



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.10.2015 Bulletin 2015/41

(51) Int Cl.:
D06F 58/28 (2006.01)

(21) Application number: **14162962.6**

(22) Date of filing: **31.03.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

- **Altinier, Fabio**
33080 Porcia (IT)
- **Quaroni, Alberto**
33080 Porcia (PN) (IT)
- **Pasquotti, Maura**
33080 Porcia (PN) (IT)

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

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

(72) Inventors:
• **Ragogna, Roberto**
33080 Porcia (PN) - Italy (IT)

(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 (7) in a tumble drum (5) of a laundry treating machine (1). The method comprises controlling the operation of

the drying cycle in dependence of at least one of an electrical and electromechanical operational parameter of the laundry treating machine, changing together with laundry humidity of laundry (3) during the drying cycle.

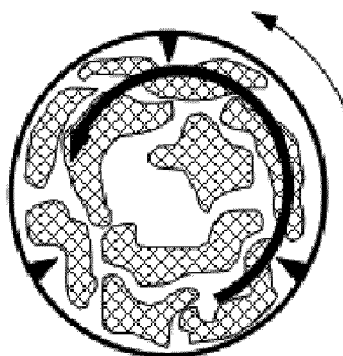


FIG. 4

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. Further there is still room for improvement in efficiency, accuracy and cost of known control methods for laundry drying cycles.

[0003] 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, 10 and 11. 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 and/or electro-mechanical drives, in particular comprising electric motors, drive trains and/or belt drives.

[0008] Tumble drying as such is known in the state of the art and not described in details below.

[0009] 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.

[0010] 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.

[0011] The proposed method according to claim 1 comprises controlling the operation or course or progress of the drying cycle in dependence of or according to the noise level of an operational parameter of the laundry treating machine. The operational parameter is characterized in that it changes together or along with laundry humidity or a humidity level of the laundry during the drying cycle.

[0012] The invention in particular is based on the finding that noise level of operational parameters of the laundry treating machine that change together with, in particular in concert with, the humidity or moisture level of the laundry contained in the drying drum, are suitable to control the drying cycle.

[0013] The noise level of respective electrical and/or electro-mechanical parameters in particular are suitable for controlling an end condition of the drying cycle, i.e. stopping the drying cycle if the laundry has reached a given or pre-set final humidity level.

[0014] In other words, the noise level of electrical and/or electro-mechanical operational parameters can be used as a control parameter for controlling the drying cycle instead of, or as a substitute of, an actual, in particular measured, value of laundry humidity or moisture of the laundry contained in the drying drum.

[0015] Respective parameters as identified by the invention relate to electrical and/or electro-mechanical operational parameters that change, and/or are modified over time during the drying cycle, wherein the change or modification goes along with and/or is correlated with the change in humidity of the laundry within the drying drum.

[0016] In particular, the time course of the noise level of the electrical and/or electro-mechanical parameter may be used instead of a time course of the actual humidity level. The time course of the noise may be controlled or verified, in particular in a continuous manner, and in case that the noise passes or crosses a preset threshold, the drying cycle may be stopped.

[0017] The threshold may for example relate or correspond to the humidity level of laundry to be obtained at the end of the drying cycle. This means, that the threshold may be determined or calculated such that the actual moisture level

of the laundry essentially matches the desired final moisture level as soon as the noise of the operational parameter reaches the stop threshold. Hence, a humidity threshold is replaced by a threshold related to the noise level of an operational parameter of electrical and/or electro-mechanical type.

[0018] Using the noise level of an electrical and/or electro-mechanical operational parameter of the laundry treating machine leads, in particular according to the findings of the invention, to comparatively accurate and reliable control options for obtaining a desired final moisture level, or for stopping the drying cycle at a pre-set or desired final moisture level.

[0019] In order to obtain adequate and/or satisfactory drying results, the noise level of the operational parameter may be calibrated against real humidity levels or moisture levels of a laundry drying cycle. The calibration may be conducted in dependence of the laundry load, i.e. weight, contained in the drying drum. The laundry weight may be determined or calculated from the noise level of electrical and/or electro-mechanical operational parameters, evaluated for example in pre-drying phase or initial phase of the laundry drying cycle. 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. Further preferably, the initial drying phase is comprised between 1 and 5 minutes from the start of drum rotation.

[0020] The laundry weight may also be used for determining the stop threshold. The stop threshold may for example be a humidity level at the end of the drying cycle. Note that stop thresholds may in addition depend on the operational settings of predefined drying programs.

[0021] For example, in one specific drying program, laundry may be intended to have a final moisture level of 12% suitable for being ironed after the drying cycle. Hence, the stop threshold may be adapted and the noise level of an operational parameter may be calibrated such that the drying cycle can be stopped at a moisture level of about 12% suitable for ironing.

[0022] In another specific drying program, the final moisture level may be intended to be about 0%, suitable for putting the laundry into the cupboard immediately after the drying process. Here, a different calibration may be used to correlate the noise level of an operational parameter to the final or desired moisture level of 0%.

[0023] In preferred embodiments, the noise of an electrical or electro-mechanical operational parameter is taken from measured at or derived from at least one of a drum electric drive motor for driving the tumble drum and, optionally, a fan which drives air through the drum or through a dryer cabinet wall.

[0024] In other words, the noise of an operational parameter of electrical and/or electro-mechanical type measured at, taken from or derived from the drum drive motor is used for controlling the drying cycle. This in particular is based on the finding that the noise of operational parameters of electrical and/or electro-mechanical type of the drum drive motor changes along with or is correlated with the humidity level of the laundry.

[0025] In particular the noise of respective parameters may show a change or modification over time that essentially corresponds to or goes along with the moisture or humidity level of the laundry during a drying cycle.

[0026] The proposed parameters are comparatively easily accessible, i.e. can be measured comparatively easily, and yet allow a comparatively accurate determination or estimation of laundry humidity or moisture level and thus control of the drying cycle.

[0027] In particular it has been found that the noise level of drum drive motor electric power consumption drops or decreases in accordance with dropping or decreasing moisture or humidity contents of the laundry during a drying cycle.

[0028] Respective parameters, in particular that of the drive motor, allow satisfactory control options to stop the drying cycle at given or predefined laundry humidity or moisture levels.

[0029] 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.

[0030] Adaptation of the drying cycle on the basis of the noise of an operational parameter 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 or halted. For further details, reference is made to embodiments and variants described herein.

[0031] It shall be noted, that the noise of operational parameter/s may be determined in a single operational time interval or from a plurality of discrete time intervals of a drying phase, stage or period of the tumble drying machine. Alternatively, the noise of operational parameter may be measured or determined continuously, in particular by using a microcontroller for measuring and/or evaluating the obtained operational parameter/s.

[0032] In case that different types of operational parameters are determined, measured or sensed in respective stages or periods, a combination of noises of the different operational parameters may be used for conducting and/or controlling the drying cycle.

[0033] In embodiments, the operational parameter may be selected from the group comprising electric power consumption, current consumption or current drain, power supply voltage and drive torque, and derivatives thereof. This in particular means that respective absolute values of the parameters may be used, but also derivatives thereof or combinations thereof may be used as operational parameter/s.

[0034] The operational parameters in particular may relate or be taken from the drum drive motor, optionally driving one or more fans. This in particular shall mean, that current, voltage, power and torque, and/or derivatives, related or taken from the drum electric drive motor, prevailing or observable during drying operations of the laundry treating machine may be used as the operational parameter whose noise is used for controlling the drying cycle, in particular for calculating or determining an end condition for the drying cycle.

[0035] The parameters, whose noise level is used for controlling the drying cycle, may be obtained or determined according to given specific calculation rules. As an input variable of the calculation rule, at least one actual value of the operational parameter may be used.

[0036] In embodiments, the laundry load quantity, i.e. the laundry load, is determined in a pre-drying or initial or upstream phase of the drying cycle, and is used as an additional parameter or control variable for controlling the time course of the drying cycle, in particular for determining a stop threshold for the drying cycle.

[0037] In particular the stop-threshold may be used for stopping the drying cycle in case that the noise of the electrical and/or electric-mechanical operational parameter reaches or passes the stop-threshold. The stop threshold in particular may be determined or calculated from or in dependency of the laundry weight. However, also other parameters and variables or methods can be used for setting or fixing the stop threshold.

[0038] The load quantity or weight of laundry in particular may be determined or calculated from the noise of at least one of the electrical and/or electro-mechanical operational parameters as mentioned further above, measured in an initial phase of the drying cycle, and preferably relating to the drum electric drive motor. Preferably, the rotational speed of the drying drum is kept at a constant level during determining and/or acquiring operational parameters for the stop threshold.

[0039] In variants, the laundry load quantity, in particular determined in an initial phase of the drying cycle, may be assigned to one of several predetermined load ranges. Each load range may be assigned to a stop threshold, i.e. a threshold for stopping the drying cycle in case that the noise level of operational parameter reaches or passes, in particular falls below or exceeds, the stop threshold. Using the load quantity or weight has the advantage that improved drying accuracy can be obtained.

[0040] Determining the stop threshold or thresholds on the basis of an initial noise level of the power consumption of the drum electric drive motor and laundry load quantity, i.e. laundry weight, can be implemented comparatively easily and may be conducted with comparatively low or moderate processing effort.

[0041] An example for such a determination is exemplarily given in table 1, which represents a type of lookup-table that can be used from a controller of the laundry treating machine in controlling the drying cycle:

Table 1: laundry load and stop threshold assignment on the basis of noise level and weight ranges for two different drying programs;

Noise level NL of power consumption (arbitrary units) in initial phase of drying cycle	Laundry load quantity [Kg] within drying drum;	Stop threshold (arbitrary units)	
		Iron program (12% residual humidity)	Cupboard program (0% residual humidity)
$0 < NL \leq 600$	load $\leq 3\text{kg}$	430	400
$600 < NL \leq 1000$	$3\text{kg} < \text{load} \leq 6\text{kg}$	630	580
$1000 < NL$	$6\text{kg} < \text{load}$	860	780

[0042] Based on table 1, a noise level of the initial power consumption of the drum electric drive motor can be assigned to a laundry load class which in turn is assigned to a specific stop threshold for the drying cycle.

[0043] In table 1, two different drying programs are exemplarily indicated, wherein in one drying program a residual laundry humidity shall lie at about 12%, which is considered optimal for ironing the laundry; and wherein in the other drying program a residual laundry humidity shall lie at about 0% so that laundry may be put into respective cupboards immediately after drying.

[0044] In embodiments, operational parameters other than the at least one electrical and/or electro-mechanical operational parameter whose noise level is used, are adjusted, selected, set, and/or kept at a predefined value in phases in which the at least one electrical and/or electro-mechanical operational parameter is determined, acquired or measured.

[0045] In particular, if the drive motor power consumption is used as an electrical operational parameter for determining the noise level thereof, the rotational speed of the drying drum, i.e. the revolutions per time unit of the drive motor, may be set or kept at a specific, i.e. preset, value, at least on phases in which actual values of respective operational parameter is determined or measured.

[0046] Determining the load quantity in particular may comprise that a defined, fixed or preset correlation, assignment or classification may be provided, according to which the laundry load quantity can be determined, i.e. estimated, from

the noise level of the operational parameter as set out further above. In particular, the laundry load quantity may be determined from a look-up table. The look-up table may be stored in a memory of the laundry treating machine. The look-up table may comprise value pairings, i.e. two, three or higher dimensional vectors, correlating a value or value range of noise level of an operational parameter with a value or value range of laundry load quantity.

[0047] In short, the stop threshold may be assigned or correlated with the laundry weight. The laundry weight in turn may be assigned or correlated with a noise level of an operational parameter. Respective data may for example be stored in the look-up table.

[0048] The values and correlations involved in determining the stop threshold may be obtained or acquired in specific test-cycles of the laundry dryer. In particular they may be based on empirical data.

[0049] 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 laundry moisture levels with sufficient and adequate accuracy.

[0050] Under the term noise level used herein, 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.

[0051] Single signal fluctuations or noise levels in particular may be calculated according to the following formula:

$$SF(\text{Signal}) = | \text{Signal}(t_i) - \text{Signal}_{(\text{average})} |,$$

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

[0052] Using the proposed noise level of electrical and/or electro-mechanical operational parameters has shown to lead to comparatively accurate and robust procedures.

[0053] 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.

[0054] An advantage of using the noise level instead of respective absolute values is that the noise level is far more independent from machine type and machine construction. Hence, by using the noise level, the proposed method shall be more easily applicable to a great variety and constructional variants of laundry dryers.

[0055] 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 determining a stop condition of or for the drying cycle. Using the noise level of the power consumption has been shown to lead to comparatively accurate methods.

[0056] 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.

[0057] 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 the tumble drum of the laundry treating machine, in particular at a predefined rotational speed, and determining a stop threshold for the drying cycle based at least on the noise level of an operational parameter of the drum electric drive motor and a desired final moisture level, which may for example be fixed by the drying program;
- c. starting the drying cycle;
- d. acquiring an operational parameter of the laundry drying machine;
- e. determining a representative of noise of the acquired operational parameter;
- f. evaluating and comparing the noise determined in step (e) against the stop threshold determined in step (b); and

g.

i) repeating steps (f) and (g) in case that the stop threshold is not yet reached; or

ii) stopping the drying cycle, in particular drying program, in case that the stop threshold is reached.

[0058] 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.

[0059] In step b) the stop threshold preferably is determined from the noise level of the power consumption of the drum electric drive motor at a preset rotational speed of the drive motor.

[0060] After having determined the stop threshold relevant for ending the drying program or a drying cycle, the drying cycle may be started. Note that the drying cycle may in variants be started together with step b), as the time needed for determining the stop threshold generally is short compared to the overall drying cycle length and effects of drying may be neglected.

[0061] According to claim 10, 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 by 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.

[0062] According to claim 11, 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.

[0063] 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.

[0064] 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 high moisture level condition;

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

FIG. 4 shows a drying drum of the laundry treating machine in a low moisture level condition;

FIG. 5 shows a pair of diagrams related to operational parameters in an intermediate laundry load quantity regime;

FIG. 6 shows a pair of diagrams related to operational parameters in a high laundry load quantity regime; and

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

[0065] 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.

[0066] 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.

[0067] 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.

[0068] 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.

[0069] 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.

[0070] A control unit 10 is provided and adapted to control and operate the condenser 6, fan 8, heater 9 and a drive motor 11 of the drying drum 4 during a drying program or drying cycle. In particular, the control unit 10 may conduct the drying cycle according to a preset drying program stored in a memory of the laundry dryer 1, in particular control unit 10.

[0071] The drying program in general may comprise a fixed standard drying cycle length. Obviously, such a standard drying cycle length may not be adequate for arbitrary laundry load levels, i.e. laundry load quantities occurring during ordinary use of the laundry dryer 1.

[0072] Hence, the control unit 10 may be implemented with a method able to stop the drying process if a desired final moisture level of the laundry is reached.

[0073] In order to adequately conduct and control a drying cycle for drying the laundry 3 contained in the drying drum 5, in particular for ending or stopping the drying cycle, the actual moisture level of the laundry 3 would be helpful. However determining directly the moisture level via sensors is comparatively costly and elaborate.

[0074] Therefore, according to an exemplary embodiment of the invention it is proposed to use the noise level of an electrical and/or electro-mechanical operational parameter of the laundry treating machine 1, which parameter changes together and along with the laundry moisture level and which can be determined or is available from the machine 1 comparatively easily, and which provides a comparatively accurate, reliable and repeatable way of obtaining desired moisture levels of the laundry.

[0075] Such a parameter in particular has been identified to be the noise level of power consumption of the drive motor 11 driving the drying drum 5 during drying cycles.

[0076] The method comprises an initial phase in which a stop threshold for a drying cycle is determined. The stop threshold in the present case is determined from a noise level of the power consumption of the drive motor 11 during an initial phase of the drying cycle in which the rotating speed of the drying drum 5 is kept at a constant level.

[0077] This is based on the finding, that the respective initial noise level of power consumption of the drive motor 11 can be assigned or correlated with the laundry load quantity contained within the drying drum 5.

[0078] Assignments and/or correlations between the initial noise level and the actual laundry weight or laundry load quantity can be based on test measurements and/or empirical results.

[0079] The initial noise level may be combined with additional parameters suitable for more precisely determining the stop threshold at which a desired residual moisture level of the laundry is or will be reached. Here, default values of a selected drying program may be used, for example.

[0080] One example of such an assignment between initial noise level and program selective stop thresholds is exemplarily given in table 1 above, which may be applied to the present case.

[0081] In a subsequent phase, i.e. after determining the stop threshold, the actual drying cycle of the laundry may be conducted. During this phase, the noise level of the power consumption of the drive motor 11 is acquired.

[0082] The acquired noise level/s is/are then compared to the stop threshold. In case that the acquired noise level is still above the stop threshold, the drying cycle is continued. In case that the acquired noise level/s is/are or fall/s below the stop threshold, the drying cycle is stopped.

[0083] The situation in which the acquired noise level falls below the stop threshold is representative or indicative of the fact that the laundry 3 contained in the drying drum 5 has reached the desired humidity or moisture level. For example the moisture level may lie at about 12% in case of a drying program providing laundry suitable for ironing. In another example, the moisture level may lie at 0% in case of a drying program providing laundry suitable for being put into a cupboard without further drying.

[0084] Using the noise level of the power consumption of the drive motor 11 has the advantage, that this operational parameter is more independent from details of laundry dryer model construction, type and other constructional and operational conditions of the laundry dryer 1.

[0085] 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 and model.

[0086] The noise level or signal fluctuation of the power consumption of the drive motor 11 SF_p can be calculated as mentioned further above.

[0087] 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 moisture level, correlating to some extent with the load quantity, i.e. laundry weight.

[0088] The moisture level changes during a drying cycle and, as has been found by the inventors, also the noise level of the power consumption of the drive motor 11 varies, in fact in a way that correlates or at least can be correlated with the laundry humidity or moisture level.

[0089] Therefore, the noise level of the power consumption of the drive motor 11 can be used instead of the humidity or moisture level of the laundry, for controlling the drying cycle.

[0090] In FIG. 2 to FIG. 4 three different scenarios with different laundry moisture level conditions are shown. In more

detail, FIG. 2 shows a drying drum of the laundry treating machine 1 in a high moisture level condition together with the tumbling behaviour of the laundry 3. FIG. 3 shows the situation in an intermediate moisture level condition, and FIG. 4 shows the situation in a low moisture level condition.

[0091] Note that the three scenarios may relate to different points of time during a drying cycle or to different starting conditions of a drying cycle.

[0092] The tumbling behaviour in FIG. 2 may for example relate to an early phase of a drying cycle, that of FIG. 3 may relate to an intermediate phase, whereas that of FIG. 4 may relate to an end phase of a drying cycle of the laundry treating machine 1, in which laundry 3 is almost dried to the pre-set moisture level.

[0093] As can be seen from FIG. 2 to FIG. 4, the path of the laundry 3 during rotations of the drying drum vary with varying laundry moisture levels, 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 of the driving motor power consumption, which inter alia may be extracted from FIG. 5 and FIG. 6.

[0094] In FIG. 5 a pair of diagrams related to an operational parameter and noise level thereof in an intermediate load regime are shown; and in FIG. 6 a pair of diagrams related to an operational parameter and noise level thereof in the high load regime 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.

[0095] In FIG. 5 and FIG. 6 respective lower graphs show the time course of the motor power MP or power consumption of the drive motor 11 during a drying cycle. As can be seen, the motor power MP decreases with time, which can be assigned to a decreasing laundry moisture level ML of laundry 3 contained in the drying drum 5.

[0096] Here, it can be seen, that the motor power MP as such varies with moisture level ML of the laundry 3, and therefore could be used as the operational parameter according to the invention. However, the motor power MP as such may be dependent on the type of machine and/or model and other factors, such as for example mounting tolerances, friction at gadgets, friction at drives, in particular belt drives, and the like.

[0097] The upper graphs in FIG. 5 and FIG. 6 show as the solid lines the time course of the noise level NL of the motor power MP, which may be calculated as indicated further above. In particular the variance and other algebraic functions may be used. The noise level (in arbitrary units) is related to the left hand ordinate in respective graphs.

[0098] It can be seen, from the solid lines in the upper graphs in FIG. 5 and FIG. 6 that the noise level NL of the motor power MP decreases with on-going time, i.e. decreases in the course of the drying cycle. Just for clarification, FIG. 5 and FIG. 6 relate to the time course of respective parameters during, i.e. in the time course, of an on-going drying cycle, in which humidity is removed from the laundry 3.

[0099] In FIG. 5 and FIG. 6, the time course of the moisture level ML of the laundry 3 contained in the drying drum 5 during a drying cycle is shown as the dashed lines. The moisture level ML relates to the right hand side ordinate and is given as a percentage (%). Clearly, the moisture level ML decreases with on-going drying time.

[0100] However it can be seen from FIG. 5 and FIG. 6 that the noise level NL of the motor power MP decreases at least in way similar to the moisture level ML.

[0101] Therefore, if the noise level NL of the motor power is calibrated in a suitable manner, or correlated with the moisture level ML, the end-point of a drying cycle can be controlled by using the noise level NL instead of measuring the humidity inside the drying drum 5.

[0102] Note that in the present graphs, the initial moisture level ML of the laundry is about 50% and is reduced to a moisture level ML of about 0%. This essentially corresponds to a cupboard program indicated in table 1 above.

[0103] Calibration and/or correlation between the noise level NL and the moisture level ML can be obtained in test measurements and/or by empirically. Respective calibrations and correlations may be stored in a database, e.g. a memory of the laundry treating machine 1, in particular the control unit 10, so that the values once determined can be retrieved during the operational life of the laundry treating machine.

[0104] A comparison between FIG. 5 and FIG. 6 shows that the behaviour of the noise level NL compared to the respective moisture level ML is different for varying operational conditions. This means that the dependency or correlation between noise level NL and moisture level ML may be different for different load conditions of the drying drum 5.

[0105] Therefore, calibrations and/or correlations may be set up or determined for several different load conditions, respectively representative of the most usual operational conditions. An example of this is shown in table 1, which may be stored as a look-up table in the memory of the control unit 10.

[0106] However, it is conceivable, that inter- or extrapolations or other algebraic functions are used in order to determine noise thresholds for intermediate load conditions.

[0107] From FIG. 5 and FIG. 6 it should become clear that the noise level NL of the motor power MP, varies in concert with the laundry moisture level ML, and can be used as reliable quantities or parameters for controlling an end-point of a drying cycle, i.e. a desired moisture level ML laundry 3 within the drying drum 5.

[0108] FIG. 7 shows a flowchart of an exemplary drying algorithm according to an embodiment of the present invention. With the proposed algorithm, a drying cycle is started after an initial start signal.

[0109] 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.

[0110] During this initial phase in which the drive motor 11 is rotated at essentially constant speed, the motor power MP is continuously measured.

[0111] The measured values of the motor power MP are then evaluated and used to calculate an initial noise level NL_INIT of the motor power MP. The calculation may be conducted as indicated above and further above.

[0112] After having determined or calculated the initial noise level NL_INIT, the laundry load quantity, i.e. the load or weight of the laundry within the drying drum 5 is to be determined, in particular calculated and/or estimated, from the initial noise level NL_INIT. Here it shall be mentioned, that the initial noise level NL_INIT is dependent on the laundry load quantity, and by suitable calibration, the initial noise level NL_INIT can be used to at least estimate the initial laundry load. Note that the initial laundry load is composed of the weight of the laundry as such and the weight of moisture soaked in the laundry 3.

[0113] Based on the laundry load quantity, and, as the case may be in the use of the initial noise level NL_INIT, and/or parameter settings of the drying program, a noise threshold NL_THR is determined or calculated in a subsequent step.

[0114] As a calculation rule for the noise threshold the following relation may be used:

$$NL_THR = func(NL_INIT, DRYING_PROGRAM, ...);$$

which shall mean that the noise threshold NL_THR can be calculated as a function of at least the initial noise level NL_INIT and parameter settings (DRYING_PROGRAM) of the drying program selected for drying the laundry 3.

[0115] After having determined the noise threshold NL_THR, the method can be switched to the real drying cycle mode in which moisture is extracted from the laundry 3. In the drying cycle mode, the control unit 10 continuously acquires the motor power MP and determines the actual noise level/s NL.

[0116] The actual noise level/s NL so determined are then evaluated, in particular compared with, the noise threshold NL_THR determined in previous operational steps.

[0117] In case that the actual noise level NL still lies above the noise threshold NL_THR, i.e. has not reached or passed the noise threshold NL_THR, the control unit 10 continues the drying cycle and proceeds with acquiring actual noise levels NL and comparing them with the noise threshold NL_THR.

[0118] In case that the actual noise level NL reaches, falls below, i.e. passes, the noise threshold NL_THR, the control unit 10 determines that the predefined moisture level ML of the laundry 3 is reached and stops the drying cycle. Hence, the drying cycle is and can reliably be stopped as soon as the desired moisture level ML is reached.

[0119] 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.

[0120] 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 ML;
- complicated or extra humidity and/or moisture sensors can be 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 initial load quantities and initial humidity levels;
- the drying algorithm and method can be applied to different types of laundry and textiles, e.g. cotton, synthetic, etc.

List of reference numerals

[0121]

1 laundry dryer

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

- NL noise level
- NL_INIT initial noise level
- NL_THR noise threshold
- 15 ML moisture level
- MP motor power

Claims

- 20 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 controlling the operation of the drying cycle in dependence of the noise level (NL) of an operational parameter (MP) of the laundry treating machine (1), changing together with laundry humidity (ML) of laundry (3) during the drying cycle.
- 25 2. Method according to claim 1, wherein the operational parameter (MP) is taken from a drum electric drive motor (11) for driving the tumble drum (5).
- 30 3. Method according to one of claims 1 or 2, wherein the operational parameter is selected from the group comprising electric power consumption (MP), current consumption, power supply voltage, drive torque.
- 35 4. Method according to at least one of claims 1 to 3, wherein the noise level (NL) is calculated as the absolute variation of respective operational values relative to the mean value, the mean square deviation of operational values, the root mean square deviation of operational values.
- 40 5. Method according to at least one of claims 1 to 4, wherein the laundry load quantity contained in the drum (5) is determined in an initial phase of the drying cycle and is used as an additional parameter for controlling the time course of the drying cycle, in particular for determining a stop threshold (NL_THR) for the drying cycle.
- 45 6. Method according to claim 5, 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).
- 7. Method according to claim 5 or 6, wherein the laundry load quantity is assigned to one of several predefined load ranges, wherein each load range is assigned to a stop threshold (NL_THR) for stopping the drying cycle in case that the noise level of the operational parameter reaches or passes the stop threshold (NL_THR).
- 50 8. Method according to at least one of claims 1 to 7, wherein operational parameters other than the operational parameter (MP) whose noise level is used, are adjusted to predefined values at least in phases of determining the operational parameter (MP).
- 55 9. Method according to at least one of claims 1 to 8, comprising the steps of:
 - a. starting a tumble drying program;
 - b. rotating the tumble drum (5) of the laundry treating machine (1), in particular at a predefined rotational speed, and determining a stop threshold (NL_THR) for a drying cycle of the drying program based at least on the noise level of an operational parameter (MP) of the drum electric drive motor (11) and a desired final moisture level;
 - c. starting the drying cycle;
 - d. acquiring an operational parameter (MP) of the laundry drying machine (1);

- e. determining a representative of noise (NL) of the acquired operational parameter;
- f. evaluating and comparing the noise determined in step (e) against the stop threshold (NL_THR); and
- g.

- 5 i) repeating steps (f) and (g) in case that the stop threshold (NL_THR) is not yet reached; or
 ii) stopping the drying cycle, in particular drying program, in case that the stop threshold (NL_THR) is reached.

- 10 10. 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) by a method according to at least one of claims 1 to 9.

- 15 11. 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 9.

20

25

30

35

40

45

50

55

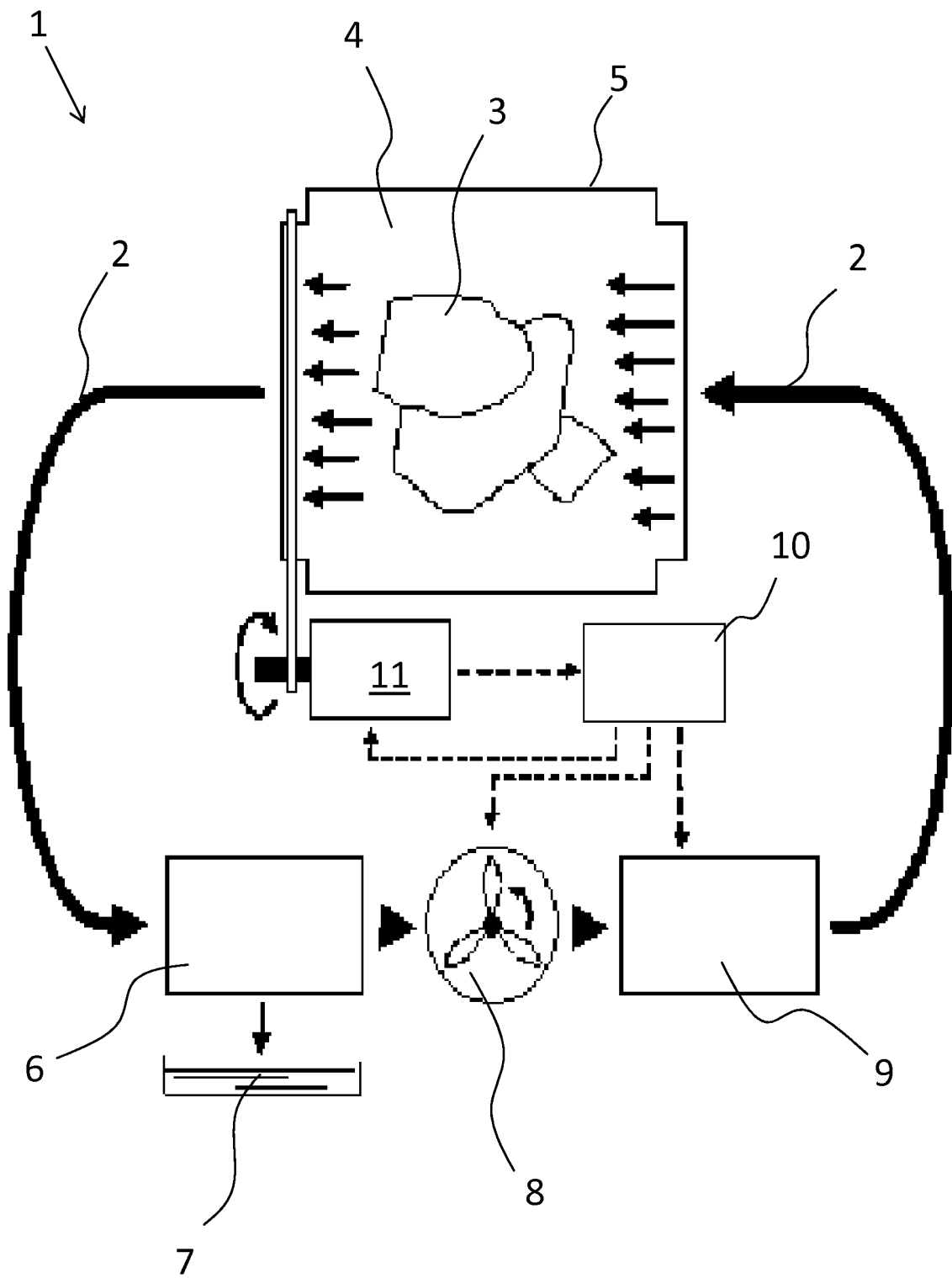


FIG. 1

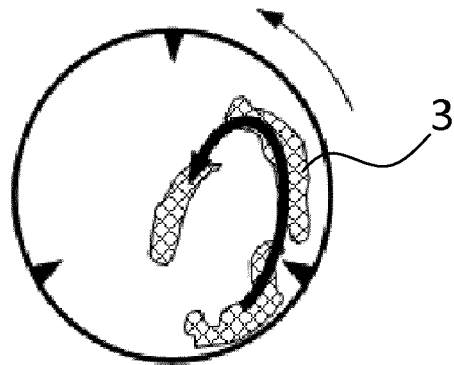


FIG. 2

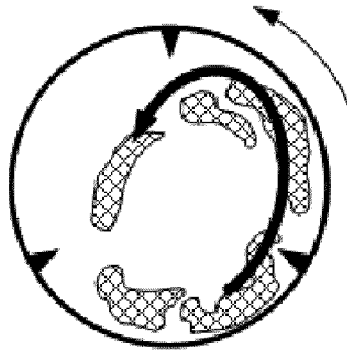


FIG. 3

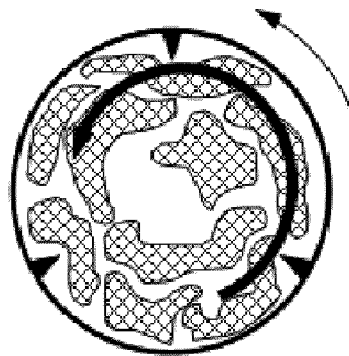


FIG. 4

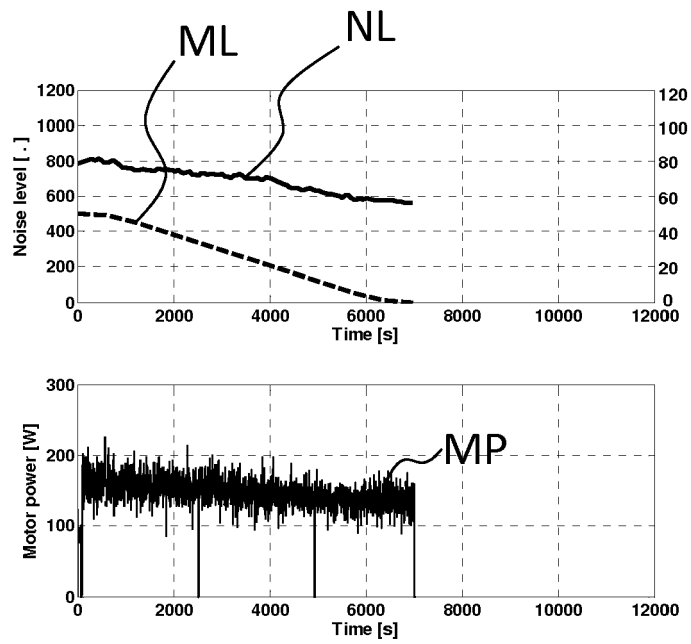


FIG. 5

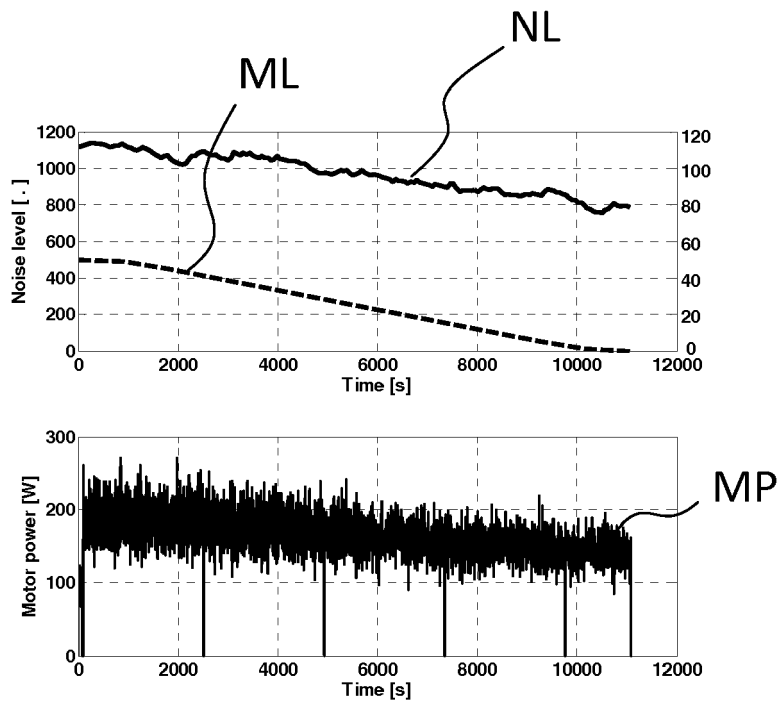


FIG. 6

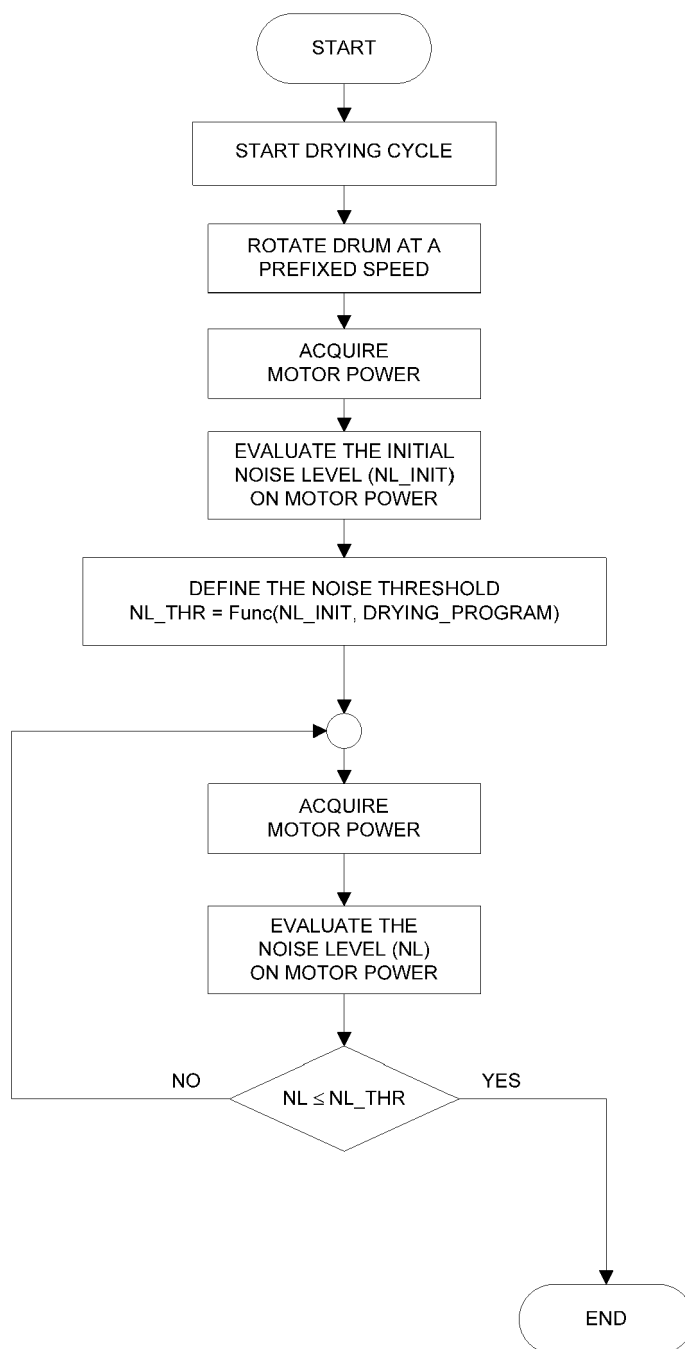


FIG. 7



EUROPEAN SEARCH REPORT

 Application Number
 EP 14 16 2962

5

10

15

20

25

30

35

40

45

50

55

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 *	1-11	INV. D06F58/28
X	DE 196 51 883 C1 (TELEFUNKEN MICROELECTRON [DE]) 2 April 1998 (1998-04-02) * column 1, line 57 - column 2, line 30 * * column 2, line 40 - column 4, line 23 * * claims 1-3; figures 1,2 *	1,10,11	
A	EP 1 988 209 A2 (ELECTROLUX HOME PROD CORP [BE]) 5 November 2008 (2008-11-05) * abstract; claims 1-10; figure 1 *	1-11	
A	EP 2 221 412 A1 (BSH BOSCH SIEMENS HAUSGERAETE [DE]) 25 August 2010 (2010-08-25) * paragraphs [0004] - [0005] * * paragraphs [0021] - [0030] * * figures 1-3 *	1-11	TECHNICAL FIELDS SEARCHED (IPC) D06F
A	US 2012/005840 A1 (JANG HOYONG [KR] ET AL) 12 January 2012 (2012-01-12) * paragraphs [0211], [0224] - [0225] * * claim 14; figures 11,16 *	1-11	
A	EP 0 898 009 A1 (BOSCH SIEMENS HAUSGERAETE [DE] BSH BOSCH SIEMENS HAUSGERAETE [DE]) 24 February 1999 (1999-02-24) * paragraphs [0007] - [0013], [0018] * * claims 1-7; figure 1 *	1,5,6, 10,11	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 19 September 2014	Examiner Weinberg, Ekkehard
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 16 2962

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-09-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2281935 A1	09-02-2011	DE 102009028358 A1 EP 2281935 A1	17-02-2011 09-02-2011
DE 19651883 C1	02-04-1998	NONE	
EP 1988209 A2	05-11-2008	AT 494416 T AT 531845 T CN 101688354 A EP 1988209 A2 EP 2152952 A2 ES 2359439 T3 ES 2377034 T3 RU 2009144147 A US 2010126038 A1 US 2012266486 A1 WO 2008131876 A2	15-01-2011 15-11-2011 31-03-2010 05-11-2008 17-02-2010 23-05-2011 21-03-2012 10-06-2011 27-05-2010 25-10-2012 06-11-2008
EP 2221412 A1	25-08-2010	AT 541984 T DE 102009001112 A1 EP 2221412 A1	15-02-2012 26-08-2010 25-08-2010
US 2012005840 A1	12-01-2012	CN 103025946 A EP 2591159 A2 US 2012005840 A1 WO 2012005511 A2	03-04-2013 15-05-2013 12-01-2012 12-01-2012
EP 0898009 A1	24-02-1999	DE 19736419 A1 EP 0898009 A1 US 6462564 B1	25-02-1999 24-02-1999 08-10-2002

EPO FORM P0459

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