

(51) International Patent Classification:
F23C 9/08 (2006.01) *F23L 7/00* (2006.01)(21) International Application Number:
PCT/EP2009/063456(22) International Filing Date:
15 October 2009 (15.10.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
08167521.7 24 October 2008 (24.10.2008) EP(71) Applicant (for all designated States except US): **L'AIR LIQUIDE SOCIETE ANONYME POUR L'ETUDE ET L'EXPLOITATION DES PROCEDES GEORGES CLAUDE** [FR/FR]; 75 Quai d'Orsay, F-75007 Paris (FR).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **SANCHEZ-MOLINERO, Ivan** [ES/FR]; 16, rue Saint-Louis, F-78000 Versailles (FR). **TSIAVA, Rémi** [FR/FR]; 71 rue André Breton, F-91250 Saint Germain Les Corbeil (FR). **LAURENT, Jacky** [FR/FR]; 5, rue du Clos de la Fontaine, F-78210 Saint Cyr L'ecole (FR). **MULON, Jacques** [FR/FR]; 1, Bld de la Paix, F-91300 Massy (FR). **PAUBEL, Xavier** [FR/FR]; 51, Avenue Jean Jaurès, F-92290 Chateaufort (FR). **RECOURT, Patrick** [FR/FR]; 5, rue Toulouse Lautrec, F-91460 Marcoussis (FR).(74) Agent: **CONAN, Philippe**; L'air Liquide S.A., Direction de la Propriété Intellectuelle, 75 Quai d'Orsay, F-75321 Paris Cedex 07 (FR).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- with amended claims (Art. 19(1))

(54) Title: METHOD FOR INJECTING BALLAST INTO AN OXYCOMBUSTION BOILER

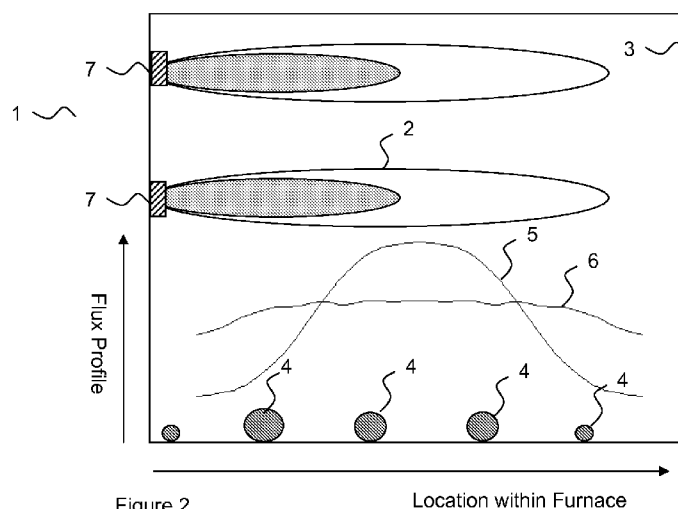


Figure 2

Location within Furnace

(57) Abstract: Method for operating an oxycombustion boiler comprising a combustion chamber (1) and at least one burner (7), said method comprising the following steps: feeding at least one fuel stream and at least one oxidant stream essentially devoid of nitrogen to said burner, said fuel being combusted in said combustion chamber to produce at least one flame (2) and flue gas; and passing into said combustion chamber a plurality of gas streams (5) wherein at least one of said gas streams is not fed to said burner and has a swirl rate between 0.05 and 5, preferably between 0.26 and 1.73.

Method for Injecting Ballast into an Oxycombustion Boiler

The present invention relates to a method for injecting fuel, oxidant and ballast into an oxycombustion boiler.

5

In an oxycombustion boiler, in which fuel, oxidant and ballast are injected, it is possible to separate a portion of the ballast in order to introduce it into the boiler at different locations from the burner, or combustion chamber jet. By using a suitable injection arrangement of this type, a number of beneficial effects may be achieved. The profile of the heat transfer flux to the walls of the boiler is smoother and a "gas curtain" is created around the flame so as to spread the heat release along the combustion chamber. This 'gas curtain' is not to be confused with 'sweep gas' which is typically used for protecting flame detectors, out of service injectors, probes, etc. The 'gas curtain' protects the furnace tubes from direct contact with the flame. Greater physical separation of the fuel and oxidant injection compared with the ballast is obtained, thus allowing more direct contact between fuel and oxidant for better combustion of difficult fuels. The ballast may consist of recycled flue gases (whether cold or not), with the advantage of having flame radiation absorption properties with respect to the predominant gases CO_2 and H_2O , or other gases or gas mixtures.

20

There are existing schemes that recycle ballast into various locations within a boiler. There exist systems using recycle injection into the burner or windbox; recycle injection into furnaces; recycle injection into the burner; and recycle, recreating a synthetic air (mixture of oxygen and recycle flue gases). This flue gas recycle is usually performed by separating one part of the main flue gas stream exiting a boiler, and redirecting it towards the boiler through appropriate ducts and impelled generally with a fan or a suction device, known to the skilled in the art.

25

There are also existing schemes in which nitrogen is injected in a boiler separately from oxygen (as such described in EP 1 517 085 A2), so as to create either nitrogen-poor or nitrogen rich atmospheres for the purpose of controlling NO_x emissions. The shielding gas is meant to be essentially devoid of nitrogen, as this invention is directed toward oxy-combustion in boilers. The goal of this oxy-combustion in boilers is to produce an exhaust stream enriched in CO_2 , and thereby facilitating CO_2 capture. Typical examples of shielding gas envisaged in the present invention are therefore flue gas recycle from oxy-combustion (composed mainly of CO_2 and H_2O), dried flue gas recycle from oxy-combustion (composed mainly of CO_2 , after condensation of moisture) or steam.

30
35

There are other boiler schemes in which Over Fire Air (OFA) is injected separately from the burners to reduce NO_x emissions. This should divide the incorporation of oxidant into the boiler so as to create at the burners a fuel-rich primary zone, while the rest of the oxidant is added at this OFA ports for achieving a complete combustion at a so-called burnout zone. An example is shown in the patent US 5626085 A. Thermal gas shielding of regions within the boiler is at issue, and not injections for affecting chemically the flame and the combustion phenomena.

Document WO2006/054990 discloses a method for injecting recycled flue gas into an oxy-boiler to temper the combustion temperature or to provide adequate dispersion of gases. Recycled flue gas is injected through the burners used as nozzles or at the fuel source. With this method the protection of the combustion chamber walls against high heat fluxes is not very efficient.

Document US-B-6422160 discloses an apparatus for the combustion of vanadium containing fuels. In order to prevent deposition of slag on the boundary walls of the waste heat boiler, recirculated flue gas is blown through nozzles which are formed concentrically around the exit opening of the boiler. The method provides a solution to limit slag deposit in some areas of the boiler but does not allow an efficient thermal protection of its combustion chamber walls.

There is a need for a method to efficiently protect the walls of a boiler combustion chamber where oxy-combustion is performed, since the combustion temperature and heat fluxes towards the walls and the heat exchangers of the boiler can be very high.

25

To that end, the invention provides a Method for operating an oxycombustion boiler comprising a combustion chamber and at least one burner, said method comprising the following steps:

- feeding at least one fuel stream and at least one oxidant stream essentially devoid of nitrogen to said burner, said fuel being combusted in said combustion chamber to produce at least one flame and flue gas; and
- passing into said combustion chamber a plurality of gas streams wherein at least one of said gas streams is not fed to said burner and has a swirl rate between 0.05 and 5, preferably between 0.26 and 1.73.

35

Said gas streams are also referred to as “shielding gas streams” or “ballast streams” in the present application.

An oxycombustion boiler generally uses an oxygen enriched gas as oxidizer. This gas usually contains between 90% and 100% of oxygen in volume. In the context of the invention, "combustion chamber" means the internal part of the boiler where hot gases circulate, that is to say where combustion occurs as well as downstream of the combustion zone, where heat exchangers are usually located. A burner is a device, usually including tubes or nozzles, used to inject the fuel(s) and/or the oxidizer(s) into the combustion chamber. Some ballast may also be injected via the burners.

The shielding gas streams are injected such that at least one of the shielding gas streams has a swirl rate between 0.05 and 5, preferably between 0.26 and 1.73. This swirl rate is defined as I_t over I_a , I_t and I_a being respectively tangential and axial impulsions of the fluid rotated in the stream. The axial direction is relative to the ballast injection mean. For example if the ballast injection shows an axis symmetry, the axial axis is the symmetry axis. Impulsions are measured when the fluid enters the combustion chamber. The bigger the swirl rate, the more intense the fluid rotation in the gas stream. The swirl can be obtained using deflectors, fins or riffled tubes at the injection point of said gas streams, or any method known to the skilled in the art. Also, at least one of said gas streams is not injected in the combustion chamber via an active burner, that is to say at least one of said gas streams is injected in the combustion chamber at a certain distance of any burner used to inject fuels and/or oxidizers participating in the combustion.

When the present invention is to be used for combustion with air as oxidant, for example at transient conditions for the oxy-boiler or at start-up of the oxy-boiler, a shielding gas stream may also be composed of flue gas recycle, but in such a case this stream would contain a non-negligible content of nitrogen (over 50% in volume). In other embodiment for this usage of air as oxidant, a shielding gas stream may even be air, which for efficiency reasons can be previously heated.

The present invention utilizes the separation of ballast injection into the furnace from the oxygen injection into the burner. There may be an arrangement of the ballast injection into the boiler according to the flux profile. There may be the creation of a gaseous ballast offset, to ensure separation between the flame and the walls of the boiler. There may be the control of the burner ballast/boiler ballast injection ratio according to the various operating parameters (fuel characteristics, boiler operating conditions, temperature levels in the chamber, etc.). The flow of injected ballast (coming from the ratio of burner injection to boiler chamber injection) and the distribution of these injections will be different, depending on the desired effect.

The method according to the invention may comprise one or several of the following characteristics:

- 5 - at least one of said gas streams enters said combustion chamber in a zone that is separate from said burner by a distance of at least 0.25 meter, preferably at least 0.5 meter, and more preferably at least 1 meter. The injection zone of at least one of said gas streams is a surface of which any point is at a minimum distance of any burner used to inject fuels and/or oxidizers participating in the combustion. The minimum distance is 0.25 meter, preferably 0.5 meter, and more preferably 1 meter.
- 10 - at least one of said gas streams enters said combustion chamber in a zone where the surface heat flux is greater than 100 kW/square meter, preferably greater than 300 kW/square meter. The surface heat flux is defined as the total heat flux received by a surface unit of wall. In the combustion chamber, the heat flux is mostly due to
15 electromagnetic radiation near the flame and mostly due to convection in the downstream area. Conduction may also contribute to the total flux.
- 20 - said gas streams are injected in a direction vertically parallel with and substantially adjacent to the walls of said combustion chamber.
- 25 - said gas streams are injected in a direction substantially perpendicular to the direction of said flame.
- 30 - said gas streams are injected in a direction substantially parallel to the direction of said flame.
- 35 - said gas streams are injected in a direction substantially convergent to said flame.
- The method of any of the above claims, wherein said gas streams comprises gas recycled from said flue gas.
- said gas streams passed into said combustion chamber vibrate at least one frequency and wherein said boiler vibrate with at least one natural frequency, the ratio between the lowest frequency created by any of said gas streams and the lowest natural frequency of said boiler being comprised between 0 and 0.95 or between 1.05 and 100, and preferably between 0 and 0.6 or between 1.3 and 5.

- said gas streams injection is controlled by measuring the amplitude of vibrations at a location of said boiler selected from the group consisting of burners, boiler walls, heat exchangers, ducts, stack, or fans.

5 In one embodiment of the present invention the ballast streams are injected vertically parallel with and substantially adjacent to the walls of the combustion chamber in a substantially downward direction. In one embodiment of the present invention the ballast streams are injected vertically parallel with and substantially adjacent to the walls of the combustion chamber in a substantially upward direction. In one embodiment of the present invention the ballast streams are injected horizontally parallel and substantially adjacent to the floor of the combustion chamber. In one embodiment of the present invention the ballast streams are injected horizontally parallel and substantially adjacent to the ceiling of the combustion chamber. In one embodiment of the present invention system data is provided to a control system, and the control system then controls the injection of the ballast streams. 10 The system data may be fuel type, fuel characteristics, boiler operating conditions, exiting flue gas composition, or exiting flue gas temperature. Ballast injection streams rate and distribution can vary as well with boiler load.

In one embodiment of the present invention sensors are mounted in the walls of the combustion chamber. These sensors provide input to a control system. The control system then controls the injection of the ballast streams. The sensors may measure wall temperature, tube skin temperature, water wall fluid temperature, tube fluid temperature, furnace gas temperature, heat flux into the furnace wall, heat flux into the tubes or heat flux into the water walls. 20

25 The ballast injection regulation is designed within this context on the flow rate and as a function of the flux measurements on the walls, but it may also take place as a function of the tube skin temperatures, or overall parameters such as the incoming power or the boiler combustion temperature outlet temperature, once the typical flux profile has been established for a combustion chamber configuration and a burner design. 30

In another embodiment of the present invention, a gaseous offset may also be produced. This offset may be envisaged either for protecting the walls of the boiler from direct contact of the end of the flame (impingement) or for protecting them from lateral contact of the flame. Direct contact of the flame on the walls has devastating effects on the integrity of the metal tubes that make up the walls of the chamber in usual boiler configurations. The points of possible impingement can be predicted in advance, thereby facilitating the arrangement of the injections into the boiler. As indicated in Figure 2, in 35

order to avoid lateral contact of the flames on the tubes, the ballast gas may be injected in parallel with the walls. This configuration may profit from the flux smoothing effect described above. As indicated in Figure 3, in order to avoid direct contact of the flames, which is more probable and at the same time the most damaging, which has the greatest chance of occurring at the end of the flame, the ballast may be injected along the back wall of the furnace.

The ratio of ballast injected in the burners over the ballast injected into the furnace, may depend on a number of operational criteria. This ratio may depend on the fuel characteristics. For example, with a difficult fuel (i.e. pitch difficult to atomize, wet fuels, fuels with a high content of incombustibles, fuels of a dangerous nature, etc.): the ballast injection ratio will be predominantly transferred towards the boiler, in order to allow and oxidant-rich combustion close to the burner. For a fuel with a high nitrogen content: to promote reaction mechanisms that reduce NO_x formation, the ballast injection ratio will be displaced towards the burners, so as to create fuel-rich conditions at the flame. This ratio can also vary with boiler load, with a ratio displaced towards the boiler, in order to allow oxygen-rich conditions close to the burner to improve flame stability at low boiler load. Combined to this, the ratio may depend on operating conditions such as tube skin temperature, maximum flux measurement, and other operational criteria known to the skilled artisan.

In one embodiment of the present invention a large amount of ballast gas may be injected with two operating positions (e.g. on/off), with the advantage of a simplified process and a simplified control scheme, and with the disadvantage of increased implementation complexity, potential flexibility issues, and the associated pressure drop through the system. In another embodiment of the present invention, a lesser amount of ballast gas injection may incorporate a flow rate regulation in order to end up with the desired flux smoothing performance, with the advantage of greater control and more predictable results, and the disadvantage of a more complex process and a more complex control scheme.

The region where gas streams are passed into is selected from the group consisting of:

- the combustion chamber,
- a zone within the combustion chamber of predominantly radiant heat transfer,
- a zone within the combustion chamber of maximum heat flux,
- a zone within the combustion chamber where the heat flux exceeds a predetermined value,

- a zone within the combustion chamber where the flue gas temperature is at a maximum, and
- a zone within the combustion chamber where the flue gas temperature exceeds a predetermined value.

5

Elements to be protected can be selected from the group consisting of:

- the walls of the combustion chamber,
- the sides of the combustion chamber,
- heat transfer elements positioned within the combustion chamber,
- 10 • heat transfer elements positioned within a zone of predominantly radiant heat transfer within the combustion chamber, and
- the boiler elements in contact with the flue gas.

15 The shielding gas streams may be located, oriented, and controlled such that the shielding gas is injected vertically parallel with and substantially adjacent to the walls of the combustion chamber. The shielding gas streams may be located, oriented, and controlled such that the shielding gas is injected vertically parallel with and substantially adjacent to the heat transfer elements positioned within the combustion chamber. In the present invention the ballast streams may be located, oriented, and controlled such that the shielding
20 gas is injected horizontally parallel and substantially adjacent to the heat transfer elements positioned within the combustion chamber. The ballast streams may be located, oriented, and controlled such that the shielding gas is injected horizontally parallel and substantially adjacent to the heat transfer elements positioned within the combustion chamber.

25 The shielding gas streams may be located, oriented, and controlled such that the shielding gas is injected vertically parallel with and substantially adjacent to one or more zones within the combustion chamber where the heat flux exceeds a predetermined value. The shielding gas streams may be located, oriented, and controlled such that the shielding gas is injected in a direction substantially parallel to the direction of the combustion
30 chamber jet.

The shielding gas streams may be located, oriented, and controlled such that the shielding gas is injected in a direction substantially perpendicular to the direction of the combustion chamber jet. The shielding gas streams may be located, oriented, and
35 controlled such that the shielding gas is injected in a direction substantially convergent to the direction of the combustion chamber jet. The feeding ports for the shielding gas streams into the combustion chamber may be located more than 1 meter away from the burner jet.

The invention may further comprise:

- providing system data into a control system,
- controlling the injection of the shielding gas streams with this control system.

5 The system data may be selected from the group consisting of:

- fuel type,
- fuel characteristics,
- fuel flows,
- oxidant characteristics,
- 10 • oxidant flows,
- ballast gas characteristics to the burners,
- ballast gas flows to the burners,
- boiler operating conditions,
- exiting flue gas composition, and
- 15 • exiting flue gas temperature.

The present invention may further comprise:

- mounting sensors in or on the elements of the combustion chamber,
- inputting the output of the sensors into a control system,
- 20 • controlling the injection of the shielding gas streams with this control system.

The sensors may measure a variable selected from the group consisting of wall temperature, tube skin temperature, water wall fluid temperature, tube fluid temperature, furnace gas temperature, and heat flux. The shielding gas may comprise recycled flue gas.

25 The totality of injection of recycled flue gas into the boiler may be in the form of shielding gas.

The total injection of recycled flue gas into the boiler may be shared among ballast gas injected at the burners level and in the form of shielding gas. The ballast gas injected at the
30 burners level may be injected separately to an oxidant stream. The ballast gas injected at the burners level may be injected after being mixed with an oxidant stream.

The shielding gas streams passing into the combustion chamber region may comprise at least one frequency with an amplitude of vibration, and wherein the boiler system comprises
35 at least one natural frequency. The ratio between the lowest frequency created by at least one of the shielding gas injections and the lowest natural frequency of the boiler system may be comprised between 0 and 0.95 or between 1.05 and 100, and preferably between 0 and 0.6 or between 1.3 and 5.

The flow of the different shielding gas injections may be controlled by the measure of the amplitude of the vibration at a location of the oxy-boiler selected from the group consisting of:

- burners,
- oxy-boiler walls,
- heat exchangers,
- ducts,
- stack,
- fans.

The shielding gas streams may have a controlled composition. The shielding gas streams may have undergone a clean-up treatment before injection. The shielding gas streams may have undergone a partial clean-up treatment before injection, aiming specifically at reducing the concentration of certain components. The shielding gas streams may have undergone a partial clean-up treatment before injection, aiming specifically at reducing the concentration of corrosive components. The shielding gas streams may have undergone a total or partial drying, so as to reduce the moisture content of these streams.

The shielding gas streams may be injected at temperatures between about -50°C to about 1500°C , preferably between about 100°C and about 250°C . The shielding gas streams may be injected at ambient temperature. The shielding gas streams may have undergone thermal exchange against other fluids before injection. The shielding gas streams may have undergone pre-heating before injection. The shielding gas streams may be injected at different temperature levels at each injection point.

Other features and advantages of the invention will appear from a reading of the description that follows. Embodiments of the invention are provided as non-limiting examples.

Figure 1 a schematic representation of the variation in heat flux experienced within the side walls of a furnace of a typical boiler as a function of flame profile.

Figure 2 is a schematic representation of the variation in heat flux within the side walls of furnace of a typical boiler, as a function of flame profile, as modified by one embodiment of the present invention.

Figure 3 is a schematic representation one aspect of the present invention.

Turning now to Figure 1, one aspect of the present invention results in the smoothing, levelling or flattening of the flux profile 5 on the walls 3 of the combustion chamber. As may be seen in the figure, the transfer profile 5 corresponding to an oxygen flame has a

non-uniform shape. For an oxygen flame 2, the main component of this transfer is radiation, owing to the high flame core temperature and above all the gases that predominantly make up the oxycombustion flue gases, namely CO₂ and H₂O, radiating at high temperature. The non-homogeneous temperature distribution along the length of the flame 2 results in a non-uniform heat flux 5 along the corresponding length of the furnace wall. This results in non-linear heat transfer issues, potential concerns about furnace wall (or tube wall) temperatures and other problems regarding localized excessive temperature concentrations.

As indicated in Figure 2, the proposed way of making this flux more uniform is to inject the ballast 4 along the side of the flame 2, along the side of the walls 3 that would ordinarily be absorbing this heat, so as to effectively create a gas curtain. This ballast gas curtain may contain gases that are not transparent to the radiation (i.e. CO₂, H₂O, coming for example from a flue gas recycle), and therefore absorb the radiation 5 of the flame 2 due to the fact of being comparatively cooler. In one embodiment of the current invention, a greater ballast 4 may be injected near the transfer peak to allow the height of the transfer peak to be reduced.

In Figure 3, gas streams 4 are injected parallel to the wall opposite to the fuel and oxidant streams injection, so as to protect heat exchangers of the boiler.

The advantages brought by the invention include:

- the creation of a gaseous ballast offset , to ensure efficient protection of the walls of the boiler combustion chamber and internal elements ;
- the control of the burner ballast / boiler ballast injection ratio according to the various operating parameters (fuel type, operating conditions, temperature levels in the chamber, etc.).

CLAIMS

1. Method for operating an oxycombustion boiler comprising a combustion chamber (1) and at least one burner (7), said method comprising the following steps:
 - 5 - feeding at least one fuel stream and at least one oxidant stream essentially devoid of nitrogen to said burner (7), said fuel being combusted in said combustion chamber (1) to produce at least one flame (2) and flue gas; and
 - passing into said combustion chamber (1) a plurality of gas streams (4) wherein at least one of said gas streams (4) is not fed to said burner (7) and has a swirl rate
10 between 0.05 and 5, preferably between 0.26 and 1.73.
2. The method of claim 1, wherein at least one of said gas streams (4) enters said combustion chamber (1) in a zone that is separate from said burner (7) by a distance of at least 0.25 meter, preferably at least 0.5 meter, and more preferably at least 1 meter.
15
3. The method of claims 1 or 2, wherein at least one of said gas streams (4) enters said combustion chamber (1) in a zone where the surface heat flux is greater than 100 kW/square meter, preferably greater than 300 kW/square meter.
- 20 4. The method of any of claims 1 or 3, wherein said gas streams (4) are injected in a direction vertically parallel with and substantially adjacent to the walls (3) of said combustion chamber.
5. The method of any of claims 1 to 3, wherein said gas streams (4) are injected in a
25 direction substantially perpendicular to the direction of said flame (2).
6. The method of any of claims 1 to 3, wherein said gas streams (4) are injected in a direction substantially parallel to the direction of said flame (2).
- 30 7. The method of any of claims 1 to 3, wherein said gas streams (4) are injected in a direction substantially convergent to said flame (2).
8. The method of any of the above claims, wherein said gas streams (4) comprises gas recycled from said flue gas.
35
9. The method of any of the above claims, wherein said gas streams (4) passed into said combustion chamber (1) vibrate at least one frequency and wherein said boiler vibrate with at least one natural frequency, the ratio between the lowest frequency created by any of said

gas streams (4) and the lowest natural frequency of said boiler being comprised between 0 and 0.95 or between 1.05 and 100, and preferably between 0 and 0.6 or between 1.3 and 5.

10. The method of claim 9, wherein said gas streams (4) injection is controlled by measuring the amplitude of vibrations at a location of said boiler selected from the group consisting of burners, boiler walls, heat exchangers, ducts, stack, or fans.

AMENDED CLAIMS
received by the International Bureau on
21 December 2009 (21.12.2009)

CLAIMS

1. Method for operating an oxycombustion boiler comprising a combustion chamber (1) and at least one burner (7), said method comprising the following steps:
 - 5 - feeding at least one fuel stream and at least one oxidant stream essentially devoid of nitrogen to said burner (7), said fuel being combusted in said combustion chamber (1) to produce at least one flame (2) and flue gas; and
 - passing into said combustion chamber (1) a plurality of gas streams (4) wherein at least one of said gas streams (4) is not fed to said burner (7) and has a swirl rate
10 between 0.05 and 5, preferably between 0.26 and 1.73.
2. The method of claim 1, wherein at least one of said gas streams (4) enters said combustion chamber (1) in a zone that is separate from said burner (7) by a distance of at least 0.25 meter, preferably at least 0.5 meter, and more preferably at least 1 meter.
15
3. The method of claims 1 or 2, wherein at least one of said gas streams (4) enters said combustion chamber (1) in a zone where the surface heat flux is greater than 100 kW/square meter, preferably greater than 300 kW/square meter.
- 20 4. The method of any of claims 1 to 3, wherein said gas streams (4) are injected in a direction vertically parallel with and substantially adjacent to the walls (3) of said combustion chamber.
5. The method of any of claims 1 to 3, wherein said gas streams (4) are injected in a
25 direction substantially perpendicular to the direction of said flame (2).
6. The method of any of claims 1 to 3, wherein said gas streams (4) are injected in a direction substantially parallel to the direction of said flame (2).
- 30 7. The method of any of claims 1 to 3, wherein said gas streams (4) are injected in a direction substantially convergent to said flame (2).
8. The method of any of the above claims, wherein said gas streams (4) comprises gas recycled from said flue gas.
35
9. The method of any of the above claims, wherein said gas streams (4) passed into said combustion chamber (1) vibrate at least one frequency and wherein said boiler vibrate with at least one natural frequency, the ratio between the lowest frequency created by any of said

gas streams (4) and the lowest natural frequency of said boiler being comprised between 0 and 0.95 or between 1.05 and 100, and preferably between 0 and 0.6 or between 1.3 and 5.

10. The method of claim 9, wherein said gas streams (4) injection is controlled by measuring the amplitude of vibrations at a location of said boiler selected from the group consisting of burners, boiler walls, heat exchangers, ducts, stack, or fans.

1/2

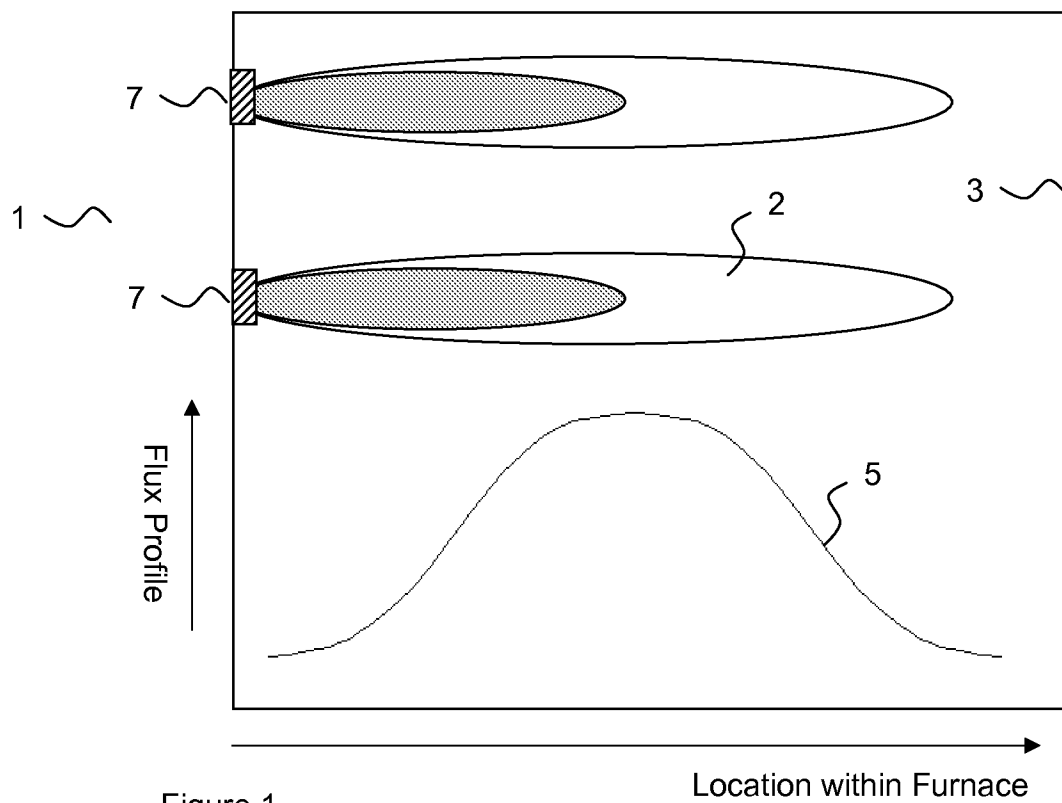


Figure 1

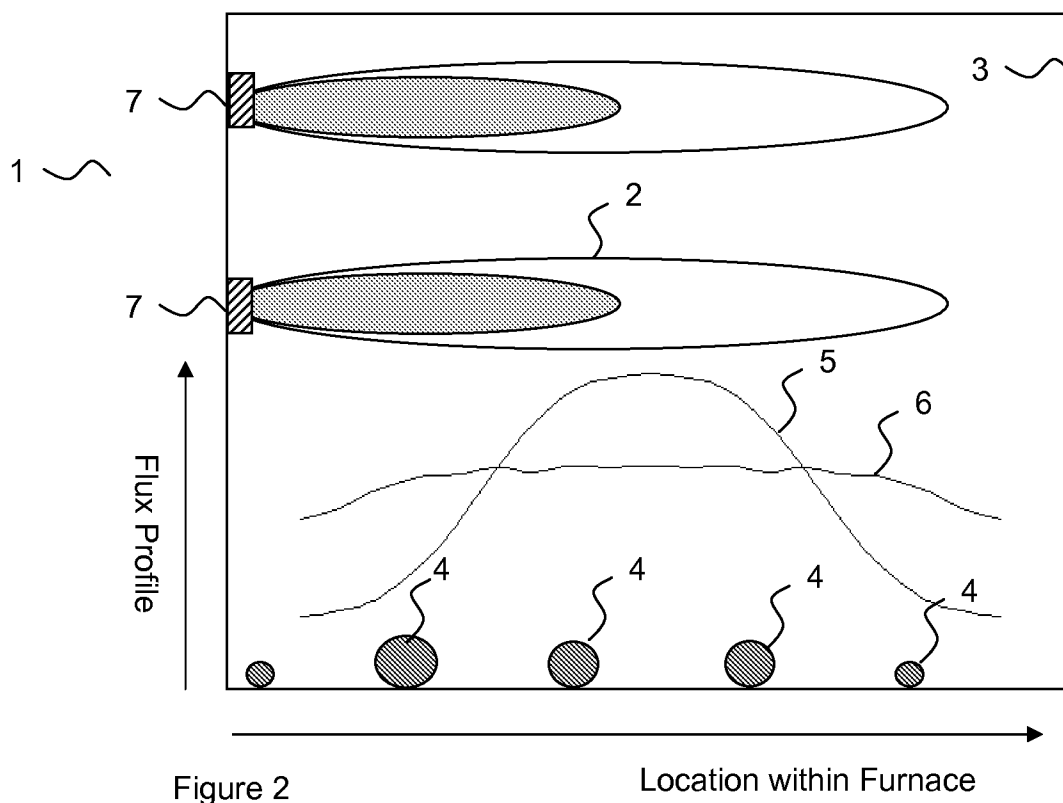


Figure 2

2/2

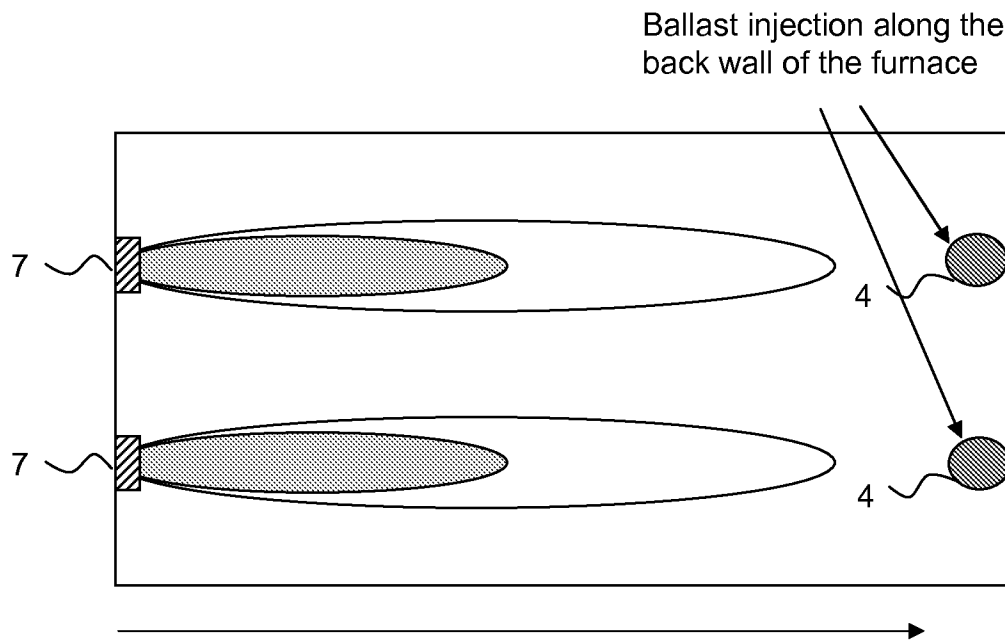


Figure 3

Location within Furnace

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2009/063456

A. CLASSIFICATION OF SUBJECT MATTER
INV. F23C9/08 F23L7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F23C F23L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2006/054990 A (JUPITER OXYGEN CORP [US]) 26 May 2006 (2006-05-26) cited in the application page 1, paragraph 1 page 6, paragraph 15 - page 7, paragraph 16 page 8, paragraph 21 - page 10, paragraph 24 page 11, paragraph 27 figure 1	1
A	US 6 422 160 B1 (WULFERT HOLGER [DE] ET AL) 23 July 2002 (2002-07-23) cited in the application column 5, line 50 - column 6, line 16; figures 5-7 ----- -/--	1



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

G document member of the same patent family

Date of the actual completion of the international search

27 November 2009

Date of mailing of the international search report

08/12/2009

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Gavriliu, Costin

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2009/063456

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 195 20 720 A1 (EVT ENERGIE & VERFAHRENSTECH [DE]) 19 December 1996 (1996-12-19) column 3, line 61 - column 4, line 48 column 5, line 28 - line 45 figures 3,5,6 -----	1
A	EP 1 580 485 A (BABCOCK HITACHI KK [JP]) 28 September 2005 (2005-09-28) column 14, line 9 - line 29 figure 9 -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2009/063456

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 2006054990	A	26-05-2006	AU 2004325009 A1 BR PI0419159 A CA 2587260 A1 CN 101056719 A EA 200701019 A1 EP 1824616 A1 JP 2008519958 T	26-05-2006 11-12-2007 26-05-2006 17-10-2007 26-10-2007 29-08-2007 12-06-2008
US 6422160	B1	23-07-2002	NONE	
DE 19520720	A1	19-12-1996	NONE	
EP 1580485	A	28-09-2005	AU 2003261754 A1 CA 2507814 A1 CN 1714256 A WO 2004053392 A1 JP 4174311 B2 JP 2004190981 A KR 20050085508 A US 2006115780 A1	30-06-2004 24-06-2004 28-12-2005 24-06-2004 29-10-2008 08-07-2004 29-08-2005 01-06-2006