Clothes tumble dryer and method for controlling the same

A condenser-type clothes tumble dryer comprising temperature sensor means (5, 6) to detect a temperature difference value between the drying air entering the condenser (4) and the drying air exiting the condenser (4), humidity sensor means (5) to detect a humidity value of the drying air entering the condenser, control means coupled to said humidity sensor means (5), memory means for storing a threshold temperature-difference value ($\Delta T_{TH}$) and a threshold relative-humidity value ($RH_{inTH}$), which are representative of a pre-determined dryness degree of the load and depend on the particular drying cycle selected by the user, the control means are further adapted to compare said values for switching off said heating means (3) when at least said temperature difference value ($\Delta T$) reaches up to said threshold temperature-difference value ($\Delta T_{TH}$) or at least said relative humidity value ($RH_{in}$) reaches down to said threshold relative-humidity value ($RH_{inTH}$).
Description

[0001] The present invention refers to a clothes tumble dryer and a method for controlling the same.

[0002] An important feature in tumble dryers is the ability of the drying process to be stopped as soon as the moisture content of the washload has been brought down to the desired value. In fact, if the drying process be interrupted too early, the resulting moisture content in the washload would be too high and this would again entail a number of obvious disadvantages. On the other hand, interrupting a drying process too late practically means an unnecessarily high energy usage, while the resulting too low a moisture content of the washload causes it to be subject to increased creasing, reduced ironability, increased likelihood for the washload items to suffer shrinking or undergo such other adverse effects as becoming statically charged.

[0003] Condenser-type tumble dryers are known in the art to comprise a closed-loop drying air circuit adapted to cause heated drying air to circulate through a perforated rotating drum, and a condenser adapted to remove the moisture from the hot moisture-laden drying air exiting the drum upon having flown through the drying load contained therein, as well as moisture sensors adapted to detect the moisture content of the air exiting the drum. Thus, the drying process is stopped when the moisture content of the drying air leaving the drum is sensed to have reached down to a pre-established value. However, this method has been unable to provide really satisfactory results, since it has been practically found that the actual moisture content of the drying load upon interruption of the drying process is greatly affected also by such variables as the amount of drying load items in the drum and the type and nature of the fabrics being handled.

[0004] Also known in the art are condenser-type tumble dryers, in which electrodes are arranged in the drum for measuring the electrical resistance of the load, based on the fact that such electrical resistance is a parameter that is in direct relation with, i.e. dependent on the moisture content of the drying load items. Other prior-art solutions call for the use of a drum that is comprised of two halves, wherein the conductivity between such halves is then measured to control the drying process. This method, however, is unable to ensure any reliable measurement of the moisture content of the drying load items, mainly owing to conductivity values being affected by such factors as water hardness.

[0005] It therefore is a main object of the present invention to provide a clothes tumble drier of the above-mentioned kind, in which a desired moisture content of the drying load can be automatically attained to a high degree of accuracy at the interruption of the drying process, and this in a manner that is highly independent of factors such as the amount of drying load, the type of fabrics being handles, the initial moisture content of the drying load, as well as water hardness.

[0006] According to the present invention, this aim is reached in a clothes tumble dryer having the characteristics as recited and defined in the appended claims 1 to 14.

[0007] According to the present invention, the above-mentioned aim is also reached in a method for controlling a clothes tumble dryer as defined and recited in the appended claims 15 to 26.

[0008] Anyway, features and advantages of the present invention may be more readily understood from the description that is given below by way of a non-limiting example with reference to the accompanying drawings, in which:

- Figure 1 is a schematic view of a clothes tumble dryer according to the present invention;
- Figure 2 is a flow chart describing a method for controlling a clothes tumble dryer according to the present invention;
- Figure 3 is a diagrammatical view of the course followed versus time by the relative humidity of the drying air entering the condenser during a drying process, along with the threshold values of relative humidity corresponding to a pre-established drying degree;
- Figure 4 is a diagrammatical view of the course followed versus time by the temperature of the drying air entering the condenser and the temperature of the drying air exiting the condenser during a drying process;
- Figure 5 is a diagrammatical view versus time of the temperature difference pattern between the drying air entering the condenser and the drying air exiting the condenser during a drying process, along with the threshold values of such temperature difference corresponding to a pre-established drying degree;
- Figure 6 is a diagrammatical view versus time of the pattern of the end-of-cycle coefficients \(dH\) and \(dT\), as well as the control quantity \(D\) in the case of an “Extra Dry” drying cycle;
- Figure 7 is a diagrammatical view versus time of the pattern of the end-of-cycle coefficients \(dH\) and \(dT\), as well as the control quantity \(D\) in the case of a “Dry Cottons” drying cycle;
- Figure 8 is a diagrammatical view versus time of the pattern of the end-of-cycle coefficients \(dH\) and \(dT\), as well as the control quantity \(D\) in the case of a “Slightly Damp” drying cycle;
The tumble dryer according to the present invention - as generally indicated by the reference numeral 1 in the Figures - comprises a closed-loop drying air circuit adapted to cause heated drying air to be circulated through a perforated rotating drum 2 holding the washload to be dried, heating means 3 adapted to heat up said drying air, an air-cooled condenser 4 adapted to remove the moisture from the hot moisture-laden drying air exiting the drum after having flown through the washload to be dried, an open-loop cooling air circuit adapted to cause a stream of cooling air taken in from outside to circulate through and over the condenser 4 to cool it, and be eventually exhausted again into the outside atmosphere.

The above-mentioned tumble dryer also calls for temperature sensor means 5, 6 to be provided in correspondence to a drying-air condenser inlet 7, and the temperature sensor means 5, 6 to also receive the temperature difference values \( \Delta T \) during the operation of the tumble drier.

The above-mentioned tumble dryer also calls for temperature sensor means 5, 6 to be provided in correspondence to a drying-air condenser inlet 7, in order to detect a temperature difference value \( \Delta T \) between the drying air entering the condenser 4 and the drying air exiting the same condenser 4; it further calls for humidity sensor means 5 to be provided in correspondence to the drying-air condenser inlet 7, in order to detect a relative humidity value \( RH_{in} \) of the drying air entering the condenser.

In addition, the above-mentioned tumble dryer comprises control means coupled to both the humidity sensor means 5, so as to be able to receive the humidity values \( RH_{in} \), and the temperature sensor means 5, 6 to also receive the temperature difference values \( \Delta T \).
The drying-air condenser inlet 7 substantially represents the zone of the condenser at which the drying air to be dehydrated, and flowing in from the first manifold arrangement, enters the first array of fluid passageways 14, whereas the drying-air condenser outlet 8 represents the zone of the condenser at which the dehydrated drying air exits the first array of fluid passageways 14 to flow into the second manifold arrangement 13.

Most obviously, these zones are not fluidly connected with the cooling air passageways, since both the inlet and the outlet of such second array of fluid passageways 15 are suitably separated from the drying-air condenser inlet 7 and the drying-air condenser outlet 8, respectively.

In the particular embodiment, in fact, the inlet and the outlet of the second array of fluid passageways 15 are provided in a perpendicular arrangement relative to the drying-air condenser inlet 7 and the drying-air condenser outlet 8, respectively, so that the flows of drying air and the flows of cooling air practically cross each other.

The temperature and humidity sensor means 5, 6 comprise a relative humidity sensor, which is also capable of delivering accompanying temperature measurement values, and which is arranged in the vicinity of the drying-air condenser inlet 7, and a temperature sensor, such as for instance a thermocouple, which is situated in the vicinity of the drying-air condenser outlet 8. Both sensors are connected to the control means, which are adapted to receive - during the operation of the dryer - the signals being output by the sensors so as to monitor the pattern of the temperature $T_{in}$ of the drying air entering the condenser, as well as the pattern of the temperature $T_{out}$ of the drying air exiting the same condenser, along with the relative humidity $RH_{in}$ of the drying air entering the condenser.

This data acquisition process by said control means may occur either continuously or at discrete intervals, by setting in this case a proper time interval to separate successive data acquisition events during which said control means are able to acquire the temperature values $T_{in}$, $T_{out}$, and the relative humidity values $RH_{in}$ being detected and output by the sensors.

Extensive experimental tests have emphasized the fact that both the relative humidity values $RH_{in}$ and the temperature values $T_{in}$, $T_{out}$ of the drying air being detected as the clothes undergo gradual drying in the machine, fully correlate, i.e. can be brought into mutual relation with different final drying degrees of the clothes themselves.

It has in this way been possible to work out appropriate threshold temperature and relative humidity values of the drying air, which correspond to the various degrees of final drying that are usually required for clothes handled in such tumble dryers, in such a way as to ensure that reaching any of these threshold values causes the air heating means to be de-energized and, possibly, the operation of the dryer itself to be stopped by the control means.

In detail, in view of judging the final drying degree of the clothes, reference has been made - according to existing standards - to residual moisture MR (moisture regain), as assessed in terms of difference in weight of a load of clothes subjected to a drying cycle, to a same load of clothes under standard conditions, i.e. left for 24 hours in a controlled atmosphere at a temperature of 20°C and 60% of relative humidity.

Some among the most used drying cycles commonly available in tumble dryers have then been selected, i.e.:

<table>
<thead>
<tr>
<th>Drying Cycle</th>
<th>Final MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra Dry (ED)</td>
<td>-6% → 0%</td>
</tr>
<tr>
<td>Dry Cottons (DC)</td>
<td>-3% → 3%</td>
</tr>
<tr>
<td>Slightly Damp (SD)</td>
<td>4% → 8%</td>
</tr>
<tr>
<td>Iron Dry (ID)</td>
<td>8% → 16%</td>
</tr>
<tr>
<td>Mangle Dry (MD)</td>
<td>18% → 24%</td>
</tr>
</tbody>
</table>

For example, in the case of the Extra Dry cycle, the drying load - as removed from the drum at the end of the cycle, has a weight ranging from about 6% less than the weight of the above-specified standard load to almost the same weight as the standard load. On the contrary, in the case of the Iron Dry cycle, the drying load - as removed from the drum at the end of the cycle - has a weight ranging from 8% to 16% more than the weight of said standard load.

The tests performed in this connection have given rise to the graph appearing in Figure 3 illustrating the trend versus time of the relative humidity value $RH_{in}$ of the drying air as detected by the moisture sensor means 5 at the drying-air condenser inlet 7, with the heating means 3 operating, i.e. energized. As emphasized by the graph, the relative humidity $RH_{in}$ tends to decrease as the drying degree of the clothes increases. Further indicated in Figure 3 are the threshold values for the relative humidity $RH_{in\text{TH}}[ED,DC,SD,ID,M]$ of the drying air entering the condenser, which have been found as corresponding to the different degrees of drying of the clothes in the above-noted cycles ED,DC,SD,ID,M.

In the description following hereinafter, the term "relative humidity value $RH_{in}$" will be used to univocally mean the value of relative humidity of the drying air as detected by the moisture sensor means 5 at the drying-air condenser inlet 7, whereas the term "threshold relative-humidity value $RH_{in\text{TH}}[ED,DC,SD,ID,M]$" will be used to univocally mean the threshold value of relative humidity of the drying air, which - as detected again by the moisture sensor means 5 at the drying-air condenser inlet 7 - has been found to correspond to the different degrees of drying of the clothes in the cycles ED,DC,SD,ID,M as indicated above.
[0032] RH₀ is used to indicate the initial value of the relative humidity of the drying air flowing into, i.e. entering the condenser 4 as detected by the moisture sensor means 5 upon starting of the drying cycle selected by the user and, therefore, upon the heating means having been switched on.

[0033] Immediately after energization of the heating means 3, the value of RH₀ can be noticed to be extremely variable to eventually go steadier at a relative-humidity value of approx. 96 to 97% after a first stabilization transient. It has been found that the initial value RH₀ is the same for all drying cycles.

[0034] During this first transient phase, the control means of the machine do not acquire any of the relative-humidity readings RHᵢ that they receive from the moisture sensor means 5 since the related data are not representative of the real initial relative-humidity condition RHᵢ₀.

[0035] Thus, the control means are programmed to set themselves in a kind of observation state, in which they practically determine whether successive readings flowing in from the moisture sensor means 5 reveal a substantially constant value. In this connection, it will be readily appreciated that the control means may also be programmed to simply wait until a certain time interval of a duration corresponding to the aforementioned transient phase elapses, before they start acquiring the data being output by the sensor means. It has been experimentally found that such transient phase has a duration of approx. two minutes.

[0036] As this most clearly appears from the graph in Figure 3, the relative humidity RHᵢ₀ decreases as the clothes in the drum becomes increasingly dry, until it eventually reaches a respective threshold value corresponding to a certain final drying degree or state reached by the clothes themselves. For example, when the value of relative humidity RHᵢ₀ reaches down to at least approx. 68%, it has been found that degree of drying reached by the clothes being handled corresponds to a degree of drying that is typical of the Extra Dry (ED) cycle.

[0037] As a result, this relative humidity value of 68% turns out as being the threshold relative-humidity value RHᵢ₀[TH][ED] that can be associated to said Extra Dry cycle ED, and - as such - is therefore stored in the memory means for due reference. When the user then selects an Extra Dry cycle ED via the proper controls on the control panel of the tumble dryer, the control means automatically retrieve the threshold relative-humidity value RHᵢ₀[TH][ED] associated to such drying cycle from the memory means and, at the same time, enable the dryer to start operation by energizing the heating means 3, switching on the blower means 11, 16 and enabling the drum 2 to be driven rotatably.

[0038] Then, the control means - upon waiting for the initial transient observation phase to elapse - are enabled to start comparing the relative humidity value RHᵢₐ with the threshold relative-humidity value RHᵢ₀[TH][ED] for the Extra Dry [ED] cycle. When the relative humidity value RHᵢₐ is eventually found to have reached down to or below said threshold value RHᵢ₀[TH][ED], the control means will then consider the selected drying cycle as being concluded and, as a result, cause the operation of the tumble dryer to stop by de-energizing the heating means 3, switching off the blower means 11, 16 and stopping the rotation of the drum 2. Since a cool air circulation phase may also be contemplated to take place at the end of the actual drying process in order to cool down the clothes before removing them from the drum 2, when the relative humidity value RHᵢₐ is found to have reached down to or below said threshold value RHᵢ₀[TH][ED], the control means would in this case simply de-energize the heating means 3, while waiting for this cool air circulation phase to be concluded before stopping the operation of the tumble dryer.

[0039] A degree of drying of the clothes corresponding to the one that may be considered typical for the Dry Cottons (DC) cycle, has on the contrary been found to exist when the relative humidity value RHᵢₐ reaches down to at least approx. 87%. This value is therefore stored in the memory means as the threshold relative-humidity value RHᵢ₀[TH][DC] associated to said Dry Cottons [DC] drying cycle.

[0040] Summarized in the table below are the threshold relative-humidity values RHᵢ₀[TH][ED,DC,SD,ID,M] for the different drying cycles:

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Final MR</th>
<th>RHᵢ₀ Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra Dry</td>
<td>-6% → 0%</td>
<td>68%</td>
</tr>
<tr>
<td>Dry Cottons</td>
<td>-3% → 3%</td>
<td>87%</td>
</tr>
<tr>
<td>Slightly Damp</td>
<td>4% → 8%</td>
<td>93%</td>
</tr>
<tr>
<td>Iron Dry</td>
<td>8% → 16%</td>
<td>93.5%</td>
</tr>
<tr>
<td>Mangle Dry</td>
<td>18% → 24%</td>
<td>94%</td>
</tr>
</tbody>
</table>

[0041] The tests that have been carried out to this effect have furthermore produced the graph represented in Figure 4, which illustrates the trend versus time of the drying air temperature Tᵢₐ as detected by the temperature sensor means 5 at the drying-air condenser inlet 7, as well as the trend versus time of the drying air temperature Tᵢₐ as detected by the temperature sensor means 6 at the drying-air condenser outlet 8, during the operation of the heating means 3.

[0042] Emphasized in this graph is the fact that the drying cycle is basically comprised of three distinct phases, actually. A first initial transient phase, which comes immediately after the energization of the heating means 3, and in which both temperatures Tᵢₐ, Tᵢₐ and also the evaporation rate increase.
The second phase is a saturation one, in which the temperatures $T_{in}$, $T_{out}$ remain almost constant, since the thermal heating energy causes the water contained in the clothes being handled to evaporate, while the condenser is capable of dissipating most of the latent condensation heat.

There follows a third, final phase, in which the temperature of the drying air at the condenser inlet $T_{in}$ tends to increase, owing to the clothes becoming increasingly dry, i.e. less and less damp, and the temperature of the drying air at the condenser outlet $T_{out}$ tends on the contrary to decrease, since the evaporation rate is decreasing and the condenser is able to dissipate also the heat in the drying air, thereby cooling it down.

It clearly appears that the temperature difference $\Delta T$ between the drying air temperature at the condenser inlet $T_{in}$ and the drying air temperature at the condenser outlet $T_{out}$ is fully capable of being correlated to the actual residual moisture content in the clothes to be dried, i.e. the greater the value of $\Delta T = T_{in} - T_{out}$, the higher the degree of drying of the clothes.

Even in this case, the temperature values detected by the temperature sensor means 5, 6 following the energization of the heating means 3, are extremely variable and are by no means indicative of the actual trend of the temperatures. Therefore, the control means wait for this initial observation or transient phase to be concluded before starting with the acquisition of said values.

The graph in Figure 5 illustrates the trend versus time of the value of the temperature difference $\Delta T = T_{in} - T_{out}$, as well as the threshold values of this temperature difference $\Delta T_{TH}[ED, DC, SD, ID, M]$ of the drying air between condenser inlet and condenser outlet, which have been found as corresponding to the various degrees of drying due to be reached by the clothes in the respective drying cycles ED, DC, SD, ID, M.

For example, it has been found that, when the temperature difference $\Delta T$ reaches a value of at least 15°C, the degree of drying reached by the clothes in the drum corresponds to the degree of drying due to be reached in the Extra Dry cycle ED.

A temperature difference value of 15°C turns therefore out as being the threshold temperature-difference value $\Delta T_{TH}[ED]$ associable to the Extra Dry cycle ED and, as such, it is stored in the memory means.

In the description following hereinbelow, the term "temperature difference value $\Delta T$" will be used to univocally mean the value of the difference between the temperature of the drying air as detected by the temperature sensor means 5 at the drying-air condenser inlet 7 and the temperature of the drying air as detected by the temperature sensor means 6 at the drying-air condenser outlet 8, whereas the term "threshold temperature-difference value $\Delta T_{TH}$" will be used to univocally mean the threshold value of the difference between the temperature of the drying air as detected by the temperature sensor means 5 at the drying-air condenser inlet 7 and the temperature of the drying air as detected by the temperature sensor means 6 at the drying-air condenser outlet 8 that has been found to correspond to the different degrees of drying of the clothes in the cycles ED, DC, SD, ID, M in the experimental tests performed to this effect.

When a user selects an Extra Dry drying cycle ED via the proper control devices on the control panel of the tumble dryer, the control means of the machine start by automatically retrieving the threshold temperature-difference value $\Delta T_{TH}[ED]$ corresponding to that cycle from the memory means, and start dryer operation by energizing the heating elements 3, switching on the air blower means 11, 16, and enabling the drum 2 to be driven rotatably. Then, upon allowing the initial observation time to elapse, the control means are capable of comparing the value of the temperature difference $\Delta T$, as detected by the temperature sensor means 5, 6 with the threshold temperature-difference value $\Delta T_{TH}[ED]$ of the Extra Dry cycle ED. As soon as the temperature difference value $\Delta T$ reaches at least said threshold value $\Delta T_{TH}[ED]$, the control means consider the selected drying cycle as being concluded and stop dryer operation by de-energizing the heating means 3, switching off the air blower means 11, 16, and stopping drum rotation. In the case that a further unheated air circulation phase is provided to take place after the conclusion of the actual drying process in order to allow the clothes to be cooled down before they are removed from the drum, the control means simply cause the heating means 3 to be de-energized when the temperature difference value $\Delta T$ reaches said threshold temperature-difference value $\Delta T_{TH}[ED]$, while waiting for said cold air circulation phase to be concluded to turn off the tumble dryer and fully stop its operation.

Summarized in the table below are the threshold temperature-difference values for the different drying cycles:

<table>
<thead>
<tr>
<th>Cycle</th>
<th>Final MR</th>
<th>$\Delta T_{TH}$ Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra Dry</td>
<td>-6% → 0%</td>
<td>15 °C</td>
</tr>
<tr>
<td>Dry Cottons</td>
<td>-3% → 3%</td>
<td>7.4 °C</td>
</tr>
<tr>
<td>Slightly Damp</td>
<td>4% → 8%</td>
<td>5.9 °C</td>
</tr>
<tr>
<td>Iron Dry</td>
<td>8% → 16%</td>
<td>5.4 °C</td>
</tr>
<tr>
<td>Mangle Dry</td>
<td>18% → 24%</td>
<td>4.9 °C</td>
</tr>
</tbody>
</table>

The threshold temperature-difference values $\Delta T_{TH}[ED, DC, SD, ID, M]$ are independent of the initial quantity of water contained in the clothes to be dried. In fact, the transition from the intermediate saturation phase to the final phase...
of the drying cycle occurs at a given value of residual moisture, i.e. moisture that is still in the clothes being dried, wherein this value solely depends on the design parameters of the condenser.

According to the present invention, the method for controlling the drying cycles in a tumble dryer calls for the drying cycle selected by the user to be first of all read and the threshold humidity value RH\textsubscript{inTH} and the threshold temperature-difference value \(\Delta T\textsubscript{TH}\) to be then set accordingly, i.e. on the basis of the selected cycle. These threshold values are retrieved from the memory means, in which they are properly stored.

Such reading of the cycle being selected and such setting of the corresponding values are performed by the control means, which are connected to the control devices in a control panel provided on the tumble dryer. The selected drying cycle is then immediately started by these control means by starting the operation of the dryer in the way described hereinbefore.

The method according to the present invention then calls for the relative humidity value RH\textsubscript{in} and the temperature value \(T_{in}\) of the drying air entering the condenser, as well as the temperature value \(T_{out}\) of the drying air exiting the condenser to be detected as the drying cycle goes on. The control means acquire the data delivered by the humidity and temperature sensor means 5, 6 so as to monitor the trend of the relative humidity RH\textsubscript{in} and the temperature difference value \(\Delta T\) as the drying cycle progresses.

The method provides for the so detected relative humidity value RH\textsubscript{in} to be compared with the threshold humidity value RH\textsubscript{inTH} that has been set in accordance with the drying cycle selected by the user, and for the temperature difference value \(\Delta T\) to be compared with the threshold temperature difference value \(\Delta T\textsubscript{TH}\) that has again been set in accordance with the drying cycle selected by the user.

The method then provides for the heating means 3 to be switched off when at least the temperature difference value \(\Delta T\) reaches up to or beyond the threshold temperature-difference value \(\Delta T\textsubscript{TH}\) or when at least said humidity value RH\textsubscript{in} reached down to or below the threshold humidity value RH\textsubscript{inTH}.

When one of these threshold values is reached, further to switching off the heating means 3, the method may also provide for the tumble dryer to be fully stopped from operating, under de-energization of the air-circulating blower means 11, 16 and the motor means used to rotatably drive the drum.

The method preferably also provides for a transient observation phase to be included immediately upon the heating means 3 having so been switched on, in which the control means just wait for the humidity and temperature data from the sensor means to become steadier before they start acquiring said data.

The provision of two distinct threshold values, i.e. RH\textsubscript{inTH} and \(\Delta T\textsubscript{TH}\), for each drying cycle that can be selected by the user, ensures greater effectiveness and accuracy in detecting the actual end-of-cycle condition, particularly in the case of drying cycles, such as Slightly Damp, Iron Dry and Mangle Dry, requiring less drying, i.e. a lower degree of dryness in the clothes, and having threshold values that lie rather close by.

It has been found and demonstrated experimentally that the trend of both RH\textsubscript{in} and \(\Delta T\) does not depend on the weight of the drying load, i.e. the amount of clothes to be dried.

The method for controlling the drying cycles in a clothes tumble dryer according to the present invention is not limited by, i.e. does not necessarily require the use of a condenser that is made and designed as has been described above by way of example. In the case of a tumble dryer that makes use of a different type of condenser, or a different condenser design, the trend of both temperature difference \(\Delta T\) and relative humidity RH\textsubscript{in} will in fact be much the same as the trends that have been found in the course of the above-described experimental tests considered herein, since the thermodynamics at the basis of these trends is anyway the same, regardless of the condenser being actually used.

The curves describing the trend versus time of humidity RH\textsubscript{in} and temperature difference \(\Delta T\) will most obviously have a different steepness, and different will clearly be also the threshold values RH\textsubscript{inTH}, \(\Delta T\textsubscript{TH}\) corresponding to the degrees of drying to be reached in the various drying cycles that can be selected by the user.

Also the drying cycles that are made available to the user may of course be set and fixed according to principles that differ from the aforesaid ones based on residual moisture as compared to a same drying load under standard conditions as a control parameter.

It can however be most readily appreciated that - even in the presence of a different condenser design - it is anyway possible for both the threshold relative-humidity values RH\textsubscript{inTH} of the drying air entering the condenser and the threshold temperature-difference values \(\Delta T\textsubscript{TH}\) of the drying air entering and exiting the condenser attributable to the various user-selectable drying cycles to be derived experimentally.

Such threshold values will then be made available to the control means via the memory means as soon as the operation of the tumble dryer is started, in accordance with the particular drying cycle selected by the user.

In a preferred embodiment of the present invention, the control means are adapted to numerically filter the signals they receive from the moisture and temperature sensor means 5, 6 so as to eliminate all detected values that are found to significantly depart from the main trend versus time of both the relative humidity values RH\textsubscript{in} and temperature difference values \(\Delta T\) being monitored by said control means during the drying cycle, i.e. as the clothes in the drum undergo drying.

Basically, the control means are adapted to discard any distorted, altered or perturbed value as may be detected.
by the moisture and temperature sensors, in such manner as to solely retain the main dynamics of the evolution of relative humidity \( RH_{in} \) and temperature difference \( \Delta T \) with time.

[0069] Such disturbances in detected values include perturbed measurements that do not correspond to the actual humidity and temperature values and can occur due to such measurements being affected by the dynamic, i.e. flow conditions of the drying air.

[0070] A further cause of disturbance in detected values may be due to the fact that, for an even and effective drying of the clothes being tumbled in the drum to be ensured, during the drying cycle there are provided reversal periods, in which the heating means 3 are switched off and the drum is rotated in the reverse direction, i.e. counter-rotated so as to allow the clothes held therein to be counter-tumbled and reshuffled. These reversal periods last just a few seconds and are separated from each other by pre-determined intervals of a few minutes each provided therebetween.

[0071] Most obviously, detections performed by the sensor means within these reversal periods tend to result in the measurement of humidity values \( RH_{in} \) and temperature difference values \( \Delta T \) that deviate to a rather considerable extent from the trend of the corresponding values that are on the contrary detected when the heating means 3 are switched on. In fact, as this can clearly be noticed in the graphs appearing in Figures 3, 4 and 5, in correspondence to, i.e. during said reversal periods the temperature-difference curve \( \Delta T \) shows minimum-value peaks, whereas the relative-humidity curve \( RH_{in} \) shows maximum-value peaks.

[0072] The control means filter these humidity values \( RH_{in} \) and temperature difference values \( \Delta T \) with the aid of a numeric low-pass filter.

[0073] In particular, the control means associate a first numeric low-pass filter to the humidity values \( RH_{in} \) and a second numeric low-pass filter to the temperature difference values \( \Delta T \), while both filters preferably comprise a numeric unit-gain low-pass filter of the first order according to following formulas:

\[
y_n = a \cdot y_{n-1} + (1-a) \cdot RH_{in}
\]

\[
u_n = a \cdot u_{n-1} + (1-a) \cdot \Delta T
\]

in which the coefficient \( a \) represents the parameter of the filters, the detected relative-humidity values \( RH_{in} \) represent the input variables of the first filter at the different instants \( n \), and \( y_n \) represents the current value of the first filter at the different instants \( n \), whereas the detected temperature-difference values \( \Delta T \) represent the input variables of the second filter at the different instants \( n \) and \( u_n \) represents the current value of the second filter at the different instants \( n \).

[0074] It has been found experimentally that - for the application considered - the parameter \( a \) of the filters can take a value ranging from 0.9 to 0.99.

[0075] In the particular embodiment being described, it has been opted to use the same value of the parameter \( a \) for all drying cycles selectable by the user, and for both the numeric filters, in order to avoid weighing too heavily on the processing load of the control means.

[0076] However, in order to ensure a more specific filtering effect, the value of the parameter \( a \) may vary in accordance with the various drying cycles that can be selected by the user, while within a same cycle selected by the user, the value of the parameter \( a \) may again differ in the two numeric low-pass filters.

[0077] The values of the parameter \( a \) of the filters are stored in the memory means and are adapted to be retrieved by the control means when the drying cycle selected by the user is started.

[0078] The control means acquire the relative-humidity values \( RH_{in} \) and the temperature-difference values \( \Delta T \) detected by the corresponding sensor means, and then calculate, i.e. work out the related numeric filters to obtain a corresponding filtered relative-humidity value \( RH_{in,filtered} \) and a corresponding filtered temperature-difference value \( \Delta T_{filtered} \) giving the curves indicated in Figures 3 and 5.

[0079] The control means are adapted to compare each such filtered relative-humidity value \( RH_{in,filtered} \) with the respective threshold relative-humidity value \( RH_{in,TH[ED,DC,SD,ID,M]} \) corresponding to the actual drying cycle selected by the user, and are furthermore adapted to compare each such filtered temperature-difference value \( \Delta T_{filtered} \) with the respective threshold temperature-difference value \( \Delta T_{TH[ED,DC,SD,ID,M]} \) that corresponds to the actual drying cycle selected by the user.

[0080] In particular, the control means are adapted to determine a first end-of-cycle coefficient \( dH \) and a second end-of-cycle coefficient \( dT \), which represent how close the filtered relative-humidity value \( RH_{in,filtered} \) has got to the respective threshold value \( RH_{in,TH[ED,DC,SD,ID,M]} \), and how close the filtered temperature-difference value \( \Delta T_{filtered} \) has got to the respective threshold value \( \Delta T_{TH[ED,DC,SD,ID,M]} \), respectively. These coefficients are determined by comparing the filtered values with the respective threshold values, according to following formulas:
These end-of-cycle coefficients \(dH\) and \(dT\) turn therefore out as being pure numbers that tend to unit as the filtered values \(RH_{\text{in,filtered}}\) and \(\Delta T_{\text{filtered}}\) get closer to the respective threshold values \(RH_{\text{in,TH}}[ED,DC,LH,ID,M]\) and \(\Delta T_{\text{TH}}[ED,DC,LH,ID,M]\).

Thus, the control means are adapted to compose the end-of-cycle coefficients \(dH\) and \(dT\) so as to obtain a single control quantity \(D\), on the basis of which they therefore decide that the drying cycle is to be caused to stop. This control quantity \(D\) is obtained by calculating the weighted average of the end-of-cycle coefficients \(dH\) and \(dT\) through a weight factor \(\delta\) that determines the specific contribution of the individual coefficients in accordance with the drying cycle selected, according to following formula:

\[
D = \delta \cdot dT + (100 - \delta) \cdot dH,
\]

wherein the value of the weight factor \(\delta\) depends on the selected cycle, so as to determine which quantity, between relative humidity \(RH_{\text{in}}\) and temperature difference \(\Delta T\), is more significant in view of identifying the end-of-cycle condition. The weight factor \(\delta\) is variable between 0 and 100 and depends on the selected cycle.

This is of particular value in the case of drying cycles as the Iron Dry and Mangle Dry ones, in which it is the value of temperature difference \(\Delta T\) that prevailingly determines said end-of-cycle condition, since the value of relative humidity \(RH_{\text{in}}\) is less reliable.

The value of the weight factor \(\delta\) has been determined experimentally for the different drying cycles provided for selection in a clothes tumble dryer, and is stored in the memory means so as to be made available for retrieval by the control means when the selected drying cycle is started.

Even the value of this stop parameter \(sD\) has been determined experimentally for the different drying cycles provided for selection in a clothes tumble dryer, and is stored in the memory means so as to be made available for retrieval by the control means when the selected drying cycle is started.

Summarized in the following table are the threshold values \(RH_{\text{in,TH}}[ED,DC,LH,ID,M]\), \(\Delta T_{\text{TH}}[ED,DC,LH,ID,M]\), the values of the end-of-cycle coefficients \(dH\) and \(dT\), the values of weight factor \(\delta\), and the values of the stop parameters \(sD\) for each one of a number of drying cycles:

<table>
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<th>Cycle</th>
<th>(RH_{\text{in,TH}})</th>
<th>(\Delta T_{\text{TH}})</th>
<th>(\delta)</th>
<th>(sD)</th>
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<tr>
<td>Extra Dry</td>
<td>68%</td>
<td>15 °C</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Dry Cottons</td>
<td>87%</td>
<td>7.4 °C</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Slightly Damp</td>
<td>93%</td>
<td>5.9 °C</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Iron Dry</td>
<td>93.5%</td>
<td>5.4 °C</td>
<td>60</td>
<td>95</td>
</tr>
<tr>
<td>Mangle Dry</td>
<td>94%</td>
<td>4.9 °C</td>
<td>60</td>
<td>85</td>
</tr>
</tbody>
</table>

When such end-of-cycle condition is found to exist by the control means, these cause the heating means to be switched off and, if provided or required so, the air-circulating blower means to be de-energized along with the motor means used to rotatably drive the dryer’s drum.

According to a preferred embodiment of the present invention, the method for controlling the operation of a clothes tumble dryer includes an initialization phase, in which the control means read the cycle that has been selected by the user and set the threshold relative-humidity values \(RH_{\text{in,TH}}[ED,DC,LH,ID,M]\), the threshold temperature-difference values \(\Delta T_{\text{TH}}[ED,DC,LH,ID,M]\), the value of the parameter \(a\) of the filters, the values of weight factor \(\delta\) and the value of...
the stop parameter sD, which correspond to the selected cycle, by retrieving the related values from the memory means.

[0090] The control means cause then the heating means 3 to be switched on and the air-circulating blower means 11, 16 to be energized along with the drum rotation driving means.

[0091] It is to be noted that in a further simplified embodiment of the present invention the end-of-cycle coefficients \( dH \) and \( dT \) can be determined by comparing the current values of temperature difference \( \Delta T \) and relative humidity \( RH_{in} \), non-filtered, with the respective threshold values. The end-of-cycle coefficients \( dH \) and \( dT \) are then composed, in the manner above described, to obtain the single control quantity \( D \) on the basis of which the control means switch off the heating means 3.

[0092] The control means are adapted to check the heating means 3 for the on/off state thereof through a proper operation sensor.

[0093] The method further includes a so-called transient observation phase, in which the control means just wait for the values of relative humidity \( RH_{in} \) and the values of temperature difference \( \Delta T \) to stabilize.

[0094] In a preferred manner, within this transient observation phase there may be provided at least a reversal period, in which the heating means 3 are switched off and the drum 2 driven to rotate in an opposite direction, i.e. counter-rotated.

[0095] When the detected values of relative humidity \( RH_{in} \) and the detected values of temperature difference \( \Delta T \) are detected to have become steadier, the control means check the heating means 3 for the on/off state thereof.

[0096] In the case that the heating means 3 are in the off state, i.e. the tumble dryer is performing a reversal period, the control means do not acquire said values of relative humidity \( RH_{in} \) and said values of temperature difference \( \Delta T \), and wait for the heating means 3 to switch to the on state thereof.

[0097] In the case that the heating means 3 are found in the on state thereof, the method calls for an initialization phase to occur, in which the control means acquire the value of relative humidity \( RH_{in} \) and the value of temperature difference \( \Delta T \) detected by the sensor means 5,6 to initialize the related numeric low-pass filters by calculating the corresponding filtered initial value of relative humidity \( RH_{in} \), filtered and the corresponding filtered initial value of temperature difference \( \Delta T \), filtered.

[0098] As a selected drying cycle progresses, the control means are adapted to acquire the relative-humidity values \( RH_{in} \), and the temperature-difference values \( \Delta T \) detected by the sensor means, and to filter these values with the aid of the numeric low-pass filters at predetermined successive time intervals; in the described embodiment there is provided a waiting time interval between two successive acquisition events of approx. 5 seconds.

[0099] The control means wait for such waiting time interval to elapse and, when this runs out, check the heating means 3 to see whether they are on or off.

[0100] In the case that the heating means 3 are found to be in the off state thereof, i.e. the tumble dryer is going through a reversal period, the control means - in a loop-like cyclic manner - wait again for the waiting time interval to elapse and, when this runs out, check again the heating means 3 for the on/off state thereof.

[0101] If the heating means 3 are on the contrary found to be in the on state thereof, the control means acquire the value of relative humidity \( RH_{in} \) and the value of temperature difference \( \Delta T \) as detected by the respective sensor means, and calculate the related numeric low-pass filters to determine the corresponding filtered relative-humidity value \( RH_{in} \), filtered and the corresponding filtered temperature-difference value \( \Delta T \), filtered, in the same manner as described hereinbefore.

[0102] Then, the control means check whether the end-of-cycle condition has eventually occurred by calculating the values of the end-of-cycle coefficients \( dH \) and \( dT \), the value of the control quantity \( D \), and comparing the resulting value of the latter with the value of the stop parameter sD.

[0103] If the value of the control quantity \( D \) turns out to be equal to or in excess of the value of the stop parameter sD, the control means switch off the heating means 3 and, if possibly provided or required so by the cycle, cause the operation of the dryer to stop.

[0104] If the value of the control quantity \( D \) is found to be lower than the value of the stop parameter sD, the control means - in a loop-like cyclic manner - wait again for the waiting time interval to elapse and, when this runs out, check the heating means 3 for the on/off state thereof in view of acquiring again the values of relative humidity \( RH_{in} \) and temperature difference \( \Delta T \), updating the related numeric low-pass filters and checking again whether the end-of-cycle condition has been reached.

Claims

1. Clothes tumble dryer comprising a closed-loop drying air circuit adapted to circulate heated drying air through a perforated rotating drum (2) holding a load to be dried, heating means (3) adapted to heat up said drying air, an air-cooled condenser (4) adapted to remove moisture from the hot moisture-laden drying air exiting said drum, an open-loop cooling air circuit adapted to circulate over and through the condenser (4) a stream of cooling air taken in from the outside ambient to cool said condenser, and to let out said stream of cooling air again into the outside ambient,
Clothes tumble dryer according to any of the preceding claims, wherein said control means are adapted to calculate a weighted average of said end-of-cycle coefficients \((dH, dT)\) through a weight factor \((\delta)\) that depends on the drying cycle selected by the user.

Clothes tumble dryer according to any of the preceding claims, wherein said weight factor \((\delta)\) depends on the selected drying cycle and said control means are adapted to retrieve the value of said weight factor \((\delta)\) from said memory means when the selected drying cycle is started.
11. Clothes tumble dryer according to any of the preceding claims, wherein reversal periods are provided during the drying cycle, in which the heating means (3) are switched off and the drum (2) is driven to rotate in the opposite direction, said control means being adapted to solely acquire said humidity values (RH_{in}) and said temperature difference values (\Delta T) when said heating means (3) are switched on.

12. Clothes tumble dryer according to any of the preceding claims, wherein said control means are adapted to acquire said relative humidity values (RH_{in}) and said temperature difference values (\Delta T) in correspondence to acquisition events that are separated from each other by a pre-set waiting time interval.

13. Clothes tumble dryer according to any of the preceding claims, wherein said numeric filters comprise a numeric unit-gain low-pass filter of the first order.

14. Clothes tumble dryer according to any of the preceding claims, wherein the value of said filtering parameter (a) ranges from 0.9 and 0.99.

15. Method for controlling a clothes tumble dryer including a closed-loop drying air circuit adapted to circulate heated drying air through the clothes to be dried held in a perforated rotating drum (2), heating means (3) adapted to heat up said drying air, an air-cooled condenser (4) adapted to remove moisture from the hot moisture-laden drying air exiting said drum, an open-loop cooling air circuit adapted to circulate over and through the condenser (4) a stream of cooling air taken in from the outside ambient to cool said condenser, and then let out again said stream of cooling air into the outside ambient, characterized in that it comprises the steps of:

- detecting a relative humidity value (RH_{in}) of the drying air entering the condenser (4), and
- detecting a temperature difference value (\Delta T) between the drying air entering the condenser (4) and the drying air exiting the condenser (4),
- retrieving, in response to said tumble dryer being started operating, a stored threshold temperature-difference value (\Delta T_{TH}) between the drying air entering the condenser (4) and the drying air exiting the condenser (4), and a stored threshold relative-humidity value (RH_{inTH}) of the drying air entering the condenser, both values depending on a drying cycle selected by the user and being representative of a pre-determined dryness degree of the clothes being handled,
- acquiring, during the operation of said tumble dryer, said relative humidity value (RH_{in}) and said temperature difference value (\Delta T) detected by the respective sensor means,
- comparing said relative humidity value (RH_{in}) with said threshold relative-humidity value (RH_{inTH}) corresponding to the drying cycle selected by the user, and
- comparing said temperature-difference value (\Delta T) with said threshold temperature-difference value (\Delta T_{TH}) for switching off said heating means (3) when at least said temperature difference value reaches said threshold temperature-difference value or at least said relative humidity value reaches said threshold relative-humidity value.

16. Method according to claim 15, further comprising the steps of:

- numerically filtering said acquired relative-humidity values (RH_{in}) and said acquired temperature-difference values (\Delta T), in order to eliminate all detected values deviating to a significant extent from the main trend versus time of said values of relative humidity (RH_{in}) and temperature difference (\Delta T) being monitored by said control means as the drying process of the clothes goes on, and establish a corresponding filtered relative-humidity value (RH_{infiltered}) and a corresponding filtered temperature-difference value (\Delta T_{filtered}).

17. Method according to claim 16, wherein said comparison step comprises the steps of:

- comparing said filtered relative-humidity value (RH_{infiltered}) with said threshold relative-humidity value (RH_{inTH}) corresponding to the drying cycle selected by the user, and
- comparing said filtered temperature-difference value (\Delta T_{filtered}) with said threshold temperature-difference value (\Delta T_{TH}) corresponding to the drying cycle selected by the user.

18. Method according to any of the preceding claims, further comprising the steps of:

- providing reversal periods during the drying cycle, in which the heating means (3) are switched off and the drum is driven to rotate in the opposite direction,
- solely acquiring said relative humidity value (RH_{in}) and said temperature difference value (\Delta T) if said heating means (3) are found to be switched on.
19. Method according to claim 16, wherein said numerical filtering step comprises the steps of:

- numerically filtering said acquired relative-humidity value (\(RH_{in}\)) through a first numeric low-pass filter, and
- numerically filtering said acquired temperature-difference value (\(\Delta T\)) through a second numeric low-pass filter.

20. Method according to claim 16, wherein said numerical filtering step further comprises the steps of:

- retrieving, in response to said tumble dryer being started operating, a stored numerical filtering parameter (\(a\)) that depends on the drying cycle selected by the user,
- numerically filtering in a differentiated manner said relative humidity value (\(RH_{in}\)) and said temperature difference value (\(\Delta T\)) on the basis of said numerical filtering parameter (\(a\)).

21. Method according to any of the preceding claims, wherein said comparison further comprises the steps of:

- determining a first end-of-cycle coefficient (\(dH\)) and a second end-of-cycle coefficient (\(dT\)) that are representative of how close the filtered relative-humidity value (\(RH_{in,\text{filtered}}\)) has got to the respective threshold value (\(RH_{\text{in,TH}}\)), and how close the filtered temperature-difference value (\(\Delta T_{\text{filtered}}\)) has got to the respective threshold value (\(\Delta T_{\text{TH}}\)), respectively.

22. Method according to any of the preceding claims, wherein said comparison step further comprises the steps of:

- calculating a weighted average of the end-of-cycle coefficients (\(dH, dT\)) through a weight factor (\(\delta\)) that depends on the selected drying cycle and determines the specific contribution of the individual coefficients in accordance with the selected cycle, so as to obtain a single control quantity (\(D\)),
- retrieving said weight factor (\(\delta\)) in accordance with the selected drying cycle.

23. Method according to any of the preceding claims, wherein said comparison step further comprises the steps of:

- comparing the value of said control quantity (\(D\)) with a stop parameter (\(sD\)) that depends on the selected drying cycle,
- retrieving the value of said stop parameter (\(sD\)) in accordance with the selected drying cycle,
- switching off the heating means (3) in the case that the value of the thus calculated control quantity (\(D\)) is found to be equal to or in excess of the value of said stop parameter (\(sD\)).

24. Method according to any of the preceding claims, wherein said acquisition step comprises the steps of:

- acquiring said relative humidity value (\(RH_{in}\)) and said temperature difference value (\(\Delta T\)) in correspondence to acquisition events that are separated from each other by a pre-set time interval.

25. Method according to claim 2, comprising the steps of:

- checking, after the tumble dryer has started operating, said relative humidity values (\(RH_{in}\)) and said temperature difference values (\(\Delta T\)) for becoming steadier,
- starting to acquire said relative humidity values (\(RH_{in}\)) and said temperature difference values (\(\Delta T\)) if these are found to have stabilized.

26. Method according to any of the preceding claims, wherein said numerical filtering step comprises the steps of:

- numerically filtering the so acquired relative humidity values (\(RH_{in}\)) through a first numeric unit-gain low-pass filter of the first order,
- numerically filtering the so acquired temperature difference values (\(\Delta T\)) through a second numeric unit-gain low-pass filter of the first order.

Amended claims in accordance with Rule 86(2) EPC.

1. Clothes tumble dryer comprising a closed-loop drying air circuit adapted to circulate heated drying air through a perforated rotating drum (2) holding a load to be dried, an air-cooled condenser (4) adapted to remove moisture
from the hot moisture-laden drying air exiting said drum, heating means (3) provided downstream the air-cooled condenser (4) for heating up the drying air to be sent again into the drum (2), an open-loop cooling air circuit adapted to circulate over and through the condenser (4) a stream of cooling air taken in from the outside ambient to cool said condenser, and to let out said stream of cooling air again into the outside ambient, temperature sensor means (5, 6) arranged at a condenser drying-air inlet (7) and at a condenser drying-air outlet (8) in order to detect a temperature difference value between the drying air entering the condenser (4) and the drying air exiting the condenser (4), characterized in that it further comprises humidity sensor means (5) arranged at said condenser drying-air inlet (7) in order to detect a humidity value of the drying air entering the condenser, control means coupled to said humidity sensor means (5) to receive said humidity value (RH_in), and coupled to said temperature sensor means (5, 6) to receive said temperature difference value ($\Delta T$) during the operation of said tumble drier, memory means for storing a threshold temperature-difference value ($\Delta T_{TH}$) between the drying air entering the condenser (4) and the drying air exiting the condenser (4), and a threshold relative-humidity value (RH_inTH) of the drying air entering the condenser, which are representative of a pre-determined dryness degree of the load and depend on the particular drying cycle selected by the user, said control means are adapted to retrieve said threshold values ($\Delta T_{TH}, RH_{inTH}$) from the memory means in response to a given drying cycle selected by the user, said control means being further adapted to compare said relative humidity value (RH_in) with said threshold relative-humidity value (RH_inTH) and said temperature difference value ($\Delta T$) with said threshold temperature-difference value ($\Delta T_{TH}$) for determining an end-of-cycle condition and switching off said heating means (3) when at least said temperature difference value ($\Delta T$) reaches said threshold temperature-difference value ($\Delta T_{TH}$) or at least said relative humidity value (RH_in) reaches said threshold relative-humidity value (RH_inTH).

15. Method for controlling a clothes tumble dryer including a closed-loop drying air circuit adapted to circulate heated drying air through the clothes to be dried held in a perforated rotating drum (2), an air-cooled condenser (4) adapted to remove moisture from the hot moisture-laden drying air exiting said drum, heating means (3) provided downstream the air-cooled condenser (4) for heating up the drying air to be sent again into the drum (2), an open-loop cooling air circuit adapted to circulate over and through the condenser (4) a stream of cooling air taken in from the outside ambient to cool said condenser, and then let out again said stream of cooling air into the outside ambient, characterized in that it comprises the steps of:

- retrieving, in response to a given drying cycle selected by the user, a stored threshold temperature-difference value ($\Delta T_{TH}$) between the drying air entering the condenser (4) and the drying air exiting the condenser (4), and a stored threshold relative-humidity value (RH_inTH) of the drying air entering the condenser, both values depending on the drying cycle selected by the user and being representative of a pre-determined dryness degree of the clothes being handled,
- detecting a relative humidity value (RH_in) of the drying air entering the condenser (4), and
- detecting a temperature difference value ($\Delta T$) between the drying air entering the condenser (4) and the drying exiting the condenser (4),
- acquiring, during the operation of said tumble dryer, said relative humidity value (RH_in) and said temperature difference value ($\Delta T$) detected by the respective sensor means,
- comparing said relative humidity value (RH_in) with said threshold relative-humidity value (RH_inTH) and said temperature difference value ($\Delta T$) with said threshold temperature-difference value ($\Delta T_{TH}$) for determining an end-of-cycle condition and switching off said heating means (3) when at least said temperature difference value reaches said threshold temperature-difference value or at least said relative humidity value reaches said threshold relative-humidity value.
FIG 2
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<td>Y</td>
<td>US 4 640 022 A (SUZUKI ET AL) 3 February 1987 (1987-02-03) * column 4, line 50 - column 15, line 22; claims 1,2; figures 1-6,8-13 *</td>
<td>1-26</td>
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The present search report has been drawn up for all claims.

Place of search: Munich
Date of completion of the search: 11 May 2006
Examiner: Lodato, A

CATEGORY OF CITED DOCUMENTS
X: particularly relevant if taken alone
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T: theory or principle underlying the invention
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D: document cited in the application
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ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO. EP 05 11 1172

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11-05-2006

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For more details about this annex: see Official Journal of the European Patent Office, No. 12/82