ABSTRACT

A system includes a heat exchanger including a first channel having a syngas flow path and a second channel having a slurry flow path. The heat exchanger, when in operation, causes a heat transfer from a syngas along the syngas flow path to a slurry along the slurry flow path. The heat transfer causes heating of the slurry from a first slurry temperature to a second slurry temperature and causes cooling of the syngas from a first syngas temperature to a second syngas temperature.
SYSTEMS AND METHODS FOR SLURRY PREHEATING

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to gasification systems, and more specifically, to systems and methods for preheating a slurry feed for a gasifier.

[0002] Integrated gasification combined cycle (IGCC) power plants are capable of generating energy from various carbonaceous feedstocks, such as coal or natural gas, relatively cleanly and efficiently. IGCC power plants generally include a gasification system used to convert the carbonaceous feedstock (e.g., a slurry feed) into a gas mixture of carbon monoxide (CO) and hydrogen (H2), i.e., syngas, by reaction with oxygen and steam in a gasifier. Unfortunately, the carbonaceous feedstock enters the gasification system at a low temperature, which may decrease an efficiency of the gasification system.

BRIEF DESCRIPTION OF THE INVENTION

[0003] Certain embodiments commensurate in scope with the originally claimed invention are summarized below. These embodiments are not intended to limit the scope of the claimed invention, but rather these embodiments are intended only to provide a brief summary of possible forms of the invention. Indeed, the invention may encompass a variety of forms that may be similar to or different from the embodiments set forth below.

[0004] In a first embodiment, a system includes a heat exchanger including a first channel having a syngas flow path and a second channel having a slurry flow path. The heat exchanger, when in operation, causes a heat transfer from a syngas along the syngas flow path to a slurry along the slurry flow path. The heat transfer causes heating of the slurry from a first slurry temperature to a second slurry temperature and causes cooling of the syngas from a first syngas temperature to a second syngas temperature.

[0005] In a second embodiment, a system includes a controller having a processor, a memory, and instructions stored on the memory and executable by the processor. The instructions include temperature control instructions to control a heat transfer in a heat exchanger from a syngas along a syngas flow path to a slurry along a slurry flow path. The instructions also include contamination detection instructions to detect a slurry contamination of the slurry with the syngas or a syngas contamination of the syngas with the slurry.

[0006] In a third embodiment, a method includes receiving a slurry at a first temperature through a first inlet of a heat exchanger. The method also includes receiving a syngas at a second temperature through a second inlet of a heat exchanger, wherein the second temperature is higher than the first temperature. The method also includes exchanging heat from the syngas to the slurry through the walls of the heat exchanger to heat the slurry to a third temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0008] FIG. 1 is a block diagram of an embodiment of an integrated gasification combined cycle (IGCC) power plant incorporating a heat exchanger for preheating a slurry feed with a hot process stream;

[0009] FIG. 2 is a block diagram of an embodiment of the integrated gasification combined cycle (IGCC) system of FIG. 1, incorporating a heat exchanger for preheating the slurry feed with a raw syngas; and

[0010] FIG. 3 is a schematic of an embodiment of the heat exchanger for preheating the slurry feed with the raw syngas.

DETAILED DESCRIPTION OF THE INVENTION

[0011] One or more specific embodiments of the present invention will be described below. In an effort to provide a concise description of these embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers’ specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

[0012] When introducing elements of various embodiments of the present invention, the articles “a,” “an,” “the,” and “said” are intended to mean that there are one or more of the elements. The terms “comprising,” “including,” and “having” are intended to be inclusive and mean that there may be additional elements other than the listed elements.

[0013] Present embodiments are directed towards preheating a carbonaceous feedstock (e.g., slurry feed) before it enters a gasification system (e.g., gasifier) of an IGCC system for various partial oxidation processes. In certain embodiments, the slurry feed is preheated using a heat exchanger that transfers heat from a hot process stream (e.g., raw syngas) within the IGCC system to the slurry feed. For example, the heat exchanger may transfer heat from the raw syngas discharged from the gasifier to the slurry feed. It may be desirable to preheat the slurry feed before it enters the gasifier to reduce the oxygen demand of the gasifier during the partial oxidation process, and thereby reduce the size on the air separation unit (ASU). Reducing the size of the ASU may also reduce the size and duty of a low temperature gas cooling (LTG) system. Indeed, reducing the size of the ASU may increase the cost benefits of the gasification system.

[0014] In particular, certain embodiments are directed towards a leak detection system with the IGCC system. For example, the leak detection system is configured to detect leaks within the heat exchanger, or within the flow lines of the IGCC system. The leak detection system may include a series of sensors along the flow line of the IGCC system or within or around the heat exchanger configured to detect a cross-contamination within the heat exchanger or within the flow lines (e.g., a leaked slurry in the syngas or a leaked syngas in the slurry). In situations where the leak detection system determines that a leak (e.g., cross-contamination) has occurred within the IGCC system or the heat exchanger, an operator or a controller can manually or automatically flush the IGCC system or the heat exchanger of the cross-contamination. In
other situations where the leak detection system detects a leak, the leak (e.g., cross-contamination) may be removed with a syngas scrubber.

[0015] With the foregoing in mind, FIG. 1 is a block diagram of an embodiment of an integrated gasification combined cycle (IGCC) power plant 10 (i.e., IGCC system 10) incorporating a heat exchanger 12 for preheating a slurry feed 14 with a hot process stream 16. As discussed in detail below, in certain embodiments, heat is exchanged, via the heat exchanger 12, from the high-temperature process stream 16 to the low-temperature slurry feed 14.

[0016] Elements of the IGCC system 10 may include a fuel source 18, such as a solid feed, that may be utilized as a source of energy for the IGCC system 10. The fuel source 18 may include coal, petroleum coke, biomass, wood-based materials, agricultural wastes, tar, coke oven gas and asphalt, or other carbon containing items. The solid fuel of the fuel source 18 may be passed to a feedstock preparation unit 20. The feedstock preparation unit 20 may, for example, resize or reshape the fuel source 18 by chopping, milling, shredding, pulverizing, briquetting, or pelleting the fuel source 18 to generate feedstock. Additionally, water, or other suitable liquids may be added to the fuel source 18 in the feedstock preparation unit 20 to create the slurry feed 14 (e.g., slurry feedstock). In other embodiments, no liquid is added to the fuel source, thus yielding dry feedstock.

[0017] In certain embodiments, the slurry feed 14 may be passed directly to a gasifier 22 from the feedstock preparation unit 20 via an unheated low flow line 24. In particular, the slurry feed 14 may enter the gasifier 22 at a temperature between approximately 450°C and 700°C. The gasifier 22 may convert the slurry feed 14 into a syngas, e.g., a combination of carbon monoxide and hydrogen. This conversion may be accomplished by subjecting the slurry feed 14 to a controlled amount of steam and oxygen at elevated pressures, e.g., from approximately 2000 kPa to 8500 kPa, and temperatures, e.g., approximately 750°C to 1000°C, depending on the type of gasifier 22 utilized. The gasification process may include the slurry feed 14 undergoing a pyrolysis process, whereby the temperature of the slurry feed 14 is increased. Temperatures inside the gasifier 22 may range from approximately 150°C to 700°C during the pyrolysis process, depending on the fuel source 18 utilized to generate the slurry feed 14. The heating of the slurry feed 14 during the pyrolysis process may generate a solid, (e.g., char), and residue gases, (e.g., carbon monoxide, hydrogen, and nitrogen). The char remaining from the feedstock from the pyrolysis process may only weigh up to approximately 30% of the weight of the original slurry feed 14.

[0018] A partial oxidation process may then occur in the gasifier 22. The partial oxidation may include introducing oxygen to the char and residue gases. The char and residue gases may react with the oxygen to form carbon dioxide and carbon monoxide, which provides heat for the subsequent gasification reactions. The temperatures during the partial oxidation process may range from approximately 700°C to 1000°C. Next, steam 21 may be introduced into the gasifier 22 during a gasification step. The char may react with the carbon dioxide and steam 21 to produce carbon monoxide and hydrogen at temperatures ranging from approximately 800°C to 1100°C. In essence, the gasifier 22 utilizes steam 21 and oxygen 44 to allow some of the slurry feed 14 to be converted into carbon monoxide and energy, which drives a second reaction that converts further slurry feed 14 to hydrogen and additional carbon dioxide. In this manner, a resultant gas (e.g., raw syngas 23) and a waste product (e.g., slag 26) is manufactured by the gasifier 22.

[0019] In particular, the resultant gas produced by the gasifier 22 may be termed raw syngas 23. The raw syngas 23 may include approximately 85% of carbon monoxide and hydrogen in equal proportions, as well as CH₄, H₂, H₂O, CO₂, N₂, HCN, and H₂S (based on the sulfur content of the slurry feed 14). In some embodiments, the raw syngas 23 may be cooled and saturated within a quench portion 28. The quench portion 28 may be an integral part of the gasifier 22 as shown, or the quench portion 28 may be a separate unit. The quench portion 28 may cool the syngas to, at, or near a saturation temperature through evaporation of a cooling fluid, such as water, causing less desirable components to solidify. In other embodiments, the raw syngas 23 may leave the gasifier 22 without being cooled and saturated within the quench portion 28. In such embodiments, the raw syngas 23 leaving the gasifier 22 may remain at higher temperatures (e.g., approximately 200°C to 250°C).

[0020] The resultant waste product produced by the gasifier 22 may be termed the slag 26. The slag 26 may flow, for example, by gravity, from the quench portion 28 of the gasifier 22 into a pressurized lock hopper 30 at regular intervals. In certain embodiments, liquid, such as water may be removed from the slag 26 within the lock hopper 30 and returned to the gasifier 22. The slag 26 may then be removed from the lock hopper 30 and directed to a slag processing system 32 where the slag 26 may be screened to reduce moisture and then directed to an offsite disposal facility. For example, the slag 26 may be used as road base or as another building material.

[0021] In certain embodiments, the raw syngas 23 flows from the gasifier 22 to a syngas scrubber 34. The syngas scrubber 34 reduces the amount of impurities (e.g., particulates and chlorides) contained in the raw syngas 23, using, for example, a water quench (as further depicted in FIG. 2). Indeed, other impurities, such as sulfides or carbon dioxide, are removed from the raw syngas 23. The removal methods may include chemical or physical absorption, adsorption, cryogenic, membranes, ceramics, microbial or algal systems, or any combination thereof. A scrubbed syngas 36 exits the syngas scrubber 34, and flows towards downstream reaction treaters of syngas. In certain embodiments, the downstream systems may include an integrated gasification combined cycle (IGCC) power plant 10 to produce power, a chemical plant to produce methanol, or other systems. In the illustrated embodiment, the downstream system includes a low temperature gas cooling (LTG) system 38.

[0022] The IGCC system 10 may further include an air separation unit (ASU) 40. In particular, the gasifier 22 reacts the slurry feed 14 provided by the feedstock preparation unit 20 with oxygen 44 from the ASU 40 and the steam 21. The ASU 40 may operate to separate air into component gases by, for example, using cryogenic distillation techniques. The ASU 40 may separate oxygen and nitrogen from the air supplied to it from a supplemental air compressor 42, and the ASU 40 may transfer the separated oxygen 44 to the gasifier 22. The slurry feed 14, the oxygen 44, and the steam 21 may be introduced to the gasifier 22 through a fuel injector system.

[0023] In certain embodiments, it may be desirable to preheat the slurry feed 14 before it is introduced to the gasifier 22. As described above, the gasification process may convert the slurry feed 14 into a syngas through an exothermic process.
The exothermic process may occur at elevated pressures and temperatures (e.g., 700° C to 1600° C) and in the presence of oxygen. The temperature of the slurry feed 14 entering the gasifier 22, which may typically be between approximately 45° C and 70° C, may be increased once the slurry feed 14 enters the gasifier 22 and before the gasification process occurs. To increase the temperature of the slurry feed 14 within the gasifier 22 before the gasification process occurs, additional oxygen 44 is provided from the ASU 40. As such, preheating the slurry feed 14 may be desirable because it reduces the oxygen 44 demand (e.g., from the ASU 40) used to heat the slurry feed 14 before the gasification process within the gasifier 22. In such embodiments, the slurry feed 14 may be preheated to a gasification temperature by the hot gas stream preparation unit 20 via the unheated flow line 24. Rather, in such embodiments, the slurry feed 14 may be passed into the heat exchanger 12 via slurry flow line 46, so that heat may be exchanged from the hot process stream 16 to the slurry feed 14. The hot process stream 16 may flow into the heat exchanger 12 through a hot process stream flow line 48. The hot process stream 16 may be any process stream flowing through the IGCC system 10 at high temperatures, such as, for example, nitrogen, CO₂, steam, exhaust gases (e.g., from a gas turbine engine, a furnace, a boiler, or another combustion system), or raw syngas 23, or any combination thereof.

The heat exchanger 12 may be any type of indirect heat exchanger, such as a shell and tube heat exchanger, a plate heat exchanger, a plate and shell heat exchanger, a plate fin heat exchanger, a plate heat exchanger, a regenerative heat exchanger, an adiabatic wheel heat exchanger, a fluid heat exchanger, a waste heat recovery unit, a dynamic scoured surface heat exchanger, or a phase-change heat exchanger. In the illustrated embodiment, a shell and tube heat exchanger 12 is provided to exchange heat from the hot process stream 16 to the slurry feed 14. In particular, the slurry feed 14 flows into the tube side of the heat exchanger 12 via the slurry flow line 46, at a low approach temperature (e.g., approximately 45° C to 70° C). In addition, the hot process stream 16 flows into the shell side of the heat exchanger 12 via the hot process stream flow line 48, at a high approach temperature (e.g., approximately 150° C to 250° C). Thus, the hot process stream 16 and the slurry feed 14 are isolated from one another using one or more specific conduits, housings, or walls, such that heat transfers through one or more walls (e.g., tubing) from the stream 16 to the slurry feed 14. In other words, the heat exchanger 12 is an indirect heat exchanger, because the hot process stream 16 and slurry feed 14 do not directly mix with one another. In certain embodiments, the hot process stream 16 may be the raw syngas 23 having the high approach temperature approximately equal to the temperature at which the raw syngas 23 leaves the gasifier 22. After passing through the shell of the heat exchanger 12, the hot process stream 16 flows out of the heat exchanger 12 for further downstream processing 50. The hot process stream 16 in the downstream processing 50 may be at a lower temperature than the hot process stream 16 entering the heat exchanger 12. Furthermore, the slurry feed 14 exiting the heat exchanger 12 may be preheated by the hot process stream 16 to temperatures between approximately 130° C to 170° C. Raising the temperature of the slurry feed 14 may decrease the oxygen 44 demand of the gasifier 22.

In the illustrated embodiment, the gasification system 10 includes one or more sensors 52 used to monitor various parameters (e.g., temperature, pressure, flow rate, gas composition, or concentration, etc.) of gas/liquid flows throughout the gasification system 10. The sensors 52 may include a temperature sensor, a pressure sensor, a flow rate sensor, a bubble sensor, a moisture sensor, a gas composition sensor, or any combination thereof. As illustrated, the sensors 52 may be located inside the heat exchanger 12, the feedstock preparation unit 20, the UFGC 38, the syngas scrubber 34, the gasifier 22, the raw syngas 23 (e.g., along and/or in syngas conduit 13), the slurry feed 14, and/or the quench portion 28. In some embodiments, the sensors 52 may be located in one or more flow lines between two sections (e.g., flow lines 24, 46, 47, 62, 64, or 66). A controller 56 may process sensor feedback received from the sensors 52 along the flow lines (e.g., flow lines 24, 46, 47, 49, 62, 64, or 66) and the memory 60, and may send control signals to various valves 54 (or actuators) of the gasification system 10 based on the sensor feedback. Because of the locations of the valves 54, the controller 56 is able to control a flow between each section of the gasification system 10. In this way, the controller 56 may govern operation of the gasification system 10 during both gasifier 22 operations and the heat exchanger 12 operations.

Furthermore, the system 10 may also include a leak detection system 70, as described below in FIG. 2, configured to detect leaks within the heat exchanger 12, the slurry flow line 46, the heated flow line 47, the hot process stream flow line 48, a cooled hot process stream flow line 49, the unheated flow line 24, or a combination thereof. In particular, the leak detection system 70 may include a series of sensors 52 along the flow lines (e.g., flow lines 24, 46, 47, 49, 62, 64, or 66) or within or around the heat exchanger 12 that may detect a cross-contamination within the heat exchanger 12 or within the flow lines (e.g., flow lines 24, 46, 47, 49, 62, 64, or 66). As described below in FIG. 2, the leak detection system 70 may work with the controller 56, one or more processors 58, a memory 60, one or more input devices 61, leak monitoring instructions stored on a non-transitory, computer readable medium, and a display 57.

FIG. 2 is a block diagram of an embodiment of the integrated gasification combined cycle (IGCC) system 10 of FIG. 1, incorporating the heat exchanger 12 for preheating the slurry feed 14 with the raw syngas 23. As described above, in some embodiments, the hot process stream 16 of FIG. 1 may be the raw syngas 23 that exits the gasifier 22 via flow line 25. Moreover, in such embodiments, the high exiting temperature of the raw syngas 23 may be used within the heat exchanger 12 to preheat the slurry feed 14 before entering the syngas scrubber 34. For example, the slurry feed 14 may be passed into the heat exchanger 12 via the slurry flow line 46 to interact thermally with the raw syngas 23 before entering the gasifier 22. In other embodiments, the slurry feed 14 may bypass the heat exchanger 12 and may flow directly into the gasifier 22 via the unheated flow line 24.

For embodiments where the slurry feed 14 enters the heat exchanger 12, the raw syngas 23 is also passed into the heat exchanger 12 via the raw syngas flow line 62 to interact thermally with the slurry feed 14 before entering the syngas scrubber 34. The raw syngas 23 may leave the gasifier 22 without being cooled and saturated, and as such, may remain at higher temperatures (e.g., approximately 200° C to 250° C). In other embodiments, the raw syngas 23 may be cooled with the quench portion 28 of the gasifier 22, and may still be at higher temperatures (e.g., approximately 150° C to 200° C). In other embodiments, the raw syngas 23 may bypass the
heat exchanger 12 via the raw syngas bypass flow line 64 and may directly enter the syngas scrubber 34.

[0029] As described above, the heat exchanger 12 may be any type or any number of heat exchangers. In the illustrated embodiment, a single shell and tube heat exchanger 12, having one or more channels, is provided to exchange heat from the raw syngas 23 to the slurry feed 14. In other embodiments, any number and any combination of different types of heat exchangers 12 may be utilized to exchange heat from the raw syngas 23 to the slurry feed 14. For example, two, three, four, five, six, or more heat exchangers may be provided within the gasification system 10. Moreover, the heat exchanger 12 may be sized to suit the needs of the gasification system 10. In particular, the heat exchanger 12, the raw syngas 23, and the slurry feed 14 are isolated from one another using one or more specific conduits, housings, or walls, such that heat transfers through one or more walls (e.g., tubing) from the raw syngas 23 to the slurry feed 14. In other words, the heat exchanger 12 is an indirect heat exchanger, because the raw syngas 23 and slurry feed 14 do not directly mix with one another.

[0030] In particular, the slurry feed 14 via the slurry flow line 46 flows through the tube of the heat exchanger 12 (e.g., a first channel or tube of the shell and tube heat exchanger 12), at a low approach temperature (e.g., approximately 45° C. to 70° C.). In addition, the raw syngas 23 (e.g., the raw syngas flow line 62) flows through the shell of the heat exchanger 12 (e.g., a second channel or shell of the shell and tube heat exchanger 12), at a high approach temperature (e.g., approximately 150° C. to 250° C.). Indeed, in certain embodiments, the raw syngas 23 may have an approach temperature entering the heat exchanger 12 approximately equal to the temperature at which the raw syngas 23 leaves the gasifier 22. In certain embodiments, slurry feed 14 that is not preheated may directly enter the gasifier 22 via the unheated flow line 24 at a temperature between approximately 45° C. and 70° C. In embodiments where the slurry feed 14 is passed through the heat exchanger 12, the slurry feed 14 is preheated to a temperature between approximately 130° C. to 170° C. In other embodiments with other types of heat exchangers 12, the arrangement of the raw syngas 23 and the slurry feed 14 may vary.

[0031] After passing through the heat exchanger 12, the raw syngas 23 flows out of the heat exchanger 12 via the cooled raw syngas flow line 66 for further processing within the syngas scrubber 34. In particular, the temperature of the raw syngas 23 in the cooled raw syngas flow line 66 may be lower than the temperature of the raw syngas 23 in the raw syngas flow line 62. Similarly, after passing through the heat exchanger 12, the raw syngas 23 via the heated flow line 47 for further processing within the gasifier 22. The unheated flow line 24 may carry the slurry feed 14 that bypasses the heat exchanger 12. In particular, the slurry feed 14 and the raw syngas 23 flowing through the flow lines (e.g., unheated flow line 24, slurry flow line 46, heated flow line 47, raw syngas flow line 62, raw syngas bypass flow line 64, or cooled raw syngas flow line 66) may be flowing at an approximately constant rate to minimize separation of the components of the raw syngas 23 or the slurry feed 14. For example, an approximately constant flow rate for the slurry feed 14 may reduce dewatering the slurry feed 14 (i.e., separating the water and solid components of the slurry feed 14). Indeed, reducing the bends and turns of the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) within the gasification system 10 may provide for more constant flow rates.

[0032] In the illustrated embodiment, the gasification system 10 may also include a leak detection system 70 configured to detect leaks within the heat exchanger 12, the slurry flow line 46, the heated flow line 47, the raw syngas flow line 62, the unheated flow line 24, or a combination thereof. The leak detection system 70 may include a series of sensors 52 along the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) or within the heat exchanger 12. In certain embodiments, the leak detection system 70 may detect a cross-contamination within the heat exchanger 12 or within the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66). For example, the leak detection system 70 may detect a cross-contamination of the slurry feed 14 from the slurry flow line 46 into the cooled raw syngas flow line 66 of the raw syngas 23. As a further example, the leak detection system 70 may detect a cross-contamination of the raw syngas 23 from the raw syngas flow line 62 into the heated flow line 47 of the slurry feed 14. Furthermore, the leak detection system 70 may detect a cross-contamination of the slurry feed 14 flowing through the tube side of the shell and tube heat exchanger 12 into the raw syngas 23 flowing through the shell side of the shell and tube heat exchanger 12. As described further below, a series of sensors 52 along the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) or within the heat exchanger 12 may provide sensor feedback to the controller 56 to determine the nature of the cross-contamination of the slurry feed 14 and/or the raw syngas 23. For example, in certain embodiments, the sensors 52 may detect the cross-contamination of the slurry feed 14 into the raw syngas 23 within the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) based on differences in temperature or pressures. In other embodiments, the sensors 52 may detect the cross-contamination within the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) based on other sensed variables, such as, for example, moisture content, bubbles, cavitation, or a combination thereof within the flow lines. In yet other embodiments, the sensors 52 may detect changes in flow rates, rapid or gradual loss in pressures, rapid or gradual loss in temperatures, reduced output into or from the gasifier, or a combination thereof.

[0033] In certain embodiments, the controller 56 may include an industrial controller, such as a double or triple redundant controller with 2, 3, or more processors. For example, the processors may include general-purpose or application-specific microprocessors. Particularly, in some embodiments, a controller may include any suitable computing device, such as a desktop computer or server. Likewise, the memory may include volatile and/or non-volatile memory, random access memory (RAM), read only memory (ROM), flash memory, hard disk drives (HDD), removable disk drives and/or removable disks (e.g., CDs, DVDs, BluRay disks, USB pen drives, etc.), or any combination thereof. Additionally, in certain embodiments, the system may include a display. In some embodiments, the display may be integrated into (e.g., mobile device screen) or separate from (e.g., distinct monitor display) the controller. As discussed below, the display may be used to present information to a user that enables the user to select various objectives using a graphical user interface. Additionally, the system may include one or more input devices that receive selections of choices from one or more users. In certain
embodiments, the input devices 61 may include mice, keyboards, touch screens, trackpads, or other input devices for receiving inputs to the controller 56.

[0034] In situations where the leak detection system 70 and the controller 56 determine a leak (e.g., cross-contamination between the slurry feed 14 and the raw syngas 23) within the gasification system 10, an operator can bypass the heat exchanger 12 by redirecting the slurry feed 14 in the slurry flow line 46 and the raw syngas in the raw syngas flow line 62 into the unheated flow line 24 and the raw syngas bypass flow line 64, respectively. In such embodiments, the operator may manually control the valves 54 of the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66), or the operator may engage the controller 56 to control the valves 54. In another embodiment, the controller 56 may automatically bypass the heat exchanger 12 and control the valves 54 of the flow lines. By bypassing the heat exchanger 12, the operator may flush the heat exchanger 12 and the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) of the cross-contamination to enable the heat exchanger 12 and/or flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) to be repaired. For example, the operator (or the controller 56) may control the valves 54 to bypass the heat exchanger 12 in a smooth manner such that the slurry flow to the gasifier 22 is approximately constant. In other embodiments, the gasification system 10 may include an automatic flush system controlled by a controller 56 that automatically redirects the raw syngas 23 and the slurry feed 14 before automatically flushing (i.e., cleaning) the heat exchanger 12 and the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) of the cross-contamination. In addition, in certain embodiments, the unheated flow line 24 and the raw syngas bypass flow line 64 (e.g., bypass flow lines) may be used by the controller 56 to adjust the amount of preheating of the slurry feed 14. For example, increasing the amount of slurry feed 14 to the unheated flow line 24 may decrease the amount of the slurry feed 14 preheated for the gasifier 22. In addition, the slurry feed 14 is compatible with the syngas scrubber 34, and so detection of the cross-contamination does not have to be immediate.

[0035] In other embodiments, a cross-contamination between the raw syngas 23 and the slurry feed 14 may be removed during downstream processing within the syngas scrubber 34. As discussed above, the syngas scrubber 34 reduces the amount of impurities 76 (e.g., particulates and chlorides) contained in the raw syngas 23, using, for example, a water quench 72 supplied with water from a water supply 74. Indeed, other impurities 76, such as sulfides and carbon dioxide, are also removed from the raw syngas 23. In particular, the syngas scrubber 34 may remove cross-contamination products (e.g., slurry feed 14 cross-contaminated into the cooled raw syngas flow line 66) as impurities 76. The impurities 76 may exit the syngas scrubber 34 and enter the syngas scrubber circulating pump 78. In certain embodiments, the impurities 76 may enter the syngas scrubber circulating pump 78 before entering the syngas scrubber 34 again through a syngas scrubber nozzle 80 via a flow line 82. In other embodiments, the controller 56 may determine that the impurities 76 encompass a significant amount of slurry feed 14 that may be used within the gasifier 22. In such embodiments, the syngas scrubber circulating pump 78 may transfer the slurry feed 14 gathered from the impurities 76 into the unheated flow line 24 from a flow line 84. In yet other embodiments, the syngas scrubber circulating pump 78 may transfer the impurities 76 to a quench water strainer 86 that removes the quench water from the impurities 76 to supply the quench ring supply 88 of the water quench 72. The quench ring supply 88.

[0036] As described above, the gasification system 10 includes multiple sensors 52 used to monitor various parameters (e.g., temperature, pressure, flow rate, gas composition, or concentration, etc.) of flow throughout the gasification system 10. In particular, the sensors 52 may be used by the leak detection system 70 to monitor various indications of a cross-contamination with a gasification system 10. For example, the sensors 52 of the leak detection system 70 may monitor the temperature of various flow lines (e.g., flow lines 24, 46, 62, 64, or 66) to determine whether the temperatures are within or outside the desired ranges. As further examples, the sensors 52 of the leak detection system 70 may monitor the changes in pressure, moisture content, concentration of bubbles, cavitation, changes in flow rates, input or output from the flow lines into/out of the gasifier 22, or a combination thereof. As illustrated, the sensors 52 may be located inside the heat exchanger 12, the syngas scrubber 34, the gasifier 22, the raw syngas 23, or the slurry feed 14. In some embodiments, the sensors 52 may be located in one or more flow lines (e.g., flow lines 24, 46, 62, 64, or 66) between two sections.

[0037] FIG. 3 is a schematic of an embodiment of the heat exchanger 12 for preheating the slurry feed 14 with the raw syngas 23. As described above, the heat exchanger 12 may include any number (e.g., two, three, four, five, six, or more) of individual heat exchangers and may encompass any form of heat exchanger (e.g., a plate heat exchanger, a plate and shell heat exchanger, a plate fin heat exchanger, a pillow plate heat exchanger, a regenerative heat exchanger, an adiabatic wheel heat exchanger, a fluid heat exchanger, a waste heat recovery unit, a dynamic scraped surface heat exchanger, a phase-change heat exchanger, or a combination thereof). In the illustrated embodiment, the heat exchanger 12 is a shell and tube heat exchanger having a shell 90 and one or more tubes 92. In particular, the slurry feed 14 may flow through the one or more tubes 92, and the raw syngas 23 may flow through the shell 90. Such that heat is transferred from the raw syngas 23 to the slurry feed 14 through the walls of the tubes 92. In other embodiments, the raw syngas 23 may flow through the one or more tubes 92, and the slurry feed 14 may flow through the shell 90. In yet other embodiments, heat may be transferred from the raw syngas 23 to the slurry feed 14 through the shell of the heat exchanger 12.

[0038] In the illustrated embodiment, the slurry feed 14 enters the one or more tubes 92 of the heat exchanger 12 via the slurry flow line 46 at a tube entrance 94. The slurry feed 14 flows through the one or more tubes 92 of the heat exchanger 12 at a low approach temperature (e.g., approximately 43° C. to 70° C.). In addition, the raw syngas 23 enters the shell of the heat exchanger 12 via the raw syngas flow line 62 at a shell entrance 96. The raw syngas 23 enters the heat exchanger 12 at a high approach temperature (e.g., approximately 150° C. to 250° C.). In certain embodiments, the heat exchanger 12 may include one or more baffles 98 that provide dividing walls (e.g., separations) within the shell 90 of the heat exchanger 12. The baffles 98 are configured to direct the flow of the fluid within the shell 90 in one or more “U-shaped” configurations, a winding configuration, a zigzag configuration, or generally any variable path configuration, such that the flow of the fluid within the shell 90 does not take the shortest possible route to a shell exit 100. For example, in the illustrated embodiment, the baffles 98 route the raw syngas 23...
in two "U-shaped" configurations (i.e., raw syngas route 101) before exiting the shell 90 at the shell exit 100. In particular, the longer raw syngas route 101 through the shell 90 increases the amount of time the raw syngas 23 is in thermal contact with the slurry feed 14 flowing through the one or more tubes 92. As the slurry feed 14 moves through the one or more tubes 92 (e.g., directional lines 102), the slurry feed 14 is preheated to a temperature between approximately 130°C to 170°C. The slurry feed 14 exits at tube 104 at a higher temperature when compared to the slurry feed 14 at the tube entrances 94, and continues down the unheated flow line 47 to gasifier 22. Likewise, the raw syngas 23 exits at the shell exit 100 at a lower temperature, and continues downstream along the cooled raw syngas flow line 66 to the syngas scrubber 34. In other embodiments with other types of heat exchangers 12, the arrangement of the raw syngas 23 and the slurry feed 14 may vary.

[0039] In the illustrated embodiment, the heat exchanger 12 may also include the leak detection system 70 configured to detect leaks within the heat exchanger 12, the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66), or a combination thereof. The leak detection system 70 may include a plurality of sensors 52 along the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) or within or around the heat exchanger 12. For example, the heat exchanger 12 may include sensors 52 along the one or more tubes 92 or within the shell 90. In certain embodiments, the leak detection system 70 may detect a cross-contamination within the heat exchanger 12 or within the flow line (e.g., flow lines 24, 46, 47, 62, 64, or 66). For example, the leak detection system 70 may detect a cross-contamination of the slurry feed 14 escaping from the tubes 92 into the shell 90 with the sensors 52. In addition, the leak detection system 70 may detect a cross-contamination of the slurry feed 14 within the cooled raw syngas flow line 66 exiting from the shell exit 100 and flowing into the syngas scrubber 34.

[0040] As described above, the gasification system 10 includes multiple sensors 52 used to monitor various parameters (e.g., temperature, pressure, flow rate, changes in temperatures, pressures, or flow rates, gas compositions or concentrations, concentration of bubbles, moisture levels, cavitation, input or output of flow lines etc.) of gas flows throughout the gasification system 10. In particular, the sensors 52 may be used by the leak detection system 70 to monitor various indications of a cross-contamination within the heat exchanger 12 of the gasification system 10. As illustrated, the sensors 52 may be located inside the heat exchanger 12 along the tubes 92 or within the shell 90. The sensors 52 may also be on the outside the heat exchanger 12, along the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66). The controller 56 may process sensor feedback received from the sensors 52 with the processor 58 and the memory 60, and may send control signals to various valves 54 (or actuators) of the gasification system 10 based on the sensor feedback. In other embodiments, the controller 56 includes leak monitoring instructions stored on a non-transitory, computer readable medium. For example, the leak monitoring (e.g., leak detection) instructions are stored in the memory 60, and are configured to be executed by the processor 58. The instructions can cause the controller 56 to control one or more sensors 52 and receive a feedback signal from one or more sensors 52 indicative of a leak condition (e.g., leak between the slurry flow line 46 and the raw syngas flow line 62). The instructions further can cause the controller 56 to control one or more valves 54 (or actuators) to automatically flush the heat exchanger 12 or the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) from the cross-contamination. In certain embodiments, the instructions can control the bypass of flow lines around the heat exchanger 12, the redirection of flow lines into the heat exchanger 12, and both.

[0041] In particular, the instruction may include temperature control instructions to control a heat transfer in the heat exchanger 12 from the raw syngas 23 along the raw syngas flow line 62 to the slurry feed 14 along the slurry flow line 46. In certain embodiments, the instructions may also include gasification monitoring instructions to monitor sensor feedback associated with the gasifier 22 that receives the slurry feed 14 from the heat exchanger 12, and the temperature control instructions are responsive to the sensor feedback associated with the gasifier 22. In some embodiments, the instructions may also include contamination detection instructions to detect a slurry contamination or a syngas contamination. For example, the instructions detect a contamination of the slurry feed 14 with the raw syngas 23 or a syngas contamination of the raw syngas 23 with the slurry feed 14. In some embodiments, the instructions may also include contamination response control instructions to initiate one or more control actions in response to the slurry feed 14 contamination or the raw syngas 23 contamination.

[0042] Technical effects of the invention include preheating the slurry feed 14 before it enters the gasifier 22 for various combustion processes. In certain embodiments, the slurry feed 14 is preheated using the heat exchanger 12 that transfers heat from the hot process stream 16 within the IGCC system to the slurry feed 14. For example, the heat exchanger 12 may transfer heat from the raw syngas 23 discharged from the gasifier 22 to the slurry feed 14. In particular, certain embodiments are directed towards the leak detection system 70. For example, the leak detection system 70 is configured to detect leaks within the heat exchanger 12, or within the flow lines (e.g., flow lines 24, 46, 47, 62, 64, or 66) of the system 10. The leak detection system 70 may include a plurality of sensors 52 along the flow lines of the IGCC system 10 or within or around the heat exchanger 12 configured to detect a cross-contamination (e.g., a leaked slurry feed 14 in the raw syngas 23 or a leaked raw syngas 23 in the slurry feed 14) within the heat exchanger 12 or within the flow lines.

[0043] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

1. A system comprising:
   a heat exchanger, comprising a first channel having a syngas flow path; and
   a second channel having a slurry flow path, wherein the heat exchanger, when in operation, causes a heat transfer from a syngas along the syngas flow path to a slurry along the slurry flow path, wherein the heat transfer causes heating of the slurry from a first slurry temperature to a second slurry temperature and causes
cooling of the syngas from a first syngas temperature to a second syngas temperature.

2. The system of claim 1, comprising a controller having a processor, a memory, and instructions stored on the memory and executable by the processor, wherein the instructions comprise temperature control instructions to control the heat transfer from the syngas along the syngas flow path to the slurry along the slurry flow path.

3. The system of claim 2, wherein the instructions comprise gasification monitoring instructions to monitor sensor feedback associated with a gasifier that receives the slurry from the heat exchanger, and the temperature control instructions are responsive to the sensor feedback associated with the gasifier.

4. The system of claim 2, wherein the instructions comprise contamination detection instructions to detect a slurry contamination of the slurry with the syngas or a syngas contamination of the syngas with the slurry.

5. The system of claim 4, wherein the instructions comprise contamination response control instructions to initiate one or more control actions in response to the slurry contamination or the syngas contamination.

6. The system of claim 1, comprising a contamination detection system comprising one or more sensors coupled to the heat exchanger, in a first slurry flow path upstream of the heat exchanger, in a second slurry flow path downstream from the heat exchanger, in a first syngas path upstream of the heat exchanger, in a second syngas path downstream from the heat exchanger, or any combination thereof.

7. The system of claim 6, wherein the one or more sensors are configured to obtain sensor input indicative of a leak condition between the slurry flow path and the syngas flow path.

8. The system of claim 6, wherein the one or more sensors comprise a temperature sensor, a pressure sensor, a flow rate sensor, a bubble sensor, a moisture sensor, a gas composition sensor, or any combination thereof.

9. The system of claim 6, wherein the contamination detection system comprises one or more valves disposed in the heat exchanger, in the first slurry flow path upstream of the heat exchanger, in the second slurry flow path downstream from the heat exchanger, in the first syngas path upstream of the heat exchanger, in the second syngas path downstream from the heat exchanger, or any combination thereof.

10. The system of claim 1, comprising a gasifier configured to generate the syngas at the first syngas temperature and receive the slurry at the second slurry temperature from the second channel.

11. The system of claim 1, comprising a scrubber configured to receive the syngas at the second syngas temperature from the first channel, wherein the scrubber is configured to separate a leaked slurry from the syngas.

12. A system, comprising:
   a controller having a processor, a memory, and instructions stored on the memory and executable by the processor, wherein the instructions comprise:
   temperature control instructions to control a heat transfer in a heat exchanger from a syngas along a syngas flow path to a slurry along a slurry flow path; and
   contamination detection instructions to detect a slurry contamination of the slurry with the syngas or a syngas contamination of the syngas with the slurry.

13. The system of claim 12, wherein the instructions comprise gasification monitoring instructions to monitor sensor feedback associated with a gasifier that receives the slurry from the heat exchanger, and the temperature control instructions are responsive to the sensor feedback associated with the gasifier.

14. The system of claim 12, wherein the instructions comprise contamination response control instructions to initiate one or more control actions in response to the slurry contamination or the syngas contamination.

15. The system of claim 12, comprising a contamination detection system having the controller and one or more sensors configured to obtain sensor input indicative of a leak condition between the slurry and the syngas in the heat exchanger.

16. The system of claim 12, comprising the heat exchanger, a gasifier that receives the slurry and produces the syngas, a scrubber that receives the syngas and removes a leaked slurry from the syngas, or a combination thereof.

17. A method, comprising:
   receiving a slurry at a first temperature through a first inlet of a heat exchanger,
   receiving a syngas at a second temperature through a second inlet of a heat exchanger, wherein the second temperature is higher than the first temperature; and
   exchanging heat from the syngas to the slurry through the walls of the heat exchanger to heat the slurry to a third temperature.

18. The method of claim 17, comprising controlling the third temperature of the slurry based on a flow rate of the slurry to the first inlet, based on the flow rate of the slurry to a gasifier, or a combination thereof.

19. The method of claim 17, comprising detecting a leaked slurry in the syngas or a leaked syngas in the slurry.

20. The method of claim 19, comprising flushing the heat exchanger of the leaked slurry or the leaked syngas by controlling one or more valves with a controller.