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(54) **A method and device for controlling the spin step of a washing or washing/drying appliance and washing or washing/drying appliance implementing said method**

(57) A method is described for controlling the spin step of a washing or washing/drying appliance, said appliance comprising a motor that rotates a drum adapted to contain a load, said spin step comprising one or more drum revolution speeds, said method comprising a check of the unbalanced condition of said load, based on a comparison between the instantaneous phase angle value and one or more threshold values, said unbalanced condition being verified in under-threshold conditions.

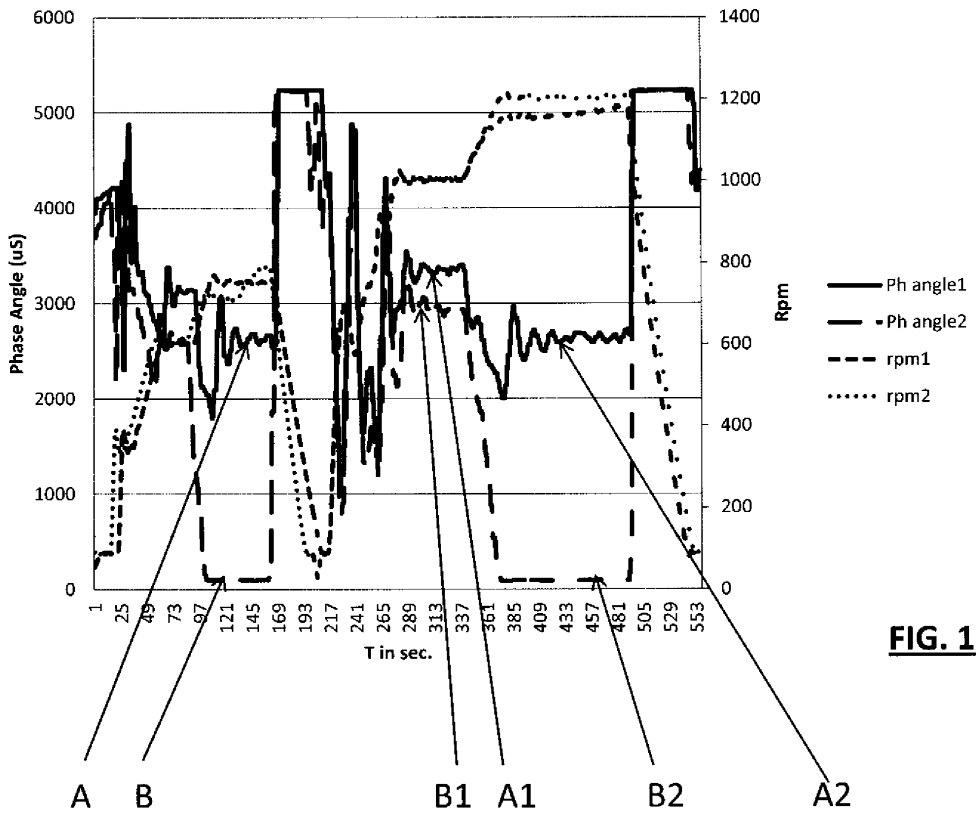

FIG. 1

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Description

[FIELD OF THE INVENTION]

[0001] The present invention relates to the field of household appliances, particularly to a method and a device for controlling the spin step of a washing or washing/drying appliance.

[0002] In addition, the present invention relates to a washing or washing/drying appliance implementing the method of the present invention.

[PRIOR ART]

[0003] It is known that, in a washing or washing/drying appliance, the revolution speed of the drum containing laundry to be washed is variable and depends on the wash cycle selection options available in the appliance itself.

[0004] Drum rotation is controlled by a motor, e.g. of the commutator type, the speed of which is determined by the quantity of alternating electric current supplied. The latter is controlled by an electronic circuit which comprises devices such as TRIAC's, which vary the parameter known as "phase angle" of the alternating current supplied to the motor, i.e. they enable and interrupt the half-waves of the alternating current at different points, which depend on the instantaneous energy that must be supplied to the motor. The instantaneous energy depends on the speed at which the motor must run and on drum load.

[0005] It can be said that the motor, the revolution speed to be attained being equal, will require a quantity of energy depending on drum load, which means not only load weight, but also load type, i.e. the water retention property of the laundry and the distribution thereof inside the drum. The latter characteristic is particularly important during the spin step, when the drum revolution speed is much faster than during the previous wash cycle steps.

[0006] In fact, during the spin step any unbalance of the load, i.e. an asymmetric positioning thereof in the drum, will generate noise, higher consumption and wear of components, which may even lead to failures of the latter.

[0007] These effects become even more marked as spin speed and/or load increase: washing appliances are available which can accept loads of more than 5 Kg, or which have a large-diameter drum, or which have a capacity up to 70 litres; in such appliances there is higher probability that the load will take a critical arrangement.

[0008] There is therefore a need for trying to eliminate any load unbalance condition during the spin step.

[0009] A method for controlling load unbalance is known which comprises sub-steps of measuring load unbalance at a relatively slow "satellization" speed, e.g. 88 rpm (compared to spin speed), but nevertheless sufficient to keep the laundry items in a "satellization" condition, i.e. in adherence to the drum. This unbalance measuring sub-step is typically carried out prior to starting the spin step; if any unbalance is detected, load redistribution procedures can be activated; the unbalance measuring step is also carried out during the spin step, between sub-steps at increasing speeds, in order to re-evaluate the unbalance during the spin step, since the unbalanced condition may arise dynamically, e.g. due to extraction of water from the items. For example, for a spin step including at least two sub-steps at different drum revolution speeds, i.e. a first one (e.g. at 600 rpm) and at least another one at a faster speed (e.g. 800-1,000 rpm), at the end of the slower first step the drum will be slowed down to the above-mentioned satellization speed of 88 rpm, when a new unbalance check will be made; depending on the result of this check, if any unbalance is detected, the spin step will be resumed by limiting the speed at the previously reached value; otherwise, if no unbalance is detected, the speed will be increased to a value corresponding to that of the second sub-step.

[0010] However, this known process cannot ensure the attainment of optimal unbalance reduction or elimination conditions, nor does it prove to be efficient when no unbalance exists. In fact, the Applicant has found out that measuring unbalance at a low speed such as a satellization speed of 88 rpm may not be representative of what will happen at spin speed; the known method also has a further drawback in that, if no unbalance exists, time and energy will be wasted to carry out an unnecessary measuring sub-step.

[0011] US-2,917,175-A describes a method for controlling the spin step of a washing machine, which is based on measuring the phase difference between voltage and current at the electric motor that drives the drum: drum rotation will be reduced below the spin value, if said difference exceeds a given threshold value.

[0012] It is therefore necessary to solve the above-described problems related to the efficiency of the procedure for controlling load unbalance during the spin step of a washing or washing/drying appliance.

[OBJECTS AND SUMMARY OF THE INVENTION]

[0013] It is one object of the present invention to solve the above-described problems.

[0014] It is the object of the present invention to provide a method for controlling the spin step of a washing or washing/drying appliance so as to ensure the utmost energy efficiency and minimize any load unbalance conditions inside the drum, thereby optimizing the energy consumption of the appliance while minimizing noise and oscillations.

[0015] It is another object of the present invention to provide a washing or washing/drying appliance which comprises a device for implementing the method for controlling the spin step in accordance with the present invention.

[0016] In particular, it is one object of the present invention, in accordance with claim 1, to provide a method for controlling the spin step of a washing or washing/drying appliance, said appliance comprising a motor that rotates a drum adapted to contain a load, said spin step comprising one or more drum revolution speeds, said method comprising a check of the unbalanced condition of said load, based on a comparison between the instantaneous phase angle value and one or more threshold values, said unbalanced condition being verified in under-threshold conditions, said phase angle being representative of the interruption time of the half-waves of the current supplied to the electric motor.

[0017] These and other objects of the present invention are achieved through a method and a washing or washing/drying appliance incorporating the features set out in the appended claims, which are intended to be an integral part of the present description.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0018] A preferred and advantageous non-limiting example of embodiment of the present invention will be described below with reference to the annexed Figure 1, which shows the trends over time of characteristic quantities relating to the spin step, such as phase angle and rpm, in two typical situations.

[DETAILED DESCRIPTION OF THE INVENTION]

[0019] In this context, the term "phase angle" refers to the OFF time of the alternating power current flowing in the TRIAC, which, as known, is an electronic component used for interrupting or not the phases of the alternating current supplied to the electric motor that drives the drum of the washing or washing/drying machine. By controlling this parameter, one can *de facto* control the quantity of electric power supplied to the motor, and hence the revolution speed thereof.

[0020] The phase angle is thus representative of the interruption time of the half-waves of the current supplied to the electric motor.

[0021] Figure 1 shows some trends of the phase-angle and rpm of the drum in two typical known cases of spin step actuation as a function of the arrangement of the load inside the drum, the initial load balance being equal.

[0022] The spin step is activated at successive angular speeds of 600, 800, 1,000 and 1,200 rpm. In both cases, between the 800 and 1,000rpm steps a known process for load unbalance control is carried out as previously described.

[0023] In the graphs, a high phase angle value corresponds to a low energy request from the motor, and vice versa. The phase angle datum corresponds to the OFF time of the TRIAC, expressed in μs, within the 10ms half-period corresponding to one half-wave of the alternating power current.

[0024] At the beginning of the spin step, angular speed increases progressively from zero to the first stable speed (600 rpm), with a very discontinuous phase angle showing large oscillations. At point A, it can be noticed that the phase angle **Ph angle1** of the first case corresponding to the revolution speed **rpm1** is significantly greater (by approx. 2,500 points) than the phase angle **Ph angle2** (point B) corresponding to the curve **rpm2** of the second case. This means that the situation of case 1 is better (as far as efficiency, noise, vibration and consumption are concerned) than that of case 2.

[0025] Therefore, during the same spin step, machine load being equal, there may be different behaviours, depending on the degree of load unbalance, which *de facto* is null in the first case described above and considerable in the second case.

[0026] This negative trend of the curve **Ph angle2** goes on throughout the whole spin step; it is noticeable that also at points A1-B1 there is a difference in the phase angle, which at 1,000 rpm "weighs" about 400 points (corresponding to approx. 400 μs) and at max. speed becomes approx. 2,600: in this case (point B2) the TRIAC is fully closed, i.e. it is supplying the maximum energy available, whereas in the other case (point A2) it is operating at approx. 75%.

[0027] The result is that the spin step corresponding to the second case (see curve rpm2) will not allow reaching the maximum angular speed of the drum, with the addition of an energy consumption that in these conditions will correspond to a 250W increase in absorbed power compared to the spin step of the first case, which in the last sub-step will reach the target value of 1,200 rpm, as shown in the curve rpm1.

[0028] In the case 1 of almost null unbalance, the intermediate unbalance control step appears to be unnecessary, whereas in the case 2 such a control appears to be ineffective, in that the phase angle takes low values also in the subsequent steps, while energy consumption is still high, indicating that unbalance persists.

[0029] It is therefore clear that an optimal control of load balance conditions would ensure higher energetic efficiency and lower noise, vibration and consumption.

[0030] The method for controlling the spin step of a washing or washing/drying appliance according to the invention is based on measuring and controlling the phase angle during the entire spin step.

[0031] To keep the drum rotating at the desired speed, the less homogeneous the load distribution (i.e. the more the load is unbalanced or misaligned), the higher the quantity of energy that will be needed; this can be continuously monitored throughout the various spin steps at different speeds by monitoring the phase angle.

[0032] As in the known technique, before starting the spin step a balance check is carried out at low speed (e.g. 88 rpm) (which step therefore precedes in time what is shown in Fig. 1).

[0033] As can also be seen in Fig. 1, at the beginning of a spin-speed sub-step, the curve indicating the phase angle and the corresponding electric power supplied shows large oscillations which tend to decrease and settle after the drum has been rotating at that given speed for a while. The initial phase angle values are not taken into account, since they are subject to large oscillations. After a certain tolerated initial transient time has elapsed (e.g. 30 s), when the phase angle value has become stable, said value can be measured and compared with a threshold value.

[0034] Said threshold value is a function of the speed at which the check is carried out, of the machine structure (drum volume, diameter and depth), and of the type of motor in use.

[0035] If the value is above threshold, the load will be considered to be balanced at that speed: for example, a first speed may be approx. 500-600 rpm. In such a case, the balance check step at satellization speed may be avoided. The spin cycle can then go on by switching to the next higher-speed step (e.g. 800 rpm), if there are multiple speeds, or proceed until the end, if there is only one speed.

[0036] If, on the contrary, the value is below threshold, it will be considered that the load is in an unbalanced condition, and therefore rotation at that speed will be stopped and a redistribution operation will be carried out, e.g. a known one consisting of alternately rotating the drum forwards and backwards at low speed (e.g. 45 rpm) a few times, e.g. three times. The spin step will then be repeated while checking the phase angle as described above. If the value is above threshold, it will be considered that the load is now balanced at that speed, and the spin cycle can go on by switching to the next higher-speed step (e.g. 1,000 rpm), if another higher speed was set, or proceed until the end, if the achieved speed was the maximum one. This succession of check and redistribution operations may be repeated for a maximum number of times, e.g. three. If after such operations the load is still unbalanced, the spin cycle will be completed at the current speed without any further acceleration, in that this will be considered to be an irrecoverable unbalanced condition.

[0037] If a next higher-speed step is carried out, the checks described for the previous step may be repeated again. If the spin program only includes two speeds, the second speed may be selected and held until the end of the cycle without any additional stops.

[0038] If the spin program includes more than two speeds, the highest speed used in the last step is usually a high value (e.g. 1,600 rpm): in this case, if the check gave a positive result in the previous steps, in this last step it will be possible to avoid executing the unbalance check. The phase angle check and the comparison thereof with a related threshold value will however still be kept active, so that the spin cycle can be stopped in the event that limit conditions which might be dangerous for the structure should be detected.

[0039] Compared to the known load balance check procedure, wherein the check is carried out systematically at a fixed speed at the end of predetermined sub-steps, the procedure of the present invention ensures optimization of times and consumptions. In fact, if the load balance verifications give positive results, the entire spin cycle will be faster because the machine will not have to be slowed down to satellization speed; this will also ensure significant energy savings. If, on the contrary, the load balance verification carried out at spin speed gives a persisting negative result, the spin cycle will be either stopped or limited to that speed for which the check gave a positive result, thus reducing noise and oscillations (which are proportional to angular speed), and also reducing the probability of failures of components due to wear.

[0040] Making a control device for implementing the above-described method is not a problem for the man skilled in the art, who will have several hardware and software alternatives available. Phase angle detectors and motor/drum speed detectors are of known types and are normally already included in the appliance.

[0041] The steps of the method may be carried out through a controller using known hardware. From a software viewpoint, the control method of the present invention can advantageously be carried out through a computer program, which comprises coding means for implementing one or more steps of the method when said program is executed by a computer. It is therefore understood that the protection scope extends to said computer program as well as to computer-readable means that comprise a recorded message, said computer-readable means comprising program coding means for implementing one or more steps of the method when said program is executed by a computer.

[0042] It is apparent that many changes may be made to the present invention by those skilled in the art without departing from the protection scope thereof as stated in the appended claims.

[0043] The TRIAC may be replaced by any other electronic component or system adapted to interrupt or not, in a controlled manner, the half-waves of the power current supplied to the electric motor, so as to determine the revolution speed of the drum.

[0044] The check of the phase angle, meaning by that the OFF time of current flowing in the TRIAC, should be considered to be equivalent to a complementary check of the ON time, i.e. the time during which current is not interrupted.

[0045] These embodiments will nonetheless still fall within the protection scope of the present invention.

Claims

1. A method for controlling the spin step of a washing or washing/drying appliance, said appliance comprising an electric motor that rotates a drum adapted to contain a load, said spin step comprising one or more drum revolution speeds, said method comprising a check of an unbalanced condition of said load, based on a comparison between the instantaneous phase angle value and one or more threshold values,

said unbalanced condition being verified in under-threshold conditions, said phase angle being representative of the interruption time of the half-waves of the current supplied to the electric motor.

2. A method according to claim 1, wherein said spin step comprises one or more drum revolution speeds, the method comprising, at a first one of said one or more revolution speeds, a succession of steps of:

- evaluating said instantaneous phase angle value, and comparing it with a first one of said threshold values;
- if said instantaneous value is above threshold, continuing until the end of the spin step if there is only one speed, or switching to the next speed value if there are more than one speeds;
- if said instantaneous value is under threshold, performing a load redistribution operation and then repeating said succession of steps at least once.

3. A method according to claim 2, wherein said spin step is ended if said repetition of said succession of steps for a number of times equal to three gives said instantaneous value under said first threshold.

4. A method according to claim 2, wherein, when switching to said next speed value, said succession of steps is repeated at said next speed value through a comparison with a second threshold value.

5. A method according to claim 1 or 2 or 3, wherein said evaluation of the instantaneous phase angle value starts after a certain transient time has elapsed from the start of the rotation of the drum at a corresponding speed, when the oscillations of said instantaneous value have decreased and become stable.

6. A device for controlling the spin step of a washing or washing/drying appliance, comprising means for implementing each one of said steps of the method according to any one of claims 1 to 5.

7. A washing or washing/drying appliance comprising a device for controlling the spin step as claimed in claim 6.

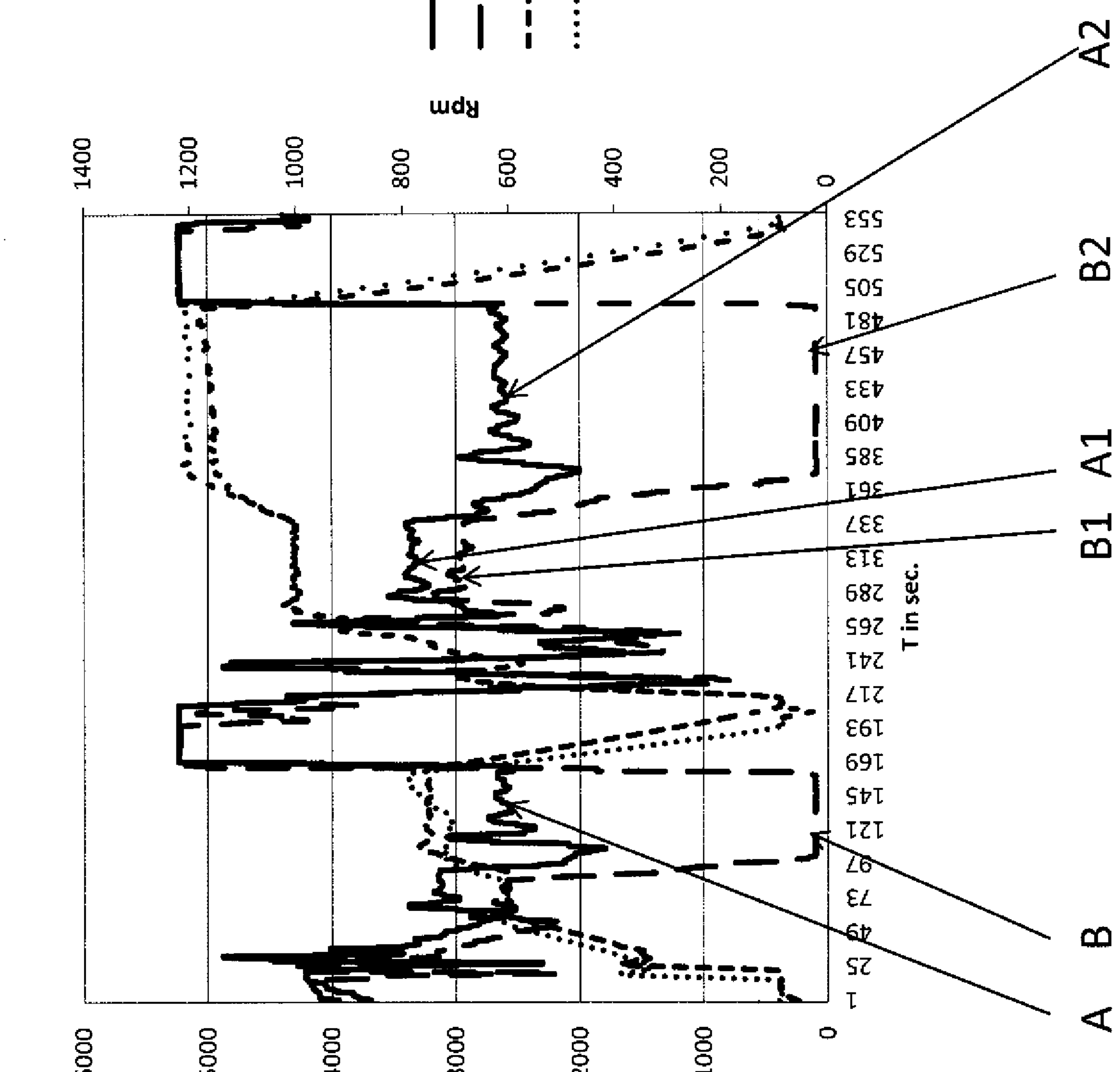
Phase Angle (us)
6000
5000
4000
3000
2000
1000
0
Rpm
1400
1200
1000
800
600
400
200
0
1
25
49
73
97
121
145
169
193
217
241
265
289
313
337
361
385
409
433
457
481
505
529
553
T in sec.
Ph angle1
Ph angle2
rpm1
rpm2
A
B
B1
A1
B2
A2

FIG. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 12 19 6799

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2 917 175 A (TOMA JOHN W) 15 December 1959 (1959-12-15) * column 3, lines 3-8; column 7, line 49 - column 8, line 45; claims; figures 7-10, 13 *	1-7	INV. D06F37/20
A	US 5 543 698 A (TAO JINGHAN [US] ET AL) 6 August 1996 (1996-08-06) * column 1, lines 5-12; column 4, lines 38-58; column 5, line 36 - column 7, line 4; column 8, lines 19-42; claim 1 *	1-7	
A	US 6 038 724 A (CHBAT NICOLAS WADIH [US] ET AL) 21 March 2000 (2000-03-21) * column 2, lines 28-40; column 5, line 49 - column 6, line 47; claim 1 *	1-7	
A	EP 1 342 826 A1 (PRIMUS N V [BE]) 10 September 2003 (2003-09-10) * paragraphs [0001], [0024], [0041], [0046]; claims 1-8; figures *	1-7	TECHNICAL FIELDS SEARCHED (IPC)
A	EP 0 468 862 A1 (SEXTANT AVIONIQUE [FR] CROUZET ELECTROMENAGER [FR]) 29 January 1992 (1992-01-29) * the whole document *	1-7	D06F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	9 April 2013	Clivio, Eugenio

CATEGORY OF CITED DOCUMENTS

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09-04-2013

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

REFERENCES CITED IN THE DESCRIPTION

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