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(54) **METHOD FOR CONTROLLING THE OPERATION OF A COMBUSTION APPLIANCE**

(57) Method (100) for controlling the operation of a combustion appliance (1), in particular a gas boiler and more particularly a combi gas boiler, during a heating up process, the method (100) comprising measuring (S101) a time duration (Δt) of the heating up process until a target temperature (T_s) is achieved, determining (S102) an expected time duration (Δt^*) of the heating up process

based on said target temperature (T_s), determining (S103) a time deviation (TD), the time deviation (TD) being the difference between the measured time duration (Δt) and the expected time duration (Δt^*), and determining (S104) the presence of an error in the operation of the combustion appliance (1), if the time deviation (TD) is greater than at least a time error value (ϵ_1 , ϵ_2).

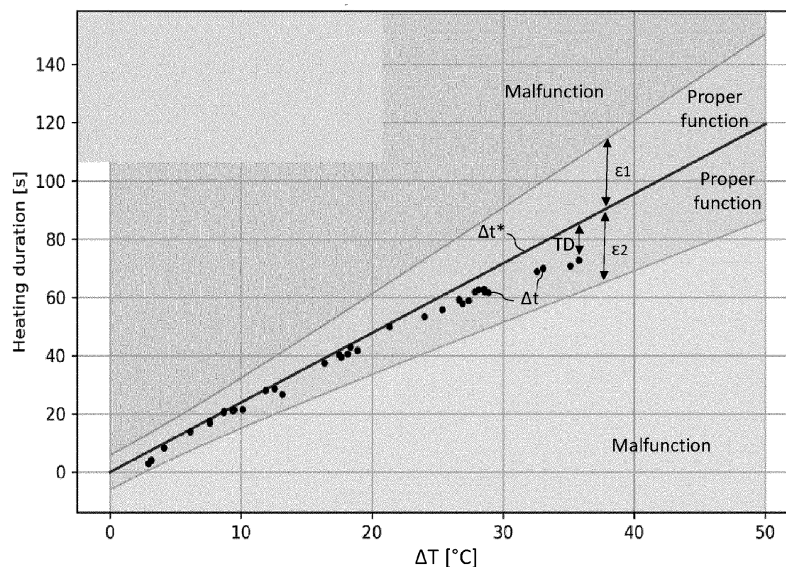


FIG. 4

Description

[0001] The invention relates to a method for controlling the operation of a combustion appliance, in particular a gas boiler and more particularly a combi gas boiler. Also, the invention relates to a computer program product executed by a computer carrying out the above method, a data processing apparatus comprising a processor for executing said computer program product and a combustion appliance comprising means for carrying out the method and/or said data processing apparatus. In addition, the invention relates to a use of the computer program or the data processing apparatus for the detection or prediction of a malfunction of a three way gas valve and/or the presence of gas-sided clogging in the combustion appliance, in particular in a gas boiler and more particularly a combi gas boiler.

[0002] Combustion appliances such as gas boilers combust gaseous fuel to heat water for domestic use and/or central heating system facilities in buildings. During operation, a gas valve connected to the boiler opens and gas enters into a sealed combustion chamber, where the fuel is burnt. Heat is then transferred to the water that flows over an exchanger. A pump can be used to push the hot water through to the radiators and taps. A three way mixing valve can be employed to control the temperature of the water flowing on the system. In particular, hot water enters a first port of the three way valve and mixes with cool return water entering through a second port. The resulting mix flows out through a third port and is transferred to radiators and/or taps. A three way mixing valve can be employed to control the flow of the water in the system. In particular, the valve is used for guiding the water flow between two circuits, i.e., over the plate heat exchanger or domestic hot water (DHW) circuit (internal circuit) and over the central heating (CH) circuit (external circuit).

[0003] Such a three way mixing valve can be used in combi boilers. A combi boiler is able to quickly deliver warm water when this is requested. To speed up the delivery of warm water, the boiler can maintain a high internal water temperature (even when idle). This reduces the time required to heat up the boiler. This internal heating up is called a "comfort heating".

[0004] A malfunctioning of a three way mixing valve is a common problem since it can wear or break overtime, thereby causing problems on central heating systems. There are several symptoms highlighting that the three way mixing valve could be faulty, i.e. lukewarm water in the taps, malfunctioning in the heating, unwanted heating of the CH system, obtaining only hot water in case the valve is stuck on the hot water side, etc... However, it is not straightforward to trace back each of these symptoms univocally to a faulty three way valve, since other causes can be taken into account. Therefore, in this case, a careful and time consuming inspection of all the components of the boiler is necessary in order to actually determine the real cause of the above-mentioned symptoms. Also,

such an inspection is carried out only when the malfunction has already occurred, for example when one component of the appliance has already broken.

[0005] It is therefore desirable to obtain an efficient and cost-effective method for controlling the operation of a combustion appliance and determining if an error in said operation, due for example to a malfunctioning of the three way valve, is present, or predicting if such an error is going to occur.

[0006] The object is solved by a method for controlling the operation of a combustion appliance, in particular a gas boiler and more particularly a combi gas boiler, during a heating up process, the method comprising:

measuring a time duration of the heating up process until a target temperature is achieved;
determining an expected time duration of the heating up process based on said target temperature;
determining a time deviation, the time deviation being the difference between the measured time duration and the expected time duration; and
determining the presence of an error in the operation of the combustion appliance, if the time deviation is greater than at least a time error value.

[0007] In this way, it is possible to detect the failure of the system based on the calculation of a parameter, such as the duration of the heat-up process, without the need of directly checking the single components of the system.

The heating up process is intended here as a heating process, in which the combustion appliance passes from an initial temperature to a final temperature, that can be preset temperatures. In particular, the final temperature is higher than the initial temperature. For example, the heating up process can be a "comfort heating" process of a combi boiler. Accordingly, the time duration of the heating process is intended as the time necessary to reach the final temperature, i.e. the target temperature, starting from the initial temperature, i.e. the start temperature. According to the method, a time deviation is determined and is compared to a time error value. It is noted that determining whether the time deviation is greater than said time error value means determining whether the measured time duration is much longer or much shorter (compared to the error value) than the expected time duration.

[0008] In one example, the expected time duration of the heating up process is based on:

a temperature difference between the target temperature and a start temperature; and/or
the power of the combustion appliance at a minimum speed of a fan element; and/or
the heat capacity of the combustion appliance. In other words, given specific characteristics of the combustion appliance, i.e. the heat capacity and the power of the appliance, the expected time duration of the heating up process can be calculated by simply

measuring the water temperature of the appliance. Therefore, already existing sensors, i.e. water temperature sensors, can be used for this purpose without the need of modifying the hardware of the system.

[0009] In another example, the time error value varies based on a temperature difference between the target temperature and a start temperature and/or the time error value increases by increasing a temperature difference between the target temperature and a start temperature. In other words, even considering the same combustion appliance, the time error value is not fixed and depends at least on the temperature measured and the preset temperature of the heating up process. For example, for a long heating up process, i.e. for a heating process with a large difference between the initial and final temperature, a longer time error value needs to be overcome in order to determine the presence of an error. Also, the time error value can vary based on the heat capacity and the power of the combustion appliance.

[0010] In particular, the time error value can correspond to a first time error value or a second time error value, wherein the first time error value defines a first region in which the measured time duration is longer than the expected time duration and the second time error value defines a second region in which the measured time duration is shorter than the expected time duration. Accordingly, when the measured time duration is longer than the expected time duration, the presence of an error is determined if the time deviation is greater than the first time error value. On the other hand, when the measured time duration is shorter than the expected time duration, the presence of an error is determined if the time deviation is greater than the second time error value. It is noted that with the term "region" is intended a collection of values of the time deviation for the same temperature difference between the target temperature and the starting temperature.

[0011] The first time error value can be equal to the second time error value so that the regions within the time error value where the measured time duration is different (longer or shorter) from the expected time duration extend symmetrically with respect to the expected time duration. Alternatively, the first time error value can be longer or shorter than the second time error value.

[0012] According to an example, during the heating up process, a gas burner of the combustion appliance burns at a constant load, and/or the speed of a pump element of the combustion appliance is fixed, and/or a water flow is guided over a first circuit of the combustion appliance. In particular, the heating up process can be a "comfort heating" of a combi boiler. With "first circuit" is intended here a water flow circuit that is internal to the combustion appliance, wherein the water circulates between the primary heat exchanger and the plate heat exchanger.

[0013] Before measuring the time duration of the heating up process, the method can further comprise acquiring

sensor data, and determining if the combustion appliance is performing the heating up process based on said sensor data. In particular, sensor data are acquired periodically and comprise at least a value of a water flow speed over a second circuit of the combustion appliance, and/or the functioning of a gas burner of the combustion appliance. For example, the method can determine the presence of the heating up process if the domestic hot water (DHW) of the combustion appliance (for example a boiler) flow speed is zero and the burner of the combustion appliance is burning for the DHW. It is noted that this situation is typical for a "comfort heating" of a combi boiler. Therefore, the acquisition of these sensor data are basically related to the presence of a "comfort heating" process.

[0014] In a further example, the method comprises predicting that an error in the operation of the combustion appliance is going to occur, if the time deviation is approaching the time error value after carrying out the method on the same combustion appliance for a plurality of times. In other words, by periodically repeating the method, it is possible to determine a trend in the time deviation that could show a prediction that an error is going to occur, i.e. if the time deviation is approaching the time error value. This could be very helpful in terms of the maintenance service so that a component of the combustion appliance (i.e. a valve) can be replaced or adjusted before it causes a malfunctioning of the entire heating system.

[0015] Before measuring the time duration of the heating up process, the method can further comprise reading set parameters of the combustion appliance, and/or checking if the heating up process is enabled in the combustion appliance. It is noted that the method can be carried out only if the heating up process is enabled. Should the heating up process not be enabled, there would not be any useful data to analyze.

[0016] Also, the method can comprise checking if preconditions on the operation of the internal heating process are met. In particular, the preconditions comprise that the heating up process ends when the target temperature is reached, and/or the time duration of the heating up process is longer than a minimum duration value. In case these preconditions are not satisfied, the time duration cannot be estimated in a correct way. For example, the starting temperature needs to be set after an initial adaptation period that corresponds to said minimum duration value.

[0017] According to a further example, the determined error in the operation of the combustion appliance is caused by the malfunctioning of an internal valve, in particular a three way valve, of the combustion appliance, and/or the presence of a gas-sided clogging in the combustion appliance. In this way, the malfunctioning of a three-way valve can be directly established by determining the time deviation and comparing said time deviation with the time error value, as mentioned above. Without the need of carefully inspecting all the components of the

heating system possibly causing the error, it is possible to identify the nature of the malfunctioning by simply carrying out the above described method.

[0018] In another example, in order to take the measuring errors into account, the method comprises calculating an uncertainty value of the expected time duration of the heating up process and determining the time deviation taking the uncertainty value into account.

[0019] In a further example, the method comprises initiating the heating up process of the combustion appliance in a remote manner, and/or collecting technical specification data of the combustion appliance and determining the presence of an error in the operation of the combustion appliance by a logging device connected to a cloud network, wherein in particular the logging device is a connected gateway or a thermostat having an Internet connection, and/or generating and sending a feedback information to an end user in case the presence of an error in the operation of the combustion appliance is determined. This can be extremely useful for controlling the operation of the combustion appliance in a remote manner, for example by a specialized personnel. In particular, it is possible to regularly monitor the functioning of the appliance and precisely identifying the cause of a malfunctioning or promptly initiating the maintenance service before the malfunctioning occurs.

[0020] 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.

[0021] In a further aspect of the invention, a data processing apparatus is provided. This data processing apparatus comprises a processor for executing the inventive computer program product.

[0022] According to one aspect of the invention, a combustion appliance, in particular a gas boiler and more particularly a combi gas boiler, is provided, the combustion appliance comprising means for carrying out the inventive method and/or comprising the inventive data processing apparatus. 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.

[0023] 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 at least 20% hydrogen or natural gas or mixtures thereof.

[0024] In another aspect of the invention, the use of the inventive computer program product, or of the inventive data processing apparatus for the detection or the prediction of a malfunction of a three way valve and/or the presence of gas-sided clogging in a combustion appliance, in particular a gas boiler and more particularly a combi gas boiler.

[0025] 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.

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|----|--------------|--|
| 5 | Figure 1 | shows a flow chart of a method for controlling a combustion appliance according to an example. |
| 10 | Figure 2 | show a schematic representation of a combustion appliance according to an example. |
| 15 | Figures 3A-B | show two diagrams representing the variation of the combustion appliance temperature and of the difference of temperature derivatives as a function of time. |
| 20 | Figure 4 | shows a diagram representing the time deviation of the combustion appliance as a function of the temperature. |
| 25 | Figure 5 | shows flow chart of a method for controlling a combustion appliance according to another example |

[0026] With reference to figure 1, a flow chart describing a method 100 for controlling the operation of a combustion appliance 1 is shown. In particular, the method is carried out during a heating up process, in particular a comfort heating in a combi boiler. At step S101, the method 100 comprises measuring a time duration Δt of the heating up process until a target temperature T_s is achieved. The target temperature T_s is a pre-set temperature that is related to the achievement of the particular heating up process carried out by the combustion appliance 1. An expected time duration Δt^* of the heating up process is determined at step S102. In particular, the expected time duration Δt^* is calculated based on the pre-set target temperature T_s . At step S103, a time deviation TD of the duration of the heating process is determined. In particular, the time deviation TD is the difference between the measured time duration Δt and the expected time duration Δt^* . If the time deviation TD is greater than at least a time error value ε_1 , ε_2 , an error in the operation of the combustion appliance 1 is determined at step S104.

[0027] This method is used to calculate the time required for a combustion appliance, e.g. a boiler) to heat up its internal water circuit. This calculated heat up duration is compared to the measured heat up duration. If the measured heat up duration is significantly longer or shorter (outside the error margin or time error value) than the measured heat up duration, there are two plausible causes: the three-way valve is leaking from the internal water circuit to the external water circuit, and/or a gas-sided clogging has occurred.

[0028] The error margin is derived from boiler param-

eters determined in laboratory measurements for each boiler type or variant. To reduce the error margin, a t-zero measurement can be performed at installation. During each service visit, the t-zero can be renewed.

[0029] This method is particularly useful for combi boilers. As already mentioned, a combi boiler must be able to quickly deliver warm water when this is requested. To speed up the delivery of warm water, the boiler can maintain a high internal water temperature (even when idle). This reduces the time required to heat up the boiler. This internal heat up is called a "comfort heating". A schematic drawing of a comfort heating inside a combustion appliance 1 (e.g. combi boiler) is illustrated in figure 2. The combustion appliance 1 comprises a first circuit or internal circuit IC, wherein hot water flows through the primary heat exchanger 2, the plate heat exchanger 4 and a pump element 3 and a second circuit or external circuit EC, wherein the water (cold and lukewarm) flows for example to and from radiators. A three way mixing valve 5 connects the internal circuit IC to the external circuit EC at one portion of the flowing circuit. During a comfort heating process, the primary heat exchanger powered by a gas burner 2 / plate heat exchanger 4 system burns at a constant load and the speed of the pump element 3 is fixed. Also, the three-way valve 5 is in the Domestic Hot Water (DHW)-position to guide the water flow over the internal circuit IC. The internal flow is guided over the internal circuit side of the plate heat exchanger 4. There is no flow over the external circuit-side. The position of the three-way valve 5 prevents therefore any flow over the external circuit EC.

[0030] The temperatures during a typical comfort heating are shown in Figure 3A and 3B. Figure 3A illustrates three temperature values of the combustion appliance 1 as a function of the time. The first temperature value (indicated with the letter A in the figure) represents the variation of the temperature flow, i.e. the temperature on the flow pipe (hot water leaving the combustion appliance 1). The second temperature value (indicated with the letter B in the figure) represents the variation of the return temperature, i.e. the temperature on the return pipe (water returning the combustion appliance 1 to be reheated). The third temperature value (indicated with the letter C in the figure) is located between the first and the second temperature value and represents the mean temperature of these two values. The first and the second temperature values are measured using suitable temperature sensors, such as thermistors. Figure 3A in particular describes the heating up process, i.e. comfort heating, for reaching a target temperature Ts (around 60° in the figure). The region where the heating up process is active is colored in grey. As shown in the figure, the temperatures fluctuate at the start due to an uneven distribution of temperatures. However, these temperatures damp out over time. For example, the comfort heating can start at 12:32:16, however the start temperature T0 (around 31.5° in the figure) is reached only after a fluctuation or oscillation period (OP) at 12:32:27. The period of the fluc-

tuations is a known parameter and a single period is "awaited" (11 seconds for the combustion appliance 1 referred in the figure). After this period, the method searches for a "zero passing" (ZP) of the difference between the derivatives of the flow and the return temperatures (figure 3B). It is noted that a zero passing (ZP) of this difference is a good moment to accurately sample the mean temperature. The mean temperature is sampled at the first zero passing (ZP) after the fluctuation period so that the start temperature T0 is set. The start temperature (T0) can be accurately determined with this method. The heating up process, i.e. the comfort heating, stops when the target temperature Ts is reached, for example at 12:33:32.

[0031] Figure 4 illustrates the comparison between the measured time duration Δt of the heating up process and the expected time duration Δt^* of the heating up process as a function of a temperature difference ΔT between the target temperature Ts and the start temperature T0. The expected time duration Δt^* is described by a theoretical curve and is a straight line. The theoretical curve is calculated as follows.

[0032] The comfort heating only heats up its internal circuit IC, so the energy that is inserted into the internal circuit IC is given by:

$$E_{inserted} = P_{min} \times \Delta t^*,$$

where P_{min} is the boiler power at minimum fan speed, which a boiler uses to perform a comfort heating. Δt^* is the time required to perform a comfort heating.

[0033] On the other hand, the energy that is required to heat up the boiler from its initial or start temperature (T0) to its set point or target temperature (Ts) is:

$$E_{required} = C \times \Delta T,$$

where C is the heat capacity of the boiler and ΔT is the difference between the start temperature (T0) and the target temperature (Ts). The inserted energy must be equal to the required energy during a comfort heating and the equation can be rewritten:

$$E_{inserted} = E_{required}$$

$$P_{min} \times \Delta t^* = C \times \Delta T$$

[0034] Accordingly, the comfort heating duration can be expressed as a function of the initial temperature difference :

$$\Delta t^* = (C / P_{min}) \times \Delta T$$

[0035] Back to figure 4, every measured heating time duration Δt is represented by a black dot. The black dots in this graph represent all comfort heating processes of a random boiler during a three day period. The area identified with "proper function" describes the error margin of the expected time duration Δt^* , i.e. the error of the calculated straight line representing the expected time duration Δt^* . As long as the measured heating time duration Δt is within "proper function" area, there is no concern about a possible error in the operation of the combustion appliance 1 (e.g. malfunctioning of the three way valve). On the other hand, should the measured heating time duration Δt be outside the "proper function" area, an error in the operation of the combustion appliance 1 has occurred. The area above the "proper function" area, describes the area in which the comfort heating lasts much longer than expected. Should for example the three way valve be broken, the measured heating time duration Δt will end up in this area. The area below the "proper function" area indicates the area in which a comfort heating finishes faster than expected. If the model parameters are correctly configured, the measured heating time duration Δt are not expected to end up in this area.

[0036] The time deviation TD represents the difference between the measured heating time duration Δt and the expected heating time duration Δt^* . In the figure, the measured heating time duration Δt is always shorter than the expected heating time duration Δt^* . The time deviation TD remains within the "proper function" area as long as the time deviation TD is smaller than a time error value ε_2 . In principle, the time error value can correspond to two values, i.e. ε_1 in case the measured heating time duration Δt is longer than the expected heating time duration Δt^* , that is above the straight line, or ε_2 in case the measured heating time duration Δt is shorter than the expected heating time duration Δt^* , that is below the straight line, as illustrated in figure 4.

[0037] Figure 5 describes the steps of an algorithm according to an example and describing the present method for controlling the combustion appliance 1.

[0038] The parameters of the combustion appliance 1 (i.e. combi boiler) are gathered and it is determined if "comfort heating" is enabled. If this heating up process is enabled, the analysis can proceed. On the other hand, if this heating up process is disabled, the method is stopped. In fact, there won't be any useful data to analyze.

[0039] The required sensor data is periodically obtained and the algorithm looks for a "comfort heating" in this data. As already mentioned, comfort heating is present if the DHW flow speed is zero and the boiler reports that it is burning for DHW. This combination of situations is only present during a comfort heating. therefore, if comfort heating is found, the duration of this heating up process is measured.

[0040] In the meantime, the boiler type is determined and corresponding calculation parameters are gathered. The analysis can proceed if the comfort heating is unin-

terrupted, meaning that the comfort heating ended when it reached its set point (i.e. target temperature T_s). The comfort heating must also be longer than a minimum duration value: The boiler temperatures can fluctuate heavily when a comfort heating starts, which is why a time delay (i.e. the minimum duration value) has been introduced to wait for the system to become stable. The comfort heating must always be longer than this minimum duration, which is a boiler specific parameter. It is noted that the mean temperature of the system can be sampled accurately, while omitting the temperature fluctuations, at the moment that the difference between the time derivatives of the flow and the return temperatures is zero.

[0041] If these preconditions are met, the comfort heating duration Δt (after awaiting the time delay) is measured. The boiler temperature is also sampled and the set point temperature is calculated, thereby measuring the initial temperature difference ΔT .

[0042] This information is then used to predict the time duration of the comfort heating Δt^* and to calculate the uncertainty of this prediction. The final step is to compare the measured heating duration Δt to the predicted heating duration Δt^* (+ uncertainty) to determine if an error has occurred, i.e. if the three-way valve is broken.

[0043] According to an example, a cloud based system for backwards compatibility can be used. The relevant boiler data can be collected with a logging device which is capable of sending this data to the cloud. A logging device can for example be an additionally connected gateway or a room thermostat, in both cases with an internet connection (WiFi, LoRa, GPRS, etc). A cloud based analysis can then determine if the three-way valve is functioning properly.

[0044] According to a further example, an end-user feedback can be considered in case of an error in the operation of the combustion appliance 1, i.e. a broken three-way valve. Endusers that have a boiler with a logging device can be informed, by the installer, or the boiler itself in case of an erroneous situation. Feedback can be carried out through web interface, portal for installers (Dashboard), installer application on phone when connecting a service tool, user application on phone when connection a capable room thermostat, email notifications, push notifications on connected phone, boiler HMI. The method can be triggered remotely to initiate a three-way valve check. For example, a command to initiate a comfort heating can be given to the boiler by the logging device. This logging device would simultaneously collect the relevant data and would be able to check the status of the three-way valve. In case the end user is not capable of turning off the comfort heating cycle, another person, for example the installer, would be able to do that via the dashboard through a connected logging device.

55 Reference Signs

[0045]

1	Combustion appliance
2	Primary heat exchanger
3	Pump element
4	Plate heat exchanger
5	Three way valve
100	Method
IC	Internal circuit
EC	External circuit
Δt	Measured time duration
Δt^*	Expected time duration
T_s	Target temperature
TD	Time deviation
T_0	Start temperature
ΔT	Temperature difference
$\varepsilon_1, \varepsilon_2$	time error value
OP	Oscillation period
ZP	Zero Passing

Claims

1. Method (100) for controlling the operation of a combustion appliance (1), in particular a gas boiler and more particularly a combi gas boiler, during a heating up process, the method (100) comprising:

measuring (S101) a time duration (Δt) of the heating up process until a target temperature (T_s) is achieved;
determining (S102) an expected time duration (Δt^*) of the heating up process based on said target temperature (T_s);
determining (S103) a time deviation (TD), the time deviation (TD) being the difference between the measured time duration (Δt) and the expected time duration (Δt^*); and
determining (S104) the presence of an error in the operation of the combustion appliance (1), if the time deviation (TD) is greater than at least a time error value ($\varepsilon_1, \varepsilon_2$).

2. Method (100) according to claim 1, **characterized in that** the expected time duration (Δt^*) of the heating up process is based on:

a. a temperature difference (ΔT) between the target temperature (T_s) and a start temperature (T_0); and/or
b. the power of the combustion appliance (1) at a minimum speed of a fan element; and/or
c. the heat capacity of the combustion appliance (1).

3. Method (100) according to any one of claims 1 to 2, **characterized in that**

a. the time error value ($\varepsilon_1, \varepsilon_2$) varies based on a temperature difference (ΔT) between the tar-

get temperature (T_s) and a start temperature (T_0); and/or

b. the time error value ($\varepsilon_1, \varepsilon_2$) increases by increasing a temperature difference (ΔT) between the target temperature (T_s) and a start temperature (T_0); and/or

c. the time error value ($\varepsilon_1, \varepsilon_2$) varies based on the heat capacity and the power of the combustion appliance (1).

4. Method (100) according to any one of claims 1 to 3, **characterized in that**,

a. the time error value ($\varepsilon_1, \varepsilon_2$) corresponds to a first time error value (ε_1) or a second time error value (ε_2), wherein the first time error value (ε_1) defines a first region in which the measured time duration (Δt) is longer than the expected time duration (Δt^*) and the second time error value (ε_2) defines a second region in which the measured time duration (Δt) is shorter than the expected time duration (Δt^*); and/or

b. the time error value ($\varepsilon_1, \varepsilon_2$) corresponds to a first time error value (ε_1) or a second time error value (ε_2), wherein the first time error value (ε_1) is longer or shorter than the second time error value (ε_2).

5. Method (100) according to any one of claims 1 to 4, **characterized in that**, during the heating up process,

a. a gas burner of the combustion appliance (1) burns at a constant load; and/or
b. the speed of a pump element (3) of the combustion appliance (1) is fixed; and/or
c. a water flow is guided over the internal circuit (IC) of the combustion appliance (1).

6. Method (100) according to any one of claims 1 to 5, **characterized in that**, before measuring (S101) the time duration (Δt) of the heating up process, the method (100) further comprises:

acquiring sensor data; and
determining if the combustion appliance (1) is performing the heating up process based on said sensor data,
wherein in particular sensor data are acquired periodically and comprise:

a. at least a value of a water flow speed over a second circuit (EC) of the combustion appliance (1); and/or
b. the functioning of a gas burner of the combustion appliance (1).

7. Method (100) according to any one of claims 1 to 6,

characterized in that the method (100) further comprises:

predicting that an error in the operation of the combustion appliance (1) is going to occur, if the time deviation (TD) is approaching the time error value (ε_1 , ε_2) after carrying out the method (100) on the same combustion appliance (1) for a plurality of times.

8. Method (100) according to any one of claims 1 to 7, **characterized in that**, before measuring (S101) the time duration (Δt) of the heating up process, the method (100) further comprises:

a. reading set parameters of the combustion appliance (1); and/or
b. checking if the heating up process is enabled in the combustion appliance (1); and/or
c. checking if preconditions on the operation of the internal heating process are met, wherein in particular said preconditions comprise that:

i. the heating up process ends when the target temperature is reached; and/or
ii. the time duration of the heating up process is longer than a minimum duration value.

9. Method (100) according to any one of claims 1 to 8, **characterized in that** the determined error in the operation of the combustion appliance is caused by

a. the malfunctioning of an internal valve, in particular a three way valve (5), of the combustion appliance (1); and/or
b. the presence of a gas-sided clogging in the combustion appliance (1).

10. Method (100) according to any one of claims 1 to 9, **characterized in that** the method (100) further comprises:

calculating an uncertainty value of the expected time duration (Δt^*) of the heating up process; and determining the time deviation (TD) taking the uncertainty value into account.

11. Method (100) according to any one of claims 1 to 10, **characterized in that** the method (100) further comprises:

a. initiating the heating up process of the combustion appliance (1) in a remote manner; and/or
b. collecting technical specification data of the combustion appliance (1) and determining the presence of an error in the operation of the combustion appliance (1) by a logging device connected to a cloud network, wherein in particular

the logging device is a connected gateway or a thermostat having an Internet connection; and/or

c. generating and sending a feedback information to an end user in case the presence of an error in the operation of the combustion appliance (1) is determined.

12. 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 11.

13. Data processing apparatus comprising a processor for executing the computer program product of claim 12.

14. Combustion appliance (1), in particular a gas boiler and more particularly a combi gas boiler, comprising means for carrying out the method according to one of the claims 1 to 11 and/or comprising the data processing apparatus of claim 13.

15. Use of the computer program product according to claim 12, or of the data processing apparatus according to claim 13 for the detection or the prediction of a malfunction of a three way valve and/or the presence of gas-sided clogging in a combustion appliance (1), in particular a gas boiler and more particularly a combi gas boiler.

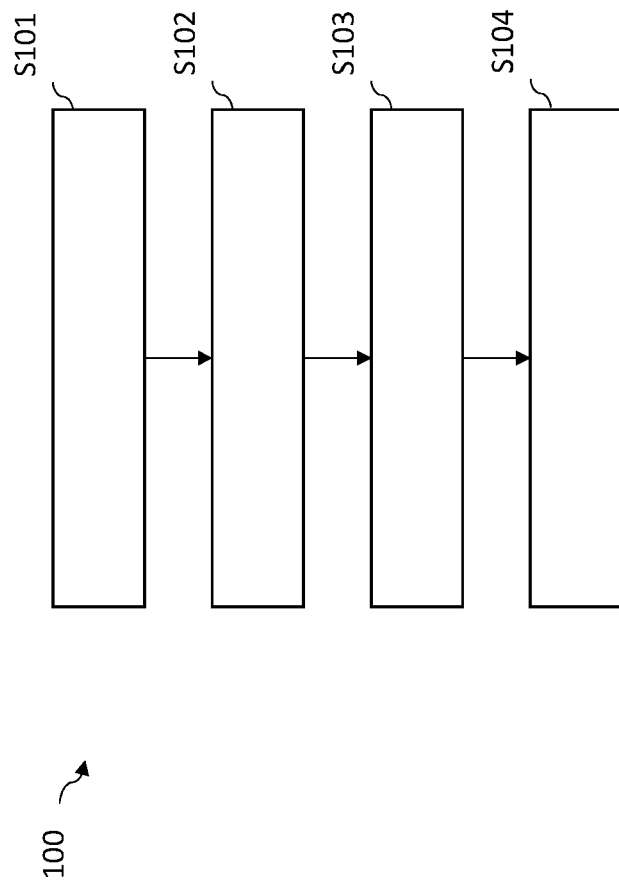


FIG. 1

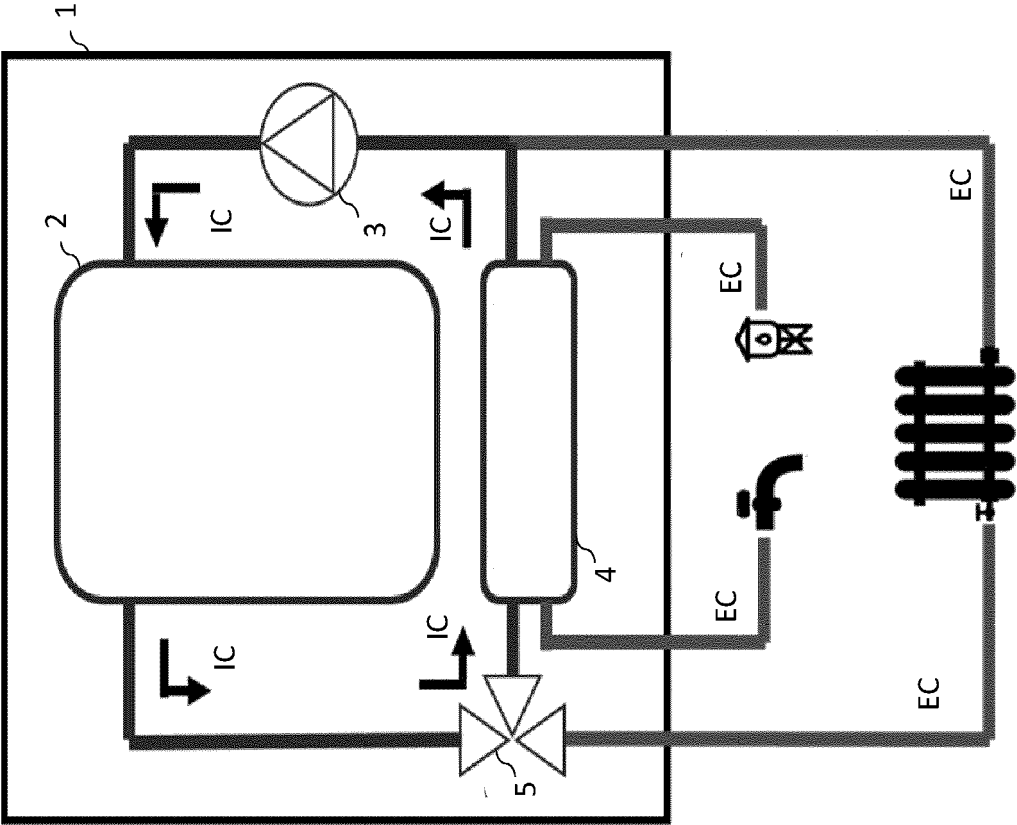


FIG. 2

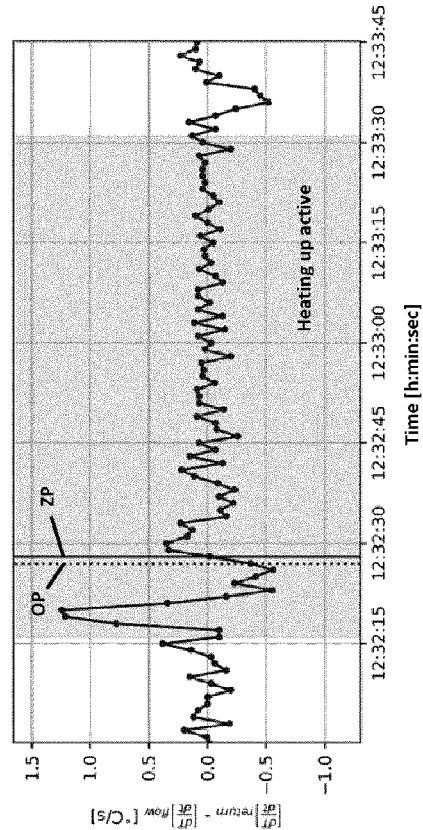


FIG. 3A

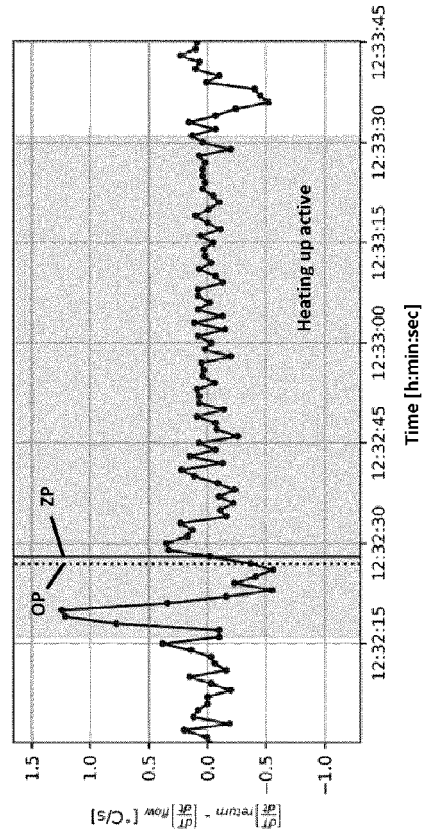


FIG. 3B

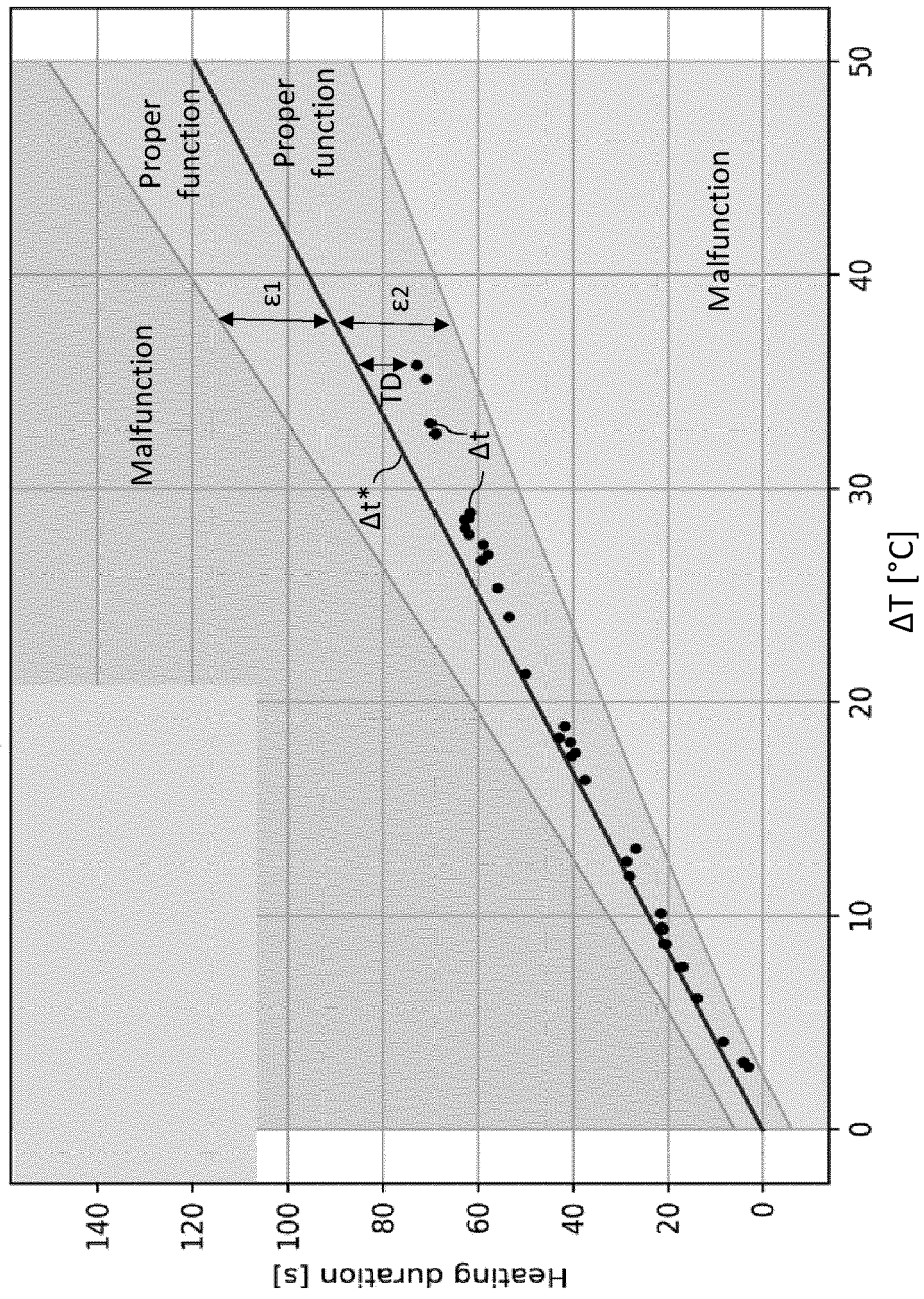


FIG. 4

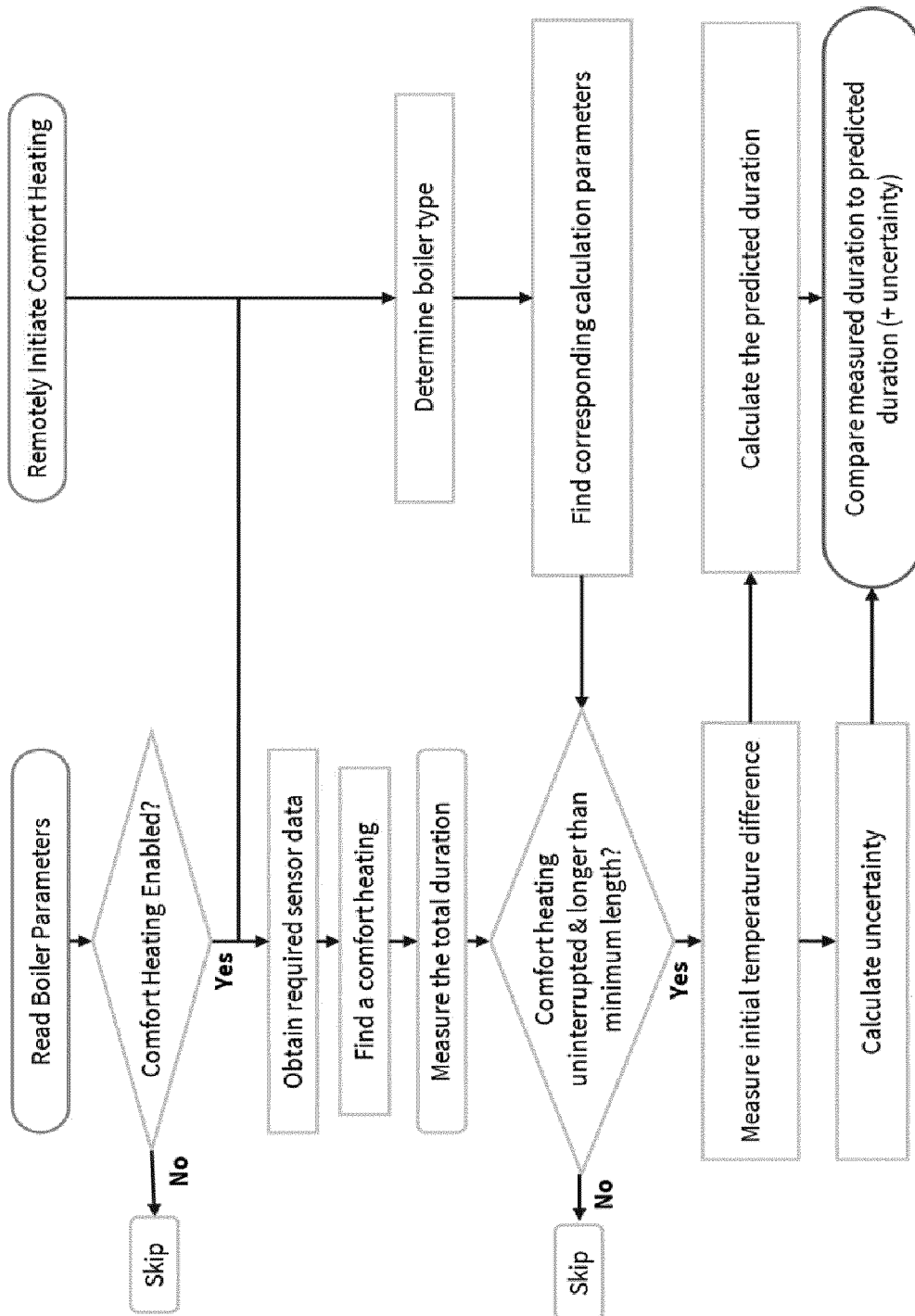


FIG. 5



EUROPEAN SEARCH REPORT

Application Number

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			F24D G05D F24H
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 4 August 2022	Examiner von Mittelstaedt, A
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