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(54) Laundry treatment apparatus and method for operating a laundry treatment apparatus

(57) The present invention relates to a method for operating a laundry treatment apparatus (1), wherein the apparatus (1) comprises: a laundry treatment chamber (3) for treating laundry by using processing air (A); a heat pump system (4) for treating said processing air (A); a cooling air blower (24) for blowing ambient air towards the heat pump system (4) to cool at least a part thereof; at least one temperature sensing device for providing a first signal indicative of ambient temperature (Tamb); a heat pump system (4) operating condition detection unit for providing a second signal (Tr) indicative of an operating condition of the heat pump system (4); the method comprising the steps of: providing an ambient temperature threshold (Ta_{THR}); determining the ambient temperature (Tamb) based on the first signal; determining whether the ambient temperature (Tamb) satisfies a prefixed condition with the ambient temperature threshold (Ta_{THR}), performing a cooling air blower (24) control procedure based on the second signal (Tr). If said prefixed condition is determined, performing the steps of: drying laundry for a first drying period (t1); determining the second signal (Tr(tl)) at the end of the first drying period (t1); and, based on said determined second signal (Tr(tl)), providing control thresholds (Tf_{ON})(Tf_{OFF}) for said second signal (Tr) to control said cooling air blower (24) during a second drying period (t2) next to said first drying period (t1).

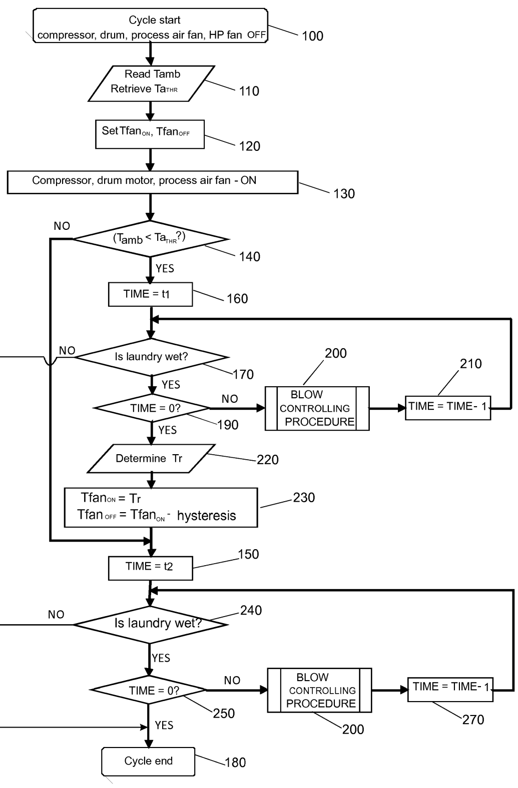

Fig. 4

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Description

[0001] The present invention concerns the field of laundry treatment apparatus, such as laundry drying apparatus and/or laundry washing drying apparatus, to which the following description refers purely by way of example.

BACKGROUND ART

[0002] Nowadays the use of laundry treatment machines, such as laundry drying machines or driers, i.e. laundry machines which dry laundry, or laundry washing and drying machines, i.e. laundry machines which wash, rinse and dry laundry, is widespread. In this respect, in the present description, where not stated differently, the term "laundry treatment machine" can be referred indiscriminately to a laundry drying machine, or to a laundry washing and drying machine.

[0003] As is known, a laundry drying machine comprises an outer casing; a laundry treatment chamber provided with a drying drum mounted inside the casing to rotate axially about a substantially horizontal axis, and positioned facing a laundry loading-unloading opening formed in the front face of the casing; a door hinged to the front face of the casing to rotate to and from a work position closing the opening in the front face and sealing the laundry drying drum; and an electric motor for rotating the laundry drying drum about its longitudinal axis inside the drying tub.

[0004] Laundry drying machines of the above type further comprise a heat-pump system designed to generate and circulate inside the drying drum, heated processing air which flows through the drum to rapidly dry the laundry inside.

[0005] More specifically, the heat pump system comprises a first heat exchanger (evaporator) for heating a refrigerator fluid, a second heat exchanger (condenser) for cooling the refrigerant fluid, an expansion device and a refrigerant loop, in which the refrigerant fluid is circulated through the first and second heat exchangers and the expansion device. A compressor is provided which is adapted to operate for circulating the refrigerant fluid through the refrigerant loop.

[0006] The heat pump system further comprises a heat pump system operation condition detection unit, such as one or more temperature sensing devices which are configured to sense temperatures associated with the operation of the heat pump system, and an electronic control unit which is configured to control the operation of the heat pump system during the drying cycle, based on the sensed temperatures and other known control parameters associated with the selected drying program.

[0007] In some kind of laundry driers, to improve the operation of the heat pump system, the latter further comprises a cooling air blower, i.e. a cooling fan, which carries off heat from one or more parts of the heat pump system, precisely from the compressor or from an auxiliary condenser, by means of ambient air, and is controlled by the electronic control unit based on a comparison between the operating temperatures and prefixed fan control temperature thresholds.

[0008] More specifically, during the laundry drying cycle, the electronic control unit switches on, or alternatively, off an electric fan motor to rotate the cooling fan, when the operating temperature is higher or respectively lower than prefixed fan control temperature thresholds, so that the compression device and/or an auxiliary condenser is cooled. The fan control temperature thresholds are usually set with predefined values as a function of a nominal working temperature, i.e. 20 °C, which is the temperature of the ambient ordinary conditions in which the laundry drying machine is designed to normally operate. Such fan control temperature thresholds are used for all the selectable dring cycles.

[0009] It is also known that the operation of heat pump system and laundry drying machine performances may be considerably affected by the ambient temperature, i.e. the temperature of the environment where the machine is placed. In fact, low ambient temperatures, for example a temperature lower than 5°C requires a long time to cause the machine to reach the right processing air temperature needed to start reducing the moisture content of the processing air, thus causing, on the one hand, a very long time to complete the laundry drying cycle and, on the other hand, high energy consumption. Moreover, prefixed fan control temperature thresholds may cause a useless switching-on of the cooling fan at low ambient temperature causing a further increase of energy consumption. Vice versa, when the ambient temperature is very high, the prefixed fan control temperature thresholds may cause the cooling fan to be switched-on too late and compressor may be cooled improperly with the concrete risk of an intervention of the compressor thermal protector, which causes still a further delay in completing the laundry drying process.

[0010] For the purpose of overcoming the above disclosed technical problems, it has been proposed a solution wherein fan control temperature thresholds are varied as a function of the ambient temperature measured before starting the laundry drying cycle. In such solution, fan control temperature thresholds provided for operating the laundry drying machine in normal ambient conditions (i.e. about 20 °C) are incremented by prefixed values when the measured ambient temperature is low, so that at the beginning of the laundry drying cycle, the heat pump system is not uselessly cooled and energy saving is therefore obtained, whereas, when the ambient temperature measured at the beginning of the laundry drying cycle is very high, the fan control temperature thresholds provided for operating the laundry drying machine in normal ambient conditions are decremented by prefixed values so that the heat pump system is cooled earlier thereby preventing the compressor and/or other components of the heat pump system to heat-up excessively, in this way, heat pump cooling performances are maintained.

[0011] For example, EP 2 333 149 discloses a laundry drying machine provided with a control unit controlling a cooling fan for cooling a portion of a heat pump system, wherein the fan control temperature thresholds are stored in a table, and may be modified based on the ambient temperature measured by temperature sensors.

[0012] Although such a solution , on the one hand, assures reliable working performances of the heat pump/drying machine during the laundry drying cycle for the whole "normal" working temperature range of drying machine, typically from 5°C to 35°C, on the other hand, the delayed switching-on of the cooling fan due to low ambient temperature, may cause condensation of moisture on electronic/electric parts, i.e. electronic boards, arranged within the laundry drying machine. In this respect, Applicant has found that during a laundry drying cycle, processing air with moisture crossing the drum may escape from the drum accidentally, i.e. blowing through drum-seals, and in low ambient temperature conditions, the moisture contained in the air may condense on electrical parts of the drying machine, causing damage of the electric/electronic components of the machine.

[0013] Since the modification of drum sealing arrangements is limited by the need of rotating the drum abutting against a stationary sealing, the Applicant conducted an in-depth study with the objective of providing a laundry treatment machine which is designed to vary the fan control temperature thresholds such that drying performances are ensured both at low and high ambient temperatures, and, at the same time, is able to reduce/avoid condensation of moisture on electronic components of the machine, when ambient temperature is low.

[0014] It is thus the object of the present invention to provide a solution which allows achieving the objective indicated above.

DISCLOSURE OF INVENTION

[0015] The invention is defined in independent claims 1 and 15. Particular embodiments are set out in the dependent claims.

[0016] In a first aspect thereof, the invention relates to a method for operating a laundry treatment apparatus, wherein the apparatus comprises a laundry treatment chamber for treating laundry by using processing air; a heat pump system for treating said processing air; a cooling air blower for blowing ambient air towards the heat pump system to cool at least a part thereof; at least one temperature sensing device for providing a first signal indicative of ambient temperature; a heat pump system operating condition detection unit for providing a second signal indicative of an operating condition of the heat pump system.

[0017] The method comprising providing an ambient temperature threshold; determining the ambient temperature based on the first signal; determining whether the ambient temperature satisfies a prefixed condition with the ambient temperature threshold; performing a cooling air blower control procedure based on the second signal.

[0018] The method further comprises: if said prefixed condition is determined, performing drying laundry for a first drying period; determining the second signal at the end of the first drying period; and, based on said determined second signal, providing control thresholds for said second signal to control said cooling air blower during a second drying period next to said first drying period.

[0019] The inventive method anticipates activation of the cooling air blower blowing ambient air inside the dryer with respect to a nominal ambient temperature operating condition, such that the humidity within the machine is reduced and condensation of moisture on sensitive components of the machine is avoided. Moreover, setting the temperature thresholds according to the current operating temperature determined when the cooling air blower is activated, makes the drying machine automatically adaptive to the ambient temperature conditions. In fact, the compressor temperature is kept around an optimum value to guarantee both an early cooling air blower activation to avoid humidity problems and high work temperature for achieving better drying performance from the heat pump system.

[0020] Preferably, the method maintains cooling air blower deactivated during said first drying period. Maintaining the air blower deactivated during the first drying period increases energy-saving of the machine.

[0021] In a further advantageous embodiment, before starting the first drying period, first and second temperature thresholds are set for said second signal with respective values which are greater than thresholds provided for controlling said cooling air blower during said second drying period; said cooling air blower control procedure being performed by selectively activating or deactivating said cooling air blower when said second signal is above said first threshold or respectively below said second threshold.

[0022] In a further advantageous embodiment, the method comprises the steps of: performing a first control cycle during the first drying period, wherein the first control cycle comprises: setting the first drying period; measuring the time of the drying cycle; performing said cooling air blower control procedure; when measured drying cycle time reaches the end of the first drying period, performing the steps of: stopping said cooling air blower control procedure; determining the second signal; varying said first and second thresholds based on said determined second signal.

[0023] In a further advantageous embodiment, the method comprises the step of performing a second control cycle during the first drying period, wherein the second control cycle comprises: setting the first drying period; measuring the time of the drying cycle; maintaining the cooling air blower deactivated; when measured drying cycle time reaches the end of the first drying period performing the steps of: stopping maintaining the cooling air blower deactivated; determining the second signal; varying said first and second thresholds based on said determined second signal; starting the second drying period wherein the cooling air blower control procedure is performed with the varied first and second thresholds.

[0024] In a further advantageous embodiment, the method comprises the step of performing a third control cycle during the first drying period wherein the third control cycle comprises: setting the first drying period; measuring the time of the drying cycle; maintaining the cooling air blower deactivated; during time measuring, performing the steps of: determining the second signal; if the second signal satisfies a prefixed condition with the first threshold: stopping maintaining the cooling air blower deactivated; determining the second signal; varying said first and second thresholds based on said determined second signal; starting the second drying period, wherein the cooling air blower control procedure is performed with the varied first and second thresholds.

[0025] Preferably, the method further comprises: selectively performing said first, or second or third control cycle based on a user selected drying program and/or based on a differential temperature value which is determined by calculating the difference between the determined ambient temperature and the ambient temperature threshold.

[0026] Preferably, the ambient temperature threshold is determined based on a user selected drying program or based on user input command performed by an input control panel.

[0027] Preferably, the ambient temperature threshold is lower than a value comprised between 5°C and 15°C.

[0028] Preferably, first drying period is estimated/set/determined as a function of the time spent by the processing air escaped from the laundry treatment chamber through its seals, to start forming condensation in the internal parts of the apparatus the said prefixed condition is determined.

[0029] Preferably, the first and second signals are provided by a temperature sensor arranged on the heat pump system.

[0030] Preferably, first drying period is comprised between about 30 and 55 minutes.

[0031] Preferably, the thresholds for said second signal are temperature thresholds.

[0032] Preferably, the prefixed condition consists in that the ambient temperature determined on the basis of the first signal is lower than the ambient temperature threshold.

[0033] In a second aspect thereof, the invention relates to a laundry treatment apparatus comprising a laundry treatment chamber for treating laundry by using processing air; a heat pump system for treating said processing air; a cooling air blower for blowing ambient air towards the heat pump system to cool at least a part thereof; at least one temperature sensing device for providing a first signal indicative of ambient temperature; a heat pump system operating condition detection unit for providing a second signal indicative of an operating condition of the heat pump system (4); wherein a control unit is configured to implement the above method.

[0034] Preferably, the at least one temperature sensing device operates as heat pump system operating condition detection unit

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] Further characteristics and advantages of the present invention will be highlighted in greater detail in the following detailed description of some of its preferred embodiments, provided with reference to the enclosed drawings. In the drawings, corresponding characteristics and/or components are identified by the same reference numbers. In particular:

Figure 1 shows a perspective view of a laundry treatment apparatus according to the invention;
Figure 2 shows a schematic view of a laundry treatment apparatus of Figure 1;
Figure 3 illustrates a schematic block diagram of components of the apparatus of Figure 2;
Figure 4 shows a flowchart illustrating the steps of the method for operating the laundry treatment apparatus according to a first embodiment of the invention;
Figure 5 shows a diagram schematically illustrating how the method controls the cooling air blower during the first and the second drying periods;
Figure 6 shows a flowchart illustrating the steps of the method for operating the laundry treatment apparatus according to a second embodiment of the invention;
Figure 7 shows a flowchart illustrating the steps of the method for operating the laundry treatment apparatus according to a third embodiment of the invention.
Figure 8 shows a flowchart illustrating the steps of a blowing control procedure implemented by the method for operating the laundry treatment apparatus according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0036] The method of the present invention has proved to be particularly advantageous when applied to a laundry drying apparatus, such as driers, as described below. It should be understood that although the method is described with reference to a laundry drying machine, other applications are contemplated. As can be appreciated, the present invention can be conveniently applied to other laundry treatment appliances, like for example laundry washing and drying machines (called also washer/driers).

[0037] With reference to Figures 1, 2 and 3, a laundry treatment machine corresponding to a laundry drying machine 1 according to the present invention is described.

[0038] In accordance with an exemplary embodiment illustrated in Figure 1, the laundry washing machine 1 is a front loading laundry drying machine. The present invention has proved to be particularly successful when applied to front loading laundry drying machines. It should in any case be understood that the present invention is not limited to this type of application. On the contrary, the present invention can be usefully applied to different types of drying devices, for example top loading laundry drying machines or top loading laundry washing and drying machines.

[0039] In accordance with an embodiment, the laundry treatment apparatus 1 comprises an external housing or cabinet 2, and a laundry treatment chamber 3, which is arranged inside the cabinet 2 and is designed to contain laundry 19 to be treated by using a processing air A. In accordance with an exemplary embodiment, laundry treatment chamber 3 comprises a rotatable perforated drum 3, where the laundry 19 to be dried can be loaded. Laundry treatment chamber 3 has a front access opening 5 closable by a door 7 preferably hinged to casing 2.

[0040] In accordance with an exemplary embodiment, the laundry treatment apparatus 1 also comprises a process air blower or fan 8 for circulating the processing air A within the drum 3.

[0041] In accordance with an exemplary embodiment, the laundry treatment chamber 3 and the process air blower 8 may be both rotated by a motor 32. However, in another embodiment, there may be provided two independent motors, one for rotating the laundry treatment chamber 3 and the other for rotating the process air blower 8. Preferably, the motor(s) may be synchronous motor(s) or permanent magnet motor(s). Preferably, motor(s) may be variable speed motor(s), preferably controlled by an inverter device (not illustrated).

[0042] In accordance with a possible embodiment, the laundry drying machine 1 is further provided with a heat pump system 4, comprising in a closed refrigerant loop 6 in this order of refrigerant flow B: a first heat exchanger 10 acting as evaporator for evaporating a refrigerant R and cooling processing air A, a compressor 14, a second heat exchanger 12 acting as condenser for cooling the refrigerant R and heating the processing air A, and an expansion device 16 from where the refrigerant R is returned to the first heat exchanger 10.

[0043] Together with the refrigerant pipes connecting the components of the heat pump system 4 in series, the heat pump system 4 may form the closed refrigerant loop 6 through which the refrigerant R in the heat pump system is circulated by the compressor 14 as indicated by arrow B. If the refrigerant R in the heat pump system 4 is operated in the transcritical or totally supercritical state, the first and second heat exchanger 10, 12 may act as gas heater and gas cooler, respectively.

[0044] In accordance with an embodiment, the expansion device 16 may be a controllable valve that operates under the control of a control unit 30 (Figure 2) to adapt the flow resistance for the refrigerant R in dependency of operating states of the heat pump system 4. In accordance with an exemplary embodiment the expansion device 16 may be a fixed, non-controllable device like a capillary tube.

[0045] The process air flow within the treatment apparatus 1 is guided through the laundry treatment chamber 3, e.g. the perforated drum, which is designed to receiving articles to be treated. The articles to be treated may be, for example, textiles, laundry 19, clothes, shoes or the like. In the embodiments here these are preferably textiles, laundry 19 or clothes.

[0046] The processing air flow is indicated by arrows A in Figure 2 and is driven by the process air blower or fan 8.

[0047] In accordance with an embodiment, heat pump system 4 further comprises a process air channel 20 which guides the processing air flow A outside the drum 3 and is provided, in turn, with different sections, comprising the section forming the battery channel 20a in which the first and second heat exchangers 10, 12 are arranged.

[0048] Preferably, the processing air exiting the second heat exchanger 12 flows into a rear channel 20b in which the processing air blower 8 is arranged. Preferably, the processing air conveyed by processing air blower 8 is guided upward in a rising channel 20c to the backside of the drum 3. The air exiting the drum 3 through the drum outlet (which is the loading opening of the drum) may be filtered by a fluff filter 22 arranged close to the drum outlet in or at the channel 20.

[0049] In accordance with an embodiment, when the heat pump system 4 is operating, the first heat exchanger 10 transfers heat from processing air A to the refrigerant R.

[0050] By cooling the processing air to lower temperatures, humidity from the processing air condensed at the first heat exchanger 10, is collected there and drained to a condensate collector 26.

[0051] Preferably, the processing air A which is cooled and dehumidified after passing the first heat exchanger 10, passes subsequently through the second heat exchanger 12 where heat is transferred from the refrigerant R to the process air A. The process air A is sucked from exchanger 12 by the blower 8 and is driven into the drum 3 where it heats up the laundry 19 and receives the humidity therefrom. The process air A exits the drum 3 and is guided in front channel 20d back to the first heat exchanger 10.

[0052] In accordance with an embodiment, the main components of the heat pump system 4 may be arranged in a base section 9 or basement of the laundry treatment apparatus 1. In this instance, the components above disclosed of the heat pump system 41 are well-known elements provided in well-known drying machine and detailed description thereof will be omitted accordingly.

[0053] In accordance with an embodiment, the laundry treatment apparatus 1 also comprises a cooling air blower 24 which is designed to carry off heat from parts of the heat pump system 4, by means of ambient air. In accordance with an exemplary embodiment the cooling air blower 24 may be preferably arranged close to the compressor 14 to remove heat from the compressor 14, during a drying operation. The cooling air flow C takes heat from (the surface of) the compressor 14.

[0054] In accordance with an exemplary embodiment illustrated in Figure 2, the cooling air blower 24 may comprise a cooling blower or fan 36 which is driven by an electric fan motor 34 controlled by the control unit 30 of the dryer 1.

[0055] In accordance with an embodiment, the laundry treatment apparatus 1 also comprises a temperature sensing device 27, which is designed to measure/detect the ambient temperature Tamb and provides a temperature signal indicative of measured ambient temperature. It should be understood that with the term 'ambient temperature" is meant the temperature measured in the ambient or environment, where the laundry treatment apparatus 1 is arranged/located. For example, when the laundry treatment apparatus 1 is arranged indoor, the ambient temperature may be indoor temperature. When the laundry treatment apparatus 1 is placed outdoor (e.g. in a garage or a veranda) the ambient temperature may be outside temperature or close to outside temperature. In accordance with an exemplary embodiment, temperature sensing device 27 may be arranged internal or external to the cabinet 2. It should in any case understood that according to a possible embodiment, the temperature sensing device 27 may be arranged inside the cabinet 2. Preferably, sensing device 27 may be arranged in order to be distant from the heating sources/components of the heat pump system 4 (i.e. where the process air flows) so that the measured temperature is not affected by heat generated inside the apparatus 1.

[0056] In accordance with an exemplary embodiment indicated in Figure 2, temperature sensing device 27 may be arranged in an upper region of laundry treatment apparatus 1, for example at, or close to, or integrated with, an input control panel 38 preferably arranged, in turn, on the front wall of the cabinet 2. However, it should be understood that alternatively, sensing device 27 may be arranged in the bottom of the cabinet 2, for example in the air path of the cooling air C sucked-in by the cooling air blower 24 such that (at least after operating the blower 24 for a short time) the detected ambient temperature is directly related to the 'ambient temperature'.

[0057] In accordance with an embodiment, the laundry treatment apparatus 1 may further comprise a temperature sensing device 28, which is configured to detect/measure/determine an operating temperature Tr associated with the operating of the heat pump system 4. In accordance with an exemplary embodiment the temperature sensing device 28 may be configured to detect/measure/determine the operating temperature Tr associated with the refrigerant R (or of a temperature dependent on the refrigerant temperature) and provides a temperature signal indicative of the operating temperature Tr. In accordance with an exemplary embodiment, temperature sensing device 28 may be arranged at the compressor output and provides the control unit 30 the temperature signal indicating the measured operating temperature Tr.

[0058] Preferably, temperature sensing device 28 may be arranged, for example, on the refrigerant fluid outlet position at the compressor 14, or on the compressor 14, or on the expansion device 16 or a position in the air flow A of the process air, or on the refrigerant fluid outlet of the first or second heat exchanger 10, 12.

[0059] As shown in Fig. 3, the laundry treatment apparatus 1 may further preferably, although not necessarily, comprise a temperature sensing device 29 which is configured to detect/measure/determine the temperature of an electronic board preferably installed on, close to, the heat pump system 4, and provides the control unit 30 a temperature signal indicative of the temperature of said electronic board. Preferably, temperature sensing device 29 may be arranged for example on, close to, an electronic board, or an inverter unit (not illustrated) controlling one or more components of the heat pump system 4, or an inverter controlling the drum motor 32.

[0060] In accordance with an embodiment, temperature sensing devices 27, 28 and 29 may comprise a temperature sensor or any similar/equivalent sensing/measuring device. In accordance with a preferred embodiment illustrated in Figure 2, the temperature sensing devices 27, 28 and 29 may comprise a temperature dependent resistor, such as for example NTC and/or PTC thermistors. It should in any case be understood that temperature sensing devices 27 or 28 or 29 are not limited only to thermistors but, according to other possible embodiments of the present invention, they may comprise any kind of electric/electronic component/circuit designed to measure/determine a temperature.

[0061] With reference to a preferred embodiment shown in Figures 1, 2 and 3, in usage, the cooling air C may be sucked-in at the bottom of the cabinet 2 and conveyed towards the compressor 14 by the cooling fan 36 for cooling the compressor 14 or parts of the compressor 14. Preferably the cooling air (at least partially passed over the compressor 14) exits the cabinet 2 through openings (not illustrated) arranged at the bottom and/or front side and/or rear side of the cabinet 2. By transferring heat from the compressor 14, during operation of the heat pump system 4, the refrigerant R is shifted to optimized thermodynamic conditions for the heat exchanges processes between the closed loops of the process air loop and the refrigerant loop 6.

[0062] Figure 3 shows a schematically block diagram of components of the laundry treatment apparatus of Figures 1 and 2, illustrating the control of the components of laundry drying machine 1.

[0063] The control unit 30 may be configured to control the operation of the components of the laundry treatment apparatus 1, i.e. the motor 32 driving the drum 3, the process air blower 8, the compressor 14, the valve 16 (optionally) and the motor 34 driving the fan 36, according to the selected drying program.

[0064] Preferably, as will be disclosed in detail hereinafter, the control unit 30 is further configured to: receive from the temperature sensing devices 27, 28 signals relating to the ambient temperature Tamb and operating temperature Tr, compare the received temperatures with a first and second temperature thresholds, hereinafter indicated with $Tfan_{ON}$ and $Tfan_{OFF}$ according to the method afterwards disclosed, switch-on the motor 34 rotating the fan 36 to cause the compressor 14 to be cooled or, alternatively, switch-off the motor 34 to stop rotation of the fan 36, based on results of comparison.

[0065] In usage, a user may select a drying program or cycle, e.g. FAST, ECONOMY, IRON-AID, by the input control panel 38. Optionally further inputs may be made, e.g. residue humidity, laundry amount or laundry type. Further, the control unit 30 may be configured to control the drum 3 and the process air blower 8 (speed) such that during the drying cycle the operation conditions of the laundry treatment apparatus 1 can be optimized in view of energy consumption/drying duration/drying result/component lifetime.

[0066] Figure 4 shows a flow chart illustrating a first embodiment of a method for operating a laundry treatment apparatus 1 as described above.

[0067] Before the drying cycle is started, the compressor 14, the processing air blower 8, the motor 32 controlling the drum 3 and the cooling air blower 24 are in a rest state (switched off/deactivated) (step 100).

[0068] Moreover, before the drying cycle is started, the method performs the step of determining/measuring the ambient temperature Tamb. Preferably, ambient temperature Tamb may be determined/measured based on the temperature signal provided by the temperature sensing device 27. It should be understood that detection of the ambient temperature Tamb may be performed when the temperature sensor 27 is considered to be in thermal equilibrium with the ambient surrounding the laundry treatment apparatus 1. Therefore, the ambient temperature Tamb detection may be performed in a period when the apparatus 1 is at rest, for example, in an interval between two drying processes which is, normally, at least one or more hours. The ambient temperature Tamb detection may also be performed in the very first instants of time when the laundry treatment apparatus 1 has been switched-on, and/or when a drying program has been started but a drying effect on laundry has not yet substantially been carried out, i.e. before a drying cycle is started. It should be understood that the ambient temperature Tamb detection may be alternatively performed up to few seconds after the drum 3 and the process air blower 8 start rotating and a process air heating device is not yet active or it has been just activated but there has been no appreciable drying effect on laundry. Moreover, it should be understood that Tamb may be alternatively, or additionally, estimated/determined/measured on the basis of the temperature signals provided by each of temperature sensing devices 28 or 29. Before the drying cycle is started, supposing that the laundry treatment apparatus 1 has remained inoperative for a relatively long period, both the refrigerant and components/parts of the heat pump system 4, such as the electronic boards, are in thermodynamic equilibrium with the environmental/ambient where the apparatus is placed, and temperature measured by each of the sensing devices 28 or 29 substantially corresponds to the ambient temperature Tamb. For taking into account situations in which the laundry treatment apparatus 1 has operated one or more drying process shortly before the ambient temperature Tamb is determined/measured, appropriate algorithms may be used for estimating the actual ambient temperature Tamb based on temperature signals provided by sensors 27, 28, 29 available in the laundry treatment apparatus 1.

[0069] In step 110, the method further performs the step of determining an ambient temperature threshold Ta_{THR}. The ambient temperature threshold Ta_{THR} is indicative of a "cool ambient condition" of the ambient/environment which may cause the moisture contained in the processing air to condense on the sensitivity components/parts of the machine 1.

[0070] In accordance with a preferred embodiment, the method may determine the ambient temperature threshold Ta_{THR} by reading a memory unit (not illustrated) wherein a prefixed value associated with the temperature threshold Ta_{THR} is stored. In accordance with a preferred embodiment the temperature threshold Ta_{THR} may be lower than about 15°C, preferably lower than 5°C. However, in accordance with another embodiment, the temperature threshold Ta_{THR} may be determined based on the selected drying program. In such a case, for example, drying programs may be associated with respective ambient temperature thresholds Ta_{THR}.

[0071] In accordance with another embodiment, ambient temperature threshold Ta_{THR} may be determined on the basis of an user input command performed by the input control panel 38. In an exemplary embodiment, the user may select, for example via a button arranged in the input control panel 38 or by any other similar input device, a level of the cool ambient condition, e.g. high cool level, medium cool level, and the method may set the ambient temperature threshold Ta_{THR} based on the selected cool level.

[0072] After the ambient temperature threshold Ta_{THR} has been determined/set, the method performs the step 120 of setting the first temperature threshold $Tfan_{ON}$ and the second temperature threshold $Tfan_{OFF}$. Preferably, the values assigned to the first $Tfan_{ON}$ and second temperature thresholds $Tfan_{OFF}$ are prefixed values $T1fan_{ON}$, $T1fan_{OFF}$ respectively, wherein the first temperature thresholds $Tfan_{ON}=T1fan_{ON}$ may be slightly higher than the second temperature threshold $Tfan_{OFF}=T1fan_{OFF}$. Preferably, the values $Tlfano_{N}$, $T1fan_{OFF}$ may be set at the working temperature of the refrigerant, i.e. the temperature that refrigerant reaches when the heat pump system has reached its stationary operative condition when working in a "not-cool environment" or "normal ambient condition", i.e. an ambient wherein the ambient temperature Tamb is above the temperature threshold Ta_{THR}. In other terms, the first and second temperature thresholds $Tfan_{ON}$, $Tfan_{OFF}$ may be set by defaults with values $T1fan_{ON}$, $T1fan_{OFF}$ that cannot be exceeded by the heat pump refrigerant operating temperature, before the heat pump system has reached its stationary operative condition when working in "normal ambient condition" (warm or heat condition). Preferably, the first and second temperature thresholds $Tfan_{ON}$,$Tfan_{OFF}$ may be set with values higher than about 50 °C, preferably 53°C or even more. It should in any case understood that values of the first $Tfan_{ON}$ and second temperature threshold $Tfan_{OFF}$ may be prefixed values stored in a memory unit (not illustrated) of the control unit 30.

[0073] As it will be described in detail hereinafter, by setting the high values of $T1fan_{ON}$, $T1fan_{OFF}$, the method ensures that when the cool ambient condition is detected, the cooling air blower is forced to be switched-off during a whole first drying period of the drying cycle, afterwards indicated with t1. The cooling air blower may kept switched-off even by providing no thresholds $Tfan_{ON}$,$Tfan_{OFF}$ at all during a whole first drying period t1 of the drying cycle, even if the presence of thresholds $Tfan_{ON}$,$Tfan_{OFF}$ during such period t1 assures an intervention of the cooling air blower in case of an unexpected increase of the heat pump refrigerant temperature during period t1.

[0074] After that, the method performs the step 130 of starting the drying cycle associated with a user selected drying program, wherein the selected drying cycle is applied to the compressor 14, the drum 3 and/or to the process air blower 8. In an exemplary embodiment, the method performs the step of switching-on the motor 32 to drive the drum 3 and the process air blower 8. However, it should be understood that if the apparatus 1 is provided with two driving motors, one for driving the drum 3 and the other one for driving the process air blower 8, the drum 3 and the process air blower 8 may be activated in different instances, e.g. first the rotation of the drum 3, and after a prefixed period (one or more minutes, for example), the process air blower 8. Similarly, the switching-on of the compressor 14 may be deferred with respect to the switching-on of the drum 3 and/or process air blower 8 motor(s).

[0075] After the drying cycle has been started, the method performs the step 140 of comparing the ambient temperature Tamb with the ambient temperature threshold Ta_{THR}. It should be understood that in accordance with an embodiment, step 140 may be performed before the step 130.

[0076] If the measured ambient temperature Tamb is above the prefixed temperature threshold Ta_{THR} (output NO in step 140), the method detects a "normal ambient condition", i.e. a condition wherein the ambient may be considered "not-cool", and there is a low percentage/amount of condensation of the processing air within the cabinet 2 out of the drum 3. Therefore the method detects the "normal ambient condition" and applies a "blow controlling procedure" hereinafter disclosed in detail, as from the step 150, wherein the cooling air blower 24 is controlled as a function of the first and second temperature thresholds $T1fan_{ON}$, $T1fan_{OFF}$ assigned by default in step 120.

[0077] If the measured ambient temperature Tamb is below the prefixed temperature threshold Ta_{THR} (output YES in step 140), the method detects a "cool ambient state" and performs a control cycle wherein the first and second temperature thresholds $Tfan_{ON}$, $Tfan_{OFF}$ are varied based on a operating temperature Tr measured after a first prefixed period t1 calculated from the beginning of the drying cycle is elapsed.

[0078] The first embodiment illustrated in Figure 4 is associated with a first control, wherein the method starts performing the step 160 of initializing a time counter, indicated with "TIME", by assigning to the latter a first period "t1" indicating the time that cooling air blower 24 has to be maintained switched-off (TIME=t1). In accordance with an embodiment, first interval t1 may have a prefixed value. In accordance with a preferred embodiment, the first period t1 may be comprised between about 30 and 55 minutes. It should in any case be understood that the first period t1 may be estimated/set/determined as a function of the time spent by the processing air escaping from the drum 3 through its seals, to start forming condensation in the internal parts of the apparatus 1.

[0079] In accordance with an embodiment, the method may determine the first period t1 based on some parameters associated with the condensation condition. In accordance, with an exemplary embodiment, the method may determine the first drying period t1 based on: the measured ambient temperature Tamb, and/or the selected drying program, and/or several drying process parameters, such as the laundry moisture, and/or the temperature of processing air, and/or the rate of processing air provided to the drum 3. For example, the first interval t1 may be varied based on a prefixed mathematical function/curve in order to consider the moisture of the processing air and/or the ambient temperature. In this case, data relating to laundry moisture, temperature of processing air, and processing air provided to the drum 3 may be provided to the control unit 30 by sensing systems (not illustrated), such as laundry moisture sensing system, temperature sensing system mounted in the machine 1. Laundry moisture/temperature sensing systems are well-known devices provided in well-known drying machines and detailed description thereof will be here omitted accordingly.

[0080] After that, the method performs the step 170 of determining whether a laundry drying condition is satisfied. In accordance with an exemplary embodiment, laundry drying condition may be satisfied when measured laundry moisture reaches a prefixed laundry moisture threshold. Laundry moisture may be measured by laundry moisture sensing device which is a well-known element provided in well-known drying machines and detailed description thereof will be here omitted accordingly.

[0081] If laundry drying condition is satisfied (output NO in step 170), the method performs the step 180, wherein it ends the drying cycle.

[0082] If laundry drying condition is not satisfied (output YES in step 170), i.e. the laundry is wet, the method performs the step 190 wherein it is verified whether the time counter TIME is zero. If not (output NO in step 190), the method performs a "blow controlling procedure" in step 200.

[0083] With reference to Figure 8, the "blow controlling procedure" (step 200), in general, comprises the step 300 wherein the heat pump system 4 operating temperature Tr is determined/measured through temperature sensing device 28. The "blow controlling procedure" comprises the step 310, wherein the operating temperature Tr is compared with the first temperature thresholds $Tfan_{ON}$. It should be understood that in this operating phase, first and second temperature thresholds $Tfan_{ON}$ $Tfan_{OFF}$ have respective values assigned by the present control method. When following step 190, temperature thresholds $Tfan_{ON}$ $Tfan_{OFF}$ are those assigned in step 120. In particular, $Tfan_{ON} > Tfan_{OFF}$.

[0084] In the "blow controlling procedure", if the operating temperature Tr is below the first temperature thresholds $Tfan_{ON}$ (output YES in the step 310), the method performs the step 320 of activating the cooling air blower 24 or keeps the cooling air blower 24 switched-on, whereas if the operating temperature Tr is above the first temperature thresholds $Tfan_{ON}$ (output NO in the step 310), the method performs the step 330 wherein the operating temperature Tr and the second temperature threshold $Tfan_{OFF}$ are compared. When the operating temperature Tr is below the second temperature thresholds $Tfan_{OFF}$ (output YES in the step 330) the cooling air blower 24 is (kept) switched off (step 340). If the temperature Tr is above the second temperature thresholds $Tfan_{OFF}$ (output NO in the step 330) the "blow controlling procedure" ends (step 350).

[0085] It should be understood that in the first drying period t1, the method forces the cooling air blower 24 to be maintained deactivated by the fan controlling procedure 200 because value $T1fan_{ON}$ is dimensioned so as to be above the operating temperature Tr during the whole first period t1. Therefore in such period t1, the blow controlling procedure implemented by the method, performs the steps 310, 330 and 350 so as to maintain the cooling air blower 24 deactivated, i.e. the electric fan motor 34 switched-off.

[0086] With reference to Figure 4, after having ended the "blow controlling procedure" following output NO in step 190, the time counter is decremented, TIME=TIME-1 (step 210) and the steps 170, 190, 200 ("blow controlling procedure") and 210 are sequentially repeated until the time counter TIME is zero, i.e. the prefixed first period t1 ends (output YES in step 190).

[0087] After that, the method performs: the step 220 of measuring/determining the heat pump system 4 operating temperature Tr, and the step 230, wherein the first and the second temperature thresholds $Tfan_{ON}$, $Tfan_{OFF}$ are varied based on the measured operating temperature Tr. In a preferred embodiment, first temperature threshold $Tfan_{ON}$ is set with the operating temperature Tr, whereas the second temperature thresholds $Tfan_{OFF}$ is set with $Tfan_{ON}$ minus a prefixed value associated with an hysteresis value. By changing the temperature thresholds $Tfan_{ON}$, $Tfan_{OFF}$ assigned at the beginning of the control procedure (step 120 in Figure 4) with new values fixed taking into account the heat pump system 4 refrigerant temperature Tr at the end of the time period t1, makes the drying machine automatically adaptive to the ambient temperature conditions, thereby improving the reduction of energy consumption of the apparatus 1 for carrying out a laundry drying cycle in a cool ambient condition.

[0088] After that, the method performs the step 150 of setting the time counter with a second period t2 (TIME =t2). In accordance with a preferred embodiment the second period t2 may be determined on the basis of the selected drying program. Period t2 may be fixed as a maximum duration time of a drying cycle to prevent the apparatus from carrying out undesirably long laundry drying cycles, as it may happen in case the condition in the following step 240 described here below is always, or for an unacceptably long drying cycle time, verified (output YES in step 240). The presence of step 150 also allows the apparatus to perform time controlled drying cycles. In the latter case, the following step 240 and its outputs can be removed from the flowchart of Figure 4.

[0089] After that, the method performs the step 240 of verifying whether the laundry drying condition is satisfied. If yes (output NO in step 240), the methods performs the step 180, i.e. ends the drying cycle, whereas if not (outputs YES in step 240), the method performs the step 250 of verifying whether the time counter TIME is zero. If not, (output NO in step 250) the method performs the "blow controlling procedure" 200 above disclosed and illustrated in Figure 8. This time the cooling air blower 24 starts to be switched-on by the "blow controlling procedure" 200 because the first and second temperature thresholds $Tfan_{ON}$, $Tfan_{OFF}$ have been varied on the basis of the current operating temperature Tr. More specifically, in the second period t2, the "blow controlling procedure" 200, instead of forcing the cooling air blower 24 to stay deactivated/switched-off as in the whole first period t1, controls the electric fan motor 34 as a function of the first $Tfan_{ON}$ and second temperature threshold $Tfan_{OFF}$ modified on the basis of current temperature condition Tr of the heat pump system 4. In other words, in the second period t2, the method performs a calibration of the first and second temperature thresholds $Tfan_{ON}$, $Tfan_{OFF}$ such that the cooling air blower 24 may be activated/switched-on when the working temperature of the heat pump system 4 is equal to the operating temperature detected/measured at the instant t1, and, at the same time, cooling air blower 24 may be deactivated/switched-off when the operating temperature of the heat pump system 4 is a prefixed hysteresis value below the operating temperature Tr detected/measured at the instant t1.

[0090] After that, "blow controlling procedure" 200 ends, the time counter is decremented, TIME=TIME-1 (step 270) and the steps 240, 250, 200 ("blow controlling procedure") and 270 are sequentially repeated until the time counter TIME is zero, i.e. the prefixed second period t2 has been elapsed (output YES in step 250), or until the laundry is dried (output NO in step 240).

[0091] After that, the method performs the "cycle end" step 180, wherein the drying cycle is interrupted. In such step, preferably, although not necessarily, a laundry cooling stage may be performed. In accordance with an embodiment, stopping of the drying cycle may preferably comprise turning off the heat pump system 4 such that heating of the processing air is stopped. Preferably, at the cooling stage, drum 4 may be kept turning, and non-heated air fed into drum 4 by the process air blower 8.

[0092] The method illustrated in figure 4 is configured to determine when drying cycle has to be stopped, by performing two different controls, i.e. a time control (step 250, 270) and laundry drying control (steps 170, 240). However the present invention is not limited to the double control to stop the drying cycle. On the contrary, in accordance with a possible embodiment, the method may be configured to perform one control, i.e. only the time control (steps 250, 270), or only the laundry drying control (steps 170, 240). Laundry drying control (steps 170, 240) may be performed in any known manner, such as by sensing laundry humidity within the drum 3 by conductimetric sensors arranged within the drum 3 to be repetitively contacted by laundry during a drying process.

[0093] Figure 5 illustrates an example diagram of the cooling air blower 24 control (in ideal apparatus 1 operating conditions) performed by the method in a "cool ambient condition" ($Tamb < Ta_{THR}$). More specifically, in Figure 5, lines A and B relate to the first $Tfan_{ON}$ and second temperature thresholds $Tfan_{OFF}$ respectively, line C relates to the variation of the heat pump system 4 operating temperature Tr, as ideally detected by temperature sensing device 28, and line D relates to the cooling air blower 24 status which may be ON (when value is zero in ordinate right axis) or OFF (when value is 1 in ordinate right axis). It should be noted that during the first period t1 (t1=50 minutes) the first and second temperature thresholds $Tfan_{ON}$ and $Tfan_{OFF}$ have high values $T1fan_{ON}$ and $T1fan_{OFF}$ (about 53°C) and the temperature of the heat pump system 4 is rising, always remaining, however, below the high values $T1fan_{ON}$ and $T1fan_{OFF}$ such that the "blow controlling procedure" implemented by the method, forces the cooling air blower 24 to be maintained switched off during period t1. At the instant t1, the first and second temperature thresholds $Tfan_{ON}$ and $Tfan_{OFF}$ are varied (reduced) as a function of the current, i.e. actual, operating temperature Tr(t1), such that the "blow controlling procedure " starts controlling the switching-on/off of the electric motor fan 34 based on the results of comparison between measured heat pump system 4 operating temperature Tr(tn) (tn>t1) and the changed temperature thresholds $Tfan_{ON}$ and $Tfan_{OFF}$.

[0094] Figure 6 relates to a flow chart of a second embodiment of the method for operating the laundry treatment apparatus 1 which is similar to the first embodiment illustrated in Figure 4, wherein the steps will be numbered, as much as possible, with the same numbers indicating of corresponding steps of the first embodiment.

[0095] More specifically, the second embodiment of the method is configured to maintain the cooling air blower 24 deactivated during the whole first drying period t1 without however performing the "blow controlling procedure" 200 of Figure 8. In other terms, in the second embodiment, the cooling air blower 24 is maintained deactivated during the whole first drying period t1 by performing a "time control" during a first part of the drying cycle. In other words, in the second embodiment the refrigerant temperature Tr is not compared repeatedly with the first and second temperature thresholds as in the step 200 of the first embodiment. In this respect, the second embodiment of the method does not have the step 200 in the first part, i.e. during the first drying period t1, and performs however the switching-off of the electric fan motor 34 during the whole first period t1. In such embodiment, first and second temperature thresholds $Tfan_{ON}$ and $Tfan_{OFF}$ are not taken into account in the first drying period t1, therefore step 120 is performed only to allow the control procedure to be inizialized..

[0096] Figure 7 relates to flow chart of a third embodiment of the method for operating the laundry treatment apparatus which is similar to the second embodiment illustrated in Figure 6, wherein the steps will be numbered, as much as possible, with the same numbers indicating of corresponding steps of the second embodiment.

[0097] The third embodiment of the method differs from the second embodiment in that it performs an additional control during the first period t1 for preventing overheating condition of the heat pump system 4, in particular the compressor 14. With reference to Figure 7, the method according to the third embodiment performs the step 500 of detecting/measuring the heat pump system 4 operating temperature Tr and the step 510 of comparing the measured operating temperature Tr with the first temperature threshold $Tfan_{ON}$ set in step 120 as described with reference to the first embodiment of the present invention. If the measured operating temperature Tr is below the first temperature threshold $Tfan_{ON}$ (output YES in step 510), the method continues to perform the steps 170,190, 500, 510 of the closed control ring until the time counter TIME reaches zero. If the measured operating temperature Tr is above the first temperature threshold $Tfan_{ON}$ (output YES in step 510), the method detects overheating condition of the heat pump system 4, in particular the compressor 14, and performs interrupting of the steps of the closed control ring, and starting the step 220 and the next steps, as described with reference to the first embodiment of the present invention.

[0098] It should be pointed out that the apparatus 1 may be configured to: determine a differential value ΔT which is indicative of the difference between the measured ambient temperature Tamb and the ambient threshold temperature Ta_{THR}, and selectively perform the first embodiment, or the second embodiment or the third embodiment based on the determined differential value ΔT. For example the first, second and third embodiments of the method may be selectively performed when differential values ΔT are $\Delta T1$, $\Delta T2$, $\Delta T3$, respectively, wherein $\Delta T1 > \Delta T2 > \Delta T3$. It should also be pointed out that first embodiment, or the second embodiment or the third embodiment may be performed by the method based on the drying program selected by a user. It should also be understood that first embodiment, or the second embodiment or the third embodiment may be selectively performed by the method on the basis of combined information about the determined differential value ΔT and the selected drying program.

[0099] The above disclosed laundry treatment apparatus is conveniently designed to vary the cooling air blower control temperature thresholds such that drying performances are ensured both at low and high ambient temperatures, and, at the same time, is able to limit/avoid condensation of moisture on electronic components of the apparatus 1. The inventive method anticipates activation of the cooling air blower that blows ambient air inside the dryer such that the humidity is reduced and condensation of moisture on sensitive components of the apparatus is avoided. Moreover, setting the temperature thresholds according to the current, i.e. actual, heat pump system operating temperature determined when the cooling air blower is activated, makes the drying machine automatically adaptive to the ambient temperature conditions. In fact the heat pump system temperature, in particular the compressor operating temperature, is kept around an optimum value to guarantee both an early cooling air blower activation to avoid humidity condensation problems and high work temperature for achieving better drying performance.

[0100] While the present invention has been described with reference to the particular embodiments shown in the figures, it should be noted that the present invention is not limited to the specific embodiments illustrated and described herein; on the contrary, further variants of the embodiments described herein fall within the scope of the present invention, which is defined in the claims.

Claims

1. Method for operating a laundry treatment apparatus (1),
wherein the apparatus (1) comprises:

- a laundry treatment chamber (3) for treating laundry by using processing air (A);
- a heat pump system (4) for treating said processing air (A);
- a cooling air blower (24) for blowing ambient air towards the heat pump system (4) to cool at least a part thereof;
- at least one temperature sensing device (27, 28, 29) for providing a first signal indicative of ambient temperature (Tamb);
- a heat pump system (4) operating condition detection unit (28) for providing a second signal (Tr) indicative of an operating condition of the heat pump system (4)

the method comprising the steps of:

- providing an ambient temperature threshold (Ta_{THR});
- determining the ambient temperature (Tamb) based on the first signal;
- determining whether the ambient temperature (Tamb) satisfies a prefixed condition with the ambient temperature threshold (Ta_{THR});
- performing a cooling air blower (24) control procedure based on the second signal (Tr);

the method being **characterized in that**

if said prefixed condition is determined, performing the steps of:

- drying laundry for a first drying period (t1);
- determining the second signal (Tr(t1)) at the end of the first drying period (t1); and
- based on said determined second signal (Tr(t1)), providing control thresholds (Tf_{ON})(Tf_{OFF}) for said second signal (Tr) to control said cooling air blower (24) during a second drying period (t2) next to said first drying period (t1).

2. Method according to claim 1, comprising the step of maintaining said cooling air blower (24) deactivated during said first drying period (t1).

3. Method according to claim 2, wherein:

- before starting the first drying period (t1), first and second thresholds (Tf_{ON})(Tf_{OFF}) are set for said second signal (Tr) with respective values ($T1f_{ON}$)($T1f_{OFF}$) which are greater than thresholds (Tf_{ON})(Tf_{OFF}) provided for controlling said cooling air blower (24) during said second drying period (t2);
- said cooling air blower (24) control procedure being performed by selectively activating or deactivating said cooling air blower (24) when said second signal (Tr) is above said first threshold (Tf_{ON}) or respectively below said second threshold (Tf_{OFF}).

4. Method according to claim 3, comprising the steps of performing a first control cycle during the first drying period (t1)
wherein the first control cycle comprises:

- setting the first drying period (t1);
- measuring the time (TIME) of the drying cycle;
- performing said cooling air blower (24) control procedure;

when measured drying cycle time (TIME) reaches the end of the first drying period (t1), performing the steps of:

- stopping said cooling air blower (24) control procedure;
- determining the second signal (Tr(t1));
- varying said first and second thresholds (Tf_{ON})(Tf_{OFF}) based on said determined second signal (Tr(t1));
- starting the second drying period (t2) wherein the cooling air blower (24) control procedure is performed with the varied first and second thresholds (Tf_{ON})(Tf_{OFF}).

5. Method according to claim 3, comprising the step of performing a second control cycle during the first drying period (t1),
wherein the second control cycle comprises:

- setting the first drying period (t1);
- measuring the time (TIME) of the drying cycle;
- maintaining the cooling air blower (24) deactivated;

when measured drying cycle time (TIME) reaches the end of the first drying period (t1) performing the steps of:

- stopping maintaining the cooling air blower (24) deactivated;
- determining the second signal (Tr(t1));
- varying said first and second thresholds (Tf_{ON})(Tf_{OFF}) based on said determined second signal (Tr(t1));
- starting the second drying period (t2) wherein the cooling air blower (24) control procedure is performed with the varied first and second thresholds (Tf_{ON})(Tf_{OFF}).

6. Method according to claim 3, comprising the step of performing a third control cycle during the first drying period (t1),
wherein the third control cycle comprises:

- setting the first drying period (t1);
- measuring the time (TIME) of the drying cycle;
- maintaining the cooling air blower (24) deactivated;

during time (TIME) measuring, performing the steps of:

- determining the second signal (Tr);

if the second signal (Tr) satisfies a prefixed condition with the first threshold (Tf_{ON}):

- stopping maintaining the cooling air blower (24) deactivated;
- determining the second signal (Tr);
- varying said first and second thresholds (Tf_{ON})(Tf_{OFF}) based on said determined second signal (Tr);
- starting the second drying period (t2), wherein the cooling air blower (24) control procedure is performed with the varied first and second thresholds (Tf_{ON})(Tf_{OFF}).

7. Method according to claims 4, 5 and 6, comprising the steps of:

selectively performing said first, or second or third control cycle based on a user selected drying program and/or based on a differential temperature value (ΔT) which is determined by calculating the difference between the determined ambient temperature (Tamb) and the ambient temperature threshold (Ta_{THR}).

8. Method according to any of the previous claims, wherein said ambient temperature threshold (Ta_{THR}) is determined based on a user selected drying program or based on user input command performed by an input control panel (38).

9. Method according to any of the previous claims, wherein said ambient temperature threshold (Ta_{THR}) is lower than a value comprised between 5°C and 15°C.

10. Method according to any of the previous claims, wherein the first drying period (t1) is estimated/set/determined as a function of the time spent by the processing air escaped from the laundry treatment chamber (3), to start forming condensation in the internal parts of the apparatus (1) when said prefixed condition is determined.

11. Method according to any of the previous claims wherein said first and second signals are provided by a temperature sensor (28) arranged on the heat pump system (4).

12. Method according to any of the previous claims, wherein the first drying period (t1) is comprised between about 30 and 55 minutes.

13. Method according to any of the previous claims, wherein said thresholds (Tf_{ON})(Tf_{OFF}) for said second signal (Tr) are temperature thresholds.

14. Method according to any of the previous claims, wherein said prefixed condition consists in that the ambient temperature (Tamb) determined on the basis of the first signal is lower than the ambient temperature threshold (Ta_{THR}).

15. Laundry treatment apparatus (1) comprising:

- a laundry treatment chamber (3) for treating laundry by using processing air (A);
- a heat pump system (4) for treating said processing air (A);
- a cooling air blower (24) for blowing ambient air towards the heat pump system (4) to cool at least a part thereof;
- at least one temperature sensing device (27, 28, 29) for providing a first signal indicative of ambient temperature (Tamb);
- a heat pump system (4) operating condition detection unit (28) for providing a second signal (Tr) indicative of an operating condition of the heat pump system (4);

characterized by comprising a control unit (30) configured to implement a method according to any one of the preceding claims.

16. Laundry treatment apparatus (1) according to claim 15 wherein said at least one temperature sensing device (28) operates as heat pump system (4) operating condition detection unit.

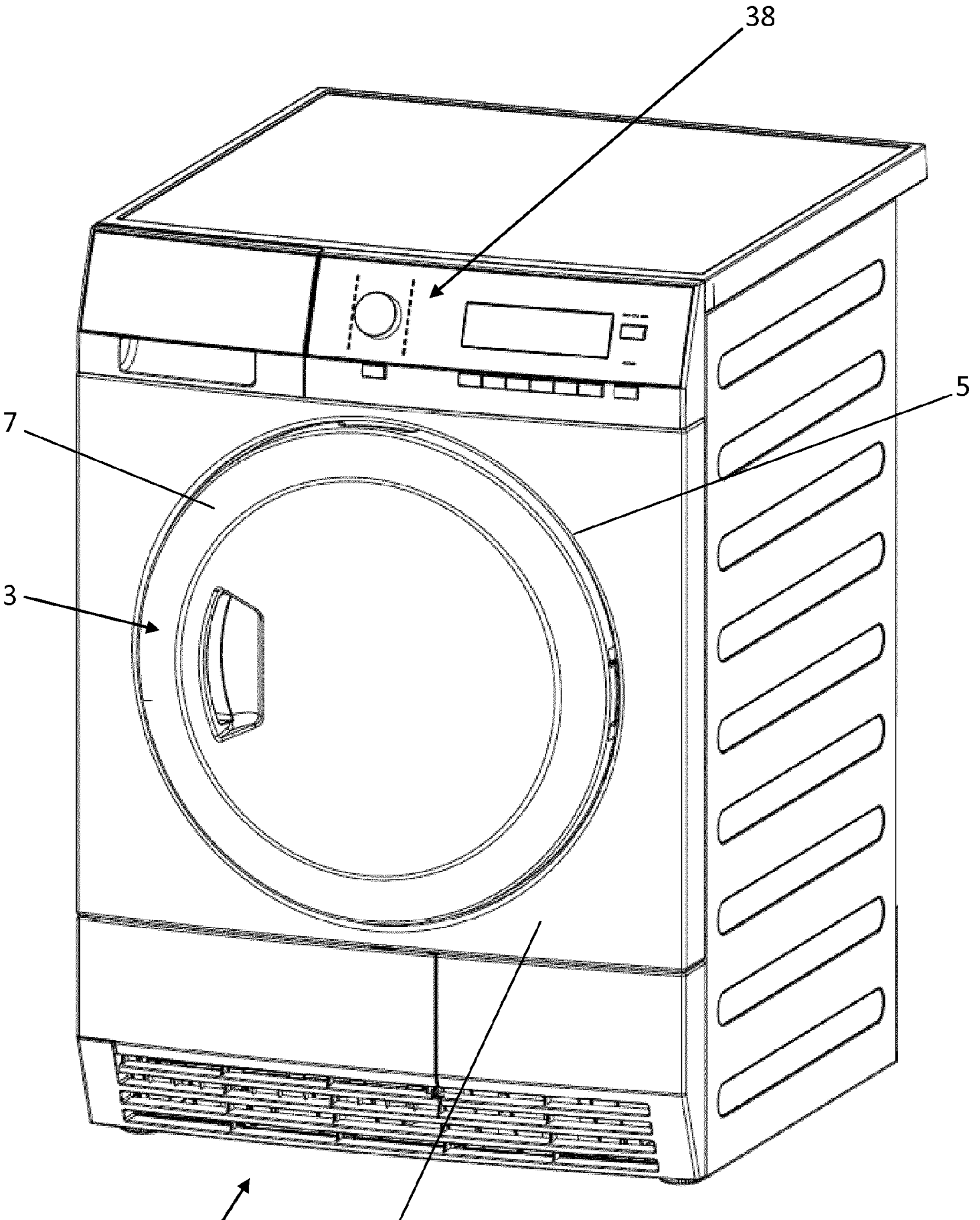
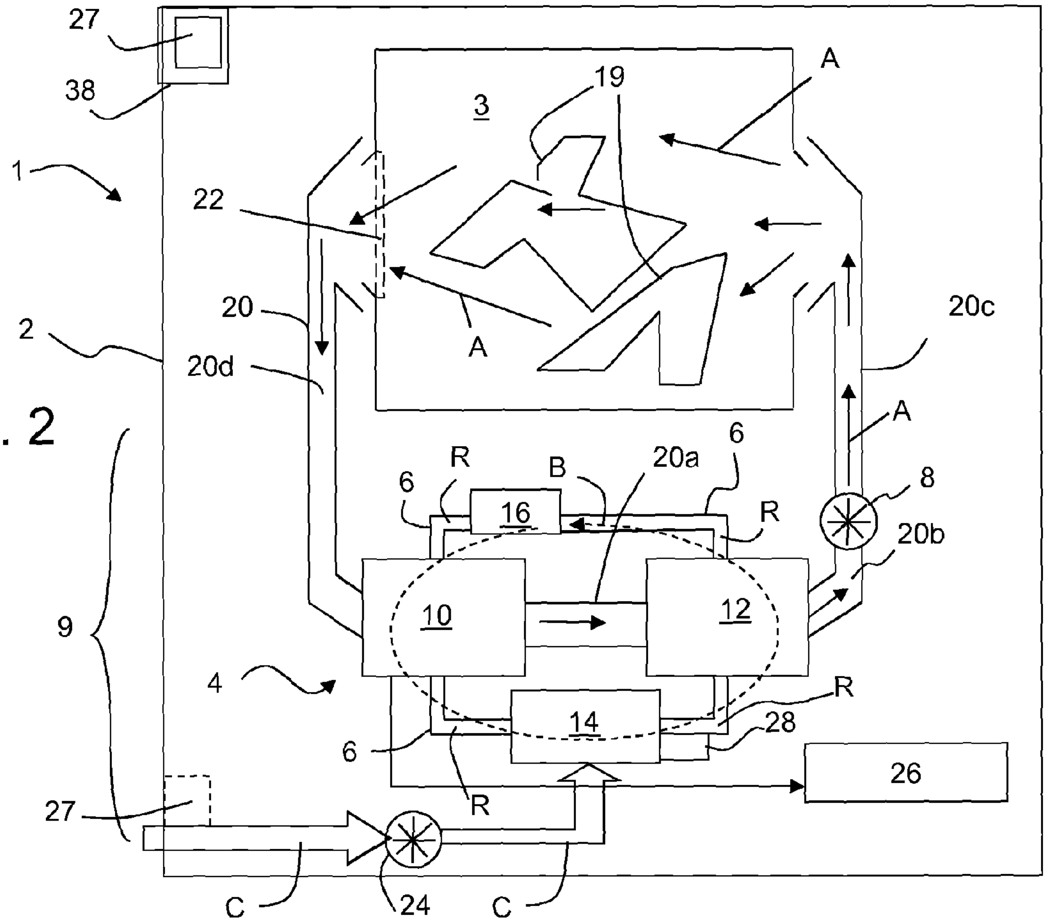


Fig. 1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2
3
19
A
22
20
20d
20c
6
R
B
20a
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20b
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R
C
24
C

Fig. 2

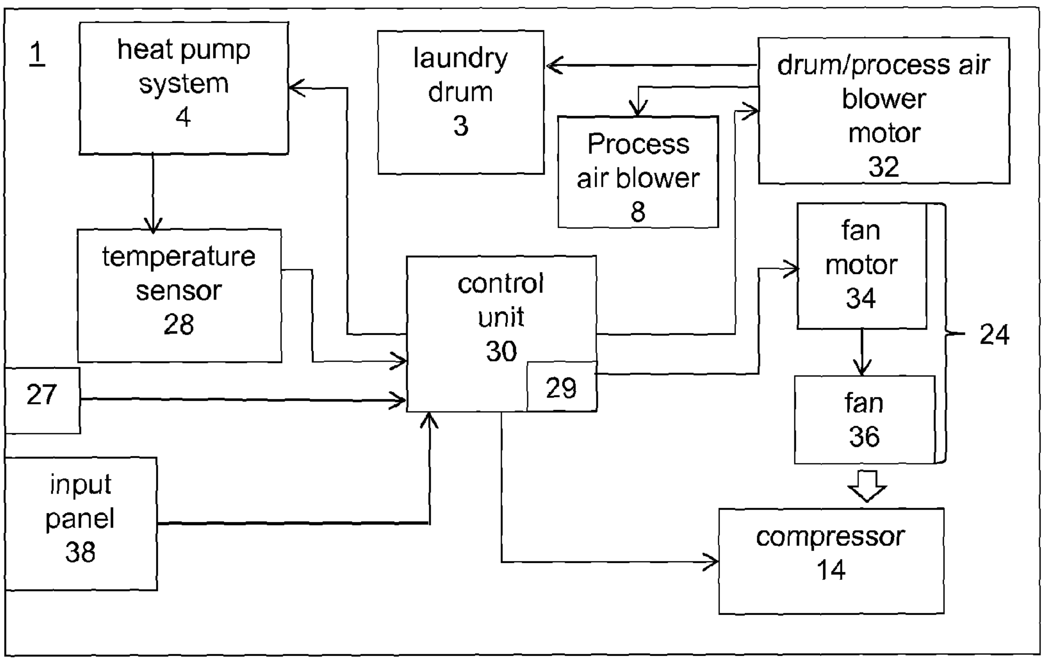

1
heat pump system 4
laundry drum 3
drum/process air blower motor 32
Process air blower 8
temperature sensor 28
control unit 30
29
fan motor 34
24
27
fan 36
input panel 38
compressor 14

Fig. 3

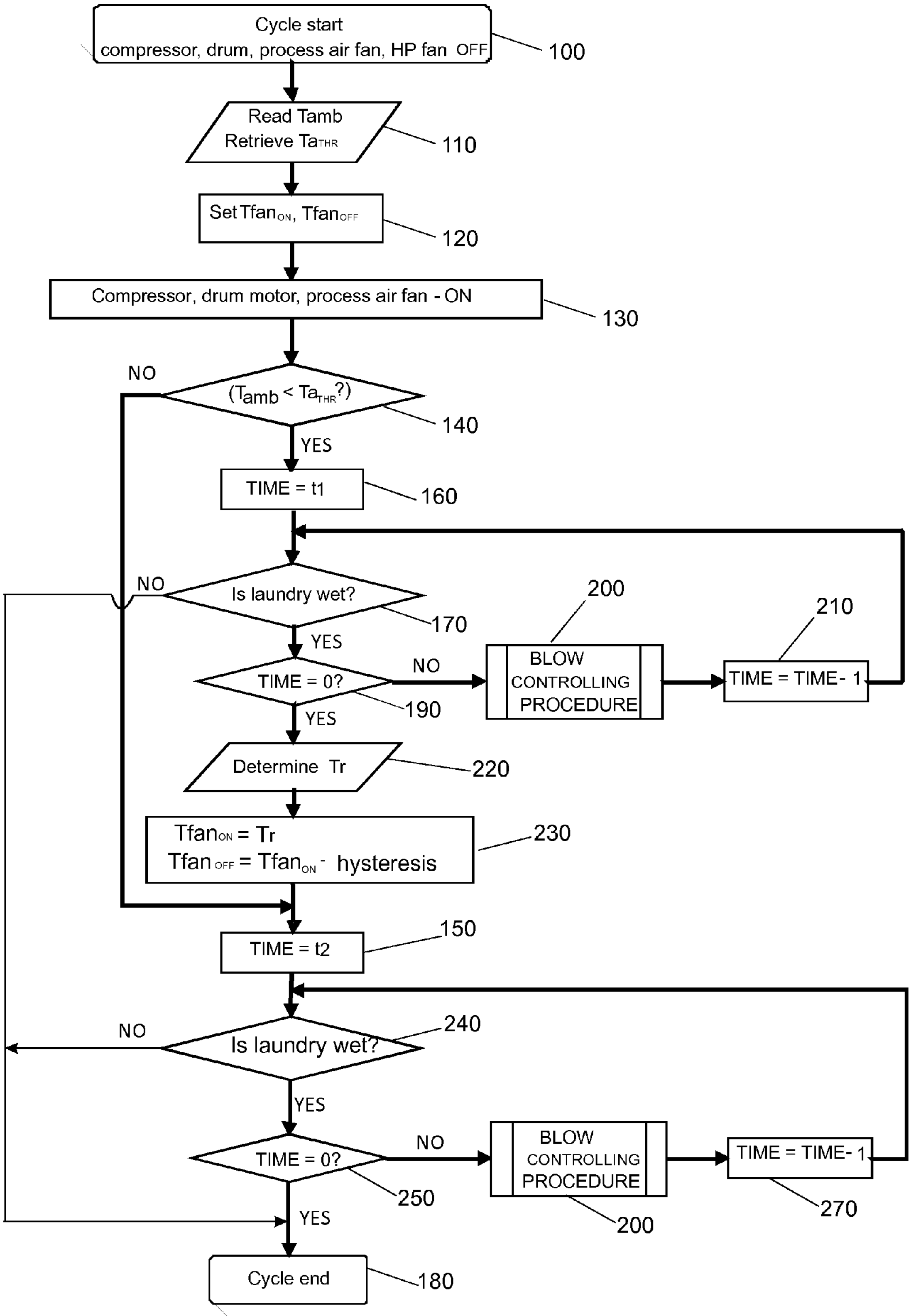
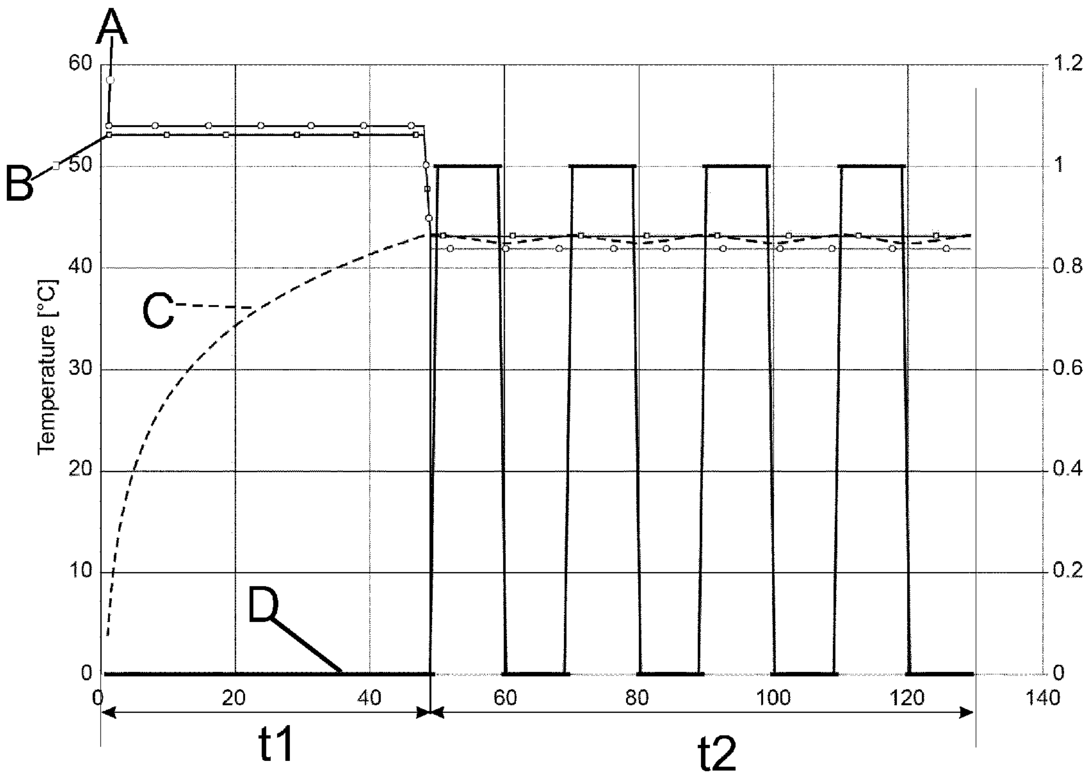

Cycle start
compressor, drum, process air fan, HP fan OFF
100
Read Tamb
Retrieve Ta THR
110
Set Tfan ON, Tfan OFF
120
Compressor, drum motor, process air fan - ON
130
NO
(Tamb < Ta THR?)
140
YES
TIME = t1
160
NO
Is laundry wet?
170
YES
TIME = 0?
190
NO
BLOW CONTROLLING PROCEDURE
200
TIME = TIME- 1
210
YES
Determine Tr
220
Tfan ON = Tr
Tfan OFF = Tfan ON - hysteresis
230
TIME = t2
150
NO
Is laundry wet?
240
YES
TIME = 0?
250
NO
BLOW CONTROLLING PROCEDURE
200
TIME = TIME- 1
270
YES
Cycle end
180

Fig. 4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B
C
D
60
50
40
30
20
10
0
Temperature [°C]
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
140
t1
t2

Fig. 5

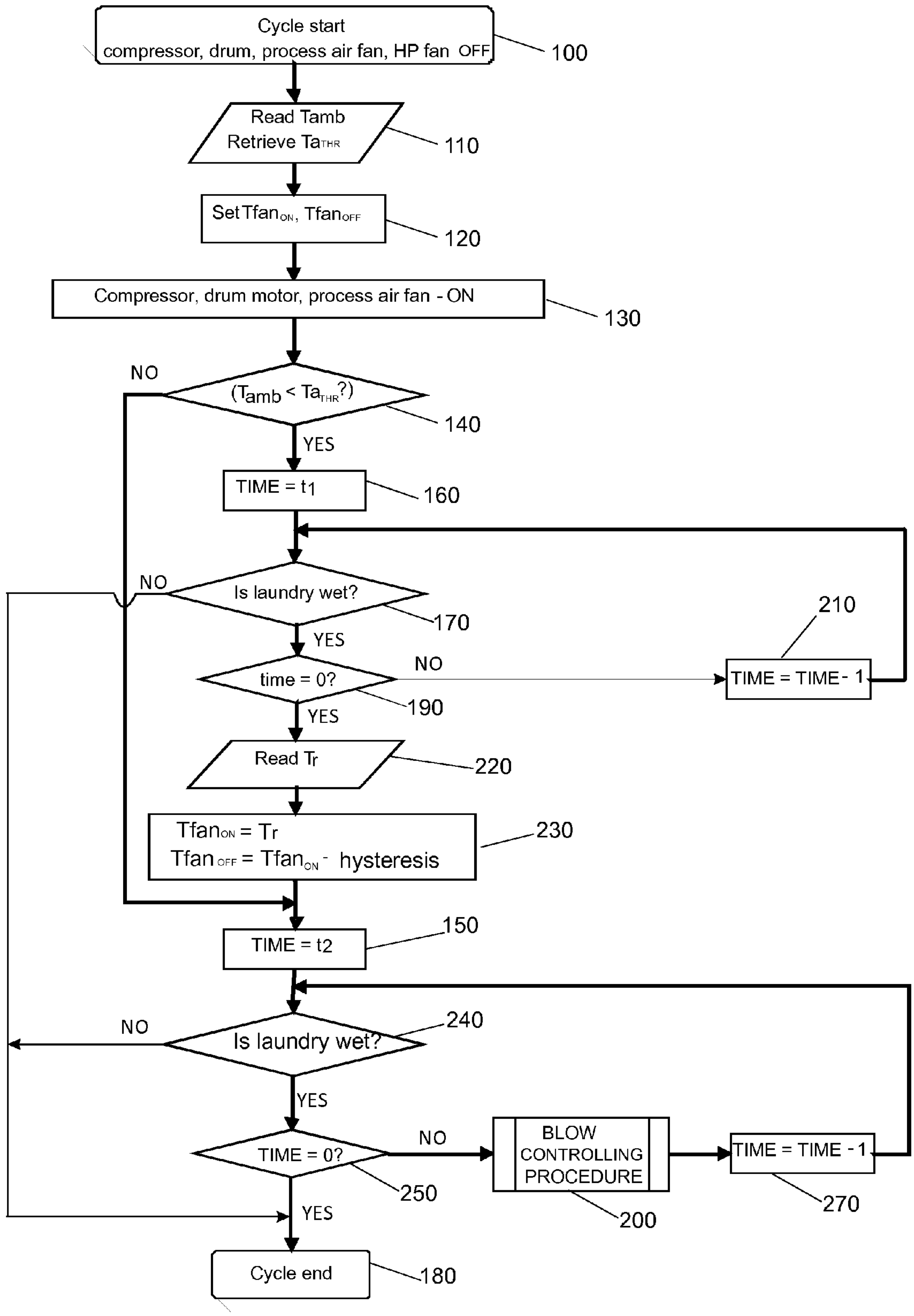
Cycle start
compressor, drum, process air fan, HP fan OFF
100
Read Tamb
Retrieve Ta_{THR}
110
Set $Tfan_{ON}$, $Tfan_{OFF}$
120
Compressor, drum motor, process air fan - ON
130
NO
(T_{amb} < Ta_{THR}?)
140
YES
TIME = t_1
160
NO
Is laundry wet?
170
YES
time = 0?
NO
190
YES
TIME = TIME - 1
210
Read Tr
220
$Tfan_{ON}$ = Tr
$Tfan_{OFF}$ = $Tfan_{ON}$ - hysteresis
230
TIME = t2
150
NO
Is laundry wet?
240
YES
TIME = 0?
NO
250
YES
BLOW CONTROLLING PROCEDURE
200
TIME = TIME - 1
270
Cycle end
180

Fig. 6

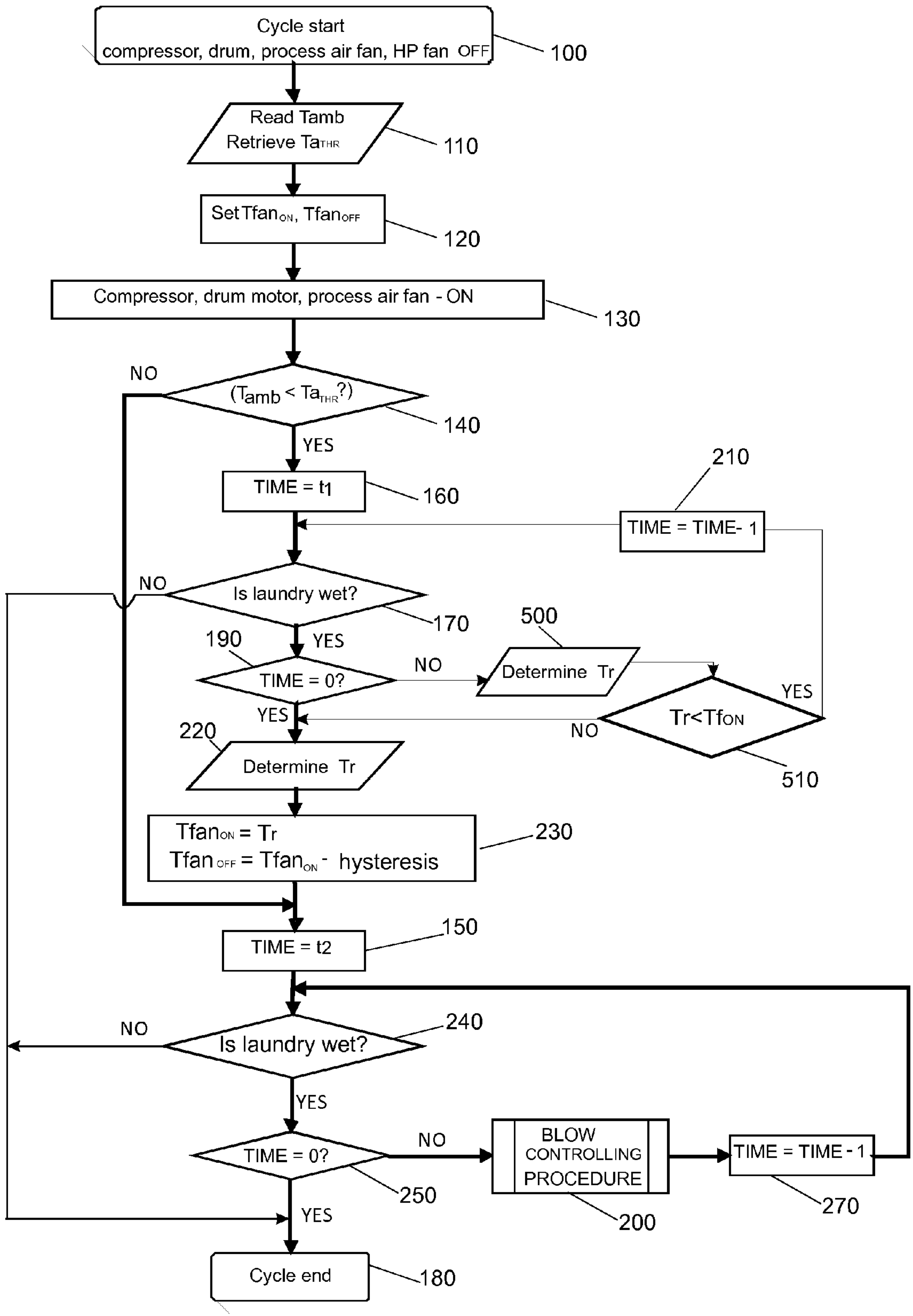
Cycle start
compressor, drum, process air fan, HP fan OFF
100
Read Tamb
Retrieve TaTHR
110
Set TfanON, TfanOFF
120
Compressor, drum motor, process air fan - ON
130
NO
(Tamb < TaTHR?)
140
YES
TIME = t1
160
210
TIME = TIME- 1
NO
Is laundry wet?
170
500
190
YES
NO
Determine Tr
TIME = 0?
YES
YES
Tr<TfON
NO
220
Determine Tr
510
TfanON = Tr
TfanOFF = TfanON - hysteresis
230
150
TIME = t2
240
NO
Is laundry wet?
YES
NO
BLOW
CONTROLLING
PROCEDURE
TIME = TIME - 1
TIME = 0?
250
270
YES
200
Cycle end
180

Fig. 7

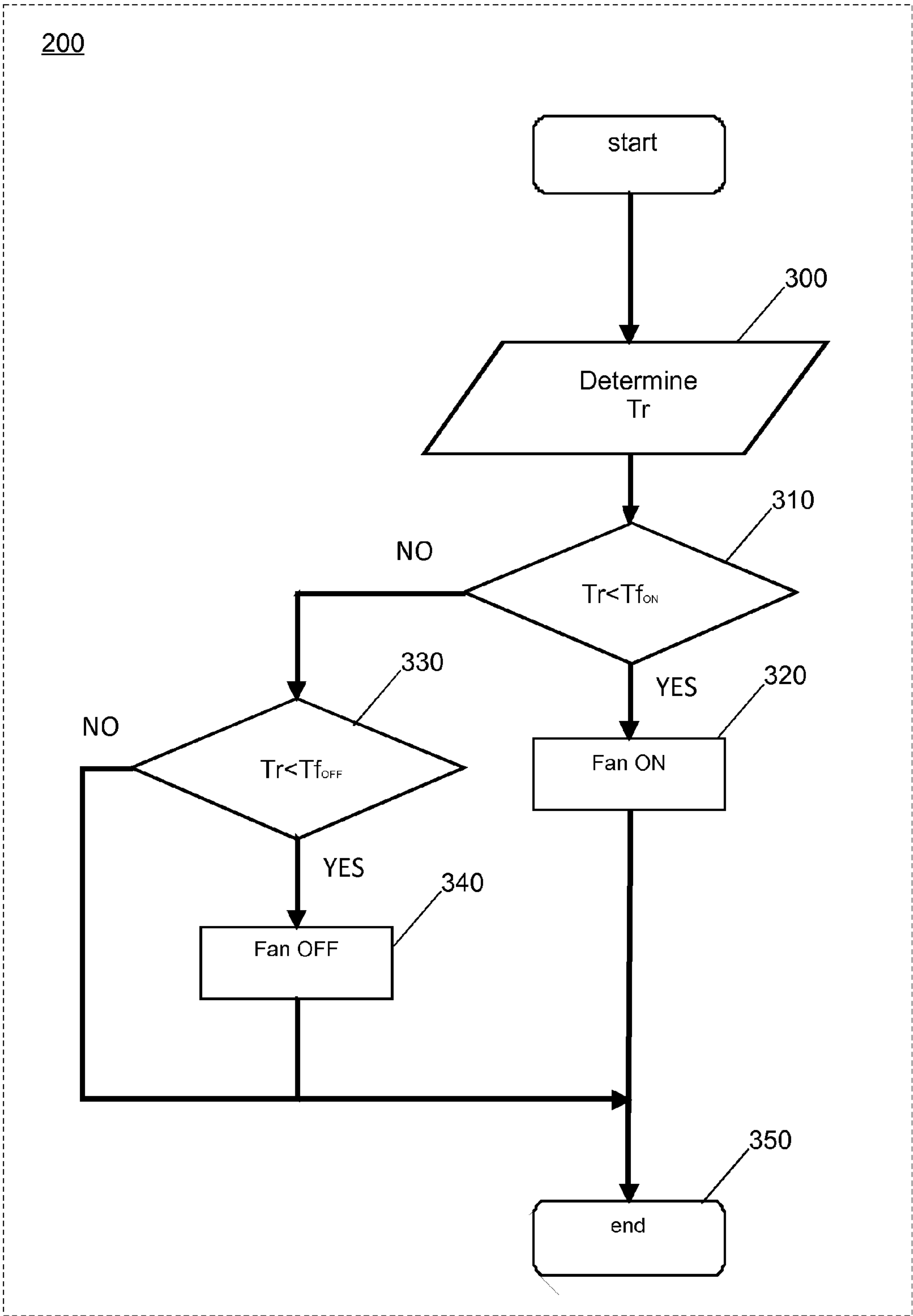
200
start
300
Determine
Tr
310
NO
Tr<Tf_ON
YES
320
Fan ON
330
NO
Tr<Tf_OFF
YES
340
Fan OFF
350
end

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 13 18 0896

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	11 February 2014	Fachin, Fabiano

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