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(54) AIR SEPARATION UNIT AND SYSTEMS INCORPORATING THE SAME

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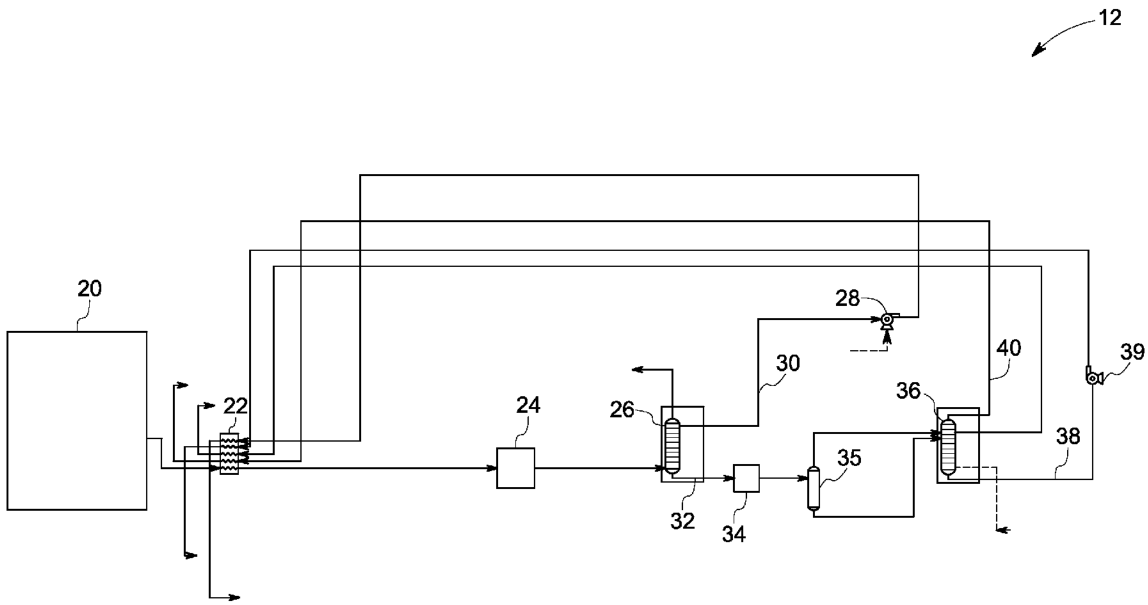
(57) ABSTRACT

A system comprising an air separation unit (ASU) is provided. The ASU is configured to produce liquid nitrogen and pressurize to higher pressure using a pump. ASU may be further configured to produce liquid oxygen that can be directly pressurized to be used in required applications. System may further include oxy-fuel combustion system, integrated gas turbines and integrated enhanced oil and/or gas recovery units. Methods of operating the system included.



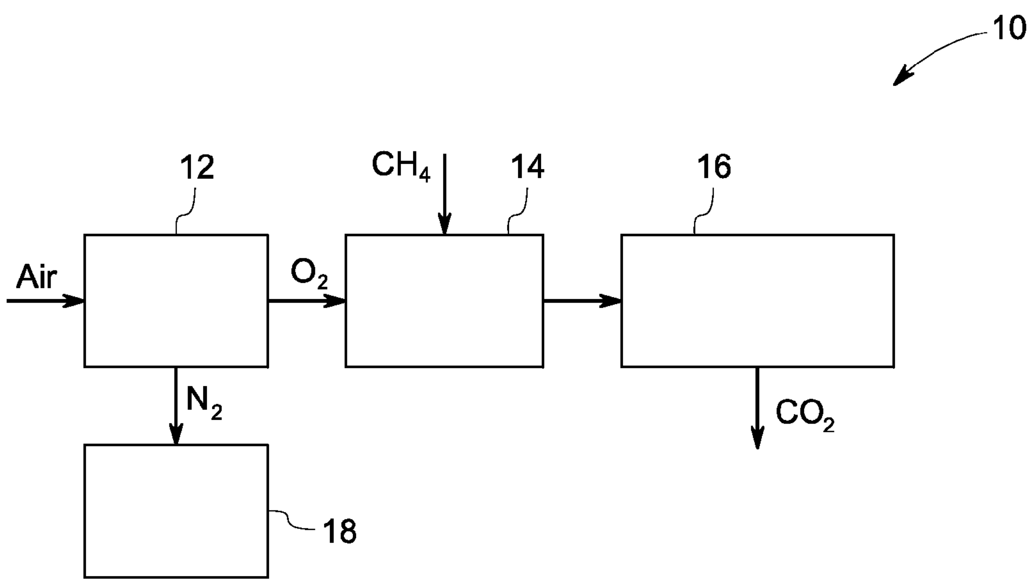


FIG. 1

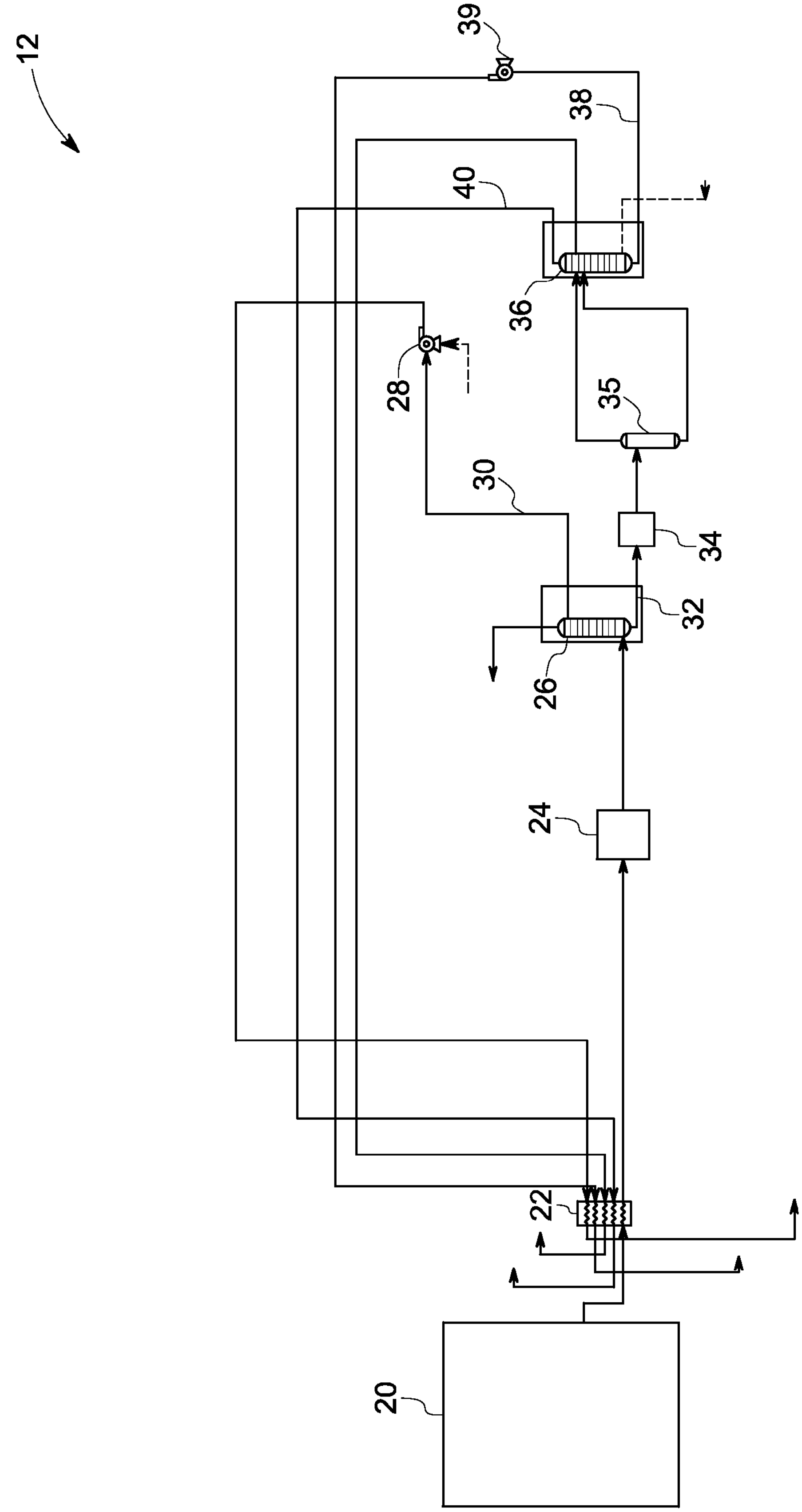


FIG. 2

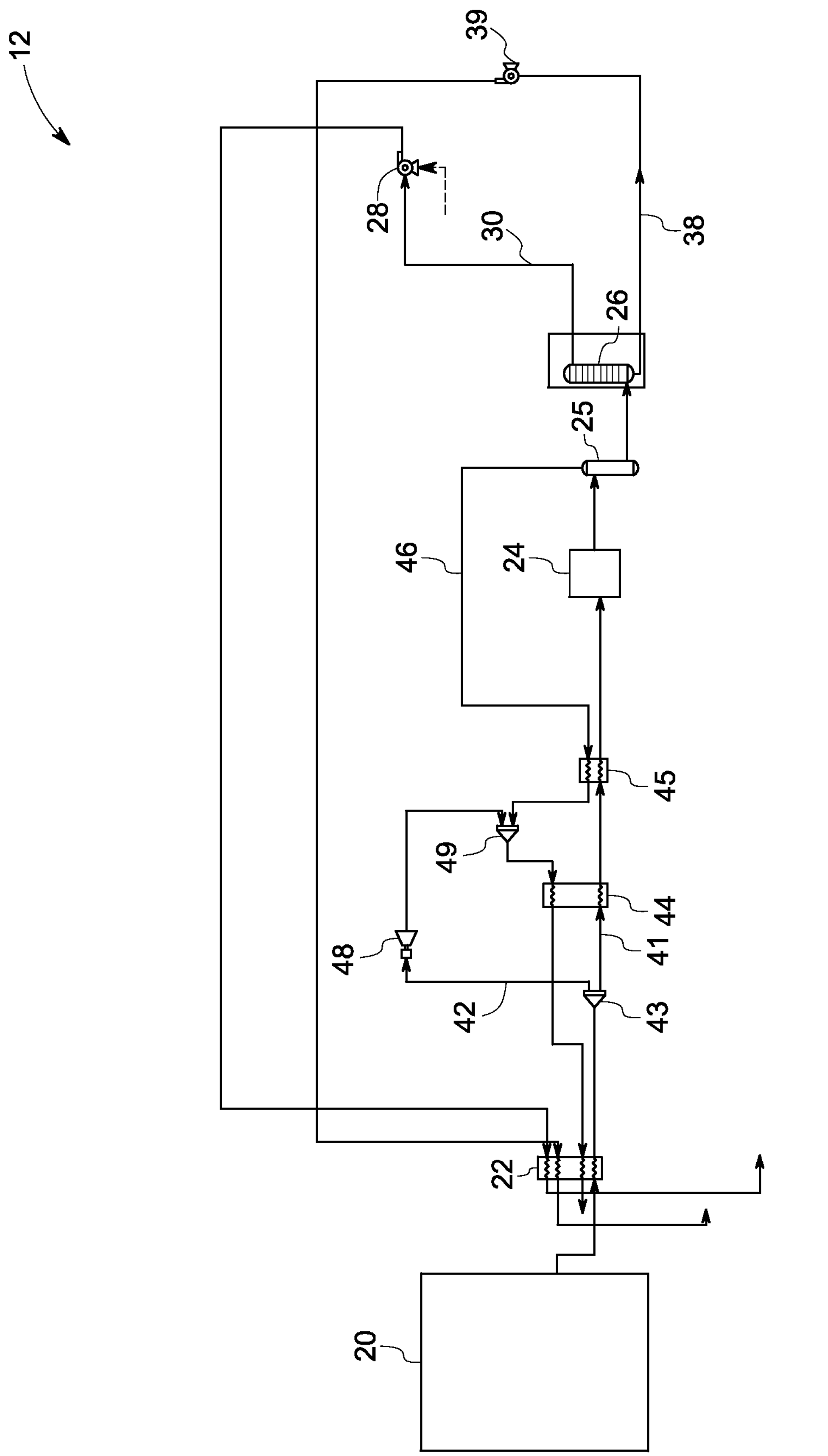


FIG. 3

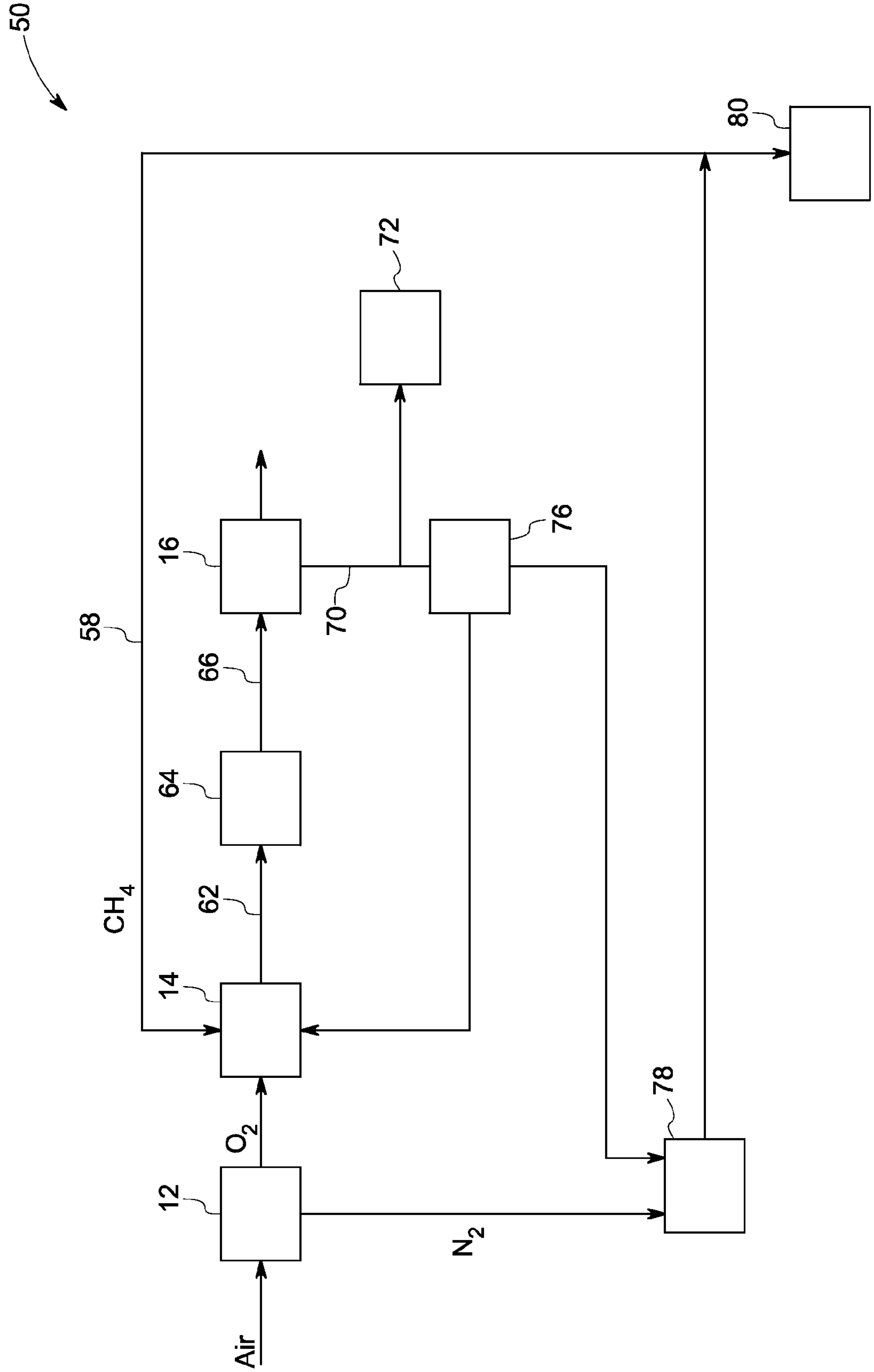


FIG. 4

AIR SEPARATION UNIT AND SYSTEMS INCORPORATING THE SAME

BACKGROUND

[0001] The invention relates generally to air separation units and systems incorporating the air separation units. More particularly, the invention relates to separation of nitrogen and oxygen from air in liquid form and systems incorporating these products for use in, for example, such applications as power generation and natural resource recovery.

[0002] Exhaust streams generated by the combustion of fossil fuels in, for example, power generation systems, contain nitrogen oxides (NO_x) and carbon monoxide (CO) as byproducts during combustion. A method for achieving near-zero NO_x, without the need for removal of NO_x from the exhaust, is the oxy-fuel combustion process. In this method, pure oxygen (typically in combination with a secondary gas such as carbon dioxide) is used as the oxidizer, as opposed to using air, thereby resulting in a flue gas with negligible NO_x emissions. Additionally, oxy-fuel combustion is an attractive technology for applications, such as carbon dioxide (CO_2) production or sequestration, that benefit from production of CO_2 with low levels of oxygen contamination. In gas turbines that operate by way of an oxy-fuel process, a CO_2 separation unit is not needed, because the main component of combustion exhaust includes primarily CO_2, and water (H_2O). By condensing H_2O a high concentration stream of CO_2 may be produced and can be used for CO_2 sequestration or other CO_2 applications.

[0003] An air separation unit (ASU) separates oxygen and nitrogen and is useful as an oxygen source for an oxy-fuel process and for separately providing high purity nitrogen. The high purity nitrogen obtained by ASU can be used for any of various applications, such as oil or gas reservoir management in an enhanced oil or gas recovery system, for instance. Nitrogen and carbon dioxide can be used as injection fluids in enhanced oil recovery (EOR). Nitrogen can be an economic alternative to carbon dioxide for EOR application.

[0004] It is advantageous if the pressure of nitrogen injected into an oil well is greater than the minimum miscible pressure (MMP) of nitrogen and that oil. Nitrogen forming a miscible slug with oil aids in freeing the oil for recovery. Therefore, generally the gaseous low-pressure nitrogen supplied by the ASU is compressed to higher pressure before injecting into the oil reservoirs. However, in these systems the nitrogen separated from the oxygen in the ASU is afterwards compressed in gaseous phase to the desired pressure, which demands a significant amount of power.

[0005] Therefore, there remains a need for a system and method for power generation that provides low levels of NOx and CO emissions, along with reduced power consumption.

BRIEF DESCRIPTION

[0006] Briefly, in one embodiment, a system is provided. The system includes an air separation unit. The air separation unit includes an air compression unit configured to produce compressed air at a pressure greater than about 3 bars; a heat-exchanger unit configured to receive and cool the compressed air to produce cooled air; a first distillation unit configured to receive the cooled air and produce a first output stream comprising liquid-nitrogen; and a first pump in direct communication with the first distillation unit and configured to pressurize the first output stream to a pressure greater than atmospheric pressure.

[0007] In another embodiment, a method is provided. The method includes the steps of compressing air in an air compression unit to a pressure greater than about 3 bars; cooling the compressed air by passing through a heat-exchanger unit; distilling the cooled air stream in a distillation unit to produce a first stream comprising liquid-nitrogen, and a second stream; and pressurizing the first stream to a pressure greater than atmospheric pressure.

[0008] In one embodiment, a system is provided. The system includes an air separation unit and an oil or gas recovery well. The air separation unit includes an air compression unit configured to produce compressed air at a pressure greater than about 3 bars; a heat-exchanger unit configured to receive and cool the compressed air to produce cooled air; a first distillation unit configured to receive the cooled air and produce liquid-nitrogen; and a first pump in direct communication with the first distillation unit and configured to pressurize the liquid-nitrogen to a pressure greater than atmospheric pressure. The oil or gas recovery well is configured to receive the liquid-nitrogen and retrieve the oil or gas.

DRAWINGS

[0009] 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:

[0010] FIG. **1** illustrates a combined oxy-fuel turbine system;

[0011] FIG. **2** is an air separation unit, according to an embodiment of the present invention;

[0012] FIG. **3** is an air separation unit, according to an embodiment of the present invention; and

[0013] FIG. **4** illustrates a turbine system, according to another embodiment of the invention.

DETAILED DESCRIPTION

[0014] Embodiments of the present invention include an ASU that may provide clean, pressurized liquid nitrogen and oxygen output and systems integrated with the ASU.

[0015] In the following specification and the claims that follow, the singular forms "a", "an" and "the" include plural referents unless the context clearly dictates otherwise.

[0016] In general, an oxy-fuel combined cycle power plant system **10** includes an air separation unit (ASU) **12**, a combustor **14**, and a power plant with cooling system **16**, as depicted in FIG. **1**. The ASU **12** separates oxygen from air, providing a supply of oxygen as an oxidizer to the combustor **14**. The combustor **14** is configured to burn fuel in the presence of this supplied oxygen, either alone or after mixing with CO_2. Nitrogen from the ASU **12** can be stored in a reservoir management unit **18** and/or used for other applications, such as, for example, recovering natural gas from gas fields or for oil recovery. Products of combustion normally contain mainly CO_2, H_2O and trace emissions of CO and O_2. The cooling system **16** embedded in power plant condenses H_2O from exhaust downstream of combustor **14**, resulting in exhaust gases exceeding 95% CO_2 composition.

[0017] In one embodiment of the present invention, a system including an ASU is provided. The ASU is configured to liquefy nitrogen at very low temperatures. In one embodiment, the ASU is also configured to liquefy oxygen. The liquid oxygen may be pumped to a pressure suitable for oxy-fuel combustion. Additionally, in some embodiments the liquid nitrogen may be pumped to a very high pressure (300-500 bars) and injected into an oil/gas reservoir for enhanced oil/gas recovery. By liquefying both nitrogen and oxygen in the high-pressure ASU, it is possible to pump them at very low temperatures, thereby increasing the overall efficiency of the plant compared to existing plants that use gaseous nitrogen and oxygen supplied by low-pressure ASUs.

[0018] In one embodiment, the system is configured to produce a carbon dioxide stream from exhaust products of the oxy-fuel combustor. In one embodiment, the carbon dioxide stream produced here is a high-content CO_2 stream. As used herein, a "high-content CO_2 stream" is defined as a stream having more than about 80% by volume of CO_2. In another embodiment, a high-content CO_2 stream contains more than about 90% by volume of CO_2. In a further embodiment, the high-content CO_2 stream contains more than about 95% by volume of CO_2. A stream "substantially free of oxygen" is defined as a stream containing less than about 1% by volume of oxygen. In one embodiment, an oxygen level of less than 10 ppm in the CO_2 exhaust stream is desirable. One example of an application where a high-content CO_2 stream is desirable is oil recovery from depleted oil recovery wells, where CO_2 stream injection is used to force oil from the well. A portion of the high-content CO_2 exhaust gases may also be recirculated to the combustor **14**, for mixing with the separated O_2 from the ASU **12**. Maintaining minimum CO emissions from the combustion helps in maintaining high combustion efficiency.

[0019] In one embodiment, system **10** comprises an ASU **12**, as shown in FIG. **2**. The ASU **12** includes an air compression unit **20**; a heat-exchanger unit **22**; a first distillation unit **26**; and a first pump **28**. As used herein, a "unit" may be made up of a single component or made up of more than one component. For example, an air compressor unit may be one compressor or may have more than one compressors combined to produce the required air compression.

[0020] The air compression unit **20** is configured to produce compressed air to a pressure greater than about 3 bars. In one embodiment, the air compression unit **20** is configured to produce a compressed air to a pressure greater than about 7 bars. In a further embodiment, the air compression unit **20** is configured to produce a compressed air at a pressure in a range from about 15 bars to about 60 bars. In one particular embodiment, the air compression unit **20** is configured to produce compressed air to a pressure up to about 40 bars. The compressed air passes through the heat-exchanger unit **22**, where the air is cooled. The cooling of compressed air is attained by the heat-exchange between different streams that pass through the heat-exchanger unit **22**. For example, cool nitrogen and/or oxygen streams separated from air may pass through the heat-exchanger unit **22** absorbing heat from the compressed air and, thereby, cooling the compressed air.

[0021] After passing through the heat-exchanger unit **22**, the cooled, compressed air may be subjected to expansion in an expander **24**, which further cools the already cooled air. In one embodiment, an expander **24** is a valve introducing a pressure difference to the incoming cooled compressed air. In the expander **24**, the cooled compressed air gets expanded suddenly to a lower pressure, resulting in further cooled, reduced pressure-compressed air. In one embodiment, the pressure of the compressed air, after passing through the expander **24** is less than about 5 bars. In one embodiment, the pressure of the air after passing through the expander **24** is less than about 3 bars. In one particular embodiment disclosed further below, the expanded air coming out of the expander **24** is at atmospheric pressure.

[0022] In one embodiment, the cooled air passed through the expander **24** enters the first distillation unit **26**. In one embodiment, the first distillation unit **26** is configured to operate at a pressure greater than about 2 bars and is called as a "high-pressure distillation unit". In one embodiment, an inlet pressure of the first distillation unit is in the range from about 3.5 bars to about 5 bars. In one embodiment, the first distillation unit **26** operates at atmospheric pressure.

[0023] The compressed air entering the first distillation unit **26** is generally at relatively low temperature. In one embodiment, the temperature of the air entering the first distillation unit **26** is in between about −150° C. and about −210° C. In one further embodiment, the temperature of the air is in the range from about −165° C. to about −185° C.

[0024] The temperature of the air entering first distillation unit **26** is determined in part by the initial pressure of the compressed air, the ability of the heat-exchanger unit **22** to cool the compressed air and the configuration of the expander **24** to expand the cooled air. A high pressure compressed air ends up giving out more heat at the time of expansion compared to air compressed to a lower pressure. Similarly, a heat-exchanger unit **22** that has low temperature coolant streams will effectively extract more heat from the compressed air compared to a heat exchanger unit **22** having higher temperature coolant streams. The volume, pressure difference, and the temperature of the expander **24** may change the heat extracted from the air passing through the expander **24**.

[0025] In one embodiment, a first output stream **30** produced from the first distillation unit **26** comprises liquid nitrogen. In one embodiment, the first output stream **30** produced from the first distillation unit **26** comprises more than about 25% of the inlet compressed air mass flow and comprises high purity liquid nitrogen. In one embodiment, the liquid nitrogen of first output stream **30** is of greater than 95% purity. In one embodiment, the liquid nitrogen is more than about 99% pure. In a particular embodiment, the liquid nitrogen is of more than 99.9% purity. In one embodiment, the temperature of first output stream **30** produced from the first distillation unit **26** is less than about −175° C. In one embodiment, the temperature of first output stream **30** is less than about −178° C. In one particular embodiment, the temperature of the first output stream **30** is in the range from about −178° C. to about −185° C.

[0026] In one embodiment, the pressure of the first output stream **30** is greater than atmospheric pressure. In one embodiment, the pressure of the first output stream **30** is greater than about 3 bars. In one particular embodiment, the pressure of the first output stream ranges from about 3.5 bars to about 5 bars. Depending on the particular application requirements, in one embodiment, the first output stream **30** is further pressurized using a first pump **28**. In one embodiment, the first pump **28** is in direct communication with the first distillation unit **26**. As used herein the "direct communication" between the pump **28** and distillation unit **26** means that the first output stream **30** from the distillation unit **26** is directly pumped to high pressure without intervening expansion or gas-liquid separation. In one embodiment the first output stream **30** is pressurized to greater than about 300 bars. In a further embodiment, the first output stream is pressurized to greater than about 400 bars. In one embodiment, the first output stream **30** is pressurized up to about 500 bars. In one embodiment, the first pump **28** is coupled to the heat-exchanger unit **22** so that the first output stream **30** pressurized by the first pump **28** passes through the heat-exchanger unit **22** thereby cooling the incoming compressed air. As used herein "coupled" merely implies fluid communication and does not prohibit the usage of intervening parts such as valves.

[0027] The first output stream **30** may be transported for different applications. In one embodiment, the first output stream **30** passes through the heat-exchanger unit **24**, thereby removing some heat from the incoming compressed air from the compressor unit **20**. The low-temperature liquid form of the first output stream **30** is comparatively more effective than gaseous nitrogen in reducing the temperature of the incoming compressed air.

[0028] After distilling out liquid nitrogen, in one embodiment, the distillation unit **26** is left with a second output stream **32** that comprises nitrogen and oxygen (FIG. **2**). The second output stream **32** may be drawn out from the distillation unit **26** and may be subjected to further distillation, using, for example a second distillation unit **36**. Depending on the pressure of the second output stream **32**, it may be further subjected to expansion in a second expander **34**, as shown in FIG. **2**. In one embodiment, the outlet pressure of the second expander **34** is near atmospheric and the temperature of the contents in a range from about −190° C. to about −195° C. In one embodiment, the vapor fraction of the output contents of second expander **34** is in the range from about 0.12 to 0.18. Depending on the temperature of the second output stream **32** and pressure ranges of second expander **34**, the stream coming out from the second expander **34** may be in a liquid state, gaseous state, or in a liquid-gas mixed state. Therefore, depending on the requirement, the second output stream **32** optionally may be subjected to a gas-liquid separation in a separator **35**. In one embodiment, both the gaseous part and liquid part of the second output stream **32** are fed into the second distillation column **36**. In one embodiment, the second distillation unit **36** is a low pressure distillation unit. The pressure at the distillation unit may be less than about 2 bars. In one embodiment, the low pressure distillation unit **36** works at atmospheric pressure.

[0029] The second distillation unit **36** may have one or more outputs. One distillation output is third output stream **38** comprising liquid oxygen. In one embodiment, the third output stream **38** is about 15 mass % or more of the inlet compressed air and comprises high purity liquid oxygen. In one embodiment, the liquid oxygen of the third output stream **38** is of greater than 95% purity. In one embodiment, the liquid oxygen is more than about 99% pure. In a particular embodiment, the liquid oxygen is of more than 99.9% purity. In one embodiment, the temperature of the third output stream **38** produced at the distillation unit **36** is less than about −175° C. In one embodiment, the temperature of the third output stream **38** is less than about −178° C.

[0030] In one embodiment, the pressure of third output stream **38** is greater than atmospheric pressure. Depending on the particular application requirements, in one embodiment, the third output stream **38** is further pressurized using a second pump **39**. In one embodiment, the third output stream **38** is pressurized to greater than about 20 bars. In a further embodiment, the third output stream **38** is pressurized in a range from about 30 bars to about 60 bars. In a particular embodiment, the third output stream is pressurized up to about 100 bars of pressure.

[0031] The third output stream **38** produced by the distillation may be transported for different applications including oxy-fuel combustion. Similar to the first output stream **30**, during conveyance to the intended application, the third output stream **38** may be routed through the heat-exchanger unit **22**, thereby helping to remove heat from the compressed air from the compressor unit **20**. The low-temperature liquid form of the third output stream **38** comprising oxygen is comparatively more effective than the gaseous oxygen in reducing the temperature of the incoming compressed air.

[0032] In one embodiment, one output of the second distillation unit is a fourth output stream **40** comprising nitrogen and oxygen. In one embodiment, the fourth output stream **40** includes both nitrogen and oxygen in gaseous form. In one embodiment, the temperature of this stream is about −190° C. In one embodiment, depending on the usage of second expander **34** and/or the distillation conditions at the second distillation unit **36**, the fourth output stream **40** measures about 40-60% of the inlet compressed air mass flow. In this embodiment, the composition of the mixed stream **40** includes about 87 mole % (of fourth output stream **40**) of nitrogen and 12 mole % of oxygen.

[0033] The fourth output stream **40** may be used for different applications, including as an oxidizer in a combustion turbine. For example, if used in a combustor that generally uses air as an oxidizer, the fourth output stream **40** will reduce the NOx emission of the combustor. In one embodiment, the stream **40** may be recycled to the air compression unit **20** or to the distillation unit **26**.

[0034] Similar to the first output stream **30** and third output stream **38**, in one embodiment, the fourth output stream **40** may contribute to the cooling of compressed air passing through the heat-exchanger unit **22**.

[0035] The pressures of compressed air supplied by the compression unit **20**, the pressure differences and the resultant cooling obtained through the expanders **24**, **34**, and the distillation conditions in the distillation units **26**, **36** may be greatly varied to achieve higher purity, higher content liquid nitrogen and/or liquid oxygen streams. All such variations are believed to be apparent to one skilled in the art considering the teachings of this disclosure.

[0036] In one variation shown in FIG. **3**, compressor unit **20** is configured to produce compressed air to a pressure greater than about 35 bars. In one embodiment, the pressure of the compressed air is about 40 bars. The high-pressure compressed air is passed through the heat-exchanger unit **22** and cooled. The cooled compressed air from the heat-exchanger unit is subjected to expansion in an expander **24**. The heat-exchanger unit **22** as used herein may be one unit or a combination of multiple heat-exchanger units. In one embodiment, the expander **24** expands the compressed air by quickly reducing pressure ("flashing") to atmospheric pressure such that the air rapidly cools to a liquid form with a temperature less than about −185° C. The cooled liquid is subjected to distillation in the first distillation unit **26** to directly produce high-purity first output stream **30** comprising liquid nitrogen and a second output stream **32** comprising liquid-oxygen. In one embodiment, both the first output stream **30** and the second output stream **32** are in liquid forms. Therefore, in one embodiment, the first distillation unit **26** is a liquid-liquid separator. In one particular embodiment, the first output stream **30** is a liquid nitrogen stream and the second output stream **32** is a liquid oxygen stream. The second output stream comprising liquid oxygen may be further subjected to pressurizing by using a pump **39** and used in different applications.

[0037] A number of heat-exchanger units and coolant streams may be effectively used to cool the air stream that is subjected to distillation in the first distillation unit **26**. In one such variation, the incoming compressed air from the compressor **20** is split in to a first stream **41** and a second stream **42** using a splitter **43**. The first stream passes through a second heat-exchanger unit **44** and third heat-exchanger unit **45** to be cooled further. The first stream **41** cooled through the multiple heat-exchangers **44**, **45** is expanded in the expander **24**. Optionally, the cooled air coming from expander **24** may be subjected to a liquid-gas separation in a separator **25**, using the liquid part for distillation unit **26** and leaving a gaseous waste stream **46** that may be routed through one or more heat-exchanger units **22**, **44**, **45** to further cool the incoming compressed air.

[0038] The second stream **42** of the compressed air from splitter **43** may be optionally used in a turbine **48** and the cooled stream **42** is mixed in a mixer **49** with the gaseous waste stream **46**. Depending on the temperature of the second stream **42**, the gaseous waste stream **46**, and the cooling demands of the heat-exchangers **44** and **45**, the second stream **42** and the gaseous waste stream **46** may be mixed before passing through any of the second heat-exchanger units **22**, **44**, and **45**. In one embodiment, the gaseous waste stream **46** is passed through the third heat-exchanger **45** and then mixed with the second stream **42** before passing through the second heat-exchanger unit **44**, thereby effectively cooling the cooled air stream **41** passing from the third heat-exchanger **45** to the expander **24**.

[0039] One particular, advantageous application of the ASUs described above is in the integration of these ASUs to an oxy-fuel gas turbine combined cycle as shown in FIG. **4**. The system **50** includes an ASU **12** providing oxygen output; a combustor **14** configured to receive oxygen from ASU **12** and to combust a fuel stream **58**, thereby generating a flue gas **62**. In one embodiment, cooling system **16** is fluidly coupled to the combustor **14** through a turbine combined cycle **64**. The gas turbine combined cycle **64** may receive flue gas **62** from the combustor **14**, and use at least a part of the energy associated with the flue gas **62** to generate electricity or perform some other work, releasing an exhaust flue gas **66**. Exhaust flue gas **66** from the gas turbine combined cycle **64** may be passed through the cooling system **16**, such as, for example, a water condensation system or HRSG, to condense water from the exhaust gas **66**, and to create a carbon dioxide stream **70**. The carbon dioxide stream **70** may be stored in a storage unit **72**. In another embodiment, the carbon dioxide stream **70** may be directed to applications that use "high-content" carbon dioxide, such as for example, a an oil/gas recovery system **78** after optional compression in a CO_2 compressor **76**. In another embodiment, at least a part of the carbon dioxide stream **70** is redirected to the combustor **14**, after optional compression in a CO_2 compressor **76**, to be mixed with the oxygen.

[0040] In one embodiment, a method of generating energy in a power plant that includes a gas turbine is provided. The method includes operating an ASU **12** (FIG. **4**) to separate oxygen from air, passing fuel to the combustor **14**, and combusting the fuel stream **58** in the combustor **14**, in the presence of oxygen. In this manner, a flue gas **62** is generated, comprising carbon dioxide and water. The flue gas **62** of the combustor **14** may be used in operating the turbine **64**, e.g., to generate electricity. The exhaust flue gas **66** of the turbine **64** can be passed through a water condensation system **16** to separate water from the exhaust gas **66**, and to produce a high-content carbon dioxide stream **70**. The high-content carbon dioxide stream **70** is substantially free of oxygen, for safety considerations in those situations where the presence of oxygen is a serious concern. As explained above, the carbon dioxide stream **70** may be stored, directed to other applications such as an oil recovery system, and/or compressed and fed back to the combustor **14**, e.g., in combination with the compressed oxygen.

[0041] While the liquid oxygen obtained by the ASU **12** may be pumped to the pressure suitable for oxy-fuel combustion in the combustor **14**, the liquid nitrogen may be pumped to a very high pressure (300-500 bars) and can be injected to the oil/gas recovery system **78**. In one embodiment, the oil/gas recovery system **78** is a natural gas recovery system. The natural gas **58** recovered from the system **78** may be fed back to the combustor **14** for the oxy-fuel combustion or stored in a natural gas storing unit **80** for using in other applications.

[0042] Advantageously, liquefying both nitrogen and oxygen in the high-pressure ASU as described above allows for these products to be pumped at very low temperatures, thereby increasing the overall efficiency of the combined gas turbine plant compared to existing plants that compress nitrogen and oxygen in gaseous phases.

[0043] Additionally, as the operation pressure of the ASU (~3-40 bar) is much lower than the pressure (300-500 bar) at which the nitrogen is injected in to the recovery system **78**, the system **50** is expected to potentially provide not only a higher overall energy efficiency but also a more compact and therefore cost-effective design compared to conventional systems using a low-pressure ASU. In one embodiment, the power consumption of the integrated systems explained herein is about 20% less compared to a conventional integrated system.

[0044] While only certain features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

1. A system, comprising:

an air separation unit (ASU) comprising:

an air compression unit configured to produce compressed air at a pressure greater than about 3 bars;

a heat-exchanger unit configured to receive and cool the compressed air to produce cooled air;

a first distillation unit configured to receive the cooled air and produce a first output stream comprising liquid-nitrogen; and

a first pump in direct communication with the first distillation unit and configured to pressurize the first output stream to a pressure greater than atmospheric pressure.

2. The system of claim **1**, wherein the first pump is configured to pressurize the first output stream to a pressure in a range from about 300 bars to about 500 bars.

3. The system of claim **1**, further comprising a natural gas or oil recovery well configured to receive the first output stream from the first pump.

4. The system of claim **1**, wherein the first pump is fluidly coupled to the heat-exchanger.

5. The system of claim **1**, wherein the first distillation unit is configured to produce a second output stream comprising nitrogen and oxygen.

6. The system of claim **1**, wherein the ASU further comprises a second distillation unit configured to receive the second output stream from the first distillation unit and produce a third output stream comprising liquid oxygen.

7. The system of claim **6**, wherein the ASU further comprises a second pump in direct communication with the second distillation unit and configured to pressurize the third output stream to a pressure in a range from about 30 bars to about 60 bars.

8. The system of claim **7**, wherein the second pump is fluidly coupled to the heat-exchanger.

9. The system of claim **1**, further comprising an oxy-fuel combustor, configured to receive the third output stream from the ASU and produce a flue gas.

10. The system of claim **9**, further comprising a turbine that is configured to receive the flue gas from combustor and produce a turbine exhaust flue gas.

11. The system of claim **10**, further comprising a condenser configured to receive the turbine exhaust flue gas and produce a carbon dioxide stream.

12. The system of claim **11**, comprising an oil recovery well configured to receive the carbon dioxide stream.

13. The system of claim **1**, wherein the air compression unit is configured to produce compressed air at a pressure in a range from about 15 bars to about 60 bars.

14. The system of claim **13**, wherein the ASU further comprises an expander in fluid communication with heat-exchanger unit and first distillation unit, and configured to expand the cooled air to atmospheric pressure.

15. A method, comprising:

compressing air in an air compression unit to a pressure greater than about 3 bars;

cooling the compressed air by passing through a heat-exchanger unit;

distilling the cooled air stream in a distillation unit to produce a first stream comprising liquid-nitrogen, and a second stream; and

pressurizing the first stream to a pressure greater than atmospheric pressure.

16. The method of claim **15**, further comprising distilling the second stream in a second distillation unit to produce a third stream comprising liquid oxygen.

17. The method of claim **16**, further comprising pressurizing the third stream to a pressure in a range from about 30 bars to about 60 bars.

18. The method of claim **15**, further comprising pressurizing the second stream to a pressure in a range from about 30 bars to about 60 bars.

19. A system, comprising:

an ASU comprising:

an air compression unit configured to produce compressed air at a pressure greater than about 3 bars;

a heat-exchanger unit configured to receive and cool the compressed air to produce cooled air;

a first distillation unit configured to receive the cooled air and produce liquid-nitrogen; and

a first pump in direct communication with the first distillation unit and configured to pressurize the liquid-nitrogen to a pressure greater than atmospheric pressure, and

an oil or gas recovery well configured to receive the liquid-nitrogen and retrieve the oil or gas.

20. The system of claim **19**, wherein the first pump is configured to pressurize the liquid nitrogen to a pressure in a range from about 300 bars to about 0 500 bars.

21. The system of claim **19**, wherein the ASU is further configured to produce liquid oxygen.

22. The system of claim **21**, wherein the ASU comprises a second pump configured to pressurize the liquid-oxygen to a pressure in a range from about 30 bars to about 60 bars.

23. The system of claim **22**, further comprising:

a combustor configured to receive the pressurized liquid oxygen to combust a fuel stream and to produce a flue gas stream;

a turbine configured to receive the flue gas stream to generate electricity and give out the exhaust flue gas;

a condenser fluidly-coupled to the turbine, and configured to receive the exhaust flue gas and produce a carbon dioxide stream; and

a compressor configured to compress the carbon dioxide stream.

24. The system of claim **23**, wherein the oil or gas recovery well is further configured to receive the carbon dioxide stream and retrieve the oil or gas.

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