

SYSTEM AND METHOD FOR OPERATING POWER GENERATION SYSTEMS

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to power generation systems and, more particularly, to methods and systems for providing fuel for an integrated gasification combined cycle power generation system.

[0002] At least some known power generation systems humidify gases entering a gas turbine engine. The moisture in the humidified gas tends to increase the mass fed into the gas turbine engine such that an increase in the efficiency of the gas turbine engine is realized. The humidification of the gases uses energy for the vaporization of the water being added to the gas stream. Additionally, the power generation system may also dry the solid fuel being fed to the gasifier. Drying is typically performed by contacting an inert gas stream with the fuel prior to injection into the gasifier. The moisture in the fuel is vaporized using energy from the fuel. The energy used humidifying the gases and the energy used drying the fuel are lost to the system and the loss tends to decrease the efficiency of the system.

BRIEF DESCRIPTION OF THE INVENTION

[0003] In one embodiment, a fuel supply system includes a supply of a flow of fuel wherein the fuel includes an amount of moisture in a first predetermined range, a supply of a flow of gas wherein the gas includes an amount of moisture in a second predetermined range and wherein the second predetermined range is less than the first predetermined range. The fuel supply system further includes a vessel configured to receive the flow of fuel and the flow of gas, mix the flow of fuel and the flow of gas, and separate the flow of fuel from the flow of gas wherein moisture is transferred from the flow of fuel to the flow of gas.

[0004] In another embodiment, a method of operating a fuel supply system includes receiving a flow of carbonaceous fuel, the fuel comprising a first amount of moisture and mixing the flow of carbonaceous fuel with a flow of a gas

such that the first amount of moisture in the fuel is reduced and a second amount of moisture in the gas is increased. The flow of gas includes an amount of heat and at least some of the amount of heat is transferred to the flow of fuel during the mixing.

[0005] In yet another embodiment, an integrated gasifier combined cycle power system includes a fuel dryer configured to receive a flow of fuel, receive a flow of fluid, transfer moisture from the fuel to the gas, and transfer heat from the gas to the fuel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Figures 1-3 show exemplary embodiments of the method and system described herein.

[0007] Figure 1 is a schematic diagram of an exemplary integrated gasification combined-cycle (IGCC) power generation system;

[0008] Figure 2 is a schematic block diagram of a portion of the integrated gasification combined-cycle (IGCC) power generation system in accordance with an embodiment of the present invention; and

[0009] Figure 3 is a schematic block diagram of a portion of the integrated gasification combined-cycle (IGCC) power generation system in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0010] The following detailed description illustrates embodiments of the invention by way of example and not by way of limitation. It is contemplated that the invention has general application to conserving energy by using waste heat from one part of the process to replace heat in another part of the process in industrial, commercial, and residential applications.

[0011] As used herein, an element or step recited in the singular and proceeded with the word "a" or "an" should be understood as not excluding plural elements or steps, unless such exclusion is explicitly recited. Furthermore, references

to “one embodiment” of the present invention are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features.

[0012] Figure 1 is a schematic diagram of an exemplary integrated gasification combined-cycle (IGCC) power generation system 10. IGCC system 10 generally includes a main air compressor 12, an air separation unit (ASU) 14 coupled in flow communication to compressor 12, a gasifier 16 coupled in flow communication to ASU 14, a syngas cooler 18 coupled in flow communication to gasifier 16, a gas turbine engine 20 coupled in flow communication to syngas cooler 18, and a steam turbine 22 coupled in flow communication to syngas cooler 18. In various embodiments, gasifier 16 and syngas cooler 18 are combined into a single integral vessel.

[0013] In operation, compressor 12 compresses ambient air that is then channeled to ASU 14. In the exemplary embodiment, in addition to compressed air from compressor 12, compressed air from a gas turbine engine compressor 24 is supplied to ASU 14. Alternatively, compressed air from gas turbine engine compressor 24 is supplied to ASU 14, rather than compressed air from compressor 12 being supplied to ASU 14. In the exemplary embodiment, ASU 14 uses the compressed air to generate oxygen for use by gasifier 16. More specifically, ASU 14 separates the compressed air into separate flows of oxygen (O_2) and a gas by-product, sometimes referred to as a “process gas.” The O_2 flow is channeled to gasifier 16 for use in generating partially combusted gases, referred to herein as “syngas” for use by gas turbine engine 20 as fuel, as described below in more detail.

[0014] The process gas generated by ASU 14 includes nitrogen and will be referred to herein as “nitrogen process gas” (NPG). The NPG may also include other gases such as, but not limited to, oxygen and/or argon. For example, in the exemplary embodiment, the NPG includes between about 95% and about 100% nitrogen. In the exemplary embodiment, at least some of the NPG flow is vented to the atmosphere from ASU 14, and at some of the NPG flow is injected into a combustion zone (not shown) within a gas turbine engine combustor 26 to facilitate

controlling emissions of engine 20, and more specifically to facilitate reducing the combustion temperature and reducing nitrous oxide emissions from engine 20. In the exemplary embodiment, IGCC system 10 includes a compressor 28 for compressing the nitrogen process gas flow before being injected into the combustion zone of gas turbine engine combustor 26.

[0015] In the exemplary embodiment, gasifier 16 converts a mixture of fuel supplied from a fuel supply 30, O₂ supplied by ASU 14, steam, and/or limestone into an output of syngas for use by gas turbine engine 20 as fuel. Although gasifier 16 may use any fuel, gasifier 16, in the exemplary embodiment, uses coal, petroleum coke, residual oil, oil emulsions, tar sands, and/or other similar fuels. Furthermore, in the exemplary embodiment, the syngas generated by gasifier 16 includes carbon dioxide. Gasifier 16 may be a fixed-bed gasifier, a fluidized-bed gasifier, and/or an entrained gasifier.

[0016] In the exemplary embodiment, syngas generated by gasifier 16 is channeled to syngas cooler 18 to facilitate cooling the syngas, as described in more detail below. The cooled syngas is channeled from syngas cooler 18 to a scrubber, and through additional cooling to a clean-up device 32 for cleaning the syngas before it is channeled to gas turbine engine combustor 26 for combustion thereof. Hydrogen sulfide (H₂S) is separated from the syngas during cleanup and is sent to a processing unit where it is converted to products, typically sulfur or sulfuric acid. Carbon dioxide (CO₂) may also be separated from the syngas during clean-up and, in the exemplary embodiment, may be vented to the atmosphere. Gas turbine engine 20 drives a generator 34 that supplies electrical power to a power grid (not shown). Exhaust gases from gas turbine engine 20 are channeled to a heat recovery steam generator 36 that generates and superheats steam for driving steam turbine 22. Power generated by steam turbine 22 drives an electrical generator 38 that provides electrical power to the power grid.

[0017] Furthermore, in the exemplary embodiment, system 10 includes a pump 40 that supplies preheated water from steam generator 36 to syngas cooler 18 to facilitate cooling the syngas channeled from gasifier 16. The boiled

water is channeled through syngas cooler 18 wherein the water is converted to steam. The steam from syngas cooler 18 is then returned to steam generator 36 for use within gasifier 16, syngas cooler 18, and/or steam turbine 22.

[0018] Figure 2 is a schematic block diagram of a portion of integrated gasification combined-cycle (IGCC) power generation system 10 (shown in Figure 1) in accordance with an embodiment of the present invention. In the exemplary embodiment, IGCC power generation system 10 includes a fuel dryer 200 in serial flow communication between fuel supply 30 and gasifier 16. Fuel dryer 200 is also in serial flow communication between syngas cooler 18 and clean-up device 32. Fuel dryer 200 is configured to receive a flow of relatively cool and wet fuel from fuel supply 30 and a flow of relatively hot and dry syngas from syngas cooler 18. The flows of syngas and fuel are encouraged to mix in fuel dryer 200 such that the syngas and fuel come into close contact with each other. During the close contact, heat is transferred from the syngas to the fuel, drying the fuel before it is channeled out of fuel dryer 200 and on to gasifier 16. Also during the close contact, moisture is transferred from the fuel to the syngas moisturizing the syngas before it is channeled out of fuel dryer 200 and on to clean-up device 32 and combustor 26. In an embodiment, an auxiliary cleanup device 202 is provided in serial flow communication between fuel dryer 200 and clean-up device 32. Auxiliary cleanup device 202 is configured to remove solids and particulates entrained in the syngas in fuel dryer 200 during the close contact between the fuel and the syngas.

[0019] Figure 3 is a schematic block diagram of a portion of integrated gasification combined-cycle (IGCC) power generation system 10 (shown in Figure 1) in accordance with another embodiment of the present invention. In the exemplary embodiment, IGCC power generation system 10 includes a fuel dryer 200 in serial flow communication between fuel supply 30 and gasifier 16. Fuel dryer 200 is also in serial flow communication between air separation unit (ASU) 14 and combustor 26. Fuel dryer 200 is configured to receive a flow of relatively cool and wet fuel from fuel supply 30 and a flow of relatively hot and dry nitrogen process gas (NPG) from ASU 14. The flows of NPG and fuel are encouraged to mix in fuel dryer 200 such that the NPG and fuel come into close contact with each other. During the

close contact, heat is transferred from the NPG to the fuel, preheating the fuel before it is channeled out of fuel dryer 200 and on to gasifier 16. Also during the close contact, moisture is transferred from the fuel to the NPG, moisturizing the NPG before it is channeled out of fuel dryer 200 and on to combustor 26. In an embodiment, an auxiliary cleanup device 202 is provided in serial flow communication between fuel dryer 200 and combustor 26. Optional auxiliary cleanup device 202 is configured to remove solids and particulates entrained in the NPG in fuel dryer 200 during the close contact between the fuel and the NPG. In various embodiments, compressor 28 is positioned in serial flow communication between fuel dryer 200 and auxiliary cleanup device 202, if used. Compressor 28 is used for compressing the NPG flow before being injected into the combustion zone of gas turbine engine combustor 26.

[0020] Although the source of preheat and drying of the fuel is described above as being syngas and/or NPG, it should be understood that any source of relatively dry gas may be used to dry and/or preheat the flow of fuel entering gasifier 16. In addition, the fuel may be stored in a hopper or silo after drying and before being injected into gasifier 16. In the exemplary embodiment, fuel dryer 200 comprises a stationary vessel. In an alternative embodiment, fuel dryer 200 comprises a movable vessel that may rotate about a longitudinal axis.

[0021] The above-described embodiments of a method and system of power generation systems provides a cost-effective and reliable means increasing the efficiency of the power generation system by using heat that would otherwise be lost to the system to perform useful work. More specifically, the methods and systems described herein facilitate drying relatively wet fuel using relatively hot and dry gases in the process that will otherwise be cooled and humidified using energy from the system. In addition, the above-described methods and systems facilitate humidifying the gas using moisture that would otherwise be discharged from the system. As a result, the methods and systems described herein facilitate increasing the efficiency of the power generation system in a cost-effective and reliable manner.

[0022] An exemplary methods and apparatus for drying fuel in a power generation system using gases being fed into the power generation system gas turbine engine to increase mass flow through the gas turbine engine are described above in detail. The systems illustrated are not limited to the specific embodiments described herein, but rather, components of each may be utilized independently and separately from other components described herein. Each system component can also be used in combination with other system components.

[0023] While the disclosure has been described in terms of various specific embodiments, it will be recognized that the disclosure can be practiced with modification within the spirit and scope of the claims.

WHAT IS CLAIMED IS:

1. A fuel supply system comprising:

a supply of a flow of fuel, said fuel comprising an amount of moisture in a first predetermined range;

a supply of a flow of gas, said gas comprising an amount of moisture in a second predetermined range, the second predetermined range being less than the first predetermined range; and

a vessel configured to:

receive said flow of fuel and said flow of gas;

mix said flow of fuel and said flow of gas; and

separate said flow of fuel from said flow of gas

wherein moisture is transferred from said flow of fuel to said flow of gas.
2. A system in accordance with Claim 1 wherein heat is transferred from said flow of gas to said flow of fuel.
3. A system in accordance with Claim 1 wherein said vessel comprises a longitudinal axis, said vessel rotatable about said longitudinal axis.
4. A system in accordance with Claim 1 wherein said flow of gas comprises a flow of nitrogen.
5. A system in accordance with Claim 1 wherein said flow of fuel comprises a flow of a carbonaceous fuel.
6. A system in accordance with Claim 1 wherein said flow of fuel comprises a flow of at least one of a solid and a liquid carbonaceous fuel.

7. A system in accordance with Claim 1 wherein said flow of gas comprises a flow of syngas.

8. A system in accordance with Claim 1 further comprising a cleanup device downstream of said vessel, said cleanup device configured to remove particles of fuel from the flow of gas exiting the vessel.

9. A method of operating a fuel supply system, said method comprising:

receiving a flow of carbonaceous fuel, the fuel comprising a first amount of moisture; and

mixing the flow of carbonaceous fuel with a flow of a gas such that the first amount of moisture in the fuel is reduced and a second amount of moisture in the gas is increased, the flow of gas comprising an amount of heat wherein at least some of the amount of heat is transferred to the flow of fuel during the mixing.

10. A method in accordance with Claim 9 wherein receiving a flow of carbonaceous fuel comprises receiving a flow of coal.

11. A method in accordance with Claim 9 wherein mixing the flow of carbonaceous fuel comprises mixing the flow of carbonaceous fuel with a flow of nitrogen.

12. A method in accordance with Claim 9 wherein mixing the flow of carbonaceous fuel with a flow of a gas comprises mixing the flow of carbonaceous fuel with a flow of syngas.

13. A method in accordance with Claim 9 wherein mixing the flow of carbonaceous fuel with a flow of a gas comprises mixing the flow of carbonaceous fuel with a flow of a gas in a vessel.

14. A method in accordance with Claim 9 wherein mixing the flow of carbonaceous fuel with a flow of a gas comprises mixing the flow of carbonaceous fuel with a flow of a gas in a vessel rotatable about a longitudinal axis of the vessel.

15. An integrated gasifier combined cycle power system comprising a fuel dryer configured to:

receive a flow of fuel;

receive a flow of fluid;

transfer moisture from the fuel to the gas; and

transfer heat from the gas to the fuel.

16. A system in accordance with Claim 15 further comprising a separator configured to separate at least a portion of the flow of fuel from the flow of fluid.

17. A system in accordance with Claim 15 wherein said fuel dryer comprises a longitudinal axis, said fuel dryer rotatable about said longitudinal axis.

18. A system in accordance with Claim 15 wherein said flow of fluid comprises a flow of at least one of a solid and a liquid carbonaceous fuel.

19. A system in accordance with Claim 15 wherein said flow of fluid comprises a flow of syngas.

20. A system in accordance with Claim 15 wherein said separator is positioned downstream of said fuel dryer, said separator configured to remove particles of fuel from the flow of fluid exiting the fuel dryer.

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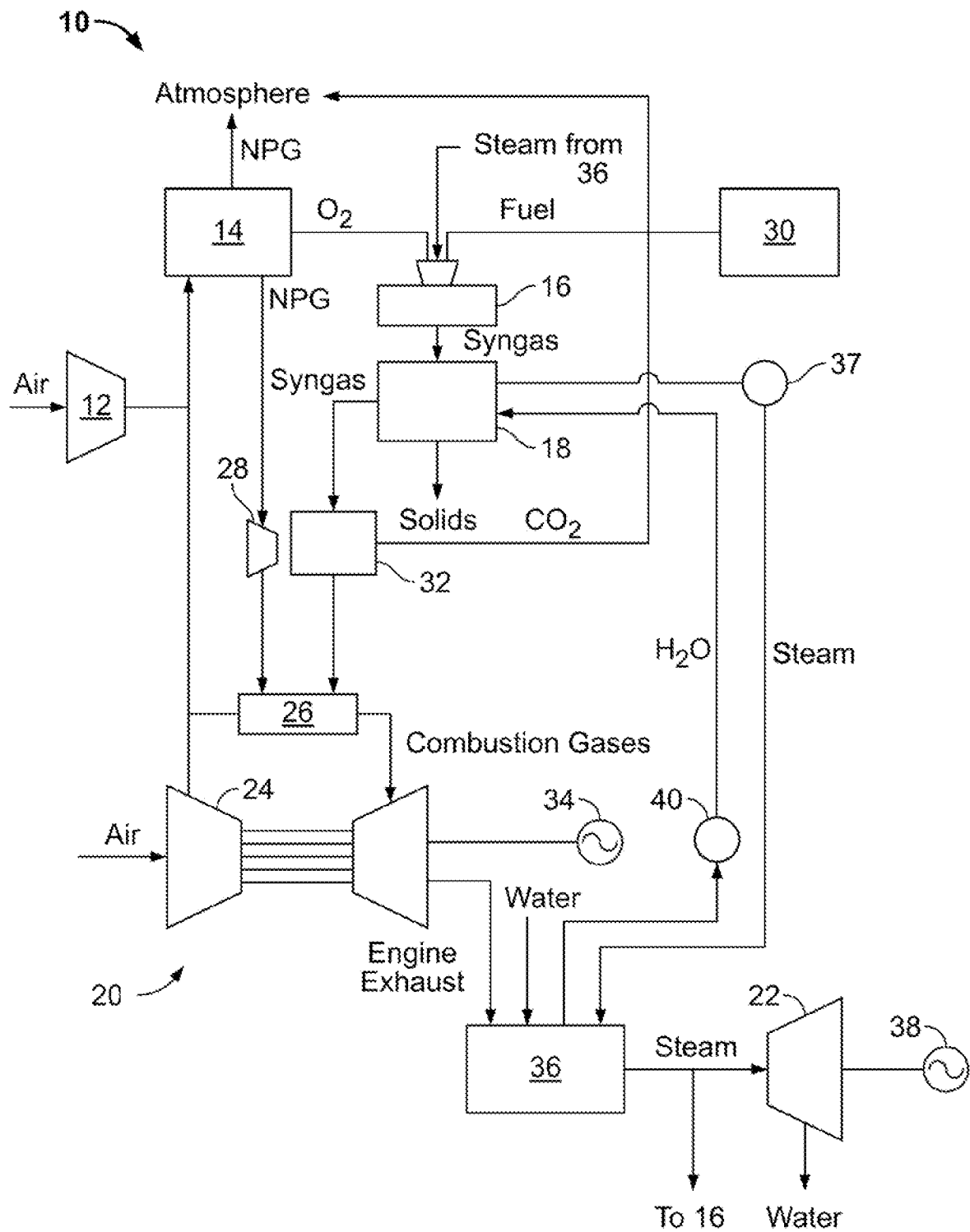


FIG. 1

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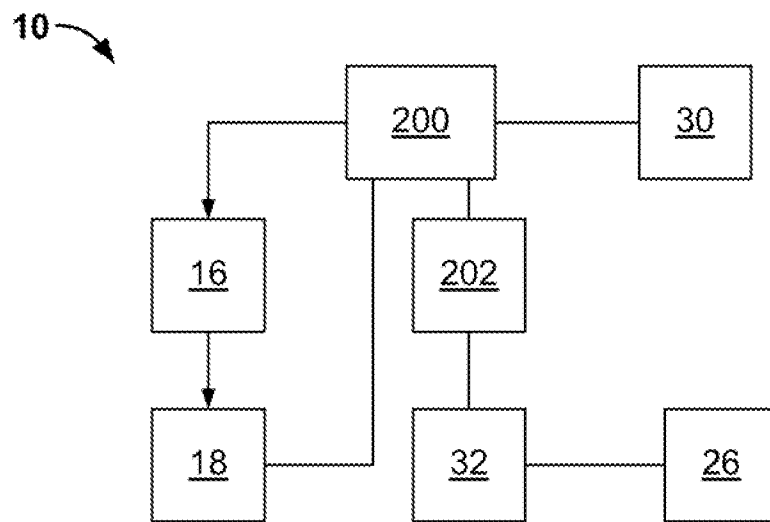


FIG. 2

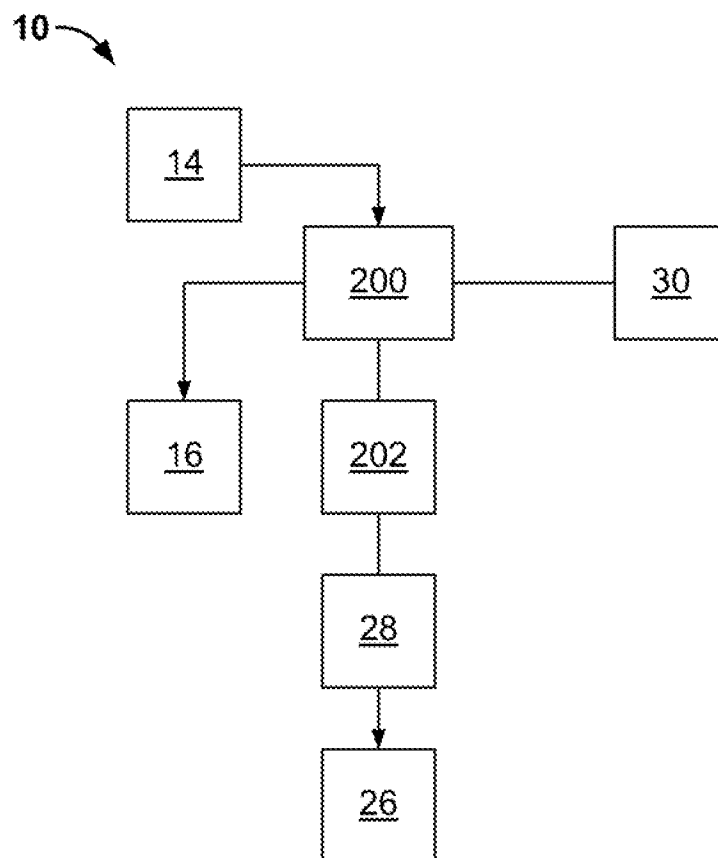


FIG. 3