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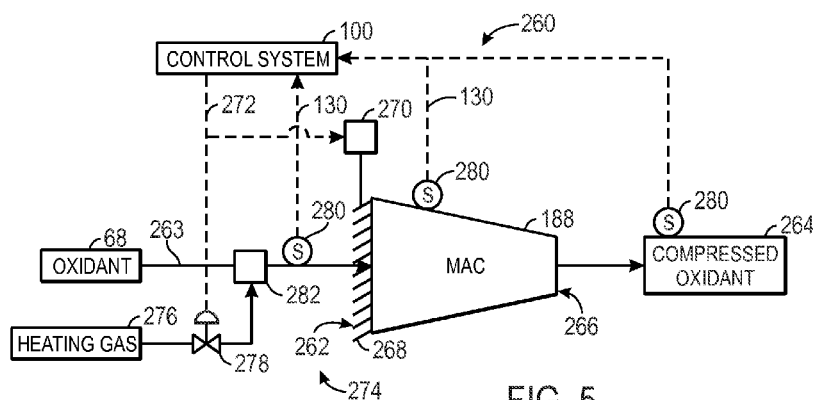
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**(54) Title:** SYSTEM AND METHOD FOR AN OXIDANT HEATING SYSTEM



**(57) Abstract:** A system includes an oxidant compressor and a gas turbine engine. The gas turbine engine includes a combustor section having a turbine combustor, a turbine driven by combustion products from the turbine combustor, and an exhaust gas compressor driven by the turbine. The exhaust gas compressor is configured to compress and route an exhaust flow to the turbine combustor and the oxidant compressor is configured to compress and route an oxidant flow to the turbine combustor. The gas turbine engine also includes an inlet oxidant heating system configured to route at least one of a first portion of the combustion products, or a second portion of the exhaust flow, or any combination thereof, to an inlet of the oxidant compressor.

## SYSTEM AND METHOD FOR AN OXIDANT HEATING SYSTEM

### CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims priority to and benefit of U.S. Provisional Patent Application No. 61/860,853, entitled “SYSTEM AND METHOD FOR AN OXIDANT HEATING SYSTEM,” filed on July 31, 2013, and U.S. Non-Provisional Patent Application No. 14/314,601, entitled “SYSTEM AND METHOD FOR AN OXIDANT HEATING SYSTEM,” filed June 25, 2014, all of which are hereby incorporated by reference in their entirety for all purposes.

### BACKGROUND

**[0002]** The subject matter disclosed herein relates to gas turbine engines, and more specifically, to systems and methods for an oxidant heating system for gas turbine engines.

**[0003]** Gas turbine engines are used in a wide variety of applications, such as power generation, aircraft, and various machinery. Gas turbine engines generally combust a fuel with an oxidant (e.g., air) in a combustor section to generate hot combustion products, which then drive one or more turbine stages of a turbine section. In turn, the turbine section drives one or more compressor stages of a compressor section. Again, the fuel and oxidant mix in the combustor section, and then combust to produce the hot combustion products. Under certain conditions, such as low temperatures, the compressor section may be susceptible to undesirable issues, such as icing and/or surging. Therefore, it may be desirable to increase an inlet temperature of the compressor section to reduce issues associated with low temperatures. Furthermore, gas turbine engines typically consume a vast amount of air as the oxidant, and output a considerable amount of exhaust gas into the atmosphere. In other words, the exhaust gas is typically wasted as a byproduct of the gas turbine operation.

## BRIEF DESCRIPTION

**[0004]** 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.

**[0005]** In a first embodiment, a system includes an oxidant compressor and a gas turbine engine. The gas turbine engine includes a combustor section having a turbine combustor, a turbine driven by combustion products from the turbine combustor, and an exhaust gas compressor driven by an exhaust flow discharged from the turbine. The exhaust gas compressor is configured to compress and route a first portion of the exhaust flow to the turbine combustor and the oxidant compressor is configured to compress and route an oxidant flow to the turbine combustor. The gas turbine engine also includes an inlet oxidant heating system, coupled to a plurality of heating gas sources, comprising a combustion products extraction conduit disposed between the turbine combustor and the turbine and an exhaust flow extraction conduit disposed between the turbine and the exhaust gas compressor. The inlet oxidant heating system is configured to route at least one of a first portion of the combustion products through the combustion products extraction conduit, or a second portion of the exhaust flow through the exhaust flow extraction conduit, or both, to an inlet of the oxidant compressor.

**[0006]** In a second embodiment, a method includes driving a turbine of a gas turbine engine with combustion products from a turbine combustor, driving an exhaust gas compressor using the turbine, compressing and routing an exhaust flow to the turbine combustor using the exhaust gas compressor, compressing and routing an oxidant flow to the turbine combustor using an oxidant compressor, and routing at least one of a first portion of the combustion products, or a second portion of the exhaust flow, or any combination thereof, to an inlet of the oxidant compressor.

[0007] In a third embodiment, a system includes instructions disposed on a non-transitory, machine readable medium. The instructions are configured to drive a turbine of a gas turbine engine with combustion products from a turbine combustor, drive an exhaust gas compressor using the turbine, compress and route an exhaust flow to the turbine combustor using the exhaust gas compressor, compress and route

an oxidant flow to the turbine combustor using an oxidant compressor, and route at least one of a first portion of the combustion products, or a second portion of the exhaust flow, or any combination thereof, to an inlet of the oxidant compressor.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0008] 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:

[0009] FIG. 1 is a diagram of an embodiment of a system having a turbine-based service system coupled to a hydrocarbon production system;

[0010] FIG. 2 is a diagram of an embodiment of the system of FIG. 1, further illustrating a control system and a combined cycle system;

[0011] FIG. 3 is a diagram of an embodiment of the system of FIGS. 1 and 2, further illustrating details of a gas turbine engine, exhaust gas supply system, and exhaust gas processing system;

[0012] FIG. 4 is a flow chart of an embodiment of a process for operating the system of FIGS. 1-3;

[0013] FIG. 5 is a schematic diagram of an embodiment of an oxidant compressor of a gas turbine system with an inlet oxidant heating system;

[0014] FIG. 6 is a schematic diagram of an embodiment of a gas turbine engine system with an inlet oxidant heating system; and

[0015] FIG. 7 is a schematic diagram of an embodiment of a gas turbine engine system with an inlet oxidant heating system with a plurality of heating sources.

## DETAILED DESCRIPTION

**[0016]** 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 an engineering or design project, numerous implementation-specific decisions are made to achieve the specific goals, such as compliance with system-related and/or business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such 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.

**[0017]** Detailed example embodiments are disclosed herein. However, specific structural and functional details disclosed herein are merely representative for purposes of describing example embodiments. Embodiments of the present invention may, however, be embodied in many alternate forms, and should not be construed as limited to only the embodiments set forth herein.

**[0018]** Accordingly, while example embodiments are capable of various modifications and alternative forms, embodiments thereof are illustrated by way of example in the figures and will herein be described in detail. It should be understood, however, that there is no intent to limit example embodiments to the particular forms disclosed, but to the contrary, example embodiments are to cover all modifications, equivalents, and alternatives falling within the scope of the present invention.

**[0019]** The terminology used herein is for describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms “comprises”, “comprising”, “includes” and/or “including”, when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude

the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

**[0020]** Although the terms first, second, primary, secondary, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, but not limiting to, a first element could be termed a second element, and, similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term “and/or” includes any, and all, combinations of one or more of the associated listed items.

**[0021]** Certain terminology may be used herein for the convenience of the reader only and is not to be taken as a limitation on the scope of the invention. For example, words such as “upper”, “lower”, “left”, “right”, “front”, “rear”, “top”, “bottom”, “horizontal”, “vertical”, “upstream”, “downstream”, “fore”, “aft”, and the like; merely describe the configuration shown in the FIGS. Indeed, the element or elements of an embodiment of the present invention may be oriented in any direction and the terminology, therefore, should be understood as encompassing such variations unless specified otherwise.

**[0022]** As discussed in detail below, the disclosed embodiments relate generally to gas turbine systems with exhaust gas recirculation (EGR), and particularly stoichiometric operation of the gas turbine systems using EGR. For example, the gas turbine systems may be configured to recirculate the exhaust gas along an exhaust recirculation path, stoichiometrically combust fuel and oxidant along with at least some of the recirculated exhaust gas, and capture the exhaust gas for use in various target systems. The recirculation of the exhaust gas along with stoichiometric combustion may help to increase the concentration level of carbon dioxide (CO<sub>2</sub>) in the exhaust gas, which can then be post treated to separate and purify the CO<sub>2</sub> and nitrogen (N<sub>2</sub>) for use in various target systems. The gas turbine systems also may employ various exhaust gas processing (e.g., heat recovery, catalyst reactions, etc.) along the exhaust recirculation path, thereby increasing the concentration level of CO<sub>2</sub>, reducing concentration levels of other emissions (e.g., carbon monoxide,



nitrogen oxides, and unburnt hydrocarbons), and increasing energy recovery (e.g., with heat recovery units). Furthermore, the gas turbine engines may be configured to combust the fuel and oxidant with one or more diffusion flames (e.g., using diffusion fuel nozzles), premix flames (e.g., using premix fuel nozzles), or any combination thereof. In certain embodiments, the diffusion flames may help to maintain stability and operation within certain limits for stoichiometric combustion, which in turn helps to increase production of CO<sub>2</sub>. For example, a gas turbine system operating with diffusion flames may enable a greater quantity of EGR, as compared to a gas turbine system operating with premix flames. In turn, the increased quantity of EGR helps to increase CO<sub>2</sub> production. Possible target systems include pipelines, storage tanks, carbon sequestration systems, and hydrocarbon production systems, such as enhanced oil recovery (EOR) systems.

**[0023]** The disclosed embodiments provide systems and methods for an inlet oxidant heating system used with a gas turbine engine with EGR. Specifically, the gas turbine engine may include a combustor section having a turbine combustor, a turbine driven by combustion products from the turbine combustor, and an exhaust gas compressor driven by the turbine. The exhaust gas compressor may compress and route an exhaust flow from the turbine to the turbine combustor and an oxidant compressor may compress and route an oxidant flow to the turbine combustor. The inlet oxidant heating system may route at least one of a first portion of the combustion products, or a second portion of the exhaust flow, or any combination thereof, to an inlet of the oxidant compressor. For example, the inlet of the oxidant compressor may convey ambient air to the oxidant compressor to be compressed and routed to the turbine combustor. A temperature of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, may be greater than a temperature of the ambient air. Thus, by combining the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, with the ambient air, the inlet oxidant heating system may increase a temperature of the mixture entering the oxidant compressor. In some embodiments, the first portion of the combustion products, or a second portion of the exhaust flow, or any combination thereof, may come from the gas turbine engine with EGR or one or more other gas

turbine engines, such as gas turbine engines located in parallel trains, which may or may not have EGR.

**[0024]** By increasing the temperature of the mixture entering the oxidant compressor, the inlet oxidant heating system may help prevent certain undesirable issues associated with low ambient temperatures, such as icing and/or surging. Specifically, icing may occur when low ambient air temperatures cause water vapor in the ambient air to freeze upon contact with components of the oxidant compressor. The ice may build up until the ice breaks off and enters the moving components of the oxidant compressor, possibly affecting operation of the oxidant compressor. Surging may occur when the oxidant compressor is unable to compress the oxidant to a desired pressure, thereby causing a flow reversal, which may affect operation of the oxidant compressor. By heating the mixture entering the oxidant compressor, the oxidant heating system may help prevent icing by avoiding conditions at which water may freeze on the components of the oxidant compressor. In addition, the use of the inlet oxidant heating system may enable inlet guide vanes of the oxidant compressor to operate in a more open position, thereby helping to prevent conditions at which surging may occur. Although other methods may be used to heat the oxidant entering the oxidant compressor, use of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, may be desirable because these gases are readily available at temperatures and pressures that make them useful for heating the oxidant. In addition, these gases may be compatible with the oxidant being compressed in the oxidant compressor and routed to the turbine combustor of the gas turbine engine. Thus, use of the inlet oxidant heating system may increase the overall efficiency of the SEGR gas turbine system and/or reduce operating costs of the SEGR gas turbine system.

**[0025]** FIG. 1 is a diagram of an embodiment of a system 10 having an hydrocarbon production system 12 associated with a turbine-based service system 14. As discussed in further detail below, various embodiments of the turbine-based service system 14 are configured to provide various services, such as electrical power, mechanical power, and fluids (e.g., exhaust gas), to the hydrocarbon production system 12 to facilitate the production or retrieval of oil and/or gas. In the illustrated

embodiment, the hydrocarbon production system 12 includes an oil/gas extraction system 16 and an enhanced oil recovery (EOR) system 18, which are coupled to a subterranean reservoir 20 (e.g., an oil, gas, or hydrocarbon reservoir). The oil/gas extraction system 16 includes a variety of surface equipment 22, such as a Christmas tree or production tree 24, coupled to an oil/gas well 26. Furthermore, the well 26 may include one or more tubulars 28 extending through a drilled bore 30 in the earth 32 to the subterranean reservoir 20. The tree 24 includes one or more valves, chokes, isolation sleeves, blowout preventers, and various flow control devices, which regulate pressures and control flows to and from the subterranean reservoir 20. While the tree 24 is generally used to control the flow of the production fluid (e.g., oil or gas) out of the subterranean reservoir 20, the EOR system 18 may increase the production of oil or gas by injecting one or more fluids into the subterranean reservoir 20.

**[0026]** Accordingly, the EOR system 18 may include a fluid injection system 34, which has one or more tubulars 36 extending through a bore 38 in the earth 32 to the subterranean reservoir 20. For example, the EOR system 18 may route one or more fluids 40, such as gas, steam, water, chemicals, or any combination thereof, into the fluid injection system 34. For example, as discussed in further detail below, the EOR system 18 may be coupled to the turbine-based service system 14, such that the system 14 routes an exhaust gas 42 (e.g., substantially or entirely free of oxygen) to the EOR system 18 for use as the injection fluid 40. The fluid injection system 34 routes the fluid 40 (e.g., the exhaust gas 42) through the one or more tubulars 36 into the subterranean reservoir 20, as indicated by arrows 44. The injection fluid 40 enters the subterranean reservoir 20 through the tubular 36 at an offset distance 46 away from the tubular 28 of the oil/gas well 26. Accordingly, the injection fluid 40 displaces the oil/gas 48 disposed in the subterranean reservoir 20, and drives the oil/gas 48 up through the one or more tubulars 28 of the hydrocarbon production system 12, as indicated by arrows 50. As discussed in further detail below, the injection fluid 40 may include the exhaust gas 42 originating from the turbine-based service system 14, which is able to generate the exhaust gas 42 on-site as needed by the hydrocarbon production system 12. In other words, the turbine-based system 14

may simultaneously generate one or more services (e.g., electrical power, mechanical power, steam, water (e.g., desalinated water), and exhaust gas (e.g., substantially free of oxygen)) for use by the hydrocarbon production system 12, thereby reducing or eliminating the reliance on external sources of such services.

**[0027]** In the illustrated embodiment, the turbine-based service system 14 includes a stoichiometric exhaust gas recirculation (SEGR) gas turbine system 52 and an exhaust gas (EG) processing system 54. The gas turbine system 52 may be configured to operate in a stoichiometric combustion mode of operation (e.g., a stoichiometric control mode) and a non-stoichiometric combustion mode of operation (e.g., a non-stoichiometric control mode), such as a fuel-lean control mode or a fuel-rich control mode. In the stoichiometric control mode, the combustion generally occurs in a substantially stoichiometric ratio of a fuel and oxidant, thereby resulting in substantially stoichiometric combustion. In particular, stoichiometric combustion generally involves consuming substantially all of the fuel and oxidant in the combustion reaction, such that the products of combustion are substantially or entirely free of unburnt fuel and oxidant. One measure of stoichiometric combustion is the equivalence ratio, or  $\phi$  ( $\Phi$ ), which is the ratio of the actual fuel/oxidant ratio relative to the stoichiometric fuel/oxidant ratio. An equivalence ratio of greater than 1.0 results in a fuel-rich combustion of the fuel and oxidant, whereas an equivalence ratio of less than 1.0 results in a fuel-lean combustion of the fuel and oxidant. In contrast, an equivalence ratio of 1.0 results in combustion that is neither fuel-rich nor fuel-lean, thereby substantially consuming all of the fuel and oxidant in the combustion reaction. In context of the disclosed embodiments, the term stoichiometric or substantially stoichiometric may refer to an equivalence ratio of approximately 0.95 to approximately 1.05. However, the disclosed embodiments may also include an equivalence ratio of 1.0 plus or minus 0.01, 0.02, 0.03, 0.04, 0.05, or more. Again, the stoichiometric combustion of fuel and oxidant in the turbine-based service system 14 may result in products of combustion or exhaust gas (e.g., 42) with substantially no unburnt fuel or oxidant remaining. For example, the exhaust gas 42 may have less than 1, 2, 3, 4, or 5 percent by volume of oxidant (e.g., oxygen), unburnt fuel or hydrocarbons (e.g., HCs), nitrogen oxides (e.g.,  $\text{NO}_x$ ), carbon monoxide (CO), sulfur

oxides (e.g., SO<sub>x</sub>), hydrogen, and other products of incomplete combustion. By further example, the exhaust gas 42 may have less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 1000, 2000, 3000, 4000, or 5000 parts per million by volume (ppmv) of oxidant (e.g., oxygen), unburnt fuel or hydrocarbons (e.g., HCs), nitrogen oxides (e.g., NO<sub>x</sub>), carbon monoxide (CO), sulfur oxides (e.g., SO<sub>x</sub>), hydrogen, and other products of incomplete combustion. However, the disclosed embodiments also may produce other ranges of residual fuel, oxidant, and other emissions levels in the exhaust gas 42. As used herein, the terms emissions, emissions levels, and emissions targets may refer to concentration levels of certain products of combustion (e.g., NO<sub>x</sub>, CO, SO<sub>x</sub>, O<sub>2</sub>, N<sub>2</sub>, H<sub>2</sub>, HCs, etc.), which may be present in recirculated gas streams, vented gas streams (e.g., exhausted into the atmosphere), and gas streams used in various target systems (e.g., the hydrocarbon production system 12).

**[0028]** Although the SEGR gas turbine system 52 and the EG processing system 54 may include a variety of components in different embodiments, the illustrated EG processing system 54 includes a heat recovery steam generator (HRSG) 56 and an exhaust gas recirculation (EGR) system 58, which receive and process an exhaust gas 60 originating from the SEGR gas turbine system 52. The HRSG 56 may include one or more heat exchangers, condensers, and various heat recovery equipment, which collectively function to transfer heat from the exhaust gas 60 to a stream of water, thereby generating steam 62. The steam 62 may be used in one or more steam turbines, the EOR system 18, or any other portion of the hydrocarbon production system 12. For example, the HRSG 56 may generate low pressure, medium pressure, and/or high pressure steam 62, which may be selectively applied to low, medium, and high pressure steam turbine stages, or different applications of the EOR system 18. In addition to the steam 62, a treated water 64, such as a desalinated water, may be generated by the HRSG 56, the EGR system 58, and/or another portion of the EG processing system 54 or the SEGR gas turbine system 52. The treated water 64 (e.g., desalinated water) may be particularly useful in areas with water shortages, such as inland or desert regions. The treated water 64 may be generated, at least in part, due to the large volume of air driving combustion of fuel within the SEGR gas turbine

system 52. While the on-site generation of steam 62 and water 64 may be beneficial in many applications (including the hydrocarbon production system 12), the on-site generation of exhaust gas 42, 60 may be particularly beneficial for the EOR system 18, due to its low oxygen content, high pressure, and heat derived from the SEGR gas turbine system 52. Accordingly, the HRSG 56, the EGR system 58, and/or another portion of the EG processing system 54 may output or recirculate an exhaust gas 66 into the SEGR gas turbine system 52, while also routing the exhaust gas 42 to the EOR system 18 for use with the hydrocarbon production system 12. Likewise, the exhaust gas 42 may be extracted directly from the SEGR gas turbine system 52 (i.e., without passing through the EG processing system 54) for use in the EOR system 18 of the hydrocarbon production system 12.

**[0029]** The exhaust gas recirculation is handled by the EGR system 58 of the EG processing system 54. For example, the EGR system 58 includes one or more conduits, valves, blowers, exhaust gas treatment systems (e.g., filters, particulate removal units, gas separation units, gas purification units, heat exchangers, heat recovery units, moisture removal units, catalyst units, chemical injection units, or any combination thereof), and controls to recirculate the exhaust gas along an exhaust gas circulation path from an output (e.g., discharged exhaust gas 60) to an input (e.g., intake exhaust gas 66) of the SEGR gas turbine system 52. In the illustrated embodiment, the SEGR gas turbine system 52 intakes the exhaust gas 66 into a compressor section having one or more compressors, thereby compressing the exhaust gas 66 for use in a combustor section along with an intake of an oxidant 68 and one or more fuels 70. The oxidant 68 may include ambient air, pure oxygen, oxygen-enriched air, oxygen-reduced air, oxygen-nitrogen mixtures, or any suitable oxidant that facilitates combustion of the fuel 70. The fuel 70 may include one or more gas fuels, liquid fuels, or any combination thereof. For example, the fuel 70 may include natural gas, liquefied natural gas (LNG), syngas, methane, ethane, propane, butane, naphtha, kerosene, diesel fuel, ethanol, methanol, biofuel, or any combination thereof.

**[0030]** The SEGR gas turbine system 52 mixes and combusts the exhaust gas 66, the oxidant 68, and the fuel 70 in the combustor section, thereby generating hot combustion gases or exhaust gas 60 to drive one or more turbine stages in a turbine

section. In certain embodiments, each combustor in the combustor section includes one or more premix fuel nozzles, one or more diffusion fuel nozzles, or any combination thereof. For example, each premix fuel nozzle may be configured to mix the oxidant 68 and the fuel 70 internally within the fuel nozzle and/or partially upstream of the fuel nozzle, thereby injecting an oxidant-fuel mixture from the fuel nozzle into the combustion zone for a premixed combustion (e.g., a premixed flame). By further example, each diffusion fuel nozzle may be configured to isolate the flows of oxidant 68 and fuel 70 within the fuel nozzle, thereby separately injecting the oxidant 68 and the fuel 70 from the fuel nozzle into the combustion zone for diffusion combustion (e.g., a diffusion flame). In particular, the diffusion combustion provided by the diffusion fuel nozzles delays mixing of the oxidant 68 and the fuel 70 until the point of initial combustion, i.e., the flame region. In embodiments employing the diffusion fuel nozzles, the diffusion flame may provide increased flame stability, because the diffusion flame generally forms at the point of stoichiometry between the separate streams of oxidant 68 and fuel 70 (i.e., as the oxidant 68 and fuel 70 are mixing). In certain embodiments, one or more diluents (e.g., the exhaust gas 60, steam, nitrogen, or another inert gas) may be pre-mixed with the oxidant 68, the fuel 70, or both, in either the diffusion fuel nozzle or the premix fuel nozzle. In addition, one or more diluents (e.g., the exhaust gas 60, steam, nitrogen, or another inert gas) may be injected into the combustor at or downstream from the point of combustion within each combustor. The use of these diluents may help temper the flame (e.g., premix flame or diffusion flame), thereby helping to reduce NO<sub>x</sub> emissions, such as nitrogen monoxide (NO) and nitrogen dioxide (NO<sub>2</sub>). Regardless of the type of flame, the combustion produces hot combustion gases or exhaust gas 60 to drive one or more turbine stages. As each turbine stage is driven by the exhaust gas 60, the SEGR gas turbine system 52 generates a mechanical power 72 and/or an electrical power 74 (e.g., via an electrical generator). The system 52 also outputs the exhaust gas 60, and may further output water 64. Again, the water 64 may be a treated water, such as a desalinated water, which may be useful in a variety of applications on-site or off-site.

**[0031]** Exhaust extraction is also provided by the SEGR gas turbine system 52 using one or more extraction points 76. For example, the illustrated embodiment

includes an exhaust gas (EG) supply system 78 having an exhaust gas (EG) extraction system 80 and an exhaust gas (EG) treatment system 82, which receive exhaust gas 42 from the extraction points 76, treat the exhaust gas 42, and then supply or distribute the exhaust gas 42 to various target systems. The target systems may include the EOR system 18 and/or other systems, such as a pipeline 86, a storage tank 88, or a carbon sequestration system 90. The EG extraction system 80 may include one or more conduits, valves, controls, and flow separations, which facilitate isolation of the exhaust gas 42 from the oxidant 68, the fuel 70, and other contaminants, while also controlling the temperature, pressure, and flow rate of the extracted exhaust gas 42. The EG treatment system 82 may include one or more heat exchangers (e.g., heat recovery units such as heat recovery steam generators, condensers, coolers, or heaters), catalyst systems (e.g., oxidation catalyst systems), particulate and/or water removal systems (e.g., gas dehydration units, inertial separators, coalescing filters, water impermeable filters, and other filters), chemical injection systems, solvent based treatment systems (e.g., absorbers, flash tanks, etc.), carbon capture systems, gas separation systems, gas purification systems, and/or a solvent based treatment system, exhaust gas compressors, any combination thereof. These subsystems of the EG treatment system 82 enable control of the temperature, pressure, flow rate, moisture content (e.g., amount of water removal), particulate content (e.g., amount of particulate removal), and gas composition (e.g., percentage of CO<sub>2</sub>, N<sub>2</sub>, etc.).

**[0032]** The extracted exhaust gas 42 is treated by one or more subsystems of the EG treatment system 82, depending on the target system. For example, the EG treatment system 82 may direct all or part of the exhaust gas 42 through a carbon capture system, a gas separation system, a gas purification system, and/or a solvent based treatment system, which is controlled to separate and purify a carbonaceous gas (e.g., carbon dioxide) 92 and/or nitrogen (N<sub>2</sub>) 94 for use in the various target systems. For example, embodiments of the EG treatment system 82 may perform gas separation and purification to produce a plurality of different streams 95 of exhaust gas 42, such as a first stream 96, a second stream 97, and a third stream 98. The first stream 96 may have a first composition that is rich in carbon dioxide and/or lean in nitrogen (e.g., a CO<sub>2</sub> rich, N<sub>2</sub> lean stream). The second stream 97 may have a second



composition that has intermediate concentration levels of carbon dioxide and/or nitrogen (e.g., intermediate concentration CO<sub>2</sub>, N<sub>2</sub> stream). The third stream 98 may have a third composition that is lean in carbon dioxide and/or rich in nitrogen (e.g., a CO<sub>2</sub> lean, N<sub>2</sub> rich stream). Each stream 95 (e.g., 96, 97, and 98) may include a gas dehydration unit, a filter, a gas compressor, or any combination thereof, to facilitate delivery of the stream 95 to a target system. In certain embodiments, the CO<sub>2</sub> rich, N<sub>2</sub> lean stream 96 may have a CO<sub>2</sub> purity or concentration level of greater than approximately 70, 75, 80, 85, 90, 95, 96, 97, 98, or 99 percent by volume, and a N<sub>2</sub> purity or concentration level of less than approximately 1, 2, 3, 4, 5, 10, 15, 20, 25, or 30 percent by volume. In contrast, the CO<sub>2</sub> lean, N<sub>2</sub> rich stream 98 may have a CO<sub>2</sub> purity or concentration level of less than approximately 1, 2, 3, 4, 5, 10, 15, 20, 25, or 30 percent by volume, and a N<sub>2</sub> purity or concentration level of greater than approximately 70, 75, 80, 85, 90, 95, 96, 97, 98, or 99 percent by volume. The intermediate concentration CO<sub>2</sub>, N<sub>2</sub> stream 97 may have a CO<sub>2</sub> purity or concentration level and/or a N<sub>2</sub> purity or concentration level of between approximately 30 to 70, 35 to 65, 40 to 60, or 45 to 55 percent by volume. Although the foregoing ranges are merely non-limiting examples, the CO<sub>2</sub> rich, N<sub>2</sub> lean stream 96 and the CO<sub>2</sub> lean, N<sub>2</sub> rich stream 98 may be particularly well suited for use with the EOR system 18 and the other systems 84. However, any of these rich, lean, or intermediate concentration CO<sub>2</sub> streams 95 may be used, alone or in various combinations, with the EOR system 18 and the other systems 84. For example, the EOR system 18 and the other systems 84 (e.g., the pipeline 86, storage tank 88, and the carbon sequestration system 90) each may receive one or more CO<sub>2</sub> rich, N<sub>2</sub> lean streams 96, one or more CO<sub>2</sub> lean, N<sub>2</sub> rich streams 98, one or more intermediate concentration CO<sub>2</sub>, N<sub>2</sub> streams 97, and one or more untreated exhaust gas 42 streams (i.e., bypassing the EG treatment system 82).

**[0033]** The EG extraction system 80 extracts the exhaust gas 42 at one or more extraction points 76 along the compressor section, the combustor section, and/or the turbine section, such that the exhaust gas 42 may be used in the EOR system 18 and other systems 84 at suitable temperatures and pressures. The EG extraction system 80 and/or the EG treatment system 82 also may circulate fluid flows (e.g., exhaust gas 42) to and from the EG processing system 54. For example, a portion of the exhaust

gas 42 passing through the EG processing system 54 may be extracted by the EG extraction system 80 for use in the EOR system 18 and the other systems 84. In certain embodiments, the EG supply system 78 and the EG processing system 54 may be independent or integral with one another, and thus may use independent or common subsystems. For example, the EG treatment system 82 may be used by both the EG supply system 78 and the EG processing system 54. Exhaust gas 42 extracted from the EG processing system 54 may undergo multiple stages of gas treatment, such as one or more stages of gas treatment in the EG processing system 54 followed by one or more additional stages of gas treatment in the EG treatment system 82.

**[0034]** At each extraction point 76, the extracted exhaust gas 42 may be substantially free of oxidant 68 and fuel 70 (e.g., unburnt fuel or hydrocarbons) due to substantially stoichiometric combustion and/or gas treatment in the EG processing system 54. Furthermore, depending on the target system, the extracted exhaust gas 42 may undergo further treatment in the EG treatment system 82 of the EG supply system 78, thereby further reducing any residual oxidant 68, fuel 70, or other undesirable products of combustion. For example, either before or after treatment in the EG treatment system 82, the extracted exhaust gas 42 may have less than 1, 2, 3, 4, or 5 percent by volume of oxidant (e.g., oxygen), unburnt fuel or hydrocarbons (e.g., HCs), nitrogen oxides (e.g., NO<sub>x</sub>), carbon monoxide (CO), sulfur oxides (e.g., SO<sub>x</sub>), hydrogen, and other products of incomplete combustion. By further example, either before or after treatment in the EG treatment system 82, the extracted exhaust gas 42 may have less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 1000, 2000, 3000, 4000, or 5000 parts per million by volume (ppmv) of oxidant (e.g., oxygen), unburnt fuel or hydrocarbons (e.g., HCs), nitrogen oxides (e.g., NO<sub>x</sub>), carbon monoxide (CO), sulfur oxides (e.g., SO<sub>x</sub>), hydrogen, and other products of incomplete combustion. Thus, the exhaust gas 42 is particularly well suited for use with the EOR system 18.

**[0035]** The EGR operation of the turbine system 52 specifically enables the exhaust extraction at a multitude of locations 76. For example, the compressor section of the system 52 may be used to compress the exhaust gas 66 without any oxidant 68 (i.e., only compression of the exhaust gas 66), such that a substantially oxygen-free

exhaust gas 42 may be extracted from the compressor section and/or the combustor section prior to entry of the oxidant 68 and the fuel 70. The extraction points 76 may be located at interstage ports between adjacent compressor stages, at ports along the compressor discharge casing, at ports along each combustor in the combustor section, or any combination thereof. In certain embodiments, the exhaust gas 66 may not mix with the oxidant 68 and fuel 70 until it reaches the head end portion and/or fuel nozzles of each combustor in the combustor section. Furthermore, one or more flow separators (e.g., walls, dividers, baffles, or the like) may be used to isolate the oxidant 68 and the fuel 70 from the extraction points 76. With these flow separators, the extraction points 76 may be disposed directly along a wall of each combustor in the combustor section.

**[0036]** Once the exhaust gas 66, oxidant 68, and fuel 70 flow through the head end portion (e.g., through fuel nozzles) into the combustion portion (e.g., combustion chamber) of each combustor, the SEGR gas turbine system 52 is controlled to provide a substantially stoichiometric combustion of the exhaust gas 66, oxidant 68, and fuel 70. For example, the system 52 may maintain an equivalence ratio of approximately 0.95 to approximately 1.05. As a result, the products of combustion of the mixture of exhaust gas 66, oxidant 68, and fuel 70 in each combustor is substantially free of oxygen and unburnt fuel. Thus, the products of combustion (or exhaust gas) may be extracted from the turbine section of the SEGR gas turbine system 52 for use as the exhaust gas 42 routed to the EOR system 18. Along the turbine section, the extraction points 76 may be located at any turbine stage, such as interstage ports between adjacent turbine stages. Thus, using any of the foregoing extraction points 76, the turbine-based service system 14 may generate, extract, and deliver the exhaust gas 42 to the hydrocarbon production system 12 (e.g., the EOR system 18) for use in the production of oil/gas 48 from the subterranean reservoir 20.

**[0037]** FIG. 2 is a diagram of an embodiment of the system 10 of FIG. 1, illustrating a control system 100 coupled to the turbine-based service system 14 and the hydrocarbon production system 12. In the illustrated embodiment, the turbine-based service system 14 includes a combined cycle system 102, which includes the SEGR gas turbine system 52 as a topping cycle, a steam turbine 104 as a bottoming

cycle, and the HRSG 56 to recover heat from the exhaust gas 60 to generate the steam 62 for driving the steam turbine 104. Again, the SEGR gas turbine system 52 receives, mixes, and stoichiometrically combusts the exhaust gas 66, the oxidant 68, and the fuel 70 (e.g., premix and/or diffusion flames), thereby producing the exhaust gas 60, the mechanical power 72, the electrical power 74, and/or the water 64. For example, the SEGR gas turbine system 52 may drive one or more loads or machinery 106, such as an electrical generator, an oxidant compressor (e.g., a main air compressor), a gear box, a pump, equipment of the hydrocarbon production system 12, or any combination thereof. In some embodiments, the machinery 106 may include other drives, such as electrical motors or steam turbines (e.g., the steam turbine 104), in tandem with the SEGR gas turbine system 52. Accordingly, an output of the machinery 106 driven by the SEGR gas turbines system 52 (and any additional drives) may include the mechanical power 72 and the electrical power 74. The mechanical power 72 and/or the electrical power 74 may be used on-site for powering the hydrocarbon production system 12, the electrical power 74 may be distributed to the power grid, or any combination thereof. The output of the machinery 106 also may include a compressed fluid, such as a compressed oxidant 68 (e.g., air or oxygen), for intake into the combustion section of the SEGR gas turbine system 52. Each of these outputs (e.g., the exhaust gas 60, the mechanical power 72, the electrical power 74, and/or the water 64) may be considered a service of the turbine-based service system 14.

**[0038]** The SEGR gas turbine system 52 produces the exhaust gas 42, 60, which may be substantially free of oxygen, and routes this exhaust gas 42, 60 to the EG processing system 54 and/or the EG supply system 78. The EG supply system 78 may treat and delivery the exhaust gas 42 (e.g., streams 95) to the hydrocarbon production system 12 and/or the other systems 84. As discussed above, the EG processing system 54 may include the HRSG 56 and the EGR system 58. The HRSG 56 may include one or more heat exchangers, condensers, and various heat recovery equipment, which may be used to recover or transfer heat from the exhaust gas 60 to water 108 to generate the steam 62 for driving the steam turbine 104. Similar to the SEGR gas turbine system 52, the steam turbine 104 may drive one or more loads or machinery

106, thereby generating the mechanical power 72 and the electrical power 74. In the illustrated embodiment, the SEGR gas turbine system 52 and the steam turbine 104 are arranged in tandem to drive the same machinery 106. However, in other embodiments, the SEGR gas turbine system 52 and the steam turbine 104 may separately drive different machinery 106 to independently generate mechanical power 72 and/or electrical power 74. As the steam turbine 104 is driven by the steam 62 from the HRSG 56, the steam 62 gradually decreases in temperature and pressure. Accordingly, the steam turbine 104 recirculates the used steam 62 and/or water 108 back into the HRSG 56 for additional steam generation via heat recovery from the exhaust gas 60. In addition to steam generation, the HRSG 56, the EGR system 58, and/or another portion of the EG processing system 54 may produce the water 64, the exhaust gas 42 for use with the hydrocarbon production system 12, and the exhaust gas 66 for use as an input into the SEGR gas turbine system 52. For example, the water 64 may be a treated water 64, such as a desalinated water for use in other applications. The desalinated water may be particularly useful in regions of low water availability. Regarding the exhaust gas 60, embodiments of the EG processing system 54 may be configured to recirculate the exhaust gas 60 through the EGR system 58 with or without passing the exhaust gas 60 through the HRSG 56.

**[0039]** In the illustrated embodiment, the SEGR gas turbine system 52 has an exhaust recirculation path 110, which extends from an exhaust outlet to an exhaust inlet of the system 52. Along the path 110, the exhaust gas 60 passes through the EG processing system 54, which includes the HRSG 56 and the EGR system 58 in the illustrated embodiment. The EGR system 58 may include one or more conduits, valves, blowers, gas treatment systems (e.g., filters, particulate removal units, gas separation units, gas purification units, heat exchangers, heat recovery units such as heat recovery steam generators, moisture removal units, catalyst units, chemical injection units, or any combination thereof) in series and/or parallel arrangements along the path 110. In other words, the EGR system 58 may include any flow control components, pressure control components, temperature control components, moisture control components, and gas composition control components along the exhaust recirculation path 110 between the exhaust outlet and the exhaust inlet of the system

52. Accordingly, in embodiments with the HRSG 56 along the path 110, the HRSG 56 may be considered a component of the EGR system 58. However, in certain embodiments, the HRSG 56 may be disposed along an exhaust path independent from the exhaust recirculation path 110. Regardless of whether the HRSG 56 is along a separate path or a common path with the EGR system 58, the HRSG 56 and the EGR system 58 intake the exhaust gas 60 and output either the recirculated exhaust gas 66, the exhaust gas 42 for use with the EG supply system 78 (e.g., for the hydrocarbon production system 12 and/or other systems 84), or another output of exhaust gas. Again, the SEGR gas turbine system 52 intakes, mixes, and stoichiometrically combusts the exhaust gas 66, the oxidant 68, and the fuel 70 (e.g., premixed and/or diffusion flames) to produce a substantially oxygen-free and fuel-free exhaust gas 60 for distribution to the EG processing system 54, the hydrocarbon production system 12, or other systems 84.

**[0040]** As noted above with reference to FIG. 1, the hydrocarbon production system 12 may include a variety of equipment to facilitate the recovery or production of oil/gas 48 from a subterranean reservoir 20 through an oil/gas well 26. For example, the hydrocarbon production system 12 may include the EOR system 18 having the fluid injection system 34. In the illustrated embodiment, the fluid injection system 34 includes an exhaust gas injection EOR system 112 and a steam injection EOR system 114. Although the fluid injection system 34 may receive fluids from a variety of sources, the illustrated embodiment may receive the exhaust gas 42 and the steam 62 from the turbine-based service system 14. The exhaust gas 42 and/or the steam 62 produced by the turbine-based service system 14 also may be routed to the hydrocarbon production system 12 for use in other oil/gas systems 116.

**[0041]** The quantity, quality, and flow of the exhaust gas 42 and/or the steam 62 may be controlled by the control system 100. The control system 100 may be dedicated entirely to the turbine-based service system 14, or the control system 100 may optionally also provide control (or at least some data to facilitate control) for the hydrocarbon production system 12 and/or other systems 84. In the illustrated embodiment, the control system 100 includes a controller 118 having a processor 120, a memory 122, a steam turbine control 124, a SEGR gas turbine system control 126,

and a machinery control 128. The processor 120 may include a single processor or two or more redundant processors, such as triple redundant processors for control of the turbine-based service system 14. The memory 122 may include volatile and/or non-volatile memory. For example, the memory 122 may include one or more hard drives, flash memory, read-only memory, random access memory, or any combination thereof. The controls 124, 126, and 128 may include software and/or hardware controls. For example, the controls 124, 126, and 128 may include various instructions or code stored on the memory 122 and executable by the processor 120. The control 124 is configured to control operation of the steam turbine 104, the SEGR gas turbine system control 126 is configured to control the system 52, and the machinery control 128 is configured to control the machinery 106. Thus, the controller 118 (e.g., controls 124, 126, and 128) may be configured to coordinate various sub-systems of the turbine-based service system 14 to provide a suitable stream of the exhaust gas 42 to the hydrocarbon production system 12.

**[0042]** In certain embodiments of the control system 100, each element (e.g., system, subsystem, and component) illustrated in the drawings or described herein includes (e.g., directly within, upstream, or downstream of such element) one or more industrial control features, such as sensors and control devices, which are communicatively coupled with one another over an industrial control network along with the controller 118. For example, the control devices associated with each element may include a dedicated device controller (e.g., including a processor, memory, and control instructions), one or more actuators, valves, switches, and industrial control equipment, which enable control based on sensor feedback 130, control signals from the controller 118, control signals from a user, or any combination thereof. Thus, any of the control functionality described herein may be implemented with control instructions stored and/or executable by the controller 118, dedicated device controllers associated with each element, or a combination thereof.

**[0043]** In order to facilitate such control functionality, the control system 100 includes one or more sensors distributed throughout the system 10 to obtain the sensor feedback 130 for use in execution of the various controls, e.g., the controls 124, 126, and 128. For example, the sensor feedback 130 may be obtained from sensors

distributed throughout the SEGR gas turbine system 52, the machinery 106, the EG processing system 54, the steam turbine 104, the hydrocarbon production system 12, or any other components throughout the turbine-based service system 14 or the hydrocarbon production system 12. For example, the sensor feedback 130 may include temperature feedback, pressure feedback, flow rate feedback, flame temperature feedback, combustion dynamics feedback, intake oxidant composition feedback, intake fuel composition feedback, exhaust composition feedback, the output level of mechanical power 72, the output level of electrical power 74, the output quantity of the exhaust gas 42, 60, the output quantity or quality of the water 64, or any combination thereof. For example, the sensor feedback 130 may include a composition of the exhaust gas 42, 60 to facilitate stoichiometric combustion in the SEGR gas turbine system 52. For example, the sensor feedback 130 may include feedback from one or more intake oxidant sensors along an oxidant supply path of the oxidant 68, one or more intake fuel sensors along a fuel supply path of the fuel 70, and one or more exhaust emissions sensors disposed along the exhaust recirculation path 110 and/or within the SEGR gas turbine system 52. The intake oxidant sensors, intake fuel sensors, and exhaust emissions sensors may include temperature sensors, pressure sensors, flow rate sensors, and composition sensors. The emissions sensors may include sensors for nitrogen oxides (e.g., NO<sub>x</sub> sensors), carbon oxides (e.g., CO sensors and CO<sub>2</sub> sensors), sulfur oxides (e.g., SO<sub>x</sub> sensors), hydrogen (e.g., H<sub>2</sub> sensors), oxygen (e.g., O<sub>2</sub> sensors), unburnt hydrocarbons (e.g., HC sensors), or other products of incomplete combustion, or any combination thereof.

**[0044]** Using this feedback 130, the control system 100 may adjust (e.g., increase, decrease, or maintain) the intake flow of exhaust gas 66, oxidant 68, and/or fuel 70 into the SEGR gas turbine system 52 (among other operational parameters) to maintain the equivalence ratio within a suitable range, e.g., between approximately 0.95 to approximately 1.05, between approximately 0.95 to approximately 1.0, between approximately 1.0 to approximately 1.05, or substantially at 1.0. For example, the control system 100 may analyze the feedback 130 to monitor the exhaust emissions (e.g., concentration levels of nitrogen oxides, carbon oxides such as CO and CO<sub>2</sub>, sulfur oxides, hydrogen, oxygen, unburnt hydrocarbons, and other products of



incomplete combustion) and/or determine the equivalence ratio, and then control one or more components to adjust the exhaust emissions (e.g., concentration levels in the exhaust gas 42) and/or the equivalence ratio. The controlled components may include any of the components illustrated and described with reference to the drawings, including but not limited to, valves along the supply paths for the oxidant 68, the fuel 70, and the exhaust gas 66; an oxidant compressor, a fuel pump, or any components in the EG processing system 54; any components of the SEGR gas turbine system 52, or any combination thereof. The controlled components may adjust (e.g., increase, decrease, or maintain) the flow rates, temperatures, pressures, or percentages (e.g., equivalence ratio) of the oxidant 68, the fuel 70, and the exhaust gas 66 that combust within the SEGR gas turbine system 52. The controlled components also may include one or more gas treatment systems, such as catalyst units (e.g., oxidation catalyst units), supplies for the catalyst units (e.g., oxidation fuel, heat, electricity, etc.), gas purification and/or separation units (e.g., solvent based separators, absorbers, flash tanks, etc.), and filtration units. The gas treatment systems may help reduce various exhaust emissions along the exhaust recirculation path 110, a vent path (e.g., exhausted into the atmosphere), or an extraction path to the EG supply system 78.

**[0045]** In certain embodiments, the control system 100 may analyze the feedback 130 and control one or more components to maintain or reduce emissions levels (e.g., concentration levels in the exhaust gas 42, 60, 95) to a target range, such as less than approximately 10, 20, 30, 40, 50, 100, 200, 300, 400, 500, 1000, 2000, 3000, 4000, 5000, or 10000 parts per million by volume (ppmv). These target ranges may be the same or different for each of the exhaust emissions, e.g., concentration levels of nitrogen oxides, carbon monoxide, sulfur oxides, hydrogen, oxygen, unburnt hydrocarbons, and other products of incomplete combustion. For example, depending on the equivalence ratio, the control system 100 may selectively control exhaust emissions (e.g., concentration levels) of oxidant (e.g., oxygen) within a target range of less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 250, 500, 750, or 1000 ppmv; carbon monoxide (CO) within a target range of less than approximately 20, 50, 100, 200, 500, 1000, 2500, or 5000 ppmv; and nitrogen oxides (NO<sub>x</sub>) within a target range of less than approximately 50, 100, 200, 300, 400, or 500 ppmv. In certain

embodiments operating with a substantially stoichiometric equivalence ratio, the control system 100 may selectively control exhaust emissions (e.g., concentration levels) of oxidant (e.g., oxygen) within a target range of less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, or 100 ppmv; and carbon monoxide (CO) within a target range of less than approximately 500, 1000, 2000, 3000, 4000, or 5000 ppmv. In certain embodiments operating with a fuel-lean equivalence ratio (e.g., between approximately 0.95 to 1.0), the control system 100 may selectively control exhaust emissions (e.g., concentration levels) of oxidant (e.g., oxygen) within a target range of less than approximately 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, or 1500 ppmv; carbon monoxide (CO) within a target range of less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, or 200 ppmv; and nitrogen oxides (e.g., NO<sub>x</sub>) within a target range of less than approximately 50, 100, 150, 200, 250, 300, 350, or 400 ppmv. The foregoing target ranges are merely examples, and are not intended to limit the scope of the disclosed embodiments.

[0046] The control system 100 also may be coupled to a local interface 132 and a remote interface 134. For example, the local interface 132 may include a computer workstation disposed on-site at the turbine-based service system 14 and/or the hydrocarbon production system 12. In contrast, the remote interface 134 may include a computer workstation disposed off-site from the turbine-based service system 14 and the hydrocarbon production system 12, such as through an internet connection. These interfaces 132 and 134 facilitate monitoring and control of the turbine-based service system 14, such as through one or more graphical displays of sensor feedback 130, operational parameters, and so forth.

[0047] Again, as noted above, the controller 118 includes a variety of controls 124, 126, and 128 to facilitate control of the turbine-based service system 14. The steam turbine control 124 may receive the sensor feedback 130 and output control commands to facilitate operation of the steam turbine 104. For example, the steam turbine control 124 may receive the sensor feedback 130 from the HRSG 56, the machinery 106, temperature and pressure sensors along a path of the steam 62, temperature and pressure sensors along a path of the water 108, and various sensors indicative of the mechanical power 72 and the electrical power 74. Likewise, the

SEGR gas turbine system control 126 may receive sensor feedback 130 from one or more sensors disposed along the SEGR gas turbine system 52, the machinery 106, the EG processing system 54, or any combination thereof. For example, the sensor feedback 130 may be obtained from temperature sensors, pressure sensors, clearance sensors, vibration sensors, flame sensors, fuel composition sensors, exhaust gas composition sensors, or any combination thereof, disposed within or external to the SEGR gas turbine system 52. Finally, the machinery control 128 may receive sensor feedback 130 from various sensors associated with the mechanical power 72 and the electrical power 74, as well as sensors disposed within the machinery 106. Each of these controls 124, 126, and 128 uses the sensor feedback 130 to improve operation of the turbine-based service system 14.

**[0048]** In the illustrated embodiment, the SEGR gas turbine system control 126 may execute instructions to control the quantity and quality of the exhaust gas 42, 60, 95 in the EG processing system 54, the EG supply system 78, the hydrocarbon production system 12, and/or the other systems 84. For example, the SEGR gas turbine system control 126 may maintain a level of oxidant (e.g., oxygen) and/or unburnt fuel in the exhaust gas 60 below a threshold suitable for use with the exhaust gas injection EOR system 112. In certain embodiments, the threshold levels may be less than 1, 2, 3, 4, or 5 percent of oxidant (e.g., oxygen) and/or unburnt fuel by volume of the exhaust gas 42, 60; or the threshold levels of oxidant (e.g., oxygen) and/or unburnt fuel (and other exhaust emissions) may be less than approximately 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 1000, 2000, 3000, 4000, or 5000 parts per million by volume (ppmv) in the exhaust gas 42, 60. By further example, in order to achieve these low levels of oxidant (e.g., oxygen) and/or unburnt fuel, the SEGR gas turbine system control 126 may maintain an equivalence ratio for combustion in the SEGR gas turbine system 52 between approximately 0.95 and approximately 1.05. The SEGR gas turbine system control 126 also may control the EG extraction system 80 and the EG treatment system 82 to maintain the temperature, pressure, flow rate, and gas composition of the exhaust gas 42, 60, 95 within suitable ranges for the exhaust gas injection EOR system 112, the pipeline 86, the storage tank 88, and the carbon sequestration system 90. As discussed above, the EG treatment

system 82 may be controlled to purify and/or separate the exhaust gas 42 into one or more gas streams 95, such as the CO<sub>2</sub> rich, N<sub>2</sub> lean stream 96, the intermediate concentration CO<sub>2</sub>, N<sub>2</sub> stream 97, and the CO<sub>2</sub> lean, N<sub>2</sub> rich stream 98. In addition to controls for the exhaust gas 42, 60, and 95, the controls 124, 126, and 128 may execute one or more instructions to maintain the mechanical power 72 within a suitable power range, or maintain the electrical power 74 within a suitable frequency and power range.

[0049] FIG. 3 is a diagram of embodiment of the system 10, further illustrating details of the SEGR gas turbine system 52 for use with the hydrocarbon production system 12 and/or other systems 84. In the illustrated embodiment, the SEGR gas turbine system 52 includes a gas turbine engine 150 coupled to the EG processing system 54. The illustrated gas turbine engine 150 includes a compressor section 152, a combustor section 154, and an expander section or turbine section 156. The compressor section 152 includes one or more exhaust gas compressors or compressor stages 158, such as 1 to 20 stages of rotary compressor blades disposed in a series arrangement. Likewise, the combustor section 154 includes one or more combustors 160, such as 1 to 20 combustors 160 distributed circumferentially about a rotational axis 162 of the SEGR gas turbine system 52. Furthermore, each combustor 160 may include one or more fuel nozzles 164 configured to inject the exhaust gas 66, the oxidant 68, and/or the fuel 70. For example, a head end portion 166 of each combustor 160 may house 1, 2, 3, 4, 5, 6, or more fuel nozzles 164, which may inject streams or mixtures of the exhaust gas 66, the oxidant 68, and/or the fuel 70 into a combustion portion 168 (e.g., combustion chamber) of the combustor 160.

[0050] The fuel nozzles 164 may include any combination of premix fuel nozzles 164 (e.g., configured to premix the oxidant 68 and fuel 70 for generation of an oxidant/fuel premix flame) and/or diffusion fuel nozzles 164 (e.g., configured to inject separate flows of the oxidant 68 and fuel 70 for generation of an oxidant/fuel diffusion flame). Embodiments of the premix fuel nozzles 164 may include swirl vanes, mixing chambers, or other features to internally mix the oxidant 68 and fuel 70 within the nozzles 164, prior to injection and combustion in the combustion chamber 168. The premix fuel nozzles 164 also may receive at least some partially mixed

oxidant 68 and fuel 70. In certain embodiments, each diffusion fuel nozzle 164 may isolate flows of the oxidant 68 and the fuel 70 until the point of injection, while also isolating flows of one or more diluents (e.g., the exhaust gas 66, steam, nitrogen, or another inert gas) until the point of injection. In other embodiments, each diffusion fuel nozzle 164 may isolate flows of the oxidant 68 and the fuel 70 until the point of injection, while partially mixing one or more diluents (e.g., the exhaust gas 66, steam, nitrogen, or another inert gas) with the oxidant 68 and/or the fuel 70 prior to the point of injection. In addition, one or more diluents (e.g., the exhaust gas 66, steam, nitrogen, or another inert gas) may be injected into the combustor (e.g., into the hot products of combustion) either at or downstream from the combustion zone, thereby helping to reduce the temperature of the hot products of combustion and reduce emissions of  $\text{NO}_x$  (e.g.,  $\text{NO}$  and  $\text{NO}_2$ ). Regardless of the type of fuel nozzle 164, the SEGR gas turbine system 52 may be controlled to provide substantially stoichiometric combustion of the oxidant 68 and fuel 70.

**[0051]** In diffusion combustion embodiments using the diffusion fuel nozzles 164, the fuel 70 and oxidant 68 generally do not mix upstream from the diffusion flame, but rather the fuel 70 and oxidant 68 mix and react directly at the flame surface and/or the flame surface exists at the location of mixing between the fuel 70 and oxidant 68. In particular, the fuel 70 and oxidant 68 separately approach the flame surface (or diffusion boundary/interface), and then diffuse (e.g., via molecular and viscous diffusion) along the flame surface (or diffusion boundary/interface) to generate the diffusion flame. It is noteworthy that the fuel 70 and oxidant 68 may be at a substantially stoichiometric ratio along this flame surface (or diffusion boundary/interface), which may result in a greater flame temperature (e.g., a peak flame temperature) along this flame surface. The stoichiometric fuel/oxidant ratio generally results in a greater flame temperature (e.g., a peak flame temperature), as compared with a fuel-lean or fuel-rich fuel/oxidant ratio. As a result, the diffusion flame may be substantially more stable than a premix flame, because the diffusion of fuel 70 and oxidant 68 helps to maintain a stoichiometric ratio (and greater temperature) along the flame surface. Although greater flame temperatures can also lead to greater exhaust emissions, such as  $\text{NO}_x$  emissions, the disclosed embodiments

use one or more diluents to help control the temperature and emissions while still avoiding any premixing of the fuel 70 and oxidant 68. For example, the disclosed embodiments may introduce one or more diluents separate from the fuel 70 and oxidant 68 (e.g., after the point of combustion and/or downstream from the diffusion flame), thereby helping to reduce the temperature and reduce the emissions (e.g., NO<sub>x</sub> emissions) produced by the diffusion flame.

**[0052]** In operation, as illustrated, the compressor section 152 receives and compresses the exhaust gas 66 from the EG processing system 54, and outputs a compressed exhaust gas 170 to each of the combustors 160 in the combustor section 154. Upon combustion of the fuel 60, oxidant 68, and exhaust gas 170 within each combustor 160, additional exhaust gas or products of combustion 172 (i.e., combustion gas) is routed into the turbine section 156. Similar to the compressor section 152, the turbine section 156 includes one or more turbines or turbine stages 174, which may include a series of rotary turbine blades. These turbine blades are then driven by the products of combustion 172 generated in the combustor section 154, thereby driving rotation of a shaft 176 coupled to the machinery 106. Again, the machinery 106 may include a variety of equipment coupled to either end of the SEGR gas turbine system 52, such as machinery 106, 178 coupled to the turbine section 156 and/or machinery 106, 180 coupled to the compressor section 152. In certain embodiments, the machinery 106, 178, 180 may include one or more electrical generators, oxidant compressors for the oxidant 68, fuel pumps for the fuel 70, gear boxes, or additional drives (e.g. steam turbine 104, electrical motor, etc.) coupled to the SEGR gas turbine system 52. Non-limiting examples are discussed in further detail below with reference to TABLE 1. As illustrated, the turbine section 156 outputs the exhaust gas 60 to recirculate along the exhaust recirculation path 110 from an exhaust outlet 182 of the turbine section 156 to an exhaust inlet 184 into the compressor section 152. Along the exhaust recirculation path 110, the exhaust gas 60 passes through the EG processing system 54 (e.g., the HRSG 56 and/or the EGR system 58) as discussed in detail above.

**[0053]** Again, each combustor 160 in the combustor section 154 receives, mixes, and stoichiometrically combusts the compressed exhaust gas 170, the oxidant 68, and

the fuel 70 to produce the additional exhaust gas or products of combustion 172 to drive the turbine section 156. In certain embodiments, the oxidant 68 is compressed by an oxidant compression system 186, such as a main oxidant compression (MOC) system (e.g., a main air compression (MAC) system) having one or more oxidant compressors (MOCs). The oxidant compression system 186 includes an oxidant compressor 188 coupled to a drive 190. For example, the drive 190 may include an electric motor, a combustion engine, or any combination thereof. In certain embodiments, the drive 190 may be a turbine engine, such as the gas turbine engine 150. Accordingly, the oxidant compression system 186 may be an integral part of the machinery 106. In other words, the compressor 188 may be directly or indirectly driven by the mechanical power 72 supplied by the shaft 176 of the gas turbine engine 150. In such an embodiment, the drive 190 may be excluded, because the compressor 188 relies on the power output from the turbine engine 150. However, in certain embodiments employing more than one oxidant compressor is employed, a first oxidant compressor (e.g., a low pressure (LP) oxidant compressor) may be driven by the drive 190 while the shaft 176 drives a second oxidant compressor (e.g., a high pressure (HP) oxidant compressor), or vice versa. For example, in another embodiment, the HP MOC is driven by the drive 190 and the LP oxidant compressor is driven by the shaft 176. In the illustrated embodiment, the oxidant compression system 186 is separate from the machinery 106. In each of these embodiments, the compression system 186 compresses and supplies the oxidant 68 to the fuel nozzles 164 and the combustors 160. Accordingly, some or all of the machinery 106, 178, 180 may be configured to increase the operational efficiency of the compression system 186 (e.g., the compressor 188 and/or additional compressors).

**[0054]** The variety of components of the machinery 106, indicated by element numbers 106A, 106B, 106C, 106D, 106E, and 106F, may be disposed along the line of the shaft 176 and/or parallel to the line of the shaft 176 in one or more series arrangements, parallel arrangements, or any combination of series and parallel arrangements. For example, the machinery 106, 178, 180 (e.g., 106A through 106F) may include any series and/or parallel arrangement, in any order, of: one or more gearboxes (e.g., parallel shaft, epicyclic gearboxes), one or more compressors (e.g.,

oxidant compressors, booster compressors such as EG booster compressors), one or more power generation units (e.g., electrical generators), one or more drives (e.g., steam turbine engines, electrical motors), heat exchange units (e.g., direct or indirect heat exchangers), clutches, or any combination thereof. The compressors may include axial compressors, radial or centrifugal compressors, or any combination thereof, each having one or more compression stages. Regarding the heat exchangers, direct heat exchangers may include spray coolers (e.g., spray intercoolers), which inject a liquid spray into a gas flow (e.g., oxidant flow) for direct cooling of the gas flow. Indirect heat exchangers may include at least one wall (e.g., a shell and tube heat exchanger) separating first and second flows, such as a fluid flow (e.g., oxidant flow) separated from a coolant flow (e.g., water, air, refrigerant, or any other liquid or gas coolant), wherein the coolant flow transfers heat from the fluid flow without any direct contact. Examples of indirect heat exchangers include intercooler heat exchangers and heat recovery units, such as heat recovery steam generators. The heat exchangers also may include heaters. As discussed in further detail below, each of these machinery components may be used in various combinations as indicated by the non-limiting examples set forth in TABLE 1.

**[0055]** Generally, the machinery 106, 178, 180 may be configured to increase the efficiency of the compression system 186 by, for example, adjusting operational speeds of one or more oxidant compressors in the system 186, facilitating compression of the oxidant 68 through cooling, and/or extraction of surplus power. The disclosed embodiments are intended to include any and all permutations of the foregoing components in the machinery 106, 178, 180 in series and parallel arrangements, wherein one, more than one, all, or none of the components derive power from the shaft 176. As illustrated below, TABLE 1 depicts some non-limiting examples of arrangements of the machinery 106, 178, 180 disposed proximate and/or coupled to the compressor and turbine sections 152, 156.



<b>106A</b>	<b>106B</b>	<b>106C</b>	<b>106D</b>	<b>106E</b>	<b>106F</b>
MOC	GEN				
MOC	GBX	GEN			
LP MOC	HP MOC	GEN			
HP MOC	GBX	LP MOC	GEN		
MOC MOC	GBX	GEN			
HP MOC	GBX	GEN	LP MOC		
MOC MOC	GBX GBX	GEN DRV			
DRV	GBX	LP MOC	HP MOC	GBX	GEN
DRV	GBX	HP MOC	LP MOC	GEN	
HP MOC	GBX CLR	LP MOC	GEN		
HP MOC	GBX CLR	LP MOC	GBX	GEN	
HP MOC	GBX HTR STGN	LP MOC	GEN		
MOC	GEN	DRV			
MOC	DRV	GEN			
DRV	MOC	GEN			
DRV	CLU	MOC	GEN		
DRV	CLU	MOC	GBX	GEN	

**TABLE 1**

[0056] As illustrated above in TABLE 1, a cooling unit is represented as CLR, a clutch is represented as CLU, a drive is represented by DRV, a gearbox is represented as GBX, a generator is represented by GEN, a heating unit is represented by HTR, a main oxidant compressor unit is represented by MOC, with low pressure and high pressure variants being represented as LP MOC and HP MOC, respectively, and a steam generator unit is represented as STGN. Although TABLE 1 illustrates the machinery 106, 178, 180 in sequence toward the compressor section 152 or the turbine section 156, TABLE 1 is also intended to cover the reverse sequence of the machinery 106, 178, 180. In TABLE 1, any cell including two or more components is intended to cover a parallel arrangement of the components. TABLE 1 is not intended to exclude any non-illustrated permutations of the machinery 106, 178, 180. These components of the machinery 106, 178, 180 may enable feedback control of temperature, pressure, and flow rate of the oxidant 68 sent to the gas turbine engine 150. As discussed in further detail below, the oxidant 68 and the fuel 70 may be supplied to the gas turbine engine 150 at locations specifically selected to facilitate isolation and extraction of the compressed exhaust gas 170 without any oxidant 68 or fuel 70 degrading the quality of the exhaust gas 170.

[0057] The EG supply system 78, as illustrated in FIG. 3, is disposed between the gas turbine engine 150 and the target systems (e.g., the hydrocarbon production system 12 and the other systems 84). In particular, the EG supply system 78, e.g., the EG extraction system (EGES) 80, may be coupled to the gas turbine engine 150 at one or more extraction points 76 along the compressor section 152, the combustor section 154, and/or the turbine section 156. For example, the extraction points 76 may be located between adjacent compressor stages, such as 2, 3, 4, 5, 6, 7, 8, 9, or 10 interstage extraction points 76 between compressor stages. Each of these interstage extraction points 76 provides a different temperature and pressure of the extracted exhaust gas 42. Similarly, the extraction points 76 may be located between adjacent turbine stages, such as 2, 3, 4, 5, 6, 7, 8, 9, or 10 interstage extraction points 76 between turbine stages. Each of these interstage extraction points 76 provides a different temperature and pressure of the extracted exhaust gas 42. By further example, the extraction points 76 may be located at a multitude of locations

throughout the combustor section 154, which may provide different temperatures, pressures, flow rates, and gas compositions. Each of these extraction points 76 may include an EG extraction conduit, one or more valves, sensors, and controls, which may be used to selectively control the flow of the extracted exhaust gas 42 to the EG supply system 78.

**[0058]** The extracted exhaust gas 42, which is distributed by the EG supply system 78, has a controlled composition suitable for the target systems (e.g., the hydrocarbon production system 12 and the other systems 84). For example, at each of these extraction points 76, the exhaust gas 170 may be substantially isolated from injection points (or flows) of the oxidant 68 and the fuel 70. In other words, the EG supply system 78 may be specifically designed to extract the exhaust gas 170 from the gas turbine engine 150 without any added oxidant 68 or fuel 70. Furthermore, in view of the stoichiometric combustion in each of the combustors 160, the extracted exhaust gas 42 may be substantially free of oxygen and fuel. The EG supply system 78 may route the extracted exhaust gas 42 directly or indirectly to the hydrocarbon production system 12 and/or other systems 84 for use in various processes, such as enhanced oil recovery, carbon sequestration, storage, or transport to an offsite location. However, in certain embodiments, the EG supply system 78 includes the EG treatment system (EGTS) 82 for further treatment of the exhaust gas 42, prior to use with the target systems. For example, the EG treatment system 82 may purify and/or separate the exhaust gas 42 into one or more streams 95, such as the CO<sub>2</sub> rich, N<sub>2</sub> lean stream 96, the intermediate concentration CO<sub>2</sub>, N<sub>2</sub> stream 97, and the CO<sub>2</sub> lean, N<sub>2</sub> rich stream 98. These treated exhaust gas streams 95 may be used individually, or in any combination, with the hydrocarbon production system 12 and the other systems 84 (e.g., the pipeline 86, the storage tank 88, and the carbon sequestration system 90).

**[0059]** Similar to the exhaust gas treatments performed in the EG supply system 78, the EG processing system 54 may include a plurality of exhaust gas (EG) treatment components 192, such as indicated by element numbers 194, 196, 198, 200, 202, 204, 206, 208, and 210. These EG treatment components 192 (e.g., 194 through 210) may be disposed along the exhaust recirculation path 110 in one or more series arrangements, parallel arrangements, or any combination of series and parallel

arrangements. For example, the EG treatment components 192 (e.g., 194 through 210) may include any series and/or parallel arrangement, in any order, of: one or more heat exchangers (e.g., heat recovery units such as heat recovery steam generators, condensers, coolers, or heaters), catalyst systems (e.g., oxidation catalyst systems), particulate and/or water removal systems (e.g., inertial separators, coalescing filters, water impermeable filters, and other filters), chemical injection systems, solvent based treatment systems (e.g., absorbers, flash tanks, etc.), carbon capture systems, gas separation systems, gas purification systems, and/or a solvent based treatment system, or any combination thereof. In certain embodiments, the catalyst systems may include an oxidation catalyst, a carbon monoxide reduction catalyst, a nitrogen oxides reduction catalyst, an aluminum oxide, a zirconium oxide, a silicone oxide, a titanium oxide, a platinum oxide, a palladium oxide, a cobalt oxide, or a mixed metal oxide, or a combination thereof. The disclosed embodiments are intended to include any and all permutations of the foregoing components 192 in series and parallel arrangements. As illustrated below, TABLE 2 depicts some non-limiting examples of arrangements of the components 192 along the exhaust recirculation path 110.

194	196	198	200	202	204	206	208	210
CU	HRU	BB	MRU	PRU				
CU	HRU	HRU	BB	MRU	PRU	DIL		
CU	HRSG	HRSG	BB	MRU	PRU			
OCU	HRU	OCU	HRU	OCU	BB	MRU	PRU	
HRU CU	HRU CU	BB	MRU	PRU				
HRSG OCU	HRSG OCU	BB	MRU	PRU	DIL			
OCU	HRSG OCU	OCU	HRSG OCU	OCU	BB	MRU	PRU	DIL
OCU	HRSG ST	HRSG ST	BB	COND	INNER	WFIL	CFIL	DIL
OCU HRSG ST	OCU HRSG ST	BB	COND	INNER	FIL	DIL		
OCU	HRSG ST	HRSG ST	OCU	BB	MRU HE COND	MRU WFIL	PRU INNER	PRU FIL CFIL
CU	HRU COND	HRU COND	HRU COND	BB	MRU HE COND WFIL	PRU INNER	PRU FIL CFIL	DIL

TABLE 2

[0060] As illustrated above in TABLE 2, a catalyst unit is represented by CU, an oxidation catalyst unit is represented by OCU, a booster blower is represented by BB, a heat exchanger is represented by HX, a heat recovery unit is represented by HRU, a heat recovery steam generator is represented by HRSG, a condenser is represented by COND, a steam turbine is represented by ST, a particulate removal unit is represented by PRU, a moisture removal unit is represented by MRU, a filter is represented by

FIL, a coalescing filter is represented by CFIL, a water impermeable filter is represented by WFIL, an inertial separator is represented by INER, and a diluent supply system (e.g., steam, nitrogen, or other inert gas) is represented by DIL. Although TABLE 2 illustrates the components 192 in sequence from the exhaust outlet 182 of the turbine section 156 toward the exhaust inlet 184 of the compressor section 152, TABLE 2 is also intended to cover the reverse sequence of the illustrated components 192. In TABLE 2, any cell including two or more components is intended to cover an integrated unit with the components, a parallel arrangement of the components, or any combination thereof. Furthermore, in context of TABLE 2, the HRU, the HRSG, and the COND are examples of the HE; the HRSG is an example of the HRU; the COND, WFIL, and CFIL are examples of the WRU; the INER, FIL, WFIL, and CFIL are examples of the PRU; and the WFIL and CFIL are examples of the FIL. Again, TABLE 2 is not intended to exclude any non-illustrated permutations of the components 192. In certain embodiments, the illustrated components 192 (e.g., 194 through 210) may be partially or completely integrated within the HRSG 56, the EGR system 58, or any combination thereof. These EG treatment components 192 may enable feedback control of temperature, pressure, flow rate, and gas composition, while also removing moisture and particulates from the exhaust gas 60. Furthermore, the treated exhaust gas 60 may be extracted at one or more extraction points 76 for use in the EG supply system 78 and/or recirculated to the exhaust inlet 184 of the compressor section 152.

**[0061]** As the treated, recirculated exhaust gas 66 passes through the compressor section 152, the SEGR gas turbine system 52 may bleed off a portion of the compressed exhaust gas along one or more lines 212 (e.g., bleed conduits or bypass conduits). Each line 212 may route the exhaust gas into one or more heat exchangers 214 (e.g., cooling units), thereby cooling the exhaust gas for recirculation back into the SEGR gas turbine system 52. For example, after passing through the heat exchanger 214, a portion of the cooled exhaust gas may be routed to the turbine section 156 along line 212 for cooling and/or sealing of the turbine casing, turbine shrouds, bearings, and other components. In such an embodiment, the SEGR gas turbine system 52 does not route any oxidant 68 (or other potential contaminants)

through the turbine section 156 for cooling and/or sealing purposes, and thus any leakage of the cooled exhaust gas will not contaminate the hot products of combustion (e.g., working exhaust gas) flowing through and driving the turbine stages of the turbine section 156. By further example, after passing through the heat exchanger 214, a portion of the cooled exhaust gas may be routed along line 216 (e.g., return conduit) to an upstream compressor stage of the compressor section 152, thereby improving the efficiency of compression by the compressor section 152. In such an embodiment, the heat exchanger 214 may be configured as an interstage cooling unit for the compressor section 152. In this manner, the cooled exhaust gas helps to increase the operational efficiency of the SEGR gas turbine system 52, while simultaneously helping to maintain the purity of the exhaust gas (e.g., substantially free of oxidant and fuel).

**[0062]** FIG. 4 is a flow chart of an embodiment of an operational process 220 of the system 10 illustrated in FIGS 1-3. In certain embodiments, the process 220 may be a computer implemented process, which accesses one or more instructions stored on the memory 122 and executes the instructions on the processor 120 of the controller 118 shown in FIG. 2. For example, each step in the process 220 may include instructions executable by the controller 118 of the control system 100 described with reference to FIG. 2.

**[0063]** The process 220 may begin by initiating a startup mode of the SEGR gas turbine system 52 of FIGS. 1-3, as indicated by block 222. For example, the startup mode may involve a gradual ramp up of the SEGR gas turbine system 52 to maintain thermal gradients, vibration, and clearance (e.g., between rotating and stationary parts) within acceptable thresholds. For example, during the startup mode 222, the process 220 may begin to supply a compressed oxidant 68 to the combustors 160 and the fuel nozzles 164 of the combustor section 154, as indicated by block 224. In certain embodiments, the compressed oxidant may include a compressed air, oxygen, oxygen-enriched air, oxygen-reduced air, oxygen-nitrogen mixtures, or any combination thereof. For example, the oxidant 68 may be compressed by the oxidant compression system 186 illustrated in FIG. 3. The process 220 also may begin to supply fuel to the combustors 160 and the fuel nozzles 164 during the startup mode

222, as indicated by block 226. During the startup mode 222, the process 220 also may begin to supply exhaust gas (as available) to the combustors 160 and the fuel nozzles 164, as indicated by block 228. For example, the fuel nozzles 164 may produce one or more diffusion flames, premix flames, or a combination of diffusion and premix flames. During the startup mode 222, the exhaust gas 60 being generated by the gas turbine engine 156 may be insufficient or unstable in quantity and/or quality. Accordingly, during the startup mode, the process 220 may supply the exhaust gas 66 from one or more storage units (e.g., storage tank 88), the pipeline 86, other SEGR gas turbine systems 52, or other exhaust gas sources.

**[0064]** The process 220 may then combust a mixture of the compressed oxidant, fuel, and exhaust gas in the combustors 160 to produce hot combustion gas 172, as indicated by block 230. In particular, the process 220 may be controlled by the control system 100 of FIG. 2 to facilitate stoichiometric combustion (e.g., stoichiometric diffusion combustion, premix combustion, or both) of the mixture in the combustors 160 of the combustor section 154. However, during the startup mode 222, it may be particularly difficult to maintain stoichiometric combustion of the mixture (and thus low levels of oxidant and unburnt fuel may be present in the hot combustion gas 172). As a result, in the startup mode 222, the hot combustion gas 172 may have greater amounts of residual oxidant 68 and/or fuel 70 than during a steady state mode as discussed in further detail below. For this reason, the process 220 may execute one or more control instructions to reduce or eliminate the residual oxidant 68 and/or fuel 70 in the hot combustion gas 172 during the startup mode.

**[0065]** The process 220 then drives the turbine section 156 with the hot combustion gas 172, as indicated by block 232. For example, the hot combustion gas 172 may drive one or more turbine stages 174 disposed within the turbine section 156. Downstream of the turbine section 156, the process 220 may treat the exhaust gas 60 from the final turbine stage 174, as indicated by block 234. For example, the exhaust gas treatment 234 may include filtration, catalytic reaction of any residual oxidant 68 and/or fuel 70, chemical treatment, heat recovery with the HRSG 56, and so forth. The process 220 may also recirculate at least some of the exhaust gas 60 back to the compressor section 152 of the SEGR gas turbine system 52, as indicated by block



236. For example, the exhaust gas recirculation 236 may involve passage through the exhaust recirculation path 110 having the EG processing system 54 as illustrated in FIGS. 1-3.

[0066] In turn, the recirculated exhaust gas 66 may be compressed in the compressor section 152, as indicated by block 238. For example, the SEGR gas turbine system 52 may sequentially compress the recirculated exhaust gas 66 in one or more compressor stages 158 of the compressor section 152. Subsequently, the compressed exhaust gas 170 may be supplied to the combustors 160 and fuel nozzles 164, as indicated by block 228. Steps 230, 232, 234, 236, and 238 may then repeat, until the process 220 eventually transitions to a steady state mode, as indicated by block 240. Upon the transition 240, the process 220 may continue to perform the steps 224 through 238, but may also begin to extract the exhaust gas 42 via the EG supply system 78, as indicated by block 242. For example, the exhaust gas 42 may be extracted from one or more extraction points 76 along the compressor section 152, the combustor section 154, and the turbine section 156 as indicated in FIG. 3. In turn, the process 220 may supply the extracted exhaust gas 42 from the EG supply system 78 to the hydrocarbon production system 12, as indicated by block 244. The hydrocarbon production system 12 may then inject the exhaust gas 42 into the earth 32 for enhanced oil recovery, as indicated by block 246. For example, the extracted exhaust gas 42 may be used by the exhaust gas injection EOR system 112 of the EOR system 18 illustrated in FIGS. 1-3.

[0067] FIG. 5 is a schematic diagram of an embodiment of a SEGR oxidant compressor system 260. Elements in FIG. 5 in common with those shown in previous figures are labeled with the same reference numerals. In the illustrated embodiment, the oxidant 68 enters an inlet 262 of the oxidant compressor 188 (e.g., main air compressor or MAC). In certain embodiments, the oxidant 68 may be conveyed to the oxidant compressor 188 via an oxidant inlet conduit 263. The oxidant compressor 188 compresses the oxidant 68 to produce compressed oxidant 264 that exits an outlet 266 of the oxidant compressor 188. The oxidant 68 entering the inlet 262 of the oxidant compressor 188 may pass through a series of inlet guide vanes (IGVs) 268, which controls the amount of the oxidant 68 that is conveyed into the oxidant compressor

188. The IGVs 268 may be disposed at an angle that may be increased or decreased to allow less or more oxidant 68 into the oxidant compressor 188. For example, an IGV actuator 270 may be coupled to the IGVs 268 to adjust the angle of the IGVs 268. In certain embodiments, the control system 100 may send an output signal 272 to the IGV actuator 270 to adjust the angle of the IGVs 268.

[0068] As shown in FIG. 5, the SEGR oxidant compressor system 260 may include an inlet oxidant heating system 274, which may be used to route a heating gas 276 to the inlet 262 of the oxidant compressor 188. The heating gas 276 may include any gas within the SEGR gas turbine system 52 at a temperature and pressure suitable for heating the oxidant 68 (e.g., exhaust gas, carbon dioxide captured from exhaust gas), but excludes the compressed oxidant 264. In other words, the heating gas 276 does not include the compressed oxidant 264 exiting directly from the outlet 266 of the oxidant compressor 188, which may be used with other inlet bleed heat (IBH) techniques. Specific examples of the heating gas 276 are described in detail below. As shown in FIG. 5, an inlet oxidant heating control valve 278 may be used to adjust a flow rate of the heating gas 276. As such, the inlet oxidant heating control valve 278 may receive the output signal 272 from the control system 100. For example, the output signal 272 to the oxidant heating control valve 278 may be based on the sensor feedback 130 from one or more sensors 280 disposed throughout the SEGR oxidant compressor system 260. In certain embodiments, the one or more sensors 280 may provide sensor feedback 130 indicative of conditions at the inlet 262, within the oxidant compressor 188, and/or at the outlet 266. For example, the sensor feedback 130 may include an inlet temperature of oxidant compressor 188, a differential pressure of the oxidant compressor 188, a total inlet flow rate of the oxidant compressor 188, or an efficiency of the oxidant compressor 188, or any combination thereof. If the sensor feedback 130 indicates that less heating of the oxidant 68 is desired, the control system 100 may send the output signal 272 to the oxidant heating control valve 278 to reduce the flow rate of the heating gas 276 to the inlet 262. Alternatively, if the sensor feedback 130 indicates that additional heating of the oxidant 68 is desired, the control system 100 may send the output signal 272 to the oxidant heating control valve 278 to increase the flow rate of the heating gas 276 to

the inlet 262. In some embodiments, the SEGR oxidant compressor system 260 may include a plurality of sources for the heating gas 276, as described in detail below, each source with its own control valve 278. In such embodiments, the plurality of control valves 278 may be used to control which of the sources of heating gas 276 are used for a particular situation. For example, the physical properties (e.g., temperature, pressure, or composition) of the heating gas 276 from each of the plurality of sources may differ from one another. As such, a particular source of heating gas 276 (e.g., a relatively hotter heating gas 276) may be used in certain situations (e.g., startup) and another source of heating gas 276 (e.g., a relatively cooler heating gas 276) may be used in other situations (e.g., normal operation). In certain embodiments, a mixer 282 may be used to combine the oxidant 68 with the heating gas 276 entering the inlet 262 of the oxidant compressor 188. In other words, the oxidant 68 is being directly mixed with the heating gas 276 (e.g., exhaust gas). Thus, the mixer 282 may be used to help increase the uniformity of the temperature of the oxidant 68 and the heating gas 276 entering the inlet 262.

**[0069]** Use of the inlet oxidant heating system 274 with the SEGR oxidant compressor system 260 may provide several benefits compared to compressor systems that do not include the inlet oxidant heating system 274. For example, the heating gas 276 may be warmer than the oxidant 68. Thus, the mixture of the heating gas 276 and the oxidant 68 provided to the inlet 262 by the inlet oxidant heating system 274 may be warmer than the oxidant 68 alone, thereby reducing the possibility of icing of the oxidant compressor 188. In addition, use of the inlet oxidant heating system 274 may enable the IGVs 268 to be operated in a more open position than without use of the inlet oxidant heating system 274, thereby reducing the possibility of surging of the oxidant compressor 188. The inlet oxidant heating system 274 may be used to adjust a flow rate of the heating gas 276 to maintain an angle of the IGVs 268 within a desired range. This means that use of the inlet oxidant heating system 274 may provide operators an additional method for adjusting a total inlet flow rate of the oxidant compressor 188. In other words, if the operators desire the total inlet flow rate of the oxidant compressor 188 to be decreased at a given IGV position, the inlet oxidant heating system 274 may be used to add additional heating gas 276 to the inlet

262. In addition, the inlet oxidant heating system 274 may be used to adjust an efficiency of the oxidant compressor 188. Specifically, by increasing the inlet flow rate of the oxidant compressor 188, the IGVs 268 may open further, thereby increasing the efficiency of the oxidant compressor 188. Moreover, the addition of the exhaust gas (e.g., heating gas 276) with the oxidant 68 may help increase production of carbon dioxide because of the increased amount of recirculated exhaust gas.

[0070] FIG. 6 is a schematic diagram of the SEGR gas turbine system 52 that includes an embodiment of the inlet oxidant heating system 274. Elements in FIG. 6 in common with those shown in previous figures are labeled with the same reference numerals. In the illustrated embodiment, the exhaust gas 60 flows along the exhaust recirculation path 110 to the HRSG 56 to generate steam. The exhaust gas 60 from the HRSG 56 may then flow to an exhaust gas blower 300, which may increase a pressure of the exhaust gas 60. For example, the exhaust gas blower 300 may be a compressor or fan. The compressed exhaust gas 60 from the exhaust gas blower 300 may then flow to an exhaust gas cooler 302, which may reduce a temperature of the exhaust gas 60. For example, the exhaust gas cooler 302 may use a fluid, such as a liquid or a gas, to cool the exhaust gas 60. In one embodiment, the exhaust gas cooler 302 may use water to cool the exhaust gas 60. The cooled exhaust gas 66 may then flow along the exhaust recirculation path 110 to the compressor section 152.

[0071] As shown in FIG. 6, a portion of the exhaust gas 60 may be used as the heating gas 276 for the inlet oxidant heating system 274. Specifically, an inlet oxidant heating conduit 304 may convey the exhaust gas 60 to the inlet exhaust gas control valve 278. As shown in FIG. 6, the inlet oxidant heating conduit 304 is coupled to the oxidant inlet conduit 263. In the illustrated embodiment, the inlet oxidant heating conduit 304 is coupled between the exhaust gas blower 300 and the exhaust gas cooler 302 so that the increased pressure of the exhaust gas 60 discharged from the exhaust gas blower 300 is used to overcome pressure losses associated with the inlet exhaust gas heating conduit 304, thereby enabling the exhaust gas 60 to enter the oxidant compressor 188. In addition, as the exhaust gas 60 upstream of the exhaust gas cooler 302 has not been cooled by the exhaust gas cooler 302, the exhaust gas 60 may be well suited for heating the oxidant 68 and reducing icing and/or surging of the oxidant

compressor 188. In some embodiments, other sources of heating gas 276 other than that shown in FIG. 6 may be used with control valves 278 for each source.

**[0072]** FIG. 7 is a schematic diagram of an embodiment of the inlet oxidant heating system 274 with a plurality of sources for heating gas 276 (e.g., “HG”). For example, in one embodiment, an intercooler 320 may be disposed downstream of the oxidant compressor 188 to cool the compressed oxidant 264. The inlet oxidant heating conduit 304 may be coupled downstream of the intercooler 320 to convey the compressed oxidant 264 to the inlet 262 of the oxidant compressor 188. In another embodiment, a booster oxidant compressor 322 may be disposed downstream of the oxidant compressor 188 and/or downstream of the intercooler 320 to further compress the compressed oxidant 264 that is then routed to the turbine combustor 160. The inlet oxidant heating conduit 304 may be coupled downstream of the booster oxidant compressor 322 and may convey the compressed oxidant 264 to the inlet 262 of the oxidant compressor 188. In other embodiments, the inlet oxidant heating conduit 304 may be coupled to various locations within the SEGR gas turbine system 52 to convey combustion products and/or exhaust gas to the inlet 262 of the oxidant compressor 188. For example, the inlet oxidant heating conduit 304 may be coupled to at least one of the exhaust inlet 184 of the compressor section 152, a compressor outlet 324 of the compressor section 152, one or more compressor stages 158, one or more turbine combustors 160, a turbine inlet 326 of the turbine section 156, one or more turbine stages 174, the exhaust outlet 182, or the exhaust gas processing system 54, or any combination thereof. In some embodiments, the sources of the heating gas 276 may be in other gas turbine systems (e.g., a second, third, or fourth gas turbine engine in a parallel gas turbine system train), other combustion systems, and so forth.

**[0073]** As described above, certain embodiments of the SEGR gas turbine system 52 may include the oxidant compressor 188 and the gas turbine engine 150. The gas turbine engine 150 may include the combustor section 154 having the turbine combustor 160, the turbine section 156 driven by combustion products from the turbine combustor 160, and the compressor section 152 driven by the turbine section 156. The compressor section 152 compresses and routes the compressed exhaust gas 170 to the turbine combustor 160, and the oxidant compressor 188 compresses and

routes the oxidant 68 to the turbine combustor 160. The inlet oxidant heating system 274 may route at least one of the portion of the compressed exhaust 170, or the portion of the exhaust gas 60, or any combination thereof (e.g., the heating gas 276), to the inlet 262 of the oxidant compressor 188. As the temperature of the gas provided by the inlet oxidant heating system 274 may be greater than the temperature of the oxidant 68 in certain situations, the inlet oxidant heating system 274 may help reduce icing and/or surging of the oxidant compressor 188. In some embodiments, there may be a plurality of sources for the heating gas 276, each of which may differ in properties from one another, and the control system 100 may be used to select a desired source of heating gas 276. Each source of heating gas 276 may have its own control valve 278 to provide enhanced flexibility for the control system 100.

#### ADDITIONAL DESCRIPTION

**[0074]** The present embodiments provide a system and method for gas turbine engines. It should be noted that any one or a combination of the features described above may be utilized in any suitable combination. Indeed, all permutations of such combinations are presently contemplated. By way of example, the following clauses are offered as further description of the present disclosure:

**[0075]** Embodiment 1. A system, comprising: an oxidant compressor; and a gas turbine engine, comprising: a combustor section having a turbine combustor; a turbine driven by combustion products from the turbine combustor; an exhaust gas compressor driven by the turbine, wherein the exhaust gas compressor is configured to compress and route an exhaust flow to the turbine combustor, and the oxidant compressor is configured to compress and route an oxidant flow to the turbine combustor; and an inlet oxidant heating system configured to route at least one of a first portion of the combustion products, or a second portion of the exhaust flow, or any combination thereof, to an inlet of the oxidant compressor.

**[0076]** Embodiment 2. The system of embodiment 1, wherein the inlet oxidant heating system is configured to combine an oxidant inlet flow to the oxidant

compressor with the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof.

[0077] Embodiment 3. The system defined in any preceding embodiment, wherein the inlet oxidant heating system is configured to at least one of reduce icing of the oxidant compressor, reduce surging of the oxidant compressor, adjust a total inlet flow rate of the oxidant compressor, or adjust an efficiency of the oxidant compressor, or any combination thereof.

[0078] Embodiment 4. The system defined in any preceding embodiment, wherein the inlet oxidant heating system comprises an inlet oxidant heating conduit configured to convey the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, to the inlet of the oxidant compressor.

[0079] Embodiment 5. The system defined in any preceding embodiment, comprising: an exhaust gas blower configured to increase a pressure of the exhaust flow from the turbine; and an exhaust gas cooler configured to cool the exhaust flow from the exhaust gas blower, wherein the inlet oxidant heating conduit is coupled between the exhaust gas blower and the exhaust gas cooler.

[0080] Embodiment 6. The system defined in any preceding embodiment, comprising a heat recovery steam generator (HRSG) disposed upstream of the exhaust gas blower, wherein the HRSG is configured to generate steam from the exhaust flow from the turbine.

[0081] Embodiment 7. The system defined in any preceding embodiment, comprising an intercooler configured to cool the oxidant flow from the oxidant compressor, wherein the inlet oxidant heating conduit is coupled downstream of the intercooler and is configured to convey a third portion of the oxidant flow to the inlet of the oxidant compressor.

[0082] Embodiment 8. The system defined in any preceding embodiment, comprising a booster oxidant compressor configured to compress the oxidant flow

from the oxidant compressor, wherein the inlet oxidant heating conduit is coupled downstream of the booster oxidant compressor and is configured to convey a fourth portion of the oxidant flow to the inlet of the oxidant compressor.

[0083] Embodiment 9. The system defined in any preceding embodiment, wherein the inlet oxidant heating conduit is coupled to at least one of a compressor inlet of the exhaust gas compressor, a compressor outlet of the exhaust gas compressor, a compressor stage of the exhaust gas compressor, the turbine combustor, a turbine inlet of the turbine, a turbine stage of the turbine, a turbine outlet of the turbine, an exhaust gas processing system, a second gas turbine engine, or a combustion system, or any combination thereof.

[0084] Embodiment 10. The system defined in any preceding embodiment, comprising an oxidant inlet conduit configured to convey an inlet oxidant flow to the inlet of the oxidant compressor, wherein the inlet oxidant heating conduit is coupled to the oxidant inlet conduit.

[0085] Embodiment 11. The system defined in any preceding embodiment, wherein the inlet oxidant heating system comprises an inlet oxidant heating control valve configured to adjust a flow rate of the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, to the inlet of the oxidant compressor.

[0086] Embodiment 12. The system defined in any preceding embodiment, comprising a sensor configured to provide a signal indicative of at least one of an inlet temperature of oxidant compressor, a differential pressure of the oxidant compressor, a total inlet flow rate of the oxidant compressor, or an efficiency of the oxidant compressor, or any combination thereof, to a control system.

[0087] Embodiment 13. The system defined in any preceding embodiment, comprising the control system configured to adjust the inlet oxidant heating control valve in response to the signal from the sensor.



**[0088]** Embodiment 14. The system defined in any preceding embodiment, wherein the inlet oxidant heating system is configured to adjust a flow rate of at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, to maintain an angle of an inlet guide vane within a range, wherein the inlet guide vane is coupled to the inlet of the oxidant compressor and is configured to adjust a total inlet flow rate of the oxidant compressor.

**[0089]** Embodiment 15. The system defined in any preceding embodiment, comprising an exhaust gas extraction system coupled to the gas turbine engine, and a hydrocarbon production system coupled to the exhaust gas extraction system.

**[0090]** Embodiment 16. The system defined in any preceding embodiment, wherein the gas turbine engine is a stoichiometric exhaust gas recirculation (SEGR) gas turbine engine.

**[0091]** Embodiment 17. A method, comprising: driving a turbine of a gas turbine engine with combustion products from a turbine combustor; driving an exhaust gas compressor using the turbine; compressing and routing an exhaust flow to the turbine combustor using the exhaust gas compressor; compressing and routing an oxidant flow to the turbine combustor using an oxidant compressor; and routing at least one of a first portion of the combustion products, or a second portion of the exhaust flow, or any combination thereof, to an inlet of the oxidant compressor.

**[0092]** Embodiment 18. The method or system defined in any preceding embodiment, comprising mixing an oxidant inlet flow to the oxidant compressor with the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof using a mixer.

**[0093]** Embodiment 19. The method or system defined in any preceding embodiment, comprising at least one of reducing icing of the oxidant compressor, reducing surging of the oxidant compressor, adjusting a total inlet flow rate of the oxidant compressor, or adjusting an efficiency of the oxidant compressor, or any combination thereof, using the inlet oxidant heating system.

**[0094]** Embodiment 20. The method or system defined in any preceding embodiment, comprising conveying the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, to the inlet of the oxidant compressor using an inlet oxidant heating conduit.

**[0095]** Embodiment 21. The method or system defined in any preceding embodiment, comprising: increasing a pressure of the exhaust flow from the turbine using an exhaust gas blower; cooling the exhaust flow from the exhaust gas blower using an exhaust gas cooler; and routing the second portion of the combustion products from the exhaust gas blower to the inlet of the oxidant compressor using the inlet oxidant heating conduit.

**[0096]** Embodiment 22. The method or system defined in any preceding embodiment, comprising routing the second portion of the exhaust flow from a heat recovery steam generator (HRSG) to the inlet of the oxidant compressor using the inlet oxidant heating conduit.

**[0097]** Embodiment 23. The method or system defined in any preceding embodiment, comprising routing a third portion of the oxidant flow from an intercooler to the inlet of the oxidant compressor using the inlet oxidant heating conduit, wherein the intercooler is configured to cool the oxidant flow from the oxidant compressor.

**[0098]** Embodiment 24. The method or system defined in any preceding embodiment, comprising routing a fourth portion of the oxidant flow from a booster oxidant compressor to the inlet of the oxidant compressor using the inlet oxidant heating conduit, wherein the booster oxidant compressor is configured to compress the oxidant flow from the oxidant compressor.

**[0099]** Embodiment 25. The method or system defined in any preceding embodiment, comprising routing at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, from at least one of a compressor inlet of the exhaust gas compressor, a compressor outlet of the exhaust gas compressor, a compressor stage of the exhaust gas compressor, the

turbine combustor, a turbine inlet of the turbine, a turbine stage of the turbine, a turbine outlet of the turbine, an exhaust gas processing system, a second gas turbine engine, or a combustion system, or any combination thereof, using the inlet oxidant heating conduit.

**[00100]** Embodiment 26. The method or system defined in any preceding embodiment, comprising: routing an inlet oxidant flow to the inlet of the oxidant compressor using an oxidant inlet conduit; and routing the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, from the inlet oxidant heating conduit to the oxidant inlet conduit.

**[00101]** Embodiment 27. The method or system defined in any preceding embodiment, comprising adjusting a flow rate of the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, using an inlet oxidant heating control valve.

**[00102]** Embodiment 28. The method or system defined in any preceding embodiment, comprising providing a signal indicative of at least one of an inlet temperature of oxidant compressor, a differential pressure of the oxidant compressor, a total inlet flow rate of the oxidant compressor, or an efficiency of the oxidant compressor, or any combination thereof, from a sensor to a control system.

**[00103]** Embodiment 29. The method or system defined in any preceding embodiment, comprising adjusting the inlet oxidant heating control valve in response to the signal from the sensor using the control system.

**[00104]** Embodiment 30. The method or system defined in any preceding embodiment, comprising adjusting a flow rate of at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, using the inlet oxidant heating system to maintain an angle of an inlet guide vane within a range, wherein the inlet guide vane is coupled to the inlet of the oxidant compressor and is configured to adjust a total inlet flow rate of the oxidant compressor.

**[00105]** Embodiment 31. A system, comprising: instructions disposed on a non-transitory, machine readable medium, wherein the instructions are configured to monitor or control operations to: drive a turbine of a gas turbine engine with combustion products from a turbine combustor; drive an exhaust gas compressor using the turbine; compress and route an exhaust flow to the turbine combustor using the exhaust gas compressor; compress and route an oxidant flow to the turbine combustor using an oxidant compressor; and route at least one of a first portion of the combustion products, or a second portion of the exhaust flow, or any combination thereof, to an inlet of the oxidant compressor.

**[00106]** Embodiment 32. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to mix an oxidant inlet flow to the oxidant compressor with the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof using a mixer.

**[00107]** Embodiment 33. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to at least one of reduce icing of the oxidant compressor, reduce surging of the oxidant compressor, adjust a total inlet flow rate of the oxidant compressor, or adjust an efficiency of the oxidant compressor, or any combination thereof, using the inlet oxidant heating system.

**[00108]** Embodiment 34. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to convey the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, to the inlet of the oxidant compressor using an inlet oxidant heating conduit.

**[00109]** Embodiment 35. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to: increase a pressure of the exhaust flow from the turbine using an exhaust gas blower; cool the exhaust flow from the exhaust gas blower using an exhaust gas

cooler; and route the second portion of the exhaust flow from the exhaust gas blower to the inlet of the oxidant compressor using the inlet oxidant heating conduit.

**[00110]** Embodiment 36. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to route the second portion of the exhaust flow from a heat recovery steam generator (HRSG) to the inlet of the oxidant compressor using the inlet oxidant heating conduit.

**[00111]** Embodiment 37. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to route a third portion of the oxidant flow from an intercooler to the inlet of the oxidant compressor using the inlet oxidant heating conduit, wherein the intercooler is configured to cool the oxidant flow from the oxidant compressor.

**[00112]** Embodiment 38. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to route a fourth portion of the oxidant flow from a booster oxidant compressor to the inlet of the oxidant compressor using the inlet oxidant heating conduit, wherein the booster oxidant compressor is configured to compress the oxidant flow from the oxidant compressor.

**[00113]** Embodiment 39. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to route at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, from at least one of a compressor inlet of the exhaust gas compressor, a compressor outlet of the exhaust gas compressor, a compressor stage of the exhaust gas compressor, the turbine combustor, a turbine inlet of the turbine, a turbine stage of the turbine, a turbine outlet of the turbine, an exhaust gas processing system, a second gas turbine engine, or a combustion system, or any combination thereof, using the inlet oxidant heating conduit.

**[00114]** Embodiment 40. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations

to: route an inlet oxidant flow to the inlet of the oxidant compressor using an oxidant inlet conduit; and route the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, from the inlet oxidant heating conduit to the oxidant inlet conduit.

**[00115]** Embodiment 41. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to adjust a flow rate of the at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, using an inlet oxidant heating control valve.

**[00116]** Embodiment 42. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to provide a signal indicative of at least one of an inlet temperature of oxidant compressor, a differential pressure of the oxidant compressor, a total inlet flow rate of the oxidant compressor, or an efficiency of the oxidant compressor, or any combination thereof, from a sensor to a control system.

**[00117]** Embodiment 43. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to adjust the inlet oxidant heating control valve in response to the signal from the sensor using the control system.

**[00118]** Embodiment 44. The method or system defined in any preceding embodiment, wherein the instructions are configured to monitor or control operations to adjust a flow rate of at least one of the first portion of the combustion products, or the second portion of the exhaust flow, or any combination thereof, using the inlet oxidant heating system to maintain an angle of an inlet guide vane within a range, wherein the inlet guide vane is coupled to an inlet of the oxidant compressor and is configured to adjust a total inlet flow rate of the oxidant compressor.

**[00119]** 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.

## CLAIMS:

1. A system, comprising:  
an oxidant compressor; and  
a gas turbine engine, comprising:  
a combustor section having a turbine combustor, wherein the turbine combustor is configured to produce combustion products;  
a turbine driven by combustion products from the turbine combustor, wherein the turbine is configured to discharge an exhaust flow;  
an exhaust gas compressor driven by the turbine, wherein the exhaust gas compressor is configured to compress and route a first portion of the exhaust flow to the turbine combustor, and the oxidant compressor is configured to compress and route an oxidant flow to the turbine combustor; and  
an inlet oxidant heating system coupled to a plurality of heating gas sources, wherein the inlet oxidant heating system comprises a combustion products extraction conduit disposed between the turbine combustor and the turbine and an exhaust flow extraction conduit disposed between the turbine and the exhaust gas compressor, and wherein the inlet oxidant heating system is configured to route a first portion of the combustion products through the combustion products extraction conduit, or a second portion of the exhaust flow through the exhaust flow extraction conduit, or both, to an inlet of the oxidant compressor.
2. The system of claim 1, wherein the inlet oxidant heating system is configured to combine an oxidant inlet flow to the oxidant compressor with the first portion of the combustion products, or the second portion of the exhaust flow, or both.
3. The system of claim 1, wherein the inlet oxidant heating system comprises an inlet oxidant heating conduit configured to receive the first portion of the combustion products from the combustion products extraction conduit, or the second portion of



the exhaust flow from the exhaust flow extraction conduit, or both, and to convey the first portion of the combustion products, the second portion of the exhaust flow, or both to the inlet of the oxidant compressor.

4. The system of claim 3, comprising:
  - an exhaust gas blower configured to increase a pressure of the exhaust flow from the turbine; and
  - an exhaust gas cooler configured to cool the exhaust flow from the exhaust gas blower, wherein the inlet oxidant heating conduit is coupled between the exhaust gas blower and the exhaust gas cooler.
5. The system of claim 4, comprising a heat recovery steam generator (HRSG) disposed upstream of the exhaust gas blower, wherein the HRSG is configured to generate steam from the exhaust flow from the turbine.
6. The system of claim 3, comprising an intercooler configured to cool the oxidant flow from the oxidant compressor, wherein the inlet oxidant heating conduit is coupled downstream of the intercooler and is configured to convey a first portion of the oxidant flow to the inlet of the oxidant compressor.
7. The system of claim 3, comprising a booster oxidant compressor configured to compress the oxidant flow from the oxidant compressor, wherein the inlet oxidant heating conduit is coupled downstream of the booster oxidant compressor and is configured to convey a first portion of the oxidant flow to the inlet of the oxidant compressor.
8. The system of claim 3, wherein the inlet oxidant heating conduit is coupled to at least one of a compressor inlet of the exhaust gas compressor, a compressor outlet of the exhaust gas compressor, a compressor stage of the exhaust gas compressor, the turbine combustor, a turbine inlet of the turbine, a turbine stage of the turbine, a turbine outlet of the turbine, an exhaust gas processing system, a second gas turbine

engine, the combustion products extraction conduit, the exhaust gas extraction conduit, or a combustion system, or any combination thereof.

9. The system of claim 1, comprising an exhaust gas extraction system coupled to the gas turbine engine, and a hydrocarbon production system coupled to the exhaust gas extraction system.

10. The system of claim 1, wherein the gas turbine engine is a stoichiometric exhaust gas recirculation (SEGR) gas turbine engine.

11. A method, comprising:

- driving a turbine of a gas turbine engine with combustion products from a turbine combustor;

- driving an exhaust gas compressor using the turbine;

- compressing and routing an exhaust flow from the turbine to the turbine combustor using the exhaust gas compressor;

- compressing and routing an oxidant flow to the turbine combustor using an oxidant compressor;

- routing a first portion of the combustion products from a first conduit disposed between the turbine combustor and the turbine to a first control valve of an inlet oxidant heating system and a second portion of the exhaust flow from a second conduit disposed between the turbine and the exhaust gas compressor to a second control valve of the inlet oxidant heating system, wherein the first control valve and the second control valve are coupled to an inlet of the oxidant compressor.

12. The method of claim 11, comprising an oxidant inlet flow to the oxidant compressor with the at least one of the first portion of the combustion products from the first conduit, or the second portion of the exhaust flow from the second conduit, or any combination thereof using a mixer.

13. The method of claim 11, comprising at least one of reducing icing of the oxidant compressor, reducing surging of the oxidant compressor, adjusting a total

inlet flow rate of the oxidant compressor, or adjusting an efficiency of the oxidant compressor, or any combination thereof, using the inlet oxidant heating system.

14. The method of claim 11, comprising conveying the at least one of the first portion of the combustion products from the first conduit, or the second portion of the exhaust flow from the second conduit, or any combination thereof, to the inlet of the oxidant compressor using an oxidant heating conduit.

15. The method of claim 14, comprising:

routing an oxidant inlet flow to the inlet of the oxidant compressor using an oxidant inlet conduit; and

routing the at least one of the first portion of the combustion products from the first conduit, or the second portion of the exhaust flow from the second conduit, or any combination thereof, from the inlet oxidant heating conduit to the oxidant inlet conduit.

16. The method of claim 11, comprising adjusting a flow rate of the at least one of the first portion of the combustion products from the first conduit, or the second portion of the exhaust flow from the second conduit, or any combination thereof, using an inlet oxidant heating control valve.

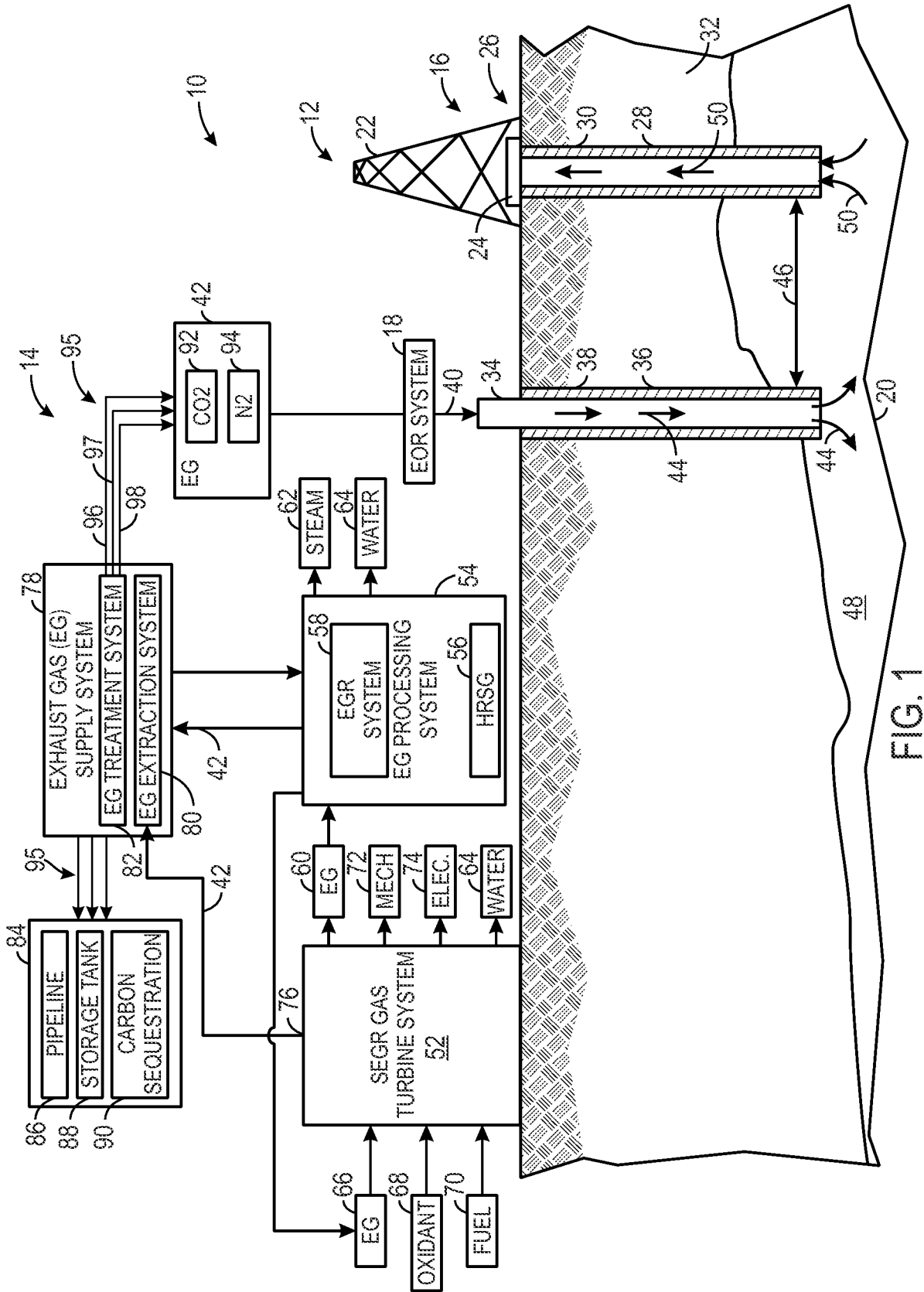
17. The method of claim 16, comprising providing a signal indicative of at least one of an inlet temperature of the oxidant compressor, a differential pressure of the oxidant compressor, a total inlet flow rate of the oxidant compressor, or an efficiency of the oxidant compressor, or any combination thereof, from a sensor to a control system.

18. The method of claim 11, comprising adjusting a flow rate of at least one of the first portion of the combustion products from the first conduit, or the second portion of the exhaust flow from the second conduit, or any combination thereof, using the inlet oxidant heating system to maintain an angle of an inlet guide vane within a

range, wherein the inlet guide vane is coupled to the inlet of the oxidant compressor and is configured to adjust a total inlet flow rate of the oxidant compressor.

19. A system, comprising:
- instructions disposed on a non-transitory, machine readable medium;
  - a processor configured to execute the instructions to:
    - drive a turbine of a gas turbine engine with combustion products from a turbine combustor;
    - drive an exhaust gas compressor using the turbine;
    - compress and route an exhaust flow from the turbine to the turbine combustor using the exhaust gas compressor;
    - compress and route an oxidant flow to the turbine combustor using an oxidant compressor; and
    - route a first portion of the combustion products from a first conduit disposed between the turbine combustor and the turbine to a first control valve of an inlet oxidant heating system and a second portion of the exhaust flow from a second conduit disposed between the turbine and the exhaust gas compressor to a second control valve of the inlet oxidant heating system, wherein the first control valve and the second control valve are coupled to an inlet of the oxidant compressor

20. The system of claim 19, wherein the processor is further configured to monitor or control operations to adjust a flow rate of at least one of the first portion of the combustion products from the first conduit, or the second portion of the exhaust flow from the second conduit, or any combination thereof, using the inlet oxidant heating system to maintain an angle of an inlet guide vane within a range, wherein the inlet guide vane is coupled to an inlet of the oxidant compressor and is configured to adjust a total inlet flow rate of the oxidant compressor.



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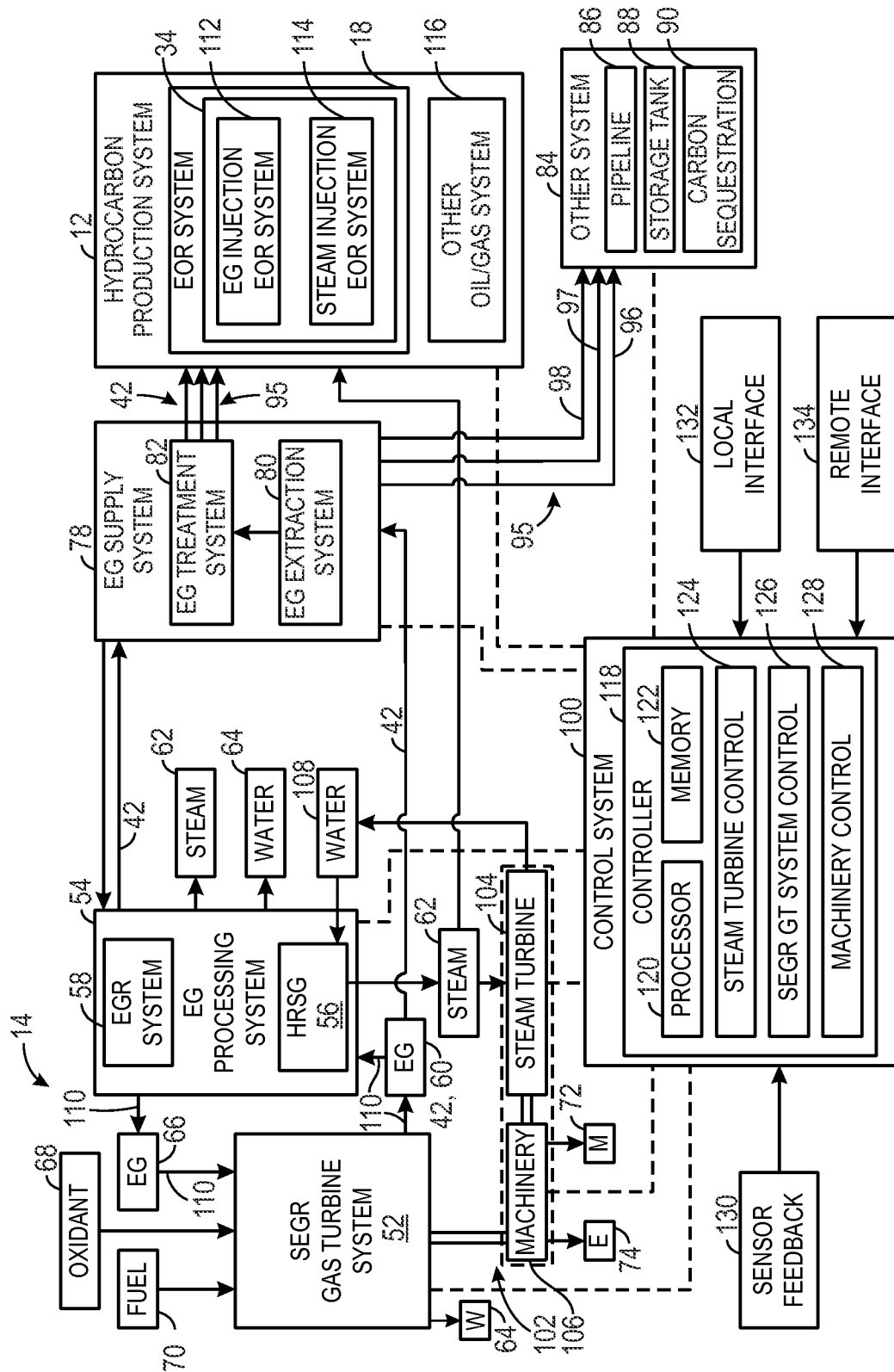


FIG. 2

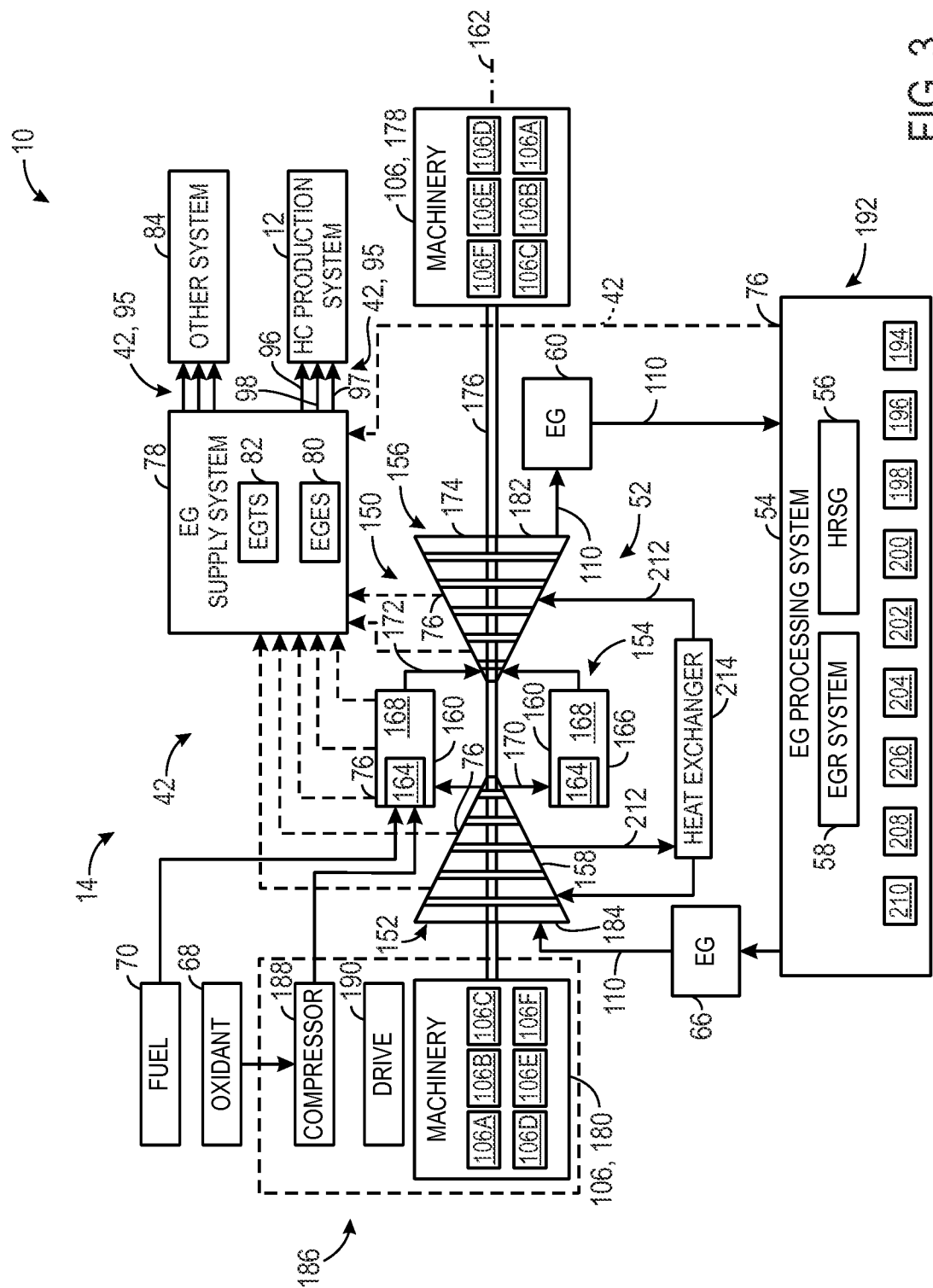


FIG. 3

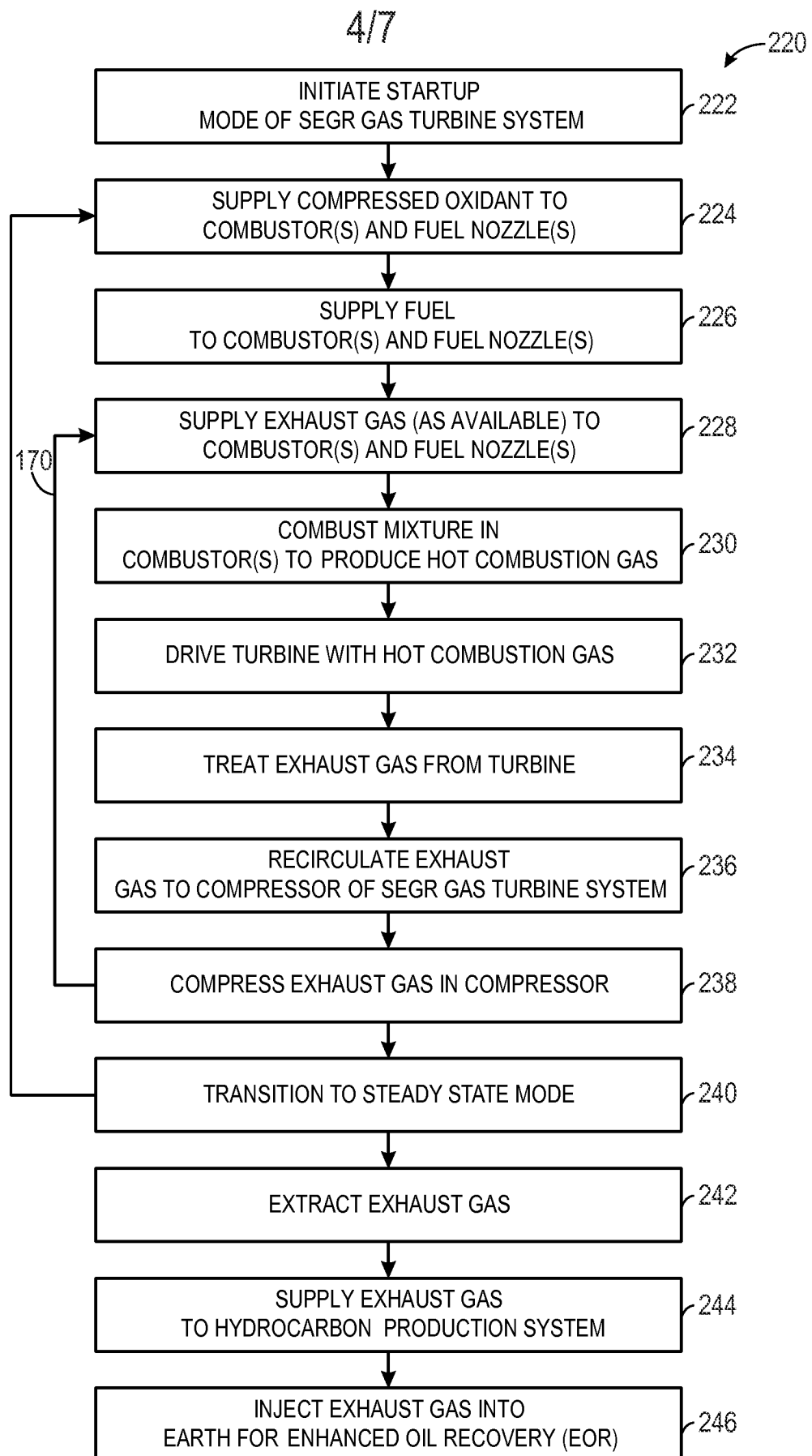


FIG. 4



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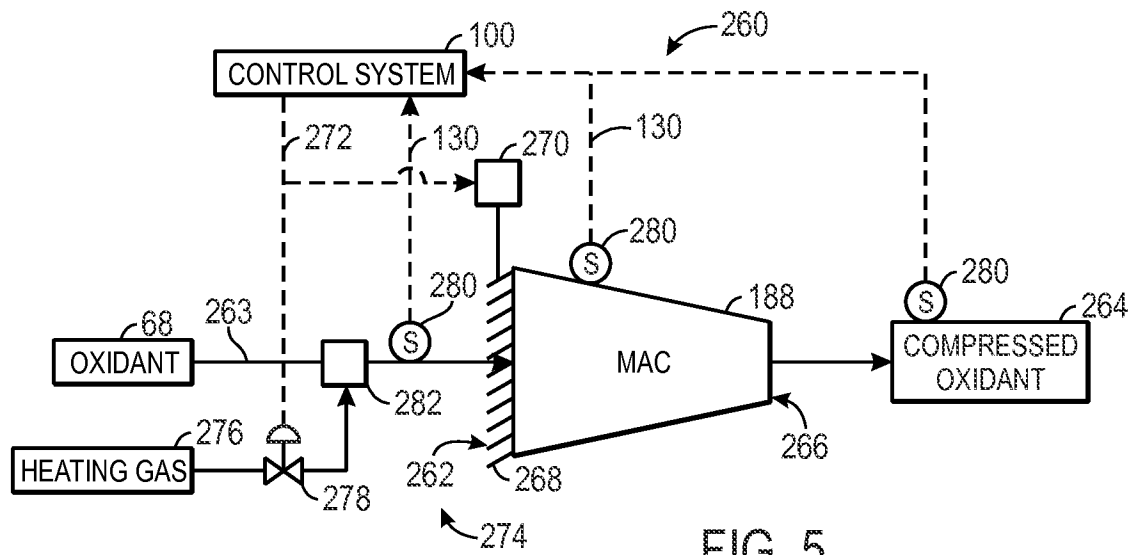


FIG. 5

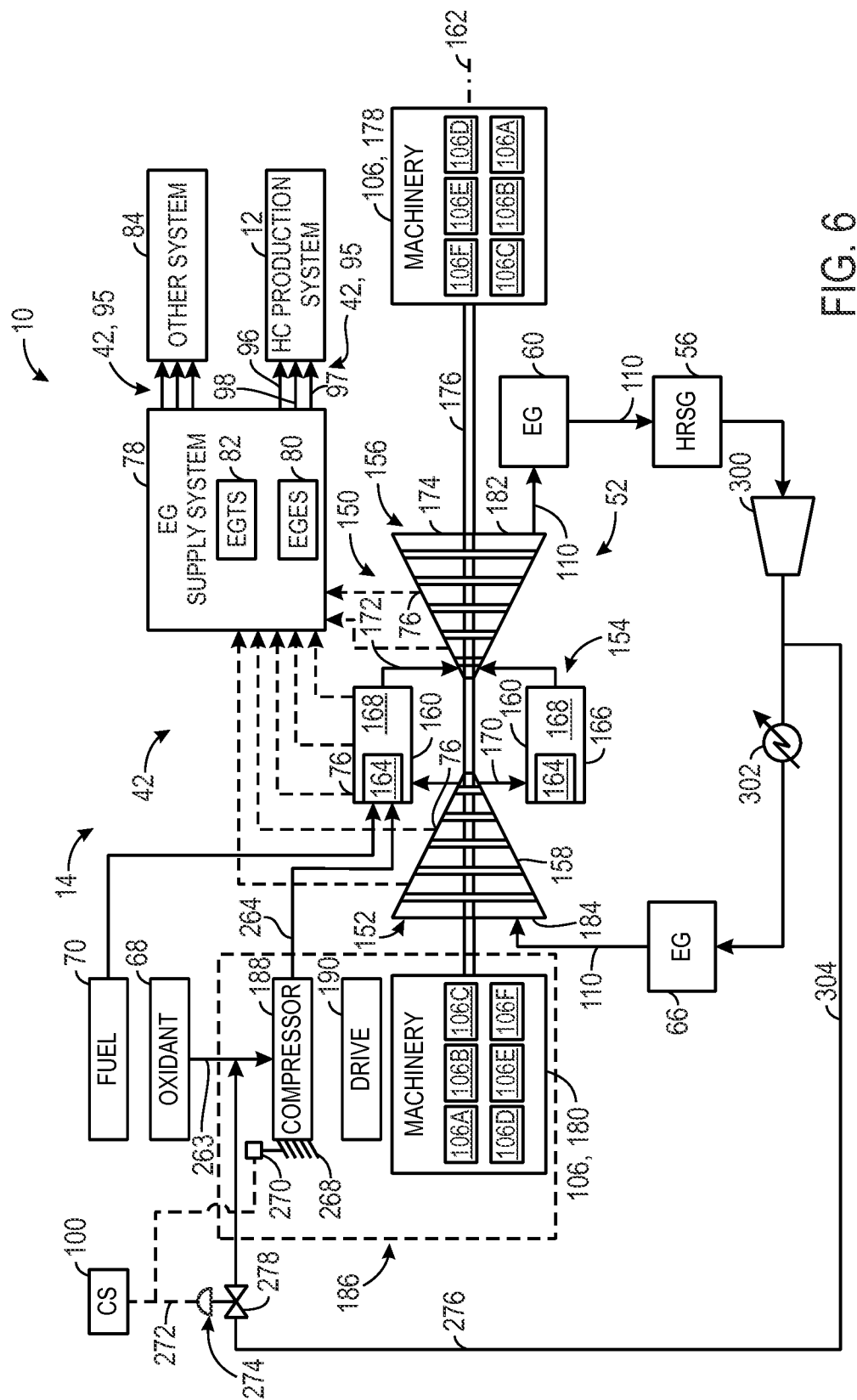


FIG. 6

