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(71) Applicant *(for all designated States except US)*: **CONSIGLIO NAZIONALE DELLE RICERCHE** [IT/IT]; P.le Aldo Moro, 7, I-00185 Roma (IT).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **MICCIO, Francesco** [IT/IT]; P.le Aldo Moro, 7, I-00185 Roma (IT). **DE RICCARDIS, Andrea** [IT/IT]; P.le Aldo Moro, 7, I-00185 Roma (IT).

(74) Agents: **SARPI, Maurizio** et al.; Studio Ferrario SRL, Via Collina, 36, I-00187 - Rome (IT).

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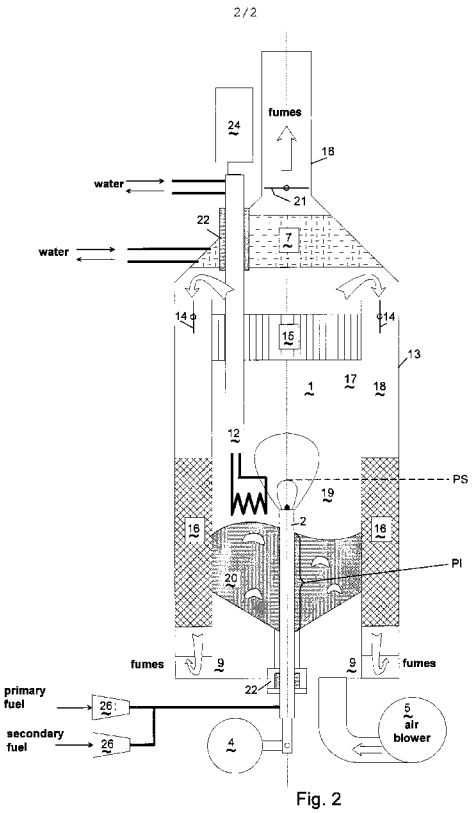

Fig. 2

(57) Abstract: A boiling- fluid-bed combustion plant with limited thermal power (example 50 kW), supplied with liquid fuel both for start-up and for continuous operation, wherein the liquid fuel is supplied through an injector (2) that can be positioned at a variable height so as to be inserted completely or only partially inside the fluid bed. This enables variation of the thermal power continuously in a range comprised at least between 40% and 100% of the nominal power, without modifying the operating temperature of the bed (20), partializing the flowrates of gas -oil and fluidization air.

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COMBUSTION FLUID-BED PLANT WHICH CAN BE FED WITH CONVENTIONAL AND ALTERNATIVE LIQUID FUELS

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DESCRIPTION

FIELD OF THE INVENTION

The present invention relates to the sector of boilers, heat generators, and heating plants and systems. More in particular, it regards a boiling-fluid-bed combustion plant having low thermal power, supplied with liquid fuel both for start-up and for continuous operation, for which the thermal power delivered varies continuously with respect to the nominal value.

In conventional boilers for residential and industrial uses supplied with liquid fuels and equipped with atomizer and burner, the power delivered cannot be varied continuously. Consequently, partialization and modulation techniques are adopted that involve transients in which operation of the boiler is not optimal either from the energy standpoint or as regards pollutant emissions. Furthermore, coupling between the burner and the boiler is optimised as a function of the average load of the boiler, and this entails significant variations of the thermal efficiency as the power delivered varies. Finally, the viscosity of the fuel used does not need to be higher than the typical values of a gas-oil, in the absence of pre-heating, to obtain high levels of atomization, consequently precluding use of oils as such of vegetable and biological origin.

Use of fluid-bed combustion systems enables the

limitations linked to continuous regulation of the power to be overcome and also enables simultaneous availability of an extremely efficient plant with low environmental impact, supplied with liquid fuels whether conventional or alternative.

It should be recalled that the fluid bed is a chamber with vertical development, in which a granular solid, for example sand, is stirred by a current of gas that traverses it by means of a distributor on which the bed is supported. Provided on top of the fluid bed is a freeboard, which enables the particles possibly entrained by the gaseous current to fall back into the bed. The high turbulence and mixing of the bed enable an ideal environment to be obtained for processes that require both transfer of material and transfer of energy, such as for example heterogeneous combustion. In this case, the bed is brought up to a moderately high temperature to enable triggering of the chemical reactions of oxidation of the fuel. The temperature is controlled easily by heat exchange with immersed surfaces and can be kept within a relatively narrow range, with major advantages in terms of efficiency of the process and limitation of pollutant and harmful species. The pollutants can be further limited thanks to the use of purposely chosen materials for the fluid bed, which have catalytic properties in addition to being mechanically resistant to abrasion.

Another advantageous characteristic of fluid-bed boilers lies in the fact that the combustion is completed in the fluid bed also in conditions of partial load or non-optimal operation of the burner on

account either of insufficient degree of atomization due to the high viscosity of the fluid or of the presence of impurities in the fuel or, yet again, of reduce atomization pressure. Furthermore, the possibility of extracting heat, not only in the convective section on the fume line, but also directly in the bed enables the temperature of the boiler to be kept practically constant, and the thermal efficiency of the boiler benefits therefrom since it is independent of the variations of the load. Finally, the thermal inertia of the material of the bed would lead to a greater intrinsic safety for operation of the boiler. The hydrocarbon vapours produced by an accidental turning-off of the burner can in fact ignite rapidly in contact with the hot material of the bed ($T > 700\ ^{\circ}C$), inhibiting formation of large pockets of combustible gases premixed with air.

PURPOSE OF THE INVENTION

The task of the present invention is to provide a boiling-fluid-bed combustion plant with limited thermal power (for example, 50 kW), fed with liquid fuel both for start-up and for continuous operation, wherein the liquid fuel is supplied through an injector that can be positioned at a variable height so as to be inserted completely or only partially within the fluid bed. This enables variation of the thermal power continuously in a range comprised at least between 40% and 100% of the nominal power, without modifying the operating temperature of the bed, partializing the flow rates of gas-oil and of fluidization air.

Further characteristics and advantages of the

invention will emerge clearly from the ensuing detailed description, with reference to the attached plates of drawings, which show by way of non-limiting example a preferred embodiment of the invention. In the plates of drawings:

Figure 1 is the block diagram of the main components of the boiler provided for enabling automatic operation thereof; and

Figure 2 is a cross-sectional view of the fluid-bed combustion plant that can be fed with conventional or alternative liquid fuels.

With reference to Figure 1, the fluid-bed (or fluidized-bed) combustion chamber 1 is equipped with a blower 5 with average delivery head for the primary and secondary air, which is introduced from below into the distribution area 9 underneath the fluid bed, and an injector 2, preferably an injector with pressure atomization, supplied by a fuel pump 3 and assisted by a limited current of air that carries out transport of the liquid fuel.

According to a peculiar characteristic of the invention, the injector 2 can be positioned at a variable height within the combustion chamber 1 by means of a linear actuator 4. The production of hot water is obtained via a primary heat exchanger 7, which is located on the fume exhaust line, and a secondary heat exchanger 8 in contact with the material of the bed. A pump 6 regulates the circulation of water. The plant is completed by an electronic control unit 11 connected to sensors 10 positioned in the combustion chamber, capable of managing operation of the pump for

circulation of the water 6, of the pump for the fuel 3, of the blower 5, and of the actuator 4.

A preferred embodiment of the invention is illustrated in Figure 2.

As may be seen in this figure, the boiler has an outer shell 13 with a preferably circular cross section with the top end in the form of a trunk for adapting the section that ends in a top flue 16. The fumes are intercepted by a butterfly valve 21 at inlet to the flue, on top of the primary heat exchanger 7. The combustion chamber proper 1 is delimited laterally by an inner shell 17, which is coaxial with respect to said outer shell 13 and has a slightly lower height, whilst set at the top is an adapter 15 for the flow at outlet from the main chamber, which also enables separation of the materials of the bed possibly entrained by the current of the fumes.

Advantageously, the inner shell 17 forms with the outer shell 13 a lateral gap or passage of the fumes 18, provided inside which is a plurality of finned surfaces 16 that occupy approximately the lower half thereof. The gap 18 communicates with the combustion chamber itself through butterfly valves 14 positioned downstream of the flow adapter 15.

The fuel injector 2 can be positioned between the area containing the fluid bed 20 and the freeboard above it 19 by means of a high-temperature sliding seal system 22 and of a linear actuator 4 driven by a servo motor. In a preferred embodiment, the sliding seal system is represented by a sleeve.

In conditions of cold start-up, the injector 2 is

positioned on top of the bed 20 (top position PS) and rapidly heats the material of the bed itself by the action of the reverberation of the flame, of the heating along the wall of the combustion chamber, and of the pre-heating of the air coming from the blower 5 taking place in the chamber of the distributor 9 at the expense of the fumes, which traverse the gap 18. Ignition of the flame is obtained via an electrical igniter.

When the temperature of the bed 20 reaches a pre-set and optimal value for combustion, the injector 2 is brought into the lower position PI, i.e., inside the fluid bed 20, also enabling use of liquid fuels of poorer quality.

The different path of the fumes during cold start-up is carried out by simultaneous operation of the butterfly valves 14 and 21, positioned at the outlet of the combustion chamber 1.

It should be noted, in fact, that the combustion gases abandoning the dense phase follow a direction opposite to the direction of fluidization, dropping down into the gap 18, thus contributing to a heating of the walls of the fluidization chamber and to the pre-heating of the combustion air.

The finned surfaces 16 provided in the lateral gap or passages 18 for the fumes, improve heat exchange between the fumes and the bed in the start-up stage.

The thermal power can be varied continuously in a range comprised between 40% and 100% of the nominal power, without modifying the operating temperature of the bed, partializing the flowrates of fuel and

fluidization air. Consequently, optimal conditions are preserved for heat exchange and for limiting the pollutant emissions of carbon monoxide (CO) and nitrogen oxides (NO_x).

The production of hot water is obtained through the two heat exchangers 7 and 12. The primary heat exchanger 7 acts by convection on the fume exhaust line. The secondary heat exchanger 12 is made up of a coil in direct contact with the material of the bed and can be positioned at different vertical heights in order to vary the thermal power exchanged. For this purpose, a second actuator 24 is provided for displacing said second heat exchanger 12 vertically. The flow rate of water circulating in the heat exchangers is regulated automatically with proportional valves as a function of the temperature of the water at output from the two heat exchangers, the temperature of the bed, and the temperature of the fumes.

CLAIMS

1) A boiling-fluid-bed plant for the combustion of conventional and alternative liquid fuels, constituted by:

a reactor;

a combustion and fluidization chamber (1) inside the plant;

a pre-heating chamber (18) outside the fluidization chamber;

a fluid bed (20) formed by a granular solid stirred within the fluidization chamber;

a device for supply and injection (2) of the fuel; and

at least one device for dispersion of the heat on the fume line (7) and at least one other device for dispersion of the heat on the fume line (12) in direct contact with the inert material (20) of the fluid bed;

2) said boiling-fluid-bed plant being characterized in that said device for supply and injection (2) of the liquid fuel can be displaced vertically within the reactor so as to be inserted completely or partially within said fluid bed (20), wherein, in the step of start-up and of initial heating of the fluidization chamber (1), the terminal of the supply device or injector (2) is set at a greater height than the fluid bed (20).

2) The boiling-fluid-bed plant as per Claim 1, characterized in that, during steady running conditions, the terminal of the supply device or injector (2) is located preferably within the fluid bed

(20).

3) The boiling-fluid-bed plant as per Claim 2, characterized in that, in the pre-heating stage, the combustion gases, abandoning the dense phase, follow a direction opposite to that of fluidization contributing to a heating of the walls (17) of the fluidization chamber (1) and to pre-heating of the combustion air.

4) The boiling-fluid-bed plant as per Claim 3, characterized in that the regulation of the instantaneous power of the system is obtained exclusively through the continuous variation of the flowrate of fuel injected.

5) The boiling-fluid-bed plant as per Claim 4, characterized in that the temperature of the bed is regulated through the use of devices for dispersion of the heat (12) in direct contact with the fluid bed (20).

6) The boiling-fluid-bed plant as per Claim 5, characterized in that, in steady running conditions, it can be supplied, in the absence of pre-heating of the fuel, also with non-treated oils of any origin that have a viscosity higher than that of a gas-oil and impurities, which are introduced into the fluid bed (20).

7) The boiling-fluid-bed plant as per Claim 6, characterized in that the fluid bed is made of a material having catalytic properties so as to enable practically total combustion of the hydrocarbons and obtain extremely low levels of pollutant emissions.

8) The boiling-fluid-bed plant as per Claim 1, characterized in that the reactor has an outer shell

with a preferably circular cross section (13) with the top end having a progressively smaller cross section that ends in a top flue (16) at inlet to which the fumes are intercepted by a butterfly valve (21) positioned above a primary heat exchanger (7), the combustion chamber proper (1) being delimited laterally by an inner shell (17), which is coaxial with respect to said outer shell (13) and has a slightly smaller height, whereas set on top is an adapter (15) for the flow leaving the main chamber, which also enables separation of the materials of the bed possibly entrained by the current of fumes.

9) The boiling-fluid-bed plant as per Claim 1, characterized in that the inner shell (17) forms with the outer shell (13) a lateral gap or passage for the fumes (18), provided inside which is a plurality of finned surfaces (16), which occupy approximately the lower half thereof; said gap (18) communicating with the combustion chamber itself through the butterfly valves (14), which are positioned downstream of the flow adapter (15) and actuation of which enables a different path for the fumes during cold start-up of the plant.

10) The boiling-fluid-bed plant as per Claim 1, characterized in that the fuel injector (2) can be positioned between the area containing the fluid bed (20) and the freeboard (19) above it by means of a high-temperature sliding seal system (22), and a linear actuator (4) driven by a servo motor.

11) The boiling-fluid-bed plant as per Claim 1, characterized in that, in conditions of cold start-up,

the injector (2) is positioned on top of the bed (20) (PS) and rapidly heats the material of the bed itself by the action of the reverberation of the flame, of the heating along the wall of the combustion chamber, and of the pre-heating of the air coming from the blower (5) taking place in the distribution chamber (9) at the expense of the fumes that traverse the gap (18).

12) The boiling-fluid-bed plant as per Claim 1, characterized in that, when the temperature of the bed (20) reaches a pre-set and optimal value for combustion, the injector (2) is brought into the bottom position (PI), i.e., inside the fluid bed (20), also enabling the use of liquid fuels of poorer quality supplied by a pump (26).

13) The boiling-fluid-bed plant as per Claim 1, characterized in that the heat exchanger (12) in direct contact with the material of the bed is constituted by a coil that can be positioned at different vertical heights, in order to vary the thermal power exchanged, by means of an actuator (24).

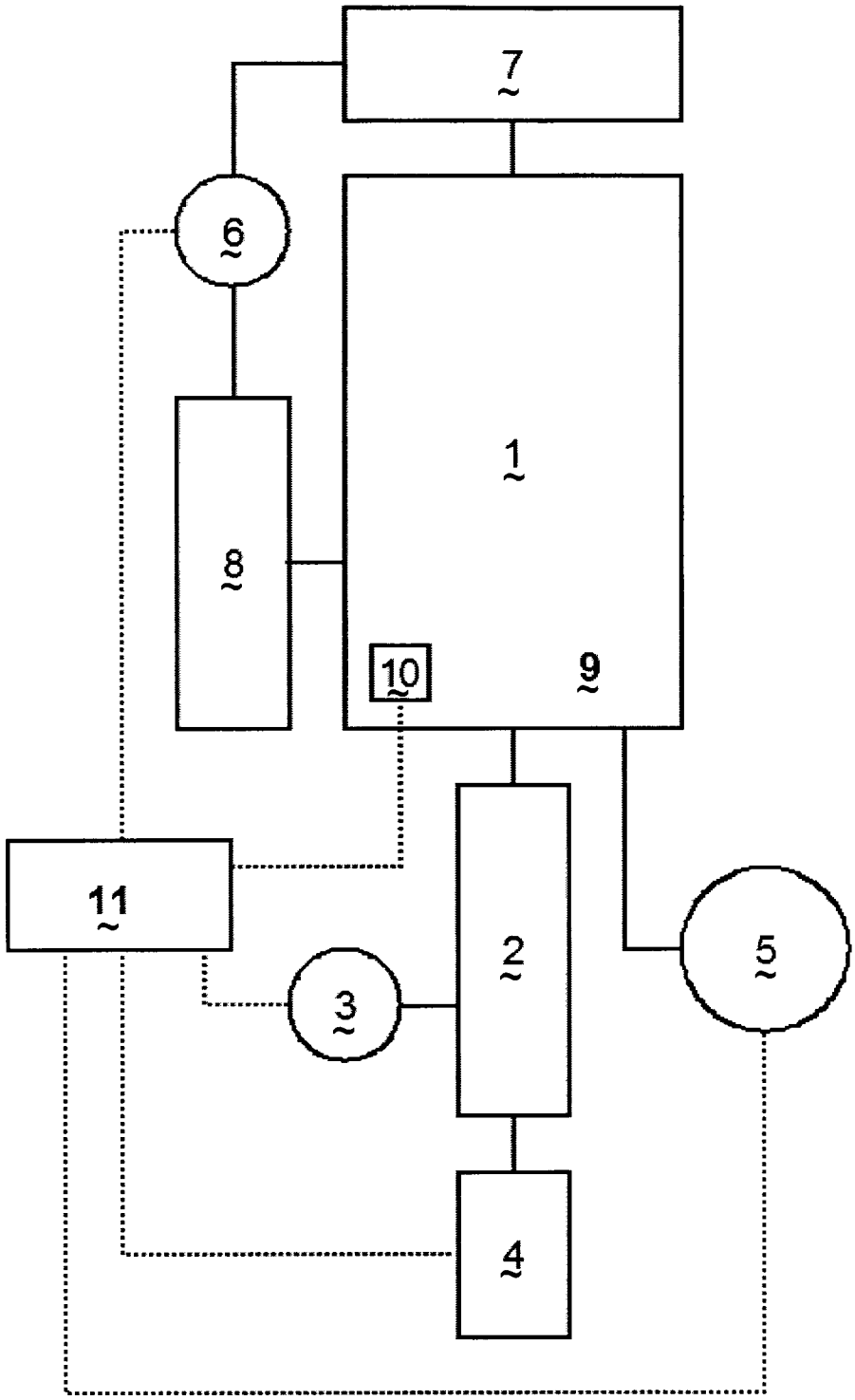

Fig. 1

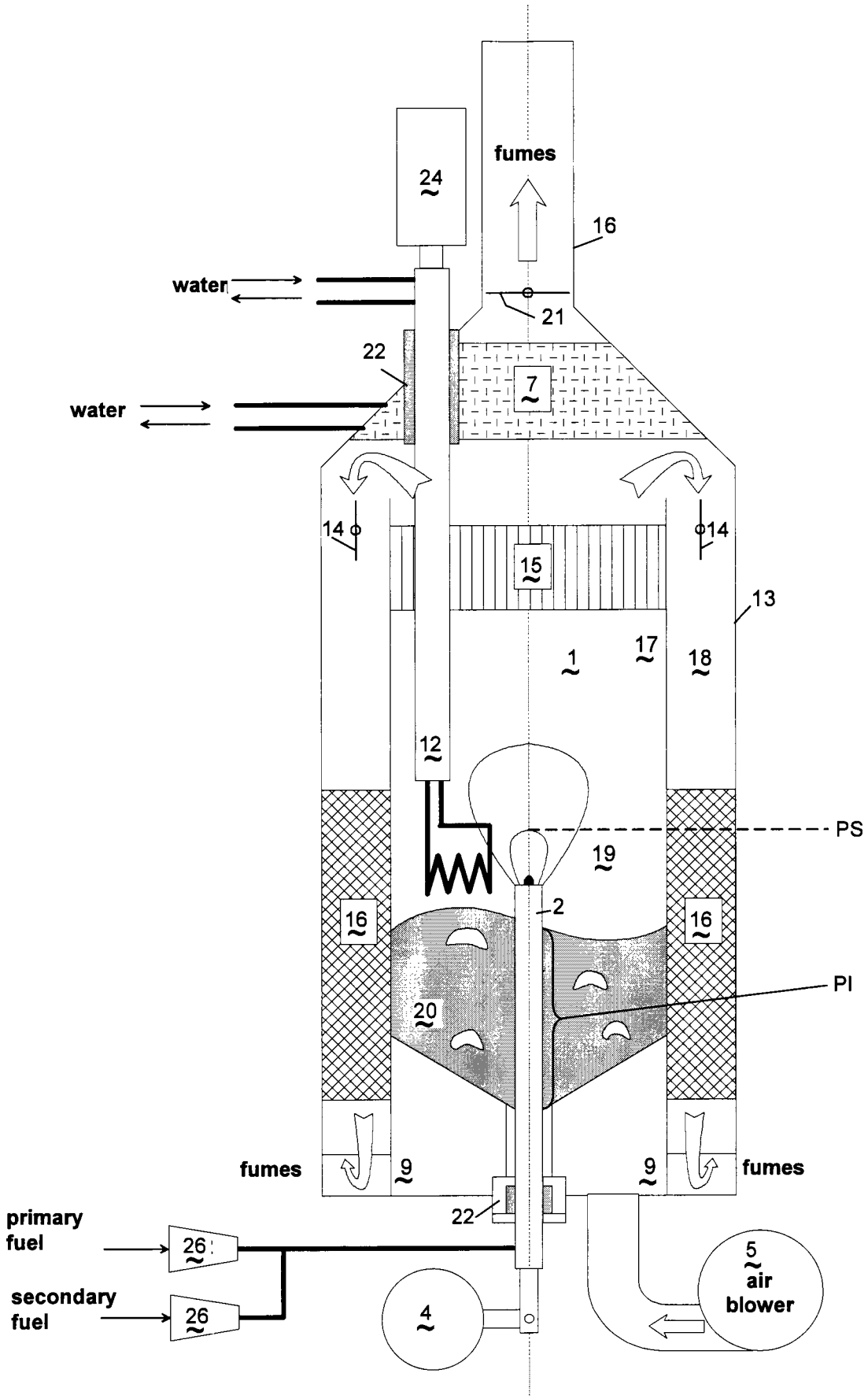
fumes
24
16
water
21
22
water
7
14
14
15
13
1
17
18
12
PS
19
2
16
16
PI
20
fumes
9
9
fumes
22
primary fuel
26
secondary fuel
26
4
5
air blower

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2011/000207

A. CLASSIFICATION OF SUBJECT MATTER
INV. F23C5/06 F23C10/12 F23C10/01 F23G5/30 F23G7/05
F23C10/22 F23C10/28
ADD.
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 F23G F23M

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.
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Harder, Sebastian

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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