of ions at or near the inside surface **215**. In other embodiments, the concentration gradient of ions may increase at least 100-fold along the radially inward direction from the inside surface **215** of the conduit **205**. Thus, the concentration of ions at or near the center **230** may be at least 100 times the concentration of ions at or near the inside surface **215**. In other embodiments, the concentration gradient of the ions may increase at least 1000-fold along the radially inward direction from the inside surface **215** of the conduit **205**. Thus, the concentration of ions at or near the center **230** may be at least 1000 times the concentration of ions at or near the inside surface **215**.

[0030] FIG. 3 depicts a flow diagram for a method of preparing a system for minimizing corrosion in supercritical water gasification components according to an embodiment. The processes described herein are merely exemplary; additional, fewer, and/or alternative processes may be used without departing from the scope of this disclosure. In some embodiments, a conduit may be provided **305**. As previously described herein, the conduit is not limited in size, shape, or dimension. In some embodiments, the conduit may have an inside surface and an outside surface. In some embodiments, the conduit may generally be configured to receive a fluid having a plurality of ions dispersed therein. In some embodiments, the conduit may be further configured to receive the fluid at a first end and transmit the fluid to a second end thereof. This may be completed by any method now known or later developed for transmitting a fluid, and is not limited by this disclosure. Furthermore, any number of components may be used to effect transmission of the fluid, such as, for example, pumps and/or the like. These additional components may be attached to the conduit at any location.

[0031] In various embodiments, a plurality of electrodes may be positioned **310** on the conduit. In some embodiments, the electrodes may be positioned **310** about at least a portion of the outside surface of the conduit. Positioning **310** is not limited by this disclosure, and may include, for example, depositing, affixing, adhering, placing, and/or the like. In some embodiments, the electrodes may include a plurality of hyperbolic electrodes, as described in greater detail herein. In some embodiments, the electrodes may be connected to a power source that can provide an electrical current across the electrodes. In some embodiments, the plurality of electrodes may be positioned to exert an electrophoretic force on a plurality of ions in the fluid when the electrical current is provided across the electrodes. In particular embodiments, the electrophoretic force may be directed in a radially inward direction, as described in greater detail herein. In some embodiments, the radial

electrophoretic force may reduce or prevent the ions from coming into contact with at least a portion of the inside surface, as described in greater detail herein. In some embodiments, the radial electrophoretic force may allow movement of the plurality of ions with the fluid through the conduit from the first end to the second end, as described herein.

[0032] In various embodiments, a heater may be attached **315** to the conduit. In some embodiments, the heater may be thermally coupled to the conduit. In some embodiments, the heater may be configured to heat the fluid in the conduit. In particular embodiments, the heater may heat the fluid to a critical temperature. In some embodiments, a controller may be attached **320** to the heater. In particular embodiments, the controller may be configured to cause the heater to heat the fluid in the conduit, as described in greater detail herein.

[0033] In various embodiments, a pressurization apparatus may be attached **325** to the conduit. In some embodiments, the pressurization apparatus may be in fluid communication with the conduit. In some embodiments, the pressurization apparatus may be configured to pressurize the fluid in the conduit. In particular embodiments, the pressurization may be configured to pressurize the fluid above a critical pressure. In some embodiments, a controller may be attached **330** to the pressurization apparatus. In particular embodiments, the controller may be configured to cause the pressurization apparatus to pressurize the fluid in the conduit, as described in greater detail herein.

[0034] FIG. 4 depicts a flow diagram for a method of minimizing corrosion in supercritical water gasification components and for controlling ion concentration in a subcritical to supercritical process, according to various embodiments. The processes described herein are merely exemplary; additional, fewer, or alternative processes may be used without departing from the scope of this disclosure.

[0035] In various embodiments, a fluid may be provided **405** into the conduit. In some embodiments, the fluid may be provided **405** into a first end of the conduit. In some embodiments, the conduit may be configured to direct the fluid to a second end thereof, as described in greater detail herein. In some embodiments, the fluid may contain a plurality of ions. In particular embodiments, the ions may be corrosive to the conduit if they come into contact with an inside surface of the conduit.

[0036] In various optional embodiments, the fluid may be heated **410**. In some embodiments, the fluid may be heated **410** with a heater, as described in greater detail herein. In particular embodiments, the fluid may be heated **410** with the heater to a temperature near or above a critical point. In some embodiments, the critical point may be about 623 K.

[0037] In various optional embodiments, the fluid may be pressurized **415**. In some embodiments, the fluid may be pressurized **415** with a pressurization apparatus, as described in greater detail herein. In particular embodiments, the fluid may be pressurized **415** with the pressurization apparatus to a pressure near or above a critical point. In some embodiments, the critical point may be about 22 MPa.

[0038] In various embodiments, a plurality of electrodes may be positioned **420** on the conduit, and a current may be applied **425** across the electrodes. In some embodiments, the electrodes may be positioned **420** in a manner that, when the electrical current is applied **425** across the electrodes, an electrophoretic force may result. In some embodiments, the electrophoretic force may be substantially directed upon a plurality of ions in the fluid in a radially inward direction with respect to a radius of the conduit, as described in greater detail herein. In some embodiments, the electrophoretic force upon the ions may result in at least one corrosion protection area on the inside of the conduit where at least a portion of the ions may not come in contact with at least a portion the inside surface of the conduit within the corrosion protection area, as described in greater detail herein. In some

embodiments, the electrophoretic force upon the ions may result in at least one corrosion protection area on the inside of the conduit where at least a portion of the ions at or near the inside surface is reduced or diminished. In particular embodiments, the at least a portion of the ions at or near the inside surface may be reduced or diminished relative to the number of ions that are at or near the surface of the inside surface in a conduit that does not contain electrodes and/or has a current applied across the electrodes. The at least a portion of ions may be reduced by, for example, 1/2, 1/3, 1/4, 1/5, 1/6, 1/8, 1/10, 1/16, 1/32, 1/50, 1/64, 1/96, 1/100, 1/200, 1/500 or ranges or values between any two of these values. In some embodiments, however, the electrophoretic force may be such that the ions are still permitted to move with the fluid as the fluid is directed **430** through the conduit from the first end to the second end, as described in greater detail herein.

EXAMPLES

Example 1: Coal Gasification System

[0039] A coal gasification system that converts coal into carbon monoxide, hydrogen and carbon dioxide will include at least a pipe that transmits a supercritical or a near-supercritical ionic slurry from a heating apparatus to a reactor vessel. The ionic slurry, as it passes through the pipe, will be heated to a temperature of at least 623 K and pressurized to a pressure of at least 22 MPa. The pipe will be made of ceramic matrix composites and will be capable of withstanding pressures of up to 100 MPa and temperatures of up to 1000 K. However, the pipe will be susceptible to corrosion from the ionic slurry. To combat this issue, the pipe will have 4 hyperbolic metal electrodes. A power source will provide an AC current across the electrodes; the power source will provide a voltage of about 10 kV, an electric power of about 9.5 kW, and a frequency of about 500 Hz. As a result of this power across the electrodes, an electrophoretic force that is directed radially inward on the pipe will result. The electrophoretic force will be the equivalent of a force necessary to repel the ions

and create an ion concentration gradient that results in no ion concentration near the edges of the pipe to a heavy ion concentration near the center of the pipe. As a result, the ionic slurry will pass through the pipe from the heating apparatus to the reactor vessel with a reduced number of ions in the slurry coming into contact with the edges of the pipe than the number of ions that would normally come into contact with the edges of the pipe without the application of the AC current.

Example 2: Modifying Existing Pipe

[0040] A pipe that is used to transmit supercritical fluid in a gasification apparatus is susceptible to corrosion from the ions in the supercritical fluid. Previous attempts to address this issue resulted in shutting down the gasification apparatus, removing the corroded pipe, and replacing it with pipe materials that are less susceptible to corrosion. However, such attempts provided only a temporary solution, as the pipe eventually became corroded again. In addition, a significant cost was incurred due to the downtime of the gasification apparatus to replace the pipe. To better address this problem, 4 hyperbolic metal electrodes will be placed on the outside of the pipe, which is 2 meters in diameter. The electrodes will be connected to an AC power source that provides a voltage of 1 kV, an electrical power of 50 kW, and a frequency of 50 Hz across the electrodes. The AC power is sufficient to generate an electrophoretic force upon the ions in the supercritical fluid at a strength that drives the ions at least 0.5 meters from the surface of the pipe, thus reducing or preventing most of the ions from coming into contact with the walls of the pipe. Installing the system requires no downtime, as the electrodes are placed on the outside of the pipe and can be installed without interrupting the flow of supercritical fluid within the pipe. Furthermore, the application of the electrodes eliminates the need to obtain expensive pipe materials to replace sections of the pipe. As a result, the gasification apparatus is able to function more efficiently with less downtime, which decreases costs and increases profits.

[0041] In the above detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be used, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0042] The present disclosure is not to be limited in terms of the particular embodiments described in this application, which are intended as illustrations of various aspects. Many modifications and variations can be made without departing from its spirit and scope, as will be apparent to those skilled in the art. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that this disclosure is not limited to particular methods, reagents, compounds, compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting.

[0043] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from

the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0044] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (for example, bodies of the appended claims) are generally intended as “open” terms (for example, the term “including” should be interpreted as “including but not limited to,” the term “having” should be interpreted as “having at least,” the term “includes” should be interpreted as “includes but is not limited to,” et cetera). While various compositions, methods, and devices are described in terms of “comprising” various components or steps (interpreted as meaning “including, but not limited to”), the compositions, methods, and devices can also “consist essentially of” or “consist of” the various components and steps, and such terminology should be interpreted as defining essentially closed-member groups. It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases “at least one” and “one or more” to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles “a” or “an” limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases “one or more” or “at least one” and indefinite articles such as “a” or “an” (for example, “a” and/or “an” should be interpreted to mean “at least one” or “one or more”); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (for example), the bare recitation of

"two recitations," without other modifiers, means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, et cetera" is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (for example, "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, et cetera). In those instances where a convention analogous to "at least one of A, B, or C, et cetera" is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (for example, "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, et cetera). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0045] In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[0046] As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, et cetera. As a non-

limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, et cetera. As will also be understood by one skilled in the art all language such as “up to,” “at least,” and the like include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

[0047] Various of the above-disclosed and other features and functions, or alternatives thereof, may be combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art, each of which is also intended to be encompassed by the disclosed embodiments.

CLAIMS*What Is Claimed Is:*

1. A system for minimizing corrosion in supercritical water gasification components, the system comprising:

a nonconducting conduit that is configured to receive a fluid comprising a plurality of ions at a first end and transmit the fluid toward a second end thereof, the nonconducting conduit comprising an inside surface and an outside surface;

a plurality of electrodes distributed about at least a portion of the outside surface of the nonconducting conduit; and

a power source electrically connected to the plurality of electrodes, wherein the power source is configured to apply an alternating current across the plurality of electrodes, wherein the alternating current is effective to exert an electrophoretic force on the plurality of ions in the fluid.

2. The system of claim 1, wherein the electrophoretic force is substantially directed in a radially inward direction with respect to a radius of the nonconducting conduit.

3. The system of claim 1, wherein the nonconducting conduit is further configured to receive the fluid and transmit the fluid at a temperature of at least about 600 K.

4. The system of claim 1, wherein the nonconducting conduit is further configured to receive the fluid and transmit the fluid at a pressure of at least about 18 MPa.

5. The system of claim 1, wherein the electrophoretic force at least intermittently creates a concentration gradient of the plurality of ions in at least a portion of the fluid, wherein the concentration gradient increases along a radially inward direction from the inside surface of the nonconducting conduit.

6. The system of claim 5, wherein the concentration gradient increases at least 10 fold along the radially inward direction from the inside surface of the nonconducting conduit.

7. The system of claim 5, wherein the concentration gradient increases at least 100 fold along the radially inward direction from the inside surface of the nonconducting conduit.

8. The system of claim 5, wherein the concentration gradient increases at least 1000 fold along the radially inward direction from the inside surface of the nonconducting conduit.

9. The system of claim 1, further comprising:

a heater thermally coupled to the nonconducting conduit, wherein the heater is configured to heat the fluid in the nonconducting conduit; and

a controller operatively coupled to the heater,

wherein the controller is configured to cause the heater to heat the fluid in the nonconducting conduit such that the fluid is heated above a critical temperature.

10. The system of claim 9, wherein the fluid comprises water and wherein the critical temperature is at least about 623 K.

11. The system of claim 1, further comprising:

a pressurization apparatus in fluid communication with the nonconducting conduit, wherein the pressurization apparatus is configured to pressurize the fluid in the nonconducting conduit; and

a controller operatively coupled to the pressurization apparatus,

wherein the controller is configured to cause the pressurization apparatus to pressurize the fluid in the nonconducting conduit such that the fluid is pressurized above a critical pressure.

12. The system of claim 11, wherein the fluid comprises water and wherein the critical pressure is at least about 22 MPa.

13. The system of claim 1, wherein the alternating current, when applied across the plurality of electrodes, causes the radial electrophoretic force to reduce or prevent at least a portion of a plurality of ions in the fluid from coming into contact with the at least a portion of the inside surface, while permitting movement of the plurality of ions with the fluid through the nonconducting conduit from the first end toward the second end.

14. The system of claim 1, wherein the nonconducting conduit is comprised of ceramic matrix composites, stabilized alumina, stabilized zirconia, silicon carbide, a composite of silicon carbide fiber in a silicon carbide matrix, a composite of alumina fiber in an alumina matrix, or any combination thereof.

15. The system of claim 1, wherein the nonconducting conduit comprises one or more of a tensile strength of at least about 25 MPa, a Young's modulus of at least about 15 GPa, and a flexural strength of at least about 25 MPa.

16. The system of claim 1, wherein the nonconducting conduit comprises a cross-sectional shape that is circular, crescent, elliptical, oval, or semicircular.

17. The system of claim 1, wherein the nonconducting conduit has an internal radius of about 0.5 meters to about 100 meters.

18. The system of claim 1, wherein the nonconducting conduit is a pipe.

19. The system of claim 1, wherein the nonconducting conduit is a feeder conduit operatively coupled to a supercritical water gasification reactor.

20. The system of claim 19, wherein the supercritical water gasification reactor comprises one or more of a reactor vessel, a pre-heater, a condenser, a pump, and a heat exchanger.

21. The system of claim 1, wherein the plurality of electrodes comprises a plurality of hyperbolic electrodes.

22. The system of claim 1, wherein the fluid comprises a supercritical fluid or a near-supercritical fluid.

23. The system of claim 22, wherein the supercritical fluid comprises one or more of an ionic slurry, water, coal, carbon dioxide, methane, ethane, propane, ethylene, propylene, methanol, ethanol, and acetone.

24. The system of claim 1, wherein the fluid is a supercritical fluid or a near-supercritical fluid.

25. The system of claim 24, wherein the supercritical fluid comprises one or more of an ionic slurry, water, coal, carbon dioxide, methane, ethane, propane, ethylene, propylene, methanol, ethanol, and acetone.

26. The system of claim 1, wherein the power source is further configured to provide a voltage of about 1 V to about 100 kV across the plurality of electrodes.

27. The system of claim 1, wherein the power source is further configured to provide a voltage of about 10 kV across the plurality of electrodes.

28. The system of claim 1, wherein the power source is further configured to provide an electric power of about 10 kilowatts to about 100 megawatts.

29. The system of claim 1, wherein the power source is further configured to provide an electric power of at least 9.5 kilowatts.

30. The system of claim 1, wherein the power source is further configured to apply the alternating current across the plurality of electrodes at a frequency of about 10 Hz to about 100 kHz.

31. The system of claim 1, wherein the power source is further configured to apply the alternating current across the plurality of electrodes at a frequency of about 100 Hz to about 1 kHz.

32. The system of claim 1, wherein the supercritical water gasification components are configured as one of a coal gasification system, a biomass gasification system, and a waste gasification system.

33. A method of preparing a system for minimizing corrosion in supercritical water gasification components, the method comprising:

providing a nonconducting conduit configured to receive a fluid comprising a plurality of ions at a first end and transmit the fluid toward a second end thereof, wherein the nonconducting conduit comprises an inside surface and an outside surface; and

depositing a plurality of electrodes about at least a portion of the outside surface of the nonconducting conduit, wherein the plurality of electrodes, when connected to a power source, are configured to effect exertion of an electrophoretic force on the plurality of ions in the fluid.

34. The method of claim 33, wherein the electrophoretic force is substantially directed in a radially inward direction with respect to a radius of the nonconducting conduit.

35. The method of claim 33, further comprising:

thermally coupling a heater to the nonconducting conduit, wherein the heater is configured to heat the fluid in the nonconducting conduit; and

operatively coupling a controller to the heater, wherein the controller is configured to cause the heater to heat the fluid in the nonconducting conduit such that the fluid is heated above a critical temperature.

36. The method of claim 33, further comprising:

coupling a pressurization apparatus to the nonconducting conduit, wherein the pressurization apparatus is configured to pressurize the fluid in the nonconducting conduit; and

operatively coupling a controller to the pressurization apparatus, wherein the controller is configured to cause the pressurization apparatus to pressurize the fluid in the nonconducting conduit such that the fluid is pressurized above a critical pressure.

37. The method of claim 33, wherein an alternating current, when applied across the plurality of electrodes, causes the radial electrophoretic force to reduce or prevent at least a portion of the ions in the fluid from coming into contact with the at least a portion of the inside surface, while permitting movement of the plurality of ions with the fluid through the nonconducting conduit from the first end toward the second end.

38. The method of claim 33, wherein the nonconducting conduit is comprised of ceramic matrix composites, stabilized alumina, stabilized zirconia, silicon carbide, a

composite of silicon carbide fiber in a silicon carbide matrix, a composite of alumina fiber in an alumina matrix, or any combination thereof.

39. The method of claim 33, wherein the nonconducting conduit comprises one or more of a tensile strength of at least about 25 MPa, a Young's modulus of at least about 15 GPa, and a flexural strength of at least about 25 MPa.

40. The method of claim 33, wherein the nonconducting conduit comprises a cross-sectional shape that is circular, crescent, elliptical, oval, or semicircular.

41. The method of claim 33, wherein the nonconducting conduit has an internal radius of about 0.5 meters to about 100 meters.

42. The method of claim 33, wherein providing the nonconducting conduit comprises providing a pipe.

43. The method of claim 33, wherein providing the nonconducting conduit comprises providing a feeder conduit operatively coupled to a supercritical water gasification reactor.

44. The method of claim 33, further comprising providing one or more of a reactor vessel, a pre-heater, a condenser, a pump, and a heat exchanger.

45. The method of claim 33, wherein depositing the plurality of electrodes comprises depositing a plurality of hyperbolic electrodes.

46. The method of claim 33, wherein the supercritical water gasification components are configured as one of a coal gasification system, a biomass gasification system, and a waste gasification system.

47. A method of minimizing corrosion in supercritical water gasification components, the method comprising:

providing a fluid comprising a plurality of ions into a nonconducting conduit configured to receive the fluid at a first end and transmit the fluid toward a second end thereof, wherein the nonconducting conduit comprises an inside surface and an outside surface; and

applying an alternating current through a plurality of electrodes disposed about at least a portion of the outside surface of the nonconducting conduit to generate and exert an electrophoretic force on the plurality of ions.

48. The method of claim 47, further comprising:

positioning the plurality of electrodes in a manner that causes the electrophoretic force to be substantially directed in a radially inward direction with respect to a radius of the nonconducting conduit.

49. The method of claim 47, further comprising:

positioning the plurality of electrodes in a manner that causes the electrophoretic force to at least intermittently create a concentration gradient of the plurality of ions in at least a portion of the fluid, wherein the concentration gradient increases along a radially inward direction from the inside surface of the nonconducting conduit.

50. The method of claim 49, wherein the concentration gradient increases at least 10 fold along the radially inward direction from the inside surface of the nonconducting conduit.

51. The method of claim 49, wherein the concentration gradient increases at least 100 fold along the radially inward direction from the inside surface of the nonconducting conduit.

52. The method of claim 49, wherein the concentration gradient increases at least 1000 fold along the radially inward direction from the inside surface of the nonconducting conduit.

53. The method of claim 47, further comprising forming at least one corrosion protection area from the plurality of radial electrophoretic forces.

54. The method of claim 47, further comprising:

heating the fluid with a heater operatively coupled to a controller that is configured to cause the heater to heat the fluid to a temperature above a critical point.

55. The method of claim 54, wherein the fluid comprises water and wherein the critical point is at least about 623 K.

56. The method of claim 47, further comprising:

pressurizing the fluid with a pressurization apparatus operatively coupled to a controller that is configured to cause the pressurization apparatus to pressurize the fluid to a pressure above a critical point.

57. The method of claim 56, wherein the fluid comprises water and wherein the critical point is at least about 22 MPa.

58. The method of claim 47, wherein applying the alternating current across the plurality of electrodes causes the electrophoretic force to reduce or prevent at least a portion

of the plurality of ions in the fluid from coming into contact with at least a portion of the inside surface, while permitting movement of the plurality of ions through the nonconducting conduit with the fluid from the first end toward the second end.

59. The method of claim 47, wherein applying the alternating current comprises applying a voltage of about 1 V to about 100 kV across the plurality of electrodes.

60. The method of claim 47, wherein applying the alternating current comprises applying a voltage of about 10 kV across the plurality of electrodes.

61. The method of claim 47, wherein applying the alternating current comprises applying an electric power of about 10 kilowatts to about 100 megawatts.

62. The method of claim 47, wherein applying the alternating current comprises applying an electric power of at least 9.5 kilowatts.

63. The method of claim 47, wherein applying the alternating current comprises applying the alternating current at a frequency of about 10 Hz to about 100 kHz.

64. The method of claim 47, wherein applying the alternating current comprises applying the alternating current at a frequency of about 100 Hz to about 1 kHz.

65. The method of claim 47, further comprising directing the fluid from the second end of the nonconducting conduit to one or more other supercritical water gasification components.

66. A method of controlling ion concentration in a subcritical to supercritical process, the method comprising:

providing a subcritical fluid comprising a plurality of ions into a nonconducting conduit configured to receive the fluid at a first end and transmit the fluid toward a second end thereof, wherein the nonconducting conduit comprises an inside surface and an outside surface;

causing the subcritical fluid to become supercritical; and

applying an alternating current through a plurality of electrodes disposed about at least a portion of the outside surface of the nonconducting conduit to generate and exert an electromotive force on the plurality of ions to at least intermittently reduce a local concentration of ions at the inside surface.

67. The method of claim 66, further comprising:

positioning the plurality of electrodes in a manner that causes the electromotive force to be substantially directed in a radially inward direction with respect to a radius of the nonconducting conduit.

68. The method of claim 66, wherein the local concentration of ions at the inside surface forms at least one corrosion protection area for the nonconducting conduit.

69. The method of claim 66, wherein causing the subcritical fluid to become supercritical comprises:

heating the subcritical fluid with a heater thermally coupled to the nonconducting conduit, wherein the heater is operatively coupled to a controller that is configured to cause the heater to heat the subcritical fluid to a temperature above a critical point.

70. The method of claim 69, wherein the subcritical fluid comprises water and wherein the critical point is at least about 623 K.

71. The method of claim 66, wherein causing the subcritical fluid to become supercritical comprises:

pressurizing the subcritical fluid with a pressurization apparatus operatively coupled to a controller that is configured to cause the pressurization apparatus to pressurize the subcritical fluid to a pressure above a critical point.

72. The method of claim 71, wherein the fluid comprises water and wherein the critical point is at least about 22 MPa.

73. The method of claim 66, wherein applying the alternating current comprises applying a voltage of about 1 V to about 100 kV across the plurality of electrodes.

74. The method of claim 66, wherein applying the alternating current comprises applying a voltage of about 10 kV across the plurality of electrodes.

75. The method of claim 66, wherein applying the alternating current comprises applying an electric power of about 10 kilowatts to about 100 megawatts.

76. The method of claim 66, wherein applying the alternating current comprises applying an electric power of at least 9.5 kilowatts.

77. The method of claim 66, wherein applying the alternating current comprises applying the alternating current at a frequency of about 10 Hz to about 100 kHz.

78. The method of claim 66, wherein applying the alternating current comprises applying the alternating current at a frequency of about 100 Hz to about 1 kHz.

79. The method of claim 66, further comprising directing the supercritical fluid from the second end of the nonconducting conduit to one or more other supercritical water gasification components.

80. An article of manufacture that is resistant to corrosion, the article of manufacture comprising:

a nonconducting supercritical water gasification conduit that is configured to receive a fluid comprising a plurality of ions at a first end and transmit the fluid toward a second end thereof, the nonconducting supercritical water gasification conduit comprising an inside surface and an outside surface;

a plurality of electrodes distributed about at least a portion of the outside surface of the nonconducting supercritical water gasification conduit; and

a power source electrically connected to the plurality of electrodes, wherein the power source is configured to apply an alternating current across the plurality of electrodes, wherein the alternating current is effective to exert an electrophoretic force on the plurality of ions in the fluid.

81. The article of manufacture of claim 80, wherein the electrophoretic force is substantially directed in a radially inward direction with respect to a radius of the nonconducting conduit.

82. The article of manufacture of claim 80, wherein the nonconducting supercritical water gasification conduit is further configured to receive the fluid and transmit the fluid at a temperature of at least about 600 K.

83. The article of manufacture of claim 80, wherein the nonconducting supercritical water gasification conduit is further configured to receive the fluid and transmit the fluid at a pressure of at least about 18 MPa.

84. The article of manufacture of claim 80, wherein the electrophoretic force at least intermittently creates a concentration gradient of the plurality of ions in at least a portion of the fluid, wherein the concentration gradient increases along a radially inward direction from the inside surface of the nonconducting supercritical water gasification conduit.

85. The article of manufacture of claim 80, further comprising:

a heater thermally coupled to the nonconducting supercritical water gasification conduit, wherein the heater is configured to heat the fluid in the nonconducting supercritical water gasification conduit; and

a controller operatively coupled to the heater,

wherein the controller is configured to cause the heater to heat the fluid in the nonconducting conduit such that the fluid is heated above a critical temperature.

86. The article of manufacture of claim 85, wherein the fluid comprises water and wherein the critical temperature is at least about 623 K.

87. The article of manufacture of claim 80, further comprising:

a pressurization apparatus in fluid communication with the nonconducting supercritical water gasification conduit, wherein the pressurization apparatus is configured to pressurize the fluid in the nonconducting supercritical water gasification conduit; and

a controller operatively coupled to the pressurization apparatus,

wherein the controller is configured to cause the pressurization apparatus to pressurize the fluid in the nonconducting conduit such that the fluid is pressurized above a critical pressure.

88. The article of manufacture of claim 87, wherein the fluid comprises water and wherein the critical pressure is at least about 22 MPa.

89. The article of manufacture of claim 80, wherein the alternating current, when applied across the plurality of electrodes, causes the electrophoretic force to reduce or prevent at least a portion of a plurality of ions in the fluid from coming into contact with the at least a portion of the inside surface, while permitting movement of the plurality of ions with the fluid through the nonconducting conduit from the first end toward the second end.

90. The article of manufacture of claim 80, wherein the nonconducting supercritical water gasification conduit is comprised of ceramic matrix composites, stabilized alumina, stabilized zirconia, silicon carbide, a composite of silicon carbide fiber in a silicon carbide matrix, a composite of alumina fiber in an alumina matrix, or any combination thereof.

91. The article of manufacture of claim 80, wherein the nonconducting supercritical water gasification conduit comprises one or more of a tensile strength of at least about 25 MPa, a Young's modulus of at least about 15 GPa, and a flexural strength of at least about 25 MPa.

92. The article of manufacture of claim 80, wherein the nonconducting supercritical water gasification conduit comprises a cross-sectional shape that is circular, crescent, elliptical, oval, or semicircular.

93. The article of manufacture of claim 80, wherein the nonconducting supercritical water gasification conduit has a radius of about 0.5 meters to about 100 meters.

94. The article of manufacture of claim 80, wherein the nonconducting supercritical water gasification conduit is a pipe.

95. The article of manufacture of claim 80, wherein the nonconducting supercritical water gasification conduit is a feeder conduit operatively coupled to a supercritical water gasification reactor.

96. The article of manufacture of claim 80, wherein the supercritical water gasification reactor comprises one or more of a reactor vessel, a pre-heater, a condenser, a pump, and a heat exchanger.

97. The article of manufacture of claim 80, wherein the plurality of electrodes comprises a plurality of hyperbolic electrodes.

98. The article of manufacture of claim 80, wherein the fluid comprises a supercritical fluid or a near-supercritical fluid.

99. The article of manufacture of claim 98, wherein the supercritical fluid comprises one or more of an ionic slurry, water, coal, carbon dioxide, methane, ethane, propane, ethylene, propylene, methanol, ethanol, and acetone.

100. The article of manufacture of claim 80, wherein the fluid is a supercritical fluid or a near-supercritical fluid.

101. The article of manufacture of claim 100, wherein the supercritical fluid comprises one or more of an ionic slurry, water, coal, carbon dioxide, methane, ethane, propane, ethylene, propylene, methanol, ethanol, and acetone.

102. The article of manufacture of claim 80, wherein the power source is further configured to provide a voltage ranging from about 1 V to about 100 kV across the plurality of electrodes.

103. The article of manufacture of claim 80, wherein the power source is further configured to provide an electric power of about 10 kilowatts to about 100 megawatts.

104. The article of manufacture of claim 80, wherein the power source is further configured to apply the alternating current across the plurality of electrodes at a frequency of about 10 Hz to about 100 kHz.

105. The article of manufacture of claim 80, wherein the power source is further configured to apply the alternating current across the plurality of electrodes at a frequency of about 100 Hz to about 1 kHz.

106. The article of manufacture of claim 80, wherein the article of manufacture is configured as one of a coal gasification system, a biomass gasification system, and a waste gasification system.

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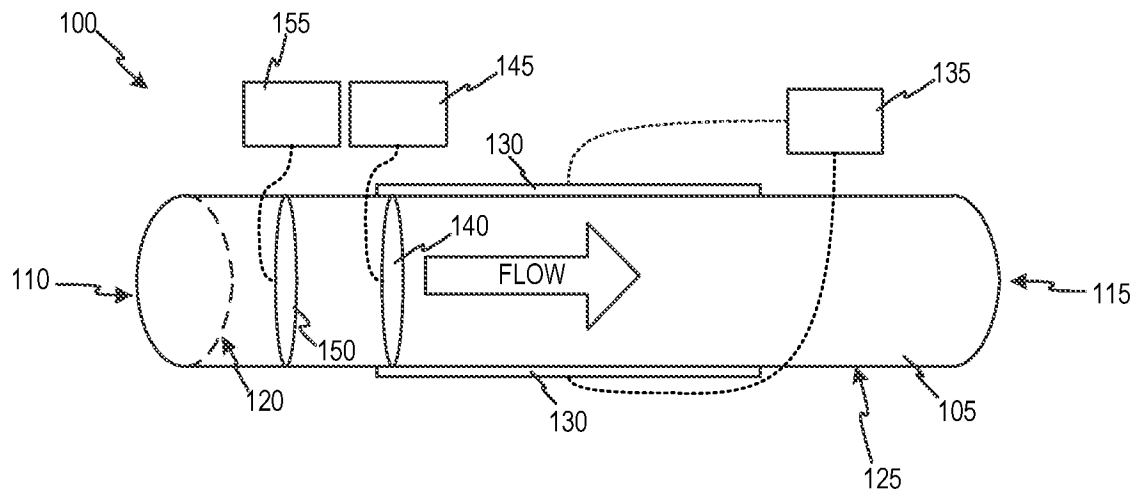


FIG. 1a

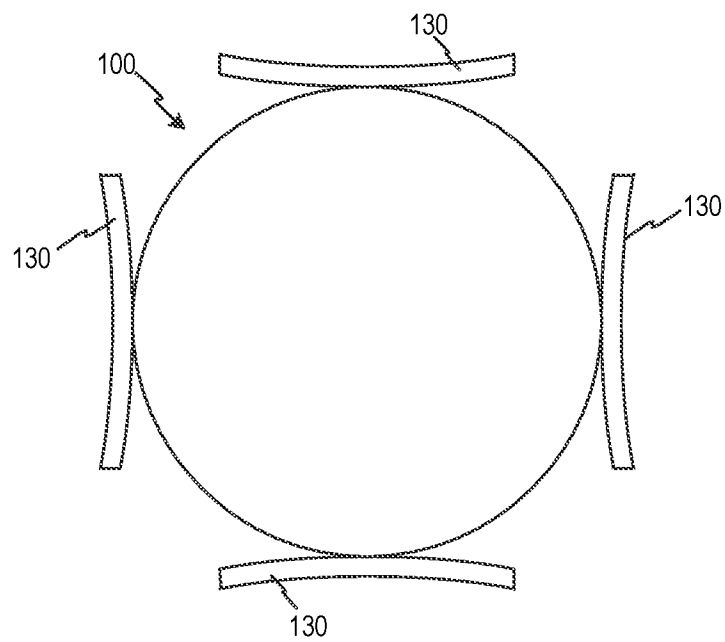


FIG. 1b

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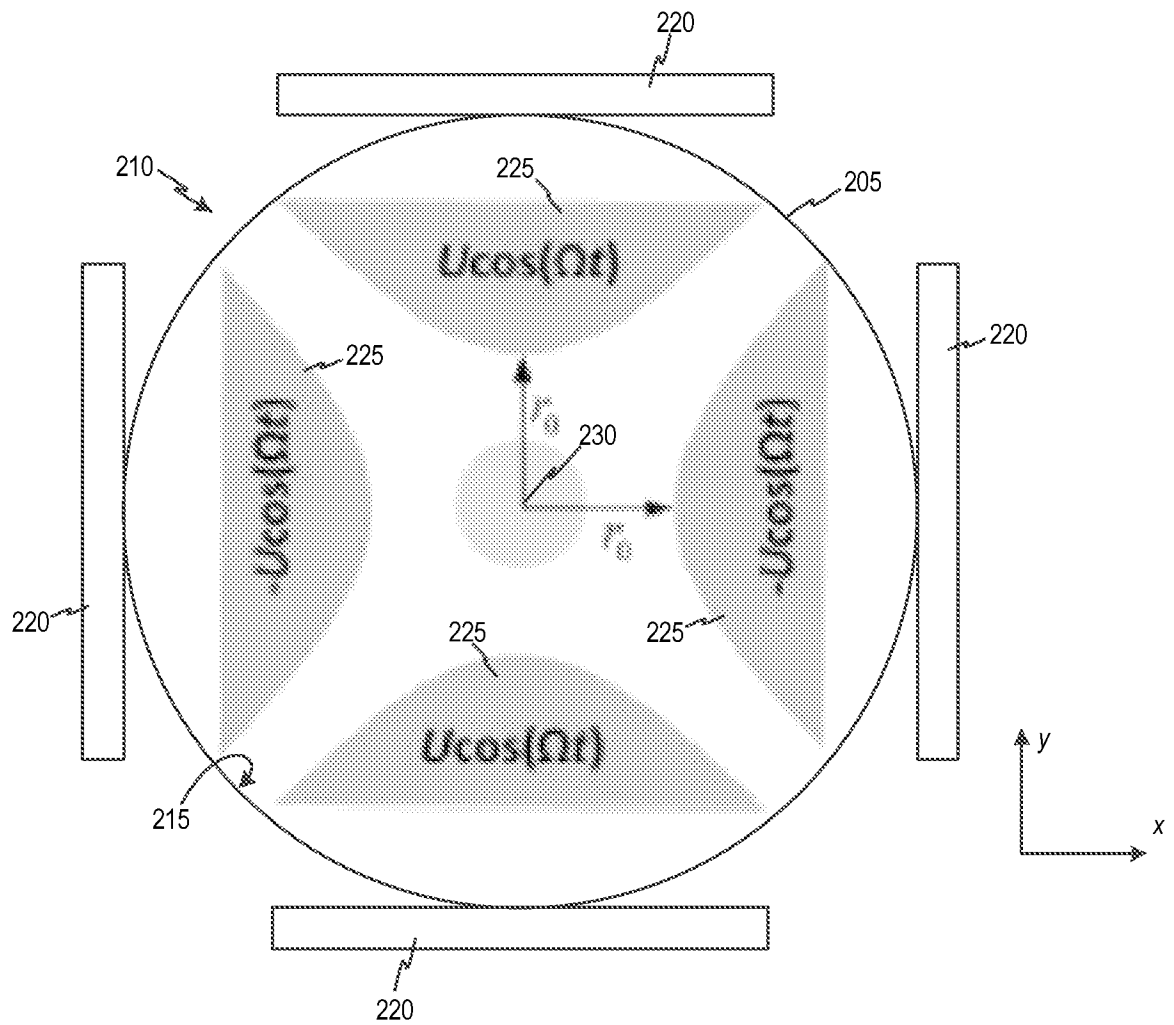


FIG. 2

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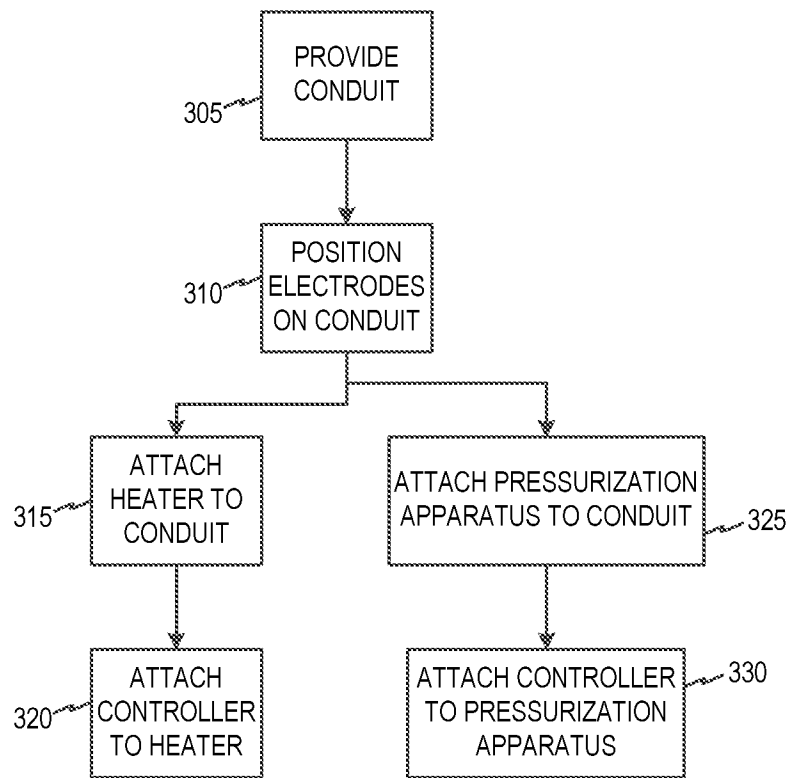


FIG. 3

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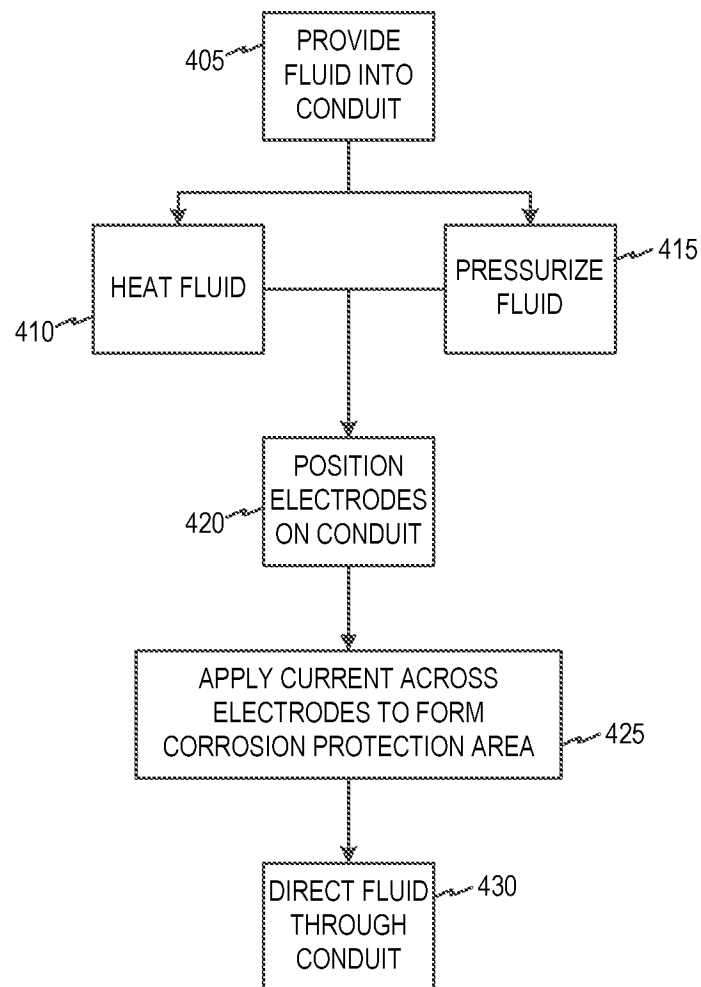


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 13/27103

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - C23F 13/00; C23F 13/04 (2013.01) USPC - 422/10; 422/7; 422/11 According to International Patent Classification (IPC) or to both national classification and IPC														
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) USPC - 422/10; 422/7; 422/11 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched USPC - all classes; NPL (keyword limited) Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PatBase; Google Scholar/Patent Search terms - Supercritical, gasification, water, corrosion, electrode, nonconducting, electrophoresis, electromotive, plastic, duct, pipe, nonconduct*, insulat*, tube*, conduit*, liner, ANDERSON w2 Kraig, SJONG w2 Angele														
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>US 2013/0008858 A1 (Howdeshell et al.); 10 January 2013 (10.01.2013); entire document, especially para [0022], [0041], [0042], and [0047]</td> <td>1-106</td> </tr> <tr> <td>A</td> <td>GB 825,184 A (Petrocokino) 09 December 1959 (09.12.1959); entire document, especially cols. 1 and 2</td> <td>1-106</td> </tr> <tr> <td>A</td> <td>EP 0246029 A2 (Syrett) 19 November 1987 (19.11.1987); entire document, especially abstract; 12, 10a; p. 4, ln 23-27; Fig. 2</td> <td>1-106</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	US 2013/0008858 A1 (Howdeshell et al.); 10 January 2013 (10.01.2013); entire document, especially para [0022], [0041], [0042], and [0047]	1-106	A	GB 825,184 A (Petrocokino) 09 December 1959 (09.12.1959); entire document, especially cols. 1 and 2	1-106	A	EP 0246029 A2 (Syrett) 19 November 1987 (19.11.1987); entire document, especially abstract; 12, 10a; p. 4, ln 23-27; Fig. 2	1-106
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Date of the actual completion of the international search 29 March 2013 (29.03.2013)		Date of mailing of the international search report 23 APR 2013												
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201		Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774												