



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.05.2023 Bulletin 2023/20

(51) International Patent Classification (IPC):
F23N 5/02 ^(2006.01) **F23N 5/00** ^(2006.01)
F23N 5/12 ^(2006.01)

(21) Application number: **21207726.7**

(52) Cooperative Patent Classification (CPC):
F23N 5/022; F23N 5/006; F23N 5/027; F23N 5/123

(22) Date of filing: **11.11.2021**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **METHOD FOR CONTROLLING A GAS BOILER**

(57) Method (100) for controlling the operation of a combustion appliance (2), in particular a gas boiler operating at least in a first heat modulation range and a second heat modulation range, the method (100) comprising monitoring (S101) the combustion process of the appliance (2) through a sensor (6) measuring a physical value, in particular an oxygen sensor or an ionization sensor; controlling (S102) an air to fuel gas ratio in a gas mixture through a pneumatic gas valve (3) when the combustion appliance (2) operates in the first heat modulation

range; and controlling (S103) the air to fuel gas ratio in a gas mixture through an electronically controlled gas valve (5) when the combustion appliance (2) operates in the second heat modulation range, wherein the method (100) comprises adjusting (S104) the electronically controlled gas valve (5) by varying a gas flow passing through said electronically controlled gas valve (5) based on a sensor signal generated by said sensor (6), when the combustion appliance (2) operates in the second heat modulation range.

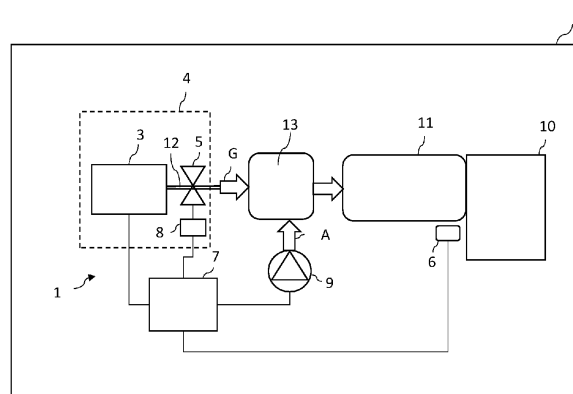


FIG. 2

Description

[0001] The invention relates to a method for controlling the operation of a combustion appliance, in particular a gas boiler. Also, the invention relates to a corresponding system for controlling the combustion appliance, 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 fuel gas to heat water for domestic use and/or central heating system facilities in buildings. The boilers can be used to operate in different modes, such as continuous-flow heaters, for preparing hot water, etc. To improve the efficiency, boilers implement a so-called heat modulation operating modus. In this way, in case the heating demand for a facility is less than the maximum capacity of the boiler, the boiler is able to modulate seamlessly between a fixed low fire rate and a high fire rate without the need of excessive numbers of boiler cycles of switching-off and switching-on. Accordingly, different heat modulation ranges can be set, wherein the combustion appliance can operate between a full value of the nominal combustion load (full load) and a reduced value of the nominal combustion load that in the following is indicated as low load.

[0003] In gas boilers, the power output is substantially determined by the setting of the supply of fuel gas and air and by the mixture ratio between air and gas that is set. Therefore, the combustion process of the boiler is influenced by said ratio. It is known that the combustion process of a boiler can be controlled by adjusting the air to fuel gas ratio using either a controller on a pneumatic gas valve or using a controller on a fully electronically controlled gas valve. Usually, a pneumatic gas valve is pre-set and will only be checked at maintenance intervals. In this case, typical heat modulation varies between 1:5 to 1:7 or between 15-20% of the nominal combustion load and 100% of the nominal combustion load. Accordingly, using this type of gas valve the heat modulation range is limited since the pneumatic gas valve can't properly operate below 15-20% of nominal load due to pneumatic control signal limitations. A fully electronically controlled gas valve can adjust the gas flow based on a sensor signal and can be set to modulate the heat in a different range, i.e. between 1:10 and 1:15. However, a fully controlled gas valve is very expensive and it is not always available for a broad range of power outputs. In addition, in case the composition of the fuel gas is changed, the configuration of the controller for adjusting the air to fuel gas ratio needs to be modified.

[0004] It is therefore desirable to obtain an efficient and cost-effective method for controlling the operation of a combustion appliance by adjusting the air to fuel gas ratio in order to reach a wider heat modulation range and an improved gas adaptiveness of a gas boiler.

[0005] The object is solved by a method for controlling

the operation of a combustion appliance, in particular a gas boiler operating at least in a first heat modulation range and a second heat modulation range, the method comprising:

monitoring the combustion process of the appliance through a sensor measuring a physical value, in particular an oxygen sensor or an ionization sensor; controlling an air to fuel gas ratio in a gas mixture through a pneumatic gas valve when the combustion appliance operates in the first heat modulation range; and controlling the air to fuel gas ratio in a gas mixture through an electronically controlled gas valve when the combustion appliance operates in the second heat modulation range, wherein the method comprises adjusting the electronically controlled gas valve by varying a gas flow passing through said electronically controlled gas valve based on a sensor signal generated by said sensor, when the combustion appliance operates in the second heat modulation range.

[0006] By combining two different gas valves for two different heat modulation ranges, it is possible to widen the whole heat modulation range of the combustion appliance without using a fully electronically controlled gas valve system or a single pneumatic gas valve for the same range. In addition, in this way, it is possible to adapt the method to an appliance combustion gas with different compositions.

[0007] In one example, in the first heat modulation range the combustion appliance can operate between 100% and 20% of the nominal combustion load and in the second heat modulation range the combustion appliance can operate between 20% and 10%, in particular between 20% and 0%, of the nominal combustion load. Accordingly, from 100% to 20% of the nominal combustion load, the heat modulation can be controlled only by the pneumatic valve and below 20% of the nominal combustion load, the heat modulation can be controlled only by the electronic valve. In this way, it is possible to widen the heat modulation range also to the low values of the nominal combustion loads. It is noted that in the heat modulation range of low values of the nominal combustion loads the pneumatic valve would not work properly due to pneumatic control signal limitations. Generally, the second heat modulation range comprises low values of the combustion load, i.e. lower than 10%-20% or at least close to 0%, whereas the first heat modulation range comprises the remaining values of the combustion load.

[0008] In particular, in order to control the air to fuel gas ratio, the method can comprise increasing the air flow rate when the nominal combustion load at which the combustion appliance operates is increased in the first and second heat modulation range by controlling the speed of a fan element. In addition or in alternative, the method can comprise decreasing the air flow rate when the nominal combustion load at which the combustion

appliance operates is decreased in the first and second heat modulation range by controlling the speed of a fan element.

[0009] In one example, monitoring the combustion process of the appliance can comprise measuring the oxygen value in a flue gas generated in the combustion appliance and the oxygen value in the flue gas is adjusted by controlling the electronically controlled gas valve based on the sensor signal generated by the sensor. The measurement of the oxygen concentration in the flue gas can be useful when hydrogen is used as fuel or combustible gas. Also, oxygen level gives a non-doubtable value on air excess ratio (or lambda). This is extremely advantageous compared to system measuring for instance the temperature of the burner to monitor the combustion process of the appliance. In fact, the burner temperature can be influenced also by load reduction due to extra resistance in the flue gas circuit due to flue system blockage, pollution, etc. Also, the heat reflection of the combustion room material can have an influence on the burner surface temperature, depending on aging of the combustion room material.

[0010] According to another example, the oxygen value in the flue gas can be set to a first set value, in particular 4.3%, when the combustion appliance operates at a full value of the nominal combustion load, the oxygen value in the flue gas can be varied to a second set value, in particular 4.8%, by varying the air flow rate and adjusting the offset setting of the gas valve in the first heat modulation range, and the oxygen value in the flue gas can be maintained to said second set value in the second heat modulation range. It is clear that the first set value and/or the second set value can have different values than mentioned above.

[0011] In particular, in the second heat modulation range the oxygen value in the flue gas can be adjusted to the second set value by controlling both the position of the electronically controlled gas valve and by controlling the air flow rate. It is noted that in this context the position of the electronically controlled gas valve is intended as the position of a component of said valve that can be moved to allow or to block the passage of the fuel gas. By suitably varying the fuel gas flow and the air flow, it is possible to maintain the oxygen value in the flue gas almost constant, for example at the second set value. However, if emissions like CO or NOx are getting too high and/or the burner surface gets too high, it is possible to vary the air to fuel gas ratio (lambda value) by acting on the electronically controlled gas valve, i.e. by varying the fuel gas flow.

[0012] In a further example, in the second heat modulation range, in order to operate the combustion appliance to a reduced value of the nominal combustion load, the gas flow passing through the electronically controlled gas valve can be reduced and the air flow rate can be decreased. In addition or in alternative, in order to operate the combustion appliance to an increased value of the nominal combustion load, the gas flow passing through

the electronically controlled gas valve can be increased and the air flow rate can be increased.

[0013] In one example, in the first heat modulation range the position of the electronically controlled gas valve can be unchanged and in the second heat modulation range the position of the electronically controlled gas valve can be changed based on the sensor signal generated by the sensor. Accordingly, the electronically controlled gas valve actively works only in the second heat modulation range.

[0014] In particular, in the first heat modulation range the electronically controlled gas valve can be set to a pre-set position and/or in the second heat modulation range the electronically controlled gas valve can be set to a position different from the pre-set position to vary the gas flow passing through the electronically controlled gas valve.

[0015] In one example, the pre-set position of the electronically controlled gas valve can be adjustable based on the type of the combustible or fuel gas. In particular, the position of this gas valve can be adapted to the combustion gas type. For example, if the oxygen value is too high at a certain fan speed, then the position of the electronically controlled gas valve can be varied and the gas flow can be increased to avoid too lean combustion. In particular, the electronically controlled gas valve can be adjusted in the first heat modulation range. Also, once the electronically controlled gas valve is adjusted to a pre-set position in the first heat modulation range, the position of said electronically controlled gas valve can be unchanged until the combustion appliance operates in the second heat modulation range.

[0016] 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.

[0017] In a further aspect of the invention, a system for controlling the operation of a combustion appliance, in particular a gas boiler, operating between at least a first heat modulation range and a second heat modulation range, is provided. The system comprises a gas valve apparatus for feeding fuel gas in a manifold of the combustion appliance, the gas valve apparatus comprising a pneumatic gas valve for controlling an air to fuel gas ratio in a gas mixture in the first heat modulation range and an electronically controlled gas valve for controlling the air to fuel gas ratio in the gas mixture in the second heat modulation range,;

a sensor for measuring a physical value, in particular an oxygen sensor or an ionization sensor, for monitoring the combustion process of the appliance, and a control unit connectable to the gas valve apparatus and the sensor,

wherein the control unit is configured to adjust the electronically controlled gas valve by varying a gas flow passing through said electronically controlled

gas valve based on a sensor signal generated by said sensor when the combustion appliance operates in the second heat modulation range.

[0018] In one example, the electronically controlled gas valve can be a throttle valve. Also, the electronically controlled gas valve can be connected to an actuator, in particular a stepper motor, connectable to the control unit to control the position of the valve in fixed steps. In addition, the system can comprise a fan element connectable to the control unit for varying the air flow rate in the first and the second heat modulation ranges.

[0019] 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.

[0020] In particular, the appliance including the present system can be a gas boiler for the combustion of hydrogen gas. In this case, it is intended a fuel gas that comprises or contains hydrogen. In particular, the fuel gas can comprise or contain at least 20 mol%, in particular at least 90 mol %, hydrogen. In general, the molar fraction of a component (indicated in mol %) in a mixture of substances is the relative number of particles (atoms/molecules/ions) of this component in the total number of particles of the mixture of substances.

[0021] In another aspect of the invention, the use of the inventive system in a combustion appliance using fuel gas having at least 20 mol % hydrogen, in particular at least 90 mol % hydrogen, or natural gas or mixtures thereof.

[0022] Using the described method and system it is possible to achieve the following advantages:

- less on/off cycles of the combustion appliance;
- less exhaust of incomplete combustion of combustibles during start;
- more efficient operated appliances because of adaptiveness to changing gas composition;
- easier commissioning of the appliances; and
- reducing cost of the components compared to expensive fully electronic controlled gas valves.

[0023] 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 combustion appliance according to an example.

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

Figures 3A-B show two diagrams representing the oxygen value in the flue gas by varying the heat load.

[0024] With reference to figure 1, a flow chart describing a method 100 for controlling the operation of a combustion appliance is shown. At step S101, the combustion process of the appliance 2 is monitored. Advantageously, the monitoring is carried out using an oxygen sensor that measures the value of the oxygen in the flue gas of the combustion appliance 2 and generates a corresponding sensor signal. It is pointed out that the measurement of oxygen value in the flue gas gives information regarding the air excess ratio of the gas mixture that was combusted by the burner.

[0025] The method 100 is applied to a combustion appliance 2 operating in a first heat modulation range and a second heat modulation range of a heat modulation operating modus. It is noted that after acquiring a change in the heat demand, i.e. a reduction or an increase in a heat demand of the appliance 2, the method switches into the heat modulation operating modus. With "heat modulation operating modus" is intended an operating modus or state of the boiler, wherein the boiler can change the power output of the burner as a consequence of a variation in the heat demand. When the heating needs for a facility connected to the boiler are below the capacity of the boiler, the boiler not using a heat modulation operating modus would undergo cycling where they would activate, satisfy the load and then deactivate. The greater the difference between the heating load and the burner output, the greater the number of boiler cycles. This produces cycle losses and add general wear of the equipment. By using the heat modulation operating modus, the boiler comprises units with multiple firing rates or multiple staged firing followed by units that can modulate between a low and high fire rate. On fan-equipped boilers, heat modulation is accomplished by varying the air and gas flow into the boiler. The heat modulation ranges are intended as ranges of values of combustion load at which the combustion appliance 2 operates during the heat modulation operating modus.

[0026] In the first heat modulation range the combustion appliance 2 operates between 100% and 20% of the nominal combustion load and in the second heat modulation range the combustion appliance 2 operates between 20% and 0%, of the nominal combustion load. Based on the fact that the combustion appliance 2 operates in the first or in the second heat modulation range, the air to fuel gas ratio can be controlled by a specific gas valve. In particular, when the combustion appliance 2 operates in the first heat modulation range (I), the air to fuel gas ratio is controlled through the pneumatic gas valve 3 (S102), whereas, when the combustion appliance 2 operates in the second heat modulation range (II), the air to fuel gas ratio is controlled through the electronically controlled gas valve 5 (S103). At step S104, when the combustion appliance 2 operates in the second heat

modulation range (II), the electronically controlled gas valve 5 is adjusted by varying a gas flow passing through said electronically controlled gas valve 5 based on a sensor signal generated by said sensor 6. For example, the electronically controlled gas valve 5 is a throttle valve or a butterfly valve and the gas flow passing through the valve can be regulated acting on the position of the internal throttle plate relative to the gas flow.

[0027] Figure 2 describes a schematic representation of system 1 for controlling the operation of a combustion appliance 2. The system 1 is part of the combustion appliance 2 and comprises a gas valve apparatus 4 for feeding fuel gas G in the manifold 11 of the combustion appliance 2 that is then mixed with air A introduced in the manifold through a fan element 9 in order to generate a gas mixture to be provided to the burner 10 of the appliance. The gas valve apparatus 4 comprises a pneumatic gas valve 3 and a gas valve 5. The gas valve 5 is a gas valve electronically controlled by an actuator, such as a stepper motor 8. According to the figure, the gas valve 5 is arranged downstream the pneumatic valve 3 along a gas duct 12.

[0028] The system 1 also comprises a sensor 6, in particular an oxygen sensor measuring the value of oxygen in the flue gas of the combustion appliance. Accordingly, the sensor 6 can be positioned close to the burner 10. It is clear that the sensor 6 can be positioned in other suitable sites of the combustion appliance 2 for a detection of the oxygen in the flue gas.

[0029] In addition, the system comprises a control unit 7 connected to the sensor 6 and to the gas valve apparatus 4, and therefore to the pneumatic valve 3 and the gas valve 5 via the motor 8. Based on the oxygen value measured by the sensor 6, i.e. based on the combustion process of the appliance 2, the control unit 7 can regulate the gas valve 5 (for example by varying the position of the valve plate) in the second heat modulation range (for example below 20% of the nominal load). Also, the control unit 7 is connected to the fan element 9 in order to regulate (i.e. increase or decrease) the air flow introduced in the manifold 11.

[0030] The system 1 also comprises a, in particular Venturi-like, mixer 13. The mixer is fluidically connected to the gas valve 5 and the fan element 9 and used to mix the air with the fuel gas. The mixer 13 is arranged downstream the fan element 9 and upstream the manifold 11. The mixture flows into the manifold 11. In an alternative non-shown embodiment the mixer can also be connected upstream the fan element, between gas valve and fan element.

[0031] The oxygen value in the flue gas is pre-set by the gas valve 5 at full load and reaches an off-set value at part, in particular low, load. During the heat modulation from 100% to 20% the pneumatic valve 3 follows the oxygen setting of the gas valve 5 towards the oxygen setting of the off-set value, as a consequence of the varying speed of the fan element 9 and as a consequence the controlling the behaviour of the pneumatic gas valve.

It is noted that in the first heat modulation range, the gas valve 5 only has an adaptation function when the gas composition is changing. The oxygen values at full load and low load are pre-set in the pneumatic gas valve 3 based on a specific gas composition. The oxygen value in the flue gas is only adjusted by the gas valve 5 when the gas composition is different from the gas composition used to pre-set the pneumatic valve 3, and therefore can have a different oxygen value in the flue gas. During the heat modulation from 20% to 10% (or better >0%), the gas valve 5 is electronically adjusted by the actuator 8 to maintain the oxygen value at part load. This adjustment is guided by the sensor 6 that monitors the combustion process of the appliance 2. The sensor is advantageously an oxygen sensor. However, other types of sensor can be used individually or in combination such as for example an ionization sensor. In the range between 20% and 10% of the nominal load, the speed of the fan 9 is suitably changed (increased or decreased).

[0032] Figure 3A shows a diagram illustrating the value of the oxygen in the flue gas as a function of the heat load. When the combustion appliance 2 operates at a full value of the nominal combustion load (full load), the oxygen value in the flue gas is set to a first set value, i.e. 4.3%. In the first heat modulation range, the oxygen value in the flue gas is varied to a second set value, i.e. for example 4.8%, by varying the air flow rate. It is noted that the line between LLs0 and Full load is drawn as a straight line, but in general it could be a curved line. In particular, by reducing the heat load (in the region below the full load), the oxygen value is increased to the second set value. In particular, the second set value is reached when the combustion appliance 2 operates at 20% of the nominal load. It is noted that until this point the position of the gas valve 5 is fixed and the control of the air to fuel gas ratio is only controlled by the pneumatic valve 3 in combination with the variation of the air flow, e.g. increasing or decreasing the speed of the fan element 9. When the combustion appliance 2 operates at 15% of the nominal load, the oxygen value is maintained at the second set value, in particular 4.8%, using the stepper motor 8 acting on the gas valve 5. The set value can have other values than 4.8%. When the combustion appliance 2 operates at 10% of the nominal load, the oxygen value is still maintained at the second set value (4.8%) always using the stepper motor 8 actuating on the gas valve 5. In this figure, 10% is mentioned as lowest value, just as an example. In fact, the method can validly apply also for lower load values, i.e. till about 0%. In particular, the speed of the fan element 9 is decreased, continuously monitored by the sensor 6 (oxygen sensor). The first goal is to have steps of 5%-point from 20% to 15%, to 10% (so known reduction of fan speed and closing of gas valve 5). Of course, different steps of percentage points can also be considered. If higher output is needed, the gas valve 5 goes back to the set position belonging to the 20% load, heat modulation is then again fully pneumatic and driven by the fan speed.

[0033] The actuator 8 acting on the gas valve 5 can also be used to adapt the settings of the gas valve 5 when a different gas composition is used. Based on the sensor signal that monitors the combustion, the oxygen value in the flue gas can be adjusted by adjusting the gas valve 5. By changing the gas valve 5, also the off-set value will follow the change so that the difference between the first set value and the second set value is maintained. This is illustrated in figure 3B. It is noted that this figure shows the oxygen value trend in a heat modulation range between 100% and 20% of the nominal load, as described in figure 3A.

[0034] The adaptation to different gas composition of fuel gas can be achieved without necessarily measuring the gas composition. In fact, knowing the oxygen value in the flue gas, it is possible to control to the desired lambda (i.e. air to fuel gas ratio). That is in general a good value for all kinds of fuel. So, if the boiler is running on propane, and the oxygen value in the flue gas is 4,8%, that approximately results in the same lambda as running the boiler on natural gas with oxygen value of 4.8% in the flue gases. By running on leaner gas, or richer gas, the desired oxygen values must approximately be the same. With the position of the gas valve 5 it is furthermore possible to determine on which gas type the combustion appliance 2 is running, and in that case it might be convenient to choose for a slightly different lambda (to avoid for example too high NO_x emissions on propane combustion or avoid undesired other combustion effects like whistling, rumbling, etc).

[0035] The present method and system can advantageously be applied to combustion appliances for combusting hydrogen or natural gas, or a mix of natural gas and hydrogen, or propane/propane+butane mixtures, or even other renewable gases like DiMethylEther (DME)/DME+(bio-)Propane+butane/DME+(bio-)Propane mixtures.

[0036] The combination of a pneumatic valve 3 and an extra electronic controlled gas valve 5, based on a sensor 6 and a control unit 7 to regulate the speed of a fan element 9 enables the use of standard components instead of complicated electronic controlled gas valves to fulfil both a deeper heat modulation range and gas adaptiveness requirements. In particular, a smart control algorithm can control the air flow (seed of the fan 9) and the position of the gas valve 5 between 20% and 10% (or better >0%) of the nominal load, the range where standard controller using a pneumatic gas valve can't operate properly anymore due to control signal limitations. The system 1 can be used in different modes, for example the 1:5 heat modulation range combined with only gas adaptiveness, 1:10 heat modulation range without gas adaptiveness and both 1:10 heat modulation range and gas adaptiveness.

Reference Signs

[0037]

1	System
2	Combustion appliance
3	Pneumatic gas valve
4	Gas valve apparatus
5	Electronically controlled gas valve
6	Sensor
7	Control unit
8	Actuator
9	Fan element
10	Burner
11	Manifold
12	Gas duct
13	mixer
100	Method
15	S101- S104 method steps
I	first heat modulation range
II	second heat modulation range
A	Air
G	Fuel gas
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Claims

1. Method (100) for controlling the operation of a combustion appliance (2), in particular a gas boiler, operating at least in a first heat modulation range and a second heat modulation range, the method (100) comprising:

monitoring (S101) the combustion process of the appliance (2) through a sensor (6) measuring a physical value, in particular an oxygen sensor or an ionization sensor;
controlling (S102) an air to fuel gas ratio in a gas mixture through a pneumatic gas valve (3) when the combustion appliance (2) operates in the first heat modulation range; and
controlling (S103) the air to fuel gas ratio in a gas mixture through an electronically controlled gas valve (5) when the combustion appliance (2) operates in the second heat modulation range,
wherein the method (100) comprises adjusting (S104) the electronically controlled gas valve (5) by varying a gas flow passing through said electronically controlled gas valve (5) based on a sensor signal generated by said sensor (6), when the combustion appliance (2) operates in the second heat modulation range.

2. Method (100) according to claim 1, **characterized in that** in the first heat modulation range the combustion appliance (2) operates between 100% and 20% of the nominal combustion load and in the second heat modulation range the combustion appliance (2) operates between 20% and 10%, in particular between 20% and 0%, of the nominal combustion load.

3. Method (100) according to any one of claims 1 to 2, **characterized in that** the method (100) further comprises:
- a. increasing the air flow rate when the nominal combustion load at which the combustion appliance (2) operates is increased in the first and second heat modulation range by controlling the speed of a fan element (9); and/or
 - b. decreasing the air flow rate when the nominal combustion load at which the combustion appliance (2) operates is decreased in the first and second heat modulation range by controlling the speed of a fan element (9).
4. Method (100) according to any one of claims 1 to 3, **characterized in that** monitoring (S101) the combustion process of the appliance (2) comprises measuring the oxygen value in a flue gas generated in the combustion appliance (2) and/or the oxygen value in the flue gas is adjusted by controlling the electronically controlled gas valve (5) based on the sensor signal generated by the sensor (6).
5. Method (100) according to claim 4, **characterized in that** the oxygen value in the flue gas is set to a first set value, in particular 4.3%, when the combustion appliance (2) operates at a full value of the nominal combustion load, the oxygen value in the flue gas is varied to a second set value, in particular 4.8%, by varying the air flow rate in the first heat modulation range, and the oxygen value in the flue gas is maintained to said second set value in the second heat modulation range.
6. Method (100) according to claim 5, **characterized in that** in the second heat modulation range the oxygen value in the flue gas is adjusted to the second set value by controlling both the position of the electronically controlled gas valve (5) and by controlling the air flow rate.
7. Method (100) according to claim 6, **characterized in that** in the second heat modulation range,
- a. in order to operate the combustion appliance to a reduced value of the nominal combustion load, the gas flow passing through the electronically controlled gas valve (5) is reduced and the air flow rate is decreased; and/or
 - b. in order to operate the combustion appliance to an increased value of the nominal combustion load, the gas flow passing through the electronically controlled gas valve (5) is increased and the air flow rate is increased.
8. Method (100) according to any one of claims 1 to 7, **characterized in that**
- a. in the first heat modulation range the position of the electronically controlled gas valve (5) is unchanged and in the second heat modulation range the position of the electronically controlled gas valve (5) is changed based on the sensor signal generated by the sensor (6); and/or
 - b. in the first heat modulation range the electronically controlled gas valve (5) is set to a pre-set position and/or in the second heat modulation range the electronically controlled gas valve (5) is set to a position different from the pre-set position to vary the gas flow passing through the electronically controlled gas valve (5).
9. Method (100) according to claim 8, **characterized in that** the pre-set position of the electronically controlled gas valve (5) is adjustable based on the type of the combustible or fuel gas.
10. Method (100) according to claim 8 or 9, **characterized in that**
- a. the electronically controlled gas valve (5) is adjusted in the first heat modulation range; and/or
 - b. once the electronically controlled gas valve (5) is adjusted to a pre-set position in the first heat modulation range, the position of said electronically controlled gas valve (5) is unchanged until the combustion appliance (2) operates in the second heat modulation range.
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 (1) for controlling the operation of a combustion appliance (2), in particular a gas boiler, operating between at least a first heat modulation range and a second heat modulation range, the system (1) comprising:
- a gas valve apparatus (4) for feeding fuel gas in a manifold (11) of the combustion appliance (2), the gas valve apparatus (4) comprising a pneumatic gas valve (3) for controlling an air to fuel gas ratio in a gas mixture in the first heat modulation range and an electronically controlled gas valve (5) for controlling the air to fuel gas ratio in the gas mixture in the second heat modulation range; ;
 - a sensor (6) for measuring a physical value, in particular an oxygen sensor or a ionization sensor, for monitoring the combustion process of the appliance (2), and
 - a control unit (7) connectable to the gas valve

apparatus (4) and the sensor (6), wherein the control unit (7) is configured to adjust the electronically controlled gas valve (5) by varying a gas flow passing through said electronically controlled gas valve (5) based on a sensor signal generated by said sensor (6) when the combustion appliance (2) operates in the second heat modulation range. 5

13. System (1) according to claim 12, characterized in that 10

- a. the electronically controlled gas valve (5) is a throttle valve and/or
- b. the electronically controlled gas valve (5) is connected to an actuator (8), in particular a stepper motor, connectable to the control unit (7) to control the position of the electronically controlled gas valve (5) in fixed steps and/or 15
- c. the electronically controlled gas valve (5) is located downstream the pneumatic valve (3) or is integrated in the pneumatic valve (3); and/or 20
- d. the system (1) comprises a fan element (9) connectable to the control unit (7) for varying the air flow rate in the first and the second heat modulation ranges. 25

14. Combustion appliance (2), in particular a gas boiler, comprising the system (1) according to any one of claims 12 to 13. 30

15. Use of the system (1) according to any one of claims 12 to 13 for a combustion appliance (2) using a fuel gas having at least 20mol %, in particular at least 90 mol %, hydrogen or natural gas. 35

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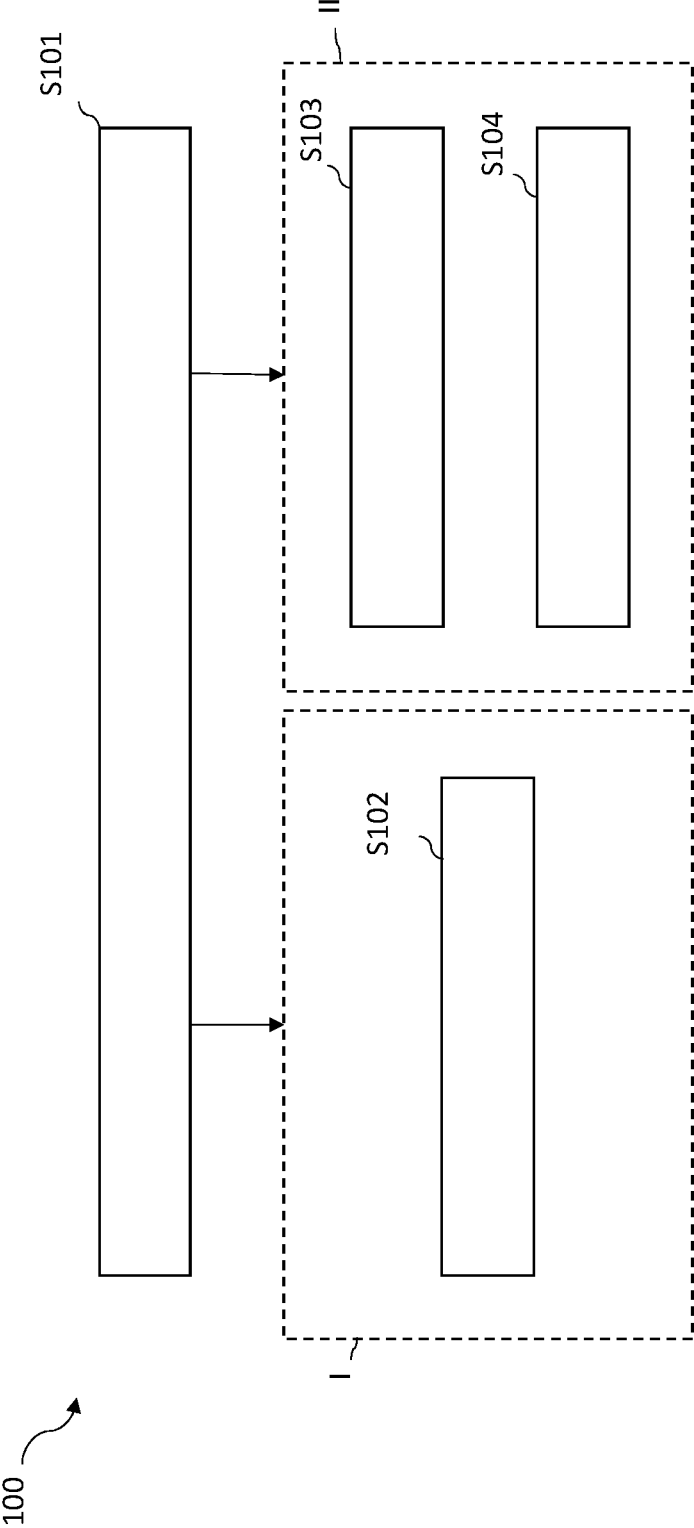


FIG. 1

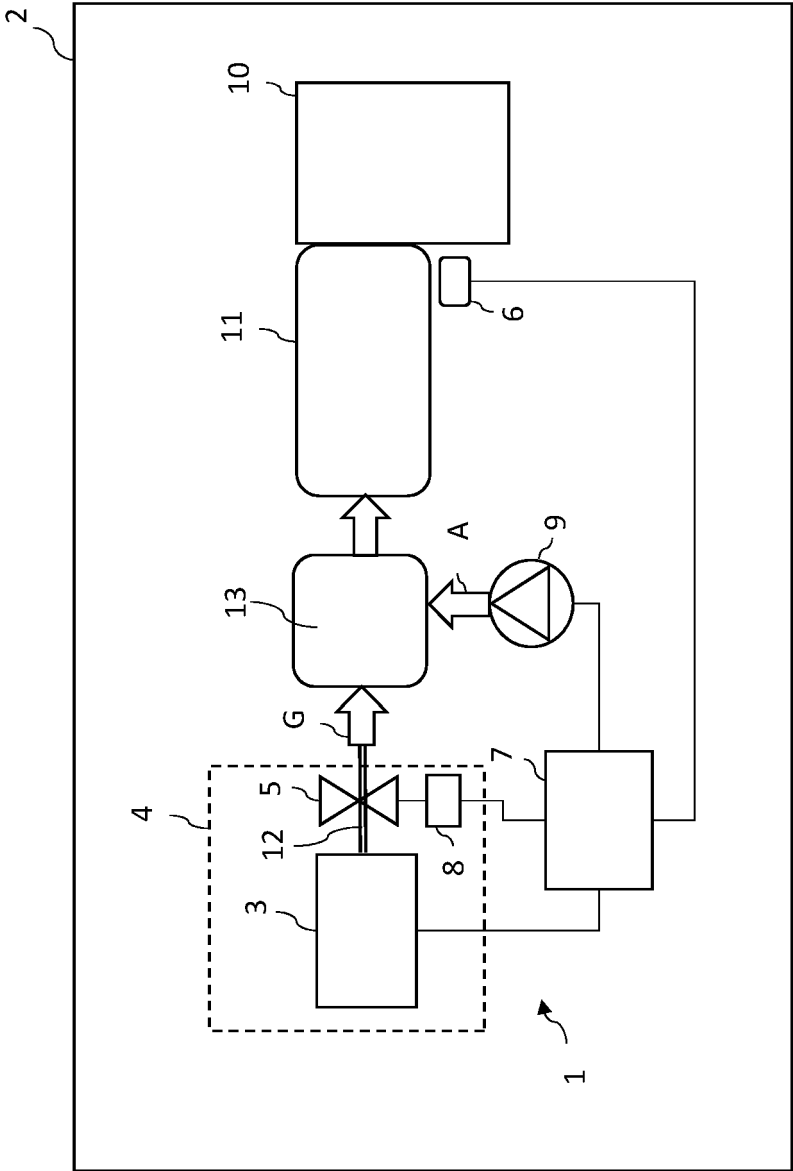


FIG. 2

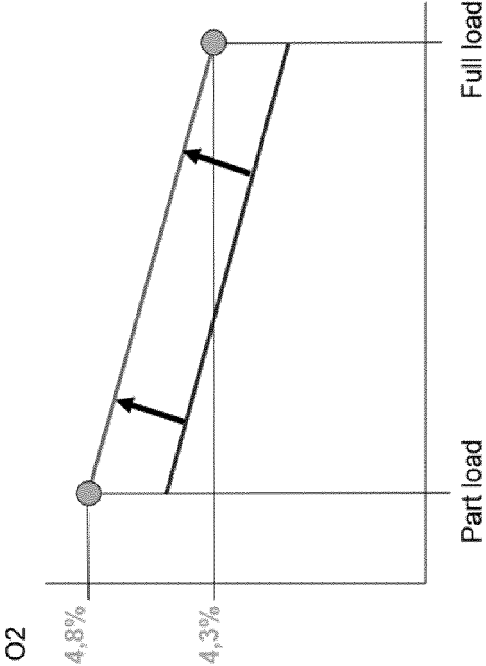


FIG. 3B

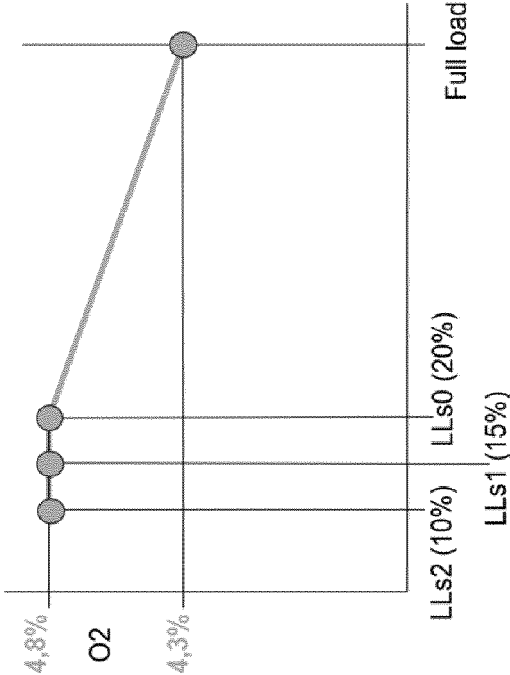


FIG. 3A



EUROPEAN SEARCH REPORT

Application Number

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Place of search Munich		Date of completion of the search 6 May 2022	Examiner Theis, Gilbert
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
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The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

06-05-2022

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