An oxycombustion circulating fluidized bed reactor includes a reactor chamber, and a gas distribution arrangement provided in the bottom section of the reactor chamber for introducing gas into the reactor chamber. A windbox chamber having gas introduction nozzles introduces gas from the windbox chamber into the reactor chamber and an has an inlet that opens into the windbox chamber. A first gas feeding system introduces gas into the windbox chamber, and a second gas feeding system introduces gas into the windbox chamber in the vicinity of at least one nozzle inlet.
TECHNICAL FIELD

[0001] The present invention relates to oxycombustion fluidized bed reactors and their operation. The invention particularly relates to an apparatus for and a method of introducing gas into such a reactor.

[0002] More specifically, the invention relates to an oxycombustion circulating fluidized bed reactor that includes a reactor chamber and a gas distribution arrangement provided in the bottom section of the reactor chamber for introducing gas into the reactor chamber, which gas distributor arrangement comprises a windbox chamber having gas introduction nozzles, the gas introduction nozzles being arranged for introducing gas from the windbox chamber into the reactor chamber and having an inlet that opens into the windbox chamber, and a first gas feeding system for introducing gas into the windbox chamber.

[0003] The invention also relates to a method of operating an oxycombustion circulating fluidized bed reactor that includes a reactor chamber and a gas distribution arrangement provided in the bottom section of the reactor chamber, in which method, gas is introduced into the reactor chamber through a windbox chamber having gas introduction nozzles with an inlet. Also, gas is introduced to the windbox chamber through a gas feeding system.

[0004] The invention further relates to a method of upgrading an existing circulating fluidized bed reactor having a windbox chamber provided with nozzles and a first gas feeding system for feeding gas to the windbox chamber, the method comprising steps of arranging a second gas feeding system having a plurality of feed pipes below the grid nozzle inlets in the windbox chamber of the existing circulating fluidized bed reactor.

BACKGROUND ART

[0005] New regulations and other demands limiting gas emissions relating to the so-called greenhouse effect have fostered the development of new technologies aimed at decreasing carbon dioxide emissions from power stations using fossil, carbonaceous fuels. While, in conventional firing, the oxygen required for burning the fuel is fed in the form of air, in oxycombustion, air is replaced with a mixture of substantially pure oxygen and recycled flue gas, which may be called an oxidant.

[0006] For example, U.S. Pat. No. 6,505,567 discloses a circulating fluidized bed steam generator, in which the combustion is supported by recycled carbon dioxide, which is a product gas of the combustion. The combustion is maintained by means of pure oxygen, which is introduced into the circulating fluidized bed steam generator. Introducing pure oxygen may create areas with a very high local temperature, which is not desired due to, e.g., the stresses generated on the constructional elements close to those areas, and an increase in the risk of bed material melting and agglomerating.

[0007] The introduction of oxygen into a circulating fluidized bed reactor is a particularly delicate process. Uneven distribution of oxygen may create local overheated spots, which are also prone to cause problems, such as agglomeration of bed material. This is particularly the case when pure oxygen is in question.

[0008] In circulating fluidized bed reactors, the fluidization gas velocities vary considerably, since the variation of the load also requires respective changes in the gas amounts fed through a grid of the reactor. The operational range of the grid is determined, e.g., by the pressure drop, which should not be excessive during high loads and yet, during low load operation, the pressure drop should be adequate to provide an even distribution of gas flow over the cross-sectional area of the grid, and to prevent flow of solids from the reaction chamber into the windbox. In practice, there is a certain minimum air flow that also must be fed through the grid during low load operation, which, in some cases, may be a limiting factor to the lowest obtainable load from the reactor.

[0009] U.S. Pat. No. 4,628,831 discloses a grid for conveying gaseous fluidization fluid to a treatment chamber using a fluidized bed. The grid comprises two separately supplied circuits of channels, a first circuit of channels with orifices widened towards the top, for providing a dense fluidized bed in the chamber, and a second circuit of tubular channels, opening out above the widened orifices, for providing a forced fluidized bed of particles in the chamber, respectively. This kind of a grid of two separate sets of nozzles and pipe networks is very complicated to manufacture.

[0010] International Application Publication No. WO 2005/119126 discloses a fluidized bed device having a combustion chamber in which the bottom section is provided with a first-type and a second-type of primary gas supply nozzles. First, the first-type nozzles are provided for injecting a first gas mixture at a first level close to the base of the chamber by means of a conventional wind box and nozzles. Second, the second-type nozzles are provided for injecting a second gas mixture enriched in oxygen at a second level above the first level. According to WO 2005/119126, the second-type nozzles comprise an arrangement for mixing oxygen with a second gaseous component within the nozzle, connected at the lower end thereof to an oxygen supply and to a supply of the second gaseous component. The second gaseous component is mentioned to be either the gas from the windbox or gas from a separate gas collector.

[0011] In this kind of an arrangement, in which the oxygen is mixed in the nozzle with the gas introduced from the wind box, the control of the oxygen ratio in the mixture is always dependent on the pressure prevailing in the wind box, and independent control is difficult, if not impossible.

[0012] Particularly, in oxycombustion circulating fluidized bed reactors, there is, in addition to a variation of gas velocities due to load variations, also a question of a proper introduction of oxygen-rich gas into the process maintained in the oxycombustion circulating fluidized bed reactor.

[0013] An object of the invention is to provide an oxycombustion circulating fluidized bed reactor that provides an advanced solution for introducing both recycled gas and oxygen-rich gas into the oxycombustion circulating fluidized bed reactor.

[0014] Another object of the invention is to provide a method of operating an oxycombustion circulating fluidized bed reactor that provides an efficient way of providing combustion at an elevated oxygen content.
A further object of the invention is to provide a method of upgrading an existing circulating fluidized bed reactor to an oxycombustion circulating fluidized bed reactor.

**DISCLOSURE OF THE INVENTION**

**[0016]** Objects of the invention are met by providing an oxycombustion circulating fluidized bed reactor that comprises a reactor chamber and a gas distribution arrangement provided in the bottom section of the reactor chamber for introducing gas into the reactor chamber, which gas distribution arrangement comprises a windbox chamber having gas introduction nozzles, the gas introduction nozzles being arranged for introducing gas from the windbox chamber into the reactor chamber and having an inlet that opens into the windbox chamber, and a first gas feeding system for introducing gas into the windbox chamber. The gas distributor arrangement further comprises a second gas feeding system for introducing gas into the wind box chamber in the vicinity of at least one nozzle inlet.

**[0017]** This way, the construction of the windbox may be of conventional materials and the grid nozzles may be simple, yet having the possibility of operating the oxycombustion circulating fluidized bed reactor with a flexibly controllable oxygen content in the gas introduced therein. This also provides a straightforward manner of retrofitting an existing air operated reactor to be upgraded into an oxycombustion circulated fluidized bed reactor.

**[0018]** Preferably, the second gas feeding system comprises a number of outlets, each of the outlets being arranged to direct the gas to be fed towards the nozzle inlet. The outlets are arranged at a distance from the nozzle inlets and are arranged to direct the gas into the nozzle inlet. This way, the mixing of the gases is commenced at the nozzle inlet and the risk of clogging of the nozzles is minimized, since the outlets are arranged below the nozzle inlet. Additionally, since the outlets are at a distance from the nozzle inlet and, thus, not mechanically coupled with the nozzle, the structure is less vulnerable to damage due to thermal stresses.

**[0019]** According to another embodiment of the invention, the majority of the nozzles in the grid of the reactor are of one type. The type of the nozzles is such that the gas flow channel in the nozzle is formed of a channel substantially without internal mixing elements, or the like. This improves the very flexible operation of the reactor, due to the fact that the second gas feeding system has only a minor effect on the operation of the first gas feeding system as such.

**[0020]** The outlet of the second gas feeding system and the nozzle inlet are preferably so arranged with respect to each other that they provide an ejector effect of some degree. In practice, the ejector effect does not need to be very efficient, since both of the first gas feeding system and the second gas feeding system are working under pressure. In practice, the outlet is preferably so arranged that the gas jet reaches the nozzle inlet.

**[0021]** The reactor chamber is provided with a particle separator for separating fluidized particles that are entrained with the gases resulting from the reactions taking place in the reaction chamber, and the particle separator is provided with a gas outlet and an outlet for separated particles. The gas outlet is arranged in flow communication with the first gas feeding system via a recycling conduit. Further, the recycling conduit is provided with a gas mixing unit and the gas mixing unit is in flow communication with a source of oxygen-rich gas. Also, the second gas feeding system is in flow communication with a source of oxygen-rich gas.

**[0022]** Objects of the invention are also met by providing a method of operating an oxycombustion circulating fluidized bed reactor, the method comprising a reactor chamber and a gas distribution arrangement provided in the bottom section of the reactor chamber, in which method, gas is introduced into the reactor chamber through a windbox chamber having gas introduction nozzles with an inlet, and in which method gas is introduced to the windbox chamber through a first gas feeding system. A stream of oxygen-rich gas is introduced through a second gas feeding system into the vicinity of the inlet of at least one nozzle in the windbox chamber.

**[0023]** The stream of oxygen-rich gas is introduced towards the inlet of at least one nozzle through an outlet in a second gas feeding system.

**[0024]** The stream of oxygen-rich gas from the second gas feeding system is introduced so that a jet of oxygen-rich gas reaches the inlet of the grid nozzle. This way, oxygen-rich gas flows only into the nozzle.

**[0025]** A mixture of recycled exhaust gas and oxygen is introduced to the windbox chamber through the first gas feeding system, and gas containing more than 90% of oxygen is introduced into the vicinity of the inlet of at least one nozzle through the second gas feeding system.

**[0026]** The mixing of the stream of oxygen-rich gas to the gas introduced through the first gas feeding system to the windbox chamber is commenced at the nozzle inlet.

**[0027]** Objects of the invention are also met by providing a method of upgrading an existing circulating fluidized bed reactor having a wind box chamber provided with nozzles and a first gas feeding system for feeding gas to the wind box chamber, the method comprising steps of arranging a second gas feeding system having a plurality of feed pipes below the grid nozzle inlets into the wind box chamber of the existing circulating fluidized bed reactor and arranging a source of oxygen-rich gas in connection with the second gas feeding system.

**[0028]** The existing circulating fluidized bed reactor is further provided with an exhaust gas recycling conduit connecting the exhaust gas conduit to the wind box chamber of the reactor. Advantageously, the source of oxygen-rich gas is further arranged in connection with the first gas feeding system, in order to increase the oxygen content of the recycled gas.

**[0029]** The recycling conduit is further connected to possibly existing secondary gas inlets.

**[0030]** This makes it possible to upgrade an existing, conventional air-operated circulating fluidized bed reactor into an oxycombustion circulating fluidized bed reactor, in which exhaust gas may be recirculated back to the reactor chamber, changing the composition of the exhaust gases, and in which oxygen is brought into the recirculated exhaust gas while the recirculated exhaust gas enters into the nozzles of the grid.

**[0031]** The claims present more details of different embodiments of the invention.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**[0032]** In the following, the invention will be described with reference to the accompanying schematic drawings, in which
FIG. 1 illustrates an oxycombustion circulating fluidized bed reactor provided with a gas distributor arrangement according to an embodiment of the invention.

FIG. 2 illustrates a detail II from FIG. 1.

FIG. 3 illustrates section III-III from FIG. 2.

FIG. 4 illustrates another embodiment of detail II.

FIG. 5 illustrates still another embodiment of detail II, and

FIG. 6 illustrates still another embodiment of detail II.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically shows an oxycombustion circulating fluidized bed reactor 10, which comprises a reactor chamber 15 and a particle separator 20 connected to the upper part of the reactor chamber 15 via a connection conduit 25. Particle separator 20 is provided with a particle outlet 30 and a gas outlet 35. The particle outlet 30 is connected to a particle return channel 40. The particle separator 20 is preferably of a centrifugal separator type. The return channel 40 may be provided, e.g., with a separate particle cooler or other particle handling system (not shown herein).

Exhaust gas, which in normal operation of combustion contains mostly CO, and H₂O, is led further to an exhaust gas conduit 45 via the gas outlet 35 of the particle separator 20. The exhaust gas is subjected to certain treatment processes, such as a heat recovery process, provided in connection with the exhaust gas conduit 45, but not shown here for clarity reasons.

The bottom section of the reactor chamber 15 is provided with a gas distribution arrangement 50, which comprises a grid 55 provided with nozzles 60, through which oxygen containing gas is introduced into the reactor chamber 15 for fluidization and process purposes. Regardless of the contents of the gas, all the gas introduced through the grid 55 participates in the fluidization of the bed material. In addition to the grid 55, the gas distribution arrangement 50 comprises a window box chamber 52 below the grid 55, into which gas introduction nozzles 60 of the grid 55 are arranged in order to introduce gas controllably from the window box chamber 52 to the reactor chamber 15. Thus, the nozzles 60 provide flow connection therebetween and have an inlet 62 that opens into the window box chamber 52. The detail II of FIG. 1 is shown in FIGS. 2 and 3, showing an exemplary embodiment of the nozzles 60 in the grid 55.

The gas distribution arrangement 50 comprises a first gas feeding system 70, which is provided for introducing gas into the window box chamber 52. The first gas feeding system 70 is in flow communication with the exhaust gas conduit 45 and with the wind box chamber 52 so as to allow a recirculation of the exhaust gas to the window box chamber 52 and further back to the reactor chamber 15. The reactor 10 is provided with a recycling conduit 95 that connects the exhaust gas conduit 45 to the first feeding system 70. The recycling conduit 95 is provided with a recycling blower 96, or the like.

The oxycombustion circulating fluidized bed reactor also comprises a source of oxygen-rich gas 100, such as an Air Separation Unit (ASU). The source of oxygen-rich gas 100 is in connection with the first gas feeding system 70 through a first gas mixing unit 75 by means of a first oxygen feed line 76. The first oxygen feed line 76 is provided with a flow control device 77, such as a valve, in order to control the amount of oxygen being fed. The recycling conduit 95, in turn, is connected to the first gas feeding system 70 through the gas mixing unit 75. Thus, in the gas mixing unit 75, a controllable amount of oxygen may be brought into the recycled exhaust gas and mixed thereto prior to entering the window box chamber 52. This way, the recycled exhaust gas and the added oxygen form oxidant gas for the combustion process.

The gas distribution arrangement 50 of the oxycombustion circulating fluidized bed reactor 10 further comprises a second gas feeding system 80. The second gas feeding system 80 preferably comprises a distribution manifold 82, or the like. The second gas feeding system 80 may be realized in various ways, in practice. In some applications, the second gas feeding system 80 may be comprised of several parts of a whole, i.e., it may be divided into sub-systems, each arranged to introduce oxygen-rich gas to a number of grid nozzles 60. The manifold is arranged at least partly in the window box chamber 52 below the grid 55. In the embodiment shown in FIGS. 1-3, a plurality of feed pipes 84 is arranged to the manifold so that each feed pipe 84 has an outlet 85, and the outlet 85 is arranged to open into the vicinity of the nozzle inlet 62. The outlet 85 of the feed pipe 84 is directed towards the inlet 62 of the nozzle 60. Thus, in operation, the gas fed through the second gas feeding system 80 is also fed towards the nozzle inlet 62. The outlet 85 of the feed pipe 84 and the nozzle inlet 62 are preferably arranged to form an ejector device. Since the second gas feeding system 80 has only a limited volume and substantially small-sized outlets, the need to utilize special high-temperature/high-oxygen content durable material is minimized.

As is depicted in FIG. 3, the inlet 62 of the nozzle 60 and the outlet 85 of the feed pipe 84 are preferably circular in cross section and coaxially arranged. The outlet 85 is arranged to open below the nozzle inlet 62, at a distance from the nozzles 60.

Depending on the actual application, the number of feed pipes 84 in relation to the number of the grid nozzles 60 may vary. Typically, at least 20% of the nozzles 60 is provided with a feed pipe 84.

The second gas feeding system 80 is in connection with the source of oxygen-rich gas 100, e.g., the Air Separation Unit (ASU). The manifold 82 is connected to the source of oxygen-rich gas 100 by means of a second oxygen feed line 83. The second oxygen feed line 83 is provided with a flow control device 81, such as a valve, in order to control the flow rate, and thus, the amount of oxygen in the oxidant fed to the reactor chamber 15. An optional inlet for other gases, steam or N₂, with a control valve, may also be provided in connection with the distribution manifold 82.

The second oxygen feed line 83 is preferably provided with a gas heating device 83' to preheat the oxygen-rich gas prior to introduction into the grid nozzles 60. In practice, the heating device may be realized in various manners.

The reactor 10 may be operated both for air combustion and oxygen-rich combustion. The first gas feeding system 70 has a branch 200 for feeding upper primary gas into the reactor chamber 15. Thus, according to an embodiment of the invention, in order to maintain the pressure drop over the grid 55 at the same level during air and oxygen-rich operation, part of the oxidant gas may be fed through the upper primary gas branch 200. The upper primary gas branch 200 is branched from the first gas feeding system 20, thus, and it is provided with a control valve 210 for controlling the amount of gas flow through the branch 200. The density of the oxidant
(mixture of the recycled exhaust and oxygen) may be even 20-25\% higher than the density of air. Thus, it is advantageous to feed part of the oxidant through the upper primary gas branch 200.

0050 The oxycombustion circulating fluidized bed reactor 10 preferably also comprises a feed system 300 for feeding secondary oxidant above the upper primary gas branch 200. The feed system 300 comprises a second gas mixing unit 310, into which, a third oxygen feed line 320 is extending from the source of oxygen-rich gas 100. The third oxygen feed line 320 is also provided with a flow control device 315, such as a control valve. The reactor 10 is provided with a second recycling conduit 97, which connects the exhaust gas conduit 45 to the second gas mixing unit 310 of the feed system 300 for secondary oxidant. The second recycling conduit 97 is provided with a recycling blower 98, or the like. According to a first embodiment of the invention, the oxycombustion circulating fluidized bed reactor 10 is operated for combustion of fuel as is described in the following. The product gas from the combustion of carbonaceous fuel, consisting mainly of CO₂ and H₂O, is at least partly recycled back to the reactor chamber 15, so that after a start-up phase, instead of air, the reactor 10 may be operated with a mixture of the product gas and oxygen. This way, the presence of nitrogen is avoided, and recovery of CO₂ from the exhaust gases may be arranged more easily.

0051 The product gas is fed through the recycling conduit 95 to the first gas mixing unit 75, in which oxygen or oxygen rich gas is mixed therein, and the mixture is introduced through the first gas feeding system 70 to the windbox chamber 52. The pressure in the wind box chamber 52 is maintained at a predetermined level. This results in substantially even gas flow through the grid 55 into the reactor chamber 15. The flow control device 77 in the first oxygen feed line 76 is controlled to maintain the oxygen content in the gas in the wind box chamber 52 at a first predetermined level. In the first embodiment, this is about 21 to about 28 vol.-%, that is, only slightly above the oxygen content of the air. The oxygen content in the wind box chamber 52 preferably is adjusted such that a risk of self-ignition of any combustible material present in the wind box chamber 52 is minimized. This also practically eliminates the need for special materials required by high-temperature and high-oxygen content circumstances. This way, the operation of the reactor 10 is reliable and safe, and the construction of the first gas feeding system 70 may be of conventional materials.

0052 The second gas feeding system 80 is utilized so that the gas in the second gas feeding system 80 is introduced in the vicinity of at least one nozzle inlet 62 into the gas flow from the windbox chamber 52 entering the inlet 62. The flow control device 81 in the second oxygen feed line 83 is controlled to maintain the oxygen content in the gas at a second predetermined level, which is higher than the first predetermined level. This way, the oxygen content of the gas fed through the grid 55 is increased, while the gas is flowing through the grid nozzles 60.

0053 The gas fed through the second feeding system 80 has an oxygen content of more than 90\%. Preferably, the gas is substantially pure oxygen.

0054 A separately controlled stream of substantially pure oxygen is fed through the second gas feeding system 80. The arrangement is designed so that, besides oxygen, an oxidant mixture from the windbox chamber 52 is also entrained into the nozzles 60. The mixing of the oxygen fed through the feed pipes 84 to the oxidant (recycled exhaust gas and added oxygen) begins immediately, and substantially, the entirety of each of the nozzles 60 is utilized for the mixing. This way, the internal construction of the nozzles 60 can be made simple, thus decreasing, for example, the risk of clogging of the nozzles 60.

0055 The grid nozzles 60 are preferably made of alloys resistant for an oxygen environment and also may be internally coated with appropriate materials. The fairly high gas velocities inside the nozzles 60 keep the surfaces clean of impurities. Even if ignition were to occur locally, the amount of generated heat remains low, and damage is minimized. The feed pipes 84 can be installed for only part of the grid nozzles 60, or all of them, depending, e.g., on the oxygen needs.

0056 The distribution manifold 82, in which a plurality of feed pipes 84 is arranged below the grid nozzle inlets 62, is very flexible, in practice. The present invention also can be applied in retrofit applications, in oxy-ready concepts with later installation of the second feeding system 80, in dual firing, and also, high-O₂ boiler concepts.

0057 Thus, according to an embodiment of the invention, a method of upgrading an existing circulating fluidized bed reactor having a wind box chamber provided with nozzles and a first gas feeding system for feeding gas to the wind box chamber comprises steps of arranging a second gas feeding system 80 having a plurality of feed pipes 84 below the grid nozzle inlets 62 in the wind box chamber of the existing circulating fluidized bed reactor. Preferably, the feed pipes 84 are arranged in the vicinity of a group of the nozzles 60 in the grid 55. The number of nozzles 60 belonging to the above-mentioned group of nozzles 60 is determined based on the process issues in question.

0058 Additionally, the first gas feeding system 70 and the second gas feeding system 80 are connected to a source of oxygen-rich gas.

0059 With a further modification of the method, the existing circulating fluidized bed reactor is provided with exhaust gas recycling conduit 45 connecting the exhaust gas conduit 45 to the wind box chamber 52. This makes it possible to provide an oxycombustion circulating fluidized bed reactor in which exhaust gas may be re-circulated back to the reactor chamber, and, in which, oxygen is brought into the circulating exhaust gas, while it enters into the grid nozzles 60.

0060 In an oxycombustion mode, the density of the oxidant may be 20-25\% higher than the density of air, which affects the pressure drop at similar velocities. The pressure drop across the grid 55 can be controlled by leading a portion of the primary oxidant stream to upper primary oxidant nozzles.

0061 Feeding different oxidant compositions through different feed points, e.g., primary, upper primary level, secondary and tertiary feed points, provides an opportunity to control the temperature (and velocity and solids density) profiles in the furnace of the reactor chamber. This enables, for instance, adjustment of the temperature in the lower bed area, which is optimal for sulfur capture with limestone.

0062 Depending on the concept, the average O₂ concentration of the oxidant (recycled gas) may be even considerably high (e.g., 60\%).

0063 Hence, the O₂ concentration in the windbox can be kept below the level considered to be acceptable regarding self-ignition of any impurities in the windbox, taking into account safety margins. A separately controlled stream of substantially pure oxygen is fed through feed pipes 84
installed inside the windbox and provided with simple nozzles that discharge at the lower end of normal grid nozzles. [0064] The total flow rate of the gas introduced through the grid 55 is regulated based on the load of the oxycombustion circulating fluidized bed reactor and/or a predetermined requirement of the amount of fluidization gas flow rate. The amount of oxygen introduced through the second gas feeding system 80 is regulated based on a predetermined target value of oxygen content of the gas introduced into the reactor.

[0065] FIG. 4 shows another embodiment of detail II shown in FIG. 1. In this embodiment, the manifold 82 is a space formed by a wall 482 arranged below the grid 55 and substantially vertically at the nozzle inlet 62, which is extending downwards from the lower plane of the grid 55. The wall 482 is provided with openings forming a slot-like outlet 85 with the periphery of the inlet 62.

[0066] FIG. 5 shows still another embodiment of detail II shown in FIG. 1. In this embodiment, the manifold 82 is formed of a set of separate chambers 582 arranged below the grid 55 and substantially vertically at the nozzle inlet 62, extending downwards from the lower plane of the grid 55. Each chamber 582 is provided with an opening forming a slot-like outlet 85, with the periphery of the inlet 62. The chambers 582 are provided with a through-hole 538 corresponding to the size of the inlet 62, the outlet 85 being arranged at the side of the hole 538 that is closest to the inlet 62.

[0067] FIG. 6 shows a modification of the arrangement shown in FIG. 2, in which the feed pipe is a simple orifice 84, which has an outlet 85, and the outlet is arranged to open into the vicinity of the nozzle inlet 62. The gas flow jet is arranged to reach the inlet nozzle 62, as depicted by the arrow.

[0068] 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. The details mentioned in connection with any embodiment above may be used in another embodiment when technically feasible.

1. An oxycombustion circulating fluidized bed reactor comprising:
   a reactor chamber; and
   a gas distribution arrangement provided in the bottom section of the reactor chamber for introducing gas into the reactor chamber, the gas distributor arrangement comprising (i) a windbox chamber having gas introduction nozzles, the gas introduction nozzles being arranged for introducing gas from the windbox chamber into the reactor chamber and having respective inlets that open into the windbox chamber, (ii) a first gas feeding system for introducing gas into the windbox chamber, and (iii) a second gas feeding system for introducing gas into the windbox chamber in the vicinity of at least one nozzle inlet.

2. An oxycombustion circulating fluidized bed reactor according to claim 1, wherein the second gas feeding system comprises a number of outlets, each of the outlets being arranged to direct the gas to be fed towards a nozzle inlet.

3. An oxycombustion circulating fluidized bed reactor according to claim 2, wherein the outlets are arranged to direct the gas into the nozzle inlet.

4. An oxycombustion circulating fluidized bed reactor according to claim 2, wherein the outlets are arranged at a distance below the nozzle inlet.

5. An oxycombustion circulating fluidized bed reactor according to claim 2, wherein the outlet and the inlet provide an ejector effect.

6. An oxycombustion circulating fluidized bed reactor according to claim 1, wherein the reactor chamber includes a particle separator for separating fluidized particles which are entrained with gases that result from the reactions taking place in the reaction chamber.

7-16. (canceled)

17. An oxycombustion circulating fluidized bed reactor according to claim 6, wherein the particle separator is provided with a gas outlet and an outlet for separated particles.

18. An oxycombustion circulating fluidized bed reactor according to claim 17, wherein the gas outlet is arranged in flow communication with the first gas feeding system via a recycling conduit.

19. An oxycombustion circulating fluidized bed reactor according to claim 18, wherein the recycling conduit includes a gas mixing unit.

20. An oxycombustion circulating fluidized bed reactor according to claim 6, wherein the gas mixing unit is in flow communication with a source of oxygen-rich gas.

21. An oxycombustion circulating fluidized bed reactor according to claim 19, wherein the gas mixing unit is in flow communication with a source of oxygen-rich gas.

22. A method of operating an oxycombustion circulating fluidized bed reactor that has a reactor chamber and a gas distribution arrangement provided in the bottom section of the reactor chamber, the method comprising:
   introducing gas into a windbox chamber, having gas introduction nozzles with respective inlets, through a first gas feeding system;
   introducing gas into the reaction chamber through the windbox chamber; and
   introducing a stream of oxygen-rich gas through a second feeding system into the vicinity of the inlet of at least one nozzle in the windbox chamber.

23. A method of operating an oxycombustion circulating fluidized bed reactor according to claim 22, further comprising introducing the stream of oxygen-rich gas from a distance towards the inlet of at least one nozzle through an outlet in the second gas feeding system.

24. A method of operating an oxycombustion circulating fluidized bed reactor according to claim 22, further comprising introducing gas containing more than 90% of oxygen into the vicinity of the inlet of at least one nozzle through the second gas feeding system.

25. A method of operating an oxycombustion circulating fluidized bed reactor according to claim 24, further comprising introducing a mixture of recycled exhaust gas and oxygen through the first gas feeding system to the windbox chamber.

26. A method of operating an oxycombustion circulating fluidized bed reactor according to claim 25, further comprising mixing the stream of oxygen-rich gas with the gas introduced through the first gas feeding system to the windbox chamber.

27. A method of operating an oxycombustion circulating fluidized bed reactor according to claim 26, wherein the stream of oxygen-rich gas induces an ejector effect to the gas in the windbox chamber.
28. A method of upgrading an existing circulating fluidized bed reactor having a windbox chamber provided with nozzles and a first gas feeding system for feeding gas to the windbox chamber, the method comprising steps of:

arranging a second gas feeding system having a plurality of feed pipes below inlets of the nozzles into the windbox chamber of the existing circulating fluidized bed reactor; and

arranging a source of oxygen-rich gas in connection with the second gas feeding system.

29. A method of upgrading an existing circulating fluidized bed reactor according to claim 28, further comprising providing the existing circulating fluidized bed reactor with an exhaust gas recycling conduit that connects the exhaust gas conduit to the windbox chamber of the reactor.

30. A method of upgrading an existing circulating fluidized bed reactor according to claim 29, further comprising feeding the source of oxygen-rich gas to the first gas feeding system.