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(54) CONTROL METHOD FOR A GAS BOILER

(57) Method (100) for controlling the ignition of a burner (5) in a combustion appliance (1), in particular a gas boiler, wherein the combustion appliance (1) is operable in an ignition phase (IP) and in an operation phase (OP) after the burner (5) has ignited, the method (100) comprising providing (S101) a mixture of air and fuel gas to the combustion appliance (1), controlling (S102) one or more actuators (2, 3) of the combustion appliance (1) to regulate the air flow and/or the fuel gas flow, and defining (S103) a lambda value during the operation of the combustion appliance (1), the lambda value being an air to fuel gas ratio of the mixture, wherein the lambda value at the ignition phase (IP) is below than 1.8, in particular it is between 1.5 and 1.7.

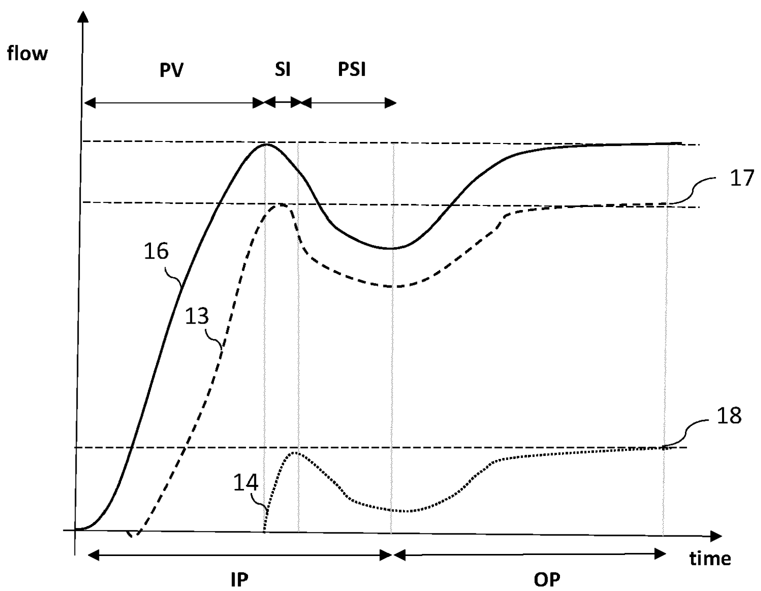

FIG. 3B

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Description

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

[0002] Gas boilers combust gas fuel 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. 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 gas and air that is set. The temperature produced by the flame is also, among other things, a function of the mix ratio between fuel gas and air. An important factor influencing the safety of the boiler is the flame or burner stability, which is defined in terms of a stable combustion and thus no or next to no occurrence of flashbacks.

[0003] The flame speed is an important factor on the flame stability and a high flame speed can cause a flashback. In case the flame speed becomes greater than the mixture velocity, the flame can traverse in the upstream direction, which is toward the burner deck and even across the burner deck into the burner causing a so-called flashback. Flashback can be triggered e.g. by a change in a ratio of the air to the fuel gas in the mixture, by a change in composition of the fuel gas. When the mixture velocity becomes too high and rises above a so-called blow-off speed, blow-off may occur which means that the flame is blown-off the burner deck, with the consequence that the flame extinguishes or suffers incomplete combustion. For this reasons, the mixture velocity and/or the flame speed needs to be controlled. The flame speed is a function of the ratio of air to fuel gas in the mixture (in the following this ratio can also be indicated as lambda). Around lambda 1 the flame speed is the highest and if lambda increases the flame speed decreases.

[0004] The control of mixture velocity is much more important when the boiler uses hydrogen as fuel gas rather than other fuel gasses such as methane. In fact, flashback can occur more easily in hydrogen boilers since the laminar flame speed of hydrogen air mixture is around eight times higher than the flame speed for methane air mixture (with reference to the stoichiometric condition).

[0005] Methods are known in prior art for controlling the value of lambda during different operations of a combustion appliance. In operation between a minimum load and a maximum load for example, the value of lambda can be controlled to continuously lower its value. Usually, during the start-up phase the premixed gas is ignited at a first lambda value that is much higher than the lambda value during the operation phase. However, this could lead to a higher risk of flashback.

[0006] It is therefore desirable to provide a method for controlling the ignition of a burner of a combustion appliance in which the risk of flashback is reduced.

[0007] The object is solved by a method for controlling the ignition of a burner in a combustion appliance, in particular a gas boiler, wherein the combustion appliance is operable in an ignition phase and in an operation phase after the burner has ignited, the method comprising:

providing a mixture of air and fuel gas to the combustion appliance,
controlling one or more actuators of the combustion appliance to regulate the air flow and/or the fuel gas flow, and
defining a lambda value during the operation of the combustion appliance, the lambda value being an air to fuel gas ratio of the mixture, wherein the lambda value at the ignition phase is below than 1.8, in particular it is comprised between 1.5 and 1.7.

[0008] Advantageously, the value of the air to the fuel gas ratio in the gas mixture is controlled to avoid the risk of flashback. As is explained below more in the detail, the invention has the advantage that the setting parameters, i.e. specific parameters for air and gas, in the ignition phase can be the same as during the operation (at the same condition).

[0009] In one example, the combustion appliance operates between a minimum load and a maximum load, the maximum load being comprised between 27kW and 29 kW, in particular 28kW and the minimum load being comprised between 6kW and 7kW, in particular 6.5kW.

[0010] In another example, the combustion appliance operates according to operational parameters, said operational parameters in the ignition phase being the same as in the operation phase. This simplifies the operation of the combustion appliance. In particular, the operational parameters comprise at least one of the air flow rate, the fuel gas flow rate, and the power of the combustion appliance.

[0011] In examples, the ignition phase the power of the combustion appliance is comprised between 12 kW and 15 kW. In particular, the ignition phase occurs at about half of the maximum power.

[0012] According to an example, the ignition phase comprise a pre-ventilation phase (PV), a spark ignition phase (SI) and a post spark ignition phase (PSI), wherein in the pre-ventilation phase (PV) the value of the air flow rate increases and the value of the fuel gas flow rate is zero. In particular, in the spark ignition phase (SI) the value of the air flow rate has reached a predetermined ignition value, in particular a local maximum value, and/or the value of the fuel gas flow rate at least partly increases in the spark ignition phase. In particular, the fuel gas flow rate continuously increases until it reaches the predetermined ignition value. The predetermined ignition value is the value by means of which the ignition works well and/or depends on the load. This value can then further increase to a maximum heat input or decrease to a minimum heat input during the operation phase.

[0013] In examples, in the post spark ignition phase (PSI) the value of both the airflow rate and the fuel gas flow rate decreases.

[0014] In one example, in the operation phase the value of both the air flow rate and the fuel gas flow rate increases to reach an air operation value and a gas operation value, respectively,. The operation value is selected such that an excess of air remains.

[0015] According to an example, the predetermined ignition value, in particular the local maximum value, of the air flow rate reached in the ignition phase corresponds to the ignition load or is arranged in a predetermined range comprising the ignition load reached in operation phase. Also, the predetermined ignition value, in particular the local maximum value, of the fuel gas flow rate reached in the ignition phase corresponds to the ignition load or is arranged in a predetermined range comprising the ignition load reached in operation phase.

[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 another aspect of the invention, a control unit is provided, the control unit performing the inventive method.

[0018] According to one aspect of the invention, a combustion appliance, in particular a gas boiler, is provided, the combustion appliance comprising:

a burner for receiving a mixture of air and fuel gas from a gas mixture channel and for combusting said mixture;
one or more actuators located upstream the gas mixture channel o regulate the air flow and/or the fuel gas flow; and
the inventive control unit connected to the one or more actuators for controlling a lambda value during the operation of the combustion appliance, the lambda value being an air to fuel gas ratio of the mixture.

[0019] In one example, the combustion appliance comprises at least two actuators including a fan element located in an air supply line and a gas valve located in a gas supply line.

[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 more than 20 mol%, preferably more than 30 mol% of hydrogen, in particular the fuel gas comprises at least 95 mol % hydrogen.

[0021] In other aspects of the invention, a data processing apparatus is provided. This data processing apparatus comprises a processor for executing the inventive computer program product. Also, a computer readable data carrier is provided, the carrier having stored thereon the inventive computer program product.

[0022] 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 schematic representation of a combustion appliance according to an example.
Figure 2	shows a flow chart of a method for controlling the operation of a combustion appliance according to an example.
Figures 3A-B	show the variation of the lambda value as a function of the load and of the air and gas flow rate as a function of the time according to an example.

[0023] Figure 1 illustrates a heating system 15 comprising a combustion appliance 1 such as gas boiler used for the combustion of fuel gas, for example containing hydrocarbons and/or hydrogen. The fuel gas is mixed with air and is provided to the burner 5 through a gas mixture channel 8, the burner 5 being coupled to a heat exchanger 7 for heating water for domestic use and/or central heating system facilities in buildings. The gas mixture channel 8 receives air from an air supply line 9 and fuel gas from a gas supply line 10. The flow of air - and correspondingly the flow of the air/fuel gas mixture - can be regulated by a fan element 2 located in the air supply line 9. Advantageously, the fan element 2 is located upstream the region where the fuel gas is inserted into the gas mixture channel 8. The gas supply line 10 is provided with a gas valve 3 for regulating the fuel gas flow entering the gas mixture channel 8. The heating system 15 comprises furthermore a control unit 4 connected to the fan element 2 and the gas valve 3 to regulate and eventually adapt the air to fuel gas ratio. A manifold mixer 6 is provided in gas mixture channel 8 at the joint region where the gas supply line 10 is connected to the gas mixture channel 8.

[0024] By acting on the fan element 2 and/or the gas valve 3, the control unit 4 can regulate the air to fuel gas ratio in the gas mixture channel 8 that is supplied to the burner 5. Accordingly, the value of lambda can be varied during the operation of the combustion appliance. For example, if the combustion appliance 1 is operating between a minimum load to a maximum load, the value of lambda can be changed in the load range between the minimum load and the maximum load.

[0025] Figure 2 shows a flow chart of the method 100 for controlling the ignition of the burner 5 of the combustion appliance 1 and in particular for operating a gas boiler, as described above, when operating in an ignition phase (IP) and in an operation phase (OP).

[0026] At step S101, the method comprises providing a mixture of air and fuel gas to the combustion appliance

1 and at step S102 the method comprises controlling one or more actuators to regulate the air flow and/or the fuel gas flow. The actuators can be for example the fan element 2 to regulate the air flow and the gas valve 3 to regulate the fuel gas flow. At step S103, the air to fuel gas ratio of the mixture is defined during the operation of the combustion appliance 1. This ratio is the lambda value. During the ignition phase, the lambda value is below 1.8. In particular, this value is between 1.5 and 1.7.

[0027] The trend of the lambda value in the load range is shown in figure 3A. In particular, the figure illustrates a comparison between a first lambda value curve 11 according to the present disclosure (thicker line) and a second lambda value curve 12 according to prior art (thinner line) describing the variation of the lambda value as a function of the operating load of the combustion appliance 1.

[0028] According to the second lambda value curve 12, or prior art lambda value, the value of lambda continuously decreases within a load range defined by a first load value (Q_1) representing the lowest load value (for example 5kW) and a second load value (Q_2) representing the highest load value (for example 25kW). Usually, at the first load value (Q_1) lambda has the highest value (for example more than 1.8) and at the second load value (Q_2) lambda assumes the smallest value (for example less than 1.3, in particular less than 1.2). It is noted that in the load range between the first and the second load values (Q_1, Q_2), the lambda value curve 12 decreases in a steep way. The ratio between the lambda value at the first load (Q_1) and the lambda value at the second load (Q_2) is more than 1.2, in particular 1.5.

[0029] The first lambda value curve 11 according to the present disclosure behaves in a completely different way. First of all, it is noted that the first lambda value curve 11 is less steep compared to the second lambda value curve 12. As a matter of fact, the ratio between the lambda value at the minimum load (Q_{min}) and the lambda value at the maximum load (Q_{max}) is less than 1.2, in particular 1.13. Furthermore, in the load range between the minimum load (Q_{min}) and the maximum load (Q_{max}) the lambda value decreases, in particular continuously decreases, and then stops to decrease in a final load range at the maximum load (Q_{max}) (second load range). In particular at the maximum load (Q_{max}), the lambda value can either increase (dashed line) or remain almost constant (straight line). It is furthermore noted that to have more margin (to consider also the tolerances of the system), the maximum load (Q_{max}) is higher than the second load (Q_2) of the second lambda value curve 12. For example, the maximum load (Q_{max}) is at 28kW.

[0030] The first lambda value curve 11 is an example of a possible behavior of the lambda value as a function of the load according to the present disclosure. In this case, the lambda value at the minimum load (Q_{min}) is 1.7 and the lambda value at the maximum load (Q_{max}) is 1.5 or 1.6, so that the ratio between the lambda value at the minimum load (Q_{min}) and the lambda value at the maximum load (Q_{max}) is 1.13 or 1.06. Of course, other specific lambda values can be considered. What is important is that the lambda value curve does not have a steep behavior in the load range between the minimum load (Q_{min}) and the maximum load (Q_{max}). In particular, it is noted that the ignition happens at circa middle power at about 12-15kW (Q_{mid}). in this case, with the lambda value is between 1,5 and 1,7 that is far from 1.85 of prior art. If the boiler works during the normal operation at this range of power the air and gas flow rate are the same of the ignition phase as shown in figure 3B.

[0031] Once the burner 5 is ignited, the system modulates following the heating request (operation phase - OP).

[0032] With reference to figure 3B, the air flow rate 13, the gas flow rate 14 and the fan speed 16 are shown as a function of time, in particular during the ignition phase (IP) and the operation phase (OP) of the combustion appliance 1. The ignition phase (IP) comprises a pre-ventilation phase (PV), a spark ignition phase (SI) and a post spark ignition phase (PSI). In the pre-ventilation phase (PV), the value of the air flow rate 13 increases and the value of the fuel gas flow rate 14 is zero. As a matter of fact, after a heating request, the fan element 2 is activated and an air sensor is able to detect the air flow. However, the gas valve 3 is still close.

[0033] In the spark ignition phase (SI) the value of the air flow rate 13 reaches a predetermined ignition value, in particular its local maximum, and the value of the fuel gas flow rate 14 firstly increases and then slightly decreases. When the air flow reaches the correct value (at not fixed rpm), the gas valve 3 opens. A gas sensor is able to measure the gas flow and the ignitor sparks to ignite the air/gas mixture.

[0034] In the post spark ignition phase (PSI) the value of both the air flow rate 13 and the fuel gas flow rate 14 slightly decreases. In the operation phase (OP), the value of both the air flow rate 13 and the fuel gas flow rate 14 increases again to reach an air operation value 17 and a gas operation value 18, respectively.

[0035] It is noted that the predetermined ignition value, in particular local maximum value, of the airflow rate 13 reached in the ignition phase (IP) corresponds to the ignition load or is in predetermined range comprising the ignition load. In other words, the air operation value 17 has basically the same value of the air flow rate value during ignition, that is at middle power, Q_{mid}.

[0036] In a similar way, the predetermined ignition value, in particular the local maximum value, of the fuel gas flow rate 14 reached in the ignition phase (IP) corresponds to the ignition load is in a predetermined range comprising the ignition load. In other words, the gas operation value 18 has basically the same value of the gas flow rate value during ignition, that is at middle power, Q_{mid}.

[0037] Therefore, the setting parameters (specific parameters for air and gas) in the ignition phase (IP) are the same as during the operation phase (OP).

[0038] A dedicated software can be used to build an air/gas curve step by step from 0% to 100% and to modify the lambda value in each point (with some software limits to have a safe behaviour).

Reference Signs

[0039]

1	Combustion appliance
2	Fan element
3	Gas valve
4	Control unit
5	Burner
6	Manifold mixer
7	Heat exchanger
8	Gas mixture channel
9	Air supply line
10	Gas supply line
11	First lambda value curve
12	Second lambda value curve (prior art)
13	Air flow rate
14	Gas flow rate
15	Heating system
16	Fan speed
17	Air operation value
18	Gas operation value
Qmin	Minimum load
Qmax	Maximum load
Q_1	First load
Q_2	Second load
Q_{mid}	Middle power
IP	Ignition phase
OP	Operation phase
PV	Pre ventilation phase
SI	Spark ignition phase
PSI	Post spark ignition phase
100	Method

Claims

1. Method (100) for controlling the ignition of a burner (5) in a combustion appliance (1), in particular a gas boiler, wherein the combustion appliance (1) is operable in an ignition phase (IP) and in an operation phase (OP) after the burner (5) has ignited, the method (100) comprising:

   providing (S101) a mixture of air and fuel gas to the combustion appliance (1), controlling (S102) one or more actuators (2, 3) of the combustion appliance (1) to regulate the air flow and/or the fuel gas flow, and
   defining (S103) a lambda value during the operation of the combustion appliance (1), the lambda value being an air to fuel gas ratio of the mixture,
   wherein the lambda value at the ignition phase (IP) is below than 1.8, in particular it is between 1.5 and 1.7.

2. Method (100) according to claim 1, **characterized in that** the combustion appliance (1) operates between a minimum load and a maximum load, the maximum load being comprised between 27kW and 29 kW, in particular 28kW and the minimum load being comprised between 6kW and 7kW, in particular 6.5kW.

3. Method (100) according to any one of claims 1 to 2, **characterized in that** the combustion appliance (1) operates according to operational parameters, said operational parameters in the ignition phase(IP) being the same as in the operation phase (OP).

4. Method (100) according to claim 3, **characterized in that** the operational parameters comprise at least one of the air flow rate, the fuel gas flow rate, and the power of the combustion appliance (1).

5. Method (100) according to any one of claims 1 to 4, **characterized in that** in the ignition phase (IP) the power of the combustion appliance (1) is comprised between 12 kW and 15 kW.

6. Method (100) according to any one of claims 1 to 5, **characterized in that** the ignition phase (IP) comprise a pre-ventilation phase (PV), a spark ignition phase (SI) and a post spark ignition phase (PSI), wherein in the pre-ventilation phase (PV) the value of the air flow rate (13) increases and the value of the fuel gas flow rate (14) is zero.

7. Method (100) according to claim 6, **characterized in that** in the spark ignition phase (SI) the value of the air flow rate (13) has reached a predetermined ignition value, in particular a local maximum, and/or the value of the fuel gas flow rate (14) at least partly increases in the spark ignition phase.

8. Method (100) according to any one of claims 6 to 7, **characterized in that** in the post spark ignition phase (PSI) the value of both the air flow rate (13) and the fuel gas flow rate (14) decreases.

9. Method (100) according to any one of claims 6 to 8, **characterized in that** in the operation phase (OP) the value of both the air flow rate (13) and the fuel gas flow rate (14) increases to reach an air operation value (17) and a gas operation value (18), respectively.

10. Method (100) according to any one of claims 6 to 9, **characterized in that**

a. the predetermined ignition value, in particular the local maximum value, of the air flow rate (13) reached in the ignition phase (IP) corresponds to the ignition load or is arranged in a predetermined range comprising the ignition load; and/or
b. the maximum value of the fuel gas flow rate (14) reached in the ignition phase (IP) corresponds to the ignition load or is arranged in predetermined range comprising the ignition load.

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. Control unit (4) for performing the method (100) according to one of the claims 1 to 10.

13. Combustion appliance (1), in particular a gas boiler, the combustion appliance (1) comprising:

a burner (5) for receiving a mixture of air and fuel gas from a gas mixture channel (8) and for combusting said mixture;
one or more actuators (2, 3) located upstream the gas mixture channel (8) to regulate the air flow and/or the fuel gas flow; and
the control unit (4) according to claim 12 connected to the one or more actuators (2, 3) for controlling a lambda value during the operation of the combustion appliance (1), the lambda value being an air to fuel gas ratio of the mixture.

14. Combustion appliance (1) according to claim 13, **characterized in that** the combustion appliance (1) comprises at least two actuators (2, 3) including a fan element (2) located in an air supply line (9) and a gas valve (3) located in a gas supply line (8).

15. Combustion appliance (1) according to claim 13 or 14, **characterized in that** the fuel gas flowing in the combustion appliance (1) comprise more than 20 mol%, preferably more than 30 mol% of hydrogen, in particular the fuel gas comprises at least 95 mol % hydrogen.

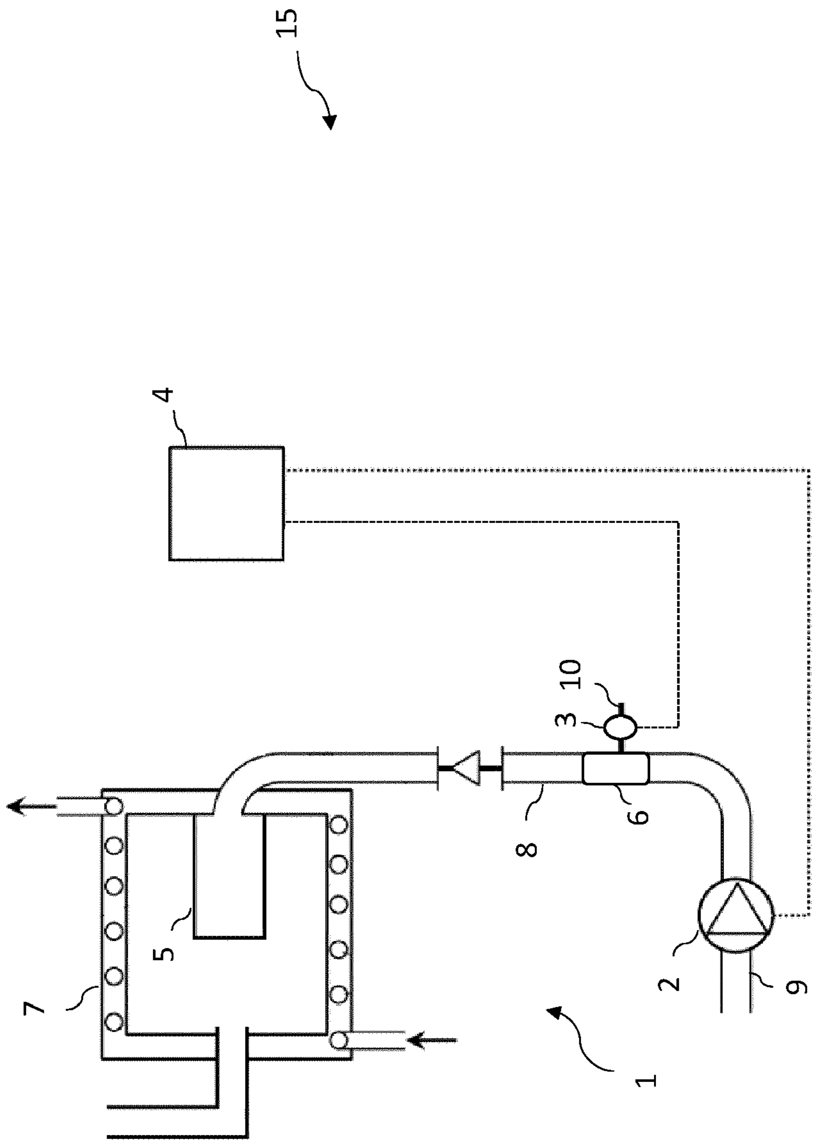

FIG. 1

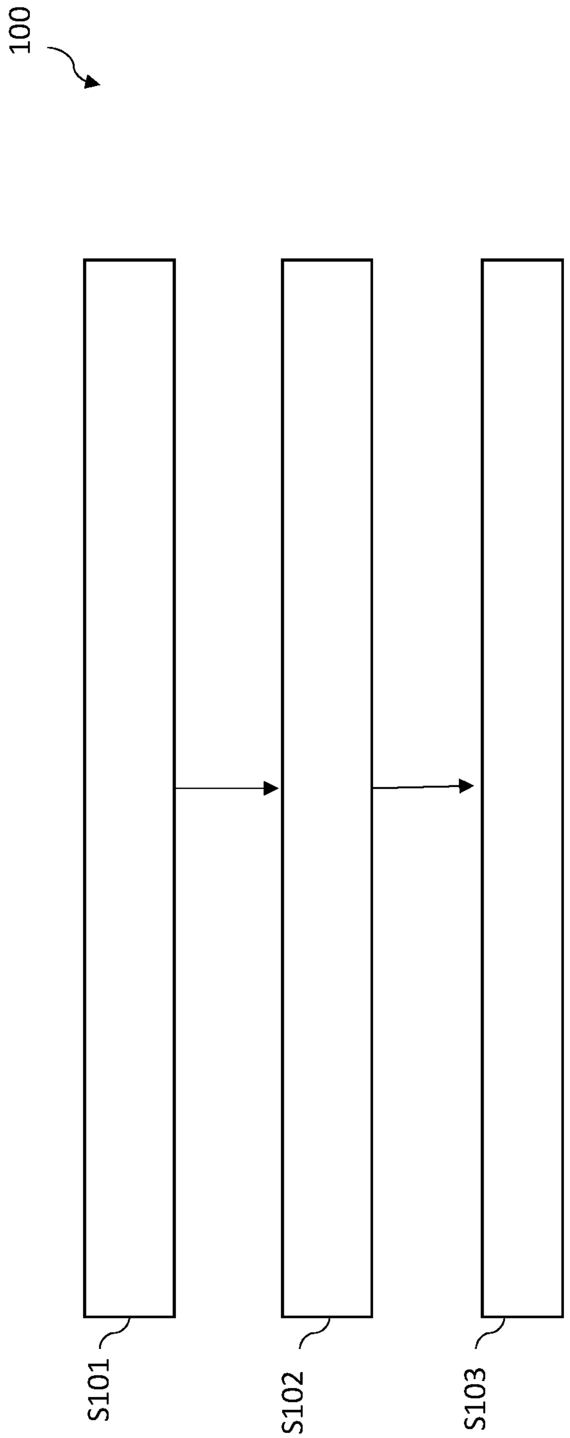

FIG. 2

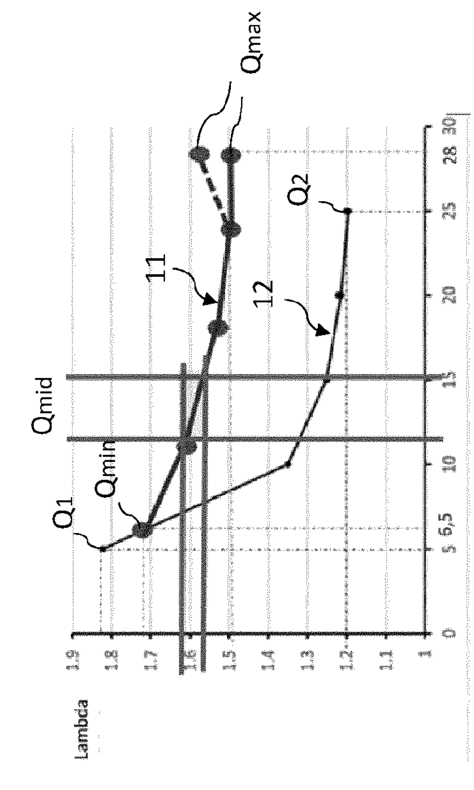
Lambda
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0
5
6,5
10
15
20
25
28
30
Load Q (kW)
Q1
Qmin
Qmid
Qmax
Q2
11
12

FIG. 3A

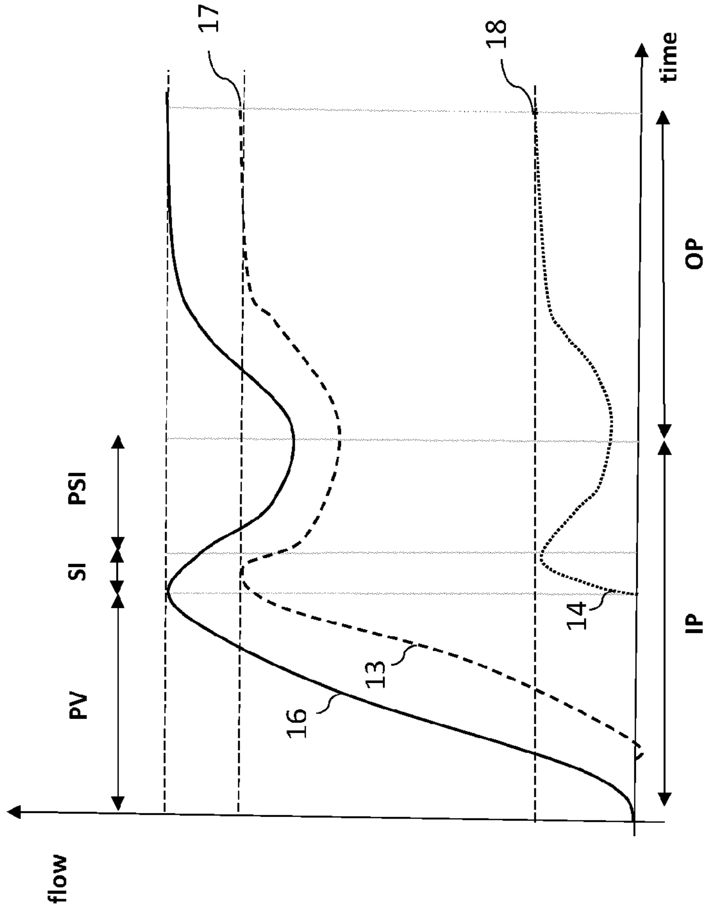
flow
time
PV
SI
PSI
IP
OP
16
13
14
17
18

FIG. 3B

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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 5089

DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 2022/163203 A1 (TEN HOEVE DIRK [NL] ET AL) 26 May 2022 (2022-05-26) * paragraphs [0001] - [0003]; figures 2a, 2b, 3a, 3b,6-8 * * paragraph [0008] - paragraph [0027] * * paragraph [0036] - paragraph [0044] * * paragraphs [0073], [0074] * * paragraph [0076] - paragraph [0078] * * paragraphs [0097], [0116], [0118] * * paragraph [0144] - paragraph [0149] * * claims 1-26 *	15	TECHNICAL FIELDS SEARCHED (IPC) F23D F23C F23N

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	10 January 2023	Hauck, Gunther

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 18 5089

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