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(54) Method of conducting a drying cycle in a laundry treating machine, laundry treating machine and electronic controller unit

(57) The present application in particular relates to a method of conducting a drying cycle for drying wet laundry in a tumble drum of a laundry treating machine (1). The method comprises a step of determining a laundry load quantity and adapting the drying cycle in dependence of the laundry load quantity. The laundry load quantity is determined from at least one actual noise of an operational parameter of an electric drive motor (11) driving the drum (5).

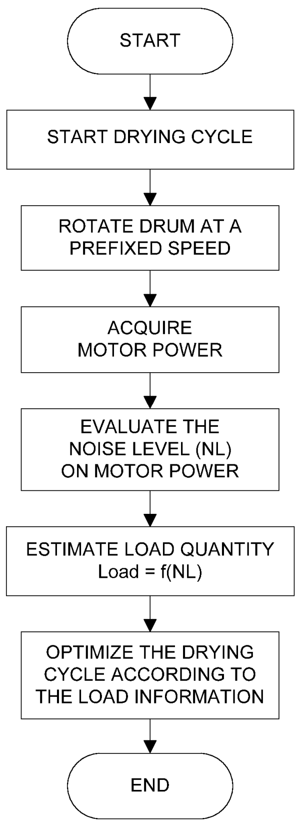

FIG. 7

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Description

[0001] The present invention in particular relates to a method of conducting or controlling a drying cycle in laundry treating machines, such as for example domestic laundry dryers or domestic laundry washer-dryers.

[0002] Laundry drying cycles and programs implemented with laundry treating machines are adequate for obtaining reduced or predetermined moisture levels of laundry after wet laundry cleaning cycles. Regarding laundry drying cycles, it is desirable to automatically control laundry drying cycles, in particular to stop the drying cycles at desired or selected moisture levels of laundry. Here it may be and has already been contemplated to use specific moisture or humidity sensors for determining the laundry moisture levels in order to stop the drying cycle at desired humidity levels. However, humidity sensors in general are quite expensive and complex to implement.

[0003] Other attempts of estimating the laundry moisture level or of estimating or determining adequate drying times have been proposed, inter alia based on signals available from the laundry treating machine like, for example, drying air temperature signals. However, the proposed methods still leave room for improvement in efficiency, accuracy and cost. Further attempts of estimating drying time and/or laundry load by measuring electrical current supplied to a motor driving the drying chamber or by measuring torque developed by such motor have been proposed in the art. However such methods have been found quite imprecise and highly dependent from laundry treating machine manufacturing tolerances which may influence the behaviour of the laundry treating chamber driving motor thereby altering the measurement of current and/or torque.

In particular, frictional forces between the drying chamber and statoric elements of the drying machine coupled thereto may consistently vary in two machines of the same model because of production and assemblying tolerances.

Therefore, it is an object of the invention to provide an improved method of conducting or controlling a drying cycle of a laundry treating machine. In particular a respective method shall be provided which shall be easily implementable and which shall be suitable for more accurately adapting and conducting drying cycles of laundry treating machines. The proposed method, in particular, shall also allow for automatically determining end- or stop-points or conditions of drying cycles for drying laundry. Further, a laundry treating machine and a respective electronic controller unit implementing a respective method shall be provided.

[0004] The above mentioned object is solved by claims 1, 13 and 14. Embodiments of the invention result from respective dependent claims.

[0005] According to claim 1, a method of conducting or controlling a drying cycle for drying wet laundry in a tumble drum of a laundry treating machine or apparatus is provided.

[0006] Respective laundry treating machines may be implemented as tumble dryers or washer-dryers, both in particular implemented as household type appliances.

[0007] In such machines, drying drums or tumble drums adapted for taking up the laundry to be dried are rotated in order to tumble the laundry contained therein for better drying results. The tumble drums in general are rotated by electric drive motors. Tumble drying as such is known in the state of the art and not described in details below.

[0008] Drying cycles in respective machines are conducted with the aim of drying wet laundry present after wet washing cycles applied to laundry. Respective drying cycles may be adapted to extract moisture from the wet laundry, and to automatically end in case that a defined or selected or preset residual moisture level or moisture content is reached. The term residual moisture level in particular shall relate to the amount or relative amount of moisture, i.e. water, still present in laundry, after a washing cycle, or, in particular, after a certain duration of the drying cycle.

[0009] A drying cycle as such may constitute an overall drying phase of drying laundry, but may also relate to selected sections or subsections of a superior or embracing drying phase or drying program to be executed by the laundry treating machine. This in particular shall mean that a drying program may comprise several drying cycles. The single drying cycles, at least one of them, may be conducted or controlled according to a method as proposed herein.

[0010] The proposed method according to claim 1 comprises a step of determining a laundry load quantity of laundry contained in the tumble drum, and adapting or controlling the laundry drying cycle in dependence of the laundry load quantity. The laundry load quantity in particular shall relate or correspond to the laundry weight contained or enclosed in the tumble drum of the laundry treating machine or shall be representative of the laundry weight contained in the tumble drum. The laundry load includes the weight of moisture wetting the laundry mass. According to the proposed method, the laundry load quantity is determined from, i.e. on the basis of, at least one noise level of an operational parameter, in particular actual operational parameter, of a drum electric drive motor driving the drum and optionally at least one fan during a drying cycle.

[0011] Respective operational parameters are comparatively easy available or can be determined or measured comparatively easily. Hence, the proposed method of conducting the drying cycle, which in particular shall comprise controlling and/or adapting the drying cycle, in a tumble dryer can easily be implemented with known tumble dryers.

[0012] Adaptation of the drying cycle on the basis of the laundry load quantity may for example comprise adapting or adjusting the drying cycle length essentially corresponding to adapting an end condition of the drying cycle, i.e. a stop point or stop condition, in which the drying cycle is stopped. Adaptation of the drying cycle on the basis of the laundry load quantity may further comprise adapting or adjusting the temperature of drying air entering the drum for drying laundry. For further details, reference is made to embodiments and variants described further below.

[0013] It shall be noted, that the noise level of an operational parameter may be determined in a single operational time interval or from a plurality of single time intervals of an actual, a pre-operating, an initial drying phase, stage or period of the tumble drying machine. Preferably, the initial drying phase is comprised between 1 and 5 minutes from the start of drum rotation.

[0014] In case that in each phase or period the noise level of the same type of operational parameter is determined, a mean value of single noise levels from respective phases may be calculated. The mean value may then be used as the noise level of the operational parameter for conducting the drying cycle.

[0015] In case that different types of noise levels are determined, measured or sensed in respective stages or periods, a combination of the different noise levels may be used for conducting the drying cycle.

[0016] The operational parameters, either a single operational parameter or different operational parameters, may be selected as described further below, in particular in connection with embodiments of the invention.

[0017] In embodiments, the operational parameter may be determined or selected from at least one of the electric power consumption, the current consumption or current drain, in particular the operational current flow through the drive motor, the power supply voltage and drive motor torque driving the drum and optionally at least a fan. This in particular shall mean, that current, voltage, power and torque of a drive motor driving the drum and optionally at least one fan, prevailing or observable during operation of the laundry treating machine, in particular during an initial operational phase of the laundry treating machine, may be used as the operational parameter for determining or calculating the laundry load quantity.

[0018] It shall be noted, that calculating the load quantity, in particular, shall mean that a specific calculation rule is provided according to which the laundry load quantity is calculated. As an input variable of the calculation rule, at least one operational parameter may be used.

[0019] Determining the load quantity, in particular, shall mean that a defined, fixed or preset correlation, assignment or classification is provided, according to which the laundry load quantity can be determined, i.e. estimated, from the at least one noise level of an operational parameter. In the latter case, it may be that the laundry load quantity is determined from a look-up table stored in a memory of the laundry treating machine, which look-up table may comprise value pairings, i.e. two or higher dimensional vectors, correlating a value or value range of the noise level of an operational parameter with a value or value range of laundry load quantity or values derived therefrom.

[0020] Coming back to the operational parameters as given above, it shall be mentioned, that these parameters can be determined or measured comparatively easy without requiring involved or complicated sensors. Further, respective parameters, and even values calculated therefrom, have turned out to be effective for obtaining the laundry load quantity contained in the drying drum with sufficient and adequate accuracy.

[0021] Under the term noise level, in particular the signal fluctuation over time of a current, voltage, power and/or torque signal shall be understood. The signal fluctuation may be an absolute fluctuation of a respective signal or it may be a relative fluctuation, in particular a fluctuation relative to the average value of the signal. For example, the noise level may be calculated as the mean square error, i.e. the variance, or the average value of the signal fluctuations.

[0022] The signal fluctuations in particular may be calculated according to the following formula:

$$SF(Signal) = \left| Signal(t_i) - Signal_{(average)} \right|,$$

wherein SF shall designate the signal fluctuation, $Signal(t_i)$ shall designate the value of an actual signal value measured or observed in or at time-point t_i, and $Signal_{(average)}$ shall designate the average or mean signal value over the relevant period of time.

[0023] Using the noise level has been found to be comparatively accurate and robust. A further advantage of using the noise level rather than respective absolute values is that the noise level is far more independent from machine type and machine construction.

[0024] Constructional details and mounting variations, probably due to manufacturing tolerances, may vary from machine to machine. Such variations in particular may influence for example frictional losses at sealings, in particular tumble drum sealings, motor belts or drive pulleys and other locations. These variations may directly and significantly influence the absolute values of current, voltage, power and torque. Respective noise levels are influenced considerably less by such variations and therefore can be used for increasing the accuracy of the method. In particular, noise-level based methods can be used essentially machine-independent, i.e. for a great variety of machine types and models.

[0025] In one particular favourable variant, the noise level of the power consumption of the drum driving motor is used as a basis for determining or calculating or estimating the laundry load quantity. Using the noise level of the power consumption has been shown to lead to methods that are very less dependent, or even completely independent, from machine construction and machine type or model. Therefore, the noise level of the power consumption is adequate for obtaining great precision and repeatability in the step of determining the laundry load quantity.

[0026] In variants, which at least in part have been addressed further above, the noise level may be calculated as the absolute variation of a respective operational value relative to its mean value, the square deviation of the operational value, the root mean square deviation of the operational value, or an average value of the operational value derivative and similar.

[0027] In embodiments the laundry load quantity may be calculated, determined or estimated from the noise level determined in an initial or in a starting phase of the drying cycle. Using an initial time interval of a drying cycle, in particular a time interval before effectively starting drying operation, may be effective in obtaining precise, reliable and repeatable results regarding the laundry load quantity de facto contained in the laundry drum.

[0028] Where appropriate, the step of calculating or determining the laundry load quantity may be repeated once or repeated for several times. Laundry load quantities so determined may be compared against each other in order to verify the laundry load quantity determined or calculated in previous iterations. Laundry load quantity iterations may be stopped if fluctuations in the calculated or determined laundry load quantity lie within a preset fluctuation range. Using iterations in laundry load quantity calculation or determination may lead to more accurate laundry load quantity values, and therefore to better drying results.

[0029] In embodiments, the actual, or a respective actual, in particular determined or measured, noise level of an operational parameter may be assigned to one of several predefined parameter ranges. Each parameter range may be assigned to a load quantity range. In other words, a correlation may be defined in which one or more ranges or intervals of the noise level of an operational parameter are assigned to adequate ranges or intervals of laundry load quantity values. The load quantity range in the proposed embodiments may be used as the laundry load quantity, in the end used for adapting or controlling the drying cycle. Alternatively, the laundry load quantity may be calculated by extrapolation or interpolation based on interval ends of the laundry load ranges.

[0030] A respective assignment between parameter ranges and laundry load ranges may be set up or based on empirical data, a series of experiments or tests and others.

[0031] The laundry load quantities determined on the basis of parameter and load ranges or intervals can be implemented comparatively easily and may be conducted with comparatively low or moderate processing effort. An example for such an assignment, based on the noise level of the operational parameter power consumption is exemplarily given in table 1:

Table 1: laundry load assignment on the basis of noise level ranges;

Noise level NL of power consumption (arbitrary units) in initial phase of drying cycle;	**Laundry load quantity [Kg] within drying drum;**
$0 < NL \leq 600$	Load $\leq$ 3 kg
$600 < NL \leq 1000$	3 kg < Load $\leq$ 6 kg
$1000 < NL$	6 kg < Load

[0032] In further embodiments, an actual laundry load quantity may be calculated as a mathematical function or relationship of the noise level of an operational parameter or of at least one noise level of an operational parameter. Such mathematical function can be retrieved from experimental data wherein the at least one noise level of an operational parameter is acquired during a rotation of a drum containing a known laundry load quantity. Using a mathematical function or relationship in some instances may lead to enhanced and more appropriate results. Note that mathematical functions and assignment tables as described beforehand can be mixed and combined, if adequate.

[0033] In embodiments, the laundry load quantity may be determined from noise level(s) of an operational parameter determined and/or measured in an operational phase in which the revolutions per time unit, i.e. the rotational speed of the respective motor, in particular the drum electric drive motor, is controlled to be essentially constant, or even is constant.

[0034] Using intervals of constant or essentially constant rotational speed is effective in obtaining accurate results with comparatively high repeatability.

[0035] Note that laundry load quantities of several phases may be used, compared and/or mutually combined, wherein in each of the several phases, the rotating speed is kept constant or at least essentially constant. The term "essentially" in particular shall relate to unavoidable fluctuations in the rotational speed. The rotational speeds of the single phases may be equal or may vary from phase to phase. The variation in the rotational speed between the phases may be random, but also may be selected according to predefined steps.

[0036] In more general terms, the previous embodiments may relate to methods in which the laundry load quantity is determined or calculated from noise level(s) of operational parameters or values identified or measured in predefined operational phases or modes of the laundry treating machine.

[0037] One such operational phase or mode for example is that of constant or essentially constant rotational speed of the drying drum. Other operational phases, in particular with defined operation and operational properties of the laundry treating machine may be considered. For example, the laundry load quantity may be determined or calculated in absence of a drying air flow passing through the drum, or during an inactive phase of heating device provided for heating drying air.

[0038] In the embodiments relating to a preset operational phase with defined operational speed of the drum electric drive motor for determining or calculating the laundry load quantity, the revolutions per time of the motor may be in the range of about 2000 to 2500 rpm, such rotational speed corresponding to a drum rotational speed in the range of about 40 to 50 rpm for a drum having a diameter of about 500 to 550 millimetres.

[0039] In embodiments, at least partially addressed already further above, the laundry load quantity may be used for controlling and/or adapting a stop or end condition of the drying cycle. In other words, the drying cycle may be stopped in dependence of the laundry load quantity, wherein the drying cycle may increase in duration the larger the laundry load quantity is, and vice versa. For example the duration of a drying cycle may be defined as a weight-dependent fraction of a pre-set unique duration, or through lookup-tables of overall durations, or weight-dependent distractions from a given time duration. The pre-set or given time duration is determined under known drying condition, i.e. for a given drying air flow rate and under known temperature thereof.

[0040] The stop condition may be, for example, an end-point or intermediate end-point of a drying program executed by the laundry drying machine. Note that a drying process or program may comprise several drying phases or drying cycles, each of which may be controlled according to the proposed method.

[0041] Furthermore, the laundry load quantity may be used for controlling the temperature of drying air entering the laundry drum so as to improve the drying process and shortening the duration thereof.

[0042] Using the laundry load quantity, and if appropriate also other variables, is at least helpful in improving and optimizing the accuracy of the laundry drying times. In particular, drying results can be improved over a comparatively wide range of different loads.

[0043] In further embodiments, the method may comprise at least the following steps:

a.starting a tumble drying program, in particular a program section incorporating or constituting a laundry drying cycle;

b.rotating a tumble drum of the laundry treating machine during at least one predefined time interval at a respective constant predefined rotational speed;

c.acquiring in each time interval at least one operational parameter of the drive motor;

d.determining a representative of noise of the acquired at least one operational parameter of the drive motor;

e.estimating, calculating, or determining the laundry load quantity on the basis of the noise of the at least one operational parameter; and

f.adapting the drying cycle, in particular the drying cycle course or drying cycle progress, on the basis of the load quantity determined in step (e).

[0044] The proposed method and method steps can easily be implemented with control units of laundry treating machines, in particular tumble dryers and washer dryers, and is/are effective in providing acceptable and adequate drying results.

[0045] In an embodiment of the method, the laundry load quantity may be calculated as a mean value from load quantities determined for each of several time intervals. This in particular applies if several time intervals are provided. Note that the mean value may be replaced by other values, in particular calculated from single laundry load quantities according to mathematical formulas

[0046] According to claim 13, a laundry treating machine is proposed which comprises a laundry drying unit, which in turn comprises an electronic controller unit configured to operate the laundry drying unit according to a method according to at least one embodiment and/or variant as described above and further above. As to advantages, reference is made to the description above and also further below.

[0047] According to claim 14, an electronic controller unit adapted to control a laundry treating machine is proposed, in which the electronic controller unit comprises a memory in which a program is stored, which is configured to carry out in a laundry treating apparatus a method as described in one of the embodiments and variants above and further above. Advantages in particular result from respective advantages of the proposed method.

[0048] In addition it shall be mentioned that the invention also may be related to an electronic controller program product adapted to execute a method as proposed above when executed on an electronic controller of a laundry treating machine. The electronic controller program product may comprise a storage unit having stored instructions which upon execution on an electronic controller unit of a laundry treating machine will implement a method as described in more details further above.

[0049] Exemplary embodiments of the invention will now be described in connection with the annexed figures, in which

FIG. 1 shows a schematic representation of a drying circuit of a laundry dryer;

FIG. 2 shows a drying drum of the laundry treating machine in a low load condition;

FIG. 3 shows a drying drum of the laundry treating machine in an intermediate load condition;

FIG. 4 shows a drying drum of the laundry treating machine in a high load condition;

FIG. 5 shows a pair of diagrams related to operational parameters in the intermediate load condition of FIG. 3;

FIG. 6 shows a pair of diagrams related to operational parameters in the high load condition of FIG. 4; and

FIG. 7 shows a flowchart of an exemplary drying algorithm.

[0050] It shall be mentioned that the laundry treating apparatus, in particular tumble dryer shown in the figures in particular is described as far as is necessary for adequately understanding the invention, however without restricting the scope of protection.

[0051] FIG. 1 shows a schematic representation of a drying circuit of a laundry dryer 1. In general, laundry dryers 1 use air as a process medium 2 which is passed through laundry 3, contained in a drying chamber 4 in most cases implemented as a drying drum 5.

[0052] In passing the process medium 2 through laundry 3, moisture contained in the laundry 3 is extracted and discharged via the process medium 2 or drying process air. In more detail, hot or heated and dry air is applied to laundry 3 in the drying chamber 4. The air takes up moisture and exits the drying chamber 4 with higher humidity and lower temperature as compared to the input.

[0053] Then, the process medium 2 is passed over a condenser 6 where the process medium 2 is cooled down such that humidity is condensed. Condensed humidity may be collected in a tank 7.

[0054] A fan 8 is used for circulating the process medium 2 in the drying circuit of the laundry dryer 1. By operation of the fan 8, the process medium is passed from the condenser 6 to a heater 9, where the process medium 2 is re-heated and thus prepared for taking up humidity when passing the drying chamber 4 again. A circulatory stream of process medium 2, generated by the fan 8 is indicated by arrows in FIG. 1.

[0055] In order to adequately conduct and control a drying cycle for drying the laundry 3 contained in the drying drum 5, it may be helpful to know the laundry load quantity, i.e. the laundry weight, contained within the drying drum 5.

[0056] For this reason, the method as proposed herein and by the present invention provides a comparatively accurate, reliable and repeatable way of how to obtain the laundry weight.

[0057] Based on the laundry weight, a control unit 10 can be adapted to control and operate the condenser 6, fan 8, heater 9 and a drive motor 11 of the drying drum 4. In particular, the control unit 10 may conduct a drying cycle according to a preset drying program stored in a memory of the laundry dryer 1, in particular control unit 10. The drying program in general may comprise a fixed standard drying cycle length. Obviously, such a standard drying cycle length is not able to fit for any laundry load levels, i.e. laundry load quantities occurring during ordinary use of the laundry dryer 1.

[0058] Hence, the control unit 10 may be implemented with a method able to determine the laundry load quantity, which then may be used to adapt the drying cycle, in particular drying time, to more adequate values. Furthermore, the determination of the laundry load quantity can be useful to control or adjust the temperature of drying air entering the drum so as to reduce the energy consumption.

[0059] The method therefore comprises a step of determining the laundry weight contained in the drying drum 4. In more details, the laundry weight in the present implementation and example is determined from a noise level of the power consumption of the drive motor 11. The determination of the noise level is conducted in an initial phase of the drying cycle, or in a pre-drying section of the drying cycle, in which the motor speed of the drive motor 11 is kept essentially at a constant level.

[0060] Using the noise level of the power consumption of the drive motor 11 has the advantage that determination of the laundry weight can be carried out more independent from details on laundry dryer model construction, type and other constructional and operational conditions.

[0061] Note that using absolute operational parameters such as the current or voltage consumption and motor torque could render the method dependent on the dryer type and dryer construction. In particular manufacturing tolerances may greatly influence respective absolute parameters, even with machines of the same type.

[0062] The noise level or signal fluctuation of the power consumption of the drive motor 11 SF_P can be calculated as follows:

$$SF_P = \left| P_{(actual)} - P_{(average)} \right|$$

[0063] This formula essentially corresponds to the formula given further above.

[0064] It shall be noted, that signal fluctuations or noise in the power consumption of the drive motor 11 is generated or caused, or depends on the laundry load quantity, i.e laundry weight.

[0065] In FIG. 2 to FIG. 4 three different scenarios with different laundry load conditions are shown. In more detail, FIG. 2 shows a drying drum of the laundry treating machine in a low load condition together with the tumbling behaviour of the laundry 3. FIG. 3 shows the situation in an intermediate load condition, and FIG. 4 shows the situation in a high load condition.

[0066] As can be seen from FIG. 2 to FIG. 4, the path of the laundry 3 within the drum during drying drum rotations vary with varying laundry load quantities, which is indicated by the different shapes of the curved arrows in FIG. 2 to FIG. 4. The differences in the laundry pathways within the drying drum 4 correlates with driving motor power consumption and hence noise level, which is illustrated for two scenarios in more details in FIG. 5 and FIG. 6.

[0067] In FIG. 5 a pair of diagrams related to operational parameters in the intermediate load regime of FIG. 3 are shown, whereas in FIG. 6 a pair of diagrams related to operational parameters in the high load regime of FIG. 4 are shown. In FIG. 5 and 6 the noise level has been shown in an amplified scale compared to the scale used for representing the motor power. The scale of the noise level can be obtained from the scale used for representing the motor power by multiplying the latter for a constant value comprised, for example, between 15 and 20. The measuring unit of noise level has been indicated as 'arbitrary units' for taking into account the amplification of the motor scale unit (Watts) generated by the constant value. The time scale is identical to all diagrams.

[0068] As can be seen from a direct comparison of corresponding diagrams, the average power consumption, i.e. motor power, in the intermediate load condition is lower than that in the high load condition. Further, also the noise level in the intermediate load condition is lower than the noise level in the high load condition. Similar relationships (not shown) can be applied with the low load regime compared to intermediate and high load regimes.

[0069] As can be seen for example from FIG. 5 and FIG. 6, an initial noise level of the power consumption of the drive motor lies in the intermediate load regime in the region of about 800 Units, whereas a corresponding noise level in the high load regime lies in the region of about 1100 Units.

[0070] The laundry weight or laundry load quantity may be determined for example according to and by use of a lookup-table, such as exemplarily given in table 1 further above.

[0071] The values contained in the lookup table may correspond to empirical measurements and tests. In the present case and in the use of the lookup table 1, the laundry load for the noise level in FIG. 5 can be assigned to a laundry load quantity in the range between 3 kg and 6 kg, whereas the noise level in FIG. 6 can be assigned to a laundry load quantity of above 6 kg.

[0072] The laundry weight quantities, i.e. values, so determined can be further improved by using rough approximations, such as for example interpolations and/or extrapolations. For example, the laundry weight in the scenario of FIG. 5, where the noise level of 800 Units of the power consumption lies in the middle between 600 Units and 1000 Units, can be interpolated to (3 kg + 6 kg)/2 = 4,5 kg. Other calculation methods may be applied.

[0073] FIG. 7 shows a flowchart of an exemplary drying algorithm. With the proposed algorithm, a drying cycle is started after an initial start signal.

[0074] After activating the drying cycle, the control unit 10 operates the drive motor 11 and drying drum 4 to rotate essentially at a constant, prefixed speed.

[0075] During this initial phase in which the drive motor 11 is rotated at essentially constant speed, the motor power consumption is continuously measured.

[0076] The measured values of the motor power consumption are then used to calculate the noise level of the motor power consumption. The calculation may be conducted according to any method mentioned above and further above.

[0077] After having determined or calculated the initial noise level, the laundry load quantity, i.e. the load of the drying drum 5 can be determined, in particular calculated and/or estimated. Reference is made to the description above.

[0078] Based on the laundry load quantity, and, as the case may be under utilization of the noise level, the drying cycle may be optimized. In particular the overall length of the drying cycle may be adapted to the laundry load quantity actually contained in the drying drum 5. Additionally the temperature of air entering the drum may be controlled or adjusted to adapt the drying air flow to the actual weight of laundry mass to be dried.

[0079] After having optimized the drying cycle, the drying cycle can be conducted until the end condition is reached, i.e. a condition in which laundry in the drying drum 5 is intended to have reached a preset or desired humidity level.

[0080] As can be seen, the method as proposed herein is effective in adequately conducting, adapting and/or controlling drying cycles of laundry dryers. In particular adaptation of the drying cycles can be achieved with comparatively low efforts, yet yielding comparatively accurate adaptations of the drying cycles.

[0081] The proposed method and, in particular, the described algorithm in particular have the following advantages:

- the proposed control method is suitable for comparatively accurately obtaining final or residual laundry moisture levels;
- complicated or extra humidity and/or moisture sensors can dispensed with;
- the method and algorithm can be applied to different dryer topologies, in particular based on electric heaters, heat-pump systems, washer-dryer and so on;
- a favourable uniformity of drying can be obtained even for different and varying load quantities;
- the drying algorithm and method can be applied to different types of laundry and textiles, e.g. cotton, synthetic, etc.

List of reference numerals

[0082]

1	laundry dryer
2	process medium
3	laundry
4	drying chamber
5	drying drum
6	condenser
7	tank
8	fan
9	heater
10	control unit
11	drive motor

Claims

1. Method of conducting a drying cycle for drying wet laundry (7) in a tumble drum (5) of a laundry treating machine (1), wherein the method comprises a step of determining a laundry load quantity and adapting the drying cycle in dependence of the laundry load quantity, wherein the laundry load quantity is determined from at least one noise level of an operational parameter of an electric drive motor (11) driving the drum (5).

2. Method according to claim 1, wherein the operational parameter is determined from at least one of: the electric power consumption, the current consumption/drain, the power supply voltage or motor torque of the drum drive motor (11).

3. Method according to claim 1 or 2, wherein the noise level is calculated as: the absolute variation of a respective

operational value relative to its mean value, or the mean square deviation of the operational value, or the root mean square deviation of the operational value, or an average value of the operational value derivative.

4. Method according to any of the preceding claims, wherein the laundry load quantity is calculated or determined from the at least one noise level of an operational parameter in an initial phase of the drying cycle comprised between 1 and 5 minutes from the start of drum rotation.

5. Method according to any of the preceding claims, wherein the laundry load quantity is determined or calculated in absence of a drying air flow passing through the drum (5), or during an inactive phase of a heating device provided for heating drying air (2).

6. Method according to any of the preceding claims, wherein the actual noise of the operational parameter is assigned to one of several predefined parameter ranges, wherein each parameter range is assigned to a load quantity range which is used as the laundry load quantity.

7. Method according to any of the preceding claims, wherein an actual laundry load quantity is calculated as a mathematical function of the at least one noise level of an operational parameter.

8. Method according to any of the preceding claims, wherein the laundry load quantity is determined from noise level of an operational parameter of an operational phase in which the revolutions per time unit of the motor (11) is controlled to be essentially constant.

9. Method according to claim 8, wherein the revolutions per time are in the range of 2000 to 2500 rpm.

10. Method according to any of the preceding claims, wherein the laundry load quantity is used for controlling and/or adapting an end condition in which the drying cycle is stopped.

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

a. starting a tumble drying program;
b. rotating a tumble drum (5) of the laundry treating machine (1) during at least one predefined time interval at a respective predefined rotational speed;
c. acquiring in each time interval at least one operational parameter of the drive motor (11);
d. determining a representative of noise of the acquired at least one operational parameter;
e. estimating, calculating, or determining the laundry load quantity on the basis of the noise of the at least one operational parameter; and
f. adapting the drying cycle on the basis of the load quantity determined in step (e).

12. Method according to claim 11, wherein the laundry load quantity is calculated as a mean value from load quantities determined for each of several time intervals.

13. Laundry treating machine (1) comprising a laundry drying unit (6 to 10) which comprises an electronic controller unit (10) configured to operate the laundry drying unit (6 to 10) according to a method according to at least one of claims 1 to 12.

14. Electronic controller unit (10) adapted to control a laundry treating machine (1), wherein the electronic controller unit (10) comprises a memory in which a program is stored, which is configured to carry out in a laundry treating machine (1) a method according to at least one of claims 1 to 12.

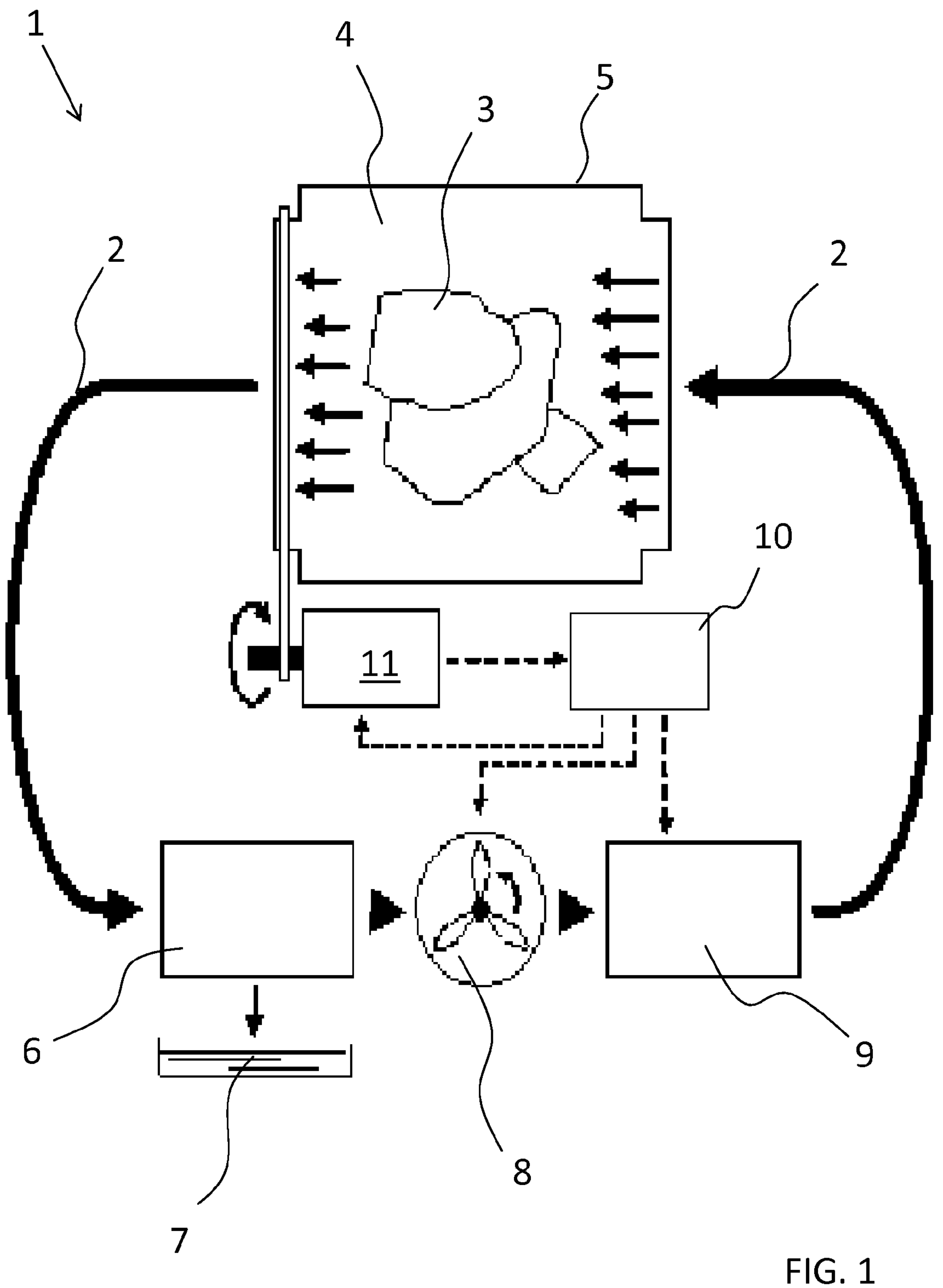

FIG. 1

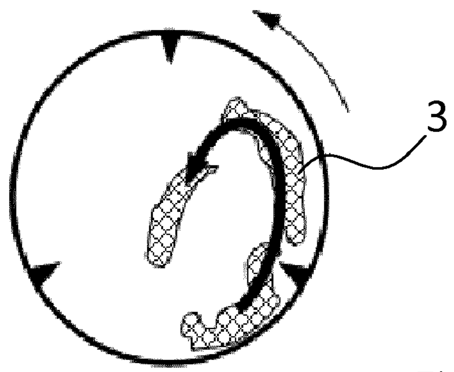

FIG. 2

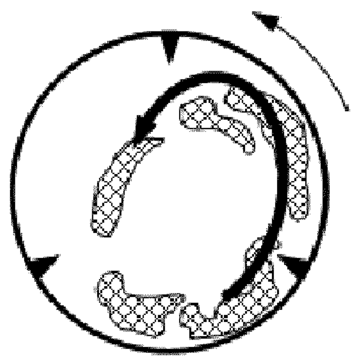

FIG. 3

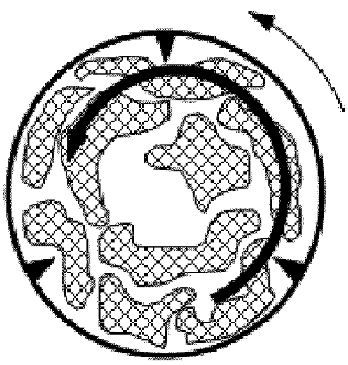

FIG. 4

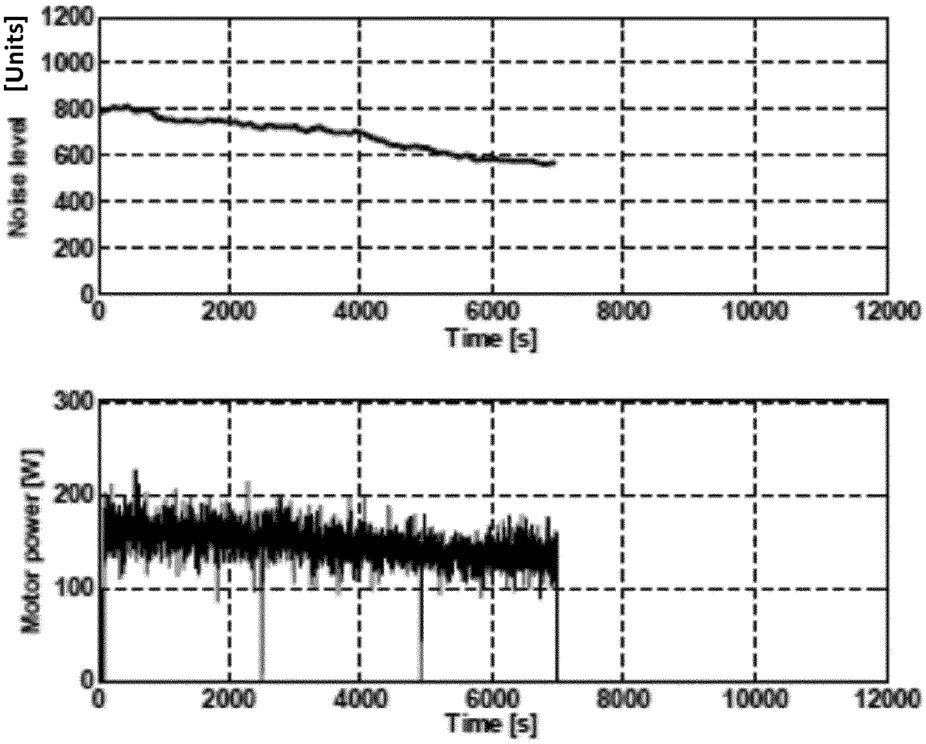
Noise level [Units]
Time [s]
Motor power [W]
Time [s]

FIG. 5

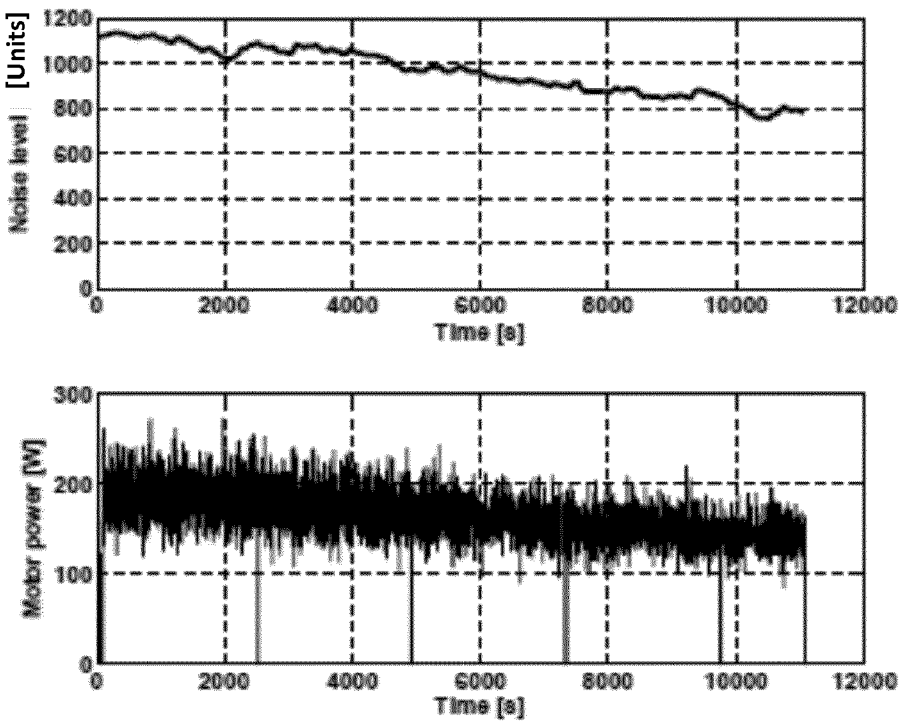
Noise level [Units]
Time [s]
Motor power [W]
Time [s]

FIG. 6

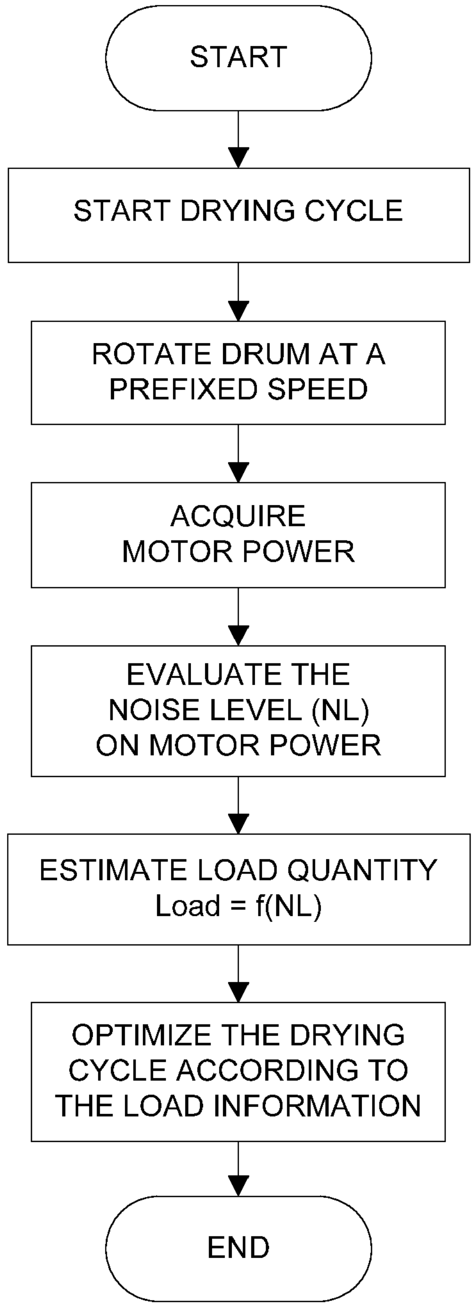
START
START DRYING CYCLE
ROTATE DRUM AT A PREFIXED SPEED
ACQUIRE MOTOR POWER
EVALUATE THE NOISE LEVEL (NL) ON MOTOR POWER
ESTIMATE LOAD QUANTITY Load = f(NL)
OPTIMIZE THE DRYING CYCLE ACCORDING TO THE LOAD INFORMATION
END

FIG. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 14 16 2963

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 281 935 A1 (BSH BOSCH SIEMENS HAUSGERAETE [DE]) 9 February 2011 (2011-02-09) * paragraphs [0005] - [0006] * * paragraphs [0009] - [0012] * * paragraphs [0015] - [0028] * * claims 1-11; figures 1-2 * -----	1-14	INV. D06F58/28
A	US 2005/028296 A1 (LEE TAE HEE [KR] ET AL) 10 February 2005 (2005-02-10) * paragraph [0031] - paragraph [0034] * * paragraph [0045] - paragraph [0057] * * claims 1-2; figures 4-9 * -----	1-14	
A	US 2012/005840 A1 (JANG HOYONG [KR] ET AL) 12 January 2012 (2012-01-12) * paragraph [0007] - paragraph [0011] * * paragraph [0211] - paragraph [0227] * * figures 6-7,10-12,14-16,19-22 * -----	1-14	
			TECHNICAL FIELDS SEARCHED (IPC)
			D06F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	18 September 2014	Weinberg, Ekkehard

CATEGORY OF CITED DOCUMENTS

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EP 14 16 2963

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18-09-2014

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