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(54) **METHOD FOR BALANCING THE LOAD IN A WASHING MACHINE OR TUMBLE DRYER, AND WASHING MACHINE OR TUMBLE DRYER**

(57) A method for balancing the load of laundry in a laundry drum (5) in a washing machine (1) or tumble dryer, comprises

- carrying out, before performing a spin step (27) in a laundry treatment program, a laundry load balancing check step (29), and:

- in the case of a balanced load, performing the spin step (27),

- in the case of an unbalanced load, not enabling the spin step (27) and performing a balancing step (29) of the load of laundry, through a sequence of movements of the laundry drum (5) at lower speeds than the rotation speed of the laundry drum (5) during the spin step (27) and, after the balancing step (29), repeating the balancing check step (28) of the load of laundry until the load of laundry resulted to be balanced from the balancing check step (29),

- varying the balancing parameters (rebal_XXX) of a next balancing step (29_{n+1}) with respect to the balancing parameters (rebal_XXX) of a previous balancing step (29_n) within the same laundry treatment program.

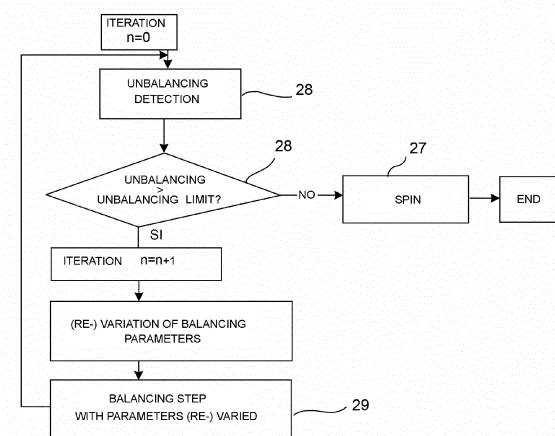


FIG. 7

Description

[0001] The present invention relates to a method for balancing the load of laundry in a washing machine or tumble dryer.

[0002] It is known that machines for washing and/or drying laundry can include, when performing an operating program thereof, one or more spin steps, i.e., steps of rotating the drum at a much higher speed than that normally provided during the washing or drying steps. In some laundry washing or drying machines, the speed reachable by the drum during the spin steps can be much higher than 1000 rpm, for example.

[0003] If, during the spin steps, the laundry load is unbalanced, i.e., arranged inside the laundry drum in a non-even manner, for example concentrated in some areas and not present in other areas, during the rotation of the drum at high speeds, the load unbalancing could cause significant vibrations, which cannot be tolerated in a domestic environment and are harmful to the appliance itself.

[0004] For this reason, known washing machines or tumble dryers with a spin function implement a laundry balancing method in the drum, comprising the steps of:

[0005] - before carrying out a spin step, checking the balance of the laundry load, i.e., checking whether the mass of laundry is evenly distributed with respect to the rotation axis of the laundry drum,

- in the case of a balanced load, enabling the performance of the spin step,
- in the case of an unbalanced load, not enabling the spin step and
- performing a laundry load balancing step, by a predetermined sequence of movements of the drum and,
- at the end of the balancing step, checking the balance of the laundry load again,

[0006] until, from the balancing check, the laundry load is considered balanced.

[0007] It is known to carry out the laundry load balancing check step by comparing the detected current values of the motor which drives the laundry drum with a reference current value.

[0008] It is also known to perform the laundry load balancing check step by comparing the detected values of the rotational speed of the laundry drum or motor which drives the laundry drum with a reference speed value.

[0009] It is also known to perform the laundry load balancing check step by comparing the detected values of acceleration of the laundry drum with a reference acceleration value.

[0010] However, known laundry balancing methods and systems have some drawbacks, which (according to the inventors) can be especially attributed to the fact that the laundry load balancing step consists of a single and unique predetermined drum movement sequence which is repeated without any variation until the laundry load is distributed evenly enough.

[0011] The known laundry balancing strategy does not take into account the fact that the reasons for the unbalancing of the laundry in the washing machine drum can be different, for example rolled-up laundry items of different sizes and weights, multiple laundry items intertwined or rolled up together, a large single laundry item, such as a sweatshirt, a bathrobe, a sheet, etc.

[0012] Furthermore, the known laundry balancing strategy does not take into account the degree of laundry load unbalancing which can instead vary considerably, for example between an unbalancing just above an acceptable threshold value and an unbalancing much higher than the acceptable threshold value. In concrete physical terms, the center of the overall mass of the drum with the laundry can be slightly or very distant from the rotation axis of the drum.

[0013] Since a single, unique, and predetermined sequence of drum balancing movements will not be optimal for all possible laundry unbalancing scenarios and reasons, the (repeated) laundry balancing steps of the prior art are undesirably time-consuming and expensive in terms of electricity.

[0014] In particular, according to the inventors, failure to achieve an even distribution of the laundry in the laundry drum by means of a single balancing cycle or a few balancing cycles could be an indication that the parameters of the sequence of movements of the laundry drum are not optimal for quick balancing and that there could be more effective drum movement sequences.

[0015] It is thus the object of the present invention to provide an improved method for balancing the laundry load in a washing machine or tumble dryer, and a washing machine or tumble dryer having features such as to overcome at least partially the drawbacks mentioned with reference to the prior art.

[0016] It is a particular object of the present invention to provide a laundry balancing method and a laundry treatment machine, in particular a washing machine or a tumble dryer, having features such as to reduce the time, and possibly the expenditure of electrical energy, required to balance the load of laundry in the drum of the machine, at least for a significant part of the possible unbalancing situations of the load of laundry inside the laundry drum of the washing machine or tumble dryer.

[0017] It is a further particular object of the invention to provide a laundry balancing method and a washing machine or tumble dryer, having features such as to balance the laundry using movement sequences of the laundry drum which are variable over time. It is a further object of the invention to suggest a new and easy method for varying parameters

of the movement sequences of the laundry drum during the laundry load balancing steps.

[0018] These and other objects are achieved by a laundry balancing method according to claim 1 and a laundry treatment machine, in particular a washing machine or tumble dryer, according to claim 12.

[0019] The dependent claims relate to advantageous and preferred embodiments.

[0020] According to an aspect of the invention, a laundry treatment machine, in particular a washing machine or tumble dryer, comprises:

- a housing,
- a laundry drum for containing the laundry to be washed, pivotally supported about a rotation axis, where the laundry drum delimits a loading opening, closable by means of a door connected to the housing, for the loading and unloading of the laundry to be washed,
- an electric motor functionally connected to the laundry drum to rotate the laundry drum about the rotation axis,
- a laundry treatment system configured to perform, on the laundry inside the laundry drum, one or more treatment steps which are different from the rotation of the laundry drum, said treatment steps comprising one or more of:
 - washing the laundry by means of soaking in water and detergent,
 - drying the laundry by means of forced ventilation,
- an electronic control system in signal connection with the electric motor, the treatment system, and a user interface for the selection of a treatment program from a plurality of treatment programs,

[0021] where the electronic control system is configured to control the electric motor and the treatment system depending on the treatment program selected by means of the user interface,

where the electronic control system comprises a balancing check module for the laundry in the laundry drum, where the user interface is configured to allow the selection and start of a treatment program comprising a spin step, where the laundry drum is rotated for example at a spin speed greater than 200 rpm, or at a spin speed in the range of 200 rpm to 1200 rpm,

where the electronic control system is configured to carry out, in response to the start of the treatment program which comprises the spin step, before performing the spin step, a balancing check of the load of laundry, and:

- in the case of a balanced load, enabling the performance of the spin step,
- in the case of an unbalanced load, not enabling the spin step and performing a step of balancing the load of laundry, through a sequence of movements of the drum at lower speeds than the rotation speed of the laundry drum during the spin step and, after the balancing step, repeat the balancing check on the load of laundry,

until, from the balancing check, the laundry load is considered balanced,

where said sequence of movements of the balancing step is defined by a group of balancing parameters, comprising the following parameters:

- rotation speed of the drum,
- variation in rotation speed of the drum,
- duration of movements of the drum,

characterized in that, in the same treatment program which comprises a spin step, the electronic control system varies the balancing parameters of a next balancing step with respect to the balancing parameters of a previous balancing step.

[0022] Varying the balancing parameters has the effect that if an attempt to balance the laundry load fails (i.e., if after a balancing step an unbalanced distribution of the laundry load is detected again), the subsequent balancing attempt is made by means of a sequence of movements of the laundry drum which is different from the previous sequence of movements.

[0023] Therefore, in the case of successful balancing of the laundry load, it is not necessary to repeat the balancing step, while in the case of failure, the subsequent balancing attempt will occur through a sequence of different movements, thus increasing the probability of success of the subsequent balancing attempt and statistically reducing the total number of balancing steps required.

[0024] Reducing the number of balancing steps, in turn, reduces the time and electricity consumption required to balance the laundry load before the spin step.

[0025] Likewise, according to a further aspect of the invention, a method for balancing the load of laundry in a laundry drum in a laundry treatment machine, in particular a washing machine or tumble dryer, comprises:

[0026] starting a laundry treatment program comprising a spin step, where the laundry drum is rotated for example at a spin speed greater than 200 rpm, or at a spin speed in the range of 200 rpm to 1200 rpm,

[0027] before performing the spin step, carrying out a balancing check of the load of laundry, and:

- in the case of a balanced load, performing the spin step,
- in the case of an unbalanced load, not enabling the spin step and performing a step of balancing the load of laundry, through a sequence of movements of the drum at lower speeds than the rotation speed of the laundry drum during the spin step and, after the balancing step, repeat the balancing check on the load of laundry,

until, from the balancing check, the laundry load is considered balanced,

[0028] where said sequence of movements of the balancing step is defined by a group of balancing parameters, comprising the following parameters:

- rotation speed of the drum,
- variation in rotation speed of the drum,
- duration of movements of the drum,

[0029] characterized in that, in the same treatment program which comprises a spin step, the balancing parameters of a next balancing step are varied with respect to the balancing parameters of a previous balancing step.

[0030] Further advantageous aspects of the invention will become apparent from the following description of some embodiments thereof, given by way of non-limiting example, with reference to the accompanying drawings, in which:

- figure 1 is a schematic section view of a laundry treatment machine according to an embodiment of the invention;
- figures 2 and 3 show diagrams of examples of methods with laundry balancing check steps and with laundry balancing steps for washing machines or tumble dryers of the prior art, described in EP0732437A1, where the ordinate indicates the rotational speed of a laundry drum, the abscissa the time, and the continuous curve indicates predetermined sequences of movement of the drum during balancing check steps and during laundry rebalancing steps, while the broken line curved branches indicate the start of a spin step following the determination that the laundry load is sufficiently balanced,

figure 4 shows a further exemplary diagram of a method with laundry balancing check steps and laundry balancing steps for washing machines or tumble dryers,

figures 5 and 6 show two exemplary diagrams of sequences of movements of the laundry drum of the laundry treatment machine with the indication of balancing parameters characterizing the sequences of movements, according to embodiments,

figure 7 shows a block diagram of the laundry load balancing method according to an embodiment of the invention, figures 8 and 9 show diagrams of variation of balancing parameters as a function of a number of repetitions of a step of balancing the laundry load, according to embodiments, in which the ordinate indicates a value indicative of an amplitude of the balancing parameter variable within a fixed interval and the abscissa indicates the number of repetitions of the laundry load balancing step,

figure 10 is a diagram showing the rotational speed trend of the electric motor that drives the laundry drum (ordinate: rotational speed of the motor, abscissa: time) for a large number of balancing steps, which shows how the sequences of movements of the individual balancing step differ from one another.

[0031] With reference to the drawings, a washing machine 1 or washer-dryer comprises a supporting and housing structure 2, in which a washing tank 3 is housed, provided with a (frontal or peripheral) opening closable by a door 4, e.g., a porthole door, hinged frontally to or on top of housing 2. A laundry drum 5 to accommodate the laundry to be washed is housed inside the washing tub 3 in a rotatable manner about a rotation axis R-R, e.g., horizontal or inclined. The laundry drum 5 can also delimit a front opening positioned at the opening of the washing tub 3 or a peripheral closable opening, in order to load and unload the laundry.

[0032] The washing machine comprises a laundry treatment system 3, 6, 7, 8, 9, 12, 13, 18, 20, 21 configured to perform one or more treatment steps on the laundry inside the laundry drum 5, in particular laundry washing steps by soaking in water and detergent and/or laundry drying steps by forced ventilation.

[0033] The washing tank 3 is adapted to contain the washing liquid during the laundry washing steps.

[0034] A washing water filling system 6 connectable to the water mains is provided to allow filling the washing tank 3 with mains water. The filling system 6 can comprise a plurality of ducts which extend from, for example, one or more,

e.g., two, supply solenoid valves 7, 8, directly or through detergent compartments of a detergent tray 9, to the washing tank 3.

[0035] A drainage duct 11 with associated drainage pump 12 which removes the washing liquid from tank 3 and which, together with the supply solenoid valves 7, 8, controls the level of liquid inside tank 3, is connected to the bottom 10 of the washing tank 3.

[0036] An electrical resistor 13 arranged inside the tank 3, in particular at the tank bottom 10, in the gap between the wall of the tank 3 and the laundry drum 5, can be provided to heat the washing liquid contained in the tank 3.

[0037] The washing machine 1 can further comprise a dispensing system 18 of the "multiple dose" type for dispensing substances for treating the laundry.

[0038] In addition or alternatively to the detergent tray 9, the dispensing system 18 comprises, for example, a plurality of reservoirs 19 for containing the treatment substances, e.g., detergent for resistant white items, detergent for delicate colored items, detergent for wool, perfuming substances, enzymes, fixing substances and/or fabric softener. The plurality of reservoirs 19 can be positioned, for example, in the porthole door 4, the detergent tray 9, or the housing 2, and the individual reservoirs 19 are dimensioned to each contain a sufficient volume of the treatment substance for a plurality of washing cycles.

[0039] The washing machine 1 can further comprise a system 20 for recirculating the washing liquid from the bottom of the tank 10 to the laundry drum 5.

[0040] The washing machine 1 can further comprise a drying system 21, e.g., a drying air circuit 22 having conveying means 23, air heating means 24, and moisture condensing means 25 of the conveyed air.

[0041] For agitating and remixing the laundry with the washing liquid, the laundry drum 5 can be driven in rotation by an electric motor 14 and a transmission 15, e.g., a belt transmission.

[0042] The operation of the washing machine 1 is controlled by an electronic control system 16 in signal connection with the electric motor 14, the treatment system 3, 6, 7, 8, 9, 12, 13, 18, 20, 21 and a user interface 17 for the selection of a treatment program from a plurality of treatment programs.

[0043] The user interface 17 can be positioned at an outer wall or door 4 of housing 2, or at an electronic device separate from housing 2. In response to the selections made by the user by means of the user interface 17, the control unit 16 drives the various components of the washing machine 1 to automatically wash and/or dry the laundry.

[0044] The electronic control system 16 is configured to control the electric motor 14 and the treatment system 3, 6, 7, 8, 9, 12, 13, 18, 20, 21 depending on the treatment program selected by means of the user interface.

[0045] The electronic control system 16 comprises a balancing check module 26 for the laundry in the laundry drum 5,

[0046] The user interface 17 is configured to allow the selection and start of a treatment program comprising a spin step 27, where the laundry drum 5 is rotated for example at a spin speed greater than 200 rpm, or at a spin speed in the range of 200 rpm to 1200,

[0047] The electronic control system 16 is configured to carry out, in response to the start of the treatment program which comprises the spin step 27, before performing the spin step 27, a balancing check 28 of the load of laundry, and:

- in the case of a balanced load, enable and perform the spin step 27,
- in the case of an unbalanced load, not enable the spin step 27 and perform a laundry load balancing step 29, through a sequence of movements of the laundry drum 5 at lower speeds than the rotation speed of the laundry drum 5 during the spin step 27 and, after the balancing step 29, repeat the balancing check 28 of the load of laundry until the load of laundry is balanced with respect to the balancing check step 28.

[0048] The sequence of movements of the balancing step 29 is defined by a group of balancing parameters (rebal_XXX), comprising the following parameters:

- rotation speed of the laundry drum 5,
- variation in rotation speed of the laundry drum 5,
- duration of movements of the laundry drum 5.

[0049] According to an aspect of the invention, in a same treatment program which comprises a spin step 27, the electronic control system 16 varies the balancing parameters (rebal_XXX (n+1)) of a next balancing step 29_{n+1} with respect to the balancing parameters (rebal_XXX(n)) of a previous balancing step 29_n.

[0050] Varying the balancing parameters (rebal_XXX) has the effect that if an attempt to balance the laundry load fails (i.e., if after a balancing step 29_n an unbalanced distribution of the laundry load is detected again), the subsequent balancing attempt (step) 29_{n+1} is performed by means of a sequence of movements of the laundry drum 5 which is different from the previous sequence of movements.

[0051] Therefore, in the case of successful balancing of the laundry load, it is not necessary to repeat the balancing step 29, while in the case of failure, the subsequent balancing attempt 29_{n+1} will occur through a sequence of different

movements, thus increasing the probability of success of the subsequent balancing attempt 29_{n+1} and statistically reducing the total number of balancing steps 29 required.

[0052] Reducing the number of balancing steps 29, in turn, reduces the time and electricity consumption required to balance the laundry load before the spin step 27.

[0053] According to an aspect of the invention, in the same treatment program which comprises a spin step 27, the electronic control system 16 varies the balancing parameters (rebal_XXX) of each next balancing step 29_{n+1} with respect to the balancing parameters (rebal_XXX) of all the previous balancing steps 29₁, ..., 29_n.

[0054] According to an embodiment, the variation of the balancing parameters (rebal_XXX) takes place, for each balancing parameter (rebal_XXX), within a predetermined range, delimited by a predetermined lower limit and a predetermined upper limit.

[0055] According to a further embodiment, the variation of the balancing parameters (rebal_XXX) takes place, for one or more or all of the balancing parameters, depending on a repetition number n+1 of the balancing step 29.

[0056] According to a further embodiment, the variation of the balancing parameters (rebal_XXX) takes place, for one or more or all of the balancing parameters (rebal_XXX),

- cyclically or
- pseudo-randomly.

[0057] According to an advantageous embodiment, at least one or more or all of the variable balancing parameters (rebal_XXX) are varied according to the repetition number of the balancing step 29 based on a trigonometric variation law (variation function), e.g., co/sinusoidal which is specific for said/each balancing parameter (rebal_XXX) (figures 8, 9).

[0058] According to an embodiment, the step of determining the balancing parameter (rebal_XXX, hereinafter the term "balancing parameter" means "the at least one, more or all the variable balancing parameters") comprises a step of calculating the balancing parameter (rebal_XXX) according to:

- a **constant component** (XXX), for example predetermined and specific for each balancing parameter (rebal_XXX) and which can be indicative of a mean, median or central value of the variable balancing parameter (rebal_XXX),
- a **variation limit** (Amplitude_XXX), or oscillation amplitude, e.g., predetermined and constant and specific for each balancing parameter (rebal_XXX), and which can be indicative of an absolute value of maximum allowable difference between the balancing parameter (rebal_XXX) and the constant component (XXX),
- a **mathematical variation function** (cos(Y_XXX)) which is dependent on the repetition number of the balancing step 29 and produces a non-constant result, for example within a range from -1 to +1,

e.g., by means of the formula:

$$rebal_XXX = XXX + Amplitude_XXX * \cos(Y_XXX) .$$

[0059] According to a preferred embodiment, the mathematical variation function (cos(Y_XXX)) is the cosine of a linear function (Y_XXX) which is dependent on the repetition number of the balancing step 29, for example:

$$Y_XXX = \frac{2\pi}{30} * iteration * Mod_freq_XXX + \frac{\pi}{2}$$

where "iteration" is the number of balancing steps n already previously performed and "Mod_freq_XXX" is a constant value, which is specific for each balancing parameter (rebal_XXX) and indicative of the frequency of the mathematical variation function.

[0060] This allows the balancing parameters (rebal_XXX) to be varied individually with different maximum oscillation amplitudes and different variation characteristics and different variation cyclicity, thus avoiding the formation of repetitive parameter patterns (considering the real conditions and realistic repetition numbers of the balancing step in a washing machine or tumble dryer with spin function).

[0061] By way of non-limiting example, but characteristic for embodiments of the invention, the balancing parameters (rebal_XXX) can comprise one, more or all of (figure 5, from left to right):

an initial deceleration ramp parameter R_REVERSE_DEC from a check drum speed S_UNB to a stop of the laundry drum 5 (this is an acceleration parameter),

a duration parameter of the drum stop at zero speed (this is a duration parameter),

a reverse acceleration ramp parameter RAMP R_REVERSE_INV after the drum has stopped at zero speed in the opposite direction to the direction of the check drum speed S_UNB, until a maximum reverse balancing speed is reached S_REVERSE (this is an acceleration parameter),

a drum rotation duration parameter T_REVERSE at the maximum reverse balancing speed S_REVERSE (this is a duration parameter),

a reverse balancing maximum speed parameter S_REVERSE (this is a speed parameter),

a deceleration ramp parameter R_REVERSE_DEC from the reverse balancing maximum speed S_REVERSE to a further stop of the laundry drum 5 (this is an acceleration parameter),

a duration parameter of the further drum stop at zero speed (this is a duration parameter),

a second acceleration ramp parameter RAMP R_REVERSE_INV after the further drum stop at zero speed in the direction of the check drum speed S_UNB, until an intermediate balancing speed is reached S_REVERSE (this is an acceleration parameter),

a drum rotation duration parameter at the intermediate balancing speed S_REVERSE (this is a duration parameter),

a balancing intermediate speed parameter S_REVERSE (this is a speed parameter),

a third acceleration ramp parameter RAMP R_Smart, after the drum rotation step at the intermediate balancing speed S_REVERSE, in the direction of the check drum speed S_UNB, until a second intermediate balancing speed S_Smart is reached (this is an acceleration parameter),

a drum rotation duration parameter at the second intermediate balancing speed S_Smart (this is a duration parameter T_smart),

a second balancing intermediate speed parameter S_Smart (this is a speed parameter),

a fourth acceleration ramp parameter RAMP R_UNB_acc, after the drum rotation step at the second intermediate balancing speed S_Smart, in the direction of the check drum speed S_UNB, until a check drum speed S_UNB is reached (this is an acceleration parameter).

[0062] The check drum speed S_UNB value during the balancing check step 28 is preferably invariable.

[0063] According to an embodiment, the balancing parameters (rebal_XXX) can comprise one, more or all of (figure 6, from left to right):

an initial deceleration ramp parameter R_REVERSE_DEC from a check drum speed S_UNB, until a minimum balancing speed S_Rebal is reached in the same rotation direction as the check drum speed S_UNB (this is an acceleration parameter),

a drum rotation duration parameter T_Rebal at the minimum balancing speed S_Rebal (this is a duration parameter),

a balancing minimum speed parameter S_Rebal (this is a speed parameter),

an acceleration ramp parameter RAMP R_Smart, after the drum rotation step at the minimum balancing speed S_Rebal, in the direction of the check drum speed S_UNB, until an intermediate balancing speed S_Smart is reached (this is an acceleration parameter),

a drum rotation duration parameter at the intermediate balancing speed S_Smart (this is a duration parameter),

a balancing intermediate speed parameter S_Smart (this is a speed parameter),

a final acceleration ramp parameter RAMP R_UNB_acc, after the drum rotation step at the intermediate balancing speed S_Smart, in the direction of the check drum speed S_UNB, until a check drum speed S_UNB is reached (this is an acceleration parameter).

[0064] The check drum speed value S_UNB during the balancing check step 28 is preferably invariable.

[0065] In general, the balancing parameters (Rebal_XXX) can comprise one or more parameters selected from the following group:

- maximum speed,
- minimum speed,
- intermediate speed,
- duration at maximum speed,
- duration at minimum speed,
- duration at intermediate speed,
- acceleration,
- deceleration,
- acceleration duration,
- deceleration duration.

[0066] Non-limiting examples of the calculation values described above are shown in the following table.

<i>XXX</i>	<i>Amplitude_XXX</i>	<i>Mod_freq_XXX</i>
$RAMP R_{REVERSE DEC}$	20	4
$RAMP R_{REVERSE INV}$	22	7
$RAMP R_{SMART}$	22	6
S_{REBAL}	10	9
$S_{REVERSE}$	12	8
T_{SMART}	4	3
$T_{REVERSE}$	2	2
T_{REBAL}	2	1

Description of the balancing check step 28

[0067] Methods and systems for checking the balancing of the load of laundry in washing machines or tumble dryers are well known to those skilled in the art, therefore they are not described in detail herein. Such known systems and methods can also be used in the washing machine 1 or tumble dryer according to the invention, as well as in the method according to the invention.

[0068] According to an embodiment, the balancing check step 28 comprises:

- a detection of electric current absorbed by the electric motor 14 which drives the laundry drum 5,
- a calculation of a variation of the absorbed electric current depending on the detected electric current, and
- a comparison of the variation of absorbed electric current with a reference current variation value,

where:

- when the calculated electric current variation is greater than the reference current variation value, the load of laundry is determined as unbalanced, and
- when the calculated electric current variation is less than the reference current variation value, the load of laundry is determined as balanced.

[0069] According to a further embodiment, the balancing check step 28 comprises:

- a detection of a rotational speed of the laundry drum 5 or the electric motor 14 which drives the laundry drum 5,
- a calculation of a rotary speed variation depending on the detected rotary speed, and
- a comparison of the calculated rotary speed variation with a reference speed variation value,

where:

- when the calculated rotary speed variation is greater than the reference speed variation value, the load of laundry is determined as unbalanced, and
- when the calculated rotary speed variation is less than the reference speed variation value, the load of laundry is determined as balanced.

[0070] According to a further embodiment, the balancing check step 28 comprises:

- a detection of an acceleration or vibration of the laundry drum 5 and
- a comparison of the acceleration or vibration of the laundry drum with a reference acceleration or vibration value,

where:

- when the detected acceleration or vibration is greater than the reference acceleration or vibration value, the load of laundry is determined as unbalanced, and
- when the detected acceleration or vibration is less than the reference acceleration or vibration value, the load of

laundry is determined as balanced.

Description of the laundry balancing method

5 **[0071]** According to an aspect of the invention, a method for balancing the load of laundry in a laundry drum 5 in a laundry treatment machine 1, in particular a washing machine 1 or tumble dryer, comprises:

starting a laundry treatment program comprising a spin step 27, where the laundry drum 5 is rotated at a spin speed greater than 200 rpm, or at a spin speed in the range of 200 rpm to 1200 rpm,
10 before performing the spin step 27, carrying out a balancing check step 29 of the load of laundry, and:

- in the case of a balanced load, performing the spin step 27,
- in the case of an unbalanced load, not enabling the spin step 27 and performing a laundry load balancing step 29 through a sequence of movements of the laundry drum 5 at lower speeds than the rotation speed of the laundry drum 5 during the spin step 27 and, after the balancing step 29, repeating the laundry load balancing check step 28 until the load of laundry is considered/determined as balanced by the balancing check step 29,

where said sequence of movements of the balancing step 29 is defined by a group of balancing parameters Rebal_XXX, comprising the following parameters:

- rotation speed of the drum,
- variation in rotation speed of the drum,
- duration of movements of the drum,

25 and in the same treatment program which comprises a spin step 27, the balancing parameters Rebal_XXX of a next balancing step 29_n+1 are varied with respect to the balancing parameters Rebal_XXX of a previous balancing step 29_n.

30 **[0072]** The further steps of the method and embodiments of the method are the same as described above with reference to the washing machine 1 or tumble dryer, but with the understanding that not all embodiments require the specific hardware (electronic control system 16, user interface 17, balancing check module 26), which is thus optional, described in relation to the washing machine 1 and tumble dryer.

List of Reference numerals

35 **[0073]**

washing machine 1
supporting and housing structure 2
40 washing tank 3
door 4
rotation axis R-R
laundry drum 5
treatment system 3, 6, 7, 8, 9, 12, 13, 18, 20, 21
45 water loading system 6
supply solenoid valves 7,8
detergent tray 9
tank bottom 10
discharge pipe 11
50 discharge pump 12
electrical resistor 13
electric motor 14
transmission 15
electronic control system 16
55 user interface 17
multiple-dose dispensing system 18
treatment substance reservoirs 19
washing liquid recirculation system 20

drying system 21
drying air circuit 22
conveying means 23
heating means 24
5 condensation means 25
balancing check module 26
spin step 27
balancing check step 28
balancing step 29
10 next balancing step 29_{n+1}
previous balancing step 29_n

Claims

1. A method for balancing the load of laundry in a laundry drum (5) in a laundry treatment machine, in particular a washing machine (1) or tumble dryer, comprising:

- carrying out, before performing a spin step (27) of a laundry treatment machine, a balancing check step (29) of the load of laundry, and:
- in the case of a balanced load, performing the spin step (27),
- in the case of an unbalanced load, not enabling the spin step (27) and performing a balancing step (29) of the load of laundry, through a sequence of movements of the laundry drum (5) at lower speeds than the rotation speed of the laundry drum (5) during the spin step (27) and, after the balancing step (29), repeating the balancing check step (28) of the load of laundry until the load of laundry results to be balanced from the balancing check step (29),

wherein said sequence of movements of the balancing step (29) is defined by a group of balancing parameters (Rebal_XXX), comprising the following parameters:

- rotation speed of the laundry drum (5),
- variation in rotation speed of the laundry drum (5),
- duration of movements of the laundry drum (5),

characterized by varying the balancing parameters (Rebal_XXX) of a next balancing step (29_{n+1}) with respect to the balancing parameters (Rebal_XXX) of a previous balancing step (29_n) within said same laundry treatment program.

2. A method according to claim 1, comprising varying the balancing parameters (rebal_XXX) of each next balancing step (29_{n+1}) with respect to the balancing parameters (rebal_XXX) of all the previous balancing steps (29₁, ..., 29_n) of the laundry treatment program.

3. A method according to claim 1 or 2, wherein the variation of the balancing parameters (rebal_XXX) takes place, for each variable balancing parameter (rebal_XXX), within a predetermined range, delimited by a predetermined lower limit and a predetermined upper limit.

4. A method according to any one of the preceding claims, wherein the variation of the balancing parameters (rebal_XXX) takes place, for one or more or all of the balancing parameters (Rebal_XXX), depending on a repetition number (n+1) of the balancing step (29).

5. A method according to any one of the preceding claims, wherein the variation of the balancing parameters (rebal_XXX) takes place, for one or more or all of the balancing parameters (rebal_XXX),

- cyclically or
- pseudo-randomly.

6. A method according to any one of the preceding claims, wherein at least one or more or all of the variable balancing parameters (rebal_XXX) are varied according to the repetition number of the balancing step (29) and based on a

trigonometric variation function, which is specific for said or each balancing parameter (rebal_XXX).

7. A method according to any one of the preceding claims, wherein the step of determining at least one of the balancing parameters (rebal_XXX) comprises a step of calculating the balancing parameter (rebal_XXX) as a function of:

- a **constant component** (XXX) indicative of a central value of the variable balancing parameter (rebal_XXX),
- a **variation limit** (Amplitude_XXX) indicative of an absolute value of maximum allowable difference between the balancing parameter (rebal_XXX) and the constant component (XXX),
- a **mathematical variation function** (cos(Y_XXX)) which is dependent on the repetition number of the balancing step (29) and which produces a variable result within a range from -1 to +1.

8. A method according to claim 7, wherein:

- the determination of at least one of the balancing parameters (rebal_XXX) takes place by means of formula $rebal_XXX = XXX + Amplitude_XXX * \cos(Y_XXX)$, and/or
- the mathematical variation function (cos(Y_XXX)) is the cosine of a linear function (Y_XXX) which is dependent on the repetition number of the balancing step (29), or

$$Y_XXX = \frac{2\pi}{30} * iteration * Mod_freq_XXX + \frac{\pi}{2},$$

wherein "iteration" is the number of balancing steps already previously performed and "Mod_freq_XXX" is a constant value, which is specific for each balancing parameter (rebal_XXX) and indicative of a frequency of the mathematical variation function.

9. A method according to any one of the preceding claims, wherein the balancing check step (28) comprises:

- a detection of electric current drawn by the electric motor (14) which operates the laundry drum (5),
- a calculation of a variation of the absorbed electric current depending on the detected electric current, and
- a comparison of the variation of the absorbed electric current with a reference current variation value,

wherein:

- when the calculated electric current variation is greater than the reference current variation value, the load of laundry is determined as unbalanced, and
- when the calculated electric current variation is less than the reference current variation value, the load of laundry is determined as balanced.

10. A method according to any one of claims 1 to 8, wherein the balancing check step (28) comprises:

- a detection of a rotational speed of the laundry drum (5) or the electric motor (14) which operates the laundry drum (5),
- a calculation of a rotary speed variation depending on the detected rotary speed, and
- a comparison of the calculated rotary speed variation with a reference speed variation value,

wherein:

- when the calculated rotary speed variation is greater than the reference speed variation value, the load of laundry is determined as unbalanced, and
- when the calculated rotary speed variation is less than the reference speed variation value, the load of laundry is determined as balanced.

11. A method according to any one of claims 1 to 8, wherein the balancing check step (28) comprises:

- a detection of an acceleration or vibration of the laundry drum (5) and
- a comparison of the acceleration or vibration of the laundry drum with a reference acceleration or vibration value,

wherein:

- when the detected acceleration or vibration is greater than the reference acceleration or vibration value, the load of laundry is determined as unbalanced, and
- when the detected acceleration or vibration is less than the reference acceleration or vibration value, the load of laundry is determined as balanced.

12. A laundry treatment machine, in particular a washing machine (1) or tumble dryer, comprising:

- a housing (2),
- a laundry drum (5) for containing the laundry to be washed, pivotally supported about a rotation axis (R-R), wherein the laundry drum (5) delimits a loading opening, which is closable by means of a door (4) connected to the housing (2), for loading and unloading the laundry to be washed,
- an electric motor (14) functionally connected to the laundry drum (5) to rotate the laundry drum (5) about the rotation axis (R-R),
- a laundry treatment system (3, 6, 7, 8, 9, 12, 13, 18, 20, 21) configured to perform, on the laundry inside the laundry drum (5), one or more treatment steps other than the rotation of the laundry drum (5), comprising laundry washing steps by soaking in water and detergent and/or laundry drying steps by ventilation,
- an electronic control system (16) in signal connection with the electric motor (14), the treatment system (3, 6, 7, 8, 9, 12, 13, 18, 20, 21) and with a user interface (17) for the selection of a treatment program from a plurality of treatment programs,

wherein the electronic control system (16) is configured to control the electric motor (14) and the treatment system (3, 6, 7, 8, 9, 12, 13, 18, 20, 21) depending on the treatment program selected by the user interface (17),

wherein the electronic control system (16) comprises a balancing check module (26) of the laundry in the laundry drum (5),

wherein the user interface (17) is configured to allow the selection and start of a treatment program which comprises a spin step (27),

wherein the electronic control system (16) is configured to:

- carry out, in response to the start of the treatment program which comprises the spin step (27), before performing the spin step (27), a balancing check (28) of the load of laundry, and:
- in the case of a balanced load, performing the spin step (27),
- in the case of an unbalanced load, not enable the spin step (27) and perform a balancing step (29) of the load of laundry, through a sequence of movements of the laundry drum (5) at lower speeds than the rotation speed of the laundry drum (5) during the spin step (27) and, after the balancing step (29), repeat the balancing check (28), until the load of laundry results to be balanced from the balancing check step (28),

wherein the sequence of movements of the balancing step (29) is defined by a group of balancing parameters (rebal_XXX), comprising the following parameters:

- rotation speed of the laundry drum (5),
- variation in rotation speed of the laundry drum (5),
- duration of movements of the laundry drum (5),

characterized in that, in the same treatment program which comprises a spin step (27), the electronic control system (16) varies the balancing parameters (rebal_XXX) of a next balancing step (29_{n+1}) with respect to the balancing parameters (rebal_XXX) of a previous balancing step (29_n).

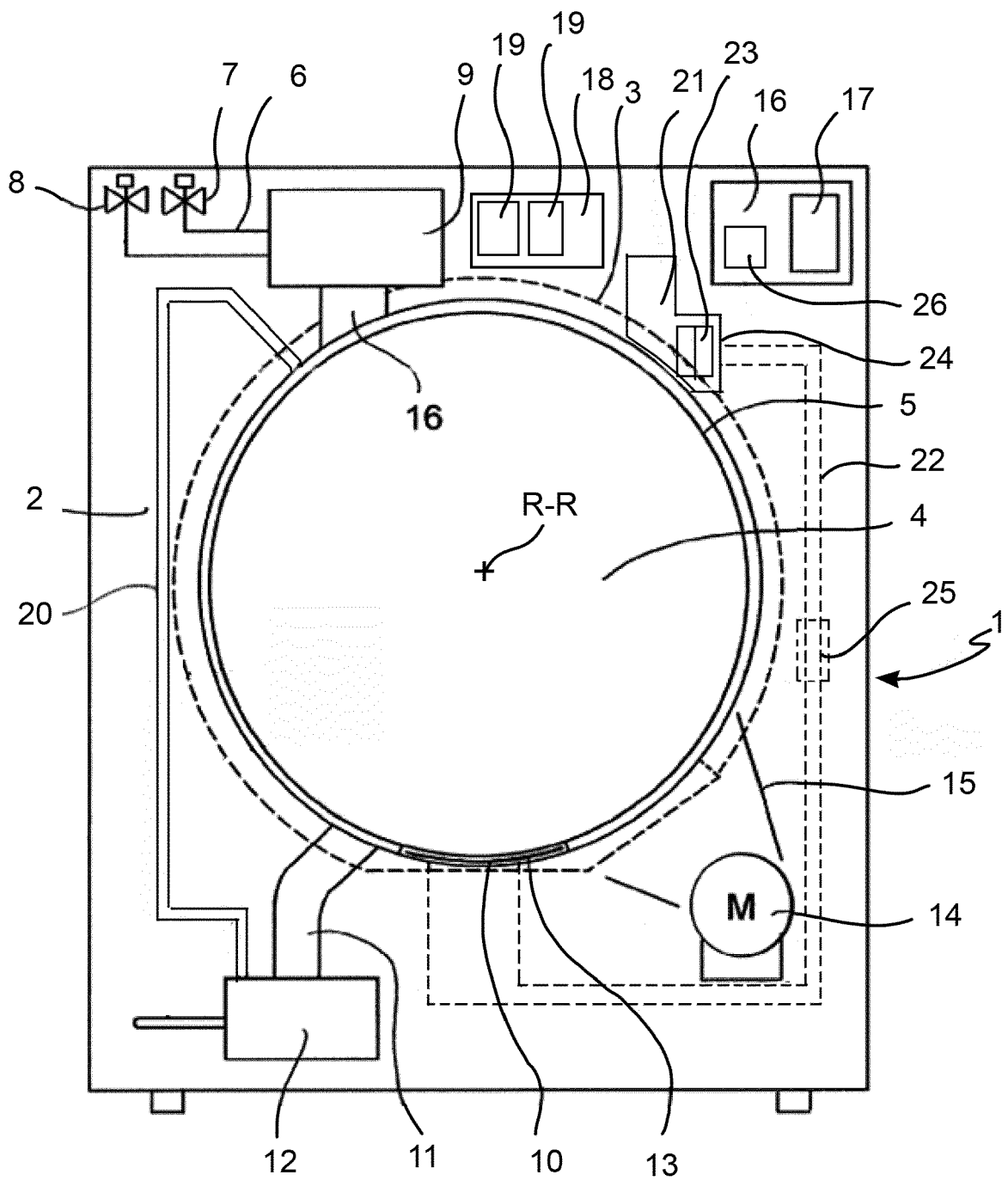


FIG. 1

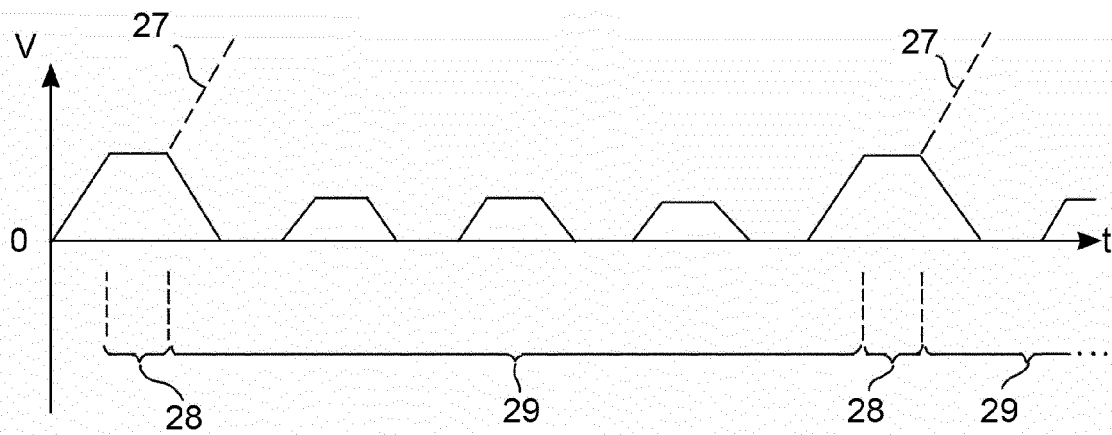


FIG. 2

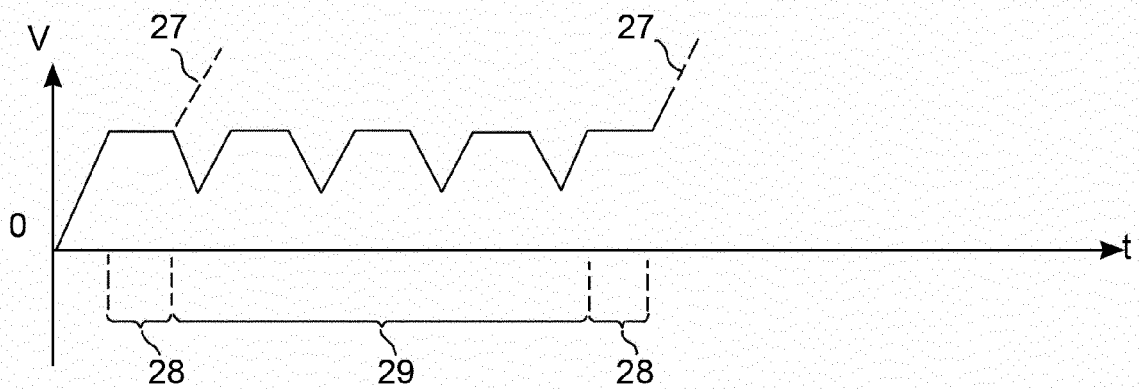


FIG. 3

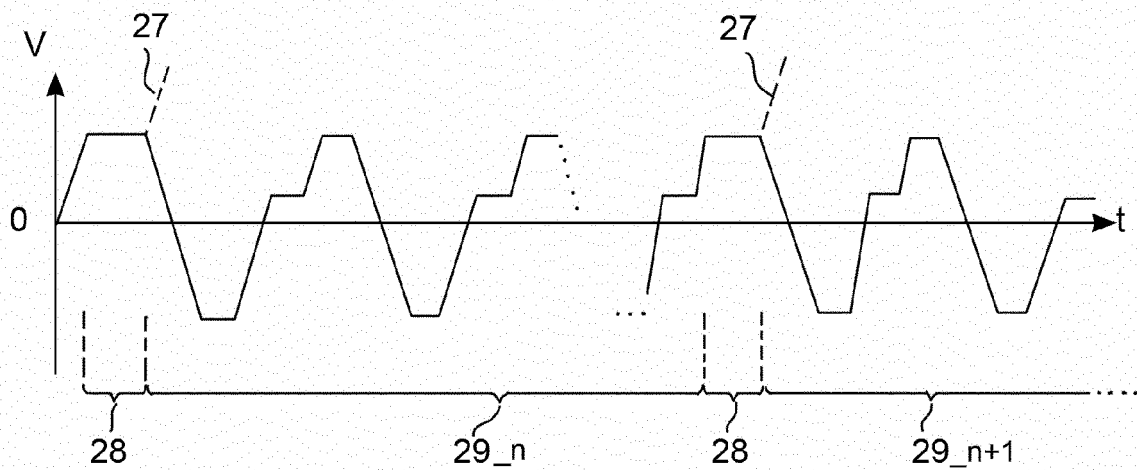


FIG. 4

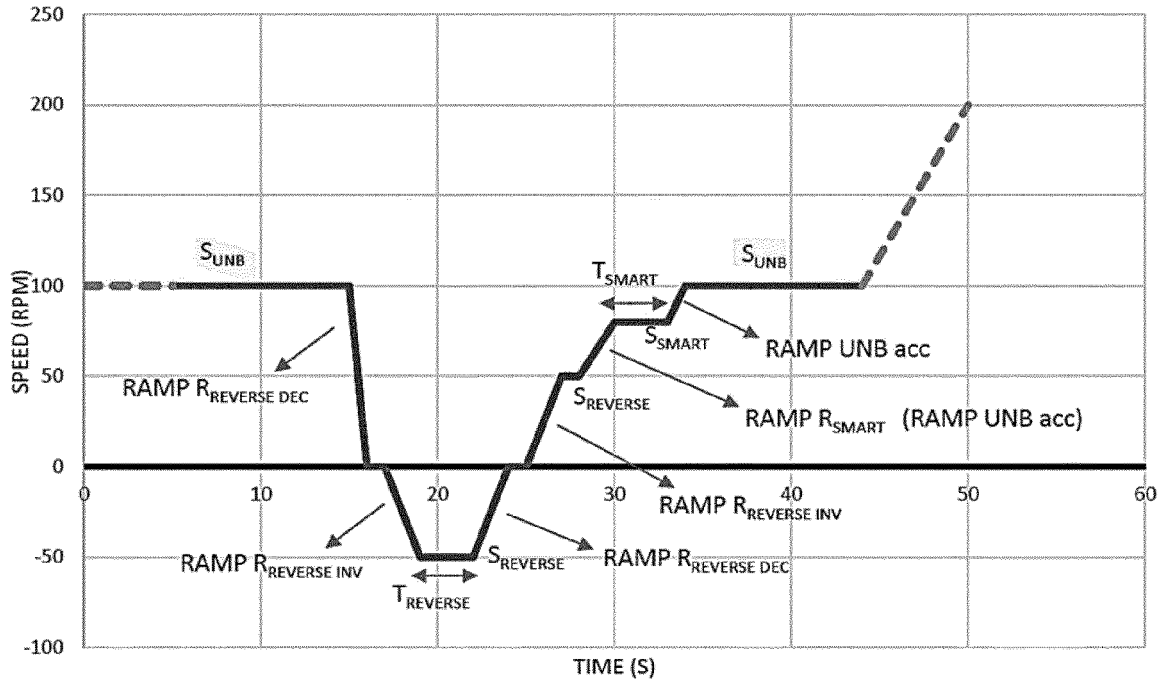


FIG. 5

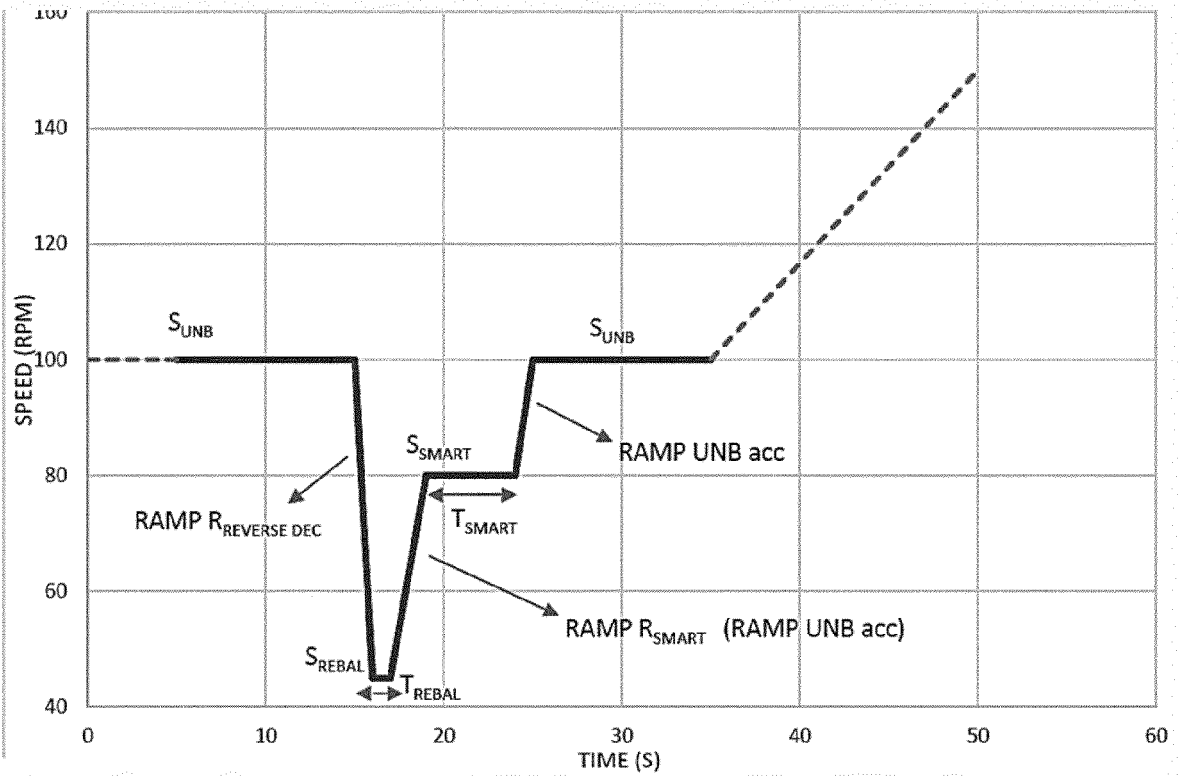


FIG. 6

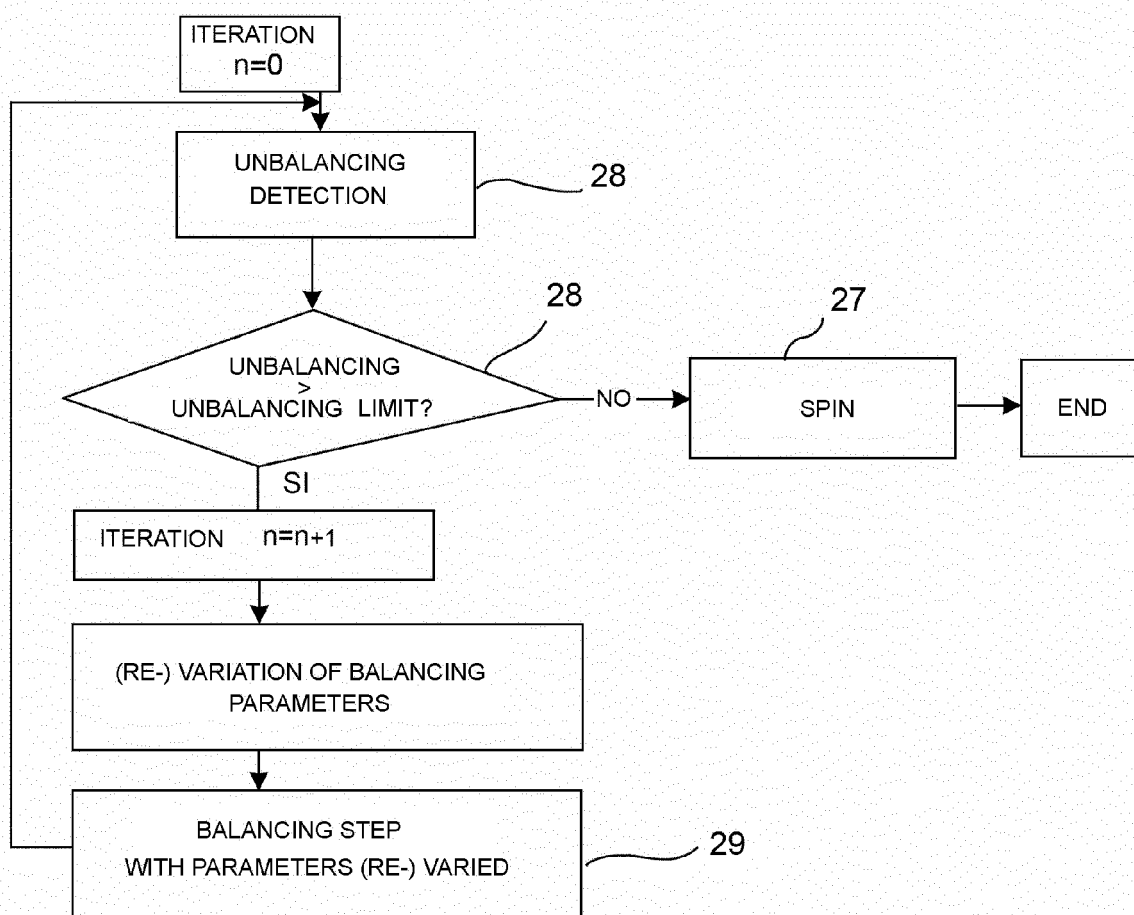


FIG. 7

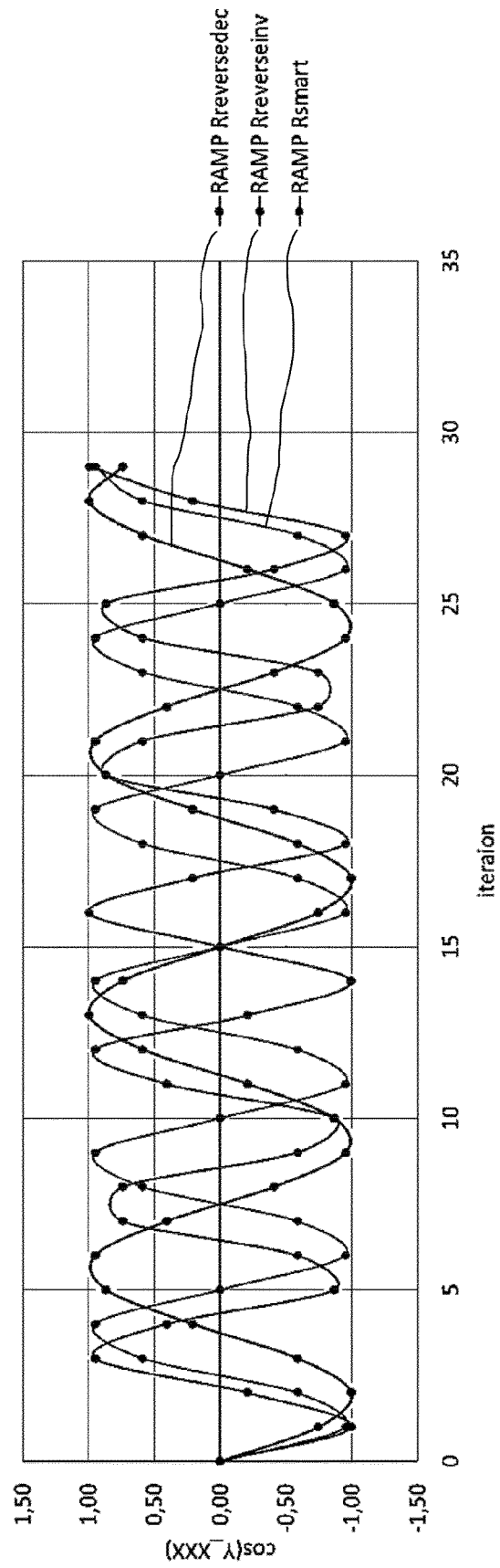


FIG. 8

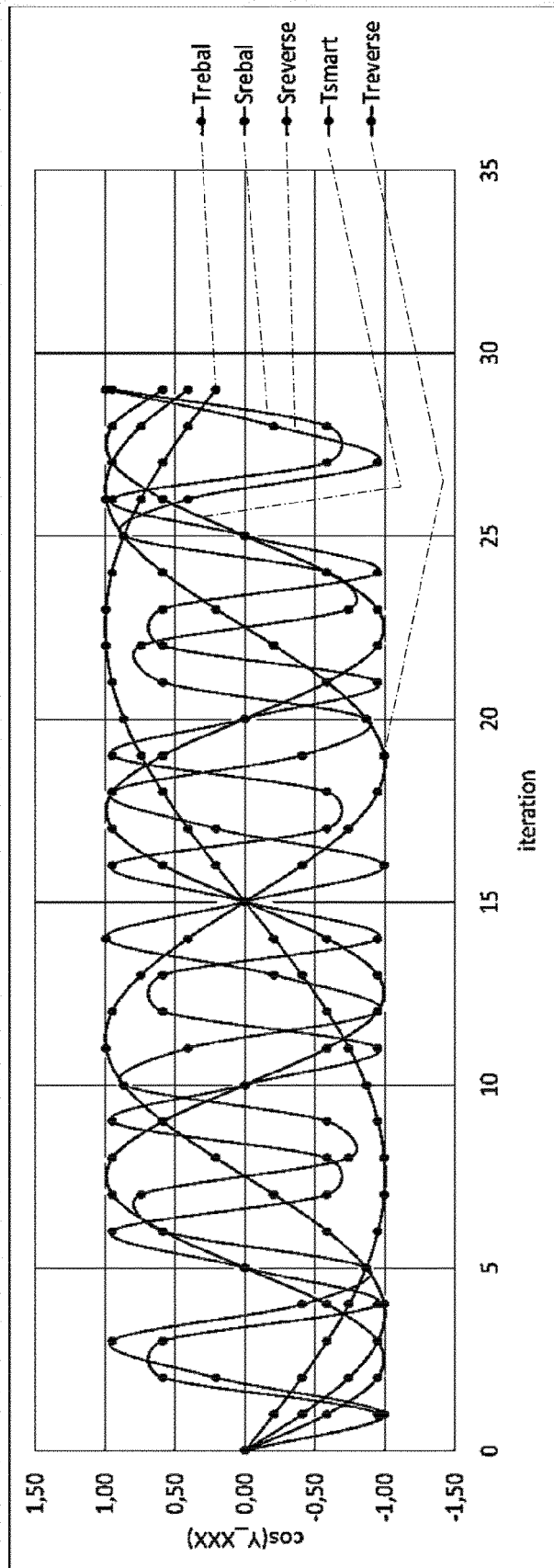


FIG. 9

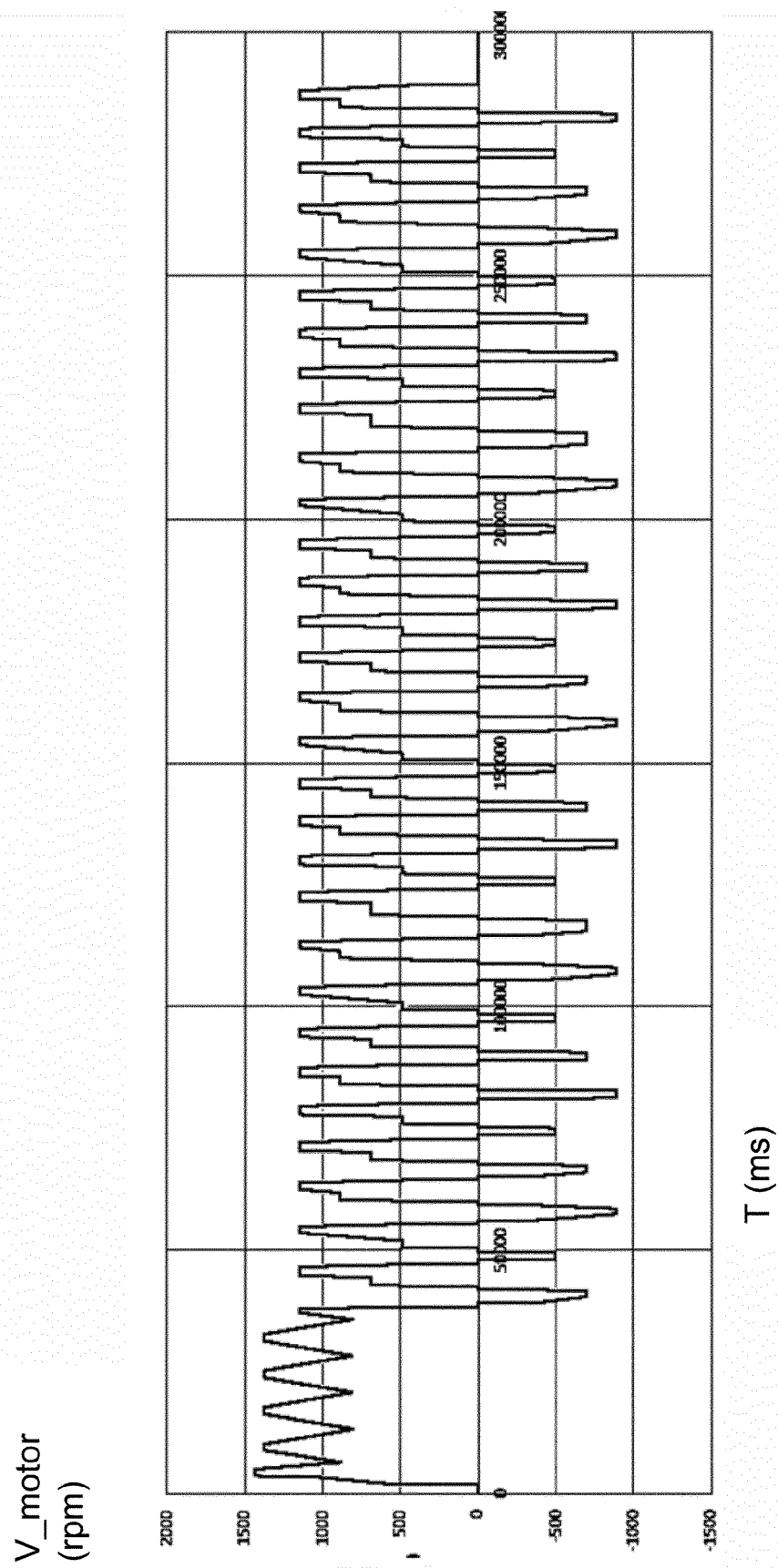


FIG. 10



EUROPEAN SEARCH REPORT

Application Number

EP 23 18 5225

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X	EP 1 297 209 A1 (SKF AUTOBALANCE SYSTEMS AB [SE]) 2 April 2003 (2003-04-02) * paragraphs [0049], [0054], [0063] - [0065]; figures 2-3, 10 *	1, 5, 10, 12	D06F34/16 D06F58/36 D06F33/40 D06F103/24 D06F103/38 D06F105/52
A	EP 1 461 487 A1 (ARCELIK AS [TR]) 29 September 2004 (2004-09-29) * paragraph [0022]; figure 1a *	1-12	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			D06F

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Place of search

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Date of completion of the search

24 August 2023

Examiner

Diaz y Diaz-Caneja

CATEGORY OF CITED DOCUMENTS

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