(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 633 291 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
08.04.2020 Bulletin 2020/15

(21) Application number: **19174655.1**

(22) Date of filing: **15.05.2019**

(51) Int Cl.:
***F25D 21/02** (2006.01)* ***F24F 11/41** (2018.01)*
F25B 47/00 (2006.01) *F25D 17/04 (2006.01)*

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

(30) Priority: **04.10.2018 EP 18198619**

(71) Applicant: **Siemens Schweiz AG**
8047 Zürich (CH)

(72) Inventors:
- **Val, Emmanuel**
  8942 Oberrieden (CH)
- **Mohajer Ashjaei, Babak**
  6003 Luzern (CH)

(74) Representative: **Maier, Daniel Oliver**
Siemens AG
Postfach 22 16 34
80506 München (DE)

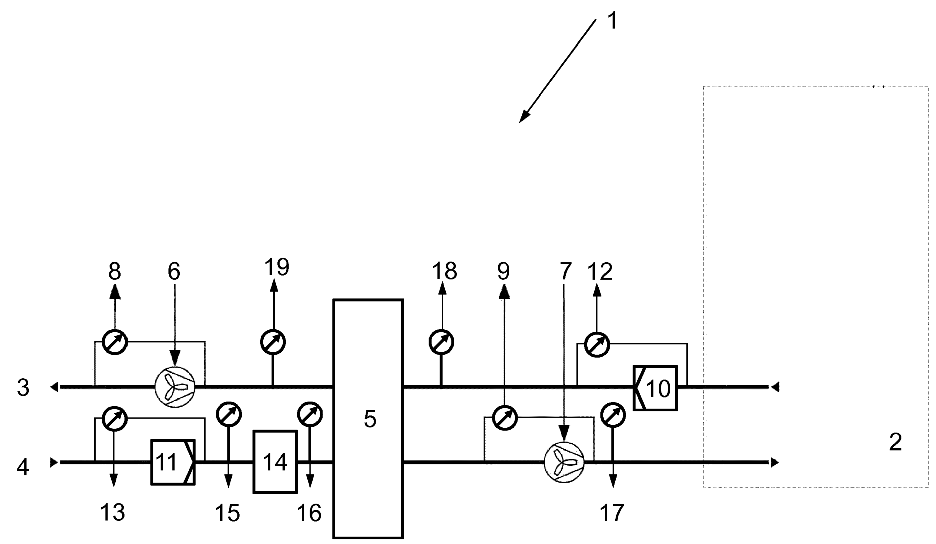
Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) METHOD AND CONTROLLER FOR SIGNALING ICING IN A HEATING, VENTILATION OR AIR-CONDITIONING EQUIPMENT

(57) Control of heating, ventilation, air-conditioning equipment. A method for signaling icing within a structure (1), the structure (1) comprising a circuit (2 - 4), the circuit (2 - 4) comprising an appliance (6, 7, 10, 11) selected from a fluid conveyor (6, 7) and/or a filter (10, 11); the structure (1) comprising a sensor (8, 9, 12, 13) in fluid communication with the appliance (6, 7, 10, 11); the method comprising the steps of: the sensor (8, 9, 12, 13) recording a first signal; the sensor (8, 9, 12, 13) recording a second signal; processing the first signal to produce a first measure and processing the second signal to produce a second measure; producing a differential measure from the second measure and from the first measure; comparing the differential measure to a predetermined threshold; and producing a signal indicative of icing if the differential measure exceeds the predetermined threshold.

FIG 1

2018P22614 – foreign filing version



EP 3 633 291 A1

Description

Background

[0001] The present disclosure relates to control of installations for heating, ventilation, and/or air-conditioning. More particularly, the present disclosure focuses on de-icing of such installations and on inhibition of clogging caused by a build-up of ice.

[0002] Installations for heating, ventilation, and/or air-conditioning frequently comprise air handling units and/or heat recovery units. These units may be arranged in the inlet ducts as well as in the outlet ducts of such installations. A sensor may be connected to record a pressure drop across an air-handling unit and/or across a heat recovery unit. An excessive value of pressure drop across an air-handling unit or across a heat recovery unit may suggest build-up of ice inside the respective unit. Also, a temperature probe can be arranged upstream of the air handling unit and/or upstream of the heat recovery unit. A signal obtained from the temperature probe may thus indicate an imminent risk.

[0003] A patent US4,416,323 issued on 22 November 1983. An application 191,881 for this patent was filed on 29 September 1980. The patent US4,416,323 deals with air cooler freeze protection.

[0004] US4,416,323 discloses a heat exchanger 10 with an inlet 11 and with an outlet 15. A plurality of tubes 13 is situated inside the heat exchanger 10 and air is drawn over the tubes 13 by fans 16. The specification discloses that the tubes 13 may contain a fluid such as water.

[0005] The heat exchanger 10 also comprises a plurality of thermocouples 19, 20. Leads 22 connect the thermocouples 19, 20 to a scanner 23. The scanner 23 monitors temperatures recorded by the thermocouples 19, 20. Whenever a temperature below 10 degrees centigrade is observed, a visible or an audible alarm may be triggered. Also, flow of air over the tubes 13 may be reduced.

[0006] The patent US3,319,657 issued on 16 May 1967. An application for this patent was filed on 16 October 1964. US3,319,657 teaches as background art closure of an air damper in the event of a temperature dropping below 36 or 38 degrees Fahrenheit. That way, damage is prevented to a heat exchange coil.

[0007] US3,319,657 also discloses relief plugs in the bends of a serpentine heat exchange coil. The relief plug comprises a plug body 60 holding a disc 64. In the event of freezing, the disc 64 is forced out of the plug body 60 thereby allowing a solid such as ice inside the heat exchange coil to expand. Whilst freezing causes no damage to the heat exchange coil itself, the relief plug may require replacement.

[0008] A patent US5101639A issued on 7 April 1992. An application No 526,857 for the patent US5101639A was filed on 21 May 1990. US5101639A deals with an air handling system utilizing direct expansion cooling.

[0009] US2008/307803A1 was published as a patent application on 18 December 2008. The patent application US2008/307803A1 has an application No 11/811,690. The application was filed on 12 June 2007. US2008/307803A1 teaches humidity control and air conditioning.

[0010] Publication of an international patent application WO2016/060609A1 took place on 21 April 2016. The application WO2016/060609A1 was filed on 15 October 2015 and claims a priority of a Swedish application of 16 October 2014. WO2016/060609A1 discloses adaptive defrosting of an air treatment system.

[0011] The present disclosure inhibits build-up of ice and/or clogging inside heat exchangers such as air handling units and/or heat recovery units. The instant disclosure confers advantages in terms of energy savings and reduces failures of heat exchangers.

Summary

[0012] The instant disclosure teaches a method for indicating and/or signaling icing in a structure and, in particular, in a circuit of the structure. The circuit preferably is a circuit for heating, ventilation and/or air-conditioning. In installations for heating, ventilation and/or air-conditioning, a quantity such as (differential) pressure, temperature, air density, fan curves etc. may be employed to indicate icing. In complex installations, inference from a single measured quantity may, however, prove unreliable.

[0013] Rather than relying on a single measured quantity, a change in measured quantities is observed. An indication of icing will be produced if the change in these measured quantities exceeds a predetermined limit.

[0014] It is also an object of the instant disclosure to indicate icing inside a heat exchanger with no relevant sensor. To that end, a change in a measured quantity associated with another component is observed. If that change is above a threshold value, a signal indicative of icing in the heat exchanger will be triggered.

[0015] It is a related object of the present disclosure to infer on icing based on differential signal. A differential signal is advantageously obtained from a sensor that connects to the upstream side as well as to the downstream side of a piece of equipment. In other words, the sensor records a differential signal across the piece of equipment.

[0016] It is yet another object of the instant disclosure to infer on icing from a time derivative of a measured value. Use of a time derivative accommodates not only for a change in a measured value, but also for its rate of change.

[0017] It is a particular object of the instant disclosure to correct measured values for changes in temperature. To that end, the sensor comprises a temperature sensor such as a PT100 probe or a thermocouple. A signal indicative of icing can then be produced based on an adjusted value.

[0018] It is still an object of the instant disclosure to take action once icing is detected in a structure. To that end, a preheater in a circuit of the structure is activated. The preheater upon activation (electrically) heats a fluid in order to inhibit icing. It is also envisaged to reverse the thrust of fluid conveyors such as fans and/or to reverse the direction of an impeller once icing is detected in a structure. It is still further envisaged to envisage reverse fluid flow from a heat exchanger once icing is detected in a structure.

[0019] It is still another object of the present disclosure to consider operating characteristics of appliances in a circuit for heating, ventilation and/or air-conditioning. To provide more flexible and more nuanced indications, characteristics of appliances such as fan speeds or damper positions are factored in.

[0020] It is also an object of the instant disclosure to provide a computer program that indicates icing. The computer program may, in particular, be stored in an isolated image. The computer program may be executed using operating-system-level virtualization.

[0021] It is still an object of the present disclosure to provide a controller that performs any of the aforementioned methods. The controller may be a building (management) controller or a controller for heating, ventilation and/or air conditioning.

[0022] It is also an object of the instant disclosure to provide a sophisticated decision making process by employing an icing curve rather than a single threshold. Use of an icing curve allows inference on icing when the problem becomes multi-dimensional. That is, an indication of icing can be produced based on a plurality of contributing factors.

[0023] It is yet another object of the present disclosure to provide a system and/or a structure and/or a building that implement(s) any of the aforementioned methods. The system may, in particular, be a heating, ventilation and/or air-conditioning system.

Brief description of the drawings

[0024] Various features will become apparent to those skilled in the art from the following detailed description of the disclosed non-limiting embodiments. The drawings that accompany the detailed description can be briefly described as follows:

FIG 1 schematically depicts a structure with controlled equipment installed in its exhaust ducts and intake ducts.

FIG 2 schematically depicts a controller for heating, ventilation and/or air-conditioning.

FIG 3 illustrates an exemplary characteristic curve.

Detailed decription

[0025] FIG 1 shows a structure 1 such as structure 1 comprising a building 2. The building 2 may, by way of non-limiting example, comprise and/or be a residential and/or commercial and/or industrial building. The structure 1 provides an exhaust duct 3. In an embodiment, the exhaust duct 3 is an exhaust conduit. The structure 1 also provides an intake duct 4. In an embodiment, the intake duct 4 is a intake conduit 4.

[0026] The exhaust duct 3 preferably comprises a first exhaust portion inside the building 2 and a second exhaust portion outside the building 2. Likewise, the intake duct 4 preferably comprises a first intake portion inside the building 2 and a second intake portion outside the building 2.

[0027] A heat exchanger 5 transfers energy between the exhaust duct 3 and the intake duct 4. To that end the exhaust duct 3 and the inlet duct 4 each comprise a portion that is coupled to the heat exchanger. That way, energy can be transferred from the coupled portion of the exhaust duct 3 to the coupled portion of the intake duct 4. Likewise, energy can be transferred from the coupled portion of the intake duct 4 to the coupled portion of the exhaust duct 3. In other words, the heat exchanger 5 couples the intake duct 4 to the exhaust duct 3 and vice versa. In an embodiment, transfer of energy is exchange of heat.

[0028] In an embodiment, the heat exchanger 5 is or comprises an air handling unit. In another embodiment, the heat exchanger 5 is or comprises a heat recovery unit. In yet another embodiment, the heat exchanger 5 is or comprises a coil.

[0029] According to an aspect of the present disclosure, a fluid conveyor 6 conveys a fluid such as air through the exhaust duct 3. Fluid conveyor 6 may, by way of non-limiting example, be a variable speed fan or an adjustable damper together with a constant speed fan or a variable speed fan together with an adjustable damper. It is envisaged that the rotational speed of a variable speed fan of the fluid conveyor 6 is set by a pulse-width modulated signal. It is also envisaged that the rotational speed of a variable speed fan of the fluid conveyor 6 is set by an inverter. It is further envisaged that the position of a damper of the fluid conveyor 6 is set by a pulse-width modulated signal. It is still further envisaged that the position of a damper of the fluid conveyor 6 is set by an inverter.

[0030] According to another aspect of the present disclosure, a fluid conveyor 7 conveys a fluid such as air through the intake duct 4. Fluid conveyor 7 may, by way of non-limiting example, be a variable speed fan or an adjustable damper together with a constant speed fan or a variable speed fan together with an adjustable damper. It is envisaged that the rotational speed of a variable speed fan of the fluid conveyor 7 is set by a pulse-width modulated signal. It is also envisaged that the rotational speed of a variable speed fan of the fluid conveyor 7 is set by an inverter. It is further envisaged that the position of a damper of the fluid conveyor 7 is set by a pulse-width modulated signal. It is still further envisaged that the position of a damper of the fluid conveyor 7 is set by an inverter.

[0031] A sensor 8 can be provided to record signals related to a fluid inside exhaust duct 3. A first port connects the sensor 8 to a portion of exhaust duct 3 that is upstream of fluid conveyor 6. A second port connects the sensor 8 to a portion of exhaust duct 3 that is downstream of fluid conveyor 6. The sensor 8 preferably comprises a pressure sensor, in particular a differential pressure sensor. In an embodiment, a differential pressure sensor 8 records a differential pressure across fluid conveyor 6. It is envisaged that the differential pressure sensor 8 comprises a diaphragm-beam type sensor element.

[0032] A sensor 9 can be provided to record signals related to a fluid inside intake duct 4. A first port connects the sensor 9 to a portion of intake duct 4 that is upstream of fluid conveyor 7. A second port connects the sensor 9 to a portion of intake duct 4 that is downstream of fluid conveyor 7. The sensor 9 preferably comprises a pressure sensor, in particular a differential pressure sensor. In an embodiment, a differential pressure sensor 9 records a differential pressure across fluid conveyor 7. It is envisaged that the differential pressure sensor 9 comprises a diaphragm-beam type sensor element.

[0033] An exhaust filter 10 is optionally comprised and/or arranged in the exhaust duct 3. The filter 10 may, by way of non-limiting example, remove particles larger than or equal to 10 micrometers in size. The exhaust filter 10 may, by way of another non-limiting example, remove particles larger than or equal to 2.5 micrometers in size. The exhaust filter 10 may, by way of yet another non-limiting example, remove particles larger than or equal to 1 micrometer in size. It is also envisaged that the filter 10 reduces percentages of volatile organic compounds.

[0034] An intake filter 11 is optionally comprised and/or arranged in the intake duct 4. The filter 11 may, by way of non-limiting example, remove particles larger than or equal to 10 micrometers in size. The intake filter 11 may, by way of another non-limiting example, remove particles larger than or equal to 2.5 micrometers in size. The intake filter 11 may, by way of yet another non-limiting example, remove particles larger than or equal to 1 micrometer in size. It is also envisaged that the filter 11 reduces percentages of volatile organic compounds.

[0035] A sensor 12 can be provided to record signals related to a fluid inside exhaust duct 3. A first port connects the sensor 12 to a portion of exhaust duct 3 that is upstream of filter 10. A second port connects the sensor 12 to a portion of exhaust duct 3 that is downstream of filter 10. The sensor 12 preferably comprises a pressure sensor, in particular a differential pressure sensor. In an embodiment, a differential pressure sensor 12 records a differential pressure across filter 10. It is envisaged that the differential pressure sensor 12 comprises a diaphragm-beam type sensor element.

[0036] A sensor 13 can be provided to record signals related to a fluid inside intake duct 4. A first port connects the sensor 13 to a portion of intake duct 4 that is upstream of filter 11. A second port connects the sensor 13 to a portion of intake duct 4 that is downstream of filter 11. The sensor 13 preferably comprises a pressure sensor, in particular a differential pressure sensor. In an embodiment, a differential pressure sensor 13 records a differential pressure across filter 11. It is envisaged that the differential pressure sensor 13 comprises a diaphragm-beam type sensor element.

[0037] A preheater 14 such as an air preheater is optionally comprised and/or arranged in the intake duct 4. The preheater 14 is preferably arranged upstream of the heat exchanger 5. That way, the preheater 14 can heat a fluid entering the heat-exchanger 5 via the intake duct 4 to a temperature above a predetermined threshold. The predetermined threshold may, by way of non-limiting example, be 273 Kelvin or 275 Kelvin or 283 Kelvin. The skilled person chooses temperatures of fluids entering the heat exchanger 5 such as to inhibit icing and/or clogging.

[0038] In an embodiment, the preheater 14 comprises an electric preheater. The preheater 14 can, in particular, comprise a heat pump. In an alternate embodiment, the preheater 14 comprises a gas-fired preheater. In yet another embodiment, the preheater 14 comprises an oil-fired preheater.

[0039] A sensor 15 can be arranged upstream of preheater 14. According to an aspect, the sensor 15 comprises a thermometer such as a thermocouple and/or a PT100 sensor. The sensor 15 may as well comprise a temperature switch. A temperature switch 15 produces a signal in response to a temperature drop below a predetermined threshold or in response to a temperature rise above a predetermined threshold. The temperature sensor 15 in combination with preheater 14 enables a control loop. Accordingly, temperatures of fluids entering the heat exchanger 5 can be kept above a predetermined threshold.

[0040] It is also envisaged that sensor 15 comprises a pressure sensor and/or a moisture sensor and/or a sensor for volatile organic compounds and/or a sensor for particular matter, in particular for particulate matter 10 micrometers or 2.5 micrometers or 1 micrometer in size. On another note, sensor 15 may comprise a density sensor.

[0041] A sensor 16 can be arranged downstream of preheater 14. According to an aspect, the sensor 16 comprises a thermometer such as a thermocouple and/or a PT100 sensor. The sensor 16 may as well comprise a temperature switch. A temperature switch 16 produces a signal in response to a temperature drop below a predetermined threshold or in response to a temperature rise above a predetermined threshold. The temperature sensor 16 in combination with preheater 14 and/or in combination with the upstream sensor 15 enables a control loop. Accordingly, temperatures of fluids entering the heat exchanger 5 can be kept above a predetermined threshold.

[0042] It is also envisaged that sensor 16 comprises a pressure sensor and/or a moisture sensor and/or a sensor for volatile organic compounds and/or a sensor for particular matter, in particular for particulate matter 10 micrometers or 2.5 micrometers or 1 micrometer in size. On another note, sensor 16 may comprise a density sensor.

[0043] Intake duct 4 comprises an outlet port. A fluid flowing through intake duct 4 enters a structure such as a commercial, industrial and/or residential building at the outlet of intake duct 4.

[0044] A sensor 17 is arranged at or near or adjacent the outlet port of intake duct 4. The sensor 17 preferably comprises a temperature sensor such as a thermocouple and/or a PT100 sensor. The sensor 17 may also comprise a temperature switch. A temperature switch 17 produces a signal in response to a temperature drop below a predetermined threshold or in response to a temperature rise above a predetermined threshold. The temperature sensor 17 in combination with the heat exchanger 5 and/or in combination with the preheater 14 enables a control loop. Accordingly, temperatures of fluids entering the commercial, residential and/or industrial building 2 can be kept above or below a predetermined threshold.

[0045] It is also envisaged that sensor 17 comprises a pressure sensor and/or a moisture sensor and/or a sensor for volatile organic compounds and/or a sensor for particular matter, in particular for particulate matter 10 micrometers or 2.5 micrometers or 1 micrometer in size. On another note, sensor 17 may comprise a density sensor.

[0046] The sensor 17 is preferably arranged less than 500 mm, in particular less than 100 mm or less than 50 mm from the outlet port of intake duct 4.

[0047] An exhaust sensor 18 can be arranged in and/or be comprised in exhaust duct 3. The sensor 18 is advantageously arranged upstream of the heat exchanger 5. According to an aspect, the sensor 18 comprises a thermometer such as a thermocouple and/or a PT100 sensor. The sensor 18 may as well comprise a temperature switch. A temperature switch 18 produces a signal in response to a temperature drop below a predetermined threshold or in response to a temperature rise above a predetermined threshold.

[0048] An additional exhaust sensor 19 can be arranged in and/or be comprised in exhaust duct 3. The sensor 19 is advantageously arranged downstream of the heat exchanger 5. According to an aspect, the sensor 19 comprises a thermometer such as a thermocouple and/or a PT100 sensor. The sensor 19 may as well comprise a temperature switch. A temperature switch 19 produces a signal in response to a temperature drop below a predetermined threshold or in response to a temperature rise above a predetermined threshold.

[0049] The exhaust sensors upstream 18 and downstream 19 of heat exchanger 5 allow determination of a temperature drop in the exhaust duct 5 across heat exchanger 5. Accordingly, measured values enabling control of the heating power and or of the cooling power of heat exchanger 5 become available.

[0050] It is also envisaged that exhaust sensor 18 comprises a pressure sensor and/or a moisture sensor and/or a sensor for volatile organic compounds and/or a sensor for particular matter, in particular for particulate matter 10 micrometers or 2.5 micrometers or 1 micrometer in size. On another note, sensor 18 may comprise a density sensor.

[0051] It is also envisaged that exhaust sensor 19 comprises a pressure sensor and/or a moisture sensor and/or a sensor for volatile organic compounds and/or a sensor for particular matter, in particular for particulate matter 10 micrometers or 2.5 micrometers or 1 micrometer in size. On another note, sensor 19 may comprise a density sensor.

[0052] Now turning to FIG 2, a controller 20 is shown with a memory 22 and with a processor 21. It is envisaged that the processor 21 is a microcontroller or a microprocessor. In an embodiment, the memory 22 is a non-volatile memory, preferably also a non-transitory memory. The processor 21 is coupled to the memory 22 such that the processor 21 may read data from the memory 22. Ideally, the processor 21 may also write data to the memory 22.

[0053] The controller 20 is coupled to the sensors 8, 9, 12, 13, 15 - 19. That is, the controller 20 may read data from the sensors 8, 9, 12, 13, 15 - 19. Ideally, the controller 20 may also transmit data such as request packages to the sensors 8, 9, 12, 13, 15 - 19. The skilled person chooses a suitable unidirectional or bidirectional interface for communication between the controller 20 and the sensors 8, 9, 12, 13, 15 - 19.

[0054] In an embodiment, the controller 20 communicates with the sensors 8, 9, 12, 13, 15 - 19 via a bus. Communication via the bus may be compatible with a predetermined communication bus protocol. In a particular embodiment, the controller 20 communicates with the sensors 8, 9, 12, 13, 15 - 19 via a Power-over-Ethernet bus as specified under IEEE 802.3af-2003. A Power-over-Ethernet bus advantageously combines signal transmission and power supply.

[0055] According to an aspect, the processor 21 is coupled to the sensors 8, 9, 12, 13, 15 - 19. That is, the processor 21 may read data from the sensors 8, 9, 12, 13, 15 - 19. Ideally, the processor 21 may also transmit data such as request packages to the sensors 8, 9, 12, 13, 15 - 19. The skilled person chooses a suitable unidirectional or bidirectional interface for communication between the processor 21 and the sensors 8, 9, 12, 13, 15 - 19.

[0056] In an embodiment, the processor 21 communicates with the sensors 8, 9, 12, 13, 15 - 19 via a bus. Communication via the bus may be compatible with a predetermined communication bus protocol. In a particular embodiment, the processor 21 communicates with the sensors 8, 9, 12, 13, 15 - 19 via a Power-over-Ethernet bus as specified under IEEE 802.3af-2003. A Power-over-Ethernet bus advantageously combines signal transmission and power supply. In other embodiments, the processor 21 communicates with the sensors 8, 9, 12, 13, 15 - 19 via busses and/or using protocols such as KNX, ModBUS, BACNET.

[0057] Now referring to FIG 3, a characteristic curve 23 such as an icing curve or a fan curve is depicted. It is envisaged that the characteristic curve 23 may be a graphical curve as well as a curve represented by a mathematical relationship.

[0058] An icing curve 23 comprises a domain 24 indicative of icing. The icing curve 23 as shown on FIG 3 is two-dimensional with a horizontal axis 25 and a vertical axis 26. The curve 23 has one measure such as pressure drop or fluid density plotted versus another measure such as the speed of a fan. According to an aspect, the icing curve 23 may have more than two dimensions. The icing curve may, in particular, have more than three or even more than five dimensions.

[0059] As described in detail herein, the instant disclosure teaches a method for signaling icing within a structure (1), the structure (1) comprising a circuit (2 - 4), the circuit (2 - 4) comprising an appliance (6, 7, 10, 11), the appliance (6, 7, 10, 11) comprising at least one of:

- a damper and/or
- a filter (10, 11) and/or
- a fluid conveyor (6, 7);

the structure (1) comprising a sensor (8, 9, 12, 13, 15 - 19) in fluid communication with the appliance (6, 7, 10, 11);
the method comprising the steps of:

the sensor (8, 9, 12, 13, 15 - 19) recording a first signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11) ;
recording a first signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11) using the sensor (8, 9, 12, 13, 15 - 19);
after recording the first signal, recording a second signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11) using the sensor (8, 9, 12, 13, 15 - 19);
processing the first signal to produce a first measure and processing the second signal to produce a second measure;
producing a differential measure as a function of the second measure and as a function of the first measure;
comparing the differential measure to an icing threshold; and
producing a signal indicative of icing within the structure (1) if the differential measure exceeds the icing threshold.

[0060] It is envisaged that the method comprises the steps of:

the sensor (8, 9, 12, 13, 15 - 19) recording a first signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11); and
after recording the first signal, the sensor (8, 9, 12, 13, 15 - 19) recording a second signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11).

[0061] It is also envisaged that the method comprises the step of:
indicating icing within the structure (1) if the differential measure exceeds the icing threshold.

[0062] In an embodiment, the icing threshold is a predetermined icing threshold. The predetermined icing threshold can, by way of non-limiting example, be less than 10 Pa or less than 100 Pa or less than 1000 Pa.

[0063] According to an aspect, the sensor (8, 9, 12, 13, 15 - 19) is a sensor configured to record a physical quantity. A physical quantity can, by way of non-limiting example, be a temperature, a pressure, in particular a differential pressure, a value of humidity, a value of fluid density, a speed of a fan, a position of a damper, or a value of particulate matter.

[0064] It is envisaged to produce a signal indicative of icing within the circuit (2 - 4) if the differential measure exceeds the icing threshold.

[0065] In the context of the present disclosure, producing a quantity as a function of quantity b does not imply that b is an exhaustive list of arguments of the function.

[0066] In an embodiment, the method comprises the steps of:

the sensor (8, 9, 12, 13, 15 - 19) recording a first signal indicative of a physical quantity of the appliance (6, 7, 10, 11); and
after recording the first signal, the sensor (8, 9, 12, 13, 15 - 19) recording a second signal indicative of a physical quantity of the appliance (6, 7, 10, 11).

[0067] In a related embodiment, the method comprises the steps of:

the sensor (8, 9, 12, 13, 15 - 19) recording a first signal indicative of a physical quantity inside the appliance (6, 7, 10, 11); and
after recording the first signal, the sensor (8, 9, 12, 13, 15 - 19) recording a second signal indicative of a physical quantity inside the appliance (6, 7, 10, 11).

[0068] The instant disclosure also teaches any of the aforementioned methods, wherein the circuit (2 - 4) comprises a heat exchanger (5), the heat exchanger (5) being different from the appliance (6, 7, 10, 11), the method comprising the step of:
producing a signal indicative of icing within the heat exchanger (5) if the differential measure exceeds the icing

threshold.

[0069] In an embodiment, the heat exchanger (5) comprises an air handling unit and/or a heat recovery unit.

[0070] The instant disclosure further teaches any of the aforementioned methods, wherein the method comprises the steps of:

determining a difference between the second measure and the first measure; and
producing the differential measure as a function of the difference between the second measure and the first measure.

[0071] The instant disclosure still further teaches any of the aforementioned methods, wherein the circuit (2 - 4) defines a flow direction,
wherein the appliance (6, 7, 10, 11) comprises a downstream side pointing in the flow direction and an upstream side arranged opposite the downstream side;
wherein the appliance (6, 7, 10, 11) comprises a downstream port arranged on the downstream side and an upstream port arranged on the upstream side; and
wherein the sensor (8, 9, 12, 13) is in fluid communication with the appliance (6, 7, 10, 11) via at least one of

- the downstream port or
- the upstream port.

[0072] In an embodiment, a flow of a fluid through the circuit (2 - 4) defines a flow direction.

[0073] The instant disclosure also teaches any of the aforementioned methods,
wherein the sensor (8, 9, 12, 13) is in fluid communication with the appliance (6, 7, 10, 11) via the downstream port and via the upstream port; and
wherein the sensor (8, 9, 12, 13) comprises a differential pressure sensor, the differential pressure sensor (8, 9, 12, 13) being arranged to produce a signal indicative of a pressure difference between the downstream port and the upstream port.

[0074] In an embodiment, the sensor (8, 9, 12, 13) comprises a first port connected to the downstream port of the appliance (6, 7, 10, 11). The sensor (8, 9, 12, 13) can also comprise a second port connected to the upstream port of the appliance (6, 7, 10, 11). The second port is advantageously different from the first port.

[0075] The instant disclosure further teaches any of the aforementioned methods, wherein the sensor (15 - 19) is or comprises a temperature sensor, the temperature sensor (15 - 19) being arranged inside the circuit (2 - 4) to produce a signal indicative of a temperature of a fluid inside the circuit (2 - 4) .

[0076] It is envisaged that the sensor (15 - 19) is or comprises a temperature sensor, the temperature sensor (15 - 19) being arranged adjacent the circuit (2 - 4) to produce a signal indicative of a temperature of a fluid, the temperature being associated with the appliance (6, 7, 10, 11) and/or being a temperature inside the appliance (6, 7, 10, 11) and/or being a temperature adjacent the appliance (6, 7, 10, 11).

[0077] It is also envisaged that the sensor (15 - 19) is or comprises a temperature sensor, the temperature sensor (15 - 19) being arranged inside the circuit (2 - 4) and adjacent the appliance (6, 7, 10, 11) to produce a signal indicative of a temperature of a fluid, the temperature being associated with the appliance (6, 7, 10, 11) and/or being a temperature inside the appliance (6, 7, 10, 11) and/or being a temperature adjacent the appliance (6, 7, 10, 11).

[0078] According to an aspect of the instant disclosure, the sensor (15 - 19) comprises a temperature sensor and also a (differential) pressure sensor.

[0079] The instant disclosure still further teaches any of the aforementioned methods, wherein the physical quantity associated with the appliance (6, 7, 10, 11) comprises a differential pressure across the appliance (6, 7, 10, 11).

[0080] The instant disclosure also teaches any of the aforementioned methods, wherein the circuit (2 - 4) additionally comprises a preheater (14), the preheater (14) being configured to heat a fluid flowing through the circuit (2 - 4) upon activation of the preheater (14), wherein the method additionally comprises the step of:
activating the preheater (14) if the differential measure exceeds the icing threshold.

[0081] The preheater (14) is advantageously different from the heat
exchanger (5). The preheater (14) is advantageously also different from the appliance (6, 7, 10, 11).

[0082] The instant disclosure further teaches any of the aforementioned methods, wherein the method comprises the steps of:

recording a first point in time when recording the first signal;
recording a second point in time when recording the second signal;
producing a time difference by determining a difference between the second point in time and the first point in time;
producing a change measure by determining a difference between the second measure and the first measure; and
producing the differential measure by relating the change measure to the time difference.

[0083] Advantageously, the method comprises the steps of:

recording a first point in time associated with the first signal; and
recording a second point in time associated with the second signal.

[0084] The structure (1) ideally comprises a clock. The method thus comprises the steps of:

reading the first point in time from the clock when recording the first signal; and
reading the second point in time from the clock when recording the second signal.

[0085] The instant disclosure still further teaches any of the aforementioned methods, wherein the appliance (6, 7, 10, 11) comprises a fluid conveyor (6, 7), the fluid conveyor (6, 7) comprising a fan and being configured to convey a fluid through the circuit (2 - 4) as a function of a speed of the fan;
wherein the method comprises the steps of:

recording a speed signal indicative of the speed of the fan;
producing a speed measure as a function of the speed signal; and
producing the differential measure additionally as a function of the speed measure.

[0086] In an embodiment, the method comprises the step of reading a speed signal indicative of the speed of the fan from the fan. In a related embodiment, the method comprises the step of reading a speed signal indicative of the speed of the fan from the fluid conveyor (6, 7). In another related embodiment, the method comprises the step of reading a speed signal indicative of the speed of the fan from the appliance (6, 7, 10, 11).

[0087] The method advantageously comprises the step of producing the differential measure as a function of the speed measure and as a function of a difference between the second measure and the first measure.

[0088] The speed measure is preferably different from the first measure and from the second measure.

[0089] The instant disclosure further teaches any of the aforementioned methods, wherein the appliance (6, 7, 10, 11) comprises a damper, the damper being configured to set a flow of a fluid through the circuit (2 - 4) as a function of a position of the damper;
wherein the method comprises the steps of:

recording a position signal indicative of the position of the damper;
producing a position measure as a function of the position signal; and
producing the differential measure additionally as a function of the position measure.

[0090] In an embodiment, the method comprises the step of reading a position signal indicative of the position of the damper from the damper. In a related embodiment, the method comprises the step of reading a position signal indicative of the position of the damper from the appliance (6, 7, 10, 11).

[0091] The method advantageously comprises the step of producing the differential measure as a function of the position measure and as a function of a difference between the second measure and the first measure.

[0092] The position measure is preferably different from the first measure and from the second measure.

[0093] The instant disclosure also teaches a computer-readable medium containing a program which executes the steps of any one of the aforementioned methods.

[0094] It is envisaged that the computer-readable medium is non-transitory.

[0095] The instant disclosure also teaches an isolated, computer-readable software package, the software package being configured for operating-system-level virtualization, the software package containing a program which performs the steps of any one of the aforementioned methods.

[0096] The instant disclosure also teaches a controller (20) comprising a processor (21) and a memory (22) storing an icing threshold, the processor (21) being in operative communication with the memory (22), the controller (20) being configured to read signals from a sensor (8, 9, 12, 13, 15 - 19), the sensor (8, 9, 12, 13, 15 - 19) being in fluid communication with an appliance (6, 7, 10, 11), the controller (20) also being configured to activate a preheater (14), the preheater (14) being configured to heat a fluid upon activation of the preheater (14); the controller (20) being configured to:

read from the sensor (8, 9, 12, 13, 15 - 19) a first signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11) ;
after reading the first signal, read from the sensor (8, 9, 12, 13, 15 - 19) a second signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11);
employ the processor (21) to process the first signal to produce a first measure and to process the second signal to produce a second measure;
employ the processor (21) to determine a difference between the second measure and the first measure;
employ the processor (21) to produce a differential measure as a function of the difference between the second measure and the first measure;
employ the processor (21) to read the icing threshold from the memory (22);
employ the processor (21) to compare the differential measure to the icing threshold; and
activate the preheater (14) if the differential measure exceeds the icing threshold.

[0097] The preheater (14) is advantageously configured to heat a fluid flowing through a circuit (2 - 4) upon activation of the preheater (14). The processor (21) ideally is in operative communication with the preheater (14) .

[0098] The instant disclosure also teaches any of the aforementioned controllers (20), wherein the controller (20) comprises a memory (22) storing an icing curve (23), the icing curve (23) comprising a domain (24) indicative of icing, wherein the controller (20) is configured to:

employ the processor (21) to produce a multi-dimensional measure as a function of the second measure and of the first measure;
employ the processor (21) to read the icing curve (23) from the memory (22);
employ the processor (21) to compare the multi-dimensional measure to the domain (24) indicative of icing of the icing curve (23); and
activate the preheater (14) if the multi-dimensional measure is within the domain (24) indicative of icing of the icing curve (23).

[0099] It is envisaged to employ the processor (21) to read from the sensor (8, 9, 12, 13, 15 - 19) a first signal indicative of a physical quantity associated with or of the appliance (6, 7, 10, 11). It is also envisaged to employ the processor (21), after reading the first signal, to read from the sensor (8, 9, 12, 13, 15 - 19) a second signal indicative of a physical quantity associated with or of the appliance (6, 7, 10, 11). It is further envisaged to employ the processor (21) to activate the preheater (14) if the differential measure is within the domain (24) indicative of icing of the icing curve (23).

[0100] The instant disclosure also teaches any of the aforementioned controllers (20), wherein the appliance (6, 7, 10, 11) comprises a fluid conveyor (6, 7), wherein the controller (20) is in operative communication with the fluid conveyor (6, 7), wherein the controller (20) comprises a memory (22) storing an icing curve (23), the icing curve determining a difference in pressure as a function of a value of fluid flow through the fluid conveyor (6, 7), the icing curve (23) comprising a domain (24) indicative of icing, wherein the controller (20) is configured to:

obtain a flow signal indicative of fluid flow through the fluid conveyor (6, 7);
employ the processor (21) to produce a flow measure as a function of the flow signal;
employ the processor (21) to produce a point value having the flow measure as a first coordinate and having the differential measure as a second coordinate;
employ the processor (21) to read the icing curve (23) from the memory (22);
employ the processor (21) to compare the point value to the domain (24) indicative of icing of the icing curve (23); and
activate the preheater (14) if the point value is within the domain (24) indicative of icing of the icing curve (23).

[0101] According to an aspect of the instant disclosure, the icing curve determines a value of fluid flow through the fluid conveyor (6, 7) as a function of a difference in pressure.

[0102] In an embodiment, the fluid conveyor (6, 7) comprises a fan and the flow signal is a speed signal such as a speed signal of the fan. In another embodiment, the fluid conveyor (6, 7) comprises a damper and the flow signal is a position signal such as a position signal of the damper.

[0103] The difference in pressure advantageously is a pressure drop. The difference in pressure yet more advantageously is a pressure drop across the appliance (6, 7, 10, 11).

[0104] In an embodiment, the point value is or comprises a point.

[0105] The icing curve (23) advantageously has one measure such as pressure drop or fluid density plotted versus another measure such as the speed of a fan. The icing curve (23) can also have one quantity such as pressure drop or fluid density plotted versus another quantity such as the speed of a fan. The icing curve (23) can further have a first quantity such as pressure drop or fluid density plotted versus a second quantity such as the speed of a fan.

[0106] The instant disclosure also teaches a system comprising a circuit (2 - 4), the circuit (2 - 4) comprising an appliance (6, 7, 10, 11), the appliance (6, 7, 10, 11) comprising at least one of:

- a damper and/or
- a filter (10, 11) and/or
- a fluid conveyor (6, 7);

the circuit (2 - 4) additionally comprising a preheater (14), the preheater (14) being configured to heat a fluid flowing through the circuit (2 - 4) upon activation of the preheater (14);
the system comprising a sensor (8, 9, 12, 13, 15 - 19) in fluid communication with the appliance (6, 7, 10, 11); and the system comprising any of the aforementioned controllers (20), the controller (20) being in operative communication with the sensor (8, 9, 12, 13, 15 - 19) and being in operative communication with the preheater (14) .

[0107] It is envisaged that the circuit comprises the sensor (8, 9, 12, 13, 15 - 19) .

[0108] In an embodiment, the system is a system for heating, ventilation and/or air-conditioning.

[0109] Any steps of a method according to the present disclosure may be embodied in hardware, in a software module executed by a processor, in a software module executed by a processor inside a container using operating-system-level virtualization, in a cloud computing arrangement, or in a combination thereof. The software may include a firmware, a hardware driver run in the operating system, or an application program. Thus, the disclosure also relates to a computer program product for performing the operations presented herein. If implemented in software, the functions described may be stored as one or more instructions on a computer-readable medium. Some examples of storage media that may be used include random access memory (RAM), read only memory (ROM), flash memory, EPROM memory, EEPROM memory, registers, a hard disk, a removable disk, other optical disks, or any available media that can be accessed by a computer or any other IT equipment and appliance.

[0110] It should be understood that the foregoing relates only to certain embodiments of the disclosure and that numerous changes may be made therein without departing from the scope of the disclosure as defined by the following claims. It should also be understood that the disclosure is not restricted to the illustrated embodiments and that various modifications can be made within the scope of the following claims.

Reference numerals

[0111]

1	structure
2	building
3	exhaust duct
4	intake duct
5	heat exchanger
6	exhaust fluid conveyor
7	intake fluid conveyor
8	sensor across exhaust fluid conveyor 6
9	sensor across intake fluid conveyor 7
10	exhaust filter
11	intake filter
12	sensor across exhaust filter 10
13	sensor across intake filter 11
14	preheater
15	intake sensor upstream of preheater 14
16	intake sensor downstream of preheater 15
17	intake sensor at or near the outlet of intake duct 4
18	exhaust sensor upstream of heat exchanger 5
19	exhaust sensor downstream of heat exchanger 5
20	controller
21	processor
22	memory
23	icing curve
24	domain indicative of icing
25	horizontal axis
26	vertical axis

Claims

1. A method for signaling icing within a structure (1), the structure (1) comprising a circuit (2 - 4), the circuit (2 - 4) comprising an appliance (6, 7, 10, 11), the appliance (6, 7, 10, 11) comprising at least one of:

- a damper and/or
- a filter (10, 11) and/or
- a fluid conveyor (6, 7);

the structure (1) comprising a sensor (8, 9, 12, 13, 15 - 19) in fluid communication with the appliance (6, 7, 10, 11);
the method comprising the steps of:

recording a first signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11) using the sensor (8, 9, 12, 13, 15 - 19);
after recording the first signal, recording a second signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11) using the sensor (8, 9, 12, 13, 15 - 19);
processing the first signal to produce a first measure and processing the second signal to produce a second measure;
producing a differential measure as a function of the second measure and as a function of the first measure;
comparing the differential measure to an icing threshold; and
producing a signal indicative of icing within the structure (1) if the differential measure exceeds the icing threshold.

2. The method according to claim 1, wherein the circuit (2 - 4) comprises a heat exchanger (5), the heat exchanger (5) being different from the appliance (6, 7, 10, 11), the method comprising the step of:
producing a signal indicative of icing within the heat exchanger (5) if the differential measure exceeds the icing threshold.

3. The method according to any of the claims 1 to 2, wherein the method comprises the steps of:

determining a difference between the second measure and the first measure; and
producing the differential measure as a function of the difference between the second measure and the first measure.

4. The method according to any of the claims 1 to 3, wherein the circuit (2 - 4) defines a flow direction,
wherein the appliance (6, 7, 10, 11) comprises a downstream side pointing in the flow direction and an upstream side arranged opposite the downstream side;
wherein the appliance (6, 7, 10, 11) comprises a downstream port arranged on the downstream side and an upstream port arranged on the upstream side; and
wherein the sensor (8, 9, 12, 13) is in fluid communication with the appliance (6, 7, 10, 11) via at least one of

- the downstream port or
- the upstream port.

5. The method according to claim 4,
wherein the sensor (8, 9, 12, 13) is in fluid commu-

nication with the appliance (6, 7, 10, 11) via the downstream port and via the upstream port; and
wherein the sensor (8, 9, 12, 13) comprises a differential pressure sensor, the differential pressure sensor (8, 9, 12, 13) being arranged to produce a signal indicative of a pressure difference between the downstream port and the upstream port.

6. The method according to any of the claims 1 to 3, wherein the sensor (15 - 19) comprises a temperature sensor, the temperature sensor (15 - 19) being arranged inside the circuit (2 - 4) to produce a signal indicative of a temperature of a fluid inside the circuit (2 - 4).

7. The method according to any of the claims 1 to 6, wherein the physical quantity associated with the appliance (6, 7, 10, 11) comprises a differential pressure across the appliance (6, 7, 10, 11).

8. The method according to any of the claims 1 to 7, wherein the circuit (2 - 4) additionally comprises a preheater (14), the preheater (14) being configured to heat a fluid flowing through the circuit (2 - 4) upon activation of the preheater (14), wherein the method additionally comprises the step of:
activating the preheater (14) if the differential measure exceeds the icing threshold.

9. The method according to any of the claims 1 to 8, wherein the method comprises the steps of:

recording a first point in time when recording the first signal;
recording a second point in time when recording the second signal;
producing a time difference by determining a difference between the second point in time and the first point in time;
producing a change measure by determining a difference between the second measure and the first measure; and
producing the differential measure by relating the change measure to the time difference.

10. The method according to any of claims 1 to 9, wherein the appliance (6, 7, 10, 11) comprises a fluid conveyor (6, 7), the fluid conveyor (6, 7) comprising a fan and being configured to convey a fluid through the circuit (2 - 4) as a function of a speed of the fan;
wherein the method comprises the steps of:

recording a speed signal indicative of the speed of the fan;
producing a speed measure as a function of the speed signal; and
producing the differential measure additionally as a function of the speed measure.

11. The method according to any of claims 1 to 10, wherein the appliance (6, 7, 10, 11) comprises a damper, the damper being configured to set a flow of a fluid through the circuit (2 - 4) as a function of a position of the damper;
wherein the method comprises the steps of:

recording a position signal indicative of the position of the damper;
producing a position measure as a function of the position signal; and
producing the differential measure additionally as a function of the position measure.

12. A computer-readable medium containing a program which executes the steps of any one of the claims 1 to 11.

13. A controller (20) comprising a processor (21) and a memory (22) storing an icing threshold, the processor (21) being in operative communication with the memory (22), the controller (20) being configured to read signals from a sensor (8, 9, 12, 13, 15 - 19), the sensor (8, 9, 12, 13, 15 - 19) being in fluid communication with an appliance (6, 7, 10, 11), the controller (20) also being configured to activate a preheater (14), the preheater (14) being configured to heat a fluid upon activation of the preheater (14); the controller (20) being configured to:

read from the sensor (8, 9, 12, 13, 15 - 19) a first signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11);
after reading the first signal, read from the sensor (8, 9, 12, 13, 15 - 19) a second signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11);
employ the processor (21) to process the first signal to produce a first measure and to process the second signal to produce a second measure;
employ the processor (21) to determine a difference between the second measure and the first measure;
employ the processor (21) to produce a differential measure as a function of the difference between the second measure and the first measure;
employ the processor (21) to read the icing threshold from the memory (22);
employ the processor (21) to compare the differential measure to the icing threshold; and
activate the preheater (14) if the differential measure exceeds the icing threshold.

14. The controller (20) according to claim 13, wherein the appliance (6, 7, 10, 11) comprises a fluid conveyor (6, 7), wherein the controller (20) is in operative communication with the fluid conveyor (6, 7), wherein the controller (20) comprises a memory (22) storing an icing curve (23), the icing curve determining a difference in pressure as a function of a value of fluid flow through the fluid conveyor (6, 7), the icing curve (23) comprising a domain (24) indicative of icing, wherein the controller (20) is configured to:

obtain a flow signal indicative of fluid flow through the fluid conveyor (6, 7);
employ the processor (21) to produce a flow measure as a function of the flow signal;
employ the processor (21) to produce a point value having the flow measure as a first coordinate and having the differential measure as a second coordinate;
employ the processor (21) to read the icing curve (23) from the memory (22);
employ the processor (21) to compare the point value to the domain (24) indicative of icing of the icing curve (23); and
activate the preheater (14) if the point value is within the domain (24) indicative of icing of the icing curve (23).

15. A system comprising a circuit (2 - 4), the circuit (2 - 4) comprising an appliance (6, 7, 10, 11), the appliance (6, 7, 10, 11) comprising at least one of:

- a damper and/or
- a filter (10, 11) and/or
- a fluid conveyor (6, 7);

the circuit (2 - 4) additionally comprising a preheater (14), the preheater (14) being configured to heat a fluid flowing through the circuit (2 - 4) upon activation of the preheater (14);
the system comprising a sensor (8, 9, 12, 13, 15 - 19) in fluid communication with the appliance (6, 7, 10, 11); and
the system comprising a controller (20) according to any of the claims 13 to 14, the controller (20) being in operative communication with the sensor (8, 9, 12, 13, 15 - 19) and being in operative communication with the preheater (14).

Amended claims in accordance with Rule 137(2) EPC.

1. A method for signaling icing within a structure (1), the structure (1) comprising a circuit (2 - 4),

the circuit (2 - 4) comprising an appliance (6, 7, 10, 11), the appliance (6, 7, 10, 11) comprising at least one of:

- a damper and/or
- a filter (10, 11) and/or
- a fluid conveyor (6, 7);

the structure (1) comprising a sensor (8, 9, 12, 13, 15 - 19) in fluid communication with the appliance (6, 7, 10, 11);
the method comprising the steps of:

recording a first signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11) using the sensor (8, 9, 12, 13, 15 - 19);
after recording the first signal, recording a second signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11) using the sensor (8, 9, 12, 13, 15 - 19);
processing the first signal to produce a first measure and processing the second signal to produce a second measure;
producing a differential measure as a function of the second measure and as a function of the first measure;
comparing the differential measure to an icing threshold; and
producing a signal indicative of icing within the structure (1) if the differential measure exceeds the icing threshold;

characterized in that
the circuit (2 - 4) additionally comprises a preheater (14), the preheater (14) being configured to heat a fluid flowing through the circuit (2 - 4) upon activation of the preheater (14), wherein the method additionally comprises the step of:
activating the preheater (14) if the differential measure exceeds the icing threshold.

2. The method according to claim 1, wherein the circuit (2 - 4) comprises a heat exchanger (5), the heat exchanger (5) being different from the appliance (6, 7, 10, 11), the method comprising the step of:
producing a signal indicative of icing within the heat exchanger (5) if the differential measure exceeds the icing threshold.

3. The method according to any of the claims 1 to 2, wherein the method comprises the steps of:

determining a difference between the second measure and the first measure; and
producing the differential measure as a function of the difference between the second measure and the first measure.

4. The method according to any of the claims 1 to 3, wherein the circuit (2 - 4) defines a flow direction,

wherein the appliance (6, 7, 10, 11) comprises a downstream side pointing in the flow direction

and an upstream side arranged opposite the downstream side;
wherein the appliance (6, 7, 10, 11) comprises a downstream port arranged on the downstream side and an upstream port arranged on the upstream side; and
wherein the sensor (8, 9, 12, 13) is in fluid communication with the appliance (6, 7, 10, 11) via at least one of

- the downstream port or
- the upstream port.

5. The method according to claim 4,

wherein the sensor (8, 9, 12, 13) is in fluid communication with the appliance (6, 7, 10, 11) via the downstream port and via the upstream port; and
wherein the sensor (8, 9, 12, 13) comprises a differential pressure sensor, the differential pressure sensor (8, 9, 12, 13) being arranged to produce a signal indicative of a pressure difference between the downstream port and the upstream port.

6. The method according to any of the claims 1 to 3, wherein the sensor (15 - 19) comprises a temperature sensor, the temperature sensor (15 - 19) being arranged inside the circuit (2 - 4) to produce a signal indicative of a temperature of a fluid inside the circuit (2 - 4).

7. The method according to any of the claims 1 to 6, wherein the physical quantity associated with the appliance (6, 7, 10, 11) comprises a differential pressure across the appliance (6, 7, 10, 11).

8. The method according to any of the claims 1 to 7, wherein the method comprises the steps of:

recording a first point in time when recording the first signal;
recording a second point in time when recording the second signal;
producing a time difference by determining a difference between the second point in time and the first point in time;
producing a change measure by determining a difference between the second measure and the first measure; and
producing the differential measure by relating the change measure to the time difference.

9. The method according to any of claims 1 to 8, wherein the appliance (6, 7, 10, 11) comprises a fluid conveyor (6, 7), the fluid conveyor (6, 7) comprising a fan and being configured to convey a fluid through the circuit (2 - 4) as a function of a speed of the fan; wherein the method comprises the steps of:

recording a speed signal indicative of the speed of the fan;
producing a speed measure as a function of the speed signal; and
producing the differential measure additionally as a function of the speed measure.

10. The method according to any of claims 1 to 9, wherein the appliance (6, 7, 10, 11) comprises a damper, the damper being configured to set a flow of a fluid through the circuit (2 - 4) as a function of a position of the damper;
wherein the method comprises the steps of:

recording a position signal indicative of the position of the damper;
producing a position measure as a function of the position signal; and
producing the differential measure additionally as a function of the position measure.

11. A computer-readable medium containing a program which executes the steps of any one of the claims 1 to 10.

12. A controller (20) comprising a processor (21) and a memory (22) storing an icing threshold, the processor (21) being in operative communication with the memory (22), the controller (20) being configured to read signals from a sensor (8, 9, 12, 13, 15 - 19), the sensor (8, 9, 12, 13, 15 - 19) being in fluid communication with an appliance (6, 7, 10, 11), the controller (20) also being configured to activate a preheater (14), the preheater (14) being configured to heat a fluid upon activation of the preheater (14); the controller (20) being configured to:

read from the sensor (8, 9, 12, 13, 15 - 19) a first signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11);
after reading the first signal, read from the sensor (8, 9, 12, 13, 15 - 19) a second signal indicative of a physical quantity associated with the appliance (6, 7, 10, 11);
employ the processor (21) to process the first signal to produce a first measure and to process the second signal to produce a second measure;
employ the processor (21) to determine a difference between the second measure and the first measure;
employ the processor (21) to produce a differential measure as a function of the difference between the second measure and the first measure;
employ the processor (21) to read the icing

threshold from the memory (22);
employ the processor (21) to compare the differential measure to the icing threshold; and
characterized in that the controller (20) is configured to:
activate the preheater (14) if the differential measure exceeds the icing threshold.

13. A system comprising a circuit (2 - 4), the circuit (2 - 4) comprising an appliance (6, 7, 10, 11), the appliance (6, 7, 10, 11) comprising at least one of:

- a damper and/or
- a filter (10, 11) and/or
- a fluid conveyor (6, 7);

the circuit (2 - 4) additionally comprising a preheater (14), the preheater (14) being configured to heat a fluid flowing through the circuit (2 - 4) upon activation of the preheater (14);
the system comprising a sensor (8, 9, 12, 13, 15 - 19) in fluid communication with the appliance (6, 7, 10, 11); and
the system comprising a controller (20) according to claim 12, the controller (20) being in operative communication with the sensor (8, 9, 12, 13, 15 - 19) and being in operative communication with the preheater (14).

FIG 1

2018P22614 – foreign filing version

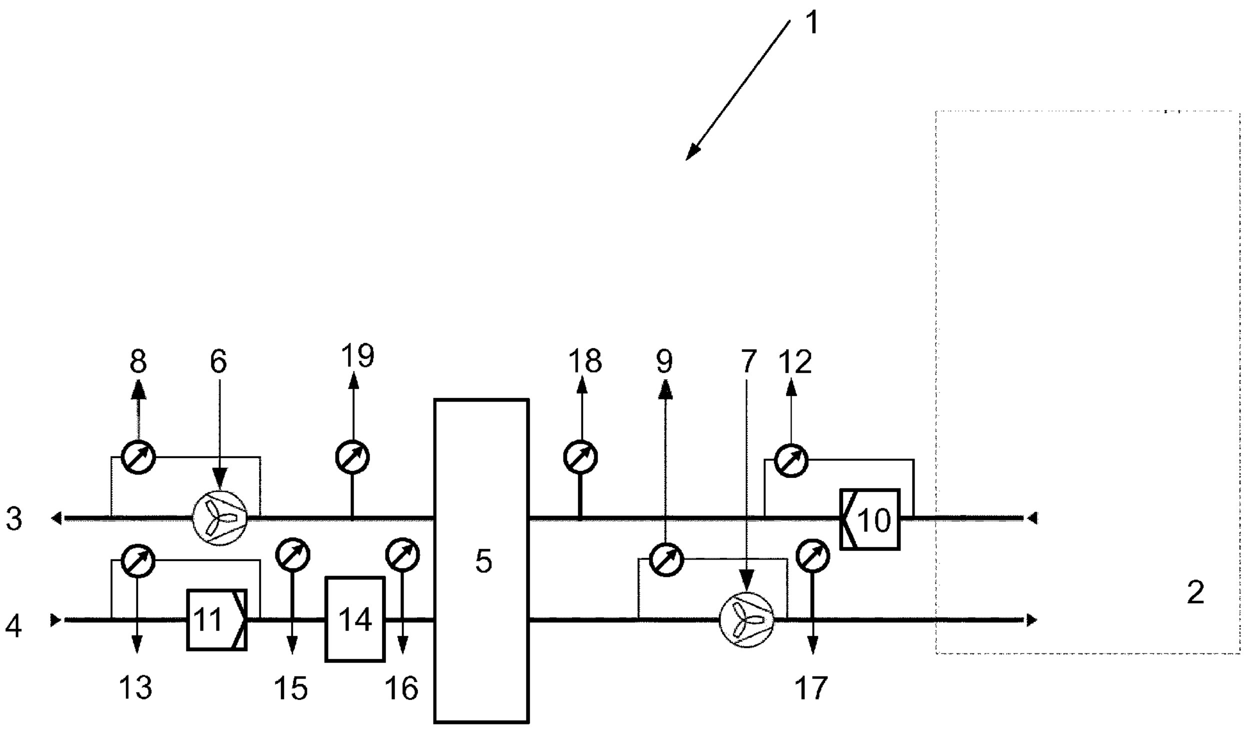


FIG 2

2018P22614 – foreign filing version

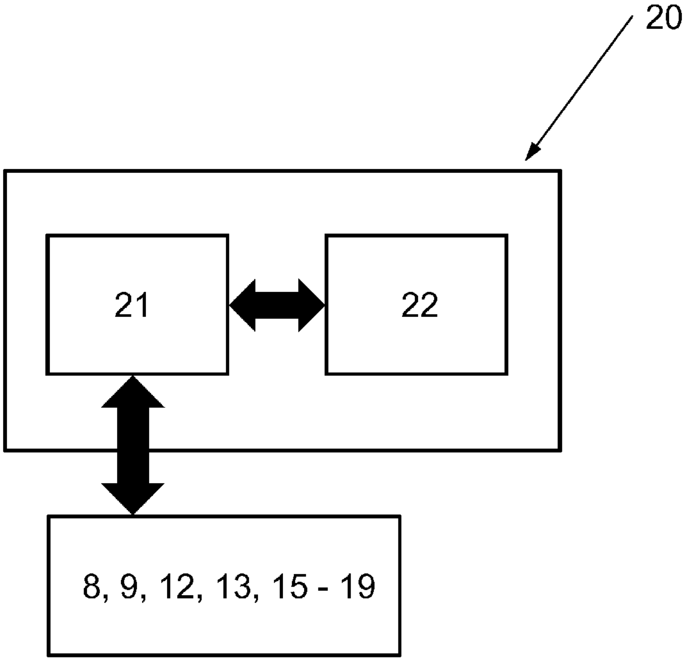
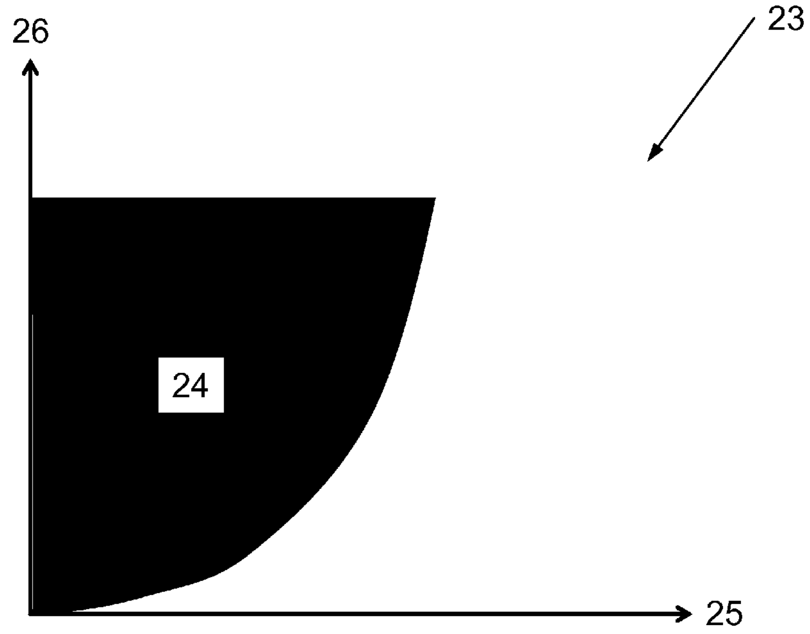


FIG 3

2018P22614 – foreign filing version



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 19 17 4655

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 101 639 A (WRUCK RICHARD A [US] ET AL) 7 April 1992 (1992-04-07) * column 3, line 44 - column 4, line 34; figures 3,4 * * column 4, lines 53-60 * -----	1-10, 12-15	INV. F25D21/02 F24F11/41 ADD. F25B47/00 F25D17/04
X A	US 2008/307803 A1 (HERZON AARON D [US]) 18 December 2008 (2008-12-18) * paragraphs [0025], [0036], [0037]; claim 1; figure 1 * -----	1-7,9,10 8,13-15	
X	WO 2016/060609 A1 (SWEGON AB [SE]) 21 April 2016 (2016-04-21) * page 10, line 1 - page 14, line 15; figures 1-4 * * page 15, line 1 - page 18, line 16 * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			F25D F25B F24F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	2 December 2019	Léandre, Arnaud

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 17 4655

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

02-12-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5101639 A	07-04-1992	NONE	
US 2008307803 A1	18-12-2008	NONE	
WO 2016060609 A1	21-04-2016	EP 3207315 A1	23-08-2017
		SE 1430145 A1	17-04-2016
		WO 2016060609 A1	21-04-2016

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 4416323 A **[0003] [0004]**
- US 191881 A **[0003]**
- US 3319657 A **[0006] [0007]**
- US 5101639 A **[0008]**
- US 526857 A **[0008]**
- US 2008307803 A1 **[0009]**
- US 11811690 B **[0009]**
- WO 2016060609 A1 **[0010]**