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

(11) EP 3 650 761 A1

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
13.05.2020 Bulletin 2020/20

(51) Int Cl.:
F24D 19/10 *(2006.01)*

(21) Application number: **19179011.2**

(22) Date of filing: **07.06.2019**

(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: **12.11.2018 EP 18205609**

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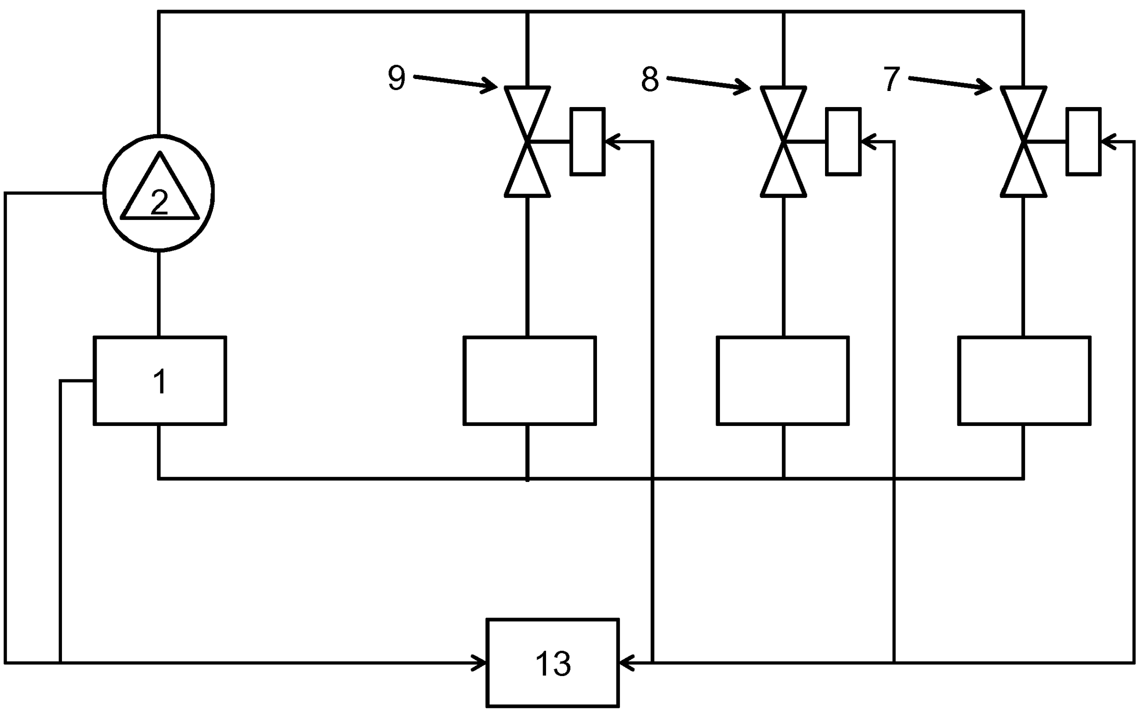
(54) **CONTROL OF HEATING, VENTILATION, AIR-CONDITIONING**

(57) Control of heating, ventilation, air-conditioning. A characteristic position is determined for each valve 7 - 9 and/or for each zone of a structure. Normalised positions are produced by referring each characteristic position to its limit value. Also, measures indicative of comfort are determined for each zone of the structure. The determined measures are used to produce deviation measures. A control algorithm relies on the deviation measures as input values. The control algorithm yields equal comfort in each zone. Also, the output values of the control algorithm for the individual valves 7 - 9 are combined with the limit values of each individual valve 7 - 9 to produce combined individual values. New limit positions for the valves 7 - 9 are finally determined as a function of the combined individual values. It is envisaged to either rely on a single such value or to average a time series of such values.

FIG 2



EP 3 650 761 A1

Description

Background

[0001] The present disclosure relates to control of heating, ventilation, air-conditioning installations and of heating, ventilation, air-conditioning systems. More particularly, the present disclosure focuses on a control device for and on a method for heating, ventilation and/or air-conditioning. The instant disclosure also relates to heating, ventilation, air-conditioning installations with a control device as disclosed hereinafter.

[0002] Installations for heating, ventilation and/or air-conditioning (HVAC) are commonly made up of a plurality of circuits. Each circuit comprises one or several terminal units to provide heating and/or cooling to various parts of a structure. Terminal units generally are heating devices or cooling devices. A terminal unit of a domestic heating system can, for instance, be a radiator.

[0003] In HVAC installations, a plethora factors such as pipe cross-sections, valve characteristics, positions of terminal units within the distribution network etc affect the flow through the circuits. These factors yield hydraulic resistances that vary throughout the system. Hydraulic resistances generally relate pressure drop and flow of a heating medium or flow of a coolant.

[0004] HVAC installations, in particular heating and cooling systems, require hydronic balancing. Hydronic balancing overcomes issues due to different hydraulic resistances of the circuits of a HVAC installation. Hydronic balancing of heating installations of commercial, residential and/or industrial sites ensures that each circuit of a system experiences adequate flow.

[0005] In the absence of proper hydronic balancing, parts of a building will be oversupplied or may be undersupplied with heat. That is, the HVAC system may not be able to supply the heating or the cooling as required. The HVAC system will thus operate inefficiently. Also, parts of a structure may experience excessive flow.

[0006] Excessive flow generally involves noisy valves and/or noisy radiators. In addition, excessive flow increases wear of mechanical parts such as electromechanical valves, membrane valves and/or pumps. As for electric pumps, waste of electric energy caused by excessive flow exacerbates the problem.

[0007] The German utility model DE202012012915U1 was filed on 24 September 2012. DE202012012915U1 teaches a heating- and/or cooling system. The system comprises a plurality of heat exchangers HK1-HK3 as well as a pump 3. Also, an adjustable valve is associated with each heat exchanger HK1-HK3. The system according to DE202012012915U1 starts with a given setting of each valve. It then monitors temperatures in the various zones of a structure. A valve stroke is then adjusted for each valve in accordance with the temperature rise in the respective zones. The process iterates until the target values for each zone are attained. The system finally reduces the capacity of the pump 3 and also lowers the settings of each valve until the speed of the pump 3 attains a minimum.

[0008] The European patent application EP3115703A1 was filed on 20 April 2016 and was published on 11 January 2017. EP3115703A1 deals with control of heating, ventilation, air-conditioning. EP3115703A1 discloses a system with a plurality of heat exchangers 10 - 12 and with valves 7 - 9 associated with the heat exchangers 10 - 12. A pump 2 conveys flow of a fluid through a circuit of the system. The system starts with adjusting each of the valves 7 - 9 to a position different from a closed position. The system then records a temperature rise quantity for each zone supplied by the system. Rather than relying on absolute values of temperature, the system according to EP3115703A1 determines rates of change for each zone. The system employs the determined changes in temperature to set limit positions for the valves 7 - 9.

[0009] An international patent application WO2013034358A1 was filed on 23 July 2012 and was published on 14 March 2013. WO2013034358A1 teaches a method for operating and/or monitoring a HVAC system. In accordance with WO2013034358A1, a dependence of energy flow on the flow of a medium is empirically determined for a given heat exchanger 11 - 13. A value of flow is then determined at which energy flow and/or temperature drop level off. A flow of energy or a temperature drop of a particular heat exchanger may increase only marginally by raising flow beyond the determined flow value. The method according to WO2013034358A1 requires knowledge of a temperature drop over a given heat exchanger 11 - 13. The method according to WO2013034358A1 also relies on measured flow values through a heat exchanger 11 - 13.

[0010] A patent application DE102017203850A1 was filed on 8 March 2017. The application DE102017203850A1 was published on 13 September 2018. DE102017203850A1 teaches a method of operating a heating installation.

[0011] Another patent application DE102014102275A1 was filed on 21 February 2014. The patent application DE102014102275A1 was published on 27 August 2015. DE102014102275A1 discloses control of a heating and/or air conditioning installation.

[0012] The present disclosure improves on control devices and on control methods for HVAC installations. The instant disclosure aims at providing hydronic balancing without requiring measurements of temperature drop and/or measurements of flow through individual heat exchangers.

Summary

[0013] The present disclosure optimizes hydronic balancing without a priori knowledge of flow values or of values of temperature drop in a circuit. Also, no prior knowledge of components and system characteristics is required. A control device and a method according to the instant disclosure yield continuous adjustments and/or improvements of limit positions of valves. The control device and the method confer advantages in environments that evolve over time due to changes in occupancy, in system characteristics or in outdoor temperature.

[0014] The instant disclosure teaches a control device and a method wherein a characteristic position is determined for each valve and/or for each zone of a structure. The characteristic positions are typically determined for a given time span such as a day. Normalised positions are produced by referring each characteristic position to its limit value. In addition, measures indicative of comfort are determined for each zone of the structure. The system may, by way of non-limiting example, determine measures such as average deviations from target values, standard deviations and/or variances. The determined measures are used to produce deviation measures. Deviation measures can, by way of non-limiting example, be produced by referring these measures to their average values or median values. A control algorithm such as a proportional, integral and/or derivative control algorithm relies on the deviation measures as input values. The control algorithm eventually yields equal comfort in each zone. That is, each zone eventually exhibits the same deviation measure. Also, the output values of the control algorithm for the individual valves are merged with the limit values of each individual valve to produce merged individual values. In a practical embodiment, a merged individual value of a valve is the sum of the output signal produced for the valve and of the limit position of the valve. New limit positions for the valves are finally determined as a function of the merged individual values. It is envisaged to either rely on a single such value or to average a time series of such values. The values can, by way of non-limiting example, be averaged over a time span of several days.

[0015] It is a related object of the instant disclosure to provide a control device and/or a method wherein the speed of a pump, valve positions in various zones of a structure, room temperatures, target values and room modes are continuously tracked. In an embodiment, the values are tracked every minute. The above steps are repeated iterated to continuously adapt to an evolving system.

[0016] It is also a related object of the instant disclosure to provide a control device and/or a method wherein combined values are averaged for individual valves over periods of more than two days, of more than five days, or even of more than ten days. Averages over long periods of time inhibit random fluctuations of the system.

[0017] It is still an object of the instant disclosure to provide a control device and/or a method with reporting functionality. It is envisaged that an indication is presented of whether the system is balanced.

[0018] It is still a related object of the instant disclosure to provide a control device and/or a method wherein indications of failures are reported. It is envisaged to report zones of a structure wherein hydronic balancing has been unsuccessful. According to an aspect of the instant disclosure, zones with insufficient supply of heating and/or cooling are reported.

[0019] It is also a related object of the instant disclosure to provide a control device and/or a method wherein indications of failures are reported. It is envisaged to report components of a heating, ventilation and/or air-conditioning circuit that are not adequately designed for their respective purpose.

[0020] The present disclosure further provides a structure with a heating and/or ventilation, and/or air-conditioning installation with a controller according to the instant disclosure. Also, the present disclosure teaches a commercial and/or residential and/or industrial building with a controller according to the instant disclosure.

Brief description of the drawings

[0021] 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 is a schematic drawing of a HVAC installation.

Fig 2 is a schematic drawing of a HVAC installation with a control unit.

FIG 3 is a flow diagram of a control algorithm.

Detailed description

[0022] The control device of the present disclosure is typically part of a heating, ventilation and/or air-conditioning installation. A HVAC installation as shown on FIG 1 comprises a heat source 1 such as a heat pump, a gas-fired burner, an oil-fired burner, a cogeneration plant, a (polymer electrolyte membrane) fuel cell, a silicone oxide fuel cell etc. A pump 2 circulates a suitable medium, such as a heating medium or a refrigerant, through the closed loop circuit 3. The medium may, by way of non-limiting example, be water, and/or a

- R-401A,
- R-404A,
- R-406A,
- R-407A,
- R-407C,
- R-408A,
- R-409A,
- R-410A,
- R-438A,
- R-500, or
- R-502

refrigerant. The fluid may also be (a blend comprising) ammonia and/or carbon dioxide. The above lists are not exhaustive.

[0023] The pump 2 preferably is an electric pump. It is envisaged that the pump 2 is a variable speed pump. In an embodiment, a pulse-width modulation unit feeds the winding(s) of a motor of the pump 2 in accordance with a duty cycle. A controller 13 advantageously sets the pressure generated by the pump 2 by feeding a motor of the pump 2 with a pulse-width modulated signal. In another embodiment, an inverter feeds the winding(s) of a motor of the pump 2. A controller 13 advantageously sets the frequency and/or other parameters of an inverter signal to set the pressure generated by the pump 2.

[0024] The closed loop circuit 3 of FIG 2 is made up of a plurality of loops 4, 5, and 6. A valve 7, 8, and 9 is arranged in each loop 4, 5, and 6. The valves 7, 8, and 9 are used to set flow through their respective loops 4, 5, and 6. At least one of the valves 7, 8, and 9 is a electromechanical valve. It is envisaged that all of the valves 7, 8, and 9 are electromechanical valves. Each of the loops 4, 5, and 6 shown on FIG 1 has a valve 7, 8, and 9. In a special embodiment, there is at least one loop with no valve. In another embodiment, at least one loop 4, 5, or 6 comprises a plurality of valves. At least one of the valves 7, 8, or 9 of the installation preferably measures temperatures and/or sets flow in accordance with measured temperatures.

[0025] The loops 4, 5, 6 also each provide at least one heat exchanger 10, 11, 12. Where the HVAC system of FIG 1 is a heating installation, the heat exchanger 10, 11, 12 will, for instance, be a radiator. Each heat exchange unit 10, 11, 12 may also comprise a plurality of heat exchangers such as a plurality of radiators.

[0026] In another embodiment, at least one heat exchanger 10, 11, 12 comprises a chilled beam. The chilled beam is preferably mounted to and/or secured to a ceiling of a room and/or of a zone. It is also envisaged that each of the heat exchangers 10, 11, 12 comprises a chilled beam.

[0027] In another embodiment, at least one heat exchanger 10, 11, 12 comprises a fan coil unit. The fan coil is preferably mounted to and/or secured to a wall of a room and/or of a zone. It is also envisaged that each of the heat exchangers 10, 11, 12 comprises a fan coil unit.

[0028] It is envisaged that each loop 4, 5, and 6 supplies a zone of a structure with heat or with cooling. In a particular embodiment, these zones are rooms of a building. The building may, for instance, be a commercial, industrial and/or residential site.

[0029] The installation as shown on FIG 2 adds a control unit 13 such as a microcontroller and/or a microprocessor to the installation. The control unit 13 of FIG 2 can be in operative communication with the pump 2. The control unit 13, in particular, functions to set the pressure applied by the pump 2. The control unit 13 also communicates with the valves 7, 8, and/or 9 of the installation and vice versa. That is, the valves 7, 8, 9 communicate their steady-state positions and/or their limit positions and/or their valve strokes to the (central) control unit 13.

[0030] A wide range of communication busses and protocols exist that provides communication functions in between valves 7, 8, 9 and control units 13. Typically, wireless solutions such as WLAN, KNX® RF, and/or Enocean® are employed. Hard-wired solutions are also commercially available. These frequently rely on Ethernet® cables or on KNX® cables. The choice of any particular wireless or hard-wired solution is also influenced by bandwidth requirements.

[0031] It is envisaged that the valves 7, 8, and/or 9 may communicate with the control unit 13 using a communication bus protocol. There are cases where the devices of an installation rely on a single communication protocol such as KNX®, Modbus, LON or BACnet®. In addition, a number of proprietary communication protocols exist. The skilled person can also use a message queuing telemetry transport (MQTT) protocol in order that the valves 7, 8, and/or 9 and the controller 13 communicate.

[0032] The control unit 13 preferably comes with a memory such as a non-transient and/or non-volatile memory. The control unit 13 also provides a memory controller to load values such as valve strokes, proportional, integral and/or derivative parameters for control etc from the memory. The valves 7, 8, and/or 9 preferably also comprise a memory and a memory controller. The memory can, by way of non-limiting example, be random access memory (RAM), flash memory, registers, a hard disk, a removable disk, or similar. The control unit 13 advantageously comprises at least one arithmetic logic unit (ALU).

[0033] It is envisaged that the control device 13 and/or the valves run an operating system. The operating system can, by way of non-limiting example, be an Android® operating system, a Windows® operating system, or a Linux® operating system such as Meego®. The operating system can be a system specifically tailored to embedded systems and/or to controllers of HVAC installations. The operating system can also be general-purpose.

[0034] Now turning to FIG 3, a control algorithm is illustrated. The control algorithm comprises a step of recording a plurality of time series of valve strokes from the valves 7, 8, 9. Valve strokes may be recorded periodically every second, every ten seconds, once per minute, once per hour etc. This list is not exhaustive. It is also envisaged that valve strokes are recorded in accordance with an asynchronous schedule. The asynchronous schedule may provide that periodic recording can be suspended as a function of system load and/or system priorities. That is, periodic recording may be suspended while the controller 13 carries out high priority tasks. High priority tasks in this context are tasks whose priority is higher than the priority of periodically recording valve strokes. Periodic recording may also be suspended while the controller 13 is in a sleep mode and/or in a doze mode and/or in an energy-savings mode.

[0035] The valve strokes can, by way of non-limiting example, be encoded in the form of an electric current between 4 mA and 20 mA. The valve strokes can, by way of another non-limiting example, be encoded in the form of an electric voltage between 0 V and 3.3 V, or between 0 V and 5 V or between 0 V and 12 V. Accordingly, the controller 13 can provide an analog-to-digital converter to change analog electric signals into digital representations. The analog-to-digital converter preferably is an integral part of the controller 13. That is, the analog-to-digital converter and the controller 13 form a single system-on-a-chip.

[0036] The valve strokes can, by way of yet another non-limiting example, be encoded in the form of digital values such as digital values comprising eight, ten, twelve, sixteen or thirty-two bits. It is envisaged that the valves 7, 8, 9 produce such digital values by means of an analog-to-digital converter. It is also envisaged that the valves 7, 8, 9 transmit digital values to the controller 13 using a predetermined communication bus protocol and a communication bus.

[0037] After reading the valve strokes, the recorded values are statistically analysed in step 14. In an embodiment, the statistical analysis 14 produces a mean valve stroke for each valve 7, 8, 9. The mean value can, by way of non-limiting example, be determined for valve strokes recorded over periods of an hour, of six hours, of twelve hours, of a day, and/or of a week. The mean value advantageously is an arithmetic mean value. In another embodiment, the statistical analysis 14 produces a median valve stroke for each valve 7, 8, 9. The median value can, by way of non-limiting example, be determined for valve strokes recorded over periods of an hour, of six hours, of twelve hours, of a day, and/or of a week.

[0038] According to an aspect of the present disclosure, the statistical analysis 14 also filters outliers. It is envisaged that the statistical analysis 14 detects and/or excludes values of valve strokes that are technically not meaningful. Negative valve strokes and/or valve strokes (significantly) exceeding a fully open valve position may not be considered technically meaningful. This list is not exhaustive. Valve strokes that are technically not meaningful are preferably not factored in when determining and/or calculating mean values and/or median values.

[0039] It is also envisaged that the statistical analysis 14 calculates standard deviations. The standard deviations can then be used to exclude values of valve strokes that deviate by more than two standard deviations or by more than three standard deviations or by more than six standard deviations from the mean value. Valve strokes that are statistical outliers are preferably not factored in when determining and/or calculating mean values and/or median values.

[0040] According to yet another aspect, the statistical analysis 14 comprises a moving average filter. That is, a moving average of valve strokes is determined and/or calculated for each valve 7, 8, 9. The moving average can, by way of non-limiting example, average over more than ten and/or over more than a hundred and/or over more than a thousand recorded values.

[0041] According to still another embodiment, the statistical analysis 14 comprises a low pass filter. The low pass filter can, by way of non-limiting example, exhibit a time constant of an hour, of six hours, of twelve hours and/or of a day. The time constant preferably is a three decibels time constant.

[0042] According to a sophisticated embodiment, step 14 performs automated feature extraction. That is, a plurality of features of a time series of valve strokes such as

- values of autocorrelation,
- kurtosis values,
- sample entropy,
- slopes of linear trends,
- absolute values related to linear trends,
- numbers of samples,
- numbers of duplicate samples,
- number of samples above the mean valve stroke,
- number of samples below the mean valve stroke,
- number of samples above the median valve stroke,
- number of samples below the median valve stroke,
- maximum values,
- arithmetic and/or geometric mean values,
- minimum values,
- skewness values,
- values of standard deviation,
- quantiles such as 5%, 10%, 50%, 63%, 90%, and/or 95% quantiles,
- values of variance,
- numbers and/or percentages of outliers that deviate from the (arithmetic) mean value by more than two, more than three and/or more than six standard deviations,
- etc.

are extracted automatically. Some of these features can optionally be tested for feature importance. Preferably, a (1 - *p*)-value is returned for every feature that was tested for feature importance. It is envisaged that all extracted features are tested for feature importance.

[0043] Step 14 advantageously forwards a single statistical value for each valve 7, 8, 9. The forwarded statistical values are then processed in step 15. The statistical values are preferably processed by rescaling them. Values of maximum positions can, by way of non-limiting example, be 100%, 90%, and/or 80%. The maximum values preferably correspond to and/or are associated with maximum valve strokes. The rescaled statistical values define allowable ranges such as ranges between 0% and 100%, between 0% and 90%, between 0% and 80%. The rescaled statistical values may also define allowable ranges such as ranges between 10% and 100%, between 10% and 90%, between 10% and 80%.

[0044] In an embodiment, the controller 13 comprises a memory storing a lookup table. The lookup table may store minimum positions, maximum positions and/or allowable ranges for at least one valve 7, 8, 9. It is envisaged that the lookup table stores minimum positions, maximum positions and/or ranges for every valve 7, 8, 9. The controller 13 advantageously loads at least one entry corresponding to or comprising a minimum position, a maximum position and/or an allowable range from the memory. The controller 13 then produces a rescaled value as a function of the entry read and as a function of a statistical value. The rescaled value for each valve 7, 8, 9 ideally is a value within the allowable range of each valve 7, 8, 9.

[0045] The control algorithm also comprises a step of recording a plurality of time series of physical quantities associated with the zones of a structure. Ideally, each physical quantity is associated with a valve 7, 8, 9 and/or with a heat exchanger 10, 11, 12. Physical quantities may be recorded periodically every second, every ten seconds, once per minute, once per hour etc. This list is not exhaustive.

[0046] It is also envisaged that physical quantities are recorded in accordance with an asynchronous schedule. The asynchronous schedule may provide that periodic recording can be suspended as a function of system load and/or system priorities. That is, periodic recording may be suspended while the controller 13 carries out high priority tasks. High priority tasks in this context are tasks whose priority is higher than the priority of periodically recording physical quantities. Periodic recording may also be suspended while the controller 13 is in a sleep mode and/or in a doze mode and/or in an energy-savings mode.

[0047] In an embodiment, the physical quantities are recorded together with the valve strokes. That is, controller 13 periodically carries out a single task. The single task comprises recording physical quantities and it comprises recording valve strokes. It is envisaged that the single task is carried out in accordance with the asynchronous schedule described above.

[0048] The physical quantity typically comprises at least one of:

- a value of temperature,
- a value of humidity,
- a value related to particulate matter 10 micrometers in size,
- a value related to particulate matter 2.5 micrometers in size,
- a value related to particulate matter 1 micrometer in size,
- a value of pressure,
- etc.

[0049] The above list is not exhaustive. In a preferred embodiment, the physical quantity is a temperature.

[0050] The physical quantities can, by way of non-limiting example, be encoded in the form of an electric current between 4 mA and 20 mA. The physical quantities can, by way of another non-limiting example, be encoded in the form of an electric voltage between 0 V and 3.3 V, or between 0 V and 5 V, or between 0 V and 12 V. Accordingly, the controller 13 can provide an analog-to-digital converter to change analog electric signals into digital representations. The analog-to-digital converter preferably is an integral part of the controller 13. That is, the analog-to-digital converter and the controller 13 form a single system-on-a-chip.

[0051] The physical quantities can, by way of yet another non-limiting example, be encoded in the form of digital values such as digital values comprising eight, ten, twelve, sixteen or thirty-two bits. It is envisaged that sensors 16, 17, 18 in each zone produce such digital values by means of an analog-to-digital converter. It is also envisaged that the sensors 16, 17, 18 transmit digital quantities to the controller 13 using a predetermined communication bus protocol and a communication bus.

[0052] After recording the physical quantities, the recorded values are analysed in step 19. In an embodiment, the analysis 19 produces a deviation from a comfort set point during comfort phases (as scheduled) deviation from optimum comfort and/or an indication of comfort for a zone of a structure. It is envisaged that the analysis 19 produces deviations from optimum comfort and/or indications of comfort for each time series and for each zone of a structure.

[0053] Step 19 preferably indicates a deviation of recorded physical quantities such as temperatures from a target value. The deviation of the recorded physical quantities from the target value can, by way of non-limiting example, comprise at least one of

- an averaged deviation of the physical quantities from the target value, such as
    - ◦ deviations of (room) temperature from a set point averaged during phases of heating and/or
    - ◦ deviations of (room) temperature from a set point averaged during phases of cooling,
- a median deviation of the physical quantities from the target value,
- a percentage of values of a time series that are below or above a target value,
- a standard deviation with respect to the target value,
- a variance of the physical quantities with respect to the target value.

[0054] The deviation of the recorded physical quantities from the target value preferably is an averaged temperature deviation from a target value of temperature. A measure of deviation from optimum comfort in the form of a temperature deviation is advantageously produced for each recorded time series of temperature values. A measure of deviation from optimum comfort in the form of a temperature deviation is advantageously also produced for each zone of a structure.

[0055] In an embodiment, the controller 13 comprises a memory storing a lookup table for target values. The lookup table stores target values for the various zones of a structure. It is envisaged that the lookup table, by way of non-limiting example, stores target values for each zone of a structure. The controller 13 advantageously loads at least one entry corresponding to or comprising a target value from the memory. The controller 13 then uses the target values to produce measures of deviation from optimum comfort.

[0056] According to an aspect of the present disclosure, the step 19 also filters outliers. It is envisaged that step 19 detects and/or excludes sensor readings and/or physical quantities that are technically not meaningful. Sensor readings and/or physical quantities that are technically not meaningful are preferably excluded from the following steps of the algorithm.

[0057] It is also envisaged that step 19 calculates standard deviations. The standard deviations can then be used to exclude values of sensor readings and/or of physical quantities that deviate by more than two standard deviations or by more than three standard deviations or by more than six standard deviations from the mean value. Sensor readings and/or of physical quantities that are statistical outliers are preferably excluded from the following steps of the algorithm.

[0058] Step 19 of measuring deviations from optimum comfort is followed by a step 20 of controlling comfort. Step 20 employs a comfort balancing controller such as a proportional, integral and/or derivative controller to balance comfort among the zones of a structure. Measures of deviation from optimum comfort are obtained from step 19. Also, rescaled statistical values can be obtained from step 15. The comfort controller uses the measures of deviation from optimum comfort for each zone as error signals. The comfort controller produces signals indicative of rescaled valve positions as functions of the error signals. The comfort controller can also produce signals indicative of rescaled valve positions as functions of the rescaled statistical values. The comfort balancing controller ideally produces such signals for each zone of a structure. Ideally, comfort balancing yields the same comfort in every zone of a structure. That is, every zone deviates from optimum comfort by the same amount (by the same temperature).

[0059] The comfort balancing controller can rely on proportional, integral and/or derivative parameters to produce the signals indicative of rescaled valve positions. The proportional, integral and/or derivative parameters are ideally stored in and read from a memory of the controller 13. The proportional, integral and/or derivative parameters can also be provided via a user interface such as a graphical user interface on a screen.

[0060] Step 20 provides output signals emanating from the comfort balancing controller. These output signals are indicative of valve strokes that yield balanced comfort in the various zones of a structure. Also, step 15 provides an output signal indicative of rescaled valve strokes for the various zones of the structure.

[0061] Step 21 produces a combined signal as a function of the output signals obtained from steps 15 and 20. It is envisaged that step 21 merges the signals obtained from steps 15 and 20. It is, in particular, envisaged that step 21 adds the signals obtained from steps 15 and 20. It is also envisaged that step 21 assigns a first weight to each signal obtained from step 15 and a second weight to each signal obtained from step 20. Step 21 then uses the first weight and the second weight produces a weighted sum of the signals obtained from steps 15 and 20.

[0062] According to an aspect of the present disclosure, an electronic adder is employed to combine signals in step 21. To that end, the electronic adder provides a first input channel for the signals obtained from step 15 and a second input channel for the signals obtained from step 20. The electronic adder can, in particular, provide additional input channels for the first weight and for the second weight. Accordingly, this adder produces a weighted sum of the signals obtained from steps 15 and 20.

[0063] According to another aspect of the present disclosure, a programmable module is employed to combine and/or to merge the signals in step 21. The electronic module can be embodied in software and/or in hardware. A hardware electronic module can, in particular, be arranged on the same system-on-a-chip with other modules. It is envisaged that the hardware electronic module is arranged on the same system-on-a-chip with a rescaling module for step 15 and with a comfort balancing module for step 20. These modules can be arranged within the same core or within different cores on the same system-on-a-chip.

[0064] Step 21 can be followed by an optional selection step 22. The combined signals are thus forwarded to a filter. The filter preferably selects maximum values or a maximum value among its input values. The filter can, in particular, apply a time frame such as a time frame of a day, of two days, of a week or of two weeks to select maximum values. It is also envisaged that the filter applies a time frame such as a time frame of at least one day, of at least two days, or of at least five days to select maximum values.

[0065] In an embodiment, a 95% quantile of input values is determined and/or calculated by the filter in step 22. The filter selects and/or forwards values among its input values that exceed the 95% quantile. The filter can, in particular, apply a time frame such as a time frame of a day, of two days, of a week, or of two weeks to select maximum values. It is also envisaged that the filter applies a time frame such as a time frame of at least one day, of at least two days, or of at least five days to select maximum values.

[0066] In an embodiment, a 90% quantile of input values is determined and/or calculated by the filter in step 22. The filter selects and/or forwards values among its input values that exceed the 90% quantile. The filter can, in particular, apply a time frame such as a time frame of a day, of two days, of a week, or of two weeks to select maximum values. It is also envisaged that the filter applies a time frame such as a time frame of at least one day, of at least two days, or of at least five days to select maximum values.

[0067] In an embodiment, an 80% quantile of input values is determined and/or calculated by the filter in step 22. The filter selects and/or forwards values among its input values that exceed the 80% quantile. The filter can, in particular, apply a time frame such as a time frame of a day, of two days, of a week or of two weeks to select maximum values. It is also envisaged that the filter applies a time frame such as a time frame of at least one day, of at least two days, or of at least five days to select maximum values.

[0068] The output signal 23 obtained from step 22 can then applied as upper limit positions to the individual valves 7, 8, 9 in the various zones of a structure. In an alternate embodiment, the output signal 24 obtained from step 21 is directly applied as upper limit positions to the individual valves 7, 8, 9 in the various zones of a structure. That is, the output of the adder in step 21 is not filtered but is directly transmitted to the valves 7, 8, 9.

[0069] In an embodiment, the controller 13 comprises a memory storing a time frame. The stored time frame can, by way of non-limiting example, cover at least one day, or at least two days, or of at least five days. The controller 13 advantageously loads the time frame from the memory. The controller 13 then produces a filtered value by applying the loaded time frame to its input values.

[0070] As described in detail herein, the instant disclosure teaches a method for control of an installation having at least two heat exchangers (10 - 12) and at least two sensors (16 - 18), the at least two heat exchangers (10 - 12) each comprising an electromechanical valve (7 - 9), the electromechanical valves (7 - 9) each being associated with one of the at least two sensors (16 - 18), each of the electromechanical valves (7 - 9) being movable between an open position allowing flow of a fluid through its heat exchanger (10 - 12) and a closed position obturating flow of a fluid through its heat exchanger (10 - 12);
the method comprising the steps of:

reading a time series of position signals from each of the electromechanical valves (7 - 9);
extracting a characterized position from each time series and rescaling the characterized position;
reading one or more sensor signals from each of the at least two sensors (16 - 18);
deriving for each of the at least two sensors (16 - 18) a physical quantity from the one or more sensor signals and a deviation measure indicative of a deviation of the physical quantity from a target value;
determining a balance measure by averaging the deviation measures;
producing an upper limit position for each of the electromechanical valves (7 - 9) based on the rescaled characterized positions and based on the deviation measures and based on the balance measure such that for each of the at least two sensors (16 -18) the deviation measure approaches the balance measure; and
moving at least one of the electromechanical valves (7 - 9) between the closed position and the upper limit position produced for the at least one electromechanical valve (7 - 9).

[0071] It is envisaged that a time series of position signals from each of the electromechanical valves (7 - 9) is a time history of position signals from each of the electromechanical valves (7 - 9). Advantageously, the at least two heat exchangers (10 - 12) each connect to and/or each are in fluid communication with an electromechanical valve (7 - 9).

[0072] Preferably, the method comprises the step of moving at least one of the electromechanical valves (7 - 9) between the closed position and the upper limit position produced for the same electromechanical valve (7 - 9).

[0073] Ideally, each of the electromechanical valves (7 - 9) is movable between an open position affording flow of a fluid through its heat exchanger (10 - 12) and a closed position obturating flow of a fluid through its heat exchanger (10 - 12).

[0074] The method ideally comprises the step of extracting a characterized position from each time series and rescaling the characterized position between a minimum value and a maximum value.

[0075] In an embodiment, the method comprises the step of selectively moving at least one of the electromechanical valves (7 - 9) between the closed position and the upper limit position produced for the at least one electromechanical valve (7 - 9).

[0076] In a particular embodiment, the method comprises the step of moving at least one of the electromechanical valves (7 - 9) between the open position and the closed position as a function of the upper limit position produced for the electromechanical valve (7 - 9).

[0077] It is envisaged that each of the electromechanical valves (7 - 9) comprises a valve actuator, each of the valve actuators being movable, preferably being selectively movable, between an open position allowing flow of a fluid through its heat exchanger (10 - 12) and through its electromechanical valve (7 - 9), and a closed position obturating flow of a fluid through its heat exchanger (10 -12) and through its electromechanical valve (7 - 9).

[0078] According to a related aspect of the instant disclosure, the method comprises the step of an actuator of at least one of the electromechanical valves (7 - 9) moving between the open position and the closed position as a function of at least one of the produced upper limit positions.

[0079] It is also envisaged that the method comprises the step of determining a balance measure by arithmetically averaging the deviation measures, preferably by arithmetically averaging the deviation measures over the at least two sensors (16 - 18).

[0080] Ideally, the balance measure is one single balance measure and/or is a unique balance measure.

[0081] It is also envisaged that the method comprises the step of determining a balance measure by determining and/or by calculating a weighted arithmetic average of the deviation measures, preferably by determining and/or by calculating a weighted arithmetic average of the deviation measures over the at least two sensors (16 - 18).

[0082] It is further envisaged that the method comprises the step of determining a balance measure by geometrically averaging the deviation measures, preferably by geometrically averaging the deviation measures over the at least two sensors (16 - 18).

[0083] It is still further envisaged that the open position is a fully open position. In the fully open position, a flow of a fluid through an electromechanical valve (7 - 9) decreases or remains unchanged when moving away from the fully open position. Also, it is envisaged that the closed position is a fully closed position and/or a seated position.

[0084] According to an aspect of the present disclosure, the method comprises the step of producing an upper limit position for each of the electromechanical valves (7 - 9) based on the rescaled characterized positions and based on the deviation measures such that for each of the at least two sensors (16 - 18) the deviation measure attains the balance measure.

[0085] In an embodiment, the installation is a heating, ventilation and/or air-conditioning installation.

[0086] According to an aspect of the instant disclosure, the electromechanical valves (7 - 9) are each associated with a different one of the at least two sensors (16 - 18).

[0087] The instant disclosure also teaches any of the aforementioned methods, wherein for each time series the characterized position is an average of the position signals of the time series.

[0088] It is envisaged that for each time series the characterized position is an arithmetic average of the position signals of the time series or a geometric average of the position signals of the time series or a weighted arithmetic average of the position signals of the time series.

[0089] The present disclosure also teaches any of the aforementioned methods, wherein the at least two sensors (16 - 18) each comprise a temperature sensor and wherein for each of the sensors (16 -18) the physical quantity is a temperature.

[0090] The instant disclosure also teaches any of the aforementioned methods, the method comprising the step of determining a balance measure by averaging the deviation measures over the at least two sensors (16 - 18).

[0091] The present disclosure further teaches any of the aforementioned methods, the method comprising for each of the electromechanical valves (7 - 9) the step of moving the electromechanical valve (7 - 9) between the closed position and the upper limit position produced for the electromechanical valve (7 - 9).

[0092] It is envisaged that the method comprises for at least one of the electromechanical valves (7 - 9) or for each of the electromechanical valves (7 - 9) the step of employing proportional and integral control to move, preferably to selectively move, the electromechanical valve (7 - 9) between the closed position and the produced upper limit position.

[0093] It is envisaged that the method comprises for at least one of the electromechanical valves (7 - 9) or for each of the electromechanical valves (7 - 9) the step of employing proportional and integral and derivative control to move, preferably to selectively move, the electromechanical valve (7 - 9) between the closed position and the produced upper limit position.

[0094] The instant disclosure still further teaches any of the aforementioned methods, the method comprising the steps of:

determining for each of the at least two sensors (16 - 18) an error signal as a difference between the deviation measure derived for the sensor (16 - 18) and the balance measure; and
determining for each of the electromechanical valves (7 - 9) an upper limit position as a function of the error signal determined for the sensor (16 - 18) associated with the electromechanical valve (7 - 9) and as a function of the rescaled characterized position of the electromechanical valve (7 - 9).

[0095] The instant disclosure also teaches the aforementioned method, the method comprising the step of:
minimizing for each of the electromechanical valves (7 - 9) the error signal for the sensor (16 - 18) associated with the electromechanical valve (7 - 9) by determining an upper limit position as a function of the error signal for the sensor (16 - 18) and as a function of the rescaled characterized position of the electromechanical valve (7 - 9).

[0096] According to an aspect, the method comprises the step of:
minimizing for each of the electromechanical valves (7 - 9) the error signal for the sensor (16 - 18) associated with the electromechanical valve (7 - 9) by using proportional and integral control to determine and/or to calculate an upper limit position as a function of the error signal for the sensor (16 - 18) and as a function of the rescaled characterized position of the electromechanical valve (7 - 9).

[0097] According to another aspect, the method comprises the step of:
minimizing for each of the electromechanical valves (7 - 9) the error signal for the sensor (16 - 18) associated with the electromechanical valve (7 - 9) by using proportional and integral and derivative control to determine and/or to calculate an upper limit position as a function of the error signal for the sensor (16 - 18) and as a function of the rescaled characterized position of the electromechanical valve (7 - 9).

[0098] The instant disclosure also teaches any of the aforementioned methods, the method comprising for each of the electromechanical valves (7 - 9) the step of rescaling the characterized position between a minimum value and a maximum value, the maximum value being indicative of the open position of the electromechanical valve (7 - 9).

[0099] It is envisaged that the method comprises for each of the electromechanical valves (7 - 9) the step of rescaling the characterized position between a minimum value and a maximum value, the maximum value corresponding to a fully open position of the electromechanical valve (7 - 9) and/or of an actuator of the electromechanical valve (7 - 9).

[0100] It is also envisaged that the method comprises for each of the electromechanical valves (7 - 9) the step of rescaling the characterized position between a minimum value and a maximum value, the minimum value being indicative of the closed position of the electromechanical valve (7 - 9).

[0101] The present disclosure also teaches any of the aforementioned methods, the method comprising the steps of:

producing a merged position indicative of a valve position by determining for at least one of the electromechanical valves (7 - 9) a sum of the produced upper limit position and of the rescaled characterized position; and
moving at least one of the electromechanical valves (7 - 9) between the closed position and the merged position.

[0102] The instant disclosure also teaches the aforementioned method, the method comprising the steps of:

comparing the merged position to a threshold value; and
if the merged position is larger than or equal to the threshold value, moving at least one of the electromechanical valves (7 - 9) between the closed position and the merged position.

[0103] The instant disclosure further teaches any of the aforementioned methods, the method comprising the steps of:

forming a second time series of filter input signals from the merged position and from a first time series of filter input signals; and
determining a threshold value as a function of the second time series of filter input signals;
comparing the merged position to the threshold value;
if the merged position is larger than or equal to the threshold value, moving at least one of the electromechanical valves (7 - 9) between the closed position and the merged position.

[0104] In an embodiment, the method comprises the step of joining the merged position and a first plurality of filter input signals to produce and/or to form a second plurality of filter input signals.

[0105] The present disclosure also teaches the aforementioned method, wherein the method comprises the step of:

producing the threshold value by determining and/or calculating a quantile of the second time series of filter input signals.

[0106] It is envisaged that the determined and/or calculated quantile is an 80% quantile or a 90% quantile or a 95% quantile of the second time series of filter input signals such that 80% or 90% or 95%, respectively, of the input signals of the second time series are less than or equal to the determined and/or calculated quantile.

[0107] It is envisaged that the controller (13) is configured to perform any of the aforementioned method steps.

[0108] The instant disclosure also teaches a computer-readable medium containing a program which executes the steps of any any of the aforementioned methods.

[0109] The computer-readable medium preferably is non-transitory.

[0110] The instant disclosure also teaches a controller (13) for an installation, the installation comprising at least two heat exchangers (10 -12) and at least two sensors (16 - 18), the at least two heat exchangers (10 - 12) each comprising an electromechanical valve (7 - 9), the electromechanical valves (7 - 9) each being associated with one of the at least two sensors (16 - 18), each of the electromechanical valves (7 - 9) being movable between an open position allowing flow of a fluid through its heat exchanger (10 - 12) and a closed position obturating flow of a fluid through its heat exchanger (10 - 12);
the controller (13) being in operative communication with each of the at least two sensors (16 - 18) and being in operative communication with each of the electromechanical valves (7 - 9); the controller (13) being configured to:

read a time series of position signals from each of the electromechanical valves (7 - 9);
extract a characterized position from each time series and rescale the characterized position;
read one or more sensor signals from each of the at least two sensors (16 - 18);
derive for each of the at least two sensors (16 - 18) a physical quantity from the one or more sensor signals and a deviation measure indicative of a deviation of the physical quantity from a target value;
determine a balance measure by averaging the deviation measures;
produce an upper limit position for each of the electromechanical valves (7 - 9) based on the rescaled characterized positions and based on the deviation measures and based on the balance measure such that for each of the at least two sensors (16 -18) the deviation measure approaches the balance meas-

ure; and

move at least one of the electromechanical valves (7 - 9) between the closed position and the upper limit position produced for the at least one electromechanical valve (7 - 9).

[0111] Preferably, the controller (13) is configured to move at least one of the electromechanical valves (7 - 9) between the closed position and the upper limit position produced for the same electromechanical valve (7 - 9).

[0112] Ideally, the controller (13) is configured to extract a characterized position from each time series and rescale the characterized position between a minimum value and a maximum value.

[0113] It is envisaged that each of the electromechanical valves (7 - 9) is in operative communication with the controller (13) such that the controller (13) is configured to set and/or to read and/or to record the position and/or the stroke of each of the electromechanical valves (7 - 9) and/or of an actuator of each of the electromechanical valves (7 - 9).

[0114] It is also envisaged that the controller (13) is in operative communication with the at least two sensors (16 - 18) such that the controller (13) is configured to read and/or to record one or more signals from each of the at least two sensors (16 - 18).

[0115] It is further envisaged that the controller (13) comprises a memory storing the minimum value and the maximum value and that the controller (13) is configured to load the minimum value and the maximum value from the memory.

[0116] It is further envisaged that the controller (13) comprises a memory storing a plurality of minimum values and a plurality of maximum values such as a minimum value and a maximum value for each of the electromechanical valves (7 - 9) and that the controller (13) is configured to load the plurality of minimum values and the plurality of maximum values from the memory.

[0117] It is still further envisaged that the controller (13) comprises a memory storing the target value and that the controller (13) is configured to load the target value from the memory.

[0118] It is still further envisaged that the controller (13) comprises a memory storing a plurality of target values such as a target value for each of the at least two sensors (16 - 18) and that the controller (13) is configured to load the plurality of target values from the memory.

[0119] It is still further envisaged that the controller (13) comprises a memory storing a plurality of target values such as a target value for each of the at least two sensors (16 - 18) and that the controller (13) is configured to load at least one of the target values of the plurality of target values from the memory.

[0120] It is further envisaged that the controller (13) is configured to set the position of at least one of the electromechanical valves (7 - 9) in accordance with a control output derived by the controller (13) using proportional and integral control.

[0121] The present disclosure also teaches a heating, ventilation and/or air-conditioning installation comprising at least two heat exchangers (10 -12) and at least two sensors (16 - 18), the at least two heat exchangers (10 - 12) each comprising an electromechanical valve (7 - 9), the electromechanical valves (7 - 9) each being associated with one of the at least two sensors (16 - 18), each of the electromechanical valves (7 - 9) being movable between an open position allowing flow of a fluid through its heat exchanger (10 - 12) and a closed position obturating flow of a fluid through its heat exchanger (10 - 12); and

the installation comprising the aforementioned controller (13).

[0122] According to an aspect of the present disclosure, the heating, ventilation and/or air-conditioning installation comprises a circuit (3), the circuit (3) comprising at least one heat source (1) and the at least two heat exchangers (10 - 12), the at least one heat source (1) and the at least two heat exchangers (10 - 12) being arranged, preferably being arranged in series, in the circuit (3).

[0123] According to another aspect of the present disclosure, the heating, ventilation and/or air-conditioning installation comprises a circuit (3), the circuit (3) comprising at least one pump (2) and the at least two heat exchangers (10 - 12), the at least one pump (2) and the at least two heat exchangers (10 - 12) being arranged, preferably being arranged in series, in the circuit (3), the at least one pump (2) being configured to convey a flow of a fluid through the at least two heat exchangers (10 - 12).

[0124] According to a related aspect, the controller (13) is in operative communication with the at least one pump (2). The controller (13) can, by way of non-limiting example, be in operative communication with the at least one pump (2) by transmission of a pulse-width modulated signal or of an inverter signal to the at least one pump (2).

[0125] The instant disclosure also teaches a heating, ventilation and/or air-conditioning installation comprising at least two heat exchangers (10 -12) and at least two sensors (16 - 18), the at least two heat exchangers (10 - 12) each comprising an electromechanical valve (7 - 9), the electromechanical valves (7 - 9) each being associated with one of the at least two sensors (16 - 18), each of the electromechanical valves (7 - 9) being movable between an open position allowing flow of a fluid through its heat exchanger (10 - 12) and a closed position obturating flow of a fluid through its heat exchanger (10 - 12); and

the installation comprising a controller (13);

the controller (13) being in operative communication with each of the at least two sensors (16 - 18) and being in operative communication with each of the electromechanical valves (7 - 9); the controller (13) being configured to:

read a time series of position signals from each of

the electromechanical valves (7 - 9);
extract a characterized position from each time series and rescale the characterized position;
read one or more sensor signals from each of the at least two sensors (16 - 18);
derive for each of the at least two sensors (16 - 18) a physical quantity from the one or more sensor signals and a deviation measure indicative of a deviation of the physical quantity from a target value;
determine a balance measure by averaging the deviation measures;
produce an upper limit position for each of the electromechanical valves (7 - 9) based on the rescaled characterized positions and based on the deviation measures and based on the balance measure such that for each of the at least two sensors (16 -18) the deviation measure approaches the balance measure; and
move at least one of the electromechanical valves (7 - 9) between the closed position and the upper limit position produced for the at least one electromechanical valve (7 - 9).

[0126] 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.

[0127] 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

[0128]

1 heat source
2 (electric) pump
3 circuit
4, 5, 6 loops
7, 8, 9 (electromechanical) valves
10, 11, 12 heat exchangers or groups of heat exchangers
13 (central) control unit
14 step of statistical analysis
15 step of rescaling
16, 17, 18 sensors
19 step of comfort analysis
20 step of comfort balancing
21 step of combining
22 step of selecting
23 output signal obtained from step 22
24 output signal obtained from step 21

Claims

1. A method for control of an installation having at least two heat exchangers (10 - 12) and at least two sensors (16 - 18), the at least two heat exchangers (10 - 12) each comprising an electromechanical valve (7 - 9), the electromechanical valves (7 - 9) each being associated with one of the at least two sensors (16 - 18), each of the electromechanical valves (7 - 9) being movable between an open position allowing flow of a fluid through its heat exchanger (10 - 12) and a closed position obturating flow of a fluid through its heat exchanger (10 - 12); **characterised in that** the method comprises the steps of:

reading a time series of position signals from each of the electromechanical valves (7 - 9);
extracting a characterized position from each time series and rescaling the characterized position;
reading one or more sensor signals from each of the at least two sensors (16 - 18);
deriving for each of the at least two sensors (16 - 18) a physical quantity from the one or more sensor signals and a deviation measure indicative of a deviation of the physical quantity from a target value;
determining a balance measure by averaging the deviation measures;
producing an upper limit position for each of the electromechanical valves (7 - 9) based on the rescaled characterized positions and based on the deviation measures and based on the balance measure such that for each of the at least two sensors (16 -18) the deviation measure approaches the balance measure; and
moving at least one of the electromechanical valves (7 - 9) between the closed position and the upper limit position produced for the at least one electromechanical valve (7 - 9).

2. The method according to claim 1, wherein for each time series the characterized position is an average of the position signals of the time series.

3. The method according to any of the claims 1 to 2, wherein the at least two sensors (16 - 18) each comprise a temperature sensor and wherein for each of the sensors (16 - 18) the physical quantity is a temperature.

4. The method according to any of the claims 1 to 3, the method comprising the step of determining a balance measure by averaging the deviation measures over the at least two sensors (16 - 18).

5. The method according to any of the claims 1 to 4, the method comprising for each of the electromechanical valves (7 - 9) the step of moving the electromechanical valve (7 - 9) between the closed position and the upper limit position produced for the electromechanical valve (7 - 9).

6. The method according to any of the claims 1 to 5, the method comprising the steps of:

determining for each of the at least two sensors (16 - 18) an error signal as a difference between the deviation measure derived for the sensor (16 - 18) and the balance measure; and
determining for each of the electromechanical valves (7 - 9) an upper limit position as a function of the error signal determined for the sensor (16 - 18) associated with the electromechanical valve (7 - 9) and as a function of the rescaled characterized position of the electromechanical valve (7 - 9).

7. The method according to claim 6, the method comprising the step of:
minimizing for each of the electromechanical valves (7 - 9) the error signal for the sensor (16 - 18) associated with the electromechanical valve (7 - 9) by determining an upper limit position as a function of the error signal for the sensor (16 - 18) and as a function of the rescaled characterized position of the electromechanical valve (7 - 9).

8. The method according to any of the claims 1 to 7, the method comprising for each of the electromechanical valves (7 - 9) the step of rescaling the characterized position between a minimum value and a maximum value, the maximum value being indicative of the open position of the electromechanical valve (7 - 9).

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

producing a merged position indicative of a valve position by determining for at least one of the electromechanical valves (7 - 9) a sum of the produced upper limit position and of the rescaled characterized position; and
moving at least one of the electromechanical valves (7 - 9) between the closed position and the merged position.

10. The method according to claim 9, the method comprising the steps of:

comparing the merged position to a threshold value; and
if the merged position is larger than or equal to the threshold value, moving at least one of the electromechanical valves (7 - 9) between the closed position and the merged position.

11. The method according to any of the claims 9 to 10, the method comprising the steps of:

forming a second time series of filter input signals from the merged position and from a first time series of filter input signals;
determining a threshold value as a function of the second time series of filter input signals;
comparing the merged position to the threshold value; and
if the merged position is larger than or equal to the threshold value, moving at least one of the electromechanical valves (7 - 9) between the closed position and the merged position.

12. The method according to claim 11, wherein the method comprises the step of:
producing the threshold value by determining a quantile of the second time series of filter input signals.

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

14. A heating, ventilation and/or air-conditioning installation comprising at least two heat exchangers (10 - 12) and at least two sensors (16 - 18), the at least two heat exchangers (10 - 12) each comprising an electromechanical valve (7 - 9), the electromechanical valves (7 - 9) each being associated with one of the at least two sensors (16 - 18), each of the electromechanical valves (7 - 9) being movable between an open position allowing flow of a fluid through its heat exchanger (10 - 12) and a closed position obturating flow of a fluid through its heat exchanger (10 - 12); and
the installation comprising a controller (13);
the controller (13) being in operative communication with each of the at least two sensors (16 - 18) and

being in operative communication with each of the electromechanical valves (7 - 9); **characterised in that** the controller (13) is configured to:

read a time series of position signals from each of the electromechanical valves (7 - 9);
extract a characterized position from each time series and rescale the characterized position;
read one or more sensor signals from each of the at least two sensors (16 - 18);
derive for each of the at least two sensors (16 - 18) a physical quantity from the one or more sensor signals and a deviation measure indicative of a deviation of the physical quantity from a target value;
determine a balance measure by averaging the deviation measures;
produce an upper limit position for each of the electromechanical valves (7 - 9) based on the rescaled characterized positions and based on the deviation measures and based on the balance measure such that for each of the at least two sensors (16 -18) the deviation measure approaches the balance measure; and
move at least one of the electromechanical valves (7 - 9) between the closed position and the upper limit position produced for the at least one electromechanical valve (7 - 9).

FIG 1

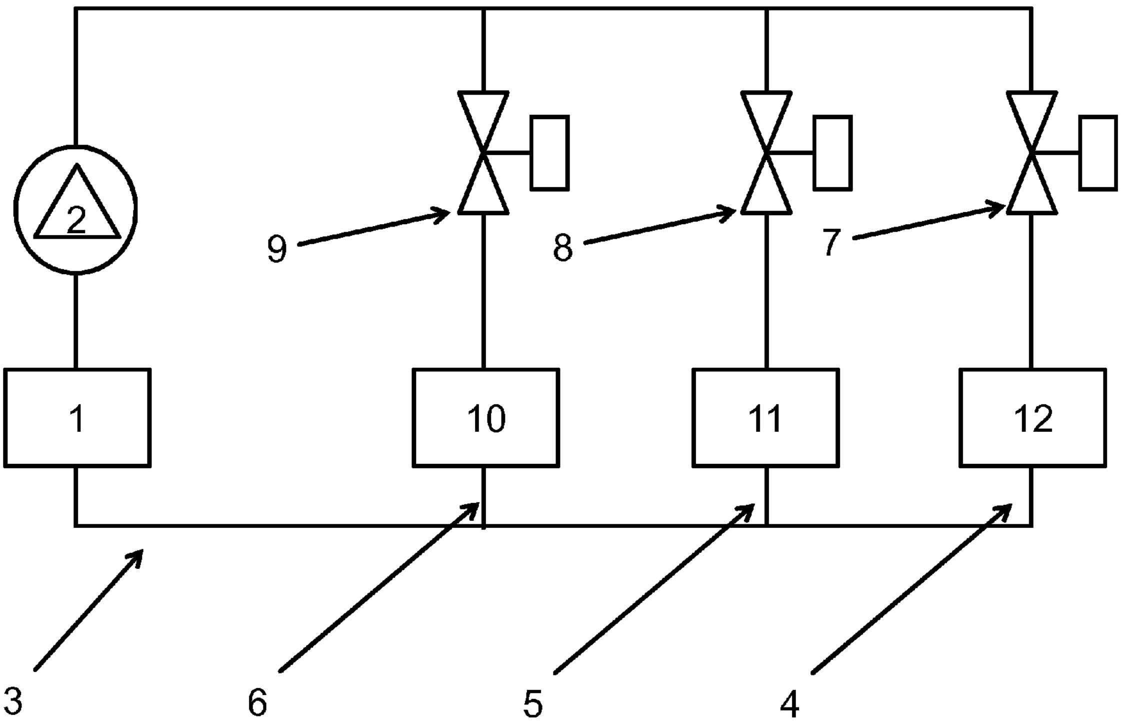


FIG 2

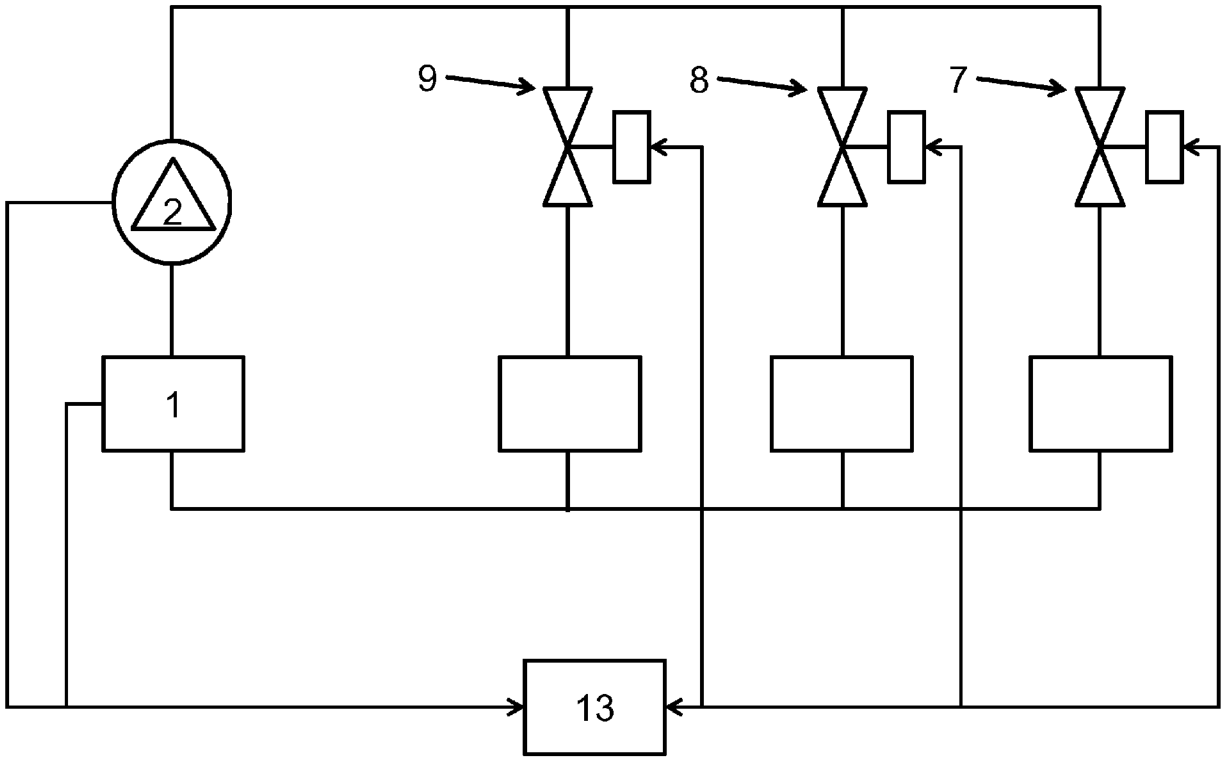
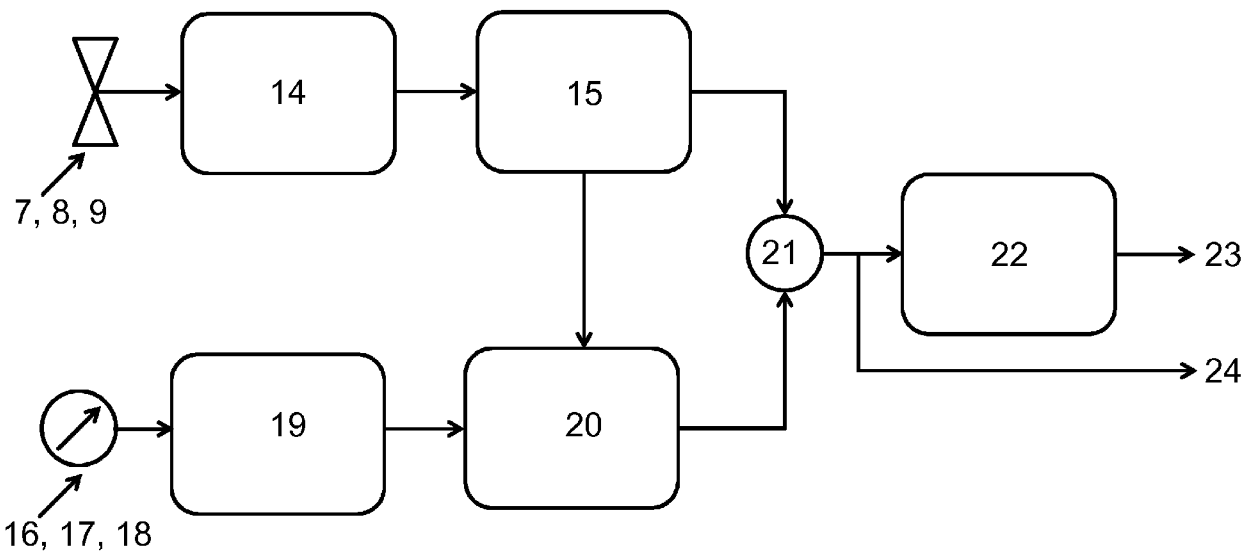


FIG 3



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EUROPEAN SEARCH REPORT

Application Number
EP 19 17 9011

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 10 2017 203850 A1 (VIESSMANN WERKE KG [DE]) 13 September 2018 (2018-09-13) * page 7, paragraph 42 - page 12, paragraph 78; figures 1,4 * -----	1-14	INV. F24D19/10
A	DE 10 2014 102275 A1 (EQ 3 HOLDING GMBH [DE]) 27 August 2015 (2015-08-27) * page 7, paragraph 49 - page 10, paragraph 84; figure 1 * -----	1-14	
A,D	EP 3 115 703 A1 (SIEMENS SCHWEIZ AG [CH]) 11 January 2017 (2017-01-11) * the whole document * -----	1-14	

TECHNICAL FIELDS SEARCHED (IPC)

F24D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	26 November 2019	Hoffmann, Stéphanie

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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