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(54) METHOD OF AND SYSTEM FOR GENERATING POWER BY OXYFUEL COMBUSTION

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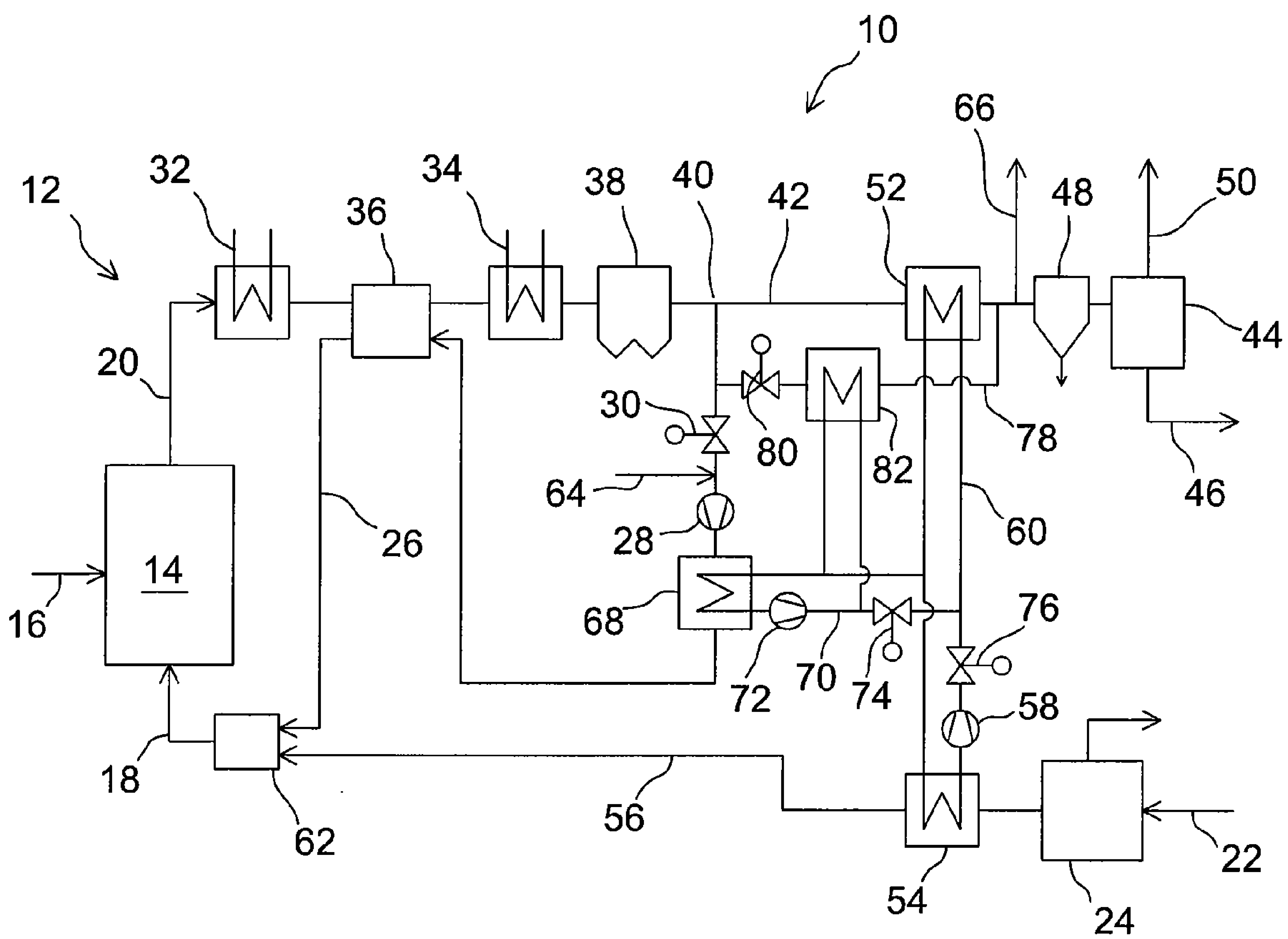
(57) **ABSTRACT**

A method of generating power by oxyfuel combustion. Carbonaceous fuel and oxidant gas are fed into a furnace. In a first operating mode, the oxidant gas includes a stream of substantially pure oxygen conveyed from an oxygen supply for combusting the fuel with the oxygen to produce exhaust gas including mainly carbon dioxide and water. The exhaust gas is discharged from the furnace and is divided into a recycling portion and an end portion. The recycling portion is recycled to the furnace. Heat is transferred from the end portion to the stream of substantially pure oxygen by circulating a liquid heat transfer medium in a passage between an exhaust gas cooler and an oxygen heater.



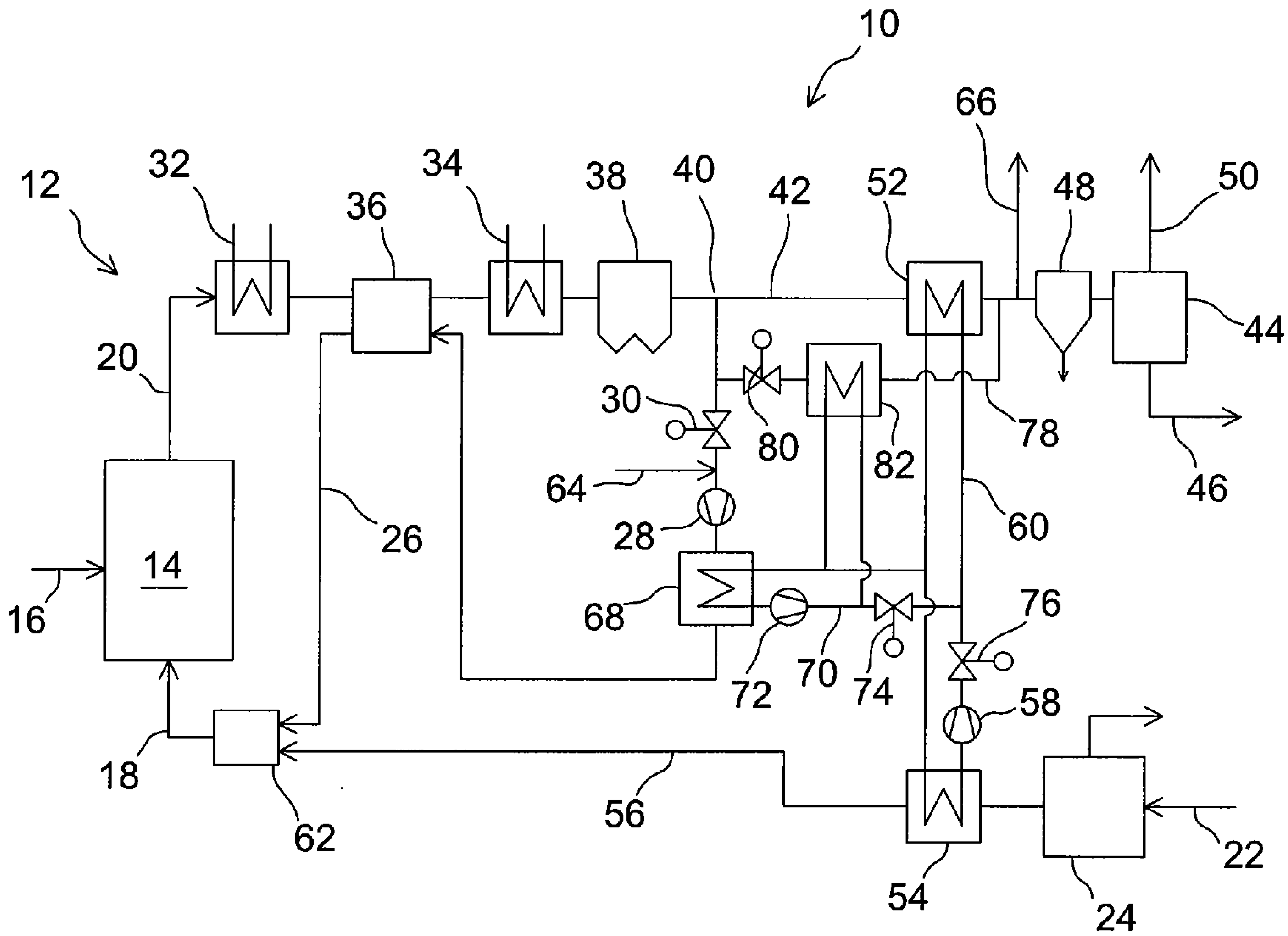

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Fig. 1

METHOD OF AND SYSTEM FOR GENERATING POWER BY OXYFUEL COMBUSTION

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a method of and a system for generating power by oxyfuel combustion. The invention especially relates to a flexi-burn or dual-firing combustion system, i.e., a system which can be easily switched between the modes of oxyfuel combustion and combustion with air.

[0003] 2. Description of the Related Art

[0004] Oxyfuel combustion is one of the methods suggested for removing CO_2 from the combustion gases of a power generating boiler, such as a pulverized coal (PC) boiler or a circulating fluidized bed (CFB) boiler. Oxyfuel combustion is based on combusting carbonaceous fuel with substantially pure oxygen, typically of about 95% purity, so as to have carbon dioxide and water as the main components of the exhaust gas discharged from the boiler. Thereby, the carbon dioxide can be captured relatively easily, without having to separate it from a gas stream having nitrogen as its main component, such as when combusting the fuel with air.

[0005] Generating power by oxyfuel combustion is more complicated than conventional combustion by air, because of the need of an oxygen supply, for example, a cryogenic or membrane based air separation unit (ASU), where oxygen is separated from other components of air. The produced exhaust gas is then ready for sequestration of CO_2 when water is removed from the oxidant, fuel and air-leakage. This purification is typically done by CO_2 condensation at a low temperature under high pressure. CO_2 can be separated from the exhaust gas, for example, by cooling it to a relatively low temperature, while compressing it to a pressure greater than one hundred ten bar.

[0006] In order to avoid very high combustion temperatures resulting from combustion with pure oxygen, it is advantageous to use an oxyfuel combustion boiler, where the combustion conditions are arranged to be close to those of air-firing combustion. This can be done by recycling exhaust gas back to the furnace so as to provide an average O_2 content of the oxidant gas of, for example, about 20 to about 28%. Such oxyfuel combustion boilers can advantageously be built by modifying existing air-firing boilers. Due to many uncertainties related to oxyfuel combustion with the capture and storage of carbon dioxide, there is also a need for dual firing boilers, i.e., boilers which can be changed from oxyfuel combustion to air-firing, and back, as easily as possible, preferably, without any changes in the actual construction. With such a dual firing boiler, it is possible to have maximum power output, by using air-firing combustion, during a high load demand, such as during the summer or the day-time, and applying oxyfuel combustion with CO_2 removal in other conditions. Also, it is possible to use a dual firing boiler in an air-firing mode, for example, when the separation unit or CO_2 sequestration unit is out of order.

[0007] U.S. Pat. No. 6,202,574 suggests a combustion system for firing fossil fuel with substantially pure oxygen to produce exhaust gas having carbon dioxide and water as its two largest constituents. A portion of the exhaust gas is recycled to the combustion chamber and the rest of the exhaust gas is compressed and stripped to produce carbon dioxide in a liquid phase. The recycled exhaust gas and the substantially pure oxygen stream are preheated by the exhaust gas in respective gas-gas heat exchangers.

[0008] German patent publication DE 103 56 703 A1 shows an oxyfuel combustion boiler system comprising a feedwater heater and a gas-gas heat exchanger acting as an oxygen heater arranged to cool the exhaust gas downstream of a recycle gas take-off.

[0009] In order to more economically generate power when minimizing carbon dioxide emissions, there is a need for an improved method of and a system for oxyfuel combustion, especially, by using a dual firing combustion system.

SUMMARY OF THE INVENTION

[0010] An object of the present invention is to provide a new method of and a system for oxyfuel combustion.

[0011] According to one aspect, the present invention provides a method of generating power by oxyfuel combustion, the method comprising the steps of feeding carbonaceous fuel into a furnace, feeding oxidant gas into the furnace, wherein, in a first operating mode, the oxidant gas comprises a stream of substantially pure oxygen conveyed from an oxygen supply for combusting the fuel with the oxygen to produce exhaust gas comprising mainly carbon dioxide and water, discharging the exhaust gas from the furnace, dividing the exhaust gas into a recycling portion and an end portion, recycling the recycling portion of the furnace, and transferring heat from the end portion to the stream of substantially pure oxygen by circulating a liquid heat transfer medium, such as water, in a passage between an exhaust gas cooler and an oxygen heater.

[0012] According to another aspect, the present invention provides a system for generating power by oxyfuel combustion, the system comprising a furnace for combusting carbonaceous fuel, an oxygen channel for feeding the substantially pure oxygen from an oxygen supply to the furnace for combusting the fuel with the oxygen to produce exhaust gas comprising mainly carbon dioxide and water, an exhaust gas channel connected to the furnace for discharging the exhaust gas from the furnace, branch piping for dividing the exhaust gas into a recycling portion and an end portion, a gas recycling channel for feeding the recycling portion of the exhaust gas to the furnace, an exhaust gas cooler arranged in the exhaust gas channel downstream of the branch piping, and an oxygen heater arranged in the oxygen channel connected by a passage for transferring heat from the end portion to the stream of substantially pure oxygen by a circulating liquid heat transfer medium in the passage.

[0013] The process of transferring heat from the exhaust gas to the oxidant gas improves the efficiency of the boiler and the process as a whole. The present invention differs from the prior art solution shown in U.S. Pat. No. 6,202,574, for example, in that the pure oxygen stream is heated by low grade heat obtained from the end portion of the exhaust gas, which is to be discharged from the system, and not from the exhaust gas upstream of the take off point of the recycled gas. Thereby, the thermal efficiency of the process is improved. While the exhaust gas cooler is at the low temperature portion of the exhaust gas channel, it may cool below the acid condensation temperature during the heat transfer. Therefore, the exhaust gas cooler is advantageously of a corrosion resistant type, such as a plastic gas cooler.

[0014] The recycling portion of the exhaust gas comprises, often in oxyfuel combustion, a majority, typically, about 65 to about 80%, of the exhaust gas discharged from the furnace, whereby the end portion of the exhaust gas is about or less than a third of the exhaust gas stream. On the other hand, the end portion is always naturally about as large as the oxygen stream. Therefore, the arranging of the exhaust gas cooler downstream of the point dividing the recycling portion provides another advantage in that the gas flows of the end portion of the exhaust gas and the oxygen stream are as large, whereby it is relatively easy to obtain an energy balance between the two flows at advantageous temperature levels. The end portion of the exhaust gas is, in practice, virtually free of dust, while being located downstream of an electron dust separator (ESP) or a bag house. This provides conditions for arranging an effective and a compact heat exchanger. It also increases the safety of the system, while there is very little of igniting or explosive dust present.

[0015] According to the present invention, heat is transferred form the exhaust gas to the oxygen flow by means of a liquid transfer medium, instead of transferring the heat directly in a gas-gas heat exchanger. This feature provides the advantage that a leak in the exhaust gas cooler, which may occur especially when the heat exchanger is used below the acid dew point temperature, may only cause a leak of water, and not a leak of explosive oxygen, into the exhaust gas channel.

[0016] Another advantage of transferring heat from the exhaust gas to the oxygen by means of a liquid heat transfer medium is that, in practice, it usually provides a relatively simple construction, although it appears to make the system more complicated. The reason for this is that the oxygen supply, typically, an air separation unit (ASU), is usually located at a portion of the power plant other than a final exhaust gas processing system, usually comprising units for cleaning, capturing and storage of carbon dioxide. Thus, the heat transferring distance may be quite long, and it is easier to transfer the heat such long distances in relatively small water tubes by making an additional excursion to much larger channels carrying hot exhaust gas or explosive oxygen gas.

[0017] According to a preferred embodiment of the present invention, the method further comprises steps of transferring heat in a gas-gas heat exchanger from the exhaust gas to the recycling portion of the exhaust gas to produce a stream of heated recycling gas. The recycling gas stream and the stream of substantially pure oxygen may be conducted to the furnace separately, but, according to a preferred embodiment of the present invention, the stream of substantially pure oxygen is mixed with the stream of heated recycling gas in a mixer arranged to connect the gas recycling channel downstream of the gas-gas heat exchanger and the oxygen channel downstream of the oxygen heater. Thus, a stream of mixed gas is formed to be fed as the oxidant gas via a channel into the furnace.

[0018] The feeding rate of the relatively pure oxygen is determined on the basis of the fuel feeding rate, so as to provide sufficiently complete combustion of the fuel. Usually, the oxygen feeding rate is controlled by monitoring the content of residual oxygen in the exhaust gas, which should stay at a suitable level, typically, about 3%. By mixing the pure oxygen stream, heated by the transfer heat medium as described above, with recycling gas heated in a gas-gas heat exchanger, it is possible to efficiently control the temperature, flow rate and oxygen content of the mixed gas to be used as the oxidant gas in the furnace.

[0019] The recycling gas channel and the oxygen channel may advantageously be divided in multiple parallel lines, which are separately connected in multiple mixers, so as to form multiple streams of mixed gas, which may be used, for example, as primary and secondary oxidant gas in the furnace. By separately controlling the gas flows in the parallel recycling gas lines and oxygen lines, it is possible to separately control the flows and oxygen contents of the oxidant gas streams.

[0020] According to a preferred embodiment of the present invention, the gas feeding rate to a boiler retrofitted from air-firing to oxycombustion is adjusted so as to maintain the original gas velocity in the furnace, whereby the oxygen content of the oxidant gas is advantageously adjusted to be near to that of air, typically, from about 18% to about 28%. The furnace temperature or heat flux of the retrofitted boiler shall advantageously also be maintained at about its original level to avoid, e.g., corrosion or material strength problems of the furnace walls.

[0021] Due to the high heat capacity of the exhaust gas generated in the oxycombustion process, having carbon dioxide as its main component, when compared to that of conventional exhaust gas, having nitrogen as its main component, the same volume flow of exhaust gas at the same temperature carries more heat in the case of oxycombustion, than in air-firing combustion. Thus, when changing an air-firing steam generating process to oxycombustion, the fuel feeding rate can be increased by at least 10%, and still maintain the original furnace temperature or heat flux. Thereby, an increased amount of heat is available, e.g., for steam generation and for heating of the oxidant gas.

[0022] According to an especially advantageous embodiment of the present invention, the first operating mode is performed alternatingly with a second operating mode, a so-called an air-firing mode, wherein the recycling portion is minimized, for example, by a damper and the oxidant gas comprises a stream of air. Advantageously, the system comprises an air intake for introducing air into the gas recycling line upstream of the gas-gas heat exchanger. Thus, the gas-gas heat exchanger is used in the second operating mode to transfer heat from the exhaust gas to the air stream.

[0023] In the second operating mode, the combustion system is advantageously decoupled from the oxygen supply, and the exhaust gas comprises nitrogen, carbon dioxide and water, as its main components. Therefore, the system is also decoupled from the carbon dioxide capturing and storage units, and the exhaust gas is released to the environment through a stack. One of the main ideas of the present invention is that it provides an oxyfuel combustion method which can be easily switched to air-firing combustion, and back, without any modifications in the actual construction, even on-line, without stopping the power generation during the change.

[0024] In the second operating mode, the oxygen supply is not in use and, because the content of the exhaust gas is that in conventional combustion, the carbon dioxide of the exhaust gas is not purified and sequestered. Thus, the auxiliary power consumption of these processes is minimized, and the system provides a higher total efficiency than that in oxygen-combustion, at the cost of releasing carbon dioxide to the environment. The air-firing operating mode is advantageously used when the demand for power is especially high, for example, in the summer or during the day-time. Alternatively, the air-firing mode may be temporarily used, e.g., based on varying economical conditions, or when the oxygen supply or carbon dioxide capturing and storage systems are, for some reason, not available.

[0025] The method advantageously comprises, in the second operating mode, a step of transferring heat from the exhaust gas to the stream of air by circulating a liquid heat transfer medium in a passage between an exhaust gas cooler and an air heater. Because the exhaust gas flow rate is, in the second operating mode, typically much higher than the flow rate of the end portion of the exhaust gas in the first operating mode, advantageously, at least one other channel with an exhaust gas cooler may be formed parallel to the exhaust gas channel portion comprising the exhaust gas cooler used in the oxycombustion mode. Thereby, the heat transfer medium is circulated in the air-firing mode between the air heater and at least two parallel exhaust gas coolers. Thus, the air stream, which has a clearly higher flow rate than does the oxygen stream in the oxycombustion mode, can be efficiently heated by the exhaust gas.

[0026] The above brief description, as well as further objects, features, and advantages of the present invention, will be more fully appreciated by reference to the following detailed description of the currently preferred, but nonetheless illustrative, embodiments of the present invention, taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

[0027] FIG. **1** is a schematic diagram of an oxy-fuel combusting power plant in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0028] FIG. **1** shows a schematic diagram of a power plant **10** in accordance with a preferred embodiment of the present invention. The power plant **10** comprises a boiler **12**, which may be, for example, a pulverized coal (PC) boiler or a circulating fluidized bed (CFB) boiler. The furnace **14** of the boiler comprises conventional fuel feeding means **16**, means for feeding oxidant gas **18** into the furnace, and an exhaust gas channel **20** for discharging exhaust gas produced by combusting the fuel with the oxygen of the oxidant gas. The details and type of some elements of the boiler **12**, such as the fuel feeding means **16** and oxidant gas feeding means **18**, depend, naturally, on the type of boiler. Such details, for example, as burners, coal mills, means for separately feeding primary and secondary inlet gas, are, however, not important for the present invention, and are, thus, not shown in FIG. **1**.

[0029] The oxidant gas is preferably a mixture of substantially pure oxygen, produced from an air stream **22** in an air separation unit (ASU) **24**, and a portion of the exhaust gas, which is recycled via an exhaust gas recycling channel **26**. The exhaust gas recycling channel **26** advantageously comprises a flow controller, such as a controllable fan **28** and/or a damper **30**, for controlling the exhaust gas recycling rate. The recycling rate of the exhaust gas is advantageously adjusted such that the average O_2 content of the oxidant gas is close to that of air, preferably, from about 18% to about 28%. In some applications of the present invention, it is also possible to introduce the streams of recycled exhaust gas and substantially pure oxygen separately, or multiple streams with different O_2 contents, into, for example, different portions of the furnace **14**.

[0030] As is conventional, the furnace **14** usually comprises evaporation surfaces, not shown in FIG. **1**, and the exhaust gas channel **20** further comprises heat exchanger surfaces **32**, **34**, for example, superheaters and economizers. For the sake of simplicity, FIG. **1** shows only two heat exchanger surfaces **32**, **34**, but, in practice, the exhaust gas channel **20** usually comprises multiple superheating, reheating and economizer surfaces for recovering heat from the exhaust gas. Between the steam generating heat exchange surfaces **32** and **34**, there is arranged a gas-gas heat exchanger **36**, usually, a regenerative heat exchanger, for transferring heat from the exhaust gas directly to the recycling portion of the exhaust gas.

[0031] The exhaust gas channel **20** usually comprises conventional units for cleaning the exhaust gas from particles and gaseous pollutants, which are, in FIG. **1**, schematically represented only by a dust separator **38**. The dust separator **38** and possible other gas cleaning units are advantageously arranged upstream of the branch point **40** of the exhaust gas recycling channel **26**. At the branch point, the exhaust gas stream is divided into a recycling portion, conveyed through the recycling gas channel **26** back to the furnace **14** and an end portion, which is conveyed through the end portion **42** of the exhaust gas channel **20** for final processing.

[0032] In accordance with the main object of oxyfuel combustion, i.e., to recover carbon dioxide from the exhaust gas, the end portion **42** of the exhaust gas channel **20** is equipped with a device, schematically represented by a carbon dioxide capturing unit **44**, for cooling, cleaning and compressing carbon dioxide. The unit **44** usually comprises a dryer for completely drying all water from the exhaust gas, and a separator for separating a stream of non-condensable gas, such as oxygen **50**, and possibly other impurities, from the carbon dioxide. A stream of carbon dioxide **46** is typically captured in a liquid or supercritical state, at a pressure of, for example, about one hundred ten bar, so that it can be transported for further use or to be stored in a suitable place. FIG. **1** shows, separately, a condensing gas cooler **48**, located upstream of the carbon dioxide capturing unit **44**, for initially removing water from the exhaust gas.

[0033] In order to transfer energy from the end portion of the exhaust gas to the stream of substantially pure oxygen, the end portion **42** of the exhaust gas channel **20** is, according to the present invention, equipped with a gas cooler **52**, which is connected by a liquid heat transfer medium circulation to an oxygen heater **54** arranged in an oxygen channel **56** downstream of the oxygen supply **24**. The heat transfer medium, usually water, is, preferably, circulated by a pump **58** in a tubing **60** extending between the gas cooler **52** and the oxygen heater **54**, which are usually, in practice, located at distant portions of the power plant **10**.

[0034] The oxygen channel **56** may be connected directly to the furnace **14**, but, according to a preferred embodiment of the present invention, the oxygen channel **56** and the exhaust gas recycling channel **26** are both connected to a mixer **62**, and a stream of mixed gas is lead as the oxidant gas to the furnace through the oxidant gas feeding means **18**. This system makes it possible to separately control the temperature, flow rate and oxygen content of the oxidant gas.

[0035] According a preferred embodiment of the present invention, the system also comprises an air intake **64** for feeding air to the furnace. The air stream is, preferably, introduced into the exhaust gas recycling channel **26** upstream of the gas-gas heat exchanger **36**, whereby it is possible to transfer heat directly form the exhaust gas to the stream of air. The purpose of the air intake **64** is to enable switching from oxyfuel combustion to air-firing combustion. Thus, when introducing air to the gas recycling line, the oxygen supply is stopped, and the recycling of exhaust gas is minimized, preferably, totally stopped, by the damper **30**. The exhaust gas comprises, in the air-firing mode, carbon dioxide and water mixed with a large amount of nitrogen, whereby, it is not possible to easily capture the carbon dioxide from the exhaust gas, which is, thus, in this case, released to the environment through a stack **66**.

[0036] While the air stream obtained from the environment is, typically, at a much lower temperature than is the recycling exhaust gas, the heating of air in the gas-gas heat exchanger **36** is usually not sufficient, but more heat is advantageously transferred to the air stream by an air heater **68**. The air heater **68** is also advantageous in order to increase the inlet temperature of the air in the gas-gas heat exchanger **36**, so as to avoid flue gas condensation and related problems on the heat exchanger surfaces. The air heater **68** is preferably connected to the exhaust gas cooler **52**, which is also used in the oxycombustion mode, by means of heat transfer medium circulation. Thus, the tubing **60** used for water circulation in the oxycombustion is in the air-firing combustion mode connected to a side tubing **70**, a so-called air heating arm, including a circulation pump **72**.

[0037] By opening a valve **74** in the air heating arm, and closing a valve **76** in the main tubing, in the so-called oxygen heating arm, the heat transfer medium can be switched to circulate through the air heater **68** instead of the oxygen heater **54**. If the water circulation pump is arranged in the common portion of the water tubing **60**, it is, in the above-described case, sufficient to have only one circulation pump. Because the flow rate of air in the air-firing mode is much higher than that of the oxygen in the oxycombustion mode, and the flow rate of exhaust gas in the air-firing mode is much larger than that of the end portion of the exhaust gas in the oxycombustion mode, the circulation rate of the heat transfer medium is advantageously lower in the oxycombustion mode than that in the air-firing mode.

[0038] According to an alternative embodiment of the present invention, parallel to the end portion of the exhaust gas channel **42**, is arranged a parallel channel portion **78**. The portion of the flue gas flowing through the parallel channel portion **78** can be varied by a damper **80** to be, for example, between about 0% and about 75%. The parallel channel portion comprises another exhaust gas cooler **82**, which is in the air-firing mode connected in parallel to the exhaust gas cooler **52**. Thus, heat is transferred in the oxycombustion mode from the exhaust gas cooler **52** to the oxygen heater **54**, and, in the air-firing combustion mode, from two exhaust gas coolers **52**, **82** to the air heater **68**. By properly adjusting the heat transfer rates, it is possible to obtain required inlet gas temperatures and sufficient cooling of the exhaust gas in both operating modes.

[0039] While the invention has been described herein by way of examples in connection with what are, at present, considered to be the most preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but is intended to cover various combinations or modifications of its features and several other applications included within the scope of the invention, as defined in the appended claims.

We claim:

1. A method of generating power by oxyfuel combustion, said method comprising the steps of:

(a) feeding carbonaceous fuel into a furnace;

(b) feeding oxidant gas into the furnace, wherein, in a first operating mode, the oxidant gas comprises a stream of substantially pure oxygen conveyed from an oxygen supply for combusting the fuel with the oxygen to produce exhaust gas comprising mainly carbon dioxide and water;

(c) discharging the exhaust gas from the furnace;

(d) dividing the exhaust gas into a recycling portion and an end portion;

(e) recycling the recycling portion to the furnace; and

(f) transferring heat from the end portion to the stream of substantially pure oxygen by circulating a liquid heat transfer medium in a passage between an exhaust gas cooler and an oxygen heater.

2. The method according to claim **1**, further comprising the steps of:

(g) transferring heat in a gas-gas heat exchanger from the exhaust gas to the recycling portion to produce a stream of heated recycling gas;

(h) mixing the stream of substantially pure oxygen with the stream of heated recycling gas so as to form a stream of mixed gas; and

(i) feeding the stream of mixed gas as the oxidant gas into the furnace.

3. The method according to claim **1**, wherein the liquid heat transfer medium is water.

4. The method according to claim **1**, wherein the exhaust gas cooler is of a corrosion resistant type.

5. The method according to claim **1**, wherein the first operating mode is performed alternatingly with a second operating mode, in which the recycling portion is minimized, and the oxidant gas comprises a stream of air.

6. The method of claim **2**, wherein the first operating mode is performed alternatingly with a second operating mode, in which the recycling portion is minimized, and the oxidant gas comprises a stream of air introduced into the gas recycling line, so as to transfer heat in the gas-gas heat exchanger from the exhaust gas to the air stream.

7. The method according to claim **5**, wherein the second operating mode comprises a step of transferring heat from the end portion of the stream of air by circulating a liquid heat transfer medium in a passage between the exhaust gas cooler and an air heater.

8. The method according to claim **6**, wherein the second operating mode comprises a step of transferring heat from the end portion of the stream of air by circulating a liquid heat transfer medium in a passage between the exhaust gas cooler and an air heater.

9. The method according to claim **7**, wherein the second operating mode comprises further steps of dividing a parallel stream from the exhaust gas stream and transferring heat from the parallel stream into the stream of air by circulating a liquid heat transfer medium between a second exhaust gas cooler and the air heater.

10. A system for generating power by oxyfuel combustion, said system comprising:

a furnace for combusting carbonaceous fuel;

an oxygen channel for feeding the substantially pure oxygen from an oxygen supply to the furnace for combusting the fuel with the oxygen to produce exhaust gas comprising mainly carbon dioxide and water;

an exhaust gas channel connected to the furnace for discharging the exhaust gas from the furnace;

branch piping for dividing the exhaust gas into a recycling portion and an end portion;

a gas recycling channel for feeding the recycling portion of the exhaust gas to the furnace; and

an exhaust gas cooler arranged in the exhaust gas channel downstream of the branch piping and an oxygen heater arranged in the oxygen channel connected by a passage for transferring heat from the end portion to the stream of substantially pure oxygen by circulating a liquid heat transfer medium in the passage.

11. The system according to claim **10**, further comprising:

a gas-gas heat exchanger for transferring heat from the exhaust gas to the recycling portion;

a mixer arranged to connect the gas recycling channel downstream of the gas-gas heat exchanger and the oxygen channel downstream of the oxygen heater for mixing the recycling portion with the stream of substantially pure oxygen so as to form a stream of mixed gas; and

a channel for feeding the stream of mixed gas as the oxidant gas into the furnace.

12. The system according to claim **10**, wherein the exhaust gas cooler is of a corrosion resistant type.

13 The system according to claim **10**, further comprising:

a flow controller arranged in the recycling gas channel for controlling the recycling portion; and

an air intake for introducing a stream of air as the oxidant gas instead of substantially pure oxygen.

14. The system according to claim **11**, further comprising:

a flow controller arranged in the recycling gas channel for controlling the recycling portion; and

an air intake for introducing a stream of air as the oxidant gas, instead of substantially pure oxygen into the gas recycling line, wherein the air intake is arranged upstream of the gas-gas heat exchanger so as to transfer heat from the exhaust gas to the air stream in the gas-gas heat exchanger.

15. The system according to claim **13**, further comprising an air heater connected by a passage to the exhaust gas cooler for transferring heat from the end portion to the stream of air by circulating a liquid heat transfer medium in the passage between the exhaust gas cooler and the air heater.

16. The system according to claim **14**, further comprising an air heater connected by a passage to the exhaust gas cooler for transferring heat from the end portion to the stream of air by circulating a liquid heat transfer medium in the passage between the exhaust gas cooler and the air heater.

17. The system according to claim **15**, further comprising:

second branch piping for dividing from the exhaust gas stream a parallel stream in a parallel channel option; and

a second exhaust gas cooler arranged in the parallel channel portion for transferring heat from the parallel stream into the stream of air by circulating a liquid heat transfer medium in a passage between the second exhaust gas cooler and the air heater.

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