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(54) METHOD FOR CONTROLLING A HEAT PUMP LAUNDRY DRYING MACHINE

(57) The invention relates to a method for controlling a heat pump laundry drying machine comprising a rotatable drum where textile is introduced and treated with a process air (A), said drum being driven in two rotation directions; a heat pump system (44) having a refrigerant circuit (40) in which a refrigerant can flow, said refrigerant circuit including a first heat exchanger (32) where the refrigerant is cooled off, a second heat exchanger (34) where the refrigerant is heated up, a compressor (36) to pressurize and circulate the refrigerant through the refrigerant circuit (40); said first and/or second heat exchanger being apt to perform heat exchange between said refrigerant flowing in said refrigerant circuit and said process air; a cooling device (42) for cooling a component (36) of the heat pump system;- a selector adapted to select alternatively at least an outdoor drying cycle for drying outdoor textiles which have a waterproof and breathable thin film material with a micro-porous structure, and at least an additional drying cycle for drying other types of textiles, wherein the outdoor drying cycle includes an outdoor main drying phase having settings for a frequency of reversion of rotations of the drum and for the heat pump operation and the additional drying cycle comprises an additional main drying phase having settings for a frequency of reversion of rotations of the drum and for the heat pump operation;wherein the method comprises:
- selecting and starting the outdoor drying cycle, and entering the outdoor main drying phase, wherein the outdoor main drying phase includes an outdoor first sub-phase (S2) and an outdoor second sub-phase (S3);
- reversing the rotation of the drum (16) in the outdoor first sub-phase at a frequency (F1) lower than a frequency in the additional main drying phase;
- entering the outdoor second sub-phase when the humidity of said outdoor textile is equal or below a first threshold;
- in the second sub-phase, reversing the rotation of the drum at a frequency (F2) lower than the drum rotation reversal frequency (F1) operated in the outdoor first sub-phase; and operating one or more of the following:
• increasing a flow rate of the process air in the drum with respect to a flow rate in the outdoor first sub-phase and with respect to a flow rate in the additional main drying phase;
• increasing a velocity of and/or a power supply to a motor (67) of the compressor (36) with respect to a velocity of and/or a power supply to a motor of the compressor in the outdoor first sub-phase and with respect to a velocity of and/or a power supply to a motor of the compressor in the additional main drying phase;
• increasing a temperature at which the cooling device (42) is activated/deactivated with respect to a temperature at which the cooling device is activated/deactivated in the outdoor first sub-phase and with respect to a temperature at which the cooling device is activated/deactivated in the additional main drying phase.

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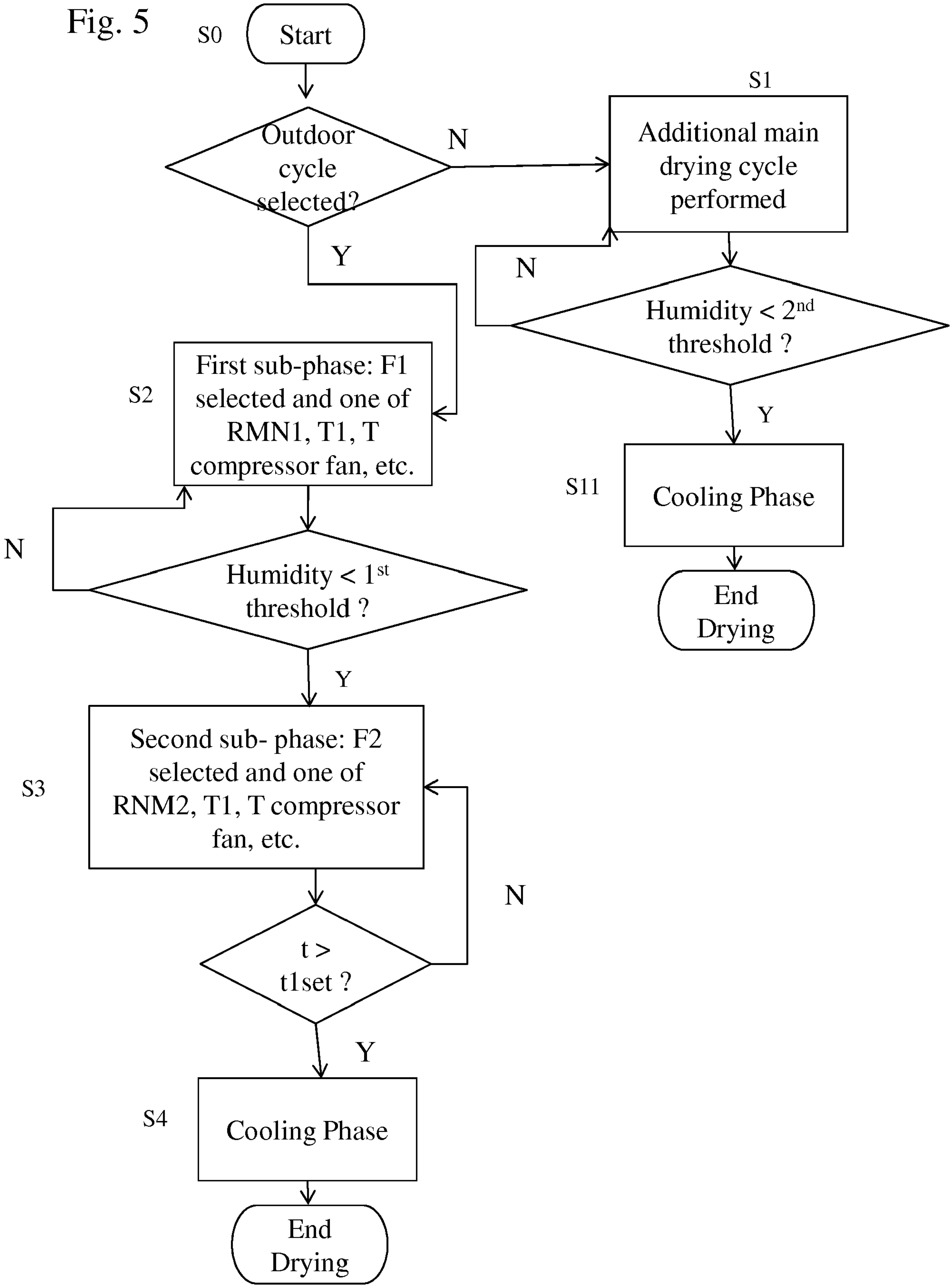
(Cont. next page)

Fig. 5


S0
Start
Outdoor cycle selected?
N
S1
Additional main drying cycle performed
Y
N
Humidity < 2nd threshold ?
S2
First sub-phase: F1 selected and one of RMN1, T1, T compressor fan, etc.
Y
S11
Cooling Phase
N
Humidity < 1st threshold ?
End Drying
Y
S3
Second sub- phase: F2 selected and one of RNM2, T1, T compressor fan, etc.
N
t > t1set ?
Y
S4
Cooling Phase
End Drying

Description

Technical field

[0001] The present invention relates to a method for controlling a heat pump laundry drying machine, wherein the drying machine comprises an outdoor textiles drying procedure for drying outdoor textiles.

Background art

[0002] For the purpose of the present disclosure, outdoor textiles have a waterproof and breathable thin film material with a micro-porous structure.

[0003] Often, clothes designed and realized for outdoor conditions include a durable water repellent (DWR), which is a coating added to fabrics at the factory to make them water-resistant or hydrophobic. Most factory-applied treatments are fluoropolymer based. Durable water repellents are commonly used in conjunction with waterproof breathable fabrics such as Gore-Tex to prevent the outer layer of fabric from becoming saturated with water. This saturation, called "wetting out", can reduce the garment’s breathability (moisture transport through the breathable membrane) and let water through. Methods for factory application of DWR treatments involve for example applying a solution of a chemical onto the surface of the fabric by spraying or dipping. More recently the chemistry is applied in the vapor phase using Chemical Vapor Deposition (CVD) machinery.

[0004] This hydrophobic chemical treatment penetrates the fibres and lowers the surface tension of the fabric, causing water to bead up and roll off the outer layer of fabric, instead of being absorbed. The DWR treatment is not permanent: the surface coating can degrade through regular wear and tear, exposure to dirt, detergent, insect repellent and other impurities causing the outer fabric to absorb water. As the DWR wears off over time, re-treatment is recommended when necessary. Certain types of fabrics need to be re-treated to maintain water-repellency, as fluoropolymers decompose over time when exposed to water and chemicals. As the garment becomes saturated with water, the breathability decreases, as the absorbed water prevents water vapour (perspiration) from passing from the inside to the outside of the garment creating a humid and wet environment inside the garment. Another drawback is that a saturated fabric attracts dirt particles, which clog the pores in the waterproof membrane, reducing breathability even after the garment has dried. Affected garments can be treated with a "spray-on" or "wash-in" treatment to improve water-repellency. Heat treatment may reactivate the factory applied repellent finish and aids the repelling of water, and other liquids such as oils.

[0005] In EP2622120, a method for controlling drying machine is provided, which includes selecting and starting an outdoor textiles drying procedure, and then entering a preheating stage, a main drying stage, and a cooling stage. In the main drying stage, a working temperature of the drying machine is lower than a working temperature of an ordinary drying procedure, and after the cooling stage, nominal water content of loaded outdoor textiles is higher than nominal water content after the ordinary drying procedure is performed. By setting an appropriate drying working temperature, damages on material and sealing strips at seams of the outdoor textiles during the drying procedure are prevented to the greatest extent. Moreover, after the drying procedure is finished, nominal water content of the outdoor textiles is higher than nominal water content of the other textiles after the ordinary drying procedure is performed, which ensures that wrinkles caused by over-drying do not occur to the outdoor textiles, and at the same time, the material and sealing strips at the seams of the outdoor textiles are prevented from being damaged. A drying machine implementing the method is also provided.

[0006] However, the disclosed treatment in a dryer does not provide the optimal solution for re-activating, also called re-proofing, outdoor clothing and textile.

Summary of the invention

[0007] The present invention relates to a method for controlling a heat pump drying machine where an outdoor drying cycle is provided, to re-activate (or "re-proof") the water repellent characteristics of outdoor textiles, such as outdoor clothes and garments.

[0008] Although it is known that a drying cycle in a dryer may improve the re-activation of the water-proofing characteristics of an outdoor textile, as disclosed in the above mentioned patent EP2622120, the Applicant has discovered that the temperature and the humidity at which the outdoor textiles are dried as disclosed and explained in the patent EP2622120 are not optimal for re-activation of the waterproof characteristics of outdoor textiles.

[0009] Applicant has indeed found that the outdoor textile, in order to have the surface treatment "re-activated", needs a drying cycle, or drying cycle phase, having relatively high temperature and low humidity, for example a temperature above 55°C and a humidity below 5%.

[0010] However, heat pump laundry dryers are not generally designed to operate at such high temperatures, that is, generally, heat pump laundry dryers operate at temperatures of the process air, and thus reached by the laundry, below

50°C, which are commonly considered high enough to dry standard clothes or textiles. If a heat pump laundry dryer reaches temperatures above 50° - 55° C in the process air, it may happen that safety measures activate which block or limit either the dryer functioning or further raise in process air temperature.

[0011] Therefore, one of the goal of the invention is to provide a drying method which achieves a proper reactivation of the waterproof characteristics of outdoor textiles - which have had for example a waterproof surface treatment during manufacturing - by means of a drying cycle especially designed for such outdoor textiles and which allows heat pump dryers to reach the required "high" temperatures, i.e. temperatures suitable for performing reactivation of the waterproof characteristics of outdoor textiles.

[0012] According to an aspect, the invention relates to a method for controlling a heat pump laundry drying machine, wherein the heat pump laundry drying machine includes:

- a rotatable drum where textile is introduced and treated with a process air, said drum being driven in two rotation directions;
- a heat pump system having a refrigerant circuit in which a refrigerant can flow, said refrigerant circuit including a first heat exchanger where the refrigerant is cooled off, a second heat exchanger where the refrigerant is heated up, a compressor to pressurize and circulate the refrigerant through the refrigerant circuit; said first and/or second heat exchanger being apt to perform heat exchange between said refrigerant flowing in said refrigerant circuit and said process air;
- a cooling device for cooling a component of the heat pump system;
- a selector adapted to select alternatively at least an outdoor drying cycle for drying outdoor textiles which have a waterproof and breathable thin film material with a micro-porous structure, and at least an additional drying cycle for drying other types of textiles, wherein the outdoor drying cycle includes an outdoor main drying phase having settings for a frequency of reversion of rotations of the drum and for the heat pump operation and the additional drying cycle comprises an additional main drying phase having settings for a frequency of reversion of rotations of the drum and for the heat pump operation;

wherein the method comprises:

- selecting and starting the outdoor drying cycle, and entering the outdoor main drying phase, wherein the outdoor main drying phase includes an outdoor first sub-phase and an outdoor second sub-phase;
- reversing the rotation of the drum in the outdoor first sub-phase at a frequency lower than a frequency in the additional main drying phase;
- entering the outdoor second sub-phase when the humidity of said outdoor textile is equal or below a first threshold;
- in the second sub-phase, reversing the rotation of the drum at a frequency lower than the drum rotation reversal frequency operated in the outdoor first sub-phase; and operating one or more of the following:
    - increasing a flow rate of the process air in the drum with respect to a flow rate in the outdoor first sub-phase and with respect to a flow rate in the additional main drying phase;
    - increasing a velocity of and/or a power supply to a motor of the compressor with respect to a velocity of and/or a power supply to a motor of the compressor in the outdoor first sub-phase and with respect to a velocity of and/or a power supply to a motor of the compressor in the additional main drying phase;
    - increasing a temperature at which the cooling device is activated/deactivated with respect to a temperature at which the cooling device is activated/deactivated in the outdoor first sub-phase and with respect to a temperature at which the cooling device is activated/deactivated in the additional main drying phase.

[0013] The laundry drying machine of the invention may be preferably a laundry dryer or a laundry washer dryer.

[0014] A heat pump laundry drying machine includes a rotatable treating chamber, such as a drum, in which the load of laundry, e.g., clothes, or other items to be washed and/or dried are placed. The laundry is made of a given textile. The treating chamber is adapted to rotate in a direction and in an opposite direction, reversing its rotation, for example driven by a motor, such as a variable speed motor in order to regulate the speed of rotation of the treating chamber.

[0015] The treating chamber is part of a process circuit, in particular for example a closed-loop air circuit in case of a condensed dryer or an open air circuit in case of a vented dryer, which in both cases includes an air duct for channelling a stream of process air to dry the load. The process air circuit is connected with its two opposite ends to the drum. For example, in case of a dryer, hot dehumidified air is fed into the drum, flowing over the laundry, and the resulting humid cool air exits the same. The humid air stream rich in water vapour is then fed into an evaporator of a heat pump, where the moist warm process air is cooled and the humidity present therein condenses. The resulting cool dehumidified air is then either vented outside the appliance in the ambient where the latter is located or it continues in the closed-loop circuit. In this second case, the dehumidified air in the process air circuit is then heated up before entering again in the drum by means of a condenser of the heat pump, and the whole loop is repeated till the end of the drying cycle. Alternatively, ambient air enters into the drum from the ambient via an inlet duct and it is heated up by the condenser of the heat pump before entering the drum. The process air is preferably blown within the process air circuit by means of a process air fan for example a variable speed fan, driven by a motor. Preferably, the motor of the fan and the motor of the treating chamber are the same motor. Different circuits are known in the art in case of a washer-dryer.

[0016] The heat pump of the drying machine includes a refrigerant circuit in which a refrigerant can flow and which connects via piping a first heat exchanger or condenser, a second heat exchanger or evaporator, a compressor and a pressure-lowering device. The refrigerant is pressurized and circulated through the system by the compressor. On the discharge side of the compressor, the hot and highly pressurized vapour is cooled in the first heat exchanger, called the condenser, until it condenses into a high pressure, moderate temperature liquid, heating up the process air before the latter is introduced into the drying chamber. The condensed refrigerant then passes through the pressure-lowering device such as an expansion device, e.g., a choke, a valve or a capillary tube. The low pressure liquid refrigerant then enters the second heat exchanger, the evaporator, in which the fluid absorbs heat and evaporates due to the heat exchange with the warm process air exiting the drum. The refrigerant then returns to the compressor and the cycle is repeated.

[0017] In order to compress the refrigerant, the compressor preferably includes an electric motor which is commonly powered by a current, for example a current coming from the mains.

[0018] The drying machine of the invention includes a selector, for example operable by the user, with which a plurality of drying cycles can be alternatively selected. A drying machine generally includes a plurality of drying cycles each designed to treat laundry made of a specific textile type or composition, such as a cotton cycle at high temperature for cotton textile; permanent press, which generally refers to coloured garments and utilizes medium heat; the knits/delicates cycle is for delicate textiles which cannot withstand very much heat; the delicate cycle uses air slightly above room temperature to gently and slowly dry fragile garments, etc. Therefore, generally the cycle is selected depending on the type of textile to be dried. Among the cycles which can be selected by the selector of the drying machine, the drying machine of the invention includes an outdoor cycle to properly dry outdoor textiles and re-activate - at least partially - their waterproof qualities.

[0019] Many different types of drying cycles can be present in the drying machine of the invention or only two different cycles, among which the outdoor cycle. In the following, the cycle which is present and can be selected in the dryer of the invention in addition to the outdoor drying cycle is called "additional drying cycle".

[0020] Each cycle can differ from the other cycles by a plurality of different settings, such for example the temperature of the process air which flows inside the drum to dry the textile, the time duration of the cycle, the speed of revolution of the drum, the number of changes in direction of revolution of the drum, the degree of humidity at which the textile is considered to be dry and the cycle terminated, etc. All these settings and the corresponding program lines for each cycle are for example included in a memory of the drying machine, for example in a main controller circuit of the drying machine. Further, each cycle, although preferably not visible to the user, may include one or more settings for the heat pump operation.

[0021] Each drying cycle includes a main drying phase, which is the phase in which the clothes and/or textile introduced in the drum are dried. Thus, the outdoor cycle includes an outdoor main drying phase, the cotton drying cycle includes a cotton main drying phase and so on. Each cycle may include also other phases, such as a cooling phase after the main drying phase, in which the laundry is cooled before the user may access them. In the cooling phase, the temperature reached by the textile in the main drying cycle Is reduced. Further, one or more of the drying cycles may include a pre-heating phase where the drum and other components of the drying machine are heated up in order to pre-warm the machine so that it reaches the optimal temperature to start the main drying phase.

[0022] The selection of a laundry drying cycle or program can be made in any possible way, for example by means of a mechanical switch or a rotatable knob, by means of buttons, one per cycle, by means of a touch screen, etc. Further, the selection can be performed by the user manually, by means of a remote control or by means of a wireless command signal, automatically due to a pre-set timer, etc.

[0023] The selection of the cycle preferably depends on the type of clothes, garment, textiles, etc. inserted in the drum.

[0024] Once the selection of the drying cycle is performed, the drying cycle starts. For example, if the outdoor cycle is selected because some outdoor textile has been introduced in the drum, the outdoor cycle starts and either immediately or after other phases, the outdoor main drying phase initiates. The outdoor main drying phase is divided in two sub-phases. The first sub-phase has at least one different setting than the second sub-phase, preferably at least two settings, as detailed below. The second sub-phase starts when a value of a parameter indicative of the humidity of the outdoor textile is detected to be equal or below a first threshold. The first threshold indicates that there is at least a certain level of dryness in the textile itself.

[0025] As mentioned, in a heat pump laundry drying machine, the laundry is dried at a relatively low temperature, e.g. the temperature of the textile present in the drum commonly does not exceed 50°C-55°C. According to the method of the invention, in order to raise the temperature of the textile to a temperature which has been found to be optimal for "proofing", that is, for re-activating at least partially the waterproof layer of the outdoor textile, first the water in the outdoor textile is preferably evaporated so that the heat provided by means of the heated process air can be used to increase the temperature of the outdoor textile and not only to evaporate the water contained therein. It is known that the latent heat of water is relatively high and a substantial temperature increase can take place only when the phase change from liquid to vapour is preferably substantially over. Thus the outdoor first sub-phase is a phase of drying the outdoor textile till a first threshold of humidity, below which the "proofing" phase starts, which is the outdoor second sub-phase. In order to reach a relatively high temperature in the outdoor first sub-phase, preferably the frequency of reversing the rotation of the drum is set lower than a frequency of reversing the rotation in the additional main drying phase.

[0026] Indeed, when rotation of the drum is reversed, a deceleration and a stop of the drum itself takes place. Since a process air fan is generally driven by the same motor that drives the drum into rotation, these deceleration and interruption of motion consequently reduce the amount of process air flowing in the drum, lowering the temperature. For this reason, the number of reversions may influence the temperature of the textile present inside the drum. Keeping the number of reversions low, that is, lower than in the additional drying cycle present in the laundry dryer, may help to increase the overall temperature of the outdoor textile contained in the drum.

[0027] Further, when the humidity in the textile is equal or below the first threshold, the outdoor second sub-phase starts.

[0028] In the second sub-phase, the heat introduced by process air is not only transformed in latent heat but may further increase the temperature of the textile itself. In order to reach a relatively high temperature for a heat pump dryer, that is, in order to reach a temperature preferably above 59°C in the outdoor second sub-phase, the number of reversions of the drum is further decreased with respect to the number of reversions in the outdoor first substep.

[0029] The reduction in the reversion number may also reduce the mechanical action (such as rubbing) on the textile which is re-activated: the reactivation is most probably a surface phenomenon - such as a cross-linking of polymers of the waterproof layer or a redistribution of the polymers on the surface - and mechanical interference of the surface of the textile may reduce or limit the re-activation process.

[0030] In addition to the reduction in reversions, a further expedient is needed in order to reach and keep the desired relatively high temperature in the outdoor second sub-phase. The expedient may be one of the followings or a combination thereof.

[0031] A first possibility might be to increase a flow rate of the process air in the drum with respect to a flow rate in the outdoor first sub-phase and with respect to a flow rate in the additional main drying phase. A higher flow rate of the process air indicates that more heat is supplied to the drum and thus a heat transfer of (sensible) heat to the textile may take place at high rate.

[0032] In addition or alternatively, a second possibility can be to increase a velocity of and/or a power supply to a motor of the compressor with respect to a velocity of and/or a power supply to a motor of the compressor in the outdoor first sub-phase and with respect to a velocity of and/or a power supply to a motor of the compressor in the additional main drying phase. In this case, the compressor needs to be a variable speed compressor. Increasing the compressor speed is preferably performed at the same time in which an increase of flow rate takes place, so that the compressor can always work under safe conditions. Variable speed compressors allow to increase to high flow rate the process air flowing in the drum and to obtain a good control of the temperature of the process air.

[0033] In addition or alternatively, a third possibility can be to increase a temperature at which a cooling device is activated with respect to a temperature at which a cooling device is activated in the outdoor first sub-phase and with respect to a temperature at which a cooling device is activated in the additional main drying phase. The cooling device can be for example a compressor cooling fan apt to blow air towards the compressor. The compressor, in order to work in safety conditions, preferably should not overheat, that is, there is a field of working conditions, function of the temperature of the compressor and of the absorbed current of the electric motor of the compressor, in which the compressor can work without overheating. In case the temperature of the compressor, or the temperature of the refrigerant detected in a point of the refrigerant circuit so as to indicate the temperature of the compressor, increases above the safety condition, preferably a fan, called compressor cooling fan, is activated to blow air against the compressor and to cool it. Increasing the temperature at which the fan starts to blow air against the compressor is preferably performed at the same time in which an increase of flow rate in the drum (and thus through the heat exchanger of the heat pump) takes place, so that the compressor can always work under safe conditions. Alternatively or in addition, the cooling device could be a different fan. Not cooling the compressor, but cooling for example other components of the laundry drying machine, such as one of the motors. Alternatively or in addition, the cooling device could be a conduit leading to the exterior of the laundry drying machine to direct cool air from the ambient outside the machine towards a component of the drying machine which may overheat during functioning.

[0034] Preferably, the invention, according to the above mentioned aspect, includes in combination or alternatively, one or more of the following characteristics.

[0035] Preferably, said outdoor first sub-phase and said outdoor second sub-phase are temporally subsequent to each other, the outdoor first sub-phase being performed first. The outdoor first sub-phase is preferably used to reduce the humidity of the outdoor textile so that the heat transferred to the textile is not only transformed in latent heat but also in sensible heat, so that the temperature of the textile can be more easily increased. After the outdoor textile is substantially dry, that is, has a humidity equal or below a first threshold, the outdoor second sub-phase, or "proofing" phase where a further increase of temperature preferably takes place, may start.

[0036] Preferably, the step of entering the outdoor second sub-phase when the humidity of said outdoor textile is equal or below a first threshold includes:

- detecting a signal indicative of the humidity of the outdoor textile.

[0037] The humidity of the outdoor textile can be checked using any know system in the art.

[0038] More preferably, the step of detecting a signal function of the humidity of the outdoor textile includes one or more of:

- detecting a conductimetric signal (Hum) from a sensor indicative of the electric resistance of the outdoor textile;
- detecting a temperature of the process air flow exiting the drum;
- detecting a temperature of the refrigerant flowing in the refrigerant circuit of the heat pump;
- detecting a temperature of the process air exiting the first or second heat exchanger of the heat pump;
- detecting a level and/or the temporal gradient of a level of water removed from the outdoor textile to be dried and collected in a water container;
- detecting an electric parameter of a motor driving the rotatable drum;
- detecting the number of activations of a pump driving water removed from the outdoor textile to a container.

[0039] The humidity of the outdoor textile present inside the drum can be detected using one (or more) of a plurality of different sensors. A combination of signals provided by different sensors can be used as well. The signal can be a direct humidity signal, for example coming from a sensor measuring a resistance of the laundry which is contacting one or more electrodes located within the drum. A higher degree of dryness corresponds to a higher electrical resistance. Alternatively or in addition, the temperature of the process air, either at the inlet or at the outlet of the drum, may give an indication of the degree of dryness of the laundry. Further, the temperature of the process air can also be measured at the exit of one of the heat exchanger of the heat pump. The temperature of the refrigerant might also give an indication of the humidity of the outdoor textile in the drum. Further, measuring the level of water in a container where the condense water collects, or the temporal gradient of a level of water removed from the container, may also indicate whether the laundry is dry or not: if for example the level of water does not increase for a given time interval, reasonably it means that there is no more water to be removed from the textile in the drum and that the textile is thus substantially dry. The number of activations of a pump driving water removed from the textile contained in the drum to a container, may also be representative of the laundry humidity status within the drum. Further, one or more electrical parameters of the drum motor may also indicate the level of humidity of the textile, such as for example the absorbed power. The textile is heavier when water is contained therein and becomes lighter the dryer it is.

[0040] Preferably, said heat pump drying machine includes a humidity sensor emitting a humidity signal indicative of the humidity of the textile and wherein the method includes:

- when said additional drying cycle is selected, terminating said additional main drying cycle when said humidity signal is below a second threshold;
- when said outdoor drying cycle is selected, terminating said outdoor second sub-phase when a pre-determined minimum duration time (t1 set) has elapsed.

[0041] More preferably, said outdoor second sub-phase is terminated when the pre-determined minimum duration time has elapsed, regardless of the value of said humidity signal.

[0042] The humidity sensor might be a sensor performing one or more of the measurements above indicated: it might be an electrode measuring the resistance of the laundry, or a temperature sensor, etc. In "ordinary" or "additional" drying cycles, that is, in cycles except the outdoor drying cycle, it is rather common that the drying cycle itself terminates when the humidity sensor emits a signal which indicates that the laundry is dry, i.e. its moisture contents is equal or lower than a predetermined amount. The level of dryness at which the cycle is terminated depends generally on the type of selected cycle, for example if an "iron press" cycle has been selected, the cycle is terminated at a humidity of the laundry which is higher than the humidity at which the cotton drying cycle is terminated. In any case, each non-outdoor cycle commonly has a "humidity threshold" (second threshold) which, when the humidity lowers below such a threshold, the cycle is ended. However, in case of the second sub-phase of the outdoor main drying phase, it is preferred to keep the high temperature for a pre-determined minimum duration time in order to regenerate the waterproof qualities of the textile, preferably independently from the signals coming from the humidity sensor. Indeed, the purpose of the second sub-phase is not to completely dry the textile (which might be already dry), but to regenerate the surface waterproof treatment, at least partially. Therefore, preferably, in the second sub-phase of the outdoor cycle, the signal coming from the humidity sensor is substantially "overruled" and considered again only when the pre-determined minimum duration time has elapsed.

[0043] This pre-determined minimum duration time may be a constant which is memorized in a memory of the drying machine and stored there during the machine manufacturing. It can be variable, and for example it can be chosen among a plurality of constants, e.g. the proper value of the duration time can be selected among the various duration time available depending on further characteristics of the drying cycle, for example on the weight of the load.

[0044] More preferably, said pre-determined minimum duration time may be set depending on temperature and/or pressure ambient conditions of the ambient where said heat pump drying machine is located. For example, the pre-determined duration time is longer in case the temperature of the ambient in which the drying machine is located is rather low or in case the humidity of the ambient in which the drying machine is located is rather high.

[0045] More preferably, said pre-determined duration time lasts at least 20 minutes. It has been shown that the minimum amount of time to obtain a regeneration of the waterproof characteristics of the textile is preferably above 20 minutes.

[0046] Preferably, said pre-determined minimum duration time is set or adjusted depending on the temperature of the outdoor textile in the outdoor second sub-phase.

[0047] Indeed, only a fraction of the real elapsed time after the beginning of the outdoor second sub-phase may be counted in order to check whether the elapsed time is above or below the pre-determined minimum duration time: Indeed, for example, to determine when the outdoor second sub-phase has to end, only the time during which the outdoor textile is above a threshold temperature is counted. All the time in which the textile is below the threshold temperature is not counted as being part of the elapsed time.

[0048] Preferably, in said outdoor second sub-phase, the outdoor textile temperature and/or a process air temperature indicative of the temperature of the outdoor textile is controlled to be equal or above 55°C. Without being bound by theory, the proofing of the outdoor textiles takes place at temperatures at above 55°C, more preferably at above 59°C. Therefore, such temperatures are reached in the drum of the drying machine of the invention during the outdoor second sub-phase and even more preferably they are kept during the whole, or the majority of the, second sub-phase.

[0049] Preferably, said heat pump laundry drying machine includes a process air fan to supply process air to the drum and wherein said additional drying cycle and said outdoor drying cycle includes a cooling phase after said additional main drying phase and said outdoor main drying phase, respectively, wherein the heat pump system (44) is off and the process air fan is on. More preferably, the outdoor cooling phase lasts at least 10 minutes. In order to safely handle the textiles after the drying phase, in particular after the outdoor main drying phase where relatively high temperatures are reached, preferably a cooling phase is introduced after the main drying phase. In the cooling phase the heat pump system is off and the process air fan is on.

[0050] Preferably, said first threshold of humidity is equal or lower than about 5%. More preferably the first threshold is lower than or equal to 4%. During the portion of the drying phase in which the water evaporates from the textile, the temperature of the textile hardly exceeds a certain value due to the fact that the heat is transferred to latent heat of evaporation. Therefore, preferably the outdoor second sub-phase, where a high temperature is desired, is initiated only when almost all water contained in the textile has evaporated.

[0051] Preferably, said second threshold is lower than or equal to about 3%. Generally, considering the intrinsic errors of humidity sensors, the textile is considered dry when the humidity of the same falls below 3%.

[0052] Preferably, a nominal water content of the outdoor textiles at the end of the outdoor cooling phase is lower than nominal water content of the other textiles after completing the additional cooling stage.

[0053] As an example, the textiles with nominal water content of 0% are defined and obtained by the following two methods alternatively: 1) the textiles are left for a first period of time, preferably at least 72 hours, in an ambient temperature between 18°C to 22°C and an ambient humidity between 60% to 70% when the weight of the textiles changes by less than 0.5% for two successive weightings, which are carried out at two-hour intervals; 2) the textiles are hung singly and separately so that air can freely circulate, and are left in an ambient temperature between 18°C to 22°C and an ambient humidity between 60% to 70% for a second period of time, preferably not less than 48 hours. And percentage values from 0% of nominal water content are calculated as relations between mass of water content and dry weight of the textiles.

[0054] Preferably, the frequency of rotation reversion in the outdoor second sub-phase is equal to zero. In order to minimize the time slots in which process air is flowing in the drum at low flow rate, preferably there is no reversion of rotation of the drum in the outdoor second sub-phase of the outdoor main drying cycle.

[0055] Preferably, the frequency of rotation reversion in the outdoor first sub-phase is equal or below 6 reversions per hour.

[0056] Preferably, in said outdoor first sub-phase, wherein in said outdoor first sub-phase, one or more of the following takes place:

- producing a process air flow rate of the process air in the drum greater than a process air flow rate in the additional main drying phase;
- driving a motor of the compressor with a velocity and/or a power supply which are greater than a velocity and/or a

power supply driving the same motor in the additional main drying phase;

- setting a temperature at which a cooling device is activated/deactivated which is greater than a temperature at which a cooling device is activated/deactivated in the additional main drying phase.

[0057] As described in connection with the outdoor second sub-phase, these expedients allow to raise the temperature inside the drum. This raise in temperature is desired to dry the clothes in a reasonable amount of time and to be allowed to start the outdoor second sub-phase. Preferably, any of the above expedients takes place contemporarily to the lowering of the frequency of rotation reversion with respect to the frequency of the additional main drying phase. Preferably, the cooling device is the compressor cooling fan.

Brief description of the drawings

[0058] 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 perspective view of a drying machine according to the invention,
- Fig. 2 a schematic overview of some components of the drying machine of Fig. 1,
- Fig. 3 a block diagram depicting some of the components of the drying machine of Fig. 1 providing signals to a control unit and/or being controlled by the control unit,
- Fig. 4 is a plurality of graphs showing the temporal behaviour of several parameters of the drying machine of the invention during the outdoor drying cycle, and
- Fig. 5 is a flow chart of the method of the invention.

[0059] Fig. 1 shows a perspective outer appearance of an exemplary laundry drying machine 2. In this embodiment, the laundry drying machine is a laundry dryer only, but in alternative embodiments the dryer function according to the control method is implemented by a laundry washer-dryer in which the rotatable drum is arranged in a tub and which provides a washing arrangement including (for example) a detergent dispenser, a heater for heating wash liquid and a drain pump for draining out of the liquids.

[0060] As shown in Fig. 1, the laundry drying machine 2 has an outer housing 4 or cabinet including a front wall 6. At the front wall 6 a loading opening 8 is provided which is closed by a door 10. In the depicted embodiment, the laundry dryer is a front-loading laundry dryer having a horizontal drum rotation axis, but in alternative embodiments the drum may be inclined relative to the horizontal and vertical directions, or the dryer may be a vertical rotation axis dryer in which the drum rotates around a vertical axis and where top-loading is provided.

[0061] The laundry drying machine 2 has a control panel 12 arranged at the upper region of the front wall 6 and a condensate drawer 14 in which the condensate collected from drying is stored until removal by the user.

[0062] In the schematic diagram of components shown in Fig. 2, the drum 16 is arranged inside the housing 4, in which laundry 18 is received. The flow of process drying air A is indicated by the arrows, wherein the drying air A leaves the drum 16 at an outlet 24 and enters a process air channel 20 at the front channel 20c. By the front channel 20c the process drying air is guided through a fluff filter element 26 towards a second heat exchanger 34 and a first heat exchanger 32. The first and second heat exchangers 32, 34 are arranged in a battery channel 20a of the process air channel 20. The first heat exchanger 32 is a condenser which heats the process drying air and the second heat exchanger 34 is an evaporator which cools the process drying air for humidity removal in form of condensed water.

[0063] The process drying air leaving the first heat exchanger 32 is entering a rear channel 20b in which a drying process air fan 28 is arranged which conveys the drying air. The process air fan 28 is driven by a motor 30, which preferably at same time drives the rotation of the drum 16. However two different motors can be provided as well. The rotation of the drum 16 can be in one direction and also in the opposite direction, that is, reversing the rotation of the drum is possible in the laundry dryer operation, by opportunely driving the drum driving motor. In the depicted embodiment, a belt driven by the motor 30 is wound around the drum mantel for driving the fan. In the depicted embodiment, in which the single motor 30 drives the process air fan 28 as well as the drum 16, the drum and process air fan 28 are driven in a synchronous manner according to the gear ratio. Preferably, the speed of the drum and/or the process air fan is adjustable. Synchronous rotation of the drum includes a forward and backward rotation according to the motor forward and backward rotation, so that the direction of rotation of the drum can also be changed, form a forward to a backward or vice versa. As an example, the fan speed is identical to the motor speed as the process air fan is arranged on an axis of the motor 30, while via the belt the rotation of the motor is gear-reduced in an exemplary ratio of motor rotation speed/drum rotation speed of 50:1.

[0064] The first and second heat exchangers 32, 34 are part of a heat pump system 44 which further comprises an expansion device 38 and a compressor 36. In the heat pump system 44 a refrigerant loop 40 is formed, wherein the refrigerant pumped by the compressor 36 passes first the condenser 32, is forwarded to the expansion device 38 from where it expands into the second heat exchanger 34 and from where it is sucked into the compressor 36. Heat can be removed from the heat pump system (in addition to the heat deposited in the drying air and laundry for drying the laundry) by activating a compressor cooling fan 42 which provides a flow of cooling air from the outside of the cabinet 4 towards the outer surfaces of the compressor 36. The compressor cooling fan can be activated, that is, it can start blowing air against the compressor, for example above a given compressor temperature, and/or it may be deactivated, that is, it may stop blowing air against the compressor, for example below a given compressor temperature. After passing the compressor 36, the cooling air blown by the compressor cooling fan 42 is exhausted out of the cabinet 4.

[0065] The condensate that is formed at the evaporator 34 flows down and collects in a condensate collector 48. From the condensate collector 48 the condensate is pumped by a draining pump 50 through a drain conduit 52 into the condensate drawer 14 from where it can be removed by the user as mentioned above. Preferably, in the condensate collector 48, the level of water can be measured by means of a level sensor and/or the temporal gradient of a level of water removed from the outdoor textile to be dried and collected can be measured as well.

[0066] One or more of the following can be present in the laundry dryer as well: at the outlet 24 of the drum 16 a temperature sensor, for example a thermocouple, is provided which detects the outlet temperature To of the drying air. At the inlet 22 of the drum 16 another temperature sensor, for example a thermocouple, is provided which detects the inlet temperature Ti of the drying air. At the outlet of the condenser 32 a temperature sensor is provided which detects the refrigerant temperature Tr at this position. Inside the drum, electrodes may be present as well to determine the degree of humidity Hum of the laundry when it contacts the electrodes, for example by means of a resistivity measurement.

[0067] Fig. 3 is a block diagram of components of the dryer 2 that interact for enabling a control unit 60 to control the drying operations or programs. The control unit 60 has a memory 62 in which program parameters and look-up tables are stored such that the control unit, by retrieving corresponding data from the memory 62, can control different basic drying programs preferably under conditions as set by the user via option selectors at the control panel 12. The user can select a program cycle among a list of different program cycles. The selection can be performed by means of a selector (not shown in the drawings and standard per se) in the panel 12. Such user-settable options are for example: the type of drying cycle (cotton, delicate, outdoor, etc.), the final drying degree, the load of the laundry loaded by the user and inputted by him/her, the type of laundry, the duration of drying, an energy option, etc.

[0068] Among the cycles, an outdoor cycle is included, which is preferably selected when outdoor textile is introduced in the laundry 16.

[0069] Preferably, each cycle includes a main drying phase and a subsequent cooling phase. A pre-heating phase may be optionally included as well.

[0070] With now reference to figure 5, the dryer 2 is switched on in step S0 and a drying cycle is selected among those selectable by the selector.

[0071] In any selected drying cycle, the control unit 60 sends control signals to a drum motor inverter 64 and may receive operation parameters therefrom. The drum motor inverter 64 supplies the power to the motor 30 driving the drum 16 and the drying air fan 28. The control unit 60 may send control signals to a compressor motor inverter 66 and may receive operation parameters therefrom. The inverter 66 powers a compressor motor 67 for driving the compressor 36. Further, the control unit 60 may control the draining pump 50, a motor 68 for driving the compressor cooling air fan 42 and optionally, if a separate motor 70 is provided for the drying air fan 28, the drying air fan motor 70. The command signals sent by the control unit 60 depend on the specific settings of the specific program (drying cycle) selected.

[0072] If an additional program - and not an outdoor program cycle - has been selected by the selector, an additional main drying cycle starts according to any prior art known program - step S1. The settings of the main drying cycle of the additional programs are stored in the memory 62 and they may relate to one or more of: a frequency of the reversion of rotations of the drum 16 during the main drying cycle, to a speed of the process or drying air fan 28, to the temperature level T1 at which the compressor cooling fan 42 activates or deactivates, the speed of the drum 16, the heat pump operation parameters. Preferably, during this additional main drying cycle, the control unit 60 monitors not only the signals coming from the motor 30 or its inverter, the compressor cooling fan 42, the compressor motor inverter, the process air fan 28, etc, but also it preferably further monitors the signals coming from one or more sensors, for example it may receive the signals from the sensors for the refrigerant temperature Tr, or for the inlet temperature Ti of the drying air, or for the outlet temperature To of the drying air, or the conductivity measurements Hum made by the electrodes in the drum 16, or the level of water in the condensate collector 48 and/or the temporal gradient of a level of water removed from the outdoor textile to be dried and collected can be measured as well, or relative to the number of activations of the draining pump 50 of the condensate collector 48. The control unit 60, when one or more of these received signals from one or more sensors indicates that a degree of humidity present in the textile present in the drum 16 is below a given threshold (second threshold), preferably for example a content of humidity in the textile is below 3 %, commands the dryer 2 to terminate the main drying cycle. If the degree of humidity is not below this second threshold, then the additional main drying cycle continues. When the main drying cycle terminates, preferably a cooling cycle - step S11 - follows.

[0073] In case the outdoor program cycle has been selected by means of the selector in the panel 12, the method of the invention provides the following.

[0074] The control unit 60 starts the outdoor main drying phase. In certain embodiment of the invention, previously to the main drying phase, additional phases may be present, for example an outdoor pre-heating phase. The outdoor main drying phase starts with the outdoor first sub-phase, step S2. The control unit 60 thus sends command signals to the drum motor inverter 64 so that a frequency F1 of reversion of rotations of the drum 16 is reduced with respect to an additional cycle present in the memory 62 of the control unit 60. Preferably, the frequency F1 is lower than the frequency of any other cycle stored in the memory 62 and selectable by the selector. For example, the frequency F1 is selected to be equal to 6 reversions per hour.

[0075] Further, one or more of the following can be performed. The number of revolutions per minute RPM1 of the motor driving the drum 16 in the outdoor first sub-phase may be increased with respect to the rpm present in the main drying phase of the additional drying cycle by means of command signals sent by the control unit 60 to the drum motor inverter 64, so as to increase the flow rate of process air in the drum 16. For example, the RPM1 can be of about 2750 rpm or 2900 rpm. Alternatively or in addition, the control unit 60 may send command signals to the drying air fan motor 70, 30 to increase its velocity with respect to a velocity in the additional drying cycle selectable in the selector. Alternatively or in addition, the control unit 60 may send command signals to the compressor cooling fan motor 68 in order to increase the temperature T1 at which the compressor cooling fan 42 activates/deactivates with respect to a temperature at which the compressor cooling fan activates/deactivates in the additional drying cycle selectable by the selector. Alternatively or in addition, the control unit 60 may send command signal to the compressor motor inverter 66 so as to increase the velocity of or the power supply to the motor 67 of the compressor 36 with respect to the velocity in the additional main drying cycle.

[0076] The first outdoor sub-phase then takes place with the settings above indicated.

[0077] The control unit 60 further monitors the signals coming from one or more sensors, for example it may receive the signals from the sensors for the refrigerant temperature Tr, or for the inlet temperature Ti of the drying air, or for the outlet temperature To of the drying air, or the conductivity measurements Hum made by the electrodes in the drum 16, or the level of water in the condensate collector 48. The control unit 60, when one or more of these signals indicate a degree of humidity present in the outdoor textile below a first threshold, preferably for example a humidity below 5 %, commands the drying machine 2 to enter the second sub-phase of the outdoor main drying cycle. If the degree of humidity of the outdoor is not below this first threshold, then the outdoor first sub-phase continues.

[0078] In the outdoor second sub-phase, step S3, the control unit 60 thus sends command signals to the drum motor inverter 64 so that the frequency F2 of reversion of rotations of the drum 16 is reduced with respect to the outdoor first sub-phase. Preferably, the frequency F2 is lower than the frequency of any other program in the memory 62 selectable by the selector. For example, the frequency F2 is selected to be equal to zero.

[0079] Further one or more of the following can be performed. The number of revolutions per minute RPM2 of the motor driving the drum 16 may be increased with respect to the outdoor first sub-phase by means of the control unit 60 sending command signals to drum motor inverter 64. This is particularly advantageous when the drum 16 and the fan 28 are driven by the same motor 30 because the flow rate of process air in the drum 16 is increased. For example the RPM can be of about 3000 rpm. Alternatively or in addition, the control unit 60 may send command signals to the drying air fan motor 70 to increase its velocity with respect to a velocity in the outdoor first sub-phase. Alternatively or in addition, the control unit 60 may send command signals to the compressor cooling fan motor in order to increase the temperature T2 at which the compressor cooling fan 42 activates with respect to a temperature at which it activates in the outdoor first sub-phase. Alternatively or in addition, the control unit 60 may send command signals to the compressor motor inverter 66 so as to increase the velocity of or the power supply to the motor of the compressor 36 with respect to the velocity of or the power supply to the motor of the compressor in the outdoor first sub-phase.

[0080] If, during either the first or the second sub-phase of the outdoor main drying phase, the control unit 60 receives a signal from any of the above described sensors indicating that the humidity of the outdoor textile has further lowered, for example below the second threshold at which the additional main drying cycle ends, the control unit 60 does not end the outdoor first or second sub-phase unless the following additional condition is verified.

[0081] The second sub-phase of the outdoor main drying phase terminates when the outdoor sub-phase has lasted at least for a predetermined duration time t1 set. This time interval can be constant, that is, in the memory 62 a fixed value of the t1 set is present, or it may change. For example this duration time may be adjusted depending on the amount of time at which the outdoor textile inside the drum 16 exceeds a temperature threshold Tthr which is preferably of about 59°C. Thus, in this embodiment, the outdoor second sub-phase is terminated when a duration time t1 set has elapsed, where t1 set depends on how much time the temperature of the outdoor textile during the second sub-phase exceeds Tthr. In this way it is ensured that the outdoor textile is kept at a desired temperature for a minimum time. Therefore this t1 set is constantly updated during the cycle and only the fraction of the time during which the temperature of the outdoor textile is above Tthr is considered. The second sub-phase therefore terminates when the t1 set is elapsed thereby ensuring that the time during which the temperature of outdoor textiles is above Tthr is sufficiently long to re-activate (or "re-proof") the water repellent characteristics of outdoor textiles. Alternatively, it is sensed how many times the temperature during the second outdoor sub-phase goes below Tthr and after a given number of times in which the temperatures drop below Tthr, the second sub-phase is duration time is adjusted, in particular extended. Alternatively, this t1set can be set depending on the ambient temperature and/or pressure conditions of the ambient in which the drying machine 2 is located, for example at the beginning of the outdoor cycle several parameters of the ambient are sensed and a corresponding fixed value of the t1 set is selected, for example from a look-up table or curve of t1 set vs. ambient conditions present in the memory 62 of the control unit 60.

[0082] After this t1 set has elapsed, then the outdoor second sub-phase is terminated and then a cooling phase may start, step S4, in order to cool the outdoor textile which has reached relatively high temperatures due to the re-activation phase (second sub-phase).

[0083] The cooling phase preferably lasts for more than 10 minutes.

[0084] Figure 4 shows the temporal behaviour of several parameters during an outdoor cycle in a drying machine 2 of the invention. In the dryer 2, an outdoor cycle has been selected. In figure 4, the division between the main drying phase and the cooling phase has been depicted, as a first vertical line which divides the first and the second sub-phase of the main drying phase, and the division between the main drying phase and the cooling phase is shown as well as another vertical line. In the graph, only the behaviour over time of the curves has been depicted, in order to show the overall curve shape, the units used are arbitrary.

[0085] The depicted graphs represent the following signal (from top to bottom):

- temperature of the process air at drum INLET (signal from a thermocouple);
- temperature of the process air at drum OUTLET (signal from a thermocouple);
- electric power supply to the dryer (total amount).

[0086] As clear from the graphs, the temperature in the outdoor first sub-phase constantly increases and in the outdoor second sub phase is substantially kept constant at a high value.

[0087] The results obtainable with the outdoor cycle of the invention can be summarized in the following Tables.

[0088] The following outdoor textiles have been texted:

1. First textile, realized by 2 knitted fabric layers, 1 raised 1 flat, bonded by polyurethane glue (Cycling, walking, not specialized mountain garments);
2. Second textile, realized in 3 layers glued together: flat knitted fabric (elastic), polyurethane membrane, flat knitted fabric (High level fabric, for running or cycling);
3. Third textile, realized in 3 layers glued together: woven external, PTFE membrane in between, internal knitted fabric to avoid abrasion (Top of the range fabric for outer shell application like mountain specialized garments); and
4. Fourth textile, realized in 100% polyammide pressed plus fluorocarbon finishing (City outdoor or casing for feather products, wind proof, or portable low bulk garment).

[0089] The following tests have been performed to test the waterproof characteristics of the textiles:

a) Rain test according to UNI EN ISO 4920 (+ gravimetric measure)
b) impact rain test -- AATCC TM 42 (+ gravimetric measure)

[0090] In these tests, the weight increase of the textile due to water presence is measured. In all tables, the percentage of weight increase with respect to the new textile is visualized (that is, after the rain test or the impact test on a new outdoor textile and on an used outdoor textile of the same type, both the new outdoor textile and the "used" outdoor textiles which underwent the outdoor drying cycle are weighted and the percentage of weight increase of the used textile with respect to the new textile is given)

Textile 1 – rain text	
New textile	0
After outdoor cycle of the invention	15,97%
After an additional cycle	44,47%
Dried in air	40,10%

TABLE 1

Textile 2 – rain text	
New textile	0
After outdoor cycle of the invention	10,10%
After an additional cycle	37,55%
Dried in air	24,78%

TABLE 2

Textile 3 – impact text	
New textile	0
After outdoor cycle of the invention	4,23%
After an additional cycle	7,81%
Dried in air	33,26%

TABLE 3

Textile 4 – rain text	
New textile	0
After outdoor cycle of the invention	4,90%
After an additional cycle	26,02%
Dried in air	26,76%

TABLE 4

[0091] As shown in the tables, the results strongly depends on the type of outdoor textile used, however whatever the textile is, the results obtained with the outdoor drying cycle are quantitatively better than the results obtainable with "other cycles".

[0092] The outdoor drying cycle of the invention is compared with:

- a "standard" drying cycle, that is, a cycle in a heat pump dryer where the temperature remains below 55°C in the main drying cycle;
- drying in air, that is, drying the outdoor garment not using a dryer but simply leaving the textile to dry in ambient air.

[0093] The best waterproof results are obtained with a new textile, where the waterproof characteristics of the fabric are intact. However, in used textiles which have been worn for a number of hours, with the method of the invention a good reactivation of the waterproof characteristics - compared to other drying methods - is achieved.

Claims

1. A method for controlling a heat pump laundry drying machine (2), wherein the heat pump laundry drying machine includes:

   - a rotatable drum (16) where textile is introduced and treated with a process air (A), said drum being driven in two rotation directions;
   - a heat pump system (44) having a refrigerant circuit (40) in which a refrigerant can flow, said refrigerant circuit including a first heat exchanger (32) where the refrigerant is cooled off, a second heat exchanger (34) where the refrigerant is heated up, a compressor (36) to pressurize and circulate the refrigerant through the refrigerant circuit (40); said first and/or second heat exchanger being apt to perform heat exchange between said refrigerant flowing in said refrigerant circuit and said process air;
   - a cooling device (42) for cooling a component (36) of the heat pump system;
   - a selector adapted to select alternatively at least an outdoor drying cycle for drying outdoor textiles which have a waterproof and breathable thin film material with a micro-porous structure, and at least an additional drying cycle for drying other types of textiles, wherein the outdoor drying cycle includes an outdoor main drying phase having settings for a frequency of reversion of rotations of the drum and for the heat pump operation and the additional drying cycle comprises an additional main drying phase having settings for a frequency of reversion of rotations of the drum and for the heat pump operation;

   wherein the method comprises:

   - selecting and starting the outdoor drying cycle, and entering the outdoor main drying phase, wherein the outdoor main drying phase includes an outdoor first sub-phase (S2) and an outdoor second sub-phase (S3);
   - reversing the rotation of the drum (16) in the outdoor first sub-phase at a frequency (F1) lower than a frequency in the additional main drying phase;
   - entering the outdoor second sub-phase when the humidity of said outdoor textile is equal or below a first

threshold;
- in the second sub-phase, reversing the rotation of the drum at a frequency (F2) lower than the drum rotation reversal frequency (F1) operated in the outdoor first sub-phase; and operating one or more of the following:

• increasing a flow rate of the process air in the drum with respect to a flow rate in the outdoor first sub-phase and with respect to a flow rate in the additional main drying phase;
• increasing a velocity of and/or a power supply to a motor (67) of the compressor (36) with respect to a velocity of and/or a power supply to a motor of the compressor in the outdoor first sub-phase and with respect to a velocity of and/or a power supply to a motor of the compressor in the additional main drying phase;
• increasing a temperature at which the cooling device (42) is activated/deactivated with respect to a temperature at which the cooling device is activated/deactivated in the outdoor first sub-phase and with respect to a temperature at which the cooling device is activated/deactivated in the additional main drying phase.

2. The method according to claim 1, wherein the step of entering the outdoor second sub-phase when the humidity of said outdoor textile is equal or below a first threshold includes:

- detecting a signal indicative of the humidity of the outdoor textile.

3. The method according to claim 2, wherein the step of detecting a signal indicative of the humidity of the outdoor textile includes one or more of:

- detecting a conductimetric signal (Hum) from a sensor indicative of the electric resistance of the outdoor textile;
- detecting a temperature of the process air flow exiting the drum (16);
- detecting a temperature of the refrigerant flowing in the refrigerant circuit (40) of the heat pump (44);
- detecting a temperature of the process air exiting the first or second heat exchanger (32, 34) of the heat pump (44);
- detecting a level and/or the temporal gradient of a level of water removed from the outdoor textile to be dried and collected in a water container;
- detecting an electric parameter of a motor driving the rotatable drum;
- detecting the number of activations of a pump driving water removed from the outdoor textile to a container.

4. The method according to any of the preceding claims, wherein said heat pump laundry drying machine (2) includes a humidity sensor emitting a humidity signal (Hum, Ti, To, Tr) indicative of the humidity of the textile and wherein the method includes:

- when said additional drying cycle is selected, terminating said additional main drying cycle when said humidity signal is equal or below a second threshold; when said outdoor drying cycle is selected, terminating said outdoor second sub-phase when a pre-determined minimum duration time (t1 set) has elapsed.,

5. The method according to claim 4, wherein said pre-determined minimum duration time (t1set) is set depending on temperature and/or pressure conditions of the ambient where said heat pump laundry drying machine (2) is located.

6. The method according to claim 4 or 5, wherein said pre-determined minimum duration time (t1 set) lasts at least 20 minutes.

7. The method according to any of claims 4 - 6, wherein said pre-determined minimum duration time (t1 set) is set or adjusted depending on the temperature of the outdoor textile in the outdoor second sub-phase.

8. The method according to any of the preceding claims, wherein, in said outdoor second sub-phase, the outdoor textile temperature and/or a process air temperature indicative of the temperature of the outdoor textile is controlled to be equal or above 55 °C.

9. The method according to any of the preceding claims, wherein said heat pump laundry drying machine (2) includes a process air fan (28) to supply process air to the drum (16) and wherein said additional drying cycle and said outdoor drying cycle includes a cooling phase (S4, S11) after said additional main drying phase and said outdoor main drying phase, respectively, wherein the heat pump system (44) is off and the process air fan (28) is on.

10. The method according to claim 9, wherein the outdoor cooling phase (S4) lasts at least 10 minutes.

11. The method according to any of the preceding claims, wherein said first threshold of humidity is equal or lower than about 5%.

12. The method according to any of the receding claims when dependent on claim 4, wherein said second threshold of humidity is lower than or equal to about 3%.

13. The method according to any of the preceding claims when dependent on claim 4, wherein a nominal water content of the outdoor textiles at the end of the outdoor cooling phase is lower than nominal water content of the other textiles after completing the additional cooling stage.

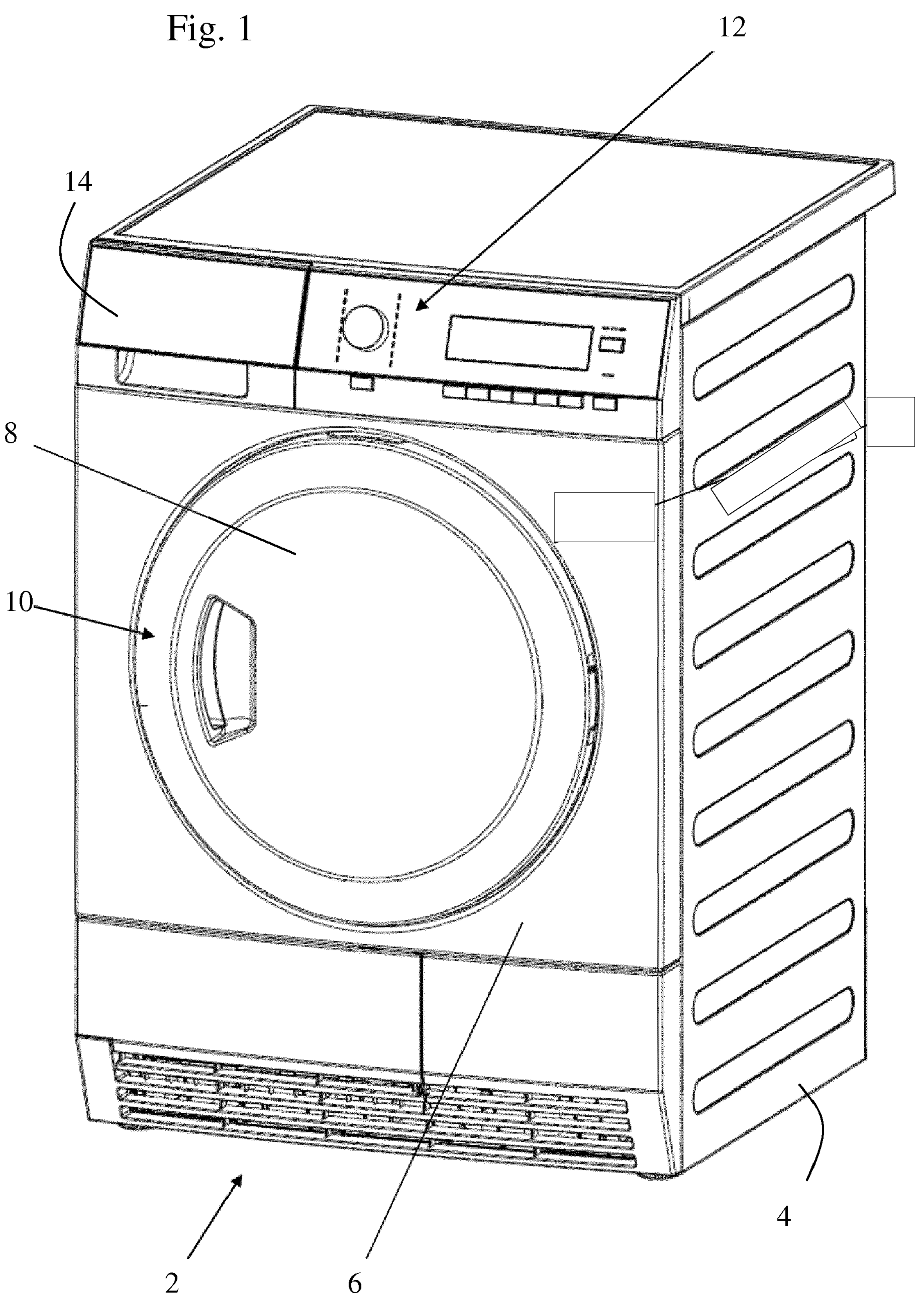
14. The method according to any of the preceding claims, wherein the frequency (F2) of rotation reversion in the outdoor second sub-phase is equal to zero.

15. The method according to any of the preceding claims, wherein the frequency (F1) of rotation reversion in the outdoor first sub-phase is equal or below 6 reversions per hour.

16. The method according to any of the preceding claims, wherein in said outdoor first sub-phase, one or more of the following takes place:

- producing a process air flow rate of the process air in the drum (16) greater than a process air flow rate in the additional main drying phase;
- driving a motor (67) of the compressor (36) with a velocity and/or a power supply which are greater than a velocity and/or a power supply driving the same motor in the additional main drying phase;
- setting a temperature at which a cooling device (42) is activated/deactivated which is greater than a temperature at which a cooling device is activated/deactivated in the additional main drying phase.

Fig. 1



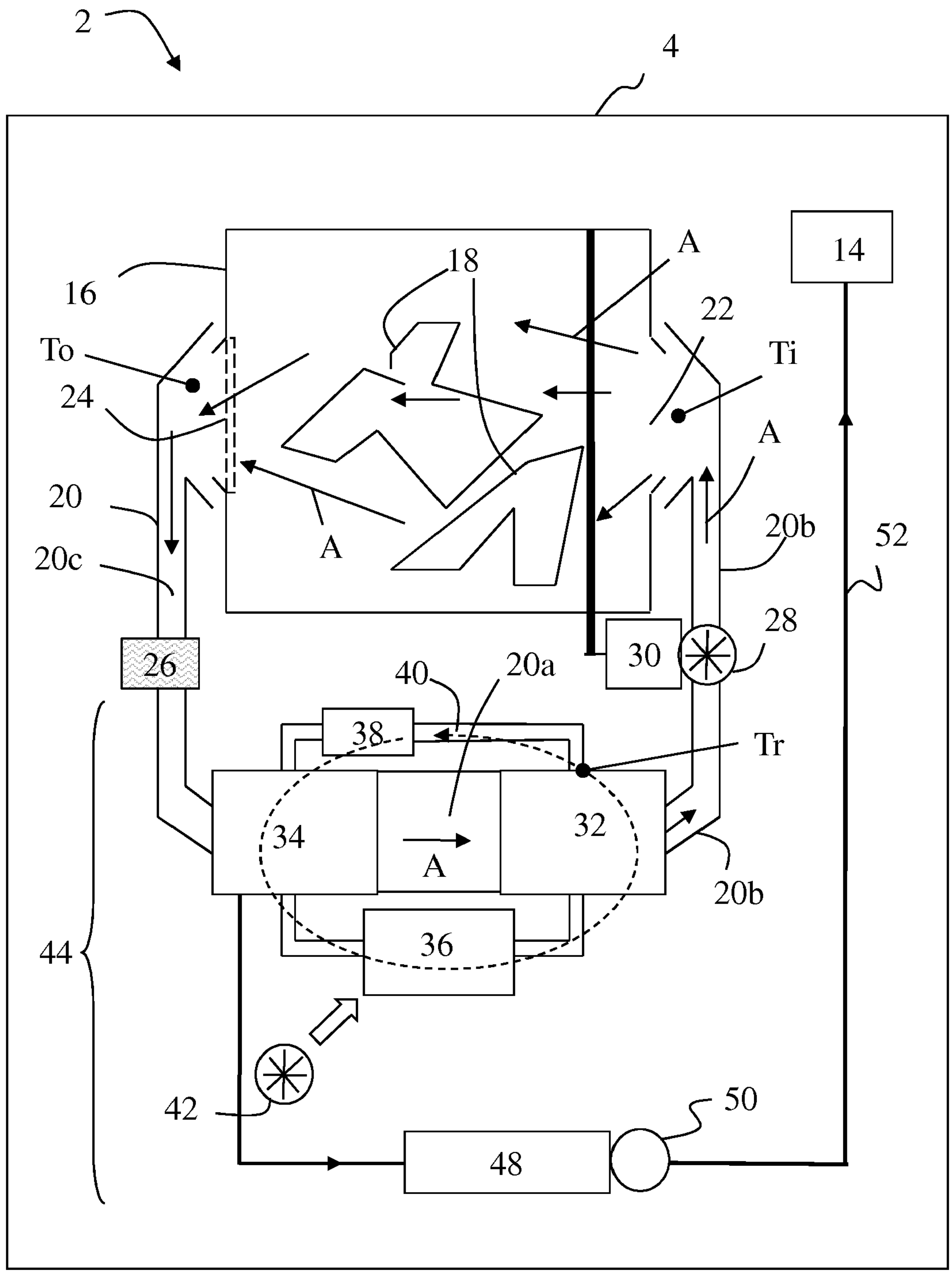
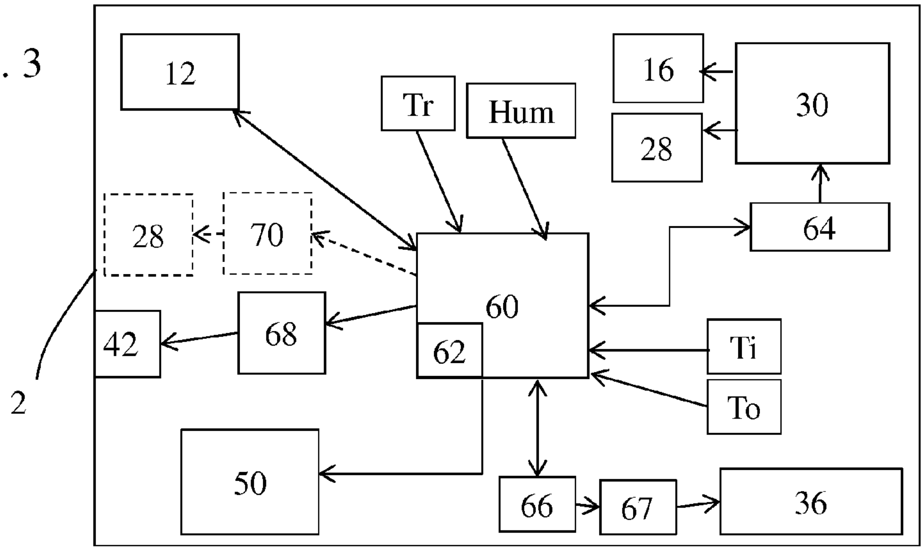

2
4
A
14
18
16
22
To
Ti
24
A
20
A
20b
52
20c
28
26
30
40
20a
38
Tr
34
32
A
20b
44
36
42
50
48

Fig. 2

Fig. 3


12
Tr
Hum
16
28
30
28
70
64
60
42
68
62
Ti
To
2
50
66
67
36

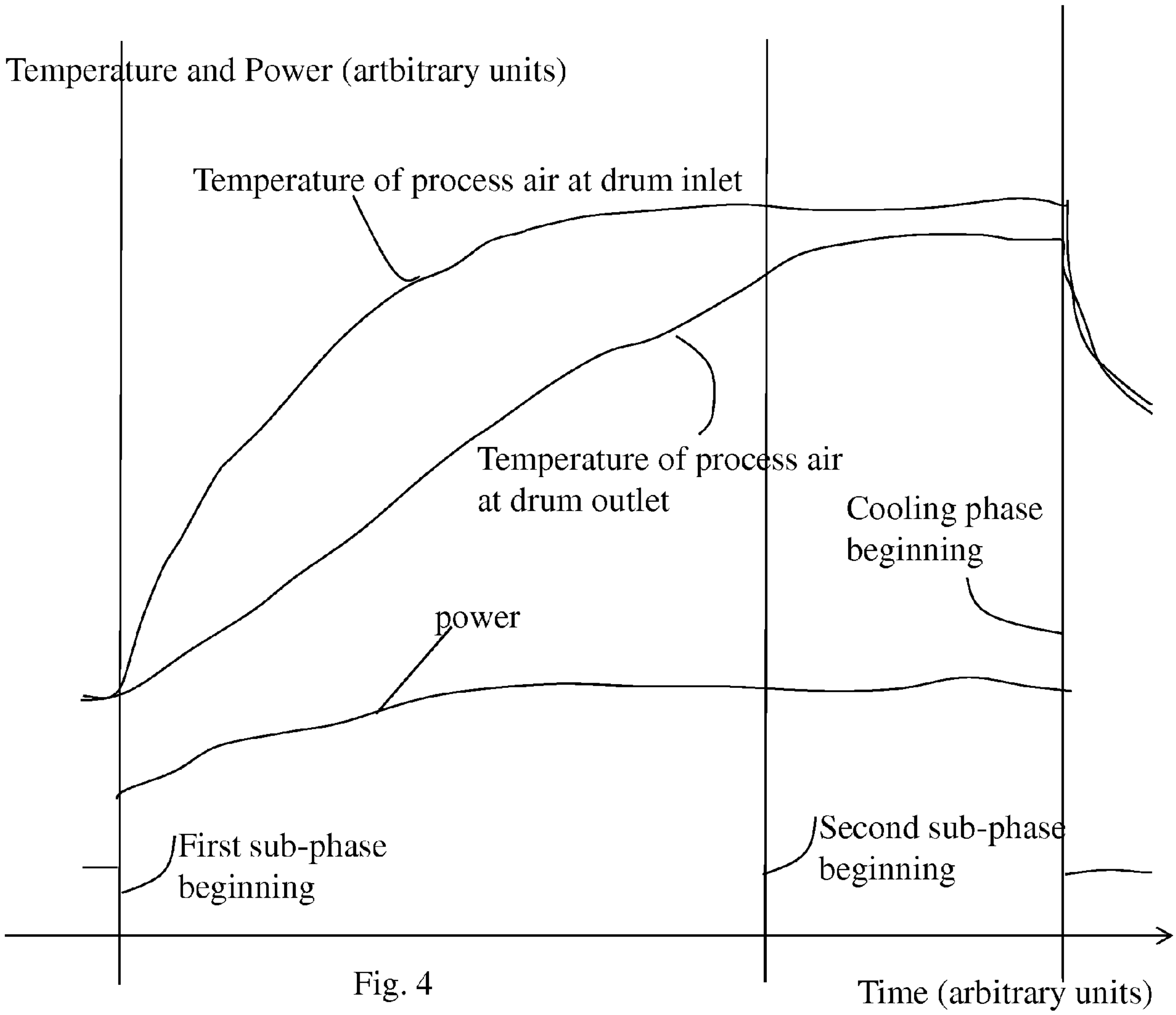
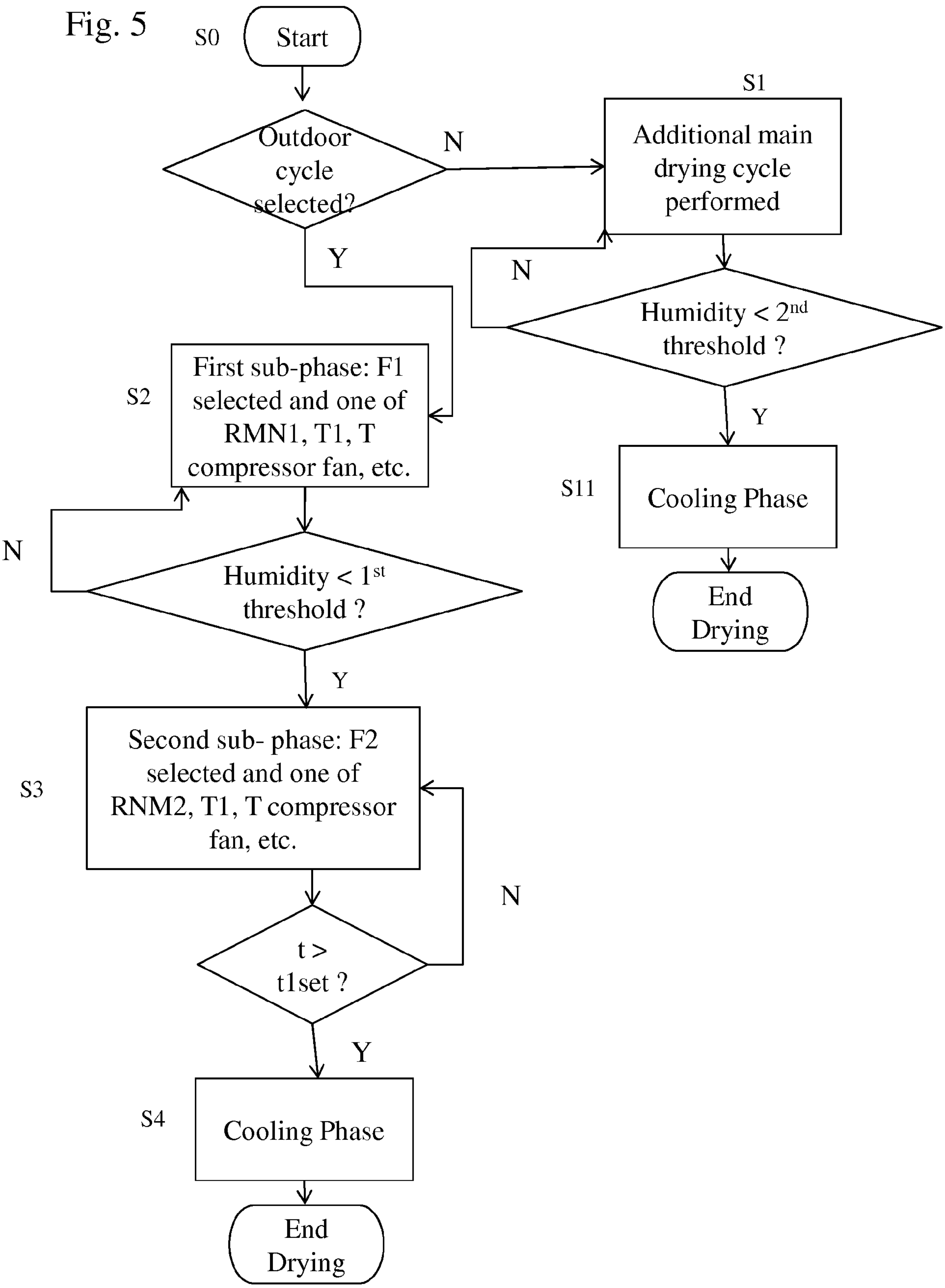

Temperature and Power (artbitrary units)
Temperature of process air at drum inlet
Temperature of process air
at drum outlet
Cooling phase
beginning
power
First sub-phase
beginning
Second sub-phase
beginning
Time (arbitrary units)

Fig. 4

Fig. 5


S0
Start
Outdoor cycle selected?
N
Y
S1
Additional main drying cycle performed
N
Humidity < 2nd threshold ?
Y
S11
Cooling Phase
End Drying
S2
First sub-phase: F1 selected and one of RMN1, T1, T compressor fan, etc.
N
Humidity < 1st threshold ?
Y
S3
Second sub- phase: F2 selected and one of RNM2, T1, T compressor fan, etc.
N
t > t1set ?
Y
S4
Cooling Phase
End Drying

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EUROPEAN SEARCH REPORT

Application Number
EP 15 20 3019

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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D06F

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	31 May 2016	Kising, Axel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 20 3019

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