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(54) **A METHOD FOR DETECTING AIR IN A HEATING OR COOLING SYSTEM, AND A HEATING OR COOLING SYSTEM**

VERFAHREN ZUR DETEKTION VON LUFT IN EINEM HEIZ- ODER KÜHLSYSTEM UND HEIZ- ODER KÜHLSYSTEM

PROCÉDÉ DE DÉTECTION D'AIR DANS UN SYSTÈME DE CHAUFFAGE OU DE REFROIDISSEMENT, ET SYSTÈME DE CHAUFFAGE OU DE REFROIDISSEMENT

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Description

[0001] Heating systems for supplying radiators or similar heating devices with hot water comprise a heat generator, typically consisting of a gas boiler or a heat pump, connected to a hydraulic circuit along which heating devices are provided, installed in various rooms of the house, e.g., wall radiators or under-floor exchangers.

[0002] The heating system heats the water and conveys it through the heating devices by means of which the heat of the water is transferred to the environment. The water is heated to a working temperature, by means of the heat generator placed in a heat exchange relationship with the hydraulic circuit, where a system for controlling the heat generator controls the activation, shutdown, and power adjustment of the heat generator, e.g., of a burner of a gas boiler or a compressor of a heat pump, as well as the activation, shutdown, and flow rate adjustment of a water circulation pump, for example for varying the flow of water conveyed through the hydraulic heating circuit.

[0003] The control system controls the operation of the heat generator and the circulation pump as a function of one or more temperature values selectable by a user and detected values of the ambient temperature in the environments to be heated and the temperature of the water in the hydraulic heating circuit.

EP2918923A1 describes a heating system according to the prior art and having features of the preamble of claim 1. EP1593916B1 and KR20040081983A describe systems of the prior art that represent a technological context for the invention.

[0004] One of the commonest problems in domestic heating systems is the presence of air bubbles in the hydraulic circuit, which results in:

- lower system energy efficiency,
- non-uniform temperatures in hydraulic circuit and heating devices (hotter and colder zones),
- noisy water circulation and circulation pump,
- anomalous operation of the heat generator, as the air bubbles cause circulation vacuums of the heat-transfer fluid, which can lead to overheating of the heat generator, resulting in damages.

[0005] In these anomalous operating conditions, the heat generator, e.g., a gas boiler, initiates safety procedures aimed at protecting the reliability thereof over time, which can result in undesired temporary or permanent operating blocks.

[0006] For these reasons, during the installation and/or extraordinary maintenance of the heating system, it is necessary and known to thoroughly de-aerate the whole heating system and the heat generator in order to ensure the optimum operation thereof.

[0007] It is also known that after completely bleeding the heating system of air, a little air tends to go back to the hydraulic circuit over time (e.g., due to leaks), which is why it is necessary to repeat the de-aeration operation periodically.

[0008] It is known to bleed the heating system of air by means of:

- a so-called de-aerator, i.e., a valve positioned in the hydraulic circuit or heat generator, manually operable for letting out residual air, and/or
- an automatic vent valve, which can be positioned in the hydraulic circuit and/or heat generator (boiler) and which performs an automatic bleeding of the air without manual intervention.

[0009] Typically, the de-aeration valves of the heating system are only opened by a skilled operator (technical service centers) and only during in-situ interventions, to avoid undesired side effects (which are difficult to manage for unskilled users) during the service life of the heating system.

[0010] Some known boilers also comprise an electronic control function for bleeding the air in both the local circuit of the boiler and the hydraulic circuit of the central heating system, which performs specific control sequences of controlling the circulation pump and a diverter valve for diverting the heat transfer fluid between the primary circuit of the boiler and the hydraulic heating circuit so as to carry the air bubbles of both circuits into the de-aerator.

[0011] This function is also generally manually activated by a skilled operator.

[0012] The air bleeding is typically carried out by skilled operators during installation or extraordinary maintenance and takes a long time, because there is no indicator of the presence of air and the only known clues for understanding whether the air has been completely bled are the circulation noises and operating anomalies of the boiler (e.g., overheating).

[0013] Similarly, the same problems arise for cooling systems and for heating and cooling systems with a hydraulic circuit.

[0014] Therefore, it is the object of the present invention to provide a method for verifying the presence of air in the heating and/or cooling system, having features such as to obviate at least some of the drawbacks of the prior art.

[0015] Within the scope of the main object, it is a particular object of the invention to provide a method which provides a more objective indicator of the presence of air in the central heating and/or cooling system.

[0016] These and other objects are achieved by a process according to claim 18, and by a heating and/or cooling system

according to claim 1.

[0017] The dependent claims relate to advantageous and preferred embodiments.

[0018] According to one aspect of the invention, there is provided a method for detecting air in a heating or cooling system, in particular a domestic system, of the type comprising:

a hydraulic circuit along which heating/cooling devices are installed, e.g., wall radiators or under-floor exchangers,
a heat/cold generator, e.g., a gas boiler or a heat pump, placed in a heat exchange relationship with the hydraulic circuit,
a water circulation pump, installed in the hydraulic circuit, to convey a flow of water into the hydraulic circuit,
an electronic control system in signal connection with the heat/cold generator and the circulation pump, to control the operation of the heat/cold generator and the circulation pump,
wherein the method comprises the steps of:

- with the circulation pump activated, detecting a parameter indicative of the water flow rate inside the hydraulic circuit,
- collecting a plurality of values of the parameter detected in a detection time interval,
- calculating a variation of the plurality of values collected in the detection time interval,
- comparing the calculated variation with a variation threshold value, and:

if the calculated variation is greater than the variation threshold value, generating a notification signal of air presence in the hydraulic circuit, and
if the calculated variation is lower than the variation threshold value, not generating the notification signal of air presence in the hydraulic circuit.

[0019] Similarly, according to an aspect of the invention, a heating or cooling system (e.g., a boiler or a heat pump system), in particular a domestic system, comprises:

a heat or cold generator, e.g., a gas boiler or a heat pump, connectable in a heat exchange relationship to a hydraulic circuit along which heating or cooling devices are installed, e.g., wall radiators or underfloor exchangers,
a water circulation pump, connectable to the hydraulic circuit, to convey a flow of water into the hydraulic circuit,
an electronic control system in signal connection with the heat/cold generator and the circulation pump, to control the operation of the heat or cold generator and the circulation pump,
comprising an air detection module configured to perform an air detection process 15, comprising one or more air detection steps 15.1, ..., 15.n where:

- with the circulation pump activated, it detects a parameter indicative of the water flow rate inside the hydraulic circuit,
- it collects a plurality of values of the parameter detected in a detection time interval,
- it calculates a variation of the plurality of values collected in the detection time interval,
- it compares the calculated variation with a variation threshold value, and:

if the calculated variation is greater than the variation threshold value, it generates notification signal of air presence in the hydraulic circuit, and
if the calculated variation is lower than the variation threshold value, it does not generate the notification signal of air presence in the hydraulic circuit.

[0020] By virtue of the correlation between the presence of air in the hydraulic circuit and the oscillation of the water flow rate, there is a more objective parameter for determining the presence of air in the hydraulic circuit. In fact, the greater the amount of air trapped inside the hydraulic circuit, the more the water flow speed and rate varies with the same (constant) operation of the circulation pump during the detection interval. In fact, the inventors have understood that the circulation vacuums produced by the air bubbles can be detected through a variation model of a signal linked to the water circulation.

[0021] The variation measurement of the flow rate or speed, detected directly or by means of the detection of flow parameters or related electrical parameters, provides an easily obtainable determination criterion, which is electronically processable and reliable.

[0022] Further advantageous aspects of the invention will become apparent from the following description of some embodiments thereof, given by way of non-limiting example, with reference to the accompanying drawings, in which:

- figure 1 is a diagrammatic view of a heating and/or cooling system according to an embodiment of the invention,

- figures 2, 3, 4, 5 are diagrammatic views of heating and/or cooling systems according to embodiments, in which:
- in figure 2, a flow rate detector is integrated into a circulation pump inside the housing of a heat or cold generator,
- in figure 3, a flow rate detector is integrated into a circulation pump installed in a hydraulic circuit outside the housing of the heat or cold generator,
- in figure 4, a flow rate detector is installed in a hydraulic circuit outside the housing of the heat or cold generator, irrespective of the circulation pump,
- in figure 5, a flow rate detector is installed in a hydraulic circuit inside the housing of the heat or cold generator, irrespective of the circulation pump,
- figure 6 is a diagram showing the trend of the flow rate (ordinate) detected in a hydraulic circuit, as a function of the time (abscissa), in a plurality of detection cycle steps, where each detection cycle comprises a plurality of detection steps at different pump circulation speeds, and where a progressive reduction of the variation of the flow rate can be seen with an increase in the number of detection and de-aeration cycles,
- figure 7 is a diagram showing, for the situation illustrated in figure 6, the trend of the standard deviation of the flow rate (ordinate) detected in the hydraulic circuit, as a function of the time (abscissa) for a pump speed set at 60% of a maximum speed, in the detection cycles from 1 to 5,
- figure 8 shows a flow diagram of the air detection method according to an embodiment,
- figure 9 shows a flow diagram of the air detection method according to a further embodiment.

[0023] With reference to the figures, a heating or cooling system 1 (e.g., a gas boiler or a heat pump system), in particular a domestic system, comprises:

a heat or cold generator 4, e.g., a gas boiler or a heat pump, connectable in a heat exchange relationship to a hydraulic circuit 2 along which heating and/or cooling devices 3 can be installed, e.g., wall radiators or underfloor exchangers,
a water circulation pump 5, connectable to the hydraulic circuit 2, to convey a flow of water into the hydraulic circuit 2,
an electronic control system 6 in signal connection with the heat or cold generator 4 and the circulation pump 5, to control the operation of the heat or cold generator 4 and the circulation pump 5,
an air detection module 7, 7' configured so as to perform an air detection process 15, comprising one or more air detection steps 15.1, ..., 15.n, where:

- with the circulation pump 5 activated (step F1) at a circulation speed, it detects a parameter x indicative of the water flow rate inside the hydraulic circuit 2 (step F2),
- it collects a plurality of values x_t of the parameter x detected in a detection time interval (step F3),
- it calculates a variation FlowRate_StdDev of the plurality of values x_t collected in the detection time interval (step F4),
- it compares the calculated variation FlowRate_StdDev with a variation threshold value Threshold_var (step F5) and:

if the calculated variation FlowRate_StdDev is greater than the variation threshold value Threshold_var, it generates a notification signal of air presence in the hydraulic circuit 2 (step F6), and
if the calculated variation FlowRate_StdDev is lower than the variation threshold value Threshold_var, it does not generate the notification signal of air presence in the hydraulic circuit.

[0024] According to an advantageous embodiment, the air detection module 7, 7' is configured so that, if during a first air detection step 15.1 of the air detection steps 15.1,...,15.n, with a first pumping speed of the circulation pump 5, the calculated variation FlowRate_StdDev is lower than the variation threshold value Threshold_var, the air detection module 7, 7' performs a further subsequent air detection step 15.2, with a further pumping speed of the circulation pump 5, which is different from the first pumping speed.

[0025] In fact, as can be seen in figures 6 and 7, which will be described in detail below, the calculated variation FlowRate_StdDev may differ significantly as a function of the flow speed. Therefore, performing the air detection process 15 by means of a plurality of air detection steps 15.1, ..., 15.n at different flow speeds of the circulation pump 5, significantly increases the reliability and result precision thereof.

[0026] According to an embodiment, the air detection process 5 and the air detection module 7, 7' perform the first air detection step 15.1 with a first pumping speed and the subsequent air detection step(s) 15.2, ..., 15.n with pumping speeds decreasing from one air detection step 15.n-1 to the subsequent air detection step 15.n (figure 6), for example in the order of number of the air detection step 15.1, ..., 15.4, the pumping speed is 100%, 80%, 60%, 40% of the maximum speed of pump 5.

[0027] The pumping speed of the circulation pump 5 is preferably constant within the same air detection step 15.n.

[0028] The duration of the detection interval is preferably constant, e.g., 25 seconds or in the range from 20 seconds to

30 seconds.

[0029] The number of values x detected and collected during the detection interval is preferably constant, e.g., 25 or in the range from 20 to 30, detected with a detection frequency of 1 value/second, for example.

[0030] The variation threshold value Threshold_var is preferably different for different pumping speeds of the circulation pump 5.

Description of further embodiments

[0031] According to an embodiment, when determining the presence of air in the hydraulic circuit 2, i.e., if the calculated variation FlowRate_StdDev is greater than the variation threshold value Threshold_var, the (reception of the) notification signal of air presence in the hydraulic circuit 2 can form the base for, or trigger subsequent method steps, e.g., one or more visual and/or acoustic notification steps and/or one or more anomaly control steps of the heat or cold generator 4 and/or the circulation pump 5, and/or a safety shutdown step of the heat or cold generator 4 and the circulation pump 5.

[0032] The visual and/or acoustic notification can occur by means of a user interface 12 of the electronic control system 6 of the heating or cooling system 1, positioned directly on board the heat or cold generator 4 or externally thereto, for example, or by means of a further user interface 12' of an air detection module 7' outside the electronic control system 6 of the heating or cooling system 1.

[0033] According to embodiments, the air detection module 7, 7' can be an electronic processing module 7 directly integrated into the electronic control system 6 of the heating or cooling system 1 or an electronic processing module 7' outside the latter and temporarily or permanently connectable to the heating or cooling system 1 (signal and/or hydraulic and/or electrical connection) as a retrofitting accessory.

[0034] According to a further embodiment of the method and system 1, in response to the notification signal of air presence an anomaly notification signal is transmitted (step F9), e.g., by cable or wirelessly (from the electronic control system 6 or the air detection module either integrated 7 or external 7', for example) to a remote server 13 (cloud) which, in response to receiving the anomaly notification signal, performs a maintenance preparation procedure (step F10).

[0035] The maintenance preparation procedure F10 can comprise sending an electronic message, e.g., by telephone, SMS, email, etc., to the user or an administrator in charge of the heating or cooling system 1.

[0036] According to an embodiment, the remote server 13:

- collects the anomaly notification signals received from a plurality of said different heating or cooling systems 1, for the entire service life of the systems 1 and keeps the anomaly notification signals stored, even of systems 1 made inoperative,
- correlates the anomaly notification signals of each system 1 with the time,
- identifies progressive increase patterns of the presence of air depending on the operating time for each system 1, as a function of the correlation of the anomaly notification signals with the time,
- compares the progressive increase patterns of the presence of air identified between different systems 1 to estimate, for the operating systems 1, a residual time without the need for de-aeration (predictive maintenance step F11).

[0037] According to an embodiment, the air detection module 7, 7' is configured to (and the air detection method comprises):

- allow the manual insertion of a starting command (step F7) for the air detection process 15, e.g., by means of an operator interface or the aforesaid user interface 12 or by means of the further user interface 12', or by means of a remote electronic device 14, such as the remote server 13, for example, in signal connection with the air detection module 7, 7', and
- in response to the command for starting the air detection process, perform the air detection process 15.

[0038] Alternatively or additionally, the air detection module 7, 7' can be configured to (and the air detection method can comprise) performing the air detection process 15 automatically as a function of a predetermined starting criterion (or set of criteria).

[0039] The starting criterion or set of criteria (and/or the verification F8 thereof) can comprise:

- a predetermined time interval, e.g., every day at a certain time or every 500 or 1000 hours, and/or
- detecting, e.g., by means of the electronic control system 6 or the air detection module 7, 7', a water flow anomaly in the hydraulic circuit 2, e.g., a low flow rate, a low water pressure, or an unstable flow rate, or a noisy flow or vibrations of the hydraulic circuit 2 and/or the heating or cooling devices 3, and/or
- detecting, e.g., by means of the electronic control system 6 or the air detection module 7, 7', a temperature control anomaly of the heating or cooling system 1.

Detailed description of the detection of parameter x indicative of the flow rate

[0040] According to an embodiment, the parameter x indicative of the flow rate is obtained (e.g., from the air detection module 7) by a flow rate signal provided by the circulation pump 5. To this end, the circulation pump 5 can comprise a flow rate sensor 8 (flowmeter) or an indirect determination device 9 for the flow rate depending on electrical parameters (of the electric motor 10) of the circulation pump 5.

[0041] According to an embodiment, the parameter x indicative of the flow rate is obtained (e.g., from the air detection module 7) by a signal of a flow rate sensor 8 (flowmeter) connected to the hydraulic circuit 2 outside the circulation pump 5, e.g., inside or outside a housing 11 of the heat or cold generator 4. Here, the parameter x indicative of the flow rate is the flow rate itself.

[0042] Alternatively, the parameter x indicative of the flow rate is obtained (e.g., from the air detection module 7) by a prevalence signal generated by the circulation pump 5, or by a signal of electric power (or electric current) absorbed by the electric motor 10 of the circulation pump 5 or by a signal of the number of revolutions or angular speed of the electric motor 10 of the circulation pump 5.

Detailed description of the calculation of the variation FlowRate_StdDev of the plurality of values x_t

[0043] According to a preferred embodiment, the calculation of the variation FlowRate_StdDev of the plurality of values x_t comprises calculating a standard deviation of the plurality of values x_t collected in the detection time interval, e.g., by means of the formula:

$$\mathrm{FlowRate\_StdDev} = \sqrt{\frac{\sum_{i=1}^{N}(x_i-\mu)^2}{N}},$$

where:

$$\mu = \frac{\sum_{i=1}^{N} x_i}{N},$$

N is the number of collected values x_t,
x_i is the individual value of the parameter x detected or determined or estimated.

[0044] According to an alternative embodiment, the calculation of the variation FlowRate_StdDev of the plurality of values x_t comprises calculating a relative standard deviation or variation coefficient.

[0045] According to a still further embodiment, the calculation of the variation FlowRate_StdDev of the plurality of values x_t comprises calculating an average value of the absolute differences between all values x of the plurality of values x_t and an average value of all values x of the plurality of values x_t.

[0046] According to a still further embodiment, the calculation of the variation FlowRate_StdDev of the plurality of values x_t comprises calculating an average value of the absolute differences between all values x of the plurality of values x_t and a central value (halfway between a maximum value and a minimum value) of all values x of the plurality of values x_t.

[0047] According to a still further embodiment, the calculation of the variation FlowRate_StdDev of the plurality of values x_t comprises calculating a degree of non-cyclicity or a degree of randomness of a sequence (in the order of time) of the values x of the plurality of values x_t. The greater the randomness, the greater the probability that the fluctuation is due to air in the system and not to cyclic pumping phenomena.

[0048] It should be noted that the name FlowRate_StdDev is an invented name which, despite the resemblance, does not necessarily indicate a standard deviation and does not necessarily refer to a flow rate, but to a parameter indicative or representative of the flow rate.

Description of figure 6

[0049] Figure 6 shows the trend of the flow rate with respect to time: during alternate steps of the air detection 15 and de-aeration process of the system 1, starting from a situation with a great amount of air in the system 1 and performing, for each

air detection process 15, a plurality of air detection steps 15.1, ..., 15.n, and, between two consecutive air detection processes 15, respectively, a de-aeration step of the system 1.

[0050] During each air detection process 15, the pumping speed of pump 5 has been modulated at 4 different speeds, from MAX to MIN.

[0051] As can be seen in figure 6, the presence of air in the hydraulic circuit 2 results in strong signal fluctuations which, however, are no longer present once the air has been eliminated.

[0052] The fluctuation measurement of the value x systematically depends on the amount of air in the water flow:

[0053] In the first and second detection processes (cycles 1 and 2 from the left in figure 6), the amount of air is very large and detectable at all speeds of pump 5.

[0054] In the third detection process (cycle 3 in figure 6), the amount of air is small and detectable only at the maximum speed of pump 5.

[0055] In the fourth and fifth detection processes (cycles 4 and 5 in figure 6), the amount of air is so small or completely absent that it is no longer detectable.

Description of figure 7

[0056] Figure 7 shows the standard deviation (ordinate) of the flow rate at a constant pump speed (60% of the maximum speed) for each test cycle shown in figure 6.

[0057] In particular, figure 7 shows that the standard deviation of the flow rate at a fixed pump speed (60%) increases as the air increases in the hydraulic circuit 2 (1st and 2nd cycle in figures 6 and 7) and decreases when the air is gradually eliminated (3rd, 4th and 5th cycles in figures 6 and 7).

[0058] The samples of values acquired when performing the tests (1 sample per second) are indicated on the axis of abscissas in figure 7, taking into account a fixed number of 25 samples per detection interval.

[0059] The heating and/or cooling system 1 described so far can be installed at a house 16 or a general building. The water circulating in the hydraulic circuit 2 is brought to a desired working temperature (heated or cooled), by means of the heat and/or cold generator 4 placed in a heat exchange relationship with the hydraulic circuit 2. The control system 6 of the heat and/or cold generator 4 (e.g., gas boiler or heat pump or geothermal generator) controls the activation, shutdown, and power adjustment of the heat and/or cold generator 4, e.g., of a burner of a gas boiler or a compressor of a heat pump, as well as the activation, shutdown, and pumping speed adjustment of the circulation pump 5.

[0060] The control system 6 controls the operation of the heat and/or cold generator 4 and the circulation pump 5 as a function of one or more temperature values selectable by a user by means of the user interface 12 or by means of an internal environment thermostat 17 with temperature selection function, as well as, possibly, as a function of values detected by one or more of an incoming water temperature sensor 18 at the inlet of the heat exchanger 22 of the heat and/or cold generator 4, an outcoming water temperature sensor 19 at the exit of the heat exchanger 22 of the heat and/or cold generator 4, an external ambient temperature sensor 20, an internal ambient temperature sensor 21 (figure 1).

[0061] Therefore, the system 1 (e.g., a boiler system or a heat pump system or a geothermal system) described so far can also be manufactured and marketed without and irrespective of the hydraulic heating circuit 2 to which it is connectable, for example, for new installations or for replacing old gas boilers or heat pumps.

List of Reference signs

[0062]

heating or cooling system 1
hydraulic circuit 2
heating or cooling devices 3
heat or cold generator 4
circulation pump 5
electronic control system 6
air detection module 7, 7'
flow rate sensor 8
indirect determination device 9
electric motor 10
heat/cold generator housing 11
user interface 12
further user interface 12'
remote server 13
remote electronic device 14

air detection process 15
air detection steps 15.1, ...15.n.
house 16
internal environment thermostat 17
incoming water temperature sensor 18
outcoming water temperature sensor 19
external ambient temperature sensor 20
internal ambient temperature sensor 21
heat exchanger 22
pump activation step F1
parameter detection step F2
value collection step F3
variation calculation step F4
comparison step F5
notification signal generation step F6
user command insertion step F7
activation criterion verification step F8
anomaly notification step F9
maintenance preparation step F10
predictive maintenance step F11

Claims

1. A heating or cooling system (1), in particular domestic, comprising:

a heat or cold generator (4) connectable in a heat exchange relationship to a hydraulic heating and/or cooling circuit (2),
a circulation pump (5), connectable to the hydraulic circuit (2), to convey a flow of water into the hydraulic circuit (2),
an electronic control system (6) in signal connection with the heat or cold generator (4) and with the circulation pump (5), to control the operation of the heat or cold generator (4) and the circulation pump (5),
characterized by comprising:

an air detection module (7, 7') configured so as to perform an air detection process (15), comprising one or more air detection steps (15.1, ..., 15.n), wherein:

- with the circulation pump (5) activated at a circulation speed, it detects a parameter (x) indicative of the flow rate of the water inside the hydraulic circuit (2),
- it collects a plurality of values (x_t) of the parameter (x) detected in a detection time interval,
- it calculates a variation (FlowRate_StdDev) of the plurality of values (x_t) collected in the detection time interval,
- it compares the calculated variation (FlowRate_StdDev) with a variation threshold value (Threshold_var) and:

if the calculated variation (FlowRate_StdDev) is greater than the variation threshold value (Threshold_var), it generates a notification signal of air presence in the hydraulic circuit (2), and
if the calculated variation (FlowRate_StdDev) is lower than the variation threshold value (Threshold_var), it does not generate the notification signal of air presence in the hydraulic circuit.

2. A system (1) according to claim 1, wherein the air detection module (7, 7') is configured so that, if during a first air detection step (15.1) of the air detection steps (15.1, ..., 15.n), with a first pumping speed of the circulation pump (5), the calculated variation (FlowRate_StdDev) is lower than the variation threshold value (Threshold_var), the air detection module (7, 7') performs a further subsequent air detection step (15.2), with a further pumping speed of the circulation pump (5) different from the first pumping speed.

3. A system (1) according to claim 2, wherein the air detection module (7, 7') performs the first air detection step (15.1) with a first pumping speed and the subsequent air detection step(s) (15.2, ..., 15.n) with pumping speeds that decrease

from one air detection step (15.n-1) to the subsequent air detection step (15.n).

4. A system (1) according to any one of the preceding claims, wherein within the same air detection step (15.n) the pumping speed of the circulation pump (5) is constant,

and/or wherein the duration of the detection interval is constant,
and/or
wherein the number of values (x) detected and collected during the detection interval is constant,
and/or
wherein the variation threshold value (Threshold_var) is different for different pumping speeds of the circulation pump (5).

5. A system (1) according to any one of the preceding claims, wherein the notification signal of air presence in the hydraulic circuit (2) triggers:

- a visual and/or acoustic notification and/or,
- an automatic anomaly control process on the heat or cold generator (4) and/or the circulation pump (5), and/or
- a safety shutdown of the heat or cold generator (4) and the circulation pump (5).

6. A system (1) according to claim 5, wherein the visual and/or acoustic notification takes place by a user interface (12) of the electronic control system (6) of the system (1), positioned for example directly on board the heat or cold generator (4) or externally thereto, or by a further user interface (12') of the air detection module (7') positioned externally to the electronic control system (6).

7. A system (1) according to any one of the preceding claims, wherein the air detection module (7) is directly integrated into the electronic control system (6) of the heating or cooling system (1),
and/or

wherein the air detection module (7') is an external electronic processing module (7') with respect to the electronic control system (6) and connectable to the system (1) temporarily or permanently as a retrofit accessory,
and/or
wherein the notification signal of air in the hydraulic circuit (2) triggers the transmission of an anomaly notification signal to a remote server (13) which, in response to receiving the anomaly notification signal, performs a maintenance preparation process.

8. A system (1) according to any one of the preceding claims, wherein the air detection module (7, 7') is configured to:

- enable the manual entry of a start command for the air detection process (15), and
- in response to the start command for the air detection process (15), perform the air detection process (15).

9. A system (1) according to any one of the preceding claims, wherein the air detection module (7, 7') is configured to perform the air detection process (15) automatically as a function of a predetermined starting criterion.

10. A system (1) according to claim 9, wherein the starting criterion is chosen from the group consisting in:

- a predetermined time interval,
- a performed detection, by the electronic control system (6) or the air detection module (7, 7'), of a water flow anomaly in the hydraulic circuit (2),
- the performed detection, by the electronic control system (6) or the air detection module (7, 7'), of a temperature control anomaly on the heating or cooling system (1).

11. A system (1) according to any one of the preceding claims, wherein the air detection module (7, 7') obtains the parameter (x) indicative of the flow rate:

- from a flow rate signal provided by the circulation pump (5), or
- from a signal of a flow rate sensor (8) connected to the hydraulic circuit (2) externally to the circulation pump (5), or
- from a head signal generated by the circulation pump (5), or

- from a signal of electric power or electric current value absorbed by the electric motor (10) of the circulation pump (5), or
- from a signal of the number of revolutions or angular speed of the electric motor (10) of the circulation pump (5).

12. A system (1) according to any one of the preceding claims, wherein the air detection module (7, 7') performs the calculation of the variation (FlowRate_StdDev) of the plurality of values (x_t) by calculating:

- the standard deviation of the plurality of values (x_t) collected in the detection time interval, or
- the variation coefficient, i.e. the relative standard deviation of the plurality of values (x_t) collected in the detection time interval, or
- a mean value of the absolute differences between all the values of the plurality of values (x_t) and a mean value of all the values of the plurality of values (x_t), or
- a mean value of the absolute differences between all the values of the plurality of values (x_t) and a central value half way between a maximum value and a minimum value of all the values of the plurality of values (x_t).

13. An air detection process (15) in a heating or cooling system (1), in particular domestic, of the type comprising:

a heat or cold generator (4) connected in a heat exchange relationship to a hydraulic heating and/or cooling circuit (2),
a circulation pump (5), connected to the hydraulic circuit (2), to convey a flow of water into the hydraulic circuit (2),
an electronic control system (6) in signal connection with the heat or cold generator (4) and with the circulation pump (5), to control the operation of the heat or cold generator (4) and the circulation pump (5),
characterized in that the air detection process (15) comprises one or more air detection steps (15.1, ..., 15.n), wherein:

- with the circulation pump (5) activated (F1) at a circulation speed, detecting a parameter (x) indicative of the flow rate of the water flow inside the hydraulic circuit (2) (F2),
- collecting a plurality of values (x_t) of the parameter (x) detected in a detection time interval (F3),
- calculating a variation (FlowRate_StdDev) of the plurality of values (x_t) collected in the detection time interval (F4),
- comparing the calculated variation (FlowRate_StdDev) with a variation threshold value (Threshold_var) (F5) and:

if the calculated variation (FlowRate_StdDev) is greater than the variation threshold value (Threshold_var), generating a notification signal of air presence in the hydraulic circuit (2) (F6), and
if the calculated variation (FlowRate_StdDev) is lower than the variation threshold value (Threshold_var), not generating the notification signal of air presence in the hydraulic circuit.

14. A process (15) according to claim 13, wherein, if during a first air detection step (15.1) of the air detection steps (15.1, ..., 15.n), with a first pumping speed of the circulation pump (5), the calculated variation (FlowRate_StdDev) is lower than the variation threshold value (Threshold_var), performing a further air detection step (15.2), using a further pumping speed of the circulation pump (5) different from the first pumping speed.

15. A process (15) according to claim 14, comprising:

- performing the first air detection step (15.1) with a first pumping speed and the subsequent air detection step(s) (15.2, ..., 15.n) with pumping speeds that decrease from one air detection step (15.n-1) to the subsequent air detection step (15.n).

16. A process (15) according to any one of claims 13 to 15,

comprising:

- in response to the notification signal of air presence in the hydraulic circuit (2), transmitting an anomaly notification signal (F9) to a remote server (13) which, in response to receiving the anomaly notification signal, performs a maintenance preparation process (F10),

and/or comprising:

- enabling the manual entry of a start command (F7) for the air detection process (15) in a user interface, and
- in response to the start command for the air detection process (15), perform the air detection process (15),

and/or comprising:
performing the air detection process (15) automatically as a function of a predetermined starting criterion.

Patentansprüche

1. Heiz- oder Kühlsystem (1), insbesondere für den Hausgebrauch, umfassend:

einen Hitze- oder Kältegenerator (4), der in einer Wärmeaustauschbeziehung mit einem hydraulischen Heiz- und/oder Kühlkreislauf (2) verbunden werden kann,
eine Umwälzpumpe (5), die mit dem Hydraulikkreislauf (2) verbunden werden kann, um einen Wasserfluss in den Hydraulikkreislauf (2) zu leiten,
ein elektronisches Steuersystem (6) in Signalverbindung mit dem Hitze- oder Kältegenerator (4) und mit der Umwälzpumpe (5), um den Betrieb des Hitze- oder Kältegenerators (4) und der Umwälzpumpe (5) zu steuern, **dadurch gekennzeichnet, dass** es Folgendes umfasst:

ein Luftdetektionsmodul (7, 7'), das so konfiguriert ist, dass es einen Luftdetektionsprozess (15) durchführt, der einen oder mehrere Luftdetektionsschritte (15.1, ..., 15.n) umfasst, wobei:

- es bei aktivierter Umwälzpumpe (5) mit einer Umwälzgeschwindigkeit einen Parameter (x) erfasst, der indikativ für die Flussrate des Wassers innerhalb des Hydraulikkreislaufs (2) ist,
- es eine Vielzahl von Werten (x_t) des in einem Detektionszeitintervall erfassten Parameters (x) sammelt,
- es eine Variation (FlowRate_StdDev) der Vielzahl der in dem Detektionszeitintervall erfassten Werte (x_t) berechnet,
- es die berechnete Variation (FlowRate_StdDev) mit einem Variationsschwellenwert (Threshold_var) vergleicht und:

wenn die berechnete Variation (FlowRate_StdDev) größer ist als der Variationsschwellenwert (Threshold_var), es ein Benachrichtigungssignal über das Vorhandensein von Luft im Hydraulikkreislauf (2) erzeugt, und
wenn die berechnete Variation (FlowRate_StdDev) kleiner ist als der Variationsschwellenwert (Threshold_var), es kein Benachrichtigungssignal über das Vorhandensein von Luft im Hydraulikkreislauf erzeugt.

2. System (1) nach Anspruch 1, wobei das Luftdetektionsmodul (7, 7') so konfiguriert ist, dass, wenn während eines ersten Luftdetektionsschritts (15.1) der Luftdetektionsschritte (15.1, ..., 15. n) bei einer ersten Pumpendrehzahl der Umwälzpumpe (5) die berechnete Variation (FlowRate_StdDev) kleiner als der Variationsschwellenwert (Threshold_var) ist, das Luftdetektionsmodul (7, 7') einen weiteren nachfolgenden Luftdetektionsschritt (15.2) bei einer weiteren Pumpendrehzahl der Umwälzpumpe (5) durchführt, die sich von der ersten Pumpendrehzahl unterscheidet.

3. System (1) nach Anspruch 2, wobei das Luftdetektionsmodul (7, 7') den ersten Luftdetektionsschritt (15.1) bei einer ersten Pumpendrehzahl und den/die nachfolgenden Luftdetektionsschritt(e) (15.2, ..., 15.n) bei Pumpendrehzahlen durchführt, die sich von einem Luftdetektionsschritt (15.n-1) zum nachfolgenden Luftdetektionsschritt (15.n) verringern.

4. System (1) nach einem der vorhergehenden Ansprüche, wobei innerhalb desselben Luftdetektionsschritts (15.n) die Pumpendrehzahl der Umwälzpumpe (5) konstant ist,

und/oder wobei die Dauer des Detektionsintervalls konstant ist,
und/oder wobei die Anzahl der während des Detektionsintervalls erfassten und gesammelten Werte (x) konstant ist,
und/oder wobei der Variationsschwellenwert (Threshold_var) für verschiedene Pumpendrehzahlen der Umwälzpumpe (5) unterschiedlich ist.

5. System (1) nach einem der vorhergehenden Ansprüche, wobei das Benachrichtigungssignal über das Vorhanden-

sein von Luft im Hydraulikkreislauf (2) Folgendes auslöst:

- eine visuelle und/oder akustische Benachrichtigung und/oder,
- einen automatischen Anomalie-Steuerprozess für den Hitze- oder Kältegenerator (4) und/oder die Umwälzpumpe (5), und/oder
- eine Sicherheitsabschaltung des Hitze- oder Kältegenerators (4) und der Umwälzpumpe (5).

6. System (1) nach Anspruch 5, wobei die visuelle und/oder akustische Benachrichtigung durch eine Benutzerschnittstelle (12) des elektronischen Steuersystems (6) des Systems (1) erfolgt, die zum Beispiel direkt an Bord des Hitze- oder Kältegenerators (4) oder außerhalb desselben positioniert ist, oder durch eine weitere Benutzerschnittstelle (12') des Luftdetektionsmoduls (7'), das außerhalb des elektronischen Steuersystems (6) positioniert ist.

7. System (1) nach einem der vorhergehenden Ansprüche, wobei das Luftdetektionsmodul (7) direkt in das elektronische Steuersystem (6) des Heiz- oder Kühlsystems (1) integriert ist,

und/oder wobei das Luftdetektionsmodul (7') ein externes elektronisches Verarbeitungsmodul (7') im Hinblick auf das elektronische Steuersystem (6) ist und vorübergehend oder dauerhaft als Nachrüstungszubehör mit dem System (1) verbunden werden kann,
und/oder wobei das Benachrichtigungssignal für Luft im Hydraulikkreislauf (2) die Übertragung eines Anomalie-Benachrichtigungssignals an einen entfernten Server (13) auslöst, der als Reaktion auf den Empfang des Anomalie- Benachrichtigungssignals einen Wartungsvorbereitungsprozess durchführt.

8. System (1) nach einem der vorhergehenden Ansprüche, wobei das Luftdetektionsmodul (7, 7') konfiguriert ist zum:

- Ermöglichen der manuellen Eingabe eines Startbefehls für den Luftdetektionsprozess (15), und
- als Reaktion auf den Startbefehl für den Luftdetektionsprozess (15), Durchführen des Luftdetektionsprozesses (15).

9. System (1) nach einem der vorhergehenden Ansprüche, wobei das Luftdetektionsmodul (7, 7') so konfiguriert ist, dass es den Luftdetektionsprozess (15) automatisch in Abhängigkeit von einem vorgegebenen Ausgangskriterium durchführt.

10. System (1) nach Anspruch 9, wobei das Ausgangskriterium ausgewählt ist aus der Gruppe, bestehend aus:

- einem vorbestimmten Zeitintervall,
- einer durchgeführten Detektion, durch das elektronische Steuersystem (6) oder das Luftdetektionsmodul (7, 7'), einer Wasserflussanomalie im Hydraulikkreislauf (2),
- der durchgeführten Detektion, durch das elektronische Steuersystem (6) oder das Luftdetektionsmodul (7, 7'), einer Anomalie in der Temperatursteuerung des Heiz- oder Kühlsystems (1).

11. System (1) nach einem der vorhergehenden Ansprüche, wobei das Luftdetektionsmodul (7, 7') den Parameter (x) erhält, der indikativ für die Flussrate ist:

- von einem Signal der Flussrate, das von der Umwälzpumpe (5) bereitgestellt wird, oder
- von einem Signal eines Flussratensensors (8), der außerhalb der Umwälzpumpe (5) mit dem Hydraulikkreislauf (2) verbunden ist, oder
- von einem von der Umwälzpumpe (5) erzeugten Kopfsignal, oder
- von einem Signal der vom Elektromotor (10) der Umwälzpumpe (5) absorbierten elektrischen Leistung oder des elektrischen Stromwerts, oder
- von einem Signal der Drehzahl oder Winkelgeschwindigkeit des Elektromotors (10) der Umwälzpumpe (5).

12. System (1) nach einem der vorhergehenden Ansprüche, wobei das Luftdetektionsmodul (7, 7') die Berechnung der Variation (FlowRate_StdDev) der Vielzahl von Werten (x_t) durchführt, indem es Folgendes berechnet:

- die Standardvariation der Vielzahl von Werten (x_t), die im Detektionszeitintervall erfasst wurden, oder
- den Variationskoeffizienten, d. h. die relative Standardvariation der Vielzahl der im Detektionszeitintervall erfassten Werte (x_t), oder
- einen Mittelwert der absoluten Unterschiede zwischen allen Werten der Vielzahl von Werten (x_t) und einem

Mittelwert aller Werte der Vielzahl von Werten (x_t), oder
- einen Mittelwert der absoluten Unterschiede zwischen allen Werten der Vielzahl von Werten (x_t) und einem Zentralwert auf halbem Weg zwischen einem Maximalwert und einem Minimalwert aller Werte der Vielzahl von Werten (x_t).

13. Luftdetektionsprozess (15) in einem Heiz- oder Kühlsystem (1), insbesondere für den Hausgebrauch, der Art umfassend:

einen Hitze- oder Kältegenerator (4), der in einer Wärmeaustauschbeziehung mit einem hydraulischen Heiz- und/oder Kühlkreislauf (2) verbunden ist,
eine Umwälzpumpe (5), die mit dem Hydraulikkreislauf (2) verbunden ist, um einen Wasserfluss in den Hydraulikkreislauf (2) zu leiten,
ein elektronisches Steuersystem (6) in Signalverbindung mit dem Hitze- oder Kältegenerator (4) und mit der Umwälzpumpe (5), um den Betrieb des Hitze- oder Kältegenerators (4) und der Umwälzpumpe (5) zu steuern,
dadurch gekennzeichnet, dass der Luftdetektionsprozess (15) einen oder mehrere Luftdetektionsschritte (15.1, ..., 15.n) umfasst, wobei:

- bei aktivierter (F1) Umwälzpumpe (5) mit einer Umwälzgeschwindigkeit, Erfassen eines Parameter (x), der indikativ für die Flussrate des Wasserflusses innerhalb des Hydraulikkreislaufs (2) (F2) ist,
- Sammeln einer Vielzahl von Werten (x_t) des in einem Detektionszeitintervall (F3) erfassten Parameters (x),
- Berechnen einer Variation (FlowRate_StdDev) der Vielzahl der in dem Detektionszeitintervall (F4) erfassten Werte (x_t),
- Vergleichen der berechneten Variation (FlowRate_StdDev) mit einem Variationsschwellenwert (Threshold_var) (F5) und:

wenn die berechnete Variation (FlowRate_StdDev) größer ist als der Variationsschwellenwert (Threshold_var), Erzeugen eines Benachrichtigungssignals über das Vorhandensein von Luft im Hydraulikkreislauf (2) (F6), und wenn die berechnete Variation (FlowRate_StdDev) kleiner ist als der Variationsschwellenwert (Threshold_var), Erzeugen keines Benachrichtigungssignals über das Vorhandensein von Luft im Hydraulikkreislauf.

14. Prozess (15) nach Anspruch 13, wobei, wenn während eines ersten Luftdetektionsschritts (15.1) der Luftdetektionsschritte (15.1, ..., 15.n) bei einer ersten Pumpendrehzahl der Umwälzpumpe (5) die berechnete Variation (FlowRate_StdDev) niedriger ist als der Variationsschwellenwert (Threshold_var), ein weiterer Luftdetektionsschritt (15.2) unter Verwendung einer weiteren Pumpendrehzahl der Umwälzpumpe (5), die sich von der ersten Pumpendrehzahl unterscheidet, durchgeführt wird.

15. Prozess (15) nach Anspruch 14, umfassend:

- Durchführen des ersten Luftdetektionsschritts (15.1) bei einer ersten Pumpendrehzahl und des/der nachfolgenden Luftdetektionsschritt(s)(e) (15.2, ..., 15.n) bei Pumpendrehzahlen, die sich von einem Luftdetektionsschritt (15.n-1) zum nachfolgenden Luftdetektionsschritt (15.n) verringern.

16. Prozess (15) nach einem der Ansprüche 13 bis 15, umfassend:

- als Reaktion auf das Benachrichtigungssignal über das Vorhandensein von Luft im Hydraulikkreislauf (2), Senden eines Anomalie-Benachrichtigungssignals (F9) an einen entfernten Server (13), der als Reaktion auf den Empfang des Anomalie-Benachrichtigungssignals einen Wartungsvorbereitungsprozess (F10) durchführt, und/oder umfassend:

- Ermöglichen der manuellen Eingabe eines Startbefehls (F7) für den Luftdetektionsprozess (15) in einer Benutzerschnittstelle, und
- als Reaktion auf den Startbefehl für den Luftdetektionsprozess (15), Durchführen des Luftdetektionsprozesses (15),

und/oder umfassend:
Durchführen des Luftdetektionsprozesses (15) automatisch in Abhängigkeit von einem vorgegebenen Start-

kriterium.

Revendications

1. Système de chauffage ou de refroidissement (1), en particulier domestique, comprenant :

un générateur de chaleur ou de froid (4) pouvant être connecté, par une relation d'échange de chaleur, à un circuit hydraulique de chauffage et/ou de refroidissement (2),
une pompe de circulation (5), pouvant être raccordée au circuit hydraulique (2), pour acheminer un flux d'eau dans le circuit hydraulique (2),
un système de commande électronique (6) en liaison par signal avec le générateur de chaleur ou de froid (4) et avec la pompe de circulation (5), pour commander le fonctionnement du générateur de chaleur ou de froid (4) et de la pompe de circulation (5),
caractérisé en ce qu'il comprend :

un module de détection d'air (7, 7') configuré de manière à réaliser un processus de détection d'air (15), comprenant une ou plusieurs étapes de détection d'air (15.1, ..., 15.n), dans lequel :

- lorsque la pompe de circulation (5) est activée à une vitesse de circulation, il détecte un paramètre (x) indiquant le débit de l'eau à l'intérieur du circuit hydraulique (2),
- il collecte une pluralité de valeurs (x_t) du paramètre (x) détecté dans un intervalle de temps de détection,
- il calcule une variation (FlowRate_StdDev) de la pluralité de valeurs (x_t) collectées dans l'intervalle de temps de détection,
- il compare la variation calculée (FlowRate_StdDev) à une valeur seuil de variation (Threshold_var) et :

si la variation calculée (FlowRate_StdDev) est supérieure à la valeur seuil de variation (Threshold_var), il génère un signal de notification de présence d'air dans le circuit hydraulique (2), et
si la variation calculée (FlowRate_StdDev) est inférieure à la valeur seuil de variation (Threshold_var), il ne génère pas de signal de notification de présence d'air dans le circuit hydraulique.

2. Système (1) selon la revendication 1, dans lequel le module de détection d'air (7, 7') est configuré pour que, si lors d'une première étape de détection d'air (15.1) des étapes de détection d'air (15.1, ..., 15.n), à une première vitesse de pompage de la pompe de circulation (5), la variation calculée (FlowRate_StdDev) est inférieure à la valeur seuil de variation (Threshold_var), le module de détection d'air (7, 7') réalise une autre étape de détection d'air suivante (15.2), à une autre vitesse de pompage de la pompe de circulation (5) différente de la première vitesse de pompage.

3. Système (1) selon la revendication 2, dans lequel le module de détection d'air (7, 7') réalise la première étape de détection d'air (15.1) à une première vitesse de pompage et la ou les étapes de détection d'air suivantes (15.2, ..., 15.n) à des vitesses de pompage qui diminuent, d'une étape de détection d'air (15.n-1) à l'étape de détection d'air suivante (15.n).

4. Système (1) selon l'une quelconque des revendications précédentes, dans lequel, au cours de la même étape de détection d'air (15.n), la vitesse de pompage de la pompe de circulation (5) est constante,

et/ou dans lequel la durée de l'intervalle de détection est constante,
et/ou dans lequel le nombre de valeurs (x) détectées et collectées au cours de l'intervalle de détection est constant,
et/ou dans lequel la valeur seuil de variation (Threshold_var) est différente pour différentes vitesses de pompage de la pompe de circulation (5).

5. Système (1) selon l'une quelconque des revendications précédentes, dans lequel le signal de notification de la présence d'air dans le circuit hydraulique (2) déclenche :

- une notification visuelle et/ou acoustique et/ou
- un processus de contrôle automatique des anomalies sur le générateur de chaleur ou de froid (4) et/ou la pompe de circulation (5), et/ou

- un arrêt de sécurité du générateur de chaleur ou de froid (4) et de la pompe de circulation (5).

6. Système (1) selon la revendication 5, dans lequel la notification visuelle et/ou acoustique est réalisée par une interface utilisateur (12) du système de commande électronique (6) du système (1), disposée par exemple directement à l'intérieur du générateur de chaleur ou de froid (4) ou à l'extérieur de celui-ci, ou par une autre interface utilisateur (12') du module de détection d'air (7') disposée à l'extérieur du système de commande électronique (6).

7. Système (1) selon l'une quelconque des revendications précédentes, dans lequel le module de détection d'air (7) est directement intégré au système de commande électronique (6) du système de chauffage ou de refroidissement (1),

et/ou dans lequel le module de détection d'air (7') est un module de traitement électronique externe (7') par rapport au système de commande électronique (6) et pouvant être connecté au système (1) de manière temporaire ou permanente en tant qu'accessoire posé après coup,
et/ou dans lequel le signal de notification de la présence d'air dans le circuit hydraulique (2) déclenche la transmission d'un signal de notification d'anomalie pour un serveur distant (13) qui, en réponse à la réception du signal de notification d'anomalie, réalise un processus de préparation à la maintenance.

8. Système (1) selon l'une quelconque des revendications précédentes, dans lequel le module de détection d'air (7, 7') est configuré pour :

- permettre l'entrée manuelle d'une instruction de démarrage pour le processus de détection d'air (15), et
- en réponse à l'instruction de démarrage du processus de détection d'air (15), réaliser le processus de détection d'air (15).

9. Système (1) selon l'une quelconque des revendications précédentes, dans lequel le module de détection d'air (7, 7') est configuré pour réaliser automatiquement le processus de détection d'air (15) en fonction d'un critère de démarrage prédéterminé.

10. Système (1) selon la revendication 9, dans lequel le critère de démarrage est choisi dans le groupe constitué de :

- un intervalle de temps prédéterminé,
- une détection réalisée par le système de commande électronique (6) ou le module de détection d'air (7, 7') d'une anomalie de flux d'eau dans le circuit hydraulique (2),
- la détection, par le système de commande électronique (6) ou le module de détection d'air (7, 7'), d'une anomalie de régulation de la température sur le système de chauffage ou de refroidissement (1).

11. Système (1) selon l'une quelconque des revendications précédentes, dans lequel le module de détection d'air (7, 7') obtient le paramètre (x) indiquant le débit :

- à partir d'un signal de débit fourni par la pompe de circulation (5), ou
- à partir du signal d'un capteur de débit (8) connecté au circuit hydraulique (2) à l'extérieur de la pompe de circulation (5), ou
- à partir d'un signal de hauteur de chute généré par la pompe de circulation (5), ou
- à partir d'un signal de puissance électrique ou de valeur de courant électrique absorbée par le moteur électrique (10) de la pompe de circulation (5), ou
- à partir d'un signal du nombre de tours ou de la vitesse angulaire du moteur électrique (10) de la pompe de circulation (5).

12. Système (1) selon l'une quelconque des revendications précédentes, dans lequel le module de détection d'air (7, 7') réalise le calcul de la variation (FlowRate_StdDev) de la pluralité de valeurs (x_t) en calculant :

- l'écart-type de la pluralité de valeurs (x_t) collectées dans l'intervalle de temps de détection, ou
- le coefficient de variation, c'est-à-dire l'écart-type relatif de la pluralité de valeurs (x_t) collectées dans l'intervalle de temps de détection, ou
- une valeur moyenne des différences absolues entre toutes les valeurs de la pluralité de valeurs (x_t) et une valeur moyenne de toutes les valeurs de la pluralité de valeurs (x_t), ou
- une valeur moyenne des différences absolues entre toutes les valeurs de la pluralité de valeurs (x_t) et une valeur centrale à mi-chemin entre une valeur maximale et une valeur minimale de toutes les valeurs de la pluralité

de valeurs (x_t).

13. Processus de détection d'air (15) dans un système de chauffage ou de refroidissement (1), en particulier domestique, du type comprenant :

un générateur de chaleur ou de froid (4) connecté par une relation d'échange de chaleur à un circuit hydraulique de chauffage et/ou de refroidissement (2),
une pompe de circulation (5), connectée au circuit hydraulique (2), pour acheminer un flux d'eau dans le circuit hydraulique (2),
un système de commande électronique (6) en liaison par signal avec le générateur de chaleur ou de froid (4) et avec la pompe de circulation (5), pour commander le fonctionnement du générateur de chaleur ou de froid (4) et de la pompe de circulation (5),
caractérisé en ce que le processus de détection d'air (15) comprend une ou plusieurs étapes de détection d'air (15.1, ..., 15.n), dans lequel :

- avec la pompe de circulation (5) activée (F1) à une vitesse de circulation, la détection d'un paramètre (x) indiquant le débit du flux d'eau à l'intérieur du circuit hydraulique (2) (F2),
- la collecte d'une pluralité de valeurs (x_t) du paramètre (x) détecté dans un intervalle de temps de détection (F3),
- le calcul d'une variation (FlowRate_StdDev) de la pluralité de valeurs (x_t) collectées dans l'intervalle de temps de détection (F4),
- la comparaison de la variation calculée (FlowRate_StdDev) à une valeur seuil de variation (Threshold_var) (F5) et :

si la variation calculée (FlowRate_StdDev) est supérieure à la valeur seuil de variation (Threshold_var), la génération d'un signal de notification de présence d'air dans le circuit hydraulique (2) (F6), et
si la variation calculée (FlowRate_StdDev) est inférieure à la valeur seuil de variation (Threshold_var), l'absence de génération de signal de notification de présence d'air dans le circuit hydraulique.

14. Processus (15) selon la revendication 13, dans lequel, si au cours d'une première étape de détection d'air (15.1) parmi les étapes de détection d'air (15.1, ..., 15.n), à une première vitesse de pompage de la pompe de circulation (5), la variation calculée (FlowRate_StdDev) est inférieure à la valeur seuil de variation (Threshold_var), la réalisation d'une étape supplémentaire de détection d'air (15.2), à l'aide d'une autre vitesse de pompage de la pompe de circulation (5) différente de la première vitesse de pompage.

15. Processus (15) selon la revendication 14, comprenant :

- la réalisation de la première étape de détection d'air (15.1) à une première vitesse de pompage et de la ou des étapes suivantes de détection d'air (15.2, ..., 15.n) à des vitesses de pompage qui diminuent, d'une étape de détection d'air (15.n-1) à l'étape de détection d'air suivante (15.n).

16. Processus (15) selon l'une quelconque des revendications 13 à 15, comprenant :

- en réponse au signal de notification de présence d'air dans le circuit hydraulique (2), la transmission d'un signal de notification d'anomalie (F9) à un serveur distant (13) qui, en réponse à la réception du signal de notification d'anomalie, réalise un processus de préparation de la maintenance (F10),
et/ou comprenant :

- le fait de permettre la saisie manuelle d'une instruction de démarrage (F7) pour le processus de détection d'air (15) dans une interface utilisateur, et
- en réponse à l'instruction de démarrage du processus de détection d'air (15), la réalisation du processus de détection d'air (15),

et/ou comprenant :
la réalisation automatique du processus de détection d'air (15) en fonction d'un critère de départ prédéterminé.

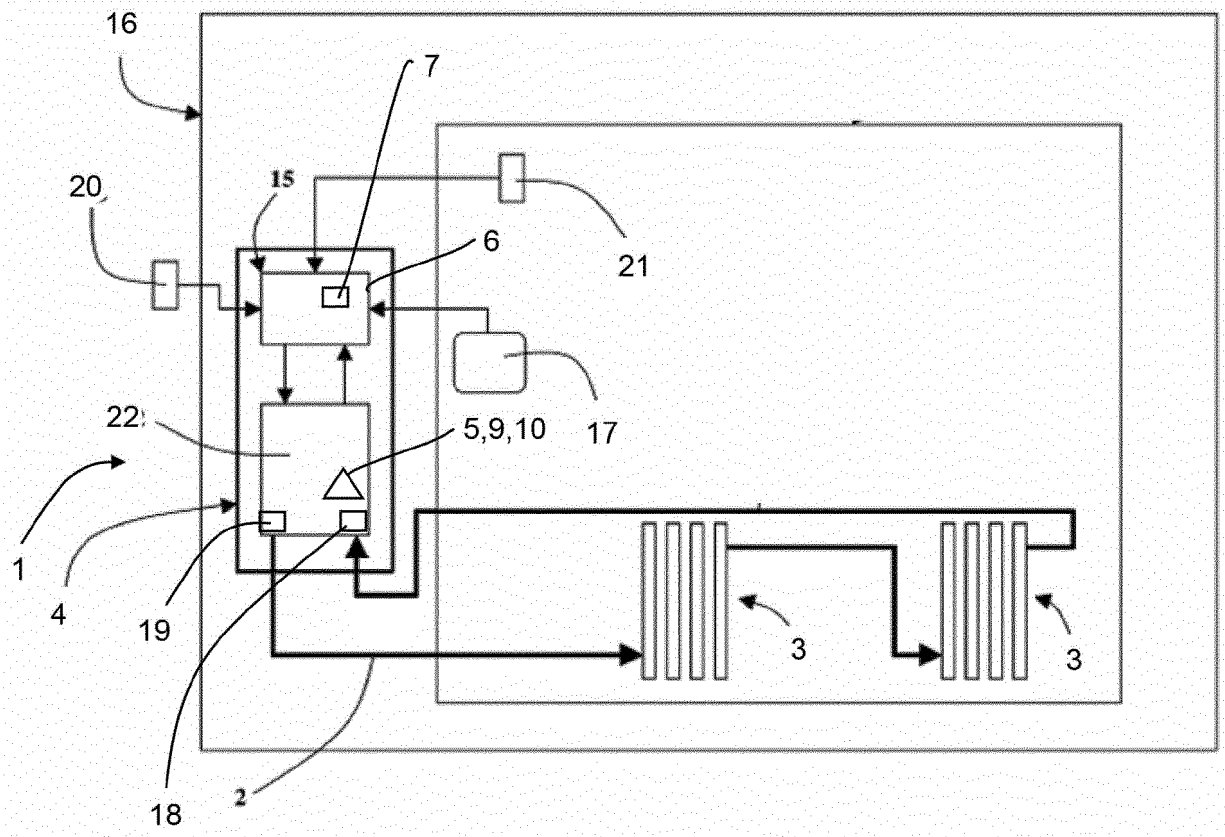
16
7
20
15
6
21
22
5,9,10
17
1
4
19
3
3
18
2

FIG. 1

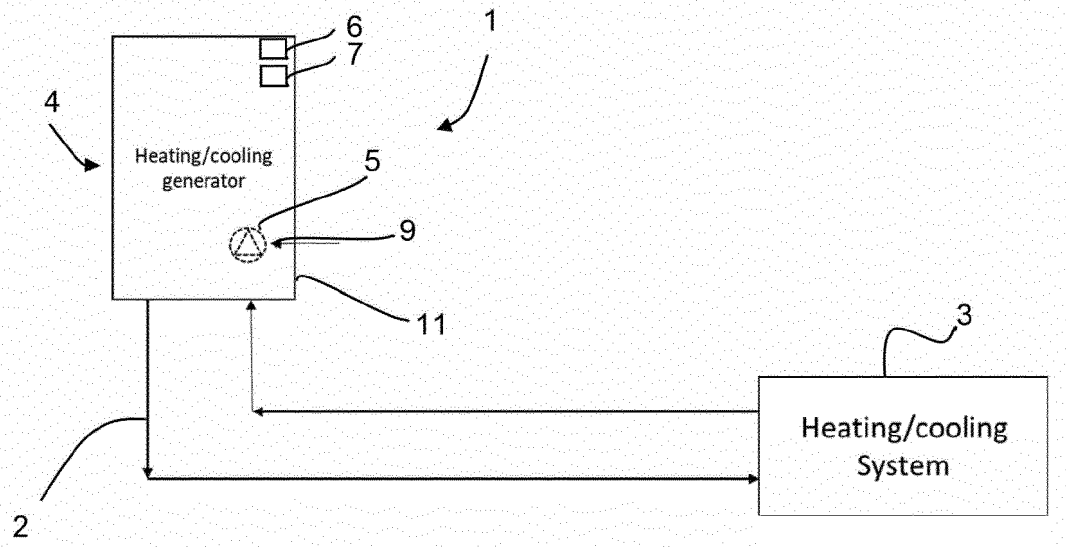
6
7
1
4
Heating/cooling generator
5
9
11
3
Heating/cooling System
2

FIG. 2

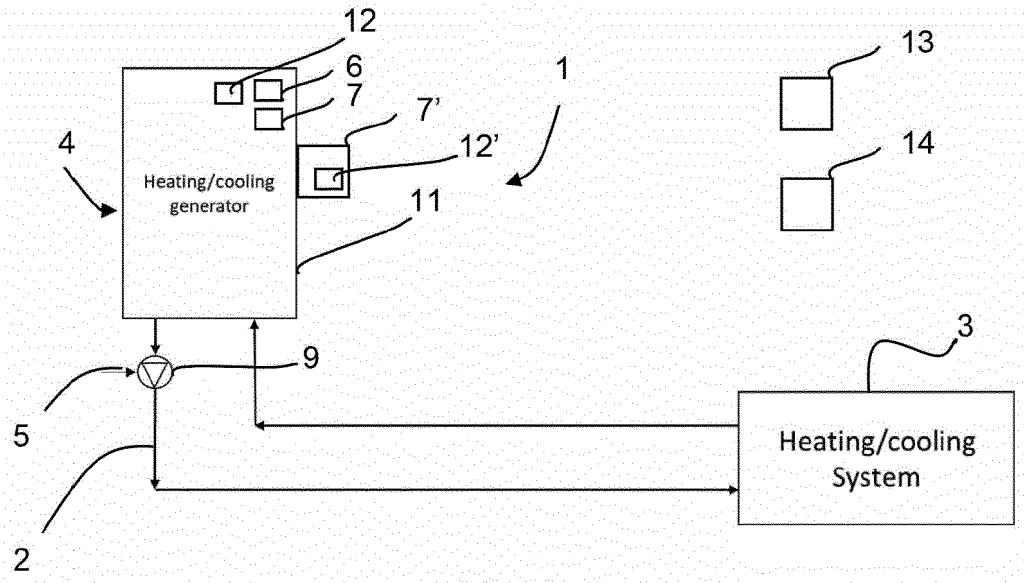

FIG. 3

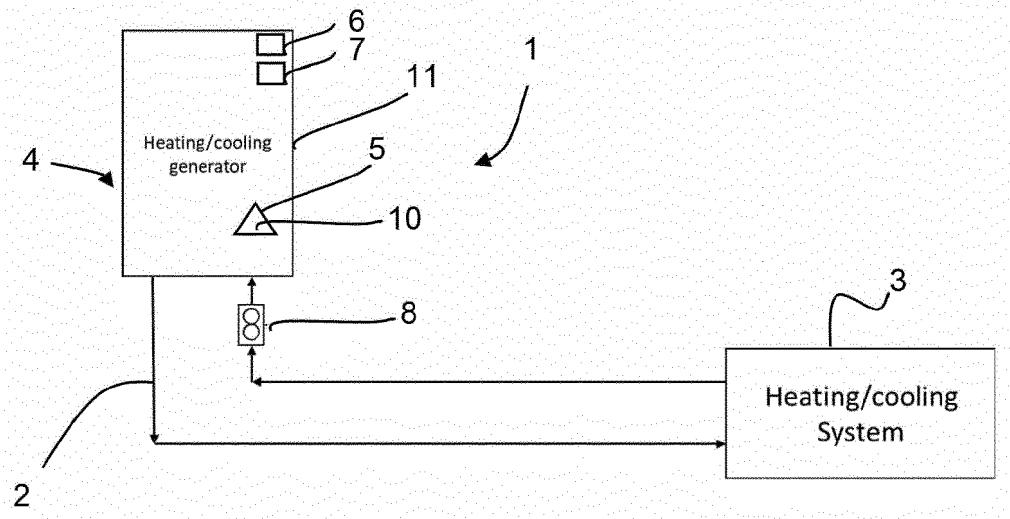

FIG. 4

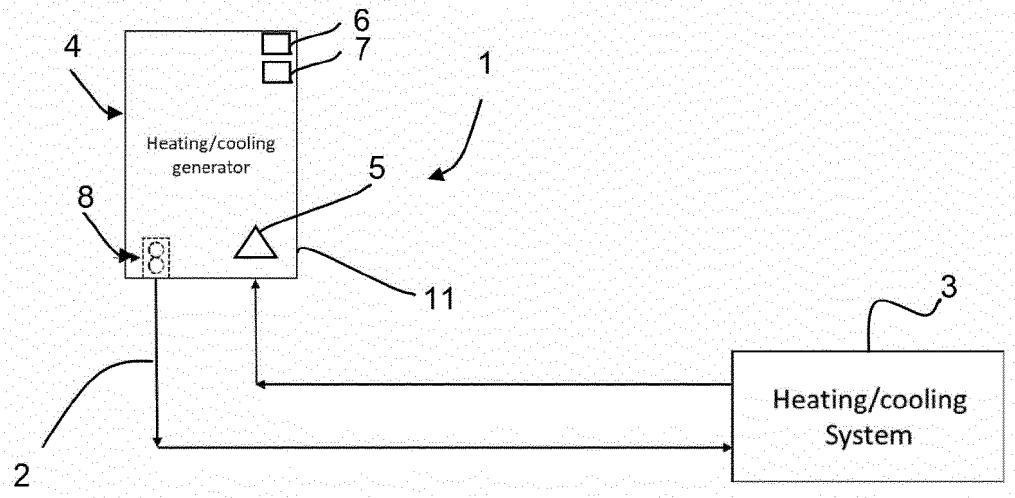

FIG. 5

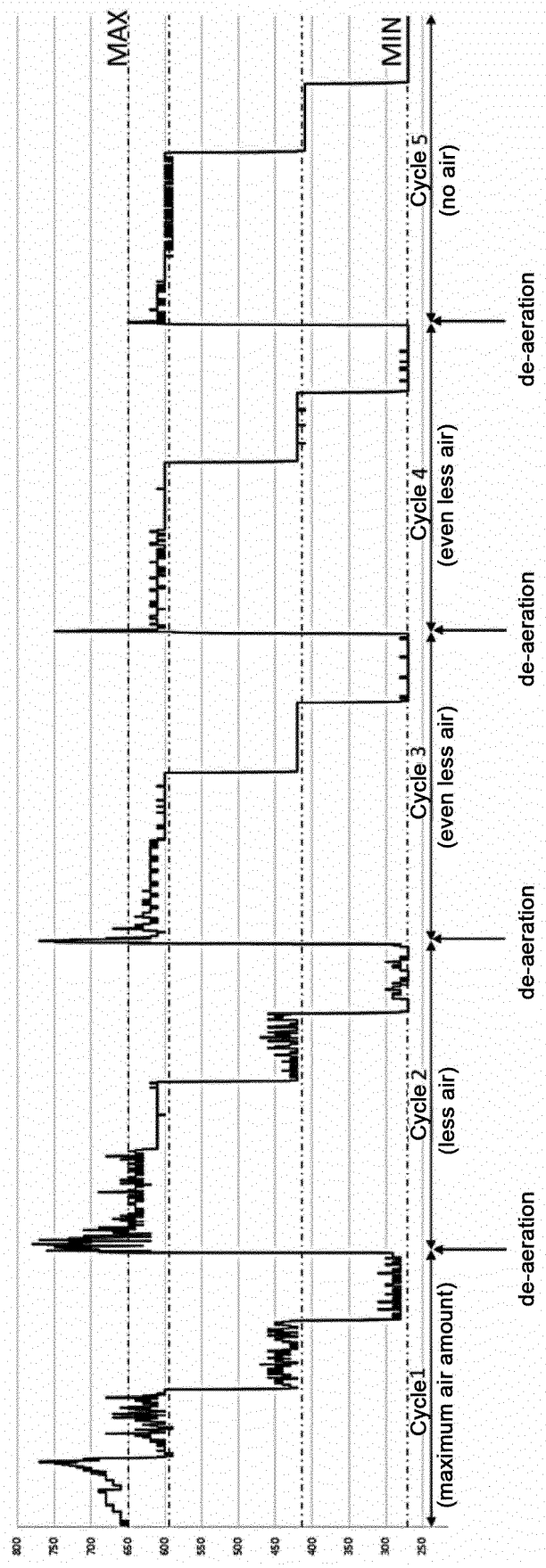
MAX
MIN
800
750
700
650
600
550
500
450
400
350
300
250
Cycle1
(maximum air amount)
de-aeration
Cycle 2
(less air)
de-aeration
Cycle 3
(even less air)
de-aeration
Cycle 4
(even less air)
de-aeration
Cycle 5
(no air)

FIG. 6

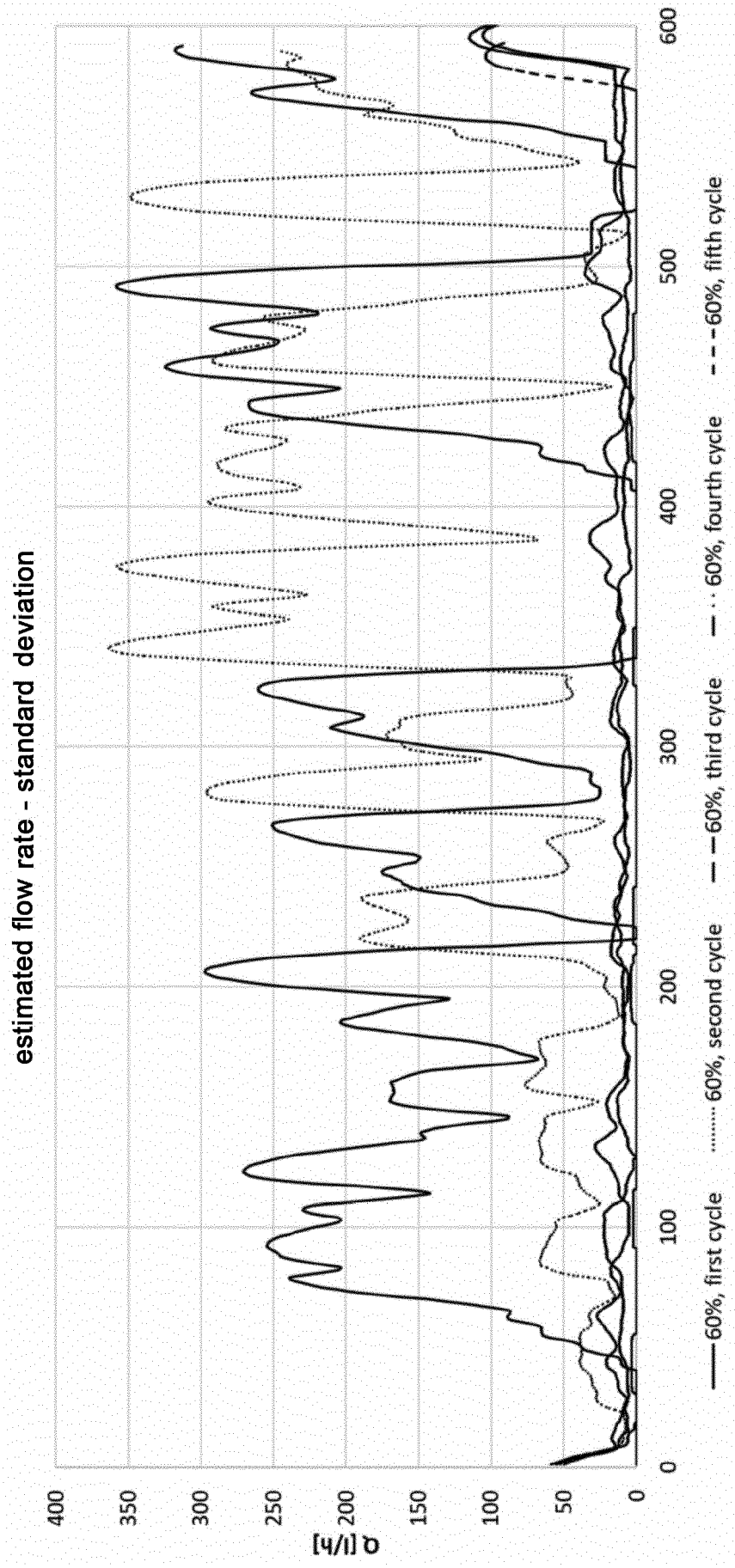
estimated flow rate - standard deviation
Q [l/h]
400
350
300
250
200
150
100
50
0
0
100
200
300
400
500
600
60%, first cycle
60%, second cycle
60%, third cycle
60%, fourth cycle
60%, fifth cycle

FIG. 7

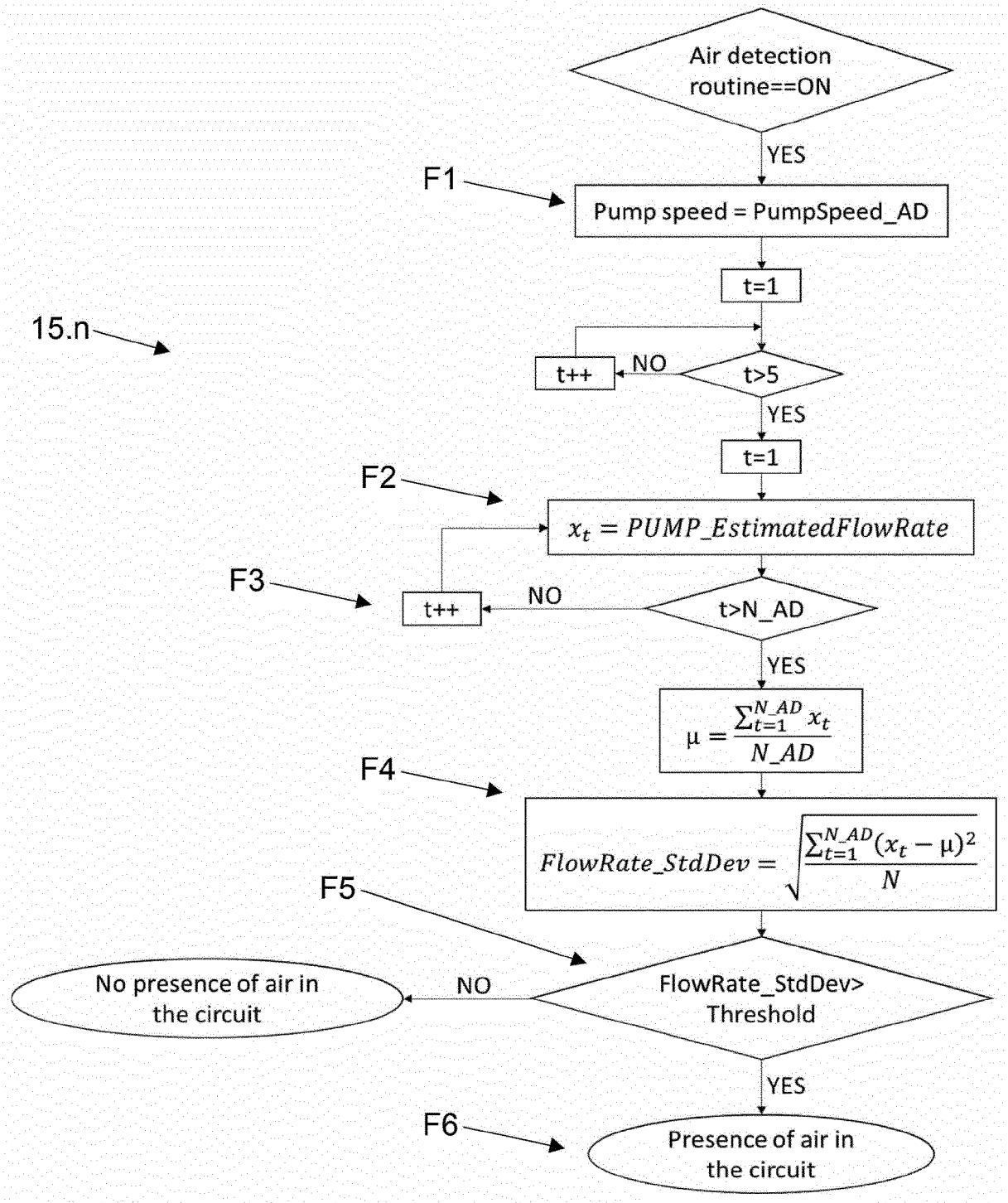
Air detection routine==ON
YES
F1
Pump speed = PumpSpeed_AD
t=1
15.n
t++
NO
t>5
YES
t=1
F2
$x_t = PUMP\_EstimatedFlowRate$
F3
t++
NO
t>N_AD
YES
$\mu = \frac{\sum_{t=1}^{N\_AD} x_t}{N\_AD}$
F4
$FlowRate\_StdDev = \sqrt{\frac{\sum_{t=1}^{N\_AD}(x_t - \mu)^2}{N}}$
F5
No presence of air in the circuit
NO
FlowRate_StdDev> Threshold
YES
F6
Presence of air in the circuit

FIG. 8

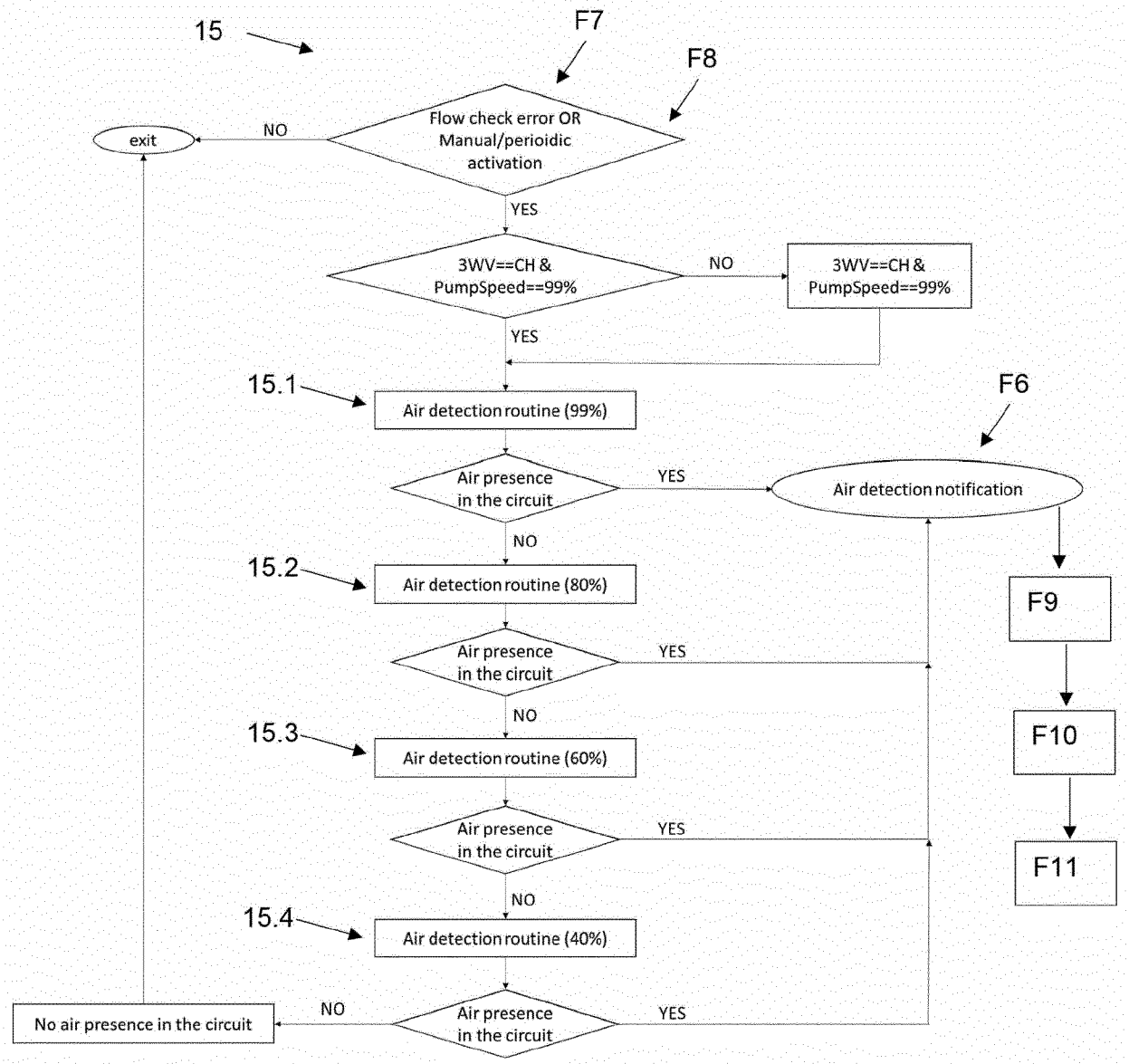
15
F7
F8
Flow check error OR Manual/perioidic activation
NO
exit
YES
3WV==CH & PumpSpeed==99%
NO
3WV==CH & PumpSpeed==99%
YES
15.1
Air detection routine (99%)
F6
Air presence in the circuit
YES
Air detection notification
NO
15.2
Air detection routine (80%)
F9
Air presence in the circuit
YES
NO
15.3
Air detection routine (60%)
F10
Air presence in the circuit
YES
NO
15.4
Air detection routine (40%)
F11
No air presence in the circuit
NO
Air presence in the circuit
YES

FIG. 9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 2918923 A1 **[0003]**
- EP 1593916 B1 **[0003]**
- KR 20040081983 A **[0003]**