Abstract: An oxyfuel combustion system for generating power that includes a furnace for combusting carbonaceous fuel and substantially pure oxygen to produce exhaust gas including mainly carbon dioxide and water. An exhaust gas channel system discharges the exhaust gas from the furnace. The exhaust gas channel system has an upstream channel, an outlet channel and a gas recycling channel. The upstream channel recycles a recycling portion of the exhaust gas through the recycling channel to the furnace, and conveys an end portion of the exhaust gas through the outlet channel for final processing. The upstream channel is divided between a first divider piece and a connecting piece into a first exhaust gas channel portion and a second exhaust gas channel portion. A gas-gas heat exchanger arranged in the first exhaust gas channel portion transfers heat from exhaust gas in the first exhaust gas channel portion to a flow of feedwater in the feedwater line, and a second economizer arranged in the exhaust gas channel system downstream of the connecting piece transfers heat from gas in the exhaust gas channel system to the flow of feedwater in the feedwater line.
BACKGROUND OF THE INVENTION

[0001] 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 dual-firing or flexi-burn combustion system, i.e., to a system which can be easily switched between the modes of oxyfuel combustion and combustion with air.

[0003] Description of the Related Art

[0004] Oxyfuel combustion is one of the methods suggested for removing CO₂ 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.
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 CO₂ when water is removed therefrom and, possibly, the exhaust gas is purified in order to reduce inert gases originating from the oxidant, fuel and air-leakage. This purification is typically done by CO₂ condensation at a low temperature under high pressure. CO₂ 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.

In order to avoid very high combustion temperatures resulting from combustion with pure oxygen, it is advantageous to use an oxyfuel combustion boiler, in which 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 O₂ content of the oxidant gas of, for example, about 20 to 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 making any changes in the 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 daytime, and to apply oxyfuel combustion with CO₂ removal in other conditions. Also, it is possible to use a dual firing boiler in an air-firing mode, for example, when the air separation unit or CO₂ sequestration unit is out of order.
A conventional boiler based on combusting carbonaceous fuel by air usually comprises a set of heat transfer surfaces, such as evaporators, superheaters, reheaters, economizers, and an air-heater, arranged sequentially in the furnace and an exhaust gas channel upstream of an electrostatic precipitator (ESP) or a fabric filter. It is also known to arrange superheaters, reheaters and economizers in parallel exhaust gas channels portions, or a low pressure economizer parallel to an air heater.

U.S. Patent No. 6,202,574 shows an oxyfuel combusting boiler having, in the exhaust gas channel, downstream of superheaters, reheaters and economizers, a further sequence set of the flue gas coolers, comprising a recycled flue gas heater, a pure oxygen heater and a feedwater heater. German patent publication DE 103 56 701 A1 shows an oxyfuel combustion boiler system comprising an oxygen heater and a recycled flue gas heater arranged in series or in parallel in the exhaust gas channel.

PCT patent publication WO 2006/1 31283 shows a dual firing oxyfuel combustion boiler having, downstream of an air heater, a series of heat exchangers, which are in an oxyfuel combustion mode connected to the feedwater supply line so as to compensate for heat energy, which is in an oxyfuel combustion mode used for the air separation or CO₂ liquefaction. This system is quite complicated due to the valves and controllers required for controlling the feedwater flow in the oxyfuel combustion mode.

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

[0011] An object of the present invention is to provide a new method of and a system for oxyfuel combustion.

[0012] According to an aspect of the present invention, a method of generating power by oxyfuel combustion is provided, 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 an exhaust gas stream from the furnace, dividing the exhaust gas stream in a final divider piece to a recycling portion and an end portion, recycling the recycling portion through a gas recycling channel to the furnace, and conveying the end portion through an outlet channel to final processing, wherein the method also comprises the steps of dividing the exhaust gas stream in a first divider piece arranged upstream of the final divider piece to a first exhaust gas stream and a second exhaust gas stream, transferring heat from the first exhaust gas stream to gas in the gas recycling channel by a gas-gas heat exchanger to form a cooled first exhaust gas stream, transferring heat from the second exhaust gas stream to a flow of feedwater in a feedwater line by a first economizer to form a cooled second exhaust gas stream, combining the cooled first exhaust gas stream and the cooled second exhaust gas stream in a connecting piece arranged upstream of the final divider piece to form a combined exhaust gas stream, and conveying at least a portion of the combined exhaust gas stream through a second economizer arranged to transfer heat from the combined exhaust gas stream to the flow of feedwater in the feedwater line.
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 substantially pure oxygen from an oxygen supply into the furnace for combusting the fuel with the oxygen to produce exhaust gas, comprising mainly carbon dioxide and water, an exhaust gas channel system connected to the furnace for discharging the exhaust gas from the furnace, wherein the exhaust gas channel system comprises an upstream channel, an outlet channel and a gas recycling channel, wherein the upstream channel is connected by a final divider piece to the gas recycling channel and the outlet channel, for recycling a first portion, a so-called recycling portion, of the exhaust gas through the recycling channel to the furnace, and for conveying a second portion, a so-called end portion, of the exhaust gas through the outlet channel for final processing, wherein the system further comprises dividing the upstream channel between a first divider piece and a connecting piece into a first exhaust gas channel portion and a second exhaust gas channel portion, a gas-gas heat exchanger arranged in the first exhaust gas channel portion to transfer heat from exhaust gas in the first exhaust gas channel portion to gas in the gas recycling channel, a first economizer arranged in the second exhaust gas channel portion to transfer heat from exhaust gas in the second exhaust gas channel portion to a flow of feedwater in a feedwater line, and a second economizer arranged in the exhaust gas channel system downstream of the connecting piece to transfer heat from gas in the exhaust gas channel system to the flow of feedwater in the feedwater line.

The power generating system according to the present invention preferably comprises an oxygen heater arranged to the oxygen channel, which oxygen heater is advantageously connected to a gas cooler arranged in the outlet channel, so as to heat the
substantially pure oxygen by heat obtained from the end portion of the exhaust gas. This oxygen heating system may consist of a gas-gas heat exchanger, in which heat is transferred directly from the end portion of the exhaust gas to the stream of substantially pure oxygen, but, advantageously, it is based on circulating a heat transfer medium, typically water, by a pump in a circulating pipe system between a separately-arranged gas cooler and an oxygen heater. When using the present invention, the feeding rate of the relatively pure oxygen is advantageously 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%.

[0015] The recycling portion of the exhaust gas 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 recycling portion of the exhaust 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 combined oxidant gas is formed to be fed via a channel into the furnace. An advantage resulting from heating the oxygen stream prior to mixing with recycling gas is the avoiding of moisture or acid gas condensation from the recycling gas on an O₂ injector pipe, which may result if the temperature of the O₂ stream is too low. Generally, the mixing of a heated pure oxygen stream with a heated recycling portion of the exhaust gas makes it possible to efficiently control the temperature, flow rate and oxygen content of the combined oxidant gas.
The gas recycling 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 a mixed gas, which may be fed to the furnace separately, for example, as primary and secondary oxidant gas. 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.

When the present invention is used for an oxyfuel combusting boiler retrofitted from an air-firing boiler, the flow rate of the recycling portion of the exhaust gas is advantageously adjusted so as to maintain the desired gas velocity in the furnace, in which 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 be maintained at about its original level to avoid, e.g., corrosion or material strength problems of the furnace walls.

Due to the high heat capacity of the exhaust gas generated in the oxyfuel combustion 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 oxyfuel combustion than in air-firing combustion. Thus, when changing an air-firing steam generation process to oxyfuel combustion, the fuel feeding rate is advantageously increased by at least 10%, whereby the original furnace temperature or heat flux can still be maintained. As a result of the increased firing, an increased amount of heat is available, e.g., for steam generation and for heating of the oxidant gas.
In a conventional air-firing boiler, a large portion of steam extracted from steam turbines is used for preheating feedwater. In an oxyfuel combustion boiler, advantageously, at least a portion of steam extracted from the steam turbines is used for driving compressors in an air separation unit (ASU) or in a carbon dioxide purification and compression unit (CCU), and, correspondingly, an increased amount of the preheating of feedwater is performed in economizers arranged in the exhaust gas channel. Because of this arrangement, and due to increased steam generation based on the increased firing mentioned above, there is in oxyfuel combustion a need for an especially efficient system of economizers.

The first economizer is advantageously arranged in the feedwater line immediately downstream of the second economizer. By such an arrangement, the first and second economizers are in a direct feedwater flow connection, i.e., that the same stream of feedwater always flows through both of the economizers, and there are no branch pipes with control valves, for controlling the flow of feedwater between the two economizers. In this way, the economizers according to the present invention provide a simple system which can be adjusted for optimal heating of the feedwater. The adjustment is preferably performed by controlling a damper in one of the first exhaust gas channel portion and the second exhaust gas channel portion, so as to vary the division ratio of the exhaust gas between the two exhaust gas channel portions.

According to a preferred embodiment of the present invention, the second economizer is arranged in the upstream channel, i.e., to the exhaust gas channel upstream of the final divider piece. Usually, the upstream channel comprises a dust separator, such as an electrostatic precipitator (ESP) or a fabric filter. The second economizer is advantageously
arranged upstream of the dust separator, whereby the temperature of the exhaust gas can be adjusted to be suitable for the operating range of the dust separator.

Typically, a majority of the exhaust gas, for example, about 80%, flows through the first exhaust gas channel portion, and a smaller portion, for example, about 20%, flows through the second exhaust gas channel portion. Thus, when the first exhaust gas stream is cooled in the gas-gas heat exchanger, for example, from about 310°C to about 210°C, and the second exhaust gas stream is cooled in the first economizer, for example, to about 170°C, the combined exhaust gas will have downstream of the connecting piece a temperature of about 200°C. Thereby, the combined exhaust gas stream is advantageously cooled in a second economizer arranged in the upstream channel from about 200°C, for example, to about 150°C. This arrangement of the economizers provides the possibility of simultaneously heating both the recycling gas, in the gas-gas exchanger, and the feedwater, in the economizers, to their optimal temperatures, without risk of acid condensation on the economizers or the downstream dust separator.

According to another preferred embodiment of the present invention, which is especially advantageous when the outlet channel comprises an exhaust gas cooler connected to an oxygen heater, the second economizer is arranged in the gas recycling channel instead of the upstream channel. Thereby, the second economizer transfers heat only from the recycling portion of the exhaust gas to the feedwater. This arrangement provides the advantage that the temperature of the exhaust gas remains relatively high, typically, about 200°C, when the exhaust gas enters the exhaust gas cooler, and the oxygen stream can correspondingly be heated by the oxygen heater to a relatively high temperature. Naturally, it is also possible to
have a split second economizer, a part of which is located in the upstream channel and another part in the gas recycling channel.

According to an especially advantageous embodiment of the present invention, the system comprises an air intake arranged in the gas recycling channel for introducing a stream of air as the oxidant gas and a damper arranged in the gas recycling channel for controlling the recycling portion. The purpose of the air intake is to render possible a second operating mode, an air-firing mode, which can be used alternatingly with the first operating mode. In the second operating mode, the recycling portion is minimized and air is used as the oxidant gas, instead of substantially pure oxygen or a combined stream of oxygen and recycling portion of the exhaust gas. The air intake is advantageously 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.

In the second operating mode, the combustion system is decoupled from the oxygen supply, and the exhaust gas comprises nitrogen, carbon dioxide and water, as its main components. Because of the large portion of nitrogen in the exhaust gas, the system is also decoupled from the carbon dioxide purification and compression unit (CCU), 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 a system for and a method of dual-firing oxyfuel combustion, which can be easily switched from oxyfuel combustion to air-firing combustion, and back, without making any modifications in the construction, even on-line, without stopping the power generation during the change.

Because, in the second operating mode, the oxygen supply is not in use and the carbon dioxide of exhaust gas is not purified and sequestered, the auxiliary power
consumption of these processes is minimized, and the system provides a higher total efficiency than in oxyfuel 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, during the summer or the day-time. Alternatively, the air-firing mode may be temporarily used, e.g., based on varying economic conditions, or when the oxygen supply, carbon dioxide purification and compression unit or carbon dioxide storage system, are, for some reason, not available.

[0027] When using the first operation mode, the initial temperature of the cold gas in the gas-gas heat exchanger, i.e., the temperature of the recycling gas, is relatively high and, thus, the exhaust gas cools in the gas-gas heat exchanger only by about 100°C, typically, to about 200°C. Therefore, the exhaust gas carriers downstream of the gas-gas heat exchanger steal a large amount of heat energy, a considerable portion of which is advantageously utilized to heat the feedwater in the second economizer. Thus, the second economizer is arranged so that the exhaust gas cools therein, in the first operating mode, preferably, by at least about 30°C, even more preferably, by at least about 40°C. Typically, the flue gas cools in the second economizer, in the first operating mode, from a temperature between about 170°C and about 220°C to a temperature between about 120°C and about 170°C, i.e., so as to stay above the acid gas dew point. In order to obtain the desired exhaust gas temperature, the first and second economizers are preferably LP economizers arranged upstream of a de-aerator. When a low pressure aerator is used, the first and second economizers can also be arranged upstream of the de-aerator.

[0028] In the second operating mode, the stream of recycling exhaust gas is advantageously replaced by an about as large a stream of air which, however, is at a much
lower temperature than is the recycling exhaust gas. Therefore, the exhaust gas cools, then, in the gas-gas heat exchanger to a much lower temperature, typically, to about 120°C. In these conditions, the temperature of the exhaust gas downstream of the gas-gas heat exchanger is, typically, already close to that of feedwater entering the second heat exchanger, and there is very little, if any, heat transfer in the second economizer. Advantageously, the temperature of the exhaust gas changes, in the second operating mode, in the second economizer by less than about 10°C.

[0029] As described above, in the oxyfuel combustion mode, a large portion of steam extracted from steam turbines is used for driving compressors in the ASU or the CCU. In the air-firing mode, when the ASU and CCU are not in use, this steam is saved for preheating the feedwater, and the need for feedwater preheating in the economizers is greatly reduced. As described above, the present arrangement decreases, in the air-firing mode, automatically, the heat transfer duty of the economizers. The preheating of the feedwater is, in the air-firing mode, also advantageously decreased by using the damper in one of the first and second exhaust gas channel portions, so as to decrease the share of exhaust gas flowing through the second exhaust gas channel portion.

[0030] 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 drawings.
BRIEF DESCRIPTION OF THE DRAWINGS

[0031] FIG. 1 is a schematic diagram of an oxyfuel-combusting power plant in accordance with a preferred embodiment of the present invention.

[0032] FIG. 2 is a schematic diagram of an oxyfuel-combusting power plant in accordance with another preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0033] 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 system 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.

[0034] The exhaust gas channel system 20 comprises an upstream channel portion 54, a recycling channel 28 and an outlet channel 58, whereby, the exhaust gas stream is divided in a final divider piece 26 into a recycling portion, conveyed through the recycling gas channel 28 back to the furnace 14, and an end portion, which is conveyed through the outlet channel 58 for final processing.
The oxidant gas is preferably a mixture of substantially pure oxygen, produced from an air stream 22 in the air separation unit (ASU) 24, and at least a portion of the recycling portion of the exhaust gas. Another portion of the recycling portion, not shown in FIG. 1, may be conducted, for example, as sealing or conveying gas for the boiler 12. The exhaust gas recycling channel 28 advantageously comprises means, such as a fan 30 and a damper 32, for controlling the exhaust gas recycling rate. The recycling rate of the exhaust gas is advantageously adjusted such that the resulting gas flow rate in the furnace 14 obtains a desired value, whereby the average $O_2$ content of the oxidant gas is, typically, 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.

As is conventional, the furnace 14 usually comprises evaporation surfaces, not shown in FIG. 1, and the upstream channel portion 54 of the exhaust gas channel system 20 further comprises heat exchanger surfaces 34, for example, superheaters, reheaters and HP economizers. For the sake of simplicity, FIG. 1 only shows one such heat exchanger surface 34, but, in practice, the upstream portion of the exhaust gas channel system usually comprises multiple superheating, reheating and HP economizer surfaces for recovering heat from the exhaust gas.

In the upstream portion 54 of the exhaust gas channel system 20 are also arranged, downstream of the steam generating heat exchange surfaces 34, a gas-gas heat exchanger 36, for example, a regenerative heat exchanger, for transferring heat from the exhaust gas directly to the recycling portion of the exhaust gas, and a first economizer 38, for
transferring heat to feedwater flowing in a feedwater line 40. According to the present invention, the gas-gas heat exchanger 36 is advantageously arranged in a first exhaust gas channel portion 42 and the first economizer 38 is arranged in a second exhaust gas channel portion 44, which channel portions are connected in parallel between an initial divider piece 46 and a connecting piece 48. One of the first exhaust gas channel portion 42 and the second exhaust gas channel portion 44 advantageously comprises a damper 50 for adjusting the division of the exhaust gas to the parallel channel portions.

[0038] Downstream of the connecting piece 48 is advantageously connected to a second economizer 52, for transferring heat from the combined stream of exhaust gas to the feedwater flowing in the feedwater line 40. By using such a combination of economizers, it is possible to simultaneously heat both the gas in the recycling channel 28, by the gas-gas heat exchanger 36, and the feedwater, by the economizers 38, 52, to their optimal temperatures without risk of acid condensation on the economizers.

[0039] The upstream portion 54 of the exhaust gas channel system 20 also usually comprises conventional units for cleaning particles and gaseous pollutants from the exhaust gas, which units are schematically represented in FIG. 1 only by a dust separator 56.

[0040] In accordance with the main object of oxyfuel combustion, i.e., to recover carbon dioxide from the exhaust gas, the outlet channel 58 is equipped with means, schematically represented by a carbon dioxide processing unit 60, for cooling, cleaning and compressing carbon dioxide. The unit 60 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 62, and other possible impurities, from the carbon dioxide. A stream of carbon dioxide 64 is typically captured in a liquid or supercritical state, at a pressure of, for
example, about one hundred ten bars, so that it can be transported to further use or to be stored in a suitable place. FIG. 1 separately shows a condensing gas cooler 66, located upstream of the carbon dioxide processing unit 60, for initially removing water from the exhaust gas.

[0041] In order to transfer energy from the end portion of the exhaust gas to the stream of substantially pure oxygen, the outlet channel 58 is preferably equipped with a gas cooler 68, which is connected by a liquid heat transfer medium circulation to an oxygen heater 70 arranged in an oxygen channel 72 downstream of the oxygen supply 24. The heat transfer medium, usually water, is preferably circulated by a pump 74 in tubing 76 extending between the gas cooler 68 and the oxygen heater 70, which are usually, in practice, located at distant portions of the power plant 10.

[0042] The oxygen channel 72 may be connected directly to the furnace 14, but, according to a preferred embodiment of the present invention, the oxygen channel 72 and the exhaust gas recycling channel 28 are both connected to a mixer 78, 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.

[0043] According to a preferred embodiment of the present invention, the system also comprises an air intake 80 for feeding air to the furnace 14. The air stream is preferably introduced into the gas recycling channel 28 upstream of the gas-gas heat exchanger 36, whereby it is possible to transfer heat directly from the exhaust gas to the stream of air. The purpose of air intake 80 is to enable switching from oxyfuel combustion to air-firing combustion. Thus, when introducing air to the gas recycling channel 28, the oxygen supply is stopped and the recycling of exhaust gas is minimized, preferably, totally stopped, by the
damper 32. 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 82.

[0044] An air stream flowing, in the air-firing mode, in the gas recycling channel 28 may advantageously already be preheated upstream of the gas-gas heat exchanger 36 by a gas heater 86. The gas heater 86, which is advantageously arranged in the gas recycling channel 28 downstream of the fan 30, may be connected to the gas cooler 68 by a side loop of the tubing 76, which is then, in the air firing mode, connected to transfer heat obtained from the end portion of the exhaust gas to the gas heater 86 instead of the oxygen heater 70. The gas heater 86 may, alternatively, be a conventional steam coil heater arranged in the gas recycling channel 28, which is preferably used only in the air-firing mode.

[0045] FIG. 2 shows a schematic diagram of a power plant ION in accordance with another preferred embodiment of the present invention. Elements of the power plant ION corresponding to similar elements in power plant 10 shown in FIG. 1 are shown with the same reference numbers as those in FIG. 1.

[0046] The power plant ION differs from the power plant 10 shown in FIG. 1 mainly in that the second economizer 52N is arranged in the gas recycling channel 28 instead of the upstream portion 54 of the exhaust gas channel system 20. Thus, the end portion of the exhaust gas remains at a higher temperature, and the oxygen stream can be heated to a higher temperature by the oxygen heater 84 than by the heater 70 of the embodiment shown in FIG. 1. The oxygen heater 84 is, here, shown as a direct gas-gas heater, but it may alternatively
comprises an oxygen heating system based on circulating a heat transfer medium between a separate exhaust gas cooler and oxygen heater, as shown in FIG. 1. It is also possible that oxygen is heated in two successive heaters, for example, first in a heating system of the type shown in FIG. 1, and then, in a direct gas-gas heat exchanger, as shown in FIG. 2.

[0047] According to a preferred embodiment of the present invention, the system comprises an air intake 80, as in the system shown in FIG. 1, for feeding, in an air-firing mode, air as the oxidant to the furnace 14. As shown in FIG. 2, though, the air stream may be preheated by a conventional steam coil heater 86N arranged in the gas recycling channel 28. If, however, the system comprises a separate exhaust gas cooler 68 connected to an oxygen heater 70 in the oxygen channel 72, by using tubing for circulating a fluid transfer medium, as shown in FIG. 1, the tubing may also contain a side loop, to be used in the air-firing mode for heating air by a gas heater arranged in the gas recycling channel 28.

[0048] 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, the 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 an exhaust gas stream from the furnace;
   (d) dividing the exhaust gas stream in a final divider piece into a recycling portion and an end portion;
   (e) recycling the recycling portion through a gas recycling channel to the furnace; and
   (f) conveying the end portion through an outlet channel to final processing,

wherein the method also comprises the steps of:
   (g) dividing the exhaust gas stream in a first divider piece, arranged upstream of the final divider piece, into a first exhaust gas stream and a second exhaust gas stream;
   (h) transferring heat from the first exhaust gas stream to gas in the gas recycling channel by a gas-gas heat exchanger to form a cooled first exhaust gas stream;
   (i) transferring heat from the second exhaust gas stream to a flow of feedwater in a feedwater line by a first economizer to form a cooled second exhaust gas stream;
(j) combining the cooled first exhaust gas stream and the cooled second exhaust gas stream in a connecting piece arranged upstream of the final divider piece to form a combined exhaust gas stream; and

(k) conveying at least a portion of the combined exhaust gas stream through a second economizer arranged to transfer heat from the combined exhaust gas stream to the flow of feedwater in the feedwater line.

2. The method according to claim 1, wherein the second economizer is arranged in the exhaust gas channel upstream of the final divider piece.

3. The method of claim 1, further comprising a step of transferring heat from the end portion of the exhaust gas to the stream of substantially pure oxygen.

4. The method of claim 3, further comprising a step of mixing the stream of substantially pure oxygen and the recycling portion as a combined oxidant gas in a mixer, and feeding the combined oxidant gas into the furnace.

5. The method according to claim 3, wherein the second economizer is arranged in the recycling channel to transfer heat from the recycling portion of the exhaust gas.

6. The method according to claim 1, wherein the first economizer is arranged in the feedwater line immediately downstream of the second economizer.
7. The method according to claim 1, further comprising a step of controlling the division ratio of the first exhaust gas stream and the second exhaust gas stream.

8. The method according to claim 2, wherein, in the first operating mode, the temperature of the exhaust gas decreases in the second economizer by at least 30°C.

9. The method according to claim 1, further comprising performing the first operating mode alternatingly with a second operating mode, in which the recycling portion is minimized, and wherein the oxidant gas comprises a stream of air introduced into the gas recycling line upstream of the gas-gas heat exchanger.

10. The method according to claim 9, wherein, in the second operating mode, the temperature of the exhaust gas changes in the second economizer by less than 10°C.

11. A system for generating power by oxyfuel combustion, the system comprising:
   a furnace for combusting carbonaceous fuel;
   an oxygen channel for feeding substantially pure oxygen from an oxygen supply into the furnace for combusting the fuel with the oxygen to produce exhaust gas comprising mainly carbon dioxide and water;
   an exhaust gas channel system connected to the furnace for discharging the exhaust gas from the furnace, wherein the exhaust gas channel system comprises an upstream channel, an outlet channel and a gas recycling channel, wherein the upstream channel is connected by a final divider piece to the gas recycling channel and the outlet channel, for
recycling a recycling portion of the exhaust gas through the recycling channel to the furnace, and for conveying an end portion of the exhaust gas through the outlet channel for final processing, wherein the upstream channel is divided between a first divider piece and a connecting piece into a first exhaust gas channel portion and a second exhaust gas channel portion;

- a gas-gas heat exchanger arranged in the first exhaust gas channel portion to transfer heat from exhaust gas in the first exhaust gas channel portion to gas in the gas recycling channel;
- a first economizer arranged in the second exhaust gas channel portion to transfer heat from exhaust gas in the second exhaust gas channel portion to a flow of feedwater in a feedwater line; and
- a second economizer arranged in the exhaust gas channel system downstream of the connecting piece to transfer heat from gas in the exhaust gas channel system to the flow of feedwater in the feedwater line.

12. The system according to claim 11, wherein the second economizer is arranged in the upstream channel.

13. The system according to claim 11, further comprising an oxygen heater arranged in the oxygen channel, connected to a gas cooler arranged in the outlet channel for heating the substantially pure oxygen by heat obtained from the end portion of the exhaust gas.
14. The system according to claim 13, further comprising a mixer to mix the substantially pure oxygen and the recycling portion as a combined oxidant gas and a channel for feeding the combined oxidant gas into the furnace.

15. The system according to claim 13, wherein the second economizer is arranged in the gas recycling channel.

16. The system according to claim 11, wherein the first economizer is arranged in the feedwater line immediately downstream of the second economizer.

17. The system according to claim 11, further comprising a damper in one of the first exhaust gas channel portion and the second exhaust gas channel portion for controlling the division ratio of the exhaust gas.

18. The system according to claim 11, further comprising:

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

   an air intake arranged in the gas recycling channel for introducing a stream of air as the oxidant gas, 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.
Fig. 1