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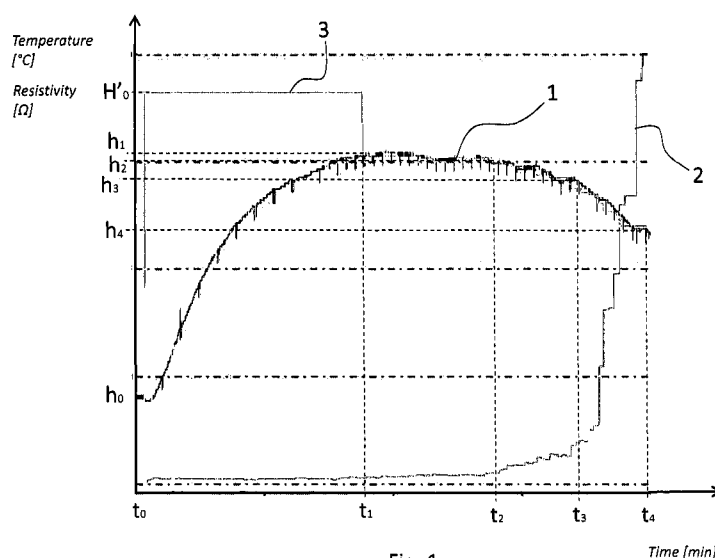
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upon receipt of that report (Rule 48.2(g))(54) Title: METHOD FOR CONTROLLING A DRYING CYCLE IN A CLOTHES DRYER, AND MACHINE IMPLEMENT-
ING SAID METHOD

Fig. 1

(57) Abstract: A method for drying laundry in a drum of a clothes dryer comprises the step of controlling the temperature of the
air circulating within the machine as a function of a parameter indicating the degree of humidity of the laundry placed in the drum.

METHOD FOR CONTROLLING A DRYING CYCLE IN A CLOTHES DRYER, AND MACHINE IMPLEMENTING SAID METHOD

DESCRIPTION

The present invention relates to a method for controlling a drying cycle in a clothes dryer, as well as to a machine implementing such a method.

In this description and in the appended claims, the term “clothes dryer” will refer to a machine of the type comprising a rotary drum loaded with wet laundry to be dried by means of an air flow heated by electric resistors.

Clothes dryers are typically machines expressly dedicated to that purpose, or else they may be machines carrying out both washing and drying processes, in which case they are usually called “washing/drying machines”.

In any case, regardless of this distinction, such machines are usually fitted with electric resistors (one or, more commonly, two) adapted to heat the air flow which is then directed towards the laundry in order to subtract moisture therefrom.

These machines typically comprise a temperature sensor that detects the temperature of the air exiting the machine drum (i.e. after it has flowed through the laundry) and, according to the known control method, the electric resistors are powered in a manner such as to keep the temperature always above a minimum threshold, so that the air flowing through the laundry is capable of subtracting moisture therefrom.

One of the two electric resistors stays always on as the laundry is being dried, whereas the other one is turned on intermittently to heat the air when the temperature of the latter falls below the preset threshold.

With this control method, at the end of the drying cycle the air temperature will rise to substantial values nearly as high as 70°C.

This implies a number of drawbacks: firstly, energy consumption is rather high; secondly, the temperature reached by the air lapping the laundry is so high that it may damage the fabrics (especially synthetic or delicate ones); finally, the user must be prevented from accessing the drum until the laundry and the drum itself have cooled down.

At the end of the drying cycle or step, there may be a load cooling step wherein the load

gradually reaches the ambient temperature; this step may take up to fifteen minutes, resulting in a longer time required for treating the laundry during the drying cycle.

In addition, ventilation means are turned on during said cooling step in order to promote forced convection to cool the laundry, further increasing energy consumption.

- 5 The present invention aims at solving these and other problems through a method in accordance with the appended claim 1.

The idea at the basis of the present invention is to control the temperature of the air circulating within the drum as a function of the degree of humidity of the laundry placed therein.

- 10 More specifically, this is accomplished by controlling the air heating device as a function of a parameter indicating the residual humidity of the laundry being treated.

In this manner it is possible to change the air temperature so that the drying action is effective throughout the cycle, thus preventing the above-described problems from arising.

- 15 As a matter of fact, controlling the temperature as a function of the degree of humidity of the laundry allows to maintain optimal thermodynamic characteristics during the drying process, which in turn reduce energy consumption and allow to obtain lower temperatures at the end of the cycle, when the humidity content in the laundry is lowest.

- The lower temperatures reached with this method, normally under 47°C at the end of the cycle, lead to further important advantages in addition to the most apparent one of reduced energy consumption: firstly, there is no risk of damaging the laundry; secondly, the user must no longer wait for the laundry to cool down before being allowed access to the drum.

- 20 This also provides a significant advantage in terms of energy consumption, since the cooling step can be eliminated or made shorter; furthermore, total treatment time is also reduced.

Another object of the present invention is a clothes dryer implementing the method according to the present invention.

Further advantageous features of the method will be set out in the appended claims.

- 30 These features as well as further advantages of the present invention will become apparent from the following description of an embodiment thereof as shown in the

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annexed drawings, which are supplied by way of non-limiting example, wherein:

Fig. 1 shows a diagram of the present method as a function of time, temperature and resistivity.

As aforementioned, the method according to the present invention provides for
5 controlling the temperature of the air lapping the laundry as a function of the degree of humidity of the latter.

In particular, said method provides for controlling the quantity of heat supplied to the laundry in the drum by setting operating parameters of an air heating device.

In particular, if the latter is an electric resistor, the resistor power supply is acted upon by
10 adjusting it or switching it off in a suitable manner.

In practice, a target temperature is set towards which the temperature of the air mass circulating within the drum is made to tend, this latter temperature being sensed by a temperature sensor arranged downstream of the drum.

The target temperature is established in a manner such that it changes as a function of
15 the degree of humidity of the laundry in the drum.

The detection of the degree of humidity of the laundry may occur in many different ways, all known in the art.

For instance, in the example shown in Fig. 1 the degree of humidity is detected by a conductivity sensor arranged inside the drum mouth, which sensor detects the
20 conductivity of the laundry items touching it.

The conductivity sensor can be schematised in this example as a capacitor with its terminals in contact with the laundry: the capacitor's discharge time is inversely proportional to the degree of humidity of the laundry; by knowing the capacitor's discharge time, one can easily deduce the resistivity (which is inverse thereto), shown by
25 line 2 in Fig. 1.

The resistivity therefore indicates, in a directly proportional manner, the degree of humidity of the laundry. If the resistivity is low, the laundry contains a high percentage of water; if it is high, the water percentage is low.

It must be pointed out right away that another method for detecting the degree of
30 humidity of the laundry provides for measuring the temperature upstream and downstream of a humidity capacitor, if the latter is present in the machine.

In these cases, two paths are made to lap each other in the capacitor: the hot air path in communication with the drum, and the cold air path in communication with the outside; some systems are known for detecting the degree of humidity in a clothes dryer (e.g. from patent application GB 2 154 721 by SANYO ELECTRIC) wherein the degree of humidity of the laundry is detected starting from the difference in temperature between a first measuring point located in the hot air path immediately upstream of the capacitor and a second measuring point located in the cold air path immediately downstream of the capacitor.

Reference will be made hereafter to measuring the degree of humidity by detecting the resistivity across the terminals of a capacitor as previously explained, being it understood that the method will remain the same even if a different type of detection is used.

According to the method according to the present invention, an air heating device, in particular an electric resistor, is controlled as a function of a target temperature, indicated by reference numeral 3 in Fig. 1, and of a detected value of the temperature of the air circulating within the drum.

In practice, a temperature sensor detects (whether directly or indirectly) the temperature of the air exiting the drum after having lapped the laundry, thereby subtracting moisture therefrom. A control unit then compares it with the value of the target temperature and supplies power to the electric resistor if the detected temperature is lower than the target temperature or switches the resistor off if the detected temperature is higher than the target temperature.

When a more accurate control is used, the resistor is supplied with a variable voltage across its terminals, thus providing progressive operation and preventing the resistor from being continually switched on and off.

In fact, Fig. 1 shows a first section between time t_0 and time t_1 where the detected resistivity 2 is at a very low level (the laundry is typically imbibed with water at the beginning of the process) of approx. 40 Ohm; as a consequence, the target temperature 3 is kept at a high level H'_0 , e.g. approx. 65°C.

The detected temperature 1 starts from the value h_0 (which normally is the ambient temperature, in the present example approx. 23°C) and then rises through the effect of

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thermal exchange with the resistor, which is kept on as a result of the comparison between the detected temperature 1 and the target temperature 3, which indicates that the former is lower than the latter.

5 In the second section between time t_1 and time t_2 , the detected resistivity 2 increases slightly, which means that a certain quantity of water has been subtracted from the laundry; the target temperature 3 is therefore initially brought to the new level h_1 , e.g. approx. 56°C , and then gradually lowered to the level h_2 of approx. 54°C .

10 In the third section between time t_2 and time t_3 , the detected resistivity 2 distinctly increases due to a further decrease in the laundry's water content; the target temperature 3 thus gradually passes from the initial level h_2 to the new level h_3 of approx. 51°C .

The electric resistor control causes the detected temperature 1 to follow the trend of the target temperature 3.

15 Finally, in the last section between time t_3 and time t_4 it can be seen that the resistivity 2 increases in a substantially exponential manner, thereby indicating that the degree of humidity of the laundry is approaching the ambient humidity (hence, at time t_4 the laundry can be considered to be dry); within this time interval the target temperature 3 is set in a manner such that it gradually becomes equal to the value h_4 of approx. 47°C .

20 It should be reminded that in prior-art methods the detected temperature increases evenly until time t_4 (up to values above 70°C); it follows that the present method ensures lower energy consumption, limited or no damage to synthetic clothes, and a shorter laundry cooling step, which may even not be necessary at all.

25 This also prevents an excessive supply of heat to the air circulating within the drum when the laundry is partially dry from overheating the circulating air without essentially providing any benefits in terms of moisture removal; in fact, the present method always maintains optimal conditions for causing the water to evaporate from the laundry without generating overheated steam.

The target temperature can be set in various ways, but in general the principle applies according to which it decreases with the degree of humidity of the laundry in the drum or with the degree of humidity of the air circulating in the machine.

30 One example of definition of the target temperature towards which the detected temperature is made to tend by appropriately controlling the heating elements is given by

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the following algorithm:

$$T_{ob}=T_i-K*(cond_{att}-cond_i)$$

where:

T_{ob} : is the target temperature value,

5 T_i : is the initialisation temperature value (which will be discussed hereafter),

K : is a constant which takes into account the conversions of the units of measure,

$cond_{att}$: is the conductivity value measured in each step of the algorithm (inverse to resistivity in the same conditions),

10 $cond_i$: is the conductivity value measured at the start of the drying cycle (inverse to resistivity in the same conditions).

T_i (initialisation temperature) is chosen so as to correspond to the value of the temperature detected at the beginning of the drying cycle.

The algorithm is used several times during the laundry drying cycle, e.g. every time the resistivity is measured, so as to have a continuous trend.

15 The definition of a target temperature based also on values measured at the beginning of the drying cycle provides the additional advantage that the target temperature will also take into account the initial parameters involved in the process, such as initial temperature and quantity of water imbibed in the laundry (since different fabrics get imbibed differently).

20 More in particular, the above algorithm is applied multiple times during one drying cycle and, in addition, the value of the constant K is changed as the detected conductivity varies.

More specifically, the value of the constant K is changed when a conductivity threshold value is reached which corresponds to approx. 15% of residual humidity in the laundry.

25 However, it may also be significantly variable as a function of parameters of the drying cycle such as load type, load weight or initial humidity.

As concerns the temperature sensor used for detecting the temperature of the circulating air, it is preferably a known NTC (Negative Temperature Coefficient) thermistor, which will not be described any further herein.

30 As far as the heating elements are concerned, as aforementioned, they are controlled as a function of the difference between the target temperature and the measured temperature

of the circulating air, so that the quantity of heat supplied to the circulating air is such that the temperature of the latter will tend towards the value of the target temperature.

As regards the machine implementing the method discussed so far, it will comprise at least one drum in which laundry can be placed to be subjected to a drying treatment, at least one humidity sensor for detecting the degree of humidity of the laundry, at least one temperature sensor for detecting the temperature of the air circulating within the drum, at least one control unit connected to the humidity and temperature sensors and adapted to control one or more heaters in a manner such as to cause the circulating air temperature to tend towards a target temperature value calculated by the control unit as a function of the degree of humidity detected by the humidity sensor.

Normally said machine may or may not be equipped with air recirculation: in machines of the first type, the air is heated by the heating elements and conveyed into the drum, where it subtracts moisture from the laundry; it is then delivered to a condenser, where it is cooled and the water contained therein condenses and is collected into a sump, after which the air returns from the condenser to the heating elements and from there to the drum.

Machines of the second type, i.e. without recirculation, are not fitted with a condenser, in that the air is taken in from the outside, heated and then delivered into the drum where it laps the laundry, after which it is discharged outside again.

In machines of the first type, the use of the method according to the present invention offers additional advantages, since the temperature reduction dependent on the degree of humidity of the laundry at the end of the drying cycle or step allows the condenser to operate in better thermodynamic conditions, i.e. with air at a lower temperature, thus reducing the temperature gap to be bridged for reaching the condensation temperature.

CLAIMS

1. A method for drying laundry in a drum of a clothes dryer,

characterised in that

it comprises the step of controlling the temperature of the air circulating within the machine as a function of a parameter indicating the degree of humidity of the laundry placed in the drum.

2. A method according to claim 1, wherein the step of controlling the temperature of the air circulating within the machine comprises the step of adjusting an air heating device.

3. A method according to claim 1 or 2, wherein the temperature of the air circulating within the machine is reduced in a manner directly proportional to the decrease in the degree of humidity of the laundry.

4. A method according to claim 1, 2 or 3, comprising the steps of:

a- detecting the degree of humidity of the laundry

b- establishing a target temperature as a function of said degree of humidity of the laundry

c- detecting the temperature of the air mass circulating within the machine

d- comparing the target temperature with the temperature of the air mass circulating within the machine

e- adjusting said air heating device in a manner such that the value of the temperature of the air mass circulating within the machine comes to match the target temperature value.

5. A method according to claim 4, wherein the step of detecting the temperature of the air mass circulating within the machine takes place downstream of the drum.

6. A method according to claim 4, wherein said steps a,b,c,d,e are repeated during a laundry drying cycle.

7. A method according to one of the preceding claims, wherein said step of establishing a target temperature as a function of said degree of humidity of the laundry takes place as per the following algorithm:

$$T_{ob}=T_i-K*(cond_{att}-cond_i)$$

where:

T_{ob} : is the target temperature value,

T_i : is the value of the initialisation temperature measured at the start of the drying cycle,

K : is a constant which takes into account the conversions of the units of measure,

cond_{att} : is the conductivity value measured in each step of the algorithm (inverse to resistivity in the same conditions),

5 cond_i : is the conductivity value measured at the start of the drying cycle (inverse to resistivity in the same conditions).

8. A machine implementing the method according to one or more of the preceding claims, of the type comprising at least one drum in which laundry can be placed to be subjected to a drying treatment, at least one humidity sensor for detecting the degree of humidity of the laundry, at least one temperature sensor for detecting the temperature of
10 the air circulating within the drum, at least one control unit connected to the humidity and temperature sensors and adapted to control one or more heaters in a manner such as to cause the circulating air temperature to tend towards a target temperature value calculated by the control unit as a function of the degree of humidity detected by the humidity sensor.

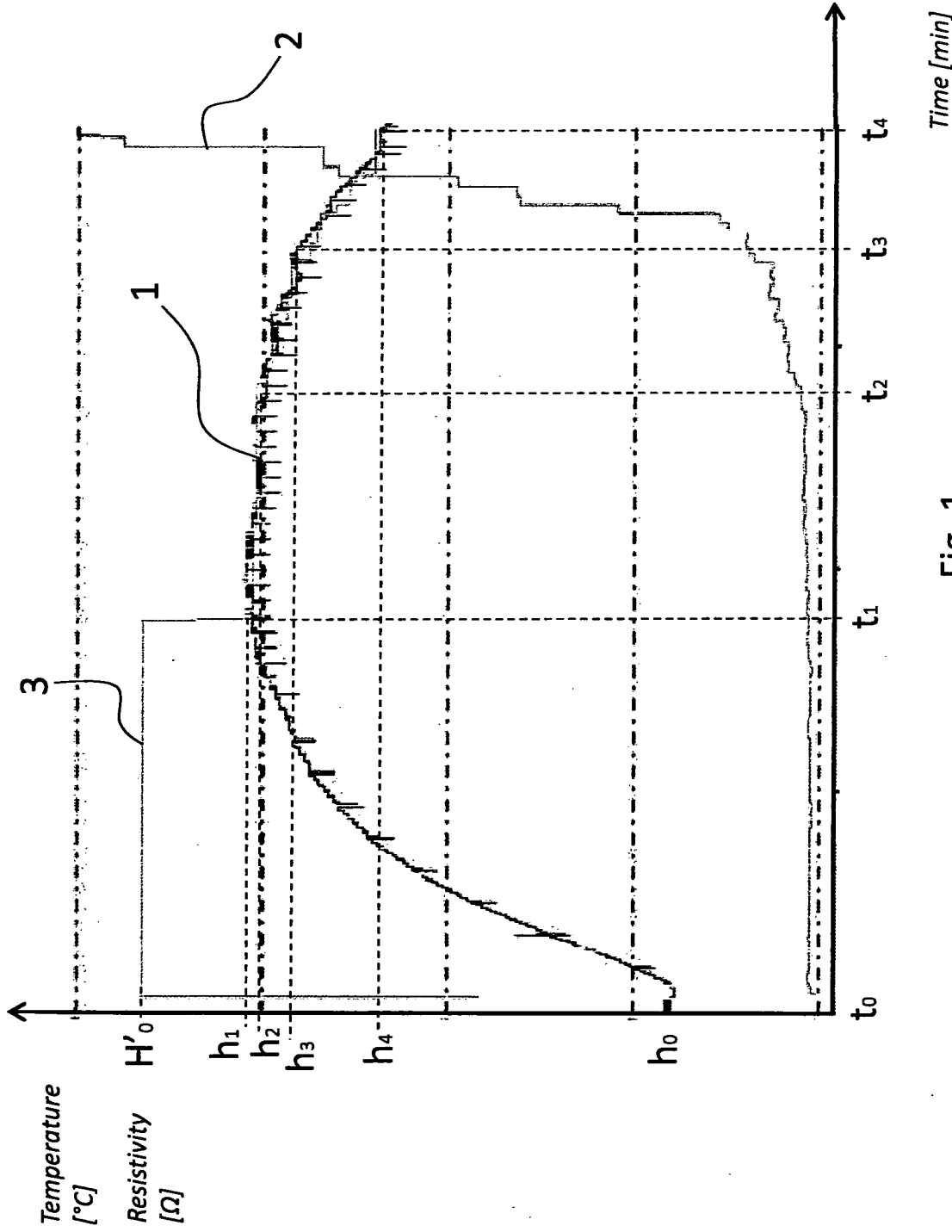


Fig. 1