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• **Vian Alessandro**
33080 Porcia (PN) (IT)
• **Zavan, Christian**
33080 Porcia (PN) (IT)

(74) Representative: **Petrucelli, Davide et al**
Electrolux Italia S.p.A.
Corso Lino Zanussi 30
33080 Porcia (PN) (IT)

(71) Applicant: **Electrolux Appliances Aktiebolag**
105 45 Stockholm (SE)

(72) Inventors:
• **Kustra, Agnieszka**
33080 Porcia (PN) (IT)

(54) **Laundry treatment apparatus with temperature dependent control**

(57) The invention relates to a method for operating a laundry treatment apparatus, in particular a heat pump dryer or washing machine having dryer function, and a laundry treatment apparatus having a heat pump system, wherein the apparatus comprises a heat pump system and a laundry treatment chamber for treating laundry using process air, and wherein the heat pump system comprises: a first heat exchanger for heating a refrigerant fluid, a second heat exchanger for cooling the refrigerant fluid, an expansion device, a refrigerant loop, in which the refrigerant fluid is circulated through the first and second heat exchangers and the expansion device, and a compressor for circulating the refrigerant fluid through the refrigerant loop, the method comprising: detecting at least one temperature signal (Tx), and, in dependency of the at least one detected temperature signal (Tx), selecting at least one predetermined temperature threshold value (T_off1, T_on1; T_off2, T_on2; T_off3, T_on3) for switching the compressor ON and/or OFF.

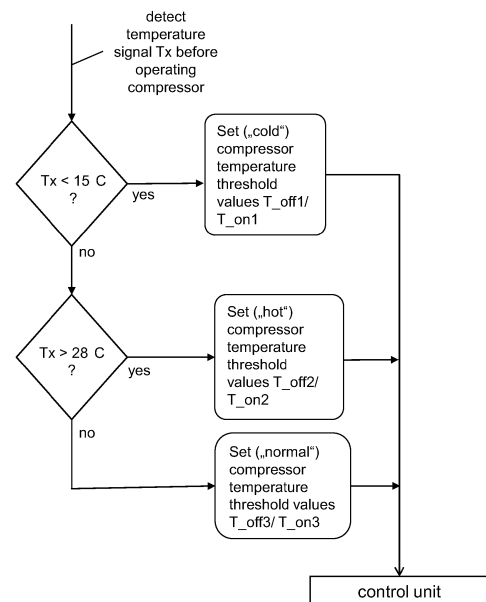


Fig. 4

Description

[0001] The invention relates to a method for operating a laundry treatment apparatus and a laundry treatment apparatus having a heat pump system.

[0002] DE 10 2005 041 145 A1 discloses a laundry dryer having a heat pump system with a variable-speed compressor. A control unit of the dryer is adapted to switch-off the compressor when a temperature threshold of hot-gas in the heat pump system is exceeded. A method for operating the laundry dryer prevents an emergency switch-off of the compressor due to high hot-gas temperature. When the temperature threshold is close to be reached, the control unit is adapted to operate the variable-speed compressor at a low power level, such that the hot-gas temperature does not reach the temperature threshold.

[0003] It is an object of the invention to provide an improved method for operating a laundry treatment apparatus having a heat pump system and an improved laundry treatment apparatus.

[0004] The invention is defined in claims 1 and 17, respectively. Particular embodiments are set out in the dependent claims.

[0005] According to claim 1, a method for operating a laundry treatment apparatus is provided, wherein the treatment apparatus may be a heat pump tumble dryer or a washing machine having a drying function. The apparatus comprises a heat pump system and a laundry treatment chamber (e.g. laundry drum) for treating laundry using process air. The heat pump system comprises a first heat exchanger (evaporator) for heating a refrigerant 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 for circulating the refrigerant fluid through the refrigerant loop.

[0006] The method for operating the laundry treatment apparatus comprises detecting at least one first temperature signal. For example the at least one temperature signal may be a refrigerant temperature detected at the exit of the second heat exchanger, a temperature of electronic boards (e.g. power board, compressor control board) or a temperature detected in an inner volume within apparatus cabinet. As a further example the at least one temperature signal may be detected by means of a temperature sensor arranged internal or external the apparatus cabinet and/or a temperature sensor may be arranged in a cooling air flow path (e.g. cooling air flow for cooling the compressor). In an embodiment the temperature signal is a signal derived from two, three or more temperature sensors arranged at different locations within the dryer cabinet. The locations of the temperatures sensors or the type of temperature to be detected thereby (e.g. refrigerant or ambient temperature) are given in the present description for different examples which are all comprised here by 'temperature signal' or 'sensor'. A mathematical function may be applied to two or more detected temperature signals to calculate or determine the 'detected' temperature signal.

[0007] The method further comprises selecting in dependency of the at least one detected first temperature signal at least one predetermined temperature threshold value for switching the compressor ON and/or OFF. If the selected temperature threshold value is exceeded during a program cycle of the treatment apparatus, the compressor is switched-off. For example the at least one predetermined threshold value may be compared to the above mentioned detected first temperature signal. For this purpose the respective temperature signal may be permanently or repeatedly detected during apparatus operation. Alternatively, the at least one predetermined temperature threshold value may be compared to any of the other temperature signals described above. For example a temperature signal indicative of an operating condition of the treatment apparatus, in particular an operating condition of the heat pump system.

[0008] In case the at least one temperature threshold value is selected in dependency of a first temperature signal (indicative of) the ambient temperature, the selected temperature threshold value(s) is (are) set in dependency of the environment condition where the treatment apparatus is placed. If a "cold" temperature environment (e.g. below 15°C) or a "normal" temperature environment (e.g. 15-30°C) is detected, the selected predetermined temperature value(s) for switching the compressor ON/OFF may be set higher in comparison to predetermined temperature level(s) selected for a "hot" environment (e.g. above 30°C). Vice versa, if a high ambient temperature is detected, the selected temperature threshold value(s) are set lower in comparison to selected threshold value(s) for normal/cold ambient temperature. Thus in high ambient temperature conditions the compressor is switched-off at a lower temperature (in relation to "normal" or "cold" environment).

[0009] The above method safely prevents an overheating of the compressor which results in a longer life time of the compressor. Further the method is intended to reduce or avoid overheat safety switch-off of the compressor which is reactive to over-temperature and which results in long switch-off durations inefficiently extending total laundry treatment times. Thus the treatment apparatus performance is improved, in particular in high ambient temperature environment or in an environment where heat generated by the apparatus during operation cannot be dissipated easily (e.g. when the apparatus is positioned in a niche or wall recess).

[0010] For example, a first temperature threshold value may be selected for switching the compressor ON and a second temperature threshold value may be selected for switching the compressor OFF. In this case the control unit is adapted to switch the compressor OFF when the temperature reaches or exceeds the first threshold value and is adapted

to switch the compressor ON when the first temperature underruns or falls below the second threshold value.

[0011] Alternatively only one temperature threshold value may be selected, wherein the compressor is switched-off when the threshold value is reached or exceeded from a lower temperature level (lower than the threshold value) and the compressor is switched-on when the same threshold value is underrun from a higher temperature level (higher than the selected threshold value).

[0012] Exemplary temperature threshold values (switch-OFF/switch-ON) to be selected for the respective detected first temperature signal (ranges) may be: "cold" environment: 75°C/ 65°C; "normal" environment: 70°C/ 60°C; "hot" environment: 65°C/50°C. Cold environment is for example $T_x < 15^\circ\text{C}$, normal environment is for example $15^\circ\text{C} \leq T_x < 28^\circ\text{C}$ and hot environment is for example $28^\circ\text{C} \leq T_x$. As described above, during an operation of the treatment apparatus, the compressor may be switched-on and/or -off in dependency of a (permanently or repeatedly) detected temperature signal, which may be the same as the detected first temperature signal for selecting the temperature threshold value(s) or may be any of the other temperature signal(s) described above or below. For example the compressor is switched-off/-on in dependency of the state of the heat pump system, in particular in dependency of the refrigerant temperature. For example, if the detected temperature signal indicates a "normal" environment temperature, the compressor may be switched-off when the or a temperature signal reaches 70°C. When the detected temperature signal falls below 60°C the compressor is switched-on again. Thus the compressor switch-off time is adapted to the actual (temperature) condition of the apparatus or heat pump system, such that compressor switch-off time is minimized.

[0013] The above method additionally provides that emergency switch-offs of the compressor by means of a safety device like a thermoprotector are prevented. For example the treatment apparatus may comprise a safety device to switch-off the compressor to prevent damage of the compressor in a critical (temperature) condition. An emergency switch-off by means of a safety device is generally long and not well controllable. Thus a drying operation is suspended unnecessarily when an emergency switch-off occurs. In general, a compressor safety device intervenes for a combined effect of compressor temperature and current absorbed by the compressor. I.e. the safety device is not controlled by a temperature signal indicating the condition of the heat pump system, for example of the refrigerant temperature. For example, if a fixed temperature threshold value would be used for all drying operations, it may occur in high ambient temperature condition (e.g. above 30°C), that the refrigerant temperature is lower than the fixed compressor switch-off threshold (i.e. the compressor is kept ON), while the safety device intervenes by switching the compressor OFF. This is mainly due to the refrigerant circuit and safety device having different thermal inertia and due to that a temperature sensor for detecting the temperature signal (e.g. of the refrigerant) and the safety device are placed at different locations within the treatment apparatus. Therefore the temperature sensor and the safety device are subject to different temperatures.

[0014] To prevent an emergency switch-off by means of a safety device, the above described at least one temperature threshold value is set, such that the compressor may be switched-off before the safety device intervenes or is activated. For example, when the detected first temperature signal is low, the at least one selected temperature threshold value may be set at a higher level, when compared to threshold value(s) selected in case of a high first temperature signal. A high value of the detected first temperature signal may result from a previous drying operation or from a high ambient temperature. In this case the treatment apparatus, in particular the compressor, reaches a critical (temperature) condition faster than in comparison to the case when detecting a low level of the first temperature signal. A low first temperature signal may be detected when the treatment apparatus has not been operated for some time, such that the treatment apparatus had time to cool down, and/or the ambient temperature is low or normal (e.g. below 30°C).

[0015] As described above, preferably a pair of temperature threshold values are selected in dependency of the at least one detected first temperature signal: (i) a switch-OFF temperature threshold value for switching the compressor OFF, and (ii) a switch-ON temperature threshold value for switching the compressor ON, wherein the switch-OFF temperature threshold value and the switch-ON temperature threshold value are different of each other (resulting in a hysteresis effect in the temperature profile). In particular the switch-ON threshold value may be lower than the switch-OFF threshold value to provide that the heat pump system is safely out of a critical condition. Thus it is prevented that the heat pump system repeatedly reaches a critical condition in short intervals, i.e. it is prevented that the compressor has to be switched-off repeatedly.

[0016] Preferably the at least one detected first temperature signal is indicative of an ambient or environment temperature of the laundry treatment apparatus. At least one detected first temperature signal may be provided by a temperature sensor capable of detecting the environment or ambient temperature at least under a predefined operation condition. As described above it may be determined whether the apparatus is located in a high temperature environment or an environment where removal of heat from a drying cycle is hindered (e.g. due to the apparatus being located in a wall recess or the like). Thereby corresponding temperature threshold value(s) may be selected to prevent e.g. emergency switch offs of the compressor due to overheating as described above.

[0017] For example the temperature sensor may be a real ambient temperature sensor, i.e. a sensor arranged outside the apparatus housing or a sensor arranged in a cooling air passage for cooling air sucked in from the outside of the apparatus housing. Or the temperature sensor may be arranged within the apparatus cabinet and is best adapted to

detect a temperature corresponding to the ambient temperature (see below).

[0018] Preferably the at least one detected temperature signal is provided by at least one temperature sensor which is capable of detecting the environment or ambient temperature at least under a predefined operation condition. A predefined operation condition may be that the laundry apparatus was non-operative for a while. For example such that a component where the temperature sensor(s) is(are) placed is cooled down for a while by blowing ambient air to the component and/or sensor. For example a sensor detecting the temperature of a refrigerant or of an electronic board or of compressor motor. Then the temperature sensor detects ambient temperature only if at the location of the sensor the apparatus component or operating fluid has cooled down (equilibrated) to ambient temperature. For example when the sensor is in contact with the heat pump system or heat pump fluid that is cooled down to ambient temperature.

[0019] According to an embodiment, temperature signals of several temperature sensors arranged at different locations within and/or outside the apparatus may be received by the control unit, wherein the control unit makes a plausibility check or evaluation of the temperature signals to conclude on an ambient temperature having high likelihood. For example, in case of several temperature sensors, the sensor signal indicating the correct or close ambient temperature is selected. For example the temperature sensor with the lowest temperature signal may indicate the ambient temperature which is true for sensors except under some conditions when a sensor is placed in contact with the second heat exchanger (evaporator) or expansion device.

[0020] Preferably the laundry treatment apparatus comprises a control unit having an associated memory, wherein at least one, at least two or more than two predetermined temperature threshold values are stored in the memory for being selectively retrieved by the control unit upon selection in dependency of the at least one detected temperature signal as described above and below.

[0021] Preferably the selection of the at least one predetermined temperature threshold value is made among

(i) a first predetermined temperature threshold value or a first pair of predetermined threshold values to be selected for a first temperature or a first temperature range of the detected temperature signal, and

(ii) at least one second predetermined temperature threshold value or at least one second pair of predetermined threshold values to be selected for a second temperature or a second temperature range of the detected temperature signal, wherein the first and second threshold values or first and second pairs of threshold values are different of each other, and wherein the first and second temperature and/or the first and second temperature ranges are different of each other. For example, if the detected first temperature signal is less than or equal to 28°C the compressor switch-OFF threshold may be set to 70°C and the compressor switch-ON threshold may be set to 60°C. In case the detected temperature signal is greater than 28°C the compressor switch-OFF threshold may be set to 65°C and compressor switch-ON threshold may be set to 50°C.

[0022] Preferably the higher the value of the detected first temperature signal or temperature range, the lower the value of the selected temperature threshold value or the selected pair of temperature threshold values.

[0023] Preferably detecting comprises detecting the at least one first temperature signal before starting a drying cycle and/or before starting to operate the compressor. For example the first temperature signal is detected shortly after a 'button' for activating the drying cycle is pushed. Alternatively or additionally the temperature signal is detected after about 1 min. after starting a drying cycle or program but while the compressor is still switched-off. For example after starting a drying cycle a process air fan (which may be connected to the drum motor) and/or an optional cooling air blower (e.g. for cooling the compressor) already operates, whereby the detected temperature may be stabilized or equalized before detecting the first temperature signal.

[0024] According to an embodiment, the first temperature signal may be detected repeatedly or permanently during a drying operation to continuously adapt the temperature threshold value(s) or pair(s) of threshold values to the present condition or state of the treatment apparatus (or heat pump system) throughout the apparatus operation. In other words the threshold value(s) may change in dependency of permanent or repeated detection of operation conditions (for example by constantly monitoring the first temperature signal). For example when the ambient temperature (i.e. the corresponding temperature signal) is in a normal range (for example 15-30°C) a first predetermined temperature threshold value or a pair of predetermined threshold values is selected or set. When the ambient temperature is in a low range (for example below 15 °C) a second temperature threshold value or a pair of predetermined threshold values. When the ambient temperature is in a hot range (for example above or 30°C) a third temperature threshold value or a pair of predetermined threshold values is set or selected.

[0025] Preferably the method further comprises (i) selecting in dependency of the at least one detected temperature signal a predetermined switch-OFF time for the compressor, and (ii) switching OFF the compressor for a predetermined switch-OFF time when the selected temperature threshold value is exceeded. For example a selected predetermined time may be 5 min. Preferably the duration of the switch-OFF time depends on the detected first temperature signal. For example the higher the detected first temperature signal (e.g. the higher the ambient temperature), the longer the selected switch-OFF time. Thereby it is provided that the apparatus (or heat pump system) has sufficient time to cool

down during compressor switch-off.

[0026] Preferably at least one, at least two or more than two predetermined switch-OFF time(s) are stored in an associated memory of the control unit for being selectively retrieved by the control unit upon selection in dependency of the at least one detected temperature signal as described above and below. For example the selection of the at least one predetermined switch-OFF time is made among

(i) a first predetermined switch-OFF time to be selected for a first temperature or a temperature range of the detected first temperature signal, and

(ii) at least one second predetermined switch-OFF time to be selected for a second temperature or a temperature range of the detected first temperature signal, wherein the first and second switch-OFF times are different of each other, and wherein the first and second temperature and/or the first and second temperature ranges are different of each other. For example, if the detected first temperature signal is less than or equal to 28°C the compressor switch-OFF time may be set to 5 min. In case the detected first temperature signal exceeds 28°C the compressor switch-OFF time may be set to 7 min.

[0027] After switching-off the compressor, preferably (i) a second temperature signal or the first temperature signal (in dependency of which the compressor is switched-on/off) is detected after the predetermined switch OFF time, and (ii) when a selected temperature threshold value is undershoot, the compressor is switched-on. In case that after the predetermined switch OFF time the selected (switch-on) threshold value is not undershoot (underrun), the compressor is not switched-on, i.e. the compressor is kept switched-off. In this case the temperature signal may be detected again after the predetermined switch OFF time as described above in steps (i) and (ii). Alternatively (after the predetermined switch-off time has elapsed once) the temperature signal is detected continuously or permanently until the selected temperature threshold value is undershoot, whereupon the compressor is switched-on. Thus the duration of the (overall) compressor switch-off time is minimized.

[0028] According to an embodiment, the method comprises repeatedly detecting the at least one first temperature signal before starting to operate the compressor to determine a first temperature gradient of the at least one first temperature signal. Alternatively the method comprises detecting at least two temperatures of at least two spaced apart positions in the cabinet of the apparatus to determine a second temperature gradient between the at least two positions. If the (first or second) temperature gradient exceeds a predetermined gradient, a predetermined temperature threshold value or a pair of predetermined threshold values is selected. A high temperature gradient may occur due to a malfunction of the temperature sensor(s) used for receiving the temperature signal(s). Thus, when a temperature gradient threshold is exceeded, this may indicate e.g. a broken temperature sensor.

[0029] For example, if the detected temperature signal is indicative of an ambient temperature, the exceeded (first or second) temperature gradient may indicate that the detected ambient temperature signal is not the real ambient temperature. In this case the selected temperature threshold value(s) for switching the compressor on/off may correspond to the threshold value(s) selected for a "cold" or "normal" temperature environment (e.g. below 28°C). Alternatively the selected threshold value(s) may be between the selected threshold value(s) for a "cold/normal" environment and a "hot" environment. Thus a middle threshold value setting may be used which takes into account the possibility of both environment conditions ("normal", "hot").

[0030] To determine whether a high (initial) first temperature signal (i.e. a temperature detected in the hot range, e.g. above 30 °C) results from a previous drying cycle or from a hot environment, the method preferably comprises: repeatedly detecting the at least one first temperature signal before starting to operate the compressor to determine a first temperature gradient of the at least one first temperature signal. When the first temperature gradient exceeds a predetermined gradient, a predetermined first temperature threshold value or a first pair of predetermined threshold values is selected. When the first temperature gradient is below the predetermined gradient, at least one predetermined second temperature threshold value or at least one second pair of predetermined threshold values is selected. The first and second temperature threshold value(s) may be different of each other.

[0031] For example, the first temperature signal may be detected at least two times, for example before and after starting a drying cycle (wherein a process air fan already starts operating) but before the compressor is operated, such that the ventilation of the blower (e.g. process air blower and/or cooling air blower) balances the temperature of the location where temperature is detected. When the initial signal is higher than the subsequently detected signal, i.e. the temperature gradient is negative, the temperature signals indicate that the treatment apparatus is located in an environment that is colder than the detected temperature, such that the above described temperature threshold values(s) for a cold/normal environment are selected. Preferably the threshold values are chosen by the control unit, among a plurality of predetermined threshold values, upon estimation of actual environment (ambient) temperature based on temperature signals and/or temperature signals difference and time elapsed between two subsequent temperature measurements by an appropriate algorithm. If a small temperature difference between the successively detected first temperature signals is detected, i.e. the corresponding gradient is almost zero, a hot or high temperature environment is indicated.

Consequently temperature threshold value(s) for a hot environment are selected.

[0032] An alternative or additional method for determining whether high (initial) first temperature signal (i.e. a temperature detected in the hot range, e.g. above 30°C) results from a previous drying cycle or from a hot environment is provided as described below. At least two temperature signals of at least two spaced apart positions in the cabinet of the apparatus are detected to determine a second temperature gradient between the at least two positions. When the second temperature gradient exceeds a predetermined gradient a first temperature threshold value or a first pair of predetermined threshold values is selected among a plurality of predetermined threshold values. A second temperature threshold value or a second pair of predetermined threshold values, further selected among a plurality of predetermined threshold values, is selected when the second temperature gradient is below the predetermined gradient. E.g. if the detected (first) temperature signals are almost the same, i.e. the temperature gradient is almost zero, an initial high temperature signal results from a hot environment, such that a hot cycle is executed. In turn when at least one of the detected temperature signals is higher than the other temperature signals, a cold environment may be indicated. For example the initial high temperature of e.g. a sensor arranged at the heat pump system results from a previous drying cycle but not from a high temperature environment.

[0033] Preferably the value or level of at least one of the first temperature signal(s), the first temperature gradient and the second temperature gradient is depending on one or more of the following: an operation state of the laundry treatment apparatus, an operation state of the heat pump system, a program cycle, a selected program for laundry treatment, and a user input or selection input by a user of the laundry treatment apparatus.

[0034] The at least one or the at least two detected first temperature signals may correspond to a temperature detected at one of the following positions in the heat pump system or within the cabinet of the laundry treatment apparatus: a refrigerant fluid outlet position at the first or second heat exchanger, an electronic board or inverter position of an electronic board or inverter controlling a component of the heat pump system, an electronic board or inverter position of an electronic board or inverter controlling a motor for driving the laundry treatment chamber being a drum, a refrigerant fluid outlet position at the compressor, the compressor, the expansion device, a position in a cooling air flow path (where e.g. the cooling air blown by a cooling air blower flows), or a position in the air flow of the process air. Additionally at least one temperature sensor may be arranged outside the treatment apparatus cabinet to detect an ambient or environment temperature instantly. Further, a (second) temperature signal which is compared to the selected threshold value(s), i.e. to determine whether the compressor is to be switched-off/-on, may correspond to a temperature detected at any of the above described positions.

[0035] According to an embodiment the at least one detected first temperature signal (Tx) is provided by combining temperature signals that are detected at different locations at or in the laundry treatment apparatus, and/or temperature signals that are detected at different time points. Preferably all combined temperature signals are detected for combining before starting the heat pump system or during or before a starting phase of a laundry treatment sequence using the heat pump system.

[0036] A laundry treatment apparatus, in particular heat pump tumble dryer or washing machine having a drying function is provided, wherein the apparatus comprises a heat pump system, a control unit adapted to control the operation of the heat pump system and a laundry treatment chamber for treating laundry using process air. The heat pump system comprises a first heat exchanger for cooling a refrigerant fluid, a second heat exchanger for heating the refrigerant fluid, an expansion device, a refrigerant loop, in which the refrigerant fluid is circulated through the first and second heat exchangers and the expansion device, a compressor for circulating the refrigerant fluid through the refrigerant loop, and at least one temperature sensor for detecting the temperature signal, wherein the control unit is adapted to implement a method according to any of the above and below described embodiments.

[0037] Any of the above described features and elements of the methods of operating a treatment apparatus may be combined in any arbitrary combination and may be implemented in a heat pump laundry dryer or heat pump washing machine having drying function as described above.

[0038] Reference is made in detail to preferred embodiments of the invention, examples of which are illustrated in the accompanying figures, which show:

Fig. 1 a schematic view of a laundry treatment apparatus having a heat pump system,

Fig. 2 a schematic block diagram of controlling components of the apparatus of Fig. 1,

Fig. 3 an exemplary flow chart showing how predetermined temperature threshold values are selected according to a first embodiment,

Fig. 4 an exemplary flow chart showing how predetermined temperature threshold values are selected according to a second embodiment,

Fig. 5 an exemplary flow chart showing the selection of predetermined temperature threshold values and the application of the temperature threshold values during an operation of the laundry treatment apparatus, and

Figs. 6a-b flow charts illustrating how to evaluate whether a high detected temperature signal is due to ambient conditions or to what the heat pump system has performed before the temperature detection.

[0039] Fig. 1 depicts a schematic representation of a laundry treatment apparatus 2 which in this embodiment is a heat pump tumble dryer. The tumble dryer having a cabinet 3 or housing comprises a heat pump system 4, including in a closed refrigerant loop 6 in this order of refrigerant flow B: a first heat exchanger 10 acting as evaporator for evaporating the refrigerant R and cooling process air, a compressor 14, a second heat exchanger 12 acting as condenser for cooling the refrigerant R and heating the process air, and an expansion device 16 from where the refrigerant R is returned to the first heat exchanger 10. Together with the refrigerant pipes connecting the components of the heat pump system 4 in series, the heat pump system 4 forms a refrigerant loop 6 through which the refrigerant R 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 can act as gas heater and gas cooler, respectively.

[0040] The expansion device 16 is a controllable valve that operates under the control of a control unit 30 (Fig. 2) to adapt the flow resistance for the refrigerant R in dependency of operating states of the heat pump system 4. In an embodiment the expansion device 16 may be a fixed, non-controllable device like a capillary tube.

[0041] The process air flow within the treatment apparatus 2 is guided through a compartment 18 of the treatment apparatus 2. The compartment 18 for receiving articles to be treated may be a drum 18. The articles to be treated are textiles, laundry 19, clothes, shoes or the like. In the embodiments here these are preferably textiles, laundry or clothes. The process air flow is indicated by arrows A in Fig. 1 and is driven by a process air blower 8 or fan. The process air channel 20 guides the process air flow A outside the drum 18 and includes different sections, including the section forming the battery channel 20a in which the first and second heat exchangers 10, 12 are arranged. The process air exiting the second heat exchanger 12 flows into a rear channel 20b in which the process air blower 8 is arranged. The air conveyed by blower 8 is guided upward in a rising channel 20c to the backside of the drum 18. The air exiting the drum 18 through the drum outlet (which is the loading opening of the drum) is filtered by a fluff filter 22 arranged close to the drum outlet in or at the channel 20.

[0042] When the heat pump system 4 is operating, the first heat exchanger 10 transfers heat from process air A to the refrigerant R. By cooling the process air to lower temperatures, humidity from the process air condenses at the first heat exchanger 10, is collected there and drained to a condensate collector 26. The process air 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. The process air is sucked from exchanger 12 by the blower 8 and is driven into the drum 18 where it heats up the laundry 19 and receives the humidity therefrom. The process air exits the drum 18 and is guided in front channel 20d back to the first heat exchanger 10. The main components of the heat pump system 4 are arranged in a base section 5 or basement of the dryer 2.

[0043] An optional cooling air blower 24 or fan unit is arranged close to the compressor 14 to remove heat from the heat pump system 4 during a drying operation.- Here as an example the cooling air flow C is taking heat from (the surface of) the compressor 14. The air blower 24 comprises a blower or fan 36 which is driven by a fan motor 34 controlled by the control unit 30 of the dryer 2. As indicated in Fig. 1, the cooling air C is sucked in at the bottom of the cabinet 3 and conveyed towards the compressor 14 for compressor cooling. The cooling air (at least partially passed over the compressor) exits the cabinet 3 through openings at the cabinet bottom and/or rear wall of the cabinet 3. By transferring heat from the compressor 14, during operation of the heat pump system 4, the refrigerant 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. Alternatively no fan unit 24 is provided.

[0044] The dryer 2 comprises a temperature sensor 28 for monitoring or detecting a temperature of the refrigerant R (or of a temperature dependent on the refrigerant temperature) at the compressor output to provide a temperature signal for the control unit 30. In this embodiment the dryer 2 comprises an additional temperature sensor 27 preferably arranged inside the cabinet 3 designed to detect the ambient temperature. The 'ambient' temperature is a measure for the temperature of the environment where the dryer 2 is placed. For example when the dryer is placed indoor, the ambient temperature is indoor temperature or when the dryer is placed outdoor (e.g. in a garage or a veranda) the temperature is or is close to outside temperature. Sensor 27 may be placed external to the cabinet 3, but is preferably internal to it and arranged at a position such that at least at specific conditions the ambient temperature or a temperature that is close to the real outside ambient temperature can be detected. As indicated in Fig. 1, sensor 27 may be placed in an upper region of dryer, for example at or close to the input panel 38. This position is distant to the heat sources or heated components (where the process air flows) and measures a temperature close to the external temperature. Alternatively, sensor 27 is placed in the bottom of the cabinet 3, for example in the air path of the cooling air C sucked in by the blower 24 such that (at least after operating the blower 24 for a short time) the detected ambient temperature is directly related

to the 'outside' ambient temperature.

[0045] As shown in Fig. 2 a further temperature sensor 29 is provided to monitor or detect the temperature of an electronic board of the control unit 30, which provides a further temperature signal for the control unit 30. Alternatively only one temperature sensor is provided, e.g. sensor 28.

[0046] Examples for locations for temperature sensors are: a refrigerant fluid outlet of the first or second heat exchanger 10, 12, an electronic board or inverter position of an electronic board or inverter controlling a component of the heat pump system 4, an electronic board or inverter position of an electronic board or inverter controlling the drum motor 32, a refrigerant fluid outlet position at the compressor 14, the compressor 14, the expansion device 16 or a position in the air flow A of the process air. Preferably one or more temperature sensors are positioned such that an operating state of the heat pump system 4 and/or ambient conditions and/or starting conditions for the heat pump system 4 may be derived or deduced from the detected temperature or from a combination of temperature signals of two or more temperature sensors. In the following temperature detection is described in more detail as an example.

[0047] Fig. 2 shows a schematic block diagram of components of the dryer of Fig. 1 illustrating the control of the dryer components. The control unit 30 is adapted to control the operation of the components of the dryer 2, for example the drum motor 32, the compressor 14, the valve 16 (optionally) and the fan motor 34, according to the selected program. Via an input panel 38 a user may select a drying program or cycle, e.g. FAST, ECONOMY, IRON-AID. Optionally further inputs may be made, e.g. residue humidity, laundry amount and/or laundry type. Further, the control unit 30 is adapted to control the air blower 24 and the compressor 14 such that during the heat pump 4 warm-up period and the following normal operation period the operation conditions of the heat pump system 4 can be optimized in view of one or more of: energy consumption / drying duration / drying result / component's lifetime.

[0048] Fig. 3 shows a flow chart illustrating an exemplary method for operating a treatment apparatus 2 as described above. Before starting to operate the compressor 14, a first temperature signal Tx is detected, e.g. from temperature sensor 28 at the compressor exit. When the heat pump system 4 is in a 'cold' state, the detected temperature signal corresponds to the ambient temperature where the treatment apparatus is placed, or the detected temperature signal is at least indicative of the ambient temperature. When the temperature signal is higher than a predetermined upper limit, e.g. 28°C, the dryer 2 or the heat pump system 4 is considered to be in a "hot" state or condition. Depending on the level of the detected first temperature signal Tx, respective predetermined temperature threshold values are selected. The respective predetermined temperature threshold values to be selected may be stored in a memory of the control unit 30 which may be adapted to select the threshold values as described above and below.

[0049] In the exemplary embodiment depicted, if $T_x > 28^\circ\text{C}$, "hot" temperature threshold values are selected and applied to the compressor control provided by the control unit 30. If the detected first temperature signal Tx is below the upper limit, e.g. 28°C, the dryer or heat pump system 4 is considered to be in a "normal" state or condition. Then the predetermined "normal" temperature threshold values are selected and applied in the control routines to control the compressor 14 via control unit 30. Self-evident that the predefined 'hot' temperature threshold values are different to the predefined 'normal' temperature threshold values. (For the embodiments below the 'hot' temperature threshold values, the 'normal' temperature threshold values and the 'cold' temperature threshold values are mutually different to each other). The 'values' may be one 'value' and can also be denoted or understood as parameter or parameters used in compressor or heat pump system control routines.

[0050] As shown in Fig. 3, preferably at least two different temperature threshold value(s) or two pairs of temperature threshold values for switching the compressor on and/or off are provided. The respective threshold value(s) are selected depending on the temperature range (below or above 28°C) in which the detected first temperature signal Tx lies. For example for each temperature range (below or above 28°C) (i) one predetermined temperature threshold value or (ii) one pair of predetermined temperature threshold values may be provided.

[0051] Depending on a repeatedly or permanently detected (second) temperature signal (e.g. of sensor 27, sensor 28 and/or sensor 29) the compressor is switched-off when the temperature signal reaches or exceeds the selected compressor switch-off temperature threshold value and is switched-on when the selected switch-on temperature threshold value is undershoot. Alternatively the compressor is switched-on and/or -off depending on the repeatedly or permanently detected first temperature signal Tx. For example only one temperature threshold value may be selected for determining when the compressor has to be switched-off and switched-on. Alternatively a pair of temperature threshold values are selected, preferably one switch-off threshold value (T_{off}) and a further switch-on threshold value (T_{on}) different from the switch-off value.

[0052] The above and below described methods provide that compressor switch-off/-on threshold values are adapted to the current/present (temperature) condition of the treatment apparatus. Thereby compressor operation is adapted to the current condition or state of the dryer 2. For example, if a "hot" environment is detected, a switch-off temperature threshold value is selected which is lower than a switch-off temperature threshold value for a "normal" environment. In a "hot" environment the capacity of the heat pump system (or treatment apparatus) to convey/discharge heat is reduced as compared to a "normal" or "cold" temperature environment. By reducing the switch-off threshold value for a detected "hot" condition it is provided that the compressor is safely switched-off in critical (temperature) conditions. Thus it is

provided that the compressor 14 is safely operated during a drying operation.

[0053] The above method provides additionally that emergency switch-offs of the compressor 14 by means of a safety device (not shown) like a thermoprotector are prevented. For example the dryer 2 may comprise a safety device to switch-off the compressor 14 to prevent damage of the compressor 14 in a critical (temperature) condition. The duration of an emergency switch-off by means of a safety device is generally long and not well controllable. Thus a drying operation is suspended unnecessarily long when an emergency switch-off of the compressor 14 occurs. In general, a compressor safety device intervenes for a combined effect of compressor temperature and current absorbed by the compressor. Thus the safety device is not controlled by a temperature signal indicating the condition of the heat pump system, for example of the refrigerant temperature. For example, if a fixed temperature threshold value would be used for all drying operations, it may occur in high ambient temperature condition (e.g. above 30°C), that the refrigerant temperature is lower than the fixed compressor switch-off threshold (i.e. the compressor is kept ON), while the safety device intervenes by switching the compressor OFF. This is mainly due to the refrigerant circuit and safety device having different thermal inertia. For example this difference is due to the situation that a temperature sensor (e.g. sensor 28) for detecting the temperature signal (e.g. of the refrigerant) and the safety device are placed at different locations within the treatment apparatus. Therefore the temperature sensor 28 and the safety device are subject to different temperatures.

[0054] To prevent an emergency switch-off by means of a safety device, the above described at least one predetermined temperature threshold value is selected, such that the compressor 14 may be switched-off before the safety device intervenes or is activated. When the detected first temperature signal Tx is low ('ambient' temperature low), the at least one selected temperature threshold value may be set at a higher level, as compared to threshold value(s) for a detected high value of the first temperature signal Tx. A detected high value of the first temperature signal Tx may result from a previous drying operation and/or from a high ambient temperature. In this case the dryer 2 or (the components of) the heat pump system 4 reaches a critical (temperature) condition faster as compared to the case when a low value of the first temperature signal Tx is detected. The first temperature signal Tx may have a low value when the dryer 2 has not been operated for some time, such that the dryer 2 is cooled down, and/or the ambient temperature is low or normal (e.g. below 28°C).

[0055] Fig. 4 shows a flow chart depicting an alternative method for operating a dryer 2. In contrast to the method shown in Fig. 3, this method provides a selection of at least three predetermined pairs of temperature threshold values T_off1..3, T_on1..3. As in the above embodiment, the respective pair of temperature threshold values T_off1..3, T_on1..3 is selected in dependency of a detected first temperature signal Tx. If the detected first temperature signal Tx is between two limiting temperature values (e.g. 15°C and 28°C) the dryer or heat pump system is considered to be in a normal state or condition, i.e. corresponding temperature threshold values T_off2/T_on2 are selected. In the control unit memory there may be provided one, two, three (as depicted in Fig. 4) or more predefined pairs of temperature threshold values for specific temperature ranges or values of the detected first temperature signal Tx. In the embodiment of Fig. 4 the pair T_off1, T_on1 is for the range Tx < 15°C, the pair T_off2, T_on2 is for the range 15°C ≤ Tx < 28°C, and the pair T_off3, T_on3 is for the range Tx > 28°C.

[0056] Fig. 5 shows a flow chart illustrating an exemplary course of selecting predetermined temperature threshold values and applying the selected temperature threshold values during a laundry treatment apparatus operation. The steps for selecting the temperature threshold values T_off1..2, T_on1..2 for switching the compressor 14 on and off correspond to the method described above in Fig. 3. Alternatively the selection of the predetermined temperature threshold values may be executed as described with respect to Fig. 4 or any other way described above and below.

[0057] According to the control sequence shown in Fig. 5, after selecting the respective threshold values T_off1..2, T_on1..2 the control unit 30 is adapted to start a drying operation. During the drying operation a second temperature signal T is detected (permanently or repeatedly) and the control unit 30 is adapted to control whether the second temperature signal T is equal to or exceeds the selected compressor switch-off threshold value T_off1..2. The detected second temperature signal T may be the same as the above described first temperature signal Tx. Alternatively the second temperature signal T may be a temperature signal different from the above first temperature signal Tx used for selecting the threshold values T_off1..2, T_on1..2. In the following the term "second temperature signal" is used to distinguish the first temperature signal Tx detected for determining the switch-on/-off threshold values for the compressor 14 from the detected (first or second) temperature signal T during an operation of the dryer 2. T and Tx may but must not be different signals.

[0058] When the detected second temperature signal T is below the respective selected switch-off threshold T_off1..2, the drying operation is continued. When the detected second temperature signal T is above the selected switch-off threshold T_off1..2 the compressor 14 is switched-off (and the drying operation suspended). After a predetermined switch-off time (e.g. 5 min.) the second temperature signal T is detected once more. When the second temperature signal T is below the selected compressor switch-on threshold value T_on1..2, the compressor 14 is switched-on and the drying operation is continued.

[0059] If (after the predetermined switch-off time) the second temperature signal T is higher than the selected switch-on threshold T_on1..2, the compressor is kept switched-off once more for the predetermined switch-off time (e.g. 5 min.).

After the switch-off time has elapsed, the second temperature signal T is detected once more to determine whether the switch-on threshold value $T_{on1..2}$ is undershot as described above.

[0060] Alternatively, after the switch-off time is expired once and the second temperature signal T is not below the selected switch-on threshold $T_{on1..2}$, the second temperature signal T may be detected permanently, such that the compressor 14 may be switched on immediately when the switch-on threshold value is undershot. Thereby the overall switch-off time of the compressor 14 is minimized.

[0061] Before starting dryer operation (here start of heat pump system), a predetermined switch-off time may be selected in dependency of the detected at least one first temperature signal Tx. For example, the higher the value of the first temperature signal (e.g. the higher the ambient temperature) the longer the duration of the predetermined switch-off time. Thereby it is provided that after switching of the compressor the dryer 2 has sufficient time to cool down. Exemplary predetermined temperature threshold values and switch-off times selected in dependency of the detected first temperature signal Tx are shown in the following table.

	$T_x < 15^{\circ}\text{C}$	$15^{\circ}\text{C} \leq T_x \leq 30^{\circ}\text{C}$	$T_x > 30^{\circ}\text{C}$
switch-OFF value (T_{off})	75°C	70°C	65°C
switch-ON value (T_{on})	65°C	60°C	50°C
compressor switch-OFF time	4 min.	5 min.	6 min.

[0062] Figs. 6a-b show flow charts of two different embodiments for evaluating whether a high detected temperature Tx (i.e. a temperature detected in the hot range, for example a temperature detected above 30°C) is due to ambient conditions or is due to operating conditions of the heat pump system 4 which were applied before the current temperature detection and resulted in the detection of the high temperature (e.g. starting a drying program immediately or shortly after a previous drying process).

[0063] As shown in Fig. 6a, an initial (high) value of the first temperature signal Tx is T1 which is measured or detected just when the machine is switched on or a drying program is selected (at that time none of the treatment apparatus components like compressor 14 or blower 8 is activated). The first temperature signal Tx may be measured by an NTC (Negative Temperature Coefficient Thermistor) or temperature sensor installed in or at the heat pump system 4 (for example sensor 28 at the compressor outlet), wherein any temperature sensor placed at other places of the apparatus 2 could be used for the same purpose. Another example would be one or more temperature sensors mounted on electronic boards, e.g. a power board and a compressor control board.

[0064] Subsequent to determining Tx the first time, the drying cycle is started which in this cycle means that the drum motor 32 rotates the drum 18 and the connected process air fan 8 for circulating air A. After a predetermined time from the start of the drying cycle (e.g. 1 min) the compressor 14 is still switched off and the temperature measurement is repeated to obtain a second temperature signal Tx = T2.

[0065] Then the two temperatures T1, T2 are compared. When the initially detected (high) temperature signal T1 is higher than the subsequently detected temperature signal T2, the treatment apparatus 2 is located in an environment that is colder than the detected temperatures T1, T2. The ventilation effect of the fan 8 leveled the initial high temperature signal T1 to the lower temperature level T2 of the apparatus environment. For example the high temperature signal T1 results from a previous drying operation of the apparatus 2, but not from a generally high temperature (ambient) environment of the dryer 2. The actual (ambient) environment may be estimated from detected temperatures T1, T2 and/or temperature difference T1-T2 and time elapsed between two subsequent temperature measurements by an appropriate algorithm. The control unit 30 selects the predetermined temperature threshold value(s) based on the (ambient) environment temperature estimated by such algorithm as described above.

[0066] When the initially detected temperature signal T1 is the same or less than the subsequently detected temperature signal T2, the dryer 2 is located at a high temperature environment. Alternatively the dryer 2 is located in an environment which does not allow sufficient removal of heat from the dryer, e.g. the dryer 2 is located in a small compartment, niche or room. Here it is determined that e.g. the ventilation effect due to the fan 8 gave no results in term of temperature decrease after a sufficiently long period of fan operation. The control unit selects the predetermined temperature threshold value(s) as described above based on the detected temperature value T1 or T2.

[0067] As shown in Fig. 6b three temperature sensors are available to detect three temperature signals Ta, Tb, Tc (at the same time) at three different positions. For example temperature sensor 28 at the refrigerant circuit, temperature sensor 27 at the upper or lower region of the cabinet 3 (see above), and a temperature sensor on the compressor control board. Sensor 28 may be in the machine basement 5, and the compressor control board is in a region over the basement 5.

[0068] The detected temperature signals Ta, Tb, Tc are compared to determine whether they are essentially the same, i.e. whether the temperature values vary within a predetermined range $\Delta T \leq \Delta T_1$ threshold. If the detected (high) tem-

perature signals Ta, Tb, Tc are essentially the same, the high temperature is due to the high temperature ambient condition. If one or more of the temperature sensors (in particular sensor 28) detects a completely different temperature, i.e. $\Delta T > \Delta T1$ threshold then the initial high temperature probably results from a previous drying cycle. In this case the ambient temperature may be normal (e.g. in the range of 15 to 30°C) or cold (e.g. below 15°C). In particular it is checked whether the temperature difference ΔT is below a further predetermined threshold $\Delta T2_{\text{threshold}} > \Delta T1_{\text{threshold}}$ such that it is concluded that there is a normal environment (normal range of ambient temperature). Otherwise ($\Delta T > \Delta T2_{\text{threshold}}$) it is a cold ambient temperature. The control unit 30 selects the appropriate predetermined temperature threshold value(s) as described above. The difference temperature ΔT may be a complex or simple function of the temperature signals Ta, Tb, Tc ($\Delta T = f(Ta, Tb, Tc)$) or only a function of two of the temperature signals.

[0069] Figs. 6a and 6b are examples of combining temperature signals measured at differently positioned temperature sensors (27, 28, 29) and/or measured at different time points and which are combined in a way by the control logic of the control unit for determining (here on a plausibility scheme) the 'external' conditions (hot/normal/cold environment) and/or 'internal' conditions (cold/warm/hot state of the heat pump system) for optimizing the control of the heat pump system operation. In the above embodiment the temperature-dependent configuration of the control parameters (temperature thresholds) results in avoiding exceptional operation interrupts by prioritized controls (compressor shut-down).

Reference Numeral List

2	heat pump tumble dryer	26	condensate collector
3	cabinet/housing	27	external temperature sensor
4	heat pump system	28	temperature sensor (compressor exit)
5	base section		
6	refrigerant loop	29	temperature sensor (electronic board)
8	blower		
10	first heat exchanger (evaporator)	30	control unit
		32	drum motor
12	second heat exchanger (condenser)	34	fan motor
		36	fan
14	compressor	38	input panel
16	expansion device	A	process air flow
18	drum (laundry compartment)	B	refrigerant flow
19	laundry	C	cooling air (flow)
20	process air channel	R	refrigerant
20a	battery channel	T, Tx	detected temperature signal
20b	rear channel	T_off1..2	compressor switch-off temperature threshold value
20c	rising channel		
20d	front channel	T_on1..2	compressor switch-on temperature threshold value
22	fluff filter		
24	cooling air blower		

Claims

1. Method for operating laundry treatment apparatus, in particular a heat pump dryer or washing machine having dryer function, wherein the apparatus (2) comprises a heat pump system (4) and a laundry treatment chamber (18) for treating laundry using process air (A), and wherein the heat pump system comprises:

a first heat exchanger (10) for heating a refrigerant fluid (R),
a second heat exchanger (12) for cooling the refrigerant fluid (R),
an expansion device (16),
a refrigerant loop (6), in which the refrigerant fluid is circulated through the first and second heat exchangers and the expansion device, and
a compressor (14) for circulating the refrigerant fluid (R) through the refrigerant loop (6),
the method comprising detecting at least one first temperature signal (Tx), **characterized by**
in dependency of the at least one detected first temperature signal (Tx), selecting at least one predetermined temperature threshold value (T_off1..3, T_on1..3) for switching the compressor (14) ON and/or OFF.

2. Method according to claim 1, wherein the method comprises selecting in dependency of the at least one detected first temperature signal a pair of temperature threshold values:

(i) a switch-OFF temperature threshold value ($T_{\text{off}1..3}$) for switching OFF the compressor, and
 (ii) a switch-ON temperature threshold value ($T_{\text{on}1..3}$) for switching ON the compressor,
 wherein the switch-OFF temperature threshold value and the switch-ON temperature threshold value are different of each other.

3. Method according to claim 1 or 2, wherein the at least one detected first temperature signal is indicative of an ambient or environment temperature of the laundry treatment apparatus.

4. Method according to claim 1, 2 or 3, wherein the at least one detected first temperature signal is provided by at least one temperature sensor (27, 28) capable of detecting the environment or ambient temperature at least under a predefined operation condition.

5. Method according to any of the previous claims, wherein the laundry treatment apparatus (2) comprises a control unit (30) having an associated memory, wherein at least one, at least two or more than two predetermined temperature threshold values ($T_{\text{off}1..3}$, $T_{\text{on}1..3}$) are stored in the memory for being selectively retrieved by the control unit upon selection in dependency of the at least one detected first temperature signal (T_x).

6. Method according to any of the previous claims, wherein the selection of the at least one predetermined temperature threshold value is made among
 a first predetermined temperature threshold value or a first pair of predetermined threshold values ($T_{\text{off}1..3}$, $T_{\text{on}1..3}$) to be selected for a first temperature or a temperature range of the detected first temperature signal (T_x),
 at least one second predetermined temperature threshold value or at least one second pair of predetermined threshold values ($T_{\text{off}1..3}$, $T_{\text{on}1..3}$) to be selected for a second temperature or a temperature range of the detected first temperature signal (T_x),
 wherein the first and second threshold values or first and second pairs of threshold values ($T_{\text{off}1..3}$, $T_{\text{on}1..3}$) are different of each other, and
 wherein the first and second temperature and/or the first and second temperature ranges are different of each other.

7. Method according to any of the previous claims, wherein the higher the detected first temperature signal or temperature range, the lower the value of the selected temperature threshold value or the selected pair of temperature threshold values ($T_{\text{off}1..3}$, $T_{\text{on}1..3}$).

8. Method according to any of the previous claims, wherein the method further comprises:

selecting in dependency of the at least one detected first temperature signal (T_x) a predetermined switch-OFF time for the compressor (14), and
 switching OFF the compressor (14) for a predetermined switch-OFF time, when the selected temperature threshold value ($T_{\text{off}1..3}$) is exceeded.

9. Method according to any of the previous claims, wherein the compressor (14) is switched OFF in dependency of the detected first temperature signal (T_x) or at least one detected second temperature signal (T).

10. Method according to any of the previous claims, wherein the method further comprises:

detecting the at least one first or second temperature signal (T , T_x) after the predetermined switch OFF time, and
 switching ON the compressor (14) when a selected temperature threshold value ($T_{\text{on}1..3}$) is undershoot.

11. Method according to any of the previous claims, wherein the method comprises:

repeatedly detecting the at least one first temperature signal (T_x) before starting to operate the compressor to determine a first temperature gradient of the at least one first temperature signal, or
 detecting at least two temperatures of at least two spaced apart positions in the cabinet of the apparatus to determine a second temperature gradient between the at least two positions,
 wherein the method further comprises selecting a predetermined temperature threshold value or a pair of predetermined threshold values when the first or second temperature gradient exceeds a predetermined gra-

dient.

12. Method according to claim 11, wherein the selected temperature threshold value or pair of temperature threshold values correspond to values selected for a low temperature signal.

13. Method according to claim 11,
wherein the selected temperature threshold value lies between threshold values selected for a low temperature signal and a high temperature signal, or
wherein the values of the selected pair of threshold values lie between the corresponding values selected for a low temperature signal and a high temperature signal.

14. Method according to any of claims 1 to 10, wherein the method comprises:

repeatedly detecting the at least one first temperature signal (Tx) before starting to operate the compressor (14) to determine a first temperature gradient of the at least one first temperature signal (Tx),
selecting a predetermined first temperature threshold value or a first pair of predetermined threshold values when the first temperature gradient exceeds a predetermined gradient, and
selecting at least one predetermined second temperature threshold value or at least one second pair of predetermined threshold values when the first temperature gradient is below the predetermined gradient.

15. Method according to any of claims 1 to 10, wherein the method further comprises:

detecting at least two temperatures of at least two spaced apart positions in the cabinet of the apparatus to determine a second temperature gradient between the at least two positions,
selecting a predetermined first temperature threshold value or a first pair of predetermined threshold values when the second temperature gradient exceeds a predetermined gradient, and
selecting at least one predetermined second temperature threshold value or at least one second pair of predetermined threshold values when the second temperature gradient is below the predetermined gradient.

16. Method according to any of the previous claims, wherein the at least one or the at least two detected first temperature signals (Tx) or the at least one second temperature signal (T) correspond to a temperature detected at one of the following positions in the heat pump system (4) or within the cabinet of the laundry treatment apparatus (2):

a refrigerant fluid outlet position at the first or second heat exchanger (10, 12),
an electronic board or inverter position of an electronic board or inverter controlling a component of the heat pump system (4),
an electronic board or inverter position of an electronic board or inverter controlling a motor for driving the laundry treatment chamber being a drum,
a refrigerant fluid outlet position at the compressor (14),
the compressor (14),
the expansion device (16), or
a position in the air flow (A) of the process air.

17. Method according to any of the previous claims, wherein the at least one detected first temperature signal (Tx) is provided by combining

- temperature signals that are detected at different locations at or in the laundry treatment apparatus,
- temperature signals that are detected at different time points, or
- temperature signals that are detected at different locations at or in the laundry treatment apparatus and temperature signals that are detected at different time points.

18. Laundry treatment apparatus, in particular heat pump tumble dryer or washing machine having a drying function, wherein the apparatus comprises a heat pump system (4), a control unit (30) adapted to control the operation of the heat pump system and a laundry treatment chamber (18) for treating laundry using process air, and wherein the heat pump system (4) comprises:

a first heat exchanger (10) for cooling a refrigerant fluid (R),
a second heat exchanger (12) for heating the refrigerant fluid (R),

an expansion device (16),
a refrigerant loop (6), in which the refrigerant fluid is circulated through the first and second heat exchangers
and the expansion device,
a compressor (14) for circulating the refrigerant fluid through the refrigerant loop (6); and
5 at least one temperature sensor for detecting a temperature signal;
wherein the control unit (30) is adapted to implement a method according to any of the previous claims.

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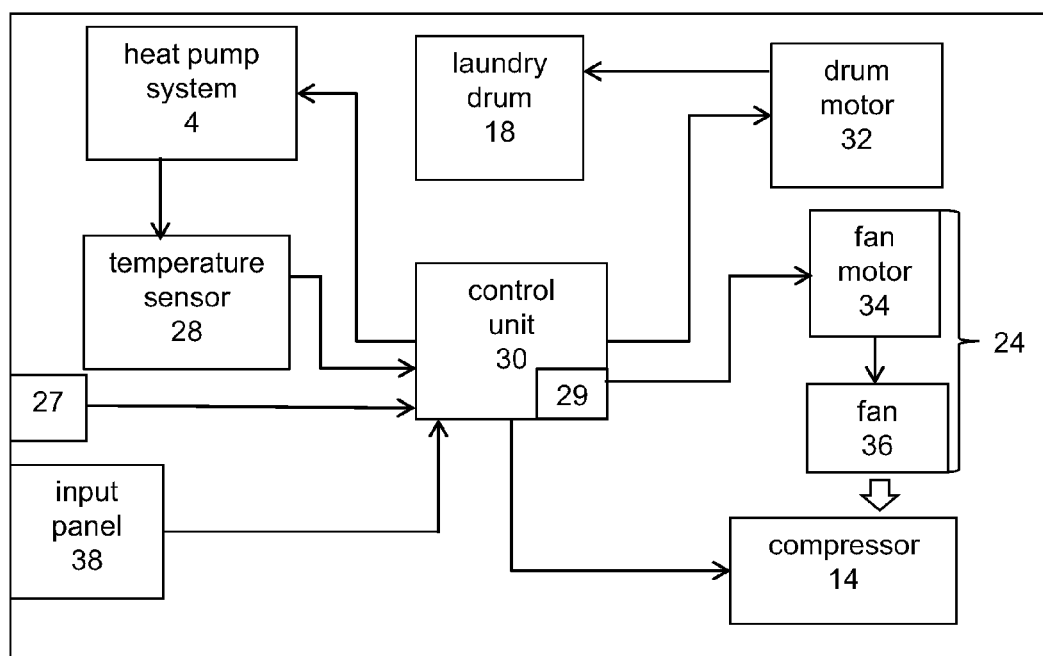
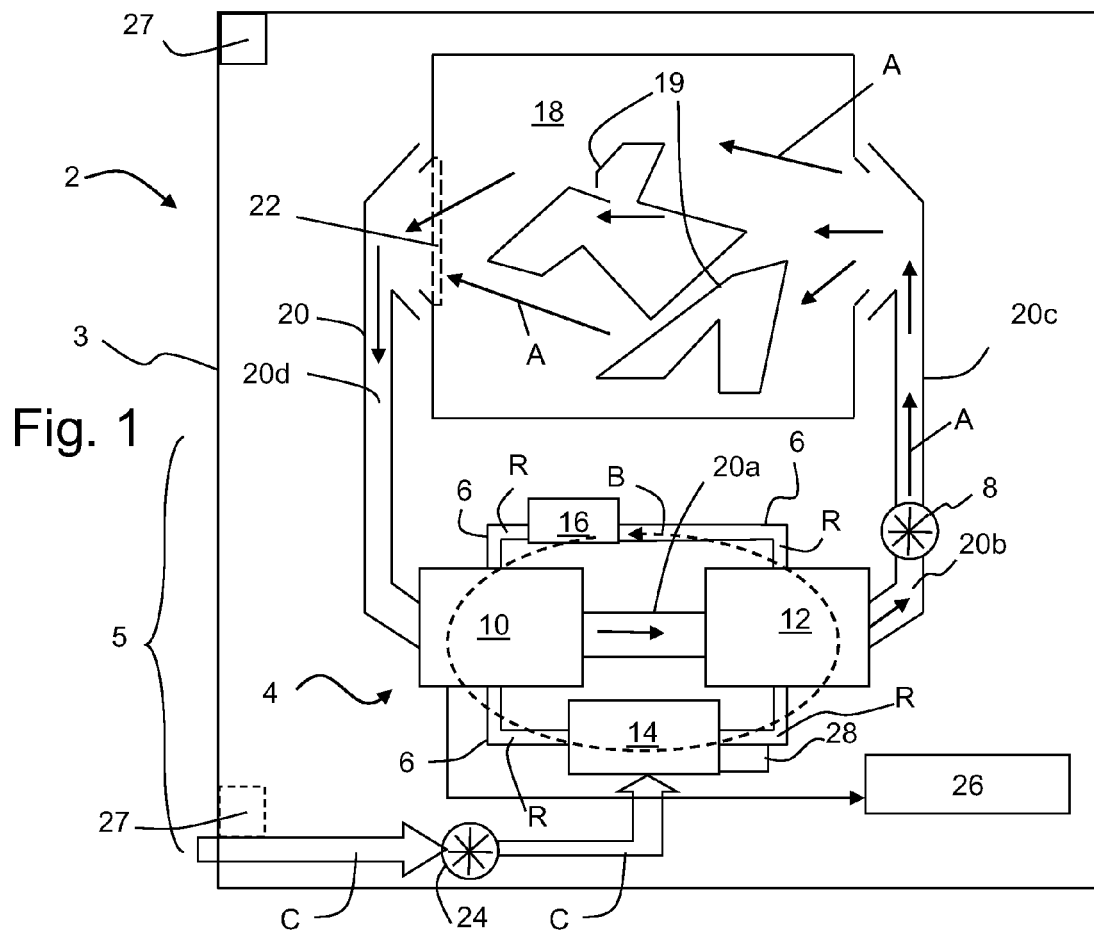
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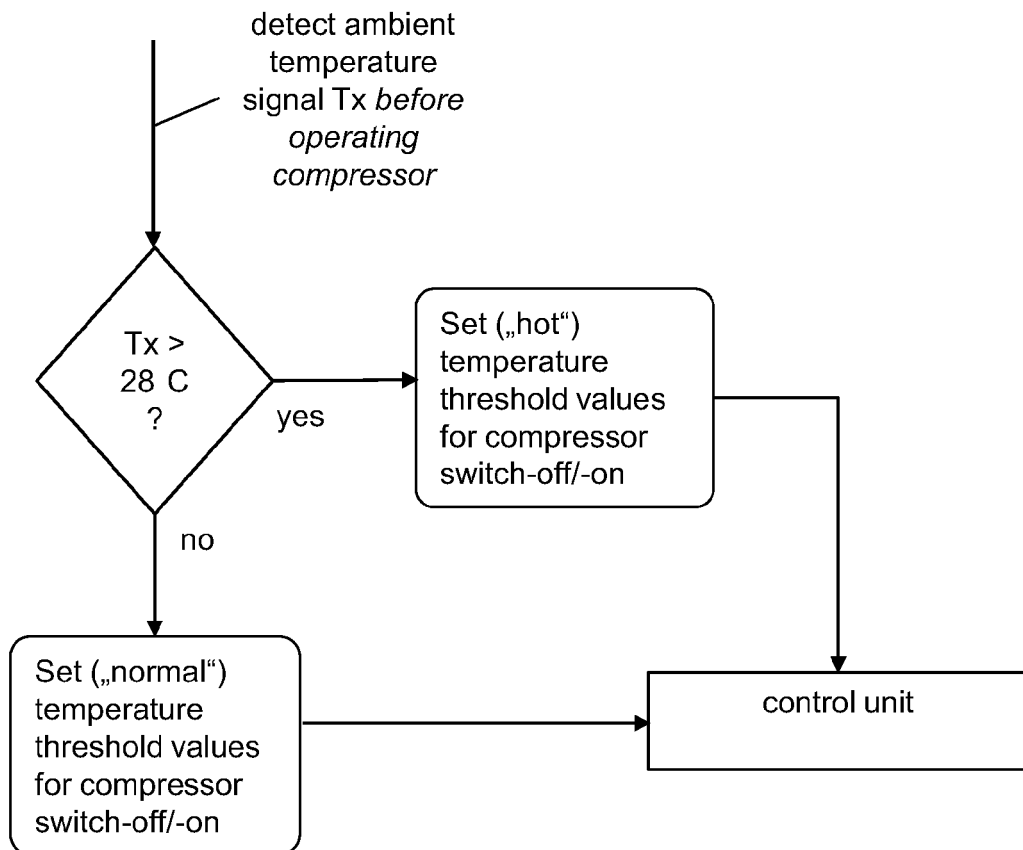


Fig. 3

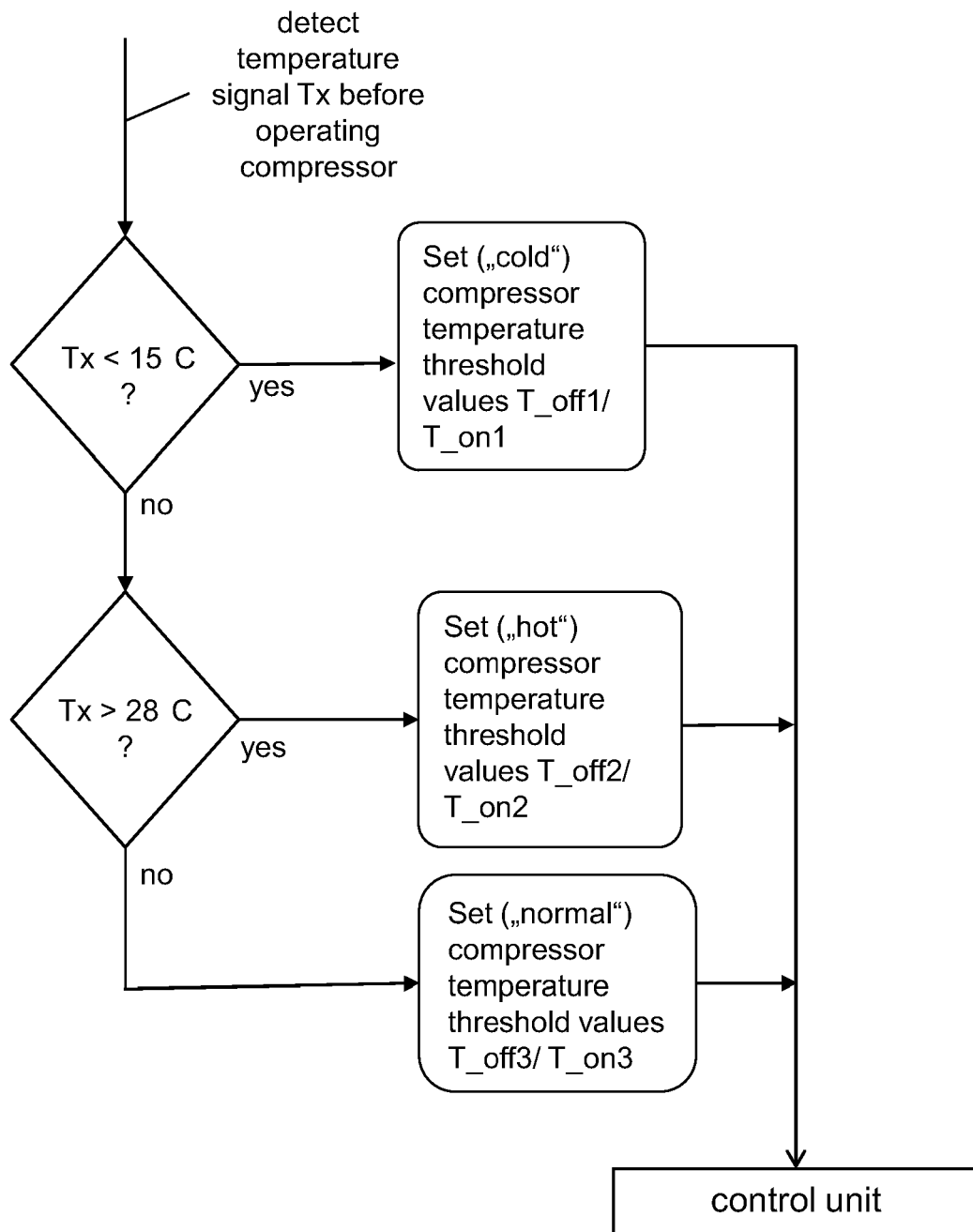
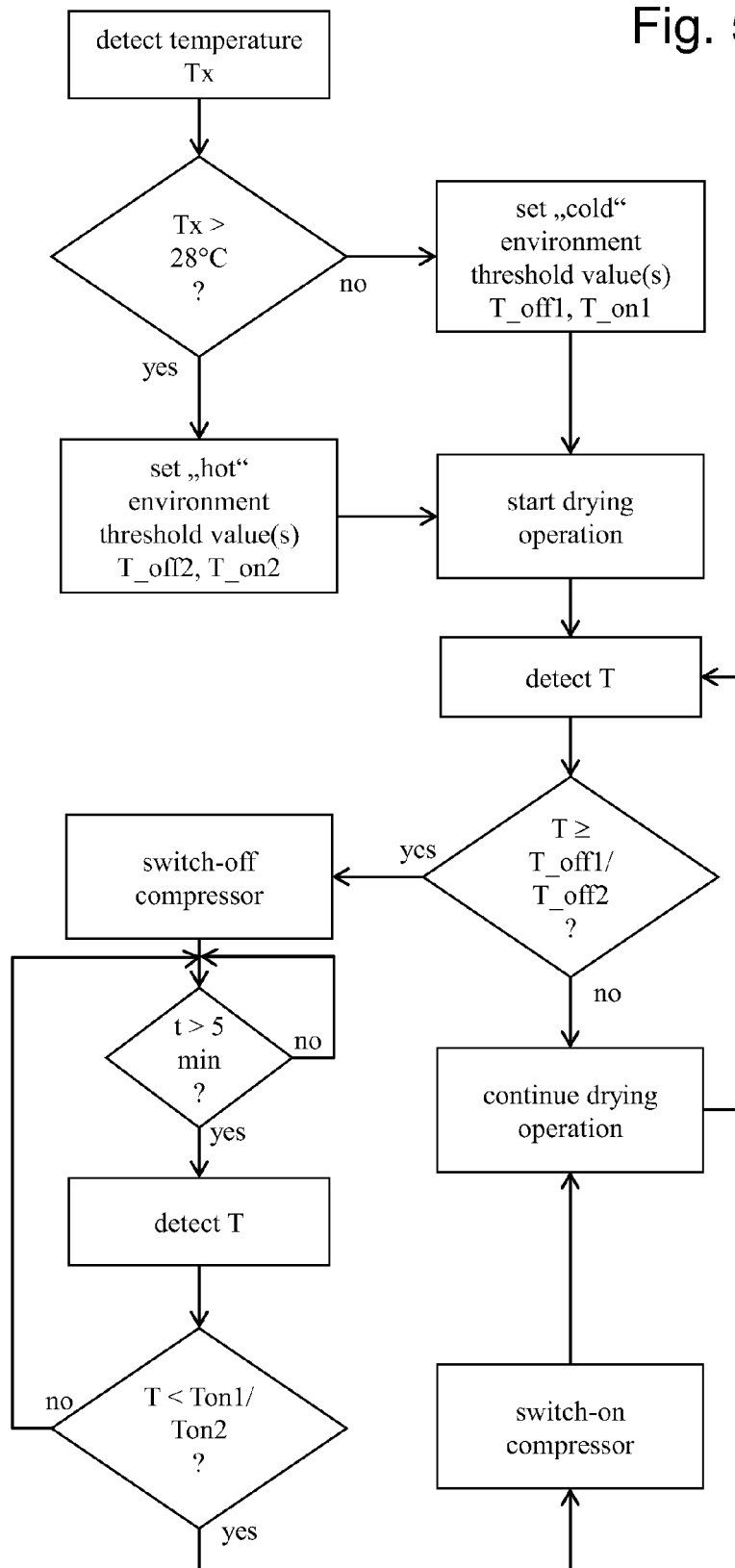
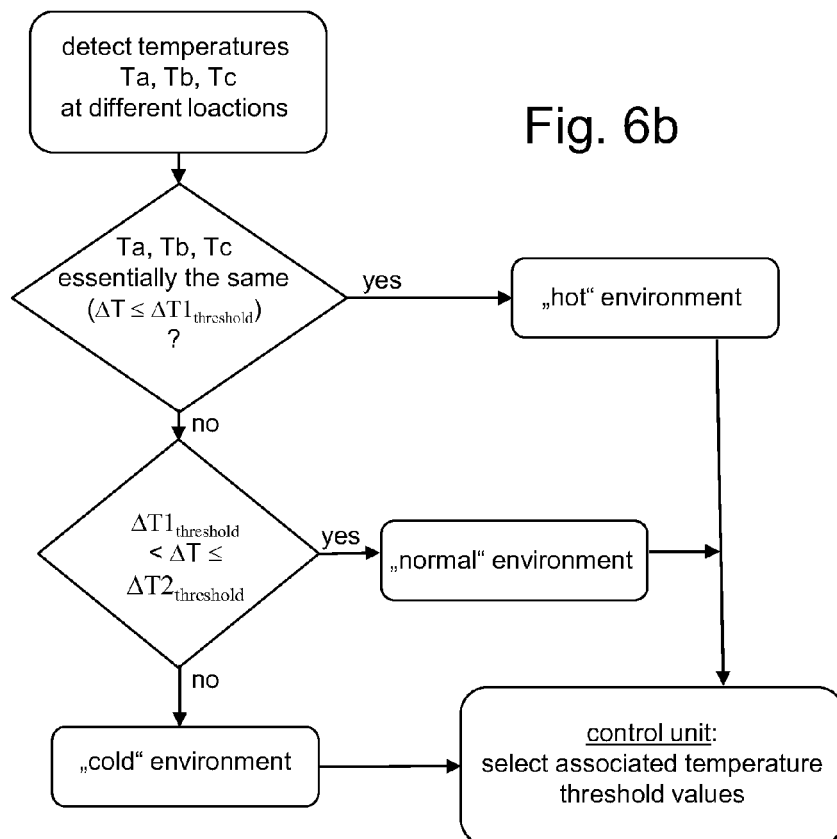
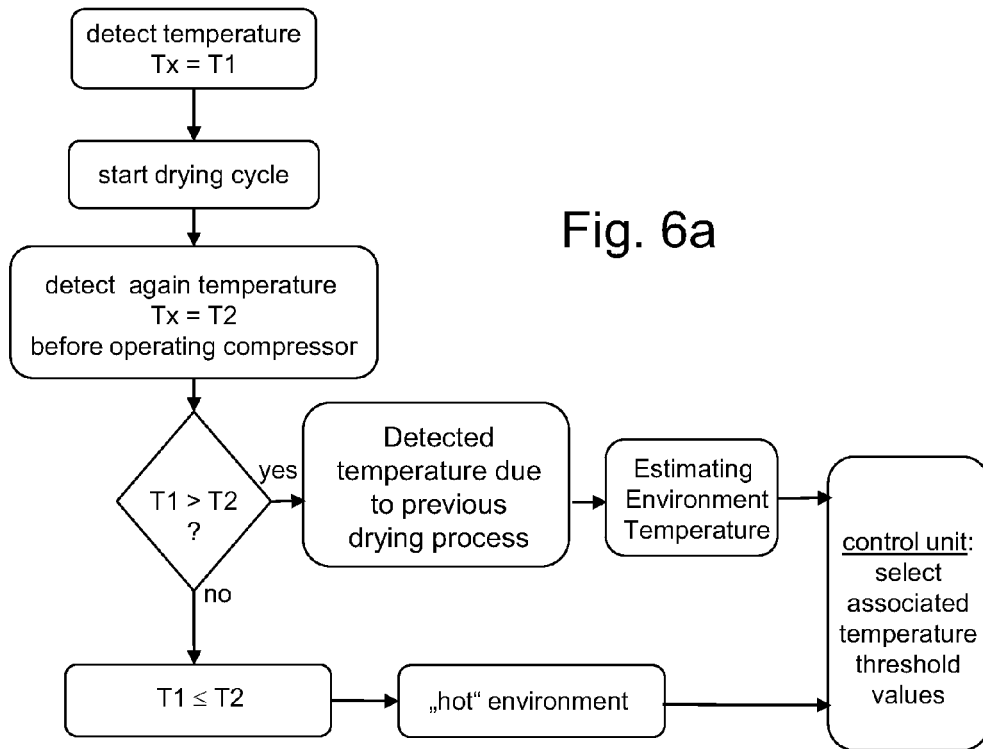


Fig. 4

Fig. 5







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Application Number
EP 13 17 0295

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Munich		31 July 2013	Jezierski, Krzysztof
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