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(54) **METHOD FOR CONTROLLING A BURNER**

(57) Method (100) for controlling the operation of a burner (2) in a combustion appliance (1), in particular in a gas boiler, the method (100) comprising: determining (S101) a temperature value of a burner deck (6); comparing (S102) the measured temperature value with a pre-determined reference temperature value, and initiating (S103) at least a control action on the operation of the combustion appliance (1) based on the comparison between the measured temperature value and the pre-determined reference temperature value, wherein the part of the burner (2).

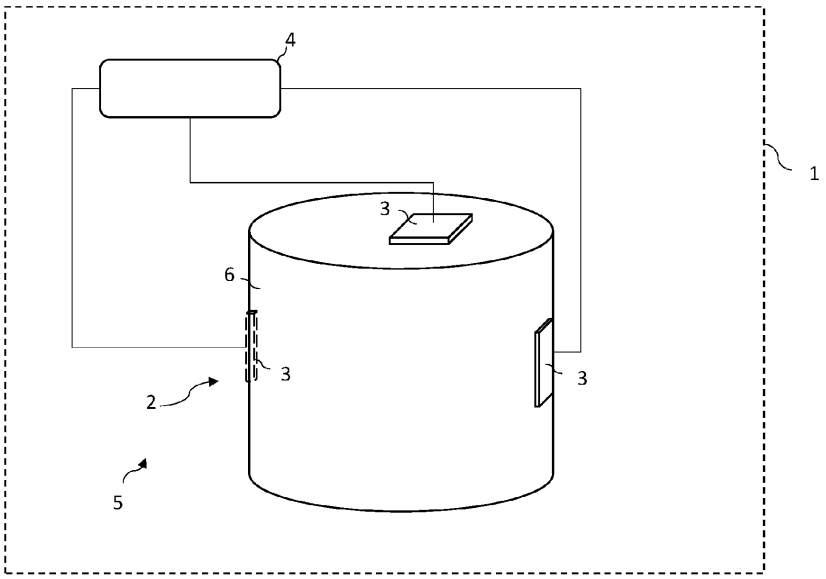

FIG 2

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Description

[0001] The invention relates to a method for controlling the operation of a burner in a combustion appliance, in particular a gas boiler. Also, the invention relates to a corresponding system for controlling the burner, to a combustion appliance comprising said system and to a use of the system. In addition, the invention relates to a computer program product executed by a computer carrying out the above method.

[0002] Combustion appliances such as gas boilers combust gas fuel to heat water for domestic use and/or central heating system facilities in buildings. Based on the characteristics of the gas mixture, the boiler's efficiency can be differently affected. When hydrogen, propane or butane containing mixtures are combusted, the flame temperatures are higher compared to the case when natural gas (with similar operational lambda values between 1 and 2) is combusted. These flame temperatures can result in overheating the burner, leading to aging or damage of the burner, burner seals, ignition pin, ionization pin and other combustion related components. In addition to the wear issues of the components, the overheating could also lead to hotspots on the burner surface which might result in auto-ignition of the combustible gas air mixture in the burner. The auto-ignition could lead to combustion upstream of the burner (i.e.in the mixing chamber). The upstream combustion is also known as flashback.

[0003] It is therefore desirable to provide a method for controlling the operation of a burner to prevent overheating and flashback, especially for gas boilers using a fuel gas different from natural gas.

[0004] WO2020197391 A1 is directed to a method for operating a premix gas burner wherein an air flow rate and a fuel gas flow rate are controlled so as to generate heat with the premix burner in accordance with a heat demand related value. The fuel gas comprises hydrogen and the method further provides a desired air excess factor relation of the air/fuel gas mixture which defines the relation between a desired air excess factor and an input variable like the heat demand related value, an air flow rate related value, or a fuel gas flow rate related value. The desired air excess factor is not a constant factor but varies for different input variable values. The fuel gas flow rate and/or the air flow rate are controlled such that an actual air excess factor converges towards the desired air excess factor while meeting the heat demand.

[0005] WO2020183289A1 is directed to a temperature sensor for gas burner having a thermocouple comprising electric conductors and a connection element to connect to the burner associated with a free end of such thermocouple. The connection element is suitable for being inserted inside a seat of the sensor formed inside a wall of the burner and having a first end suitable for being placed at the outer surface of the burner, said thermocouple being inserted inside a blind hole of the connection element which opens at a second end of said connection element. The blind hole ends with at least one part convergent towards an end zone of the hole, said part getting in contact with the thermocouple inserted inside the connection element, the connection element being made from an iron-chrome-aluminium alloy.

[0006] EP 3 779 280 A1 is directed to a heating device for a building, in which a fuel gas-air mixture flow is fed into a combustion chamber and ignited there. The heating device is used to burn a predominantly hydrogen containing fuel gas and is set up so that a catalyst material is arranged in the heater to ignite the fuel gas-air mixture. Also, a temperature sensor for monitoring the combustion is formed in the area of the catalyst material.

[0007] EP 1 923 634 B1 is directed to a method for calculating a run of burner or flame temperature from an output temperature of a burner or a flame temperature. Fuel gas and combustion air stream are adjusted according to determined fuel gas volume or mass flow and combustion air volume or mass flow. Another burner or flame temperature is measured and is compared with the calculated burner or flame temperature, where the measured temperature at a pre-set point of time is larger or smaller than the calculated temperature at the point of time at a dynamic process, so that fuel gas flow or air mass is reduced or increased.

[0008] The documents that are discussed above provide systems and methods that use the temperature sensor to control the air to fuel gas ratio of the gas mixture in a combustion appliance. However, these are not specifically configured for a protection against over heating/auto ignition also for other electronic combustion types and pneumatic operated combustion appliance.

[0009] The object of the invention is therefore to provide a method for controlling the burner that is efficient in preventing flashback and auto-ignition for combustion appliance where the fuel gas is controlled electronically or pneumatically.

[0010] The object is solved by for controlling the operation of a burner in a combustion appliance, in particular in a gas boiler, the method comprising:

determining a temperature value of a burner deck;
comparing the determined temperature value with a pre-determined reference temperature value, and
initiating at least a control action on the operation of the combustion appliance based on the comparison between the measured temperature value and the pre-determined reference temperature value.

[0011] By using one or more temperature sensors applied to the burner surface, in particular the burner's deck surface, the temperature of the burner can be adequately monitored and, if needed, corrective measures can be taken or the heating action can be aborted. It is noted that the burner material can be of stainless steel, ceramic material and/or catalytic material. The temperature sensor can measure the temperature of an internal or exter-

nal surface of the burner deck.

[0012] By adding additional monitoring of the burner temperatures to a pneumatic or electronic controlled system, the safety is increased. This method can be applied to any kind of system to prevent overheating (or flashback) or auto-ignition. In case the system can be controlled, higher lambda values will lead to lower adiabatic flame temperatures (i.e. less overheating), flame lift (flame further from the burner surface) and more flow throughput through the burner (the additional flow will cool the burner).

[0013] Determining the temperature value means that a value is measured that correlates to the burner deck temperature. That means, the value can be any physical value that correlates to the burner deck temperature. The sensor for measuring said value can be located anywhere in the combustion appliance as long as it is secured that a value can be measured that correlates with the burner deck temperature. Therefore, the burner deck temperature can be determined on the basis of the physical value measured by the sensor.

[0014] The burner deck temperature can be determined on a basis of a temperature measured by a temperature sensor. In that case the sensor is a temperature sensor and the measured value is a temperature. The temperature sensor can be located on the burner deck. In said case the temperature of the burner deck is directly measured by the temperature sensor. Alternatively, the temperature sensor can be located on a part of the burner that is different from the burner deck. In said case the burner deck temperature is determined indirectly on the basis of the temperature of the part of the burner. This is possible as the temperature of the part of the burner and the burner deck correlate with each other.

[0015] In one example, the method can comprise, in particular additionally, measuring the temperature value of at least one of a burner seal, a burner flange, a flame distributor and burner membrane. The burner seal, burner flange, flame distributor and/or burner membrane are also part of the burner. The relation between the burner deck and at least one of the burner seal, burner flange, flame distributor and burner membrane can be known so that temperature of the burner deck can be determined based on the temperature of another part of the burner.

[0016] As mentioned before, in addition to the temperature of the burner deck, other parameter correlated to the burner temperature, such as the temperature of the burner seal, burner flange, burner end cap, flame distributor and/or burner membrane can be monitored to better control the operating of the burner and avoiding overheating and flashback. In case a pre-determined reference temperature value, i.e. a maximum threshold, is exceeded, a control action can be taken.

[0017] In another example, the pre-determined reference temperature value can be an auto-ignition temperature value of a gas mixture introduced in the burner of the combustion appliance or a maximum tolerable temperature on said one part of the burner.

[0018] It is noted that the auto ignition temperature which can be monitored depends on the type of fuel gas. For example, standard auto-ignition temperature of hydrogen in air is above 510°C.

[0019] According to an example, the control action can be at least one of:

- aborting the heating process of the combustion appliance;
- varying the heat demand of the combustion appliance;
- temporarily changing the air to fuel gas ratio; and
- recalibrating the air to fuel gas ratio.

[0020] In one example, if the introduction of fuel gas is controlled pneumatically, when the measured temperature value exceeds the pre-determined reference temperature value, the heat demand can be varied. In particular, the heating request can be aborted in case the measured temperature value exceeds the pre-determined reference temperature value within a certain time frame.

[0021] In another example, if the introduction of fuel gas is controlled electronically, when the measured temperature value exceeds the pre-determined reference temperature value, the air to fuel gas ratio can be increased of a first percentage value, wherein in particular the first percentage value is 2%. In particular, the heating request can be aborted in case the measured temperature value exceeds the pre-determined reference temperature value within a certain time frame.

[0022] According to an example, the method can comprise monitoring the temperature values of a plurality of parts at the burner and determining if an offset between the measured temperature values is present. If the offset between the measured temperature values is determined, the heating request can be aborted and the combustion appliance can go to a lockout mode. It is noted that the offset can be monitored using a predictive maintenance technique. In particular, the offset can be higher than 5%.

[0023] In another example, the method can comprise checking the functioning of the temperature sensor at least during the pre-purge/boiler start and/or during the burner-off-phase.

[0024] According to one aspect of the invention, a computer program product is provided. This product comprises instructions which, when the program is executed by a computer or control unit, cause the computer or the control unit to carry out the inventive method.

[0025] In a further aspect of the invention, a system for controlling the operation of a burner in a combustion appliance, in particular in a gas boiler, preferably carrying out the inventive method, the system comprising:

at least one, in particular temperature, sensor; and
a control unit connectable to the at least one, in particular temperature, sensor,

wherein the control unit is configured to determine a burner deck (6) temperature on the basis of a value measured by the sensor (3) and to initiate at least a control action on the operation of the combustion appliance based on the comparison between the determined temperature value of the burner deck and a pre-determined reference temperature value.

[0026] In one example, the system can further comprise at least one of:

- an oxygen sensor;
- a thermocouple located in the burner (2) or in the combustion chamber;
- a thermal based catalytic sensor;.
- an optical sensor, in particular a UV sensor;
- an ionization probe;
- a flow sensor; and
- a thermal conductivity sensor.

[0027] According to one aspect of the invention, a combustion appliance, in particular a gas boiler, is provided, the combustion appliance comprising an inventive system. Examples of combustion appliances can include furnaces, water heaters, boilers, direct/in-direct make-up air heaters, power/jet burners and any other residential, commercial or industrial combustion appliance.

[0028] Using the described method and system it is possible to achieve the following advantages:

- reduction of overheating of the burner;
- reduction of the risk of auto-ignition;
- reduction of the risk of flashback due to auto-ignition; and
- application to combustion appliances with different control modality of the gas flow (pneumatic or electronic).

[0029] In particular, the present system can be used for a combustion appliance combusting fuel comprising at least 20 mol % hydrogen, in particular more than 90 mol % or a natural gas or mixtures thereof.

[0030] Examples of combustion appliances can include furnaces, water heaters, boilers, direct/in-direct make-up air heaters, power/jet burners and any other residential, commercial or industrial combustion appliance. In many cases, a combustion appliance can be modulated over a plurality of burner loads, with each burner load requiring a different flow rate of fuel gas resulting in a different heat output. At higher burner loads, more fuel gas and more air are typically provided to the burner, and at lower burner loads less fuel gas and less air are typically provided to the burner.

[0031] In another aspect of the invention the inventive system is used in a combustion appliance using as fuel gas hydrogen propane, butane or a mixture thereof.

[0032] In the figures, the subject-matter of the invention is schematically shown, wherein identical or similarly acting elements are usually provided with the same reference signs.

Figure 1 shows a flow chart of a method for controlling a burner according to an example.

Figure 2 show a schematic representation of a system in a combustion appliance according to an example.

[0033] With reference to figure 1, a flow chart describing a method 100 for controlling the operation of a burner is shown. At step S101, a temperature value of a burner deck 6 shown in fig. 2 is determined. Thereto, temperature value of at least one part of the burner 2 is measured. Based on the measured temperature value it is possible to determine the burner deck temperature. The determined temperature value is compared with a pre-determined reference temperature value at step S102 and at step S103 at least a control action on the operation of the combustion appliance 1 is initiated. It is noted that based on the type of control of the gas flow (pneumatic or electronic) a different control action can be initiated.

[0034] For example, in case of a pneumatic gas valve, the heat demand can be varied. In particular, the heat demand can be increased or decrease, thereby performing an up- or down-modulation. Depending on the burner design, the up- or down-modulation can reduce the temperature of the burner surface. The temperature is monitored constantly or with time intervals, if a maximum threshold is exceeded, the heat demand can be first increased or decreased (depending on the burner design). If the measured temperature is not successfully decreased within a certain time frame, the heating request is aborted.

[0035] In case of electronically controlled gas valve, temperature is monitored constantly or with time intervals in a similar way. However, if a maximum threshold is exceeded, the fuel to air ratio is first increased with at least 2% If the measured temperature is not successfully decreased within a certain time frame, the heating request is aborted. As addition the load lambda curve can be increased with at least 2%.

[0036] In other words, the system 5 continuously checks whether the determined temperature is within a tolerable range. If it is not the case, several control actions can be initiated in combination or alternatively. For example, it is possible either lower the temperature of the burner 2, rise the lambda value, or move to a load set point where the temperature is within the tolerable range. If the determined temperature is still not in the tolerable range, the appliance 1 can be shut off, or lock-off, or the heat demand can be terminated or can be waited for a predefined time interval to repeat the temperature determination. Also, the lambda can be recalibrated and/or the integrity of the sensor 3 can be checked.

[0037] Figure 2 describes a schematic representation of system 5 for controlling the operation of a burner 2.

The system 1 is part of the combustion appliance 1 and comprises at least one temperature sensor 3 for measuring the temperature of the burner 2, in particular a burner deck 6, and a control unit 4 for monitoring the measured temperature values by the sensor 3. The system 5 has three temperature sensors 3 that are arranged offset from each other and measure different burner deck portions 6.

[0038] The control unit 4 can be integrated in a control system of the combustion appliance 1 in order to manage the control actions of the appliance 1. Alternatively, the control unit 4 can be separated and connected to the control system of the appliance 1.. In one case the sensor 3 is integrated in the burner 2 to measure the temperature of the material of the burner deck. Preferably, the burner 2 is a fully premixed burner and is made of stainless steel, a woven, knitted or braided fabric comprising metal fibre, ceramic material, or catalytic material.

[0039] In order to improve the temperature reduction, the burner 2 can be additionally provided with a flow distributor, structural elements to distribute heat, and/or a second flow passage and/or membrane.

Reference Signs

[0040]

1	Combustion appliance
2	Burner
3	Temperature sensor
4	Control unit
5	System
6	Burner Deck
100	Method

Claims

1. Method (100) for controlling the operation of a burner (2) in a combustion appliance (1), in particular in a gas boiler, the method (100) comprising:

   determining (S101) a temperature value of a burner deck (6);
   comparing (S102) the determined temperature value with a pre-determined reference temperature value, and
   initiating (S103) at least a control action on the operation of the combustion appliance (1) based on the comparison between the measured temperature value and the pre-determined reference temperature value.

2. Method (100) according to claim 1, **characterized in that**

   a. the burner deck (6) temperature is determined on a basis of a temperature measured by a temperature sensor (3) and/or **in that**
   b. the burner deck (6) temperature is determined by use of a temperature measured by a temperature sensor (3) located on the burner deck or on a part of the burner (2) different from the burner deck (6) and/or **in that**
   c. the method (100) comprises additionally, measuring the temperature value of at least one of a burner seal, a burner flange, flame distributor and a burner membrane.

3. Method (100) according to any one of claims 1 to 2, **characterized in that** the pre-determined reference temperature value is an auto-ignition temperature value of a gas mixture introduced in the burner (2) of the combustion appliance (1) or a maximum tolerable temperature on said one part of the burner (2).

4. Method (100) according to any one of claims 1 to 3, **characterized in that** the control action is at least one of:

   a. aborting the heating process of the combustion appliance (1);
   b. varying the heat demand of the combustion appliance (1);
   c. temporarily changing the air to fuel gas ratio; and
   d. recalibrating the air to fuel gas ratio.

5. Method (100) according to any one of claims 1 to 4, **characterized in that**, if the introduction of fuel gas is controlled pneumatically, when the measured temperature value exceeds the pre-determined reference temperature value, the heat demand is varied.

6. Method (100) according to claim 5, **characterized in that** the heating request is aborted in case the measured temperature value exceeds the pre-determined reference temperature value within a certain time frame.

7. Method (100) according to any one of claims 1 to 4, **characterized in that**, if the introduction of fuel gas is controlled electronically, when the measured temperature value exceeds the pre-determined reference temperature value, the air to fuel gas ratio is increased of a first percentage value, wherein in particular the first percentage value is 2%.

8. Method (100) according to claim 7, **characterized in that** the heating request is aborted in case the measured temperature value exceeds the pre-determined reference temperature value within a certain time frame.

9. Method according to any one of claims 1 to 8, **characterized in that** the method (100) comprises monitoring the temperature values of a plurality of parts

at the burner (2) and determining if an offset between the measured temperature values is present, wherein

a. if the offset between the measured temperature values is determined, the heating request is aborted and the combustion appliance (1) goes to a lockout mode; and/or
b. the offset is monitored using a predictive maintenance technique; and/or
c. the offset is higher than 5%.

10. Method (100) according to any one of claims 1 to 9, **characterized in that** the method comprises checking the functioning of the temperature sensor (3) at least during the pre-purge/boiler start and/or during the burner-off-phase.

11. Computer program product comprising instructions which, when the program is executed by a computer or control unit, cause the computer or the control unit to carry out the method according to one of the claims 1 to 10.

12. System (5) for controlling the operation of a burner (2) in a combustion appliance (1), in particular in a gas boiler, preferably carrying out the method according to any one of claims 1 to 10, the system (5) comprising:

at least one, in particular temperature, sensor (3); and
a control unit (4) connectable to the at least one, in particular temperature, sensor (3),
wherein the control unit (7) is configured to determine a burner deck (6) temperature on the basis of a value measured by the sensor (3) and to initiate at least a control action on the operation of the combustion appliance (1) based on the comparison between the determined temperature value of the burner deck (6) and a predetermined reference temperature value.

13. System (5) according to claim 12, **characterized in that** the system (5) further comprises at least one of:

a. an oxygen sensor;
b. a thermocouple located in the burner (2) or in the combustion chamber;
c. a thermal based catalytic sensor;
d. an optical sensor, in particular a UV sensor;
e. an ionization probe;
f. a flow sensor; and
g. a thermal conductivity sensor.

14. Combustion appliance (1), in particular a gas boiler, comprising the system (5) according to any one of claims 12 to 13.

15. Use of the system (5) according to any one of claims 12 to 13 for a combustion appliance (1) using as fuel gas hydrogen, propane, butane, or a mixture thereof.

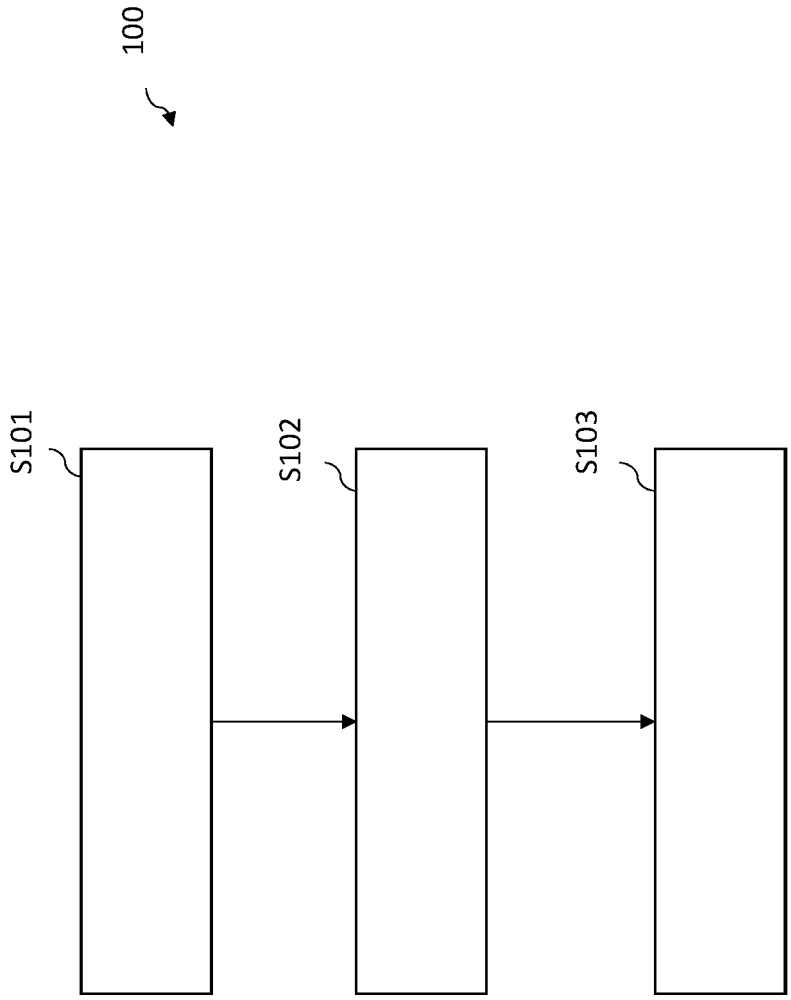

FIG 1

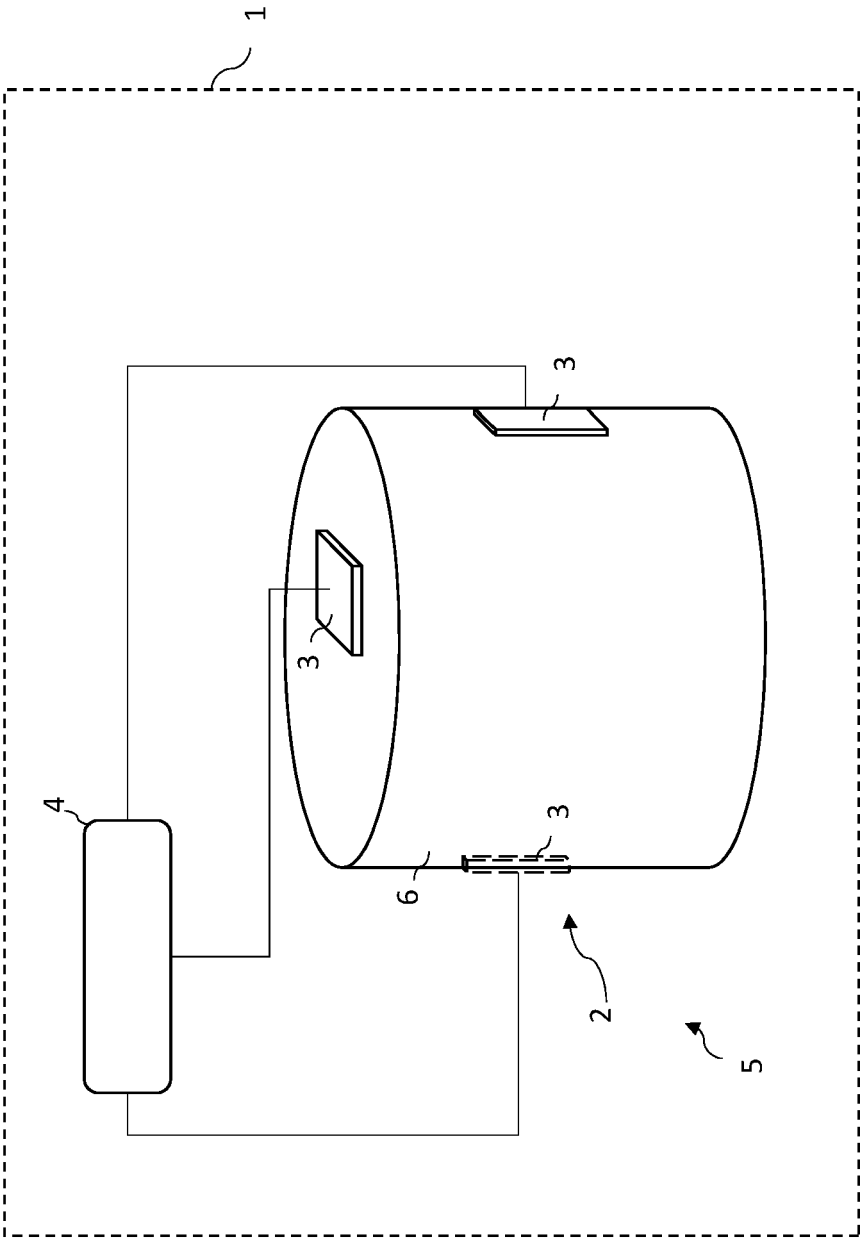

FIG 2

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EUROPEAN SEARCH REPORT

Application Number
EP 21 20 3353

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	WO 2020/182902 A1 (BEKAERT COMBUSTION TECH BV [NL]) 17 September 2020 (2020-09-17) * page 1, line 5 - line 7; figures 6-8 * * page 1, line 12 - line 18 * * page 3, line 15 - page 4, line 10 * * page 6, line 152 - line 29 * * page 12, line 24 - page 13, line 10 * * page 16, line 33 - line 37 * * page 20, line 2 - line 12 *	1-8, 10-14 9	INV. F23D14/02 F23D14/82 F23N5/10 F23N5/24
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 March 2022	Hauck, Gunther

CATEGORY OF CITED DOCUMENTS

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REFERENCES CITED IN THE DESCRIPTION

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