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(54) Title: WASHING MACHINE WITH LINEN MASS DETERMINATION

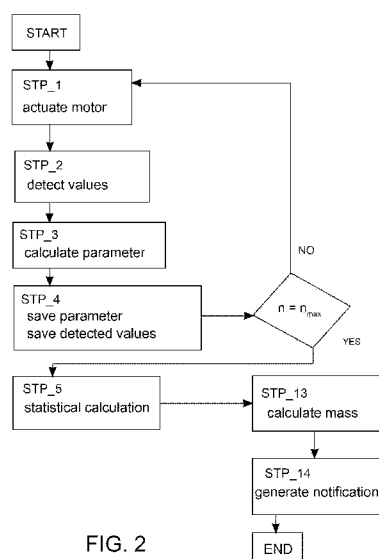


FIG. 2

(57) Abstract: A washing machine (1) comprises a linen drum (5) for containing the linen to be washed, an electric motor (14) connected to the linen drum (5) to rotate the linen drum (5) about the rotation axis (R-R), a linen treatment system to perform, on the linen inside the linen drum (5), one or more treatment steps which are different from the rotation of the linen drum (5), an electronic control system (16) in signal connection with the electric motor (14), with the treatment system and with a user interface (17) for the selection of a treatment program from a plurality of treatment programs, the electronic control system (16) comprising a module (26) for determining the mass (M) of the linen contained linen drum (5), the user interface (17) allows the entry of a command for determining the linen mass without performing the washing steps, and, in response to the entry of the command for determining the mass the program electronic control system (16) performs a procedure for determining the mass (M) of the linen contained in the linen drum and generates, by means of the user interface (17), a notification containing said suggestion for quantity and/or type of detergent.

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"Washing machine with linen mass determination"**DESCRIPTION**

[0001] The present invention relates to a household appliance for the rotary treatment of linen, in particular a washing machine, dryer, or washer-dryer machine

[0002] Domestic washing machines comprise a supporting and housing structure, inside which a washing tub is housed provided with a front opening closable by a porthole door frontally hinged to the housing. A drum for accommodating the linen to be washed, is arranged inside the washing tub in a rotatable manner about a horizontal or inclined axis. The drum, too, delimits a front opening positioned at the opening of the washing tub, to allow the loading and unloading of the linen.

[0003] The washing tub is adapted to contain the washing liquid during the linen washing steps.

[0004] To allow the loading of the washing tub with mains water and with detergent substances and additives, a washing water loading system is provided which is connectable to the water supply network. A drain duct is provided on the bottom of the washing tub, associated with a drain pump, which removes the washing liquid from the washing tub and which controls, together with the loading system, the level of liquid inside the washing tub.

[0005] To add a detergent or a treatment additive to the washing liquid, arranging a detergent tray in flow communication with the water loading system is known.

[0006] The detergent tray may be configured as a drawer which can be extracted from and inserted into the housing structure and which can be filled manually for each wash with an amount of detergent and/or treatment additive sufficient for a single washing cycle.

[0007] Washing machines with so-called "multiple dispensing" washing substance dispensing and dosing systems are also known configured to contain an amount of treatment substance sufficient for a plurality of washing cycles and to automatically dispense a controlled dose of treatment substance for each washing cycle.

[0008] For heating the washing liquid contained in the washing tub, an electrical resistor is provided, arranged inside the washing tub, in the gap between the wall of the washing tub and the linen drum.

[0009] To reduce the consumption of water and detergent, it is known to equip washing machines with recirculation systems which remove the washing liquid from the

bottom of the washing tub (where it accumulates even before touching the linen in the drum) and reintroduce it into the linen drum, so that a reduced volume of liquid is repeatedly poured on the linen to be washed.

[0010] Recirculation systems usually comprise a recirculation duct which extends outside the washing tub from a lower opening of the washing tub (for drawing the liquid to be recirculated) to an upper opening of the washing tub (for reintroducing the recirculated liquid), as well as an electric recirculation pump or ejector.

[0011] Some washing machines comprise a sensor to detect the linen load and a control device which controls the execution of a washing program also depending on the detected linen load.

[0012] The features described hereto related to washing machines of the prior art known by the applicant may be entirely or partially also implemented in at least some embodiments of an improved washing machine according to the invention.

[0013] In the prior art, the linen load is detected during the execution of a washing program which has already started, e.g. by monitoring the water absorption in the linen or by force sensors interposed between the washing tub and the housing. The detection of the linen load is intertwined with the progress of the washing program itself, and the result of the linen load detection influences the further progress of the washing program, without the possibility of user intervention, e.g. for adjusting the detergent dosage by the user, an additional filling with additional linen items or a withdrawal of a part of the linen to reduce the linen load.

[0014] Furthermore, in the prior art, linen load is usually detected when the linen is already wet and not when it is dry, making it further difficult for the user to take corrective action.

[0015] Finally, in the prior art, the linen load detection procedures are complex or require expensive detectors, and their repetitive performance in the various steps of the washing procedures takes an undesirably long time, and the result of the linen load detection is subject to many uncertainties due to the many influencing factors which cannot be predicted with certainty, e.g., the distribution of the linen inside the drum, the degree and unevenness of water absorption in the linen, the amount of water in the washing tub, etc.

[0016] It is thus the object of the present invention to provide an improved washing machine having such features as to solve at least some problems described with reference to the prior art.

[0017] It is a particular object of the invention to provide a washing machine having an improved linen load determination function, as well as such features as to allow a user to intervene on the washing program or washing parameters based on the detected linen load, or intervene on the linen load itself, e.g. before starting or continuing a washing program.

[0018] It is a further particular object of the invention to provide a washing machine having a linen load determination function, wherein the linen load determination:

[0019] - can be requested by the user independently of a specific washing program, and/or

[0020] - is done quickly and reliably, and/or

[0021] - can be performed without wetting the linen.

[0022] These and other objects are achieved by means of a rotary linen treatment household appliance configured to perform a linen treatment involving rotary agitation of the linen, such as a washing and/or drying treatment, according to the independent claim. The dependent claims relate to advantageous and preferred embodiments of the invention.

[0023] According to an aspect of the invention, a washing machine comprises:

[0024] - a housing,

[0025] - a linen drum for containing the linen to be washed, supported rotatable about a rotation axis, wherein the linen drum delimits a loading opening, which is closable by means of a door connected to the housing, for the loading and unloading of the linen to be washed,

[0026] - an electric motor functionally connected to the linen drum to rotate the linen drum about the rotation axis,

[0027] - a linen treatment system configured to perform, on the linen inside the linen drum, one or more treatment steps which are different from the rotation of the linen drum, said treatment steps comprising one or more of:

- washing the linen by means of soaking in water and detergent,
- drying the linen by means of forced ventilation,

[0028] - an electronic control system in signal connection with the electric motor, with the treatment system, and with a user interface for the selection of a treatment program from a plurality of treatment programs,

[0029] wherein 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,

[0030] wherein the electronic control system comprises a module for determining the mass of the linen contained in the linen drum,

[0031] wherein the user interface is configured for the input of a command for determining the mass (quantity meaning the *amount*) of the linen without performing said treatment steps,

[0032] wherein, in response to the input of the command for determining the linen mass without performing a treatment program, the electronic control system:

[0033] - performs a procedure for determining the linen mass of the linen contained in the linen drum,

[0034] – elaborates, depending on the determined linen mass, a suggestion for quantity and/or type of detergent,

[0035] - generates, by means of the user interface, a notification containing said suggestion for quantity and/or type of detergent,

[0036] - at the end of the procedure for determining the linen mass of the linen contained in the linen drum, puts the washing machine in a standby configuration in which:

[0037] - the user interface may receive a command for starting a selected washing program,

[0038] - the washing machine may receive a manual dosage of detergent or the user interface allows the selection of a quantity and/or type of detergent for the selected washing program.

[0039] This allows the user to take corrective action still before the start of an actual washing program, e.g. by correcting the type and/or amount of detergent or the amount of linen, or by waiting until the washing machine is optimally filled.

[0040] According to a possible embodiment, at the end of the linen mass determining procedure, the linen is neither wet nor subject to treatment substances, detergent, etc., allowing the user to freely set or vary the parameters of the washing program, including the start time, taking into account the suggestion of quantity and/or type of detergent generated through the user interface, but completely free from any constraints given by a possible treatment of the linen already started.

[0041] According to a further aspect of the invention, a washing machine comprises:

[0042] - a housing,

[0043] - a linen drum for containing the linen to be washed, supported rotatable about a rotation axis, wherein the linen drum delimits a loading opening, which is closable by means of a door connected to the housing, for the loading and unloading of the linen to be washed,

[0044] - an electric motor functionally connected to the linen drum to rotate the linen drum about the rotation axis,

[0045] - a linen treatment system configured to perform, on the linen inside the linen drum, one or more treatment steps which are different from the rotation of the linen drum, said treatment steps comprising one or more of:

- washing the linen by means of soaking in water and detergent,
- drying the linen by means of forced ventilation,

[0046] - an electronic control system in signal connection with the electric motor, with the treatment system, and with a user interface for the selection of a treatment program from a plurality of treatment programs,

[0047] wherein 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,

[0048] wherein the electronic control system comprises a module for determining the linen mass of the linen contained in the linen drum, configured to:

A) perform an initial sequence of consecutive inrush steps, each inrush step comprising:

[0049] - actuating the motor to accelerate the rotating linen drum from an initial speed v_{init} equal to zero to a predetermined maximum speed v_{max} , with a predetermined acceleration, e.g., substantially constant,

[0050] - when the predetermined maximum speed v_{max} has been reached, slowing and/or deactivating the motor so that the linen drum decelerates, e.g. freely, until the initial speed v_{init} equal to zero is reached again,

[0051] - in a detection time interval during the acceleration of the rotating linen drum from the initial speed v_{init} equal to zero to the predetermined maximum speed v_{max} , detecting the inrush current drawn by the electric motor, the rotational speed of the electric motor, the ohmic resistance of the electric motor, and the time,

B) calculating for each single inrush step a parameter of rotational power generated by the electric motor depending on the detected inrush current,

C) calculating for the entire first sequence of consecutive inrush steps an average value of the rotational power parameter values calculated for the single inrush steps,
D) determining the linen mass of the linen in the linen drum depending on the average rotational power parameter value and predetermined characterization parameters of the washing machine.

[0052] By exploiting the inrush events, i.e., acceleration events of the motor (and the linen drum) from a static condition to a maximum speed, through a predetermined, e.g., constant, acceleration ramp, the inrush current of the electric motor can be considered either solely or predominantly correlated to the mass inertial moment of the assembly formed by the drum and the linen contained therein. This simplifies the correlation of the mass inertial moment, and thus the mass itself, with the detected motor current, allowing a more accurate, reliable, and rapid determination of the linen mass.

[0053] Advantageously, the linen mass can be determined with dry linen and independently of a specific washing or drying program or a specific step in a washing or drying program.

[0054] 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 figures, in which:

[0055] - figure 1 is a diagrammatic front view of a washing machine according to an embodiment of the invention;

[0056] - figure 2 is a block chart of a procedure for determining the linen mass according to an embodiment,

[0057] - figure 3 is a block diagram of a procedure for determining the linen mass according to a further embodiment.

[0058] With reference to the figures, a washing machine 1 or washer-dryer comprises a supporting and housing structure 2, inside which a washing tub 3 is housed, provided with an opening (either frontal or peripheral) closable by a door 4 (e.g. a porthole door) hinged either frontally or on top to the housing 2. A linen drum 5 for accommodating the linen to be washed 3 is housed inside the washing tub in a rotatable manner about a rotation axis R-R, e.g. horizontal or inclined. The linen drum 5 may also delimit a front opening positioned at the opening of the washing tub 3 or a peripheral closable opening, to allow loading and unloading the linen.

[0059] The washing machine comprises a linen treatment system 3, 6, 7, 8, 9, 12, 13,

18, 20, 21 of the linen configured to perform one or more treatment steps on the linen inside the linen drum 5, in particular, linen washing steps by means of soaking in water and detergent and/or linen drying steps by means of forced ventilation.

[0060] The washing tub 3 is adapted to contain the washing liquid during the linen washing steps.

[0061] A water loading system 6 connectable to the water mains is provided to allow loading the washing tub 3 with water from the mains. The loading system 6 may comprise a plurality of ducts which extend from, for example, one or more, for example, two, supply solenoid valves 7, 8, either directly or through detergent compartments of a detergent tray 9 to the washing tub 3.

[0062] A draining duct 11 is connected to the bottom 10 of the washing tub 3 with associated draining pump 12 which removes the washing liquid from the washing tub 3 and which controls, together with the supply solenoid valves 7, 8, the liquid level inside the washing tub 3.

[0063] An electric resistor 13 may be provided inside the washing tub 3, in particular, arranged on the washing tub bottom 10, in the gap between the wall of the washing tub 3 and the linen drum 5 for heating the washing liquid contained in the washing tub 3.

[0064] The washing machine 1 may further comprise a dispensing system 18 of the "multiple dosing" type for dispensing linen treatment substances.

[0065] Either in addition or alternatively to the detergent tray 9, the dispensing system 18 comprises, for example, a plurality of tanks 19 to contain 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 tanks 19 may be, for example, positioned in the porthole door 4, in the detergent compartment 9, or in the housing 2, and the single tanks 19 are dimensioned each to contain a volume of the treatment substance sufficient for a plurality of washing cycles.

[0066] The washing machine 1 may further comprise a system 20 for recirculating the washing liquid from the bottom 10 of the washing tub to the linen drum 5.

[0067] The washing machine 1 may 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.

[0068] For agitating and remixing the linen with the washing liquid, the linen drum 5 can be actuated in rotation by an electric motor 14 and a transmission 15, e.g. a belt.

[0069] The operation of the washing machine 1 is controlled by an electronic control system 16 in signal connection with the electric motor 14, with 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.

[0070] The user interface 17 may be positioned at an exterior wall or port 4 of the housing 2, or at an electronic device separate from the 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 for automatically washing and/or drying the linen.

[0071] 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.

[0072] **Detailed description of linen mass determination independent of treatment programs**

[0073] According to an aspect of the invention, the electronic control system 16 comprises a module 26 for determining the linen mass contained in the linen drum 5, and the user interface 17 is configured for entering a linen mass determination command without performing the aforesaid treatment steps.

[0074] In response to the entry of the command for determining the linen mass without performing the treatment steps, the electronic control system 16:

[0075] - performs a procedure for determining the linen mass contained in the linen drum 5,

[0076] - generates, depending on the determined linen mass, a suggestion for quantity and/or type of detergent,

[0077] - generates, by means of the user interface 17, a notification containing said suggestion for quantity and/or type of detergent.

[0078] Furthermore, at the end of the procedure for determining the linen mass contained in the linen drum 5, the electronic control system 16 puts the washing machine 1 in a standby configuration during which:

[0079] - the user interface 17 may receive a command for starting a selected washing program,

[0080] - the washing machine 1 may receive a manual dosage of detergent or the user interface 17 allows the selection of a quantity and/or type of detergent for the selected

washing program.

[0081] This allows the user to take corrective action still before the start of an actual washing program, e.g. by correcting the type and/or amount of detergent or the amount of linen, or by waiting until the washing machine 1 is optimally filled.

[0082] At the end of the linen mass determining procedure, the linen is neither wet nor subject to treatment substances, detergent, etc., allowing the user to freely set or vary the parameters of the washing program, including the start time, taking into account the suggestion of quantity and/or type of detergent generated through the user interface 17, but completely free from any constraints given by a possible treatment of the linen already started.

[0083] According to an embodiment, the electronic control system 16 controls the user interface 17 to generate a request for the user to enter the command for determining the linen mass before entering a command to start any washing program.

[0084] Advantageously, the electronic control system 16 is configured to complete the procedure for determining the linen mass and generating the notification containing the suggestion for quantity and/or type of detergent in less than two minutes, preferably less than one minute.

[0085] This speed of response positively biases the user behavior and contributes to more optimal and economical use of detergent.

[0086] According to an embodiment, the control system 16 generates a quantitative detergent indication depending on the determined linen mass, and the user interface displays said quantitative detergent indication.

[0087] According to an embodiment, the control system 16 generates the quantitative detergent indication also depending on technical detergent data, stored in a memory of the electronic control system 16, on water hardness data, which are pre-set or may be entered by the user and, optionally, on dirt intensity data which can be entered by the user.

[0088] According to a further embodiment, the control system 16 generates the quantitative detergent indication also depending on different detergent types (e.g. liquid, powder) either selectable or settable by the user, or generates and displays (e.g. at the same time) a plurality of quantitative detergent indications in association with a plurality of different detergent types.

[0089] Advantageously, the quantitative indication of detergent includes the possibility of indicating four different detergent levels. This simplification makes the indication

intuitive and immediately understandable.

[0090] According to an embodiment, the linen mass determination command which can be entered in the user interface 17 is configured as a command for determining an amount of detergent for the linen load in the linen drum 5.

[0091] According to an embodiment, the electronic control system 16 is configured to:

[0092] - determine the linen mass M , even if not requested by the user, by means of a specific entry of a command for determining the linen mass, as a step preceding, and independent of, a linen treatment cycle which may be selected by the user, and

[0093] - perform the linen treatment cycle selected by the user depending on the determined linen mass M .

[0094] Indeed, the linen mass calculation result can be advantageously correlated not only to the amount of detergent required, but also to the amount of water, washing/drying times and temperatures, and spin speeds.

[0095] **Detailed description of the linen mass determination procedure and of the means of performing the procedure**

[0096] According to a further (and autonomous) aspect of the invention, the electronic control system 16 comprises a module 26 for determining the linen mass contained in the linen drum 5, configured to:

A) perform an initial sequence of consecutive inrush steps, each inrush step comprising:

[0097] - actuating the electric motor 14 to accelerate the rotating linen drum 5 from an initial speed v_{init} equal to zero to a predetermined maximum speed v_{max} , with a predetermined acceleration, e.g., substantially constant (step STP_1),

[0098] - when the predetermined maximum speed v_{max} has been reached, slowing and/or deactivating the motor 14 so that the linen drum decelerates, e.g. freely, until the initial speed v_{init} equal to zero is reached again,

[0099] - in a detection time interval during the acceleration of the rotating linen drum from the initial speed v_{init} equal to zero to the predetermined maximum speed v_{max} , detecting the inrush current I_{inrush} drawn by the electric motor 14, the rotational speed v of the electric motor 14 and the time t (step STP_2),

B) calculating a parameter P of rotational power generated by the electric motor 14 depending on the detected inrush current I_{inrush} for each single inrush step (step STP_3),

C) calculating for the entire first sequence of consecutive inrush steps an average value P_{avg} of the rotational power parameters P calculated for the single inrush steps (step STP_5),

D) determining the linen mass M in the linen drum 5 depending on the average value P_{avg} of the rotational power parameters P and on the predetermined characterization parameters P_0 , A of the washing machine 1 (step STP_13).

[00100] By utilizing inrush events, i.e., acceleration events of the motor 14 (and the linen drum 5) from a static condition to a maximum rotational speed, through a predetermined, e.g., constant, rotational acceleration ramp the inrush current of the electric motor 14 can be considered either solely or predominantly correlated to the mass inertial moment of the assembly of linen drum 5 and the linen contained therein. This simplifies the correlation of the mass inertial moment, and thus the mass itself, with the detected motor current 14, allowing a more accurate, reliable, and rapid determination of the linen mass.

[00101] Advantageously, the linen mass can be determined with dry linen and independently of a specific washing or drying program or a specific step in a washing or drying program.

[00102] According to an embodiment, the linen mass determination module 26 is configured to:

[00103] - detect also the ohmic resistance R of the electric motor 14 in the detection time interval during the acceleration of the rotating linen drum 5 from the initial speed v_{init} equal to zero to the predetermined maximum speed v_{max} ,

C1) calculate for the entire first sequence of consecutive inrush steps an average value R_{avg} of the ohmic resistances R of the electric motor 14 detected for the single inrush steps (step STP_5),

D1) determine the linen mass M in the linen drum 5 also depending on the average value R_{avg} of the measured ohmic resistances R of the electric motor 14 (step STP_13).

[00104] Advantageously, this allows taking account of temperature-dependent changes in the electrical characteristics of the electric motor 14, thereby increasing the linen mass determination accuracy.

[00105] Advantageously, the linen mass determination module 26 is configured to:

[00106] - include in the calculation of the rotational power parameter P for the single inrush step values of the inrush current, motor rotational speed, time, and (if provided)

ohmic resistance of the motor 14, detected starting from the initial speed v_{init} equal to zero of the linen drum 5, but with the electric motor 14 energized, until reaching an upper limit rotational speed v_{limit} of the linen drum 5, smaller than the predetermined maximum rotational speed v_{max} .

[00107] Starting from an angular speed v_{int} condition equal to zero allows ignoring the oscillating component of inertia, without having to take measurements with rotational speeds above 90rpm necessary for the centrifugal force to keep the linen immobile. Such high rotation speeds pose risks with dry linen. On the other hand, with low rotational speeds, the linen is not immobile inside the linen drum and calculations are inaccurate because the inertial moment is constantly changing. Starting from a static condition, the linen can be considered motionless for the first fractions of a second and the oscillating component resets to zero.

[00108] It is also advantageous that the angular acceleration is predetermined, e.g., constant or substantially constant over the entire extent of the detection interval, and repeated in a consistently equal manner for all consecutive detection time intervals.

[00109] According to a further embodiment, the linen mass determination module 26 is configured to:

[00110] - calculate a deviation value P_{dev} between at least two of the rotational power parameters P calculated for the first sequence of inrush steps, preferably an absolute difference P_{dev} between two extreme rotational power parameters, maximum P_{max} and minimum P_{min} (step STP_5), and

[00111] - compare the calculated deviation value P_{dev} with a threshold deviation value DEV_{limit} (step STP_5A), and

[00112] - if the calculated deviation value P_{dev} exceeds the threshold deviation value DEV_{limit} ,

AA) perform a second sequence of consecutive additional inrush steps, each additional inrush step comprising:

[00113] - actuating the electric motor to accelerate the rotating linen drum 5 from an initial speed v_{init} equal to zero to a predetermined maximum speed v_{max} , with a predetermined angular acceleration, e.g., substantially constant (step STP_8),

[00114] - when the predetermined maximum angular speed v_{max} has been reached, slowing and/or deactivating the motor 14 so that the linen drum 5 decelerates, e.g. freely, until the initial speed v_{init} equal to zero is reached again,

[00115] - in a detection time interval during the acceleration of the rotating linen drum

5 from the initial speed v_{init} equal to zero to the predetermined maximum speed v_{max} , detecting the inrush current I_{inrush} drawn by the electric motor 14, the rotational speed v of the electric motor 14, the ohmic resistance R of the electric motor 14 and the time t (step STP_9),

BB) calculate for each additional inrush step the parameter P_1 of rotational power generated by the electric motor 14 depending on the detected inrush current I_{inrush} (step STP_10),

CC) calculate for the entire second sequence of additional inrush steps an additional average value P_{avg_1} of the rotational power parameters P_1 calculated for the additional inrush steps (step STP_12),

DD) determine the linen mass M in the linen drum 5 depending on the average value P_{avg} of the rotational power parameters P and on the additional average value P_{avg_1} of the rotational power parameters P_1 and on the predetermined characterization parameters P_0 , A of the washing machine 1 (step STP_13).

[00116] This allows increasing the number of detected statistical samples and improve the calculation result if the results of the calculation of the rotational power parameter P for the first sequence of inrush steps result in being very uneven.

[00117] According to an embodiment, the linen mass determination module 26 is configured to compare (step STP_5A) an ohmic resistance parameter R (dependent on the detected ohmic resistance value R or an average ohmic resistance value R_{avg}), with a predetermined ohmic resistance threshold value R_0 (based on a default characterization (of the motor 14 and the washing machine 1 during their manufacturing) and, if the ohmic resistance parameter R exceeds the predetermined threshold value R_0 , performing said second sequence of additional consecutive inrush steps.

[00118] The second sequence of additional inrush steps may hence be necessary, independently, either based on the detected resistance criterion or based on the calculated rotational power parameter criterion.

[00119] According to an embodiment, the linen mass determination module 26 is configured to:

[00120] - during the second sequence of additional inrush steps, detect also the additional ohmic resistance R_1 of the electric motor 14 in the detection time interval during the acceleration of the rotating linen drum 5 from the initial speed v_{init} equal to zero to the predetermined maximum speed v_{max} , (step STP_9),

CC1) calculate for the entire second sequence of additional inrush steps an additional average value R_{1_avg} of the additional ohmic resistances R_1 of the electric motor 14 detected for the single additional inrush steps (step STP_12),

DD1) determine the linen mass M in the linen drum 5 also depending on the additional average value R_{1_avg} of the additional ohmic resistances R_1 of the electric motor 14 detected during the second sequence of the additional inrush steps (step STP_13).

[00121] As explained above, the inclusion of the ohmic resistance R of the motor 14, in the calculation of the linen mass M , allows taking into account variations in the electrical behavior of the motor 14 due, for example, to temperature variations (cold motor, very hot motor) and, therefore, to increase the accuracy and reliability of the result of the linen mass determination.

[00122] According to a further embodiment, the linen mass determination module 26 is configured to:

[00123] maintain an identical direction of rotation of the electric motor 14 and the linen drum 5 during the first sequence of inrush steps and/or during the second sequence of additional inrush steps and, if possible,

[00124] after the conclusion of the first sequence of inrush steps and before the beginning of the second sequence of additional inrush steps, control the electric motor 14 to perform an intermediate rotation step (linen agitation step) for a predetermined intermediate rotation time with a rotation direction opposite to the rotation direction of the motor 14 during the first sequence of inrush steps, and preferably,

[00125] stop the electric motor 14 at an additional detection initial position different from a first detection initial position in the first inrush step sequence (step STP_7).

[00126] In this manner, the linen in the linen drum 5 is singled out and redistributed, thereby increasing the likelihood of a more homogeneous distribution of the overall rotating mass, and thus more representative detection results.

[00127] According to an embodiment, the number n , e.g., ten, of consecutive inrush steps of the first sequence is greater than the number m , e.g., six, of additional inrush steps of the second sequence and, possibly less than twice the number m of additional inrush steps of the second sequence.

[00128] When calculating the linen mass M in the linen drum 5 (step STP_13), the average value P_{avg} of the rotational power parameters P calculated for the first inrush step sequence and the additional average value P_{avg_1} of the rotational power parameters P_1 calculated for the second additional inrush step sequence, as

well as if provided, the average value R_{avg} of the ohmic resistances R of the electric motor 14 detected during the first inrush step sequence and the average value R_{1_avg} of the ohmic resistances R_1 of the electric motor 14 detected during the second additional inrush step sequence are to be weighted, or are weighted average values, according to the ratio of the number of inrush steps n to the number of additional inrush steps m (step STP_13).

[00129] According to embodiments, the rotational power parameter is an integral, calculated numerically by a summation, of a product of a torque parameter T dependent on the detected inrush current I_{inrush} and a motion parameter Mov (kinematic parameter) of the motor, in a motion domain, e.g. in the time domain, cumulative (angular) position, or (angular) speed. The torque parameter T may be, for example, a value of power absorbed by the electric motor 14, such as an average power value, for each numerical summation step. The motion parameter Mov may be, for example, the speed (angular or expressed in rpm) or a speed increment (angular or expressed in rpm) of the motor 14 for each numerical summation step.

[00130] Therefore, the rotational power parameter is not an expression of instantaneous power, but of the kinematic energy of the moving system.

[00131] According to an embodiment, the calculation of the average value P_{avg} , P_{1_avg} of the rotational power parameters P , P_1 excludes the two calculated minimum and maximum extremal values, namely the minimum rotational power parameter P_{min} , P_{1_min} , and the maximum rotational power parameter P_{max} , P_{1_max} .

[00132] Similarly, the calculation of the average value R_{avg} , R_{1_avg} of the ohmic resistances R , R_1 of motor 14 excludes the two detected minimum and maximum extremal values, namely the minimum ohmic resistance R_{min} , R_{1_min} and the maximum ohmic resistance R_{max} , R_{1_max} .

[00133] This increases the statistical significance and accuracy of the linen mass determination result.

[00134] According to an embodiment, the linen mass determination module 26 is configured to compare an ohmic resistance parameter R (dependent on the detected ohmic resistance value R , R_1 or an average ohmic resistance value R_{avg} , R_{1_avg} , preferably a weighted average ohmic resistance value depending on the ratio of the number of inrush steps n and additional inrush steps m) with a predetermined ohmic resistance threshold value R_0 (based on a default characterization of the motor 14

and the washing machine 1 during manufacturing) and, if the ohmic resistance parameter R exceeds the predetermined threshold value R₀, reduce the calculated linen mass M depending on the detected ohmic resistance, in particular depending on the ohmic resistance parameter R.

[00135] This allows a sufficiently accurate determination of the linen mass even in the presence of large temperature variations (which in turn affect the electrical resistance of the windings) of the electric motor 14.

[00136] Alternatively or in addition to the detection of the electrical resistance, the linen mass determination module 26 may be configured to detect, through a temperature sensor, the temperature of the motor 14 and the calculation of the linen mass M takes place also depending on the detected temperature of the motor 14.

[00137] **Description of the theoretical basis of linen mass determination**

[00138] The motor inrush current is the name given to the peak current used in an electric motor to increase its speed from a static condition (i.e. accelerate from 0 rpm).

[00139] The motor inrush current is assumed to be related to the inertia, thus the mass of a rotating object according to the following equation:

$$I_{\text{inrush}} \approx \frac{2 \left(J_m \frac{d\omega_m}{dt} + T_d + B_m \omega_m \right)}{3p\varphi_{mg}}$$

wherein:

I_{inrush} is the motor inrush current which can be measured when the motor starts,

ω_m is the rotational speed of the rotating mass

T_d is the variable torque, which is related to the unbalanced masses

B_m is the coefficient of friction

p is the number of poles of the electric motor

φ_{mg} is the magnetic flux

J_m is the inertia, which is correlated to the mass m, located at a distance r from the rotation axis as follows

$$J_m = m r^2.$$

[00140] Assuming that unbalance effects can be neglected in the initial static condition and that the static friction coefficient does not depend on the rotational speed, the following terms can be taken as constants:

[00141] $T_d + B_m \cdot \omega_m = \text{constant}$.

[00142] Thus, as soon as the motor is actuated with the same acceleration (so that $(d\omega_m) / dt$ is also constant), the inrush current of the motor is assumed to be solely related to inertia (i.e., rotating mass).

[00143] The method implemented according to the invention correlates the inrush event with the mass within the drum.

[00144] Since this is a very fast method, more measurements can be taken and average values which are statistically more relevant and representative of reality can be calculated.

[00145] The calculated linen mass value can be advantageously correlated to the amount of detergent needed and sufficient, i.e. optimal. The speed profile of a multiple measurement scheme will be similar to a sawtooth profile.

[00146] Exemplary, non-limiting embodiments of single steps of the method of determining linen mass will be described below, wherein each of the steps described is to be considered a possible and advantageous embodiment of the more general concepts described above, and wherein each of the steps described is to be considered either disjointed or in combination with the other described steps of the method.

[00147] **Motor actuation (STP_1; STP_8):** Motor actuation 14, starting from a stationary condition (initial speed v_{init} is equal to 0 rpm) with constant acceleration. Actuation interruption of the motor 14 as soon as the linen drum speed 5 is equal to the maximum speed v_{max} . Afterward, deceleration from maximum speed v_{max} to 0rpm.

[00148] **Entity detection (STP_2; STP_9):** During the inrush step, detection and storage of the following variables time t , motor speed v_{mot} , inrush current I_{inrush} of motor 14, motor 14 ohmic resistance R . The relationship between motor speed v_{mot} and linen drum speed v_{drum} is $v_{drum} = v_{mot} / \text{transmission ratio}$.

[00149] **Parameter calculation (STP_3; STP_10):** A rotational power quantity calculated from the measured variables is integrated through numerical summation, in a motion domain, e.g., the speed domain. The integral to be implemented, i.e. the

rotational power parameter P , P_1 , corresponds, for example, to the sum of the quantity:

$$[00150] \quad P = \sum T * \Delta \text{Mot} \quad \text{or}$$

$$[00151] \quad P = \sum [(\text{motor power}_{(i)} + \text{motor power}_{(i-1)}) / 2] * [\text{Mov}_{(i)} - \text{Mov}_{(i-1)}]$$

[00152] For the sake of accuracy, the integral should extend precisely from the initial condition to the final condition of the detection interval. This may require an interpolation procedure.

[00153] **Detected and/or calculated data saving (STP_4; STP_11):**

[00154] Once the rotational power parameter P , P_1 has been calculated, the rotational power parameter P , P_1 , the ohmic resistance R , R_1 , possibly the time, and a loop counter m , n corresponding to the number of inrush steps completed so far, are saved. Figure 3 shows

[00155] **STP_1, STP_2, STP_3, STP_4 loop repetition:** The first sequence of inrush steps comprises a repetition of e.g. 10 iterations $n_{\text{max}} = 10$.

[00156] After n_{max} iterations of the inrush steps (and associated measurements and calculations) of the first sequence, the results are saved and a statistical analysis is performed.

[00157] **Statistical analysis (STP_5):** A total number of n_{max} results of rotational power parameter P and ohmic resistance R is available. In this step of the algorithm, the average value P_{avg} of the calculated rotational power parameters P is calculated. When calculating the average value, the minimum and maximum values were removed, based on the formula $P_{\text{avg}} = (\text{sum } P - P_{\text{min}} - P_{\text{max}}) / (n_{\text{max}} - 2)$.

[00158] The average R_{avg} value of the detected ohmic resistances is also calculated. When calculating the average value, the minimum and maximum values were removed, based on the formula $R_{\text{avg}} = (\text{sum } R - R_{\text{min}} - R_{\text{max}}) / (n_{\text{max}} - 2)$.

[00159] The deviation value P_{dev} between the two extremal rotational power parameters, maximum P_{max} and minimum P_{min} of the first inrush step sequence, is also calculated according to the equation $P_{\text{dev}} = P_{\text{max}} - P_{\text{min}}$.

[00160] The values P_{avg} , R_{avg} , P_{dev} are then stored.

[00161] **Verification of need for additional sampling (STP_5A):** To verify whether the calculated results are sufficiently accurate, the deviation value P_{dev} is compared to a threshold deviation value $\text{DEV}_{\text{limit}}$, and two conditions can occur:

[00162] - the calculated deviation value P_{dev} is either equal to or exceeds the

threshold deviation value DEV_limit (criterion indicative of insufficient accuracy),

[00163] - the calculated deviation value P_dev is lower than the threshold deviation value DEV_limit (criterion indicative of sufficient accuracy).

[00164] To verify whether the calculated results are affected by high motor temperature 14, the average value R_avg of the electrical resistance (affected by motor temperature) is compared with the threshold value of ohmic resistance R_0 (predetermined value based on characterization tests of the washing machine 1), and two conditions may occur:

[00165] - the average value R_avg is less than or equal to the threshold value R_0 or, for example, $R_{avg} - R_0 \leq \text{constant_comparison}$ (criterion indicative of sufficient accuracy),

[00166] - the average value R_avg exceeds the threshold value R_0 or, for example, $R_{avg} - R_0 > \text{constant_comparison}$ (a criterion indicating insufficient accuracy).

[00167] In case of sufficient accuracy (for both DEV_limit and R_0 criteria), the procedure proceeds by calculating the linen mass M (STP_13). In case of insufficient accuracy (for at least one of the DEV_limit and R_0 criteria), the second sequence of inrush steps is run (STP_6 and following, right side in Figure 3).

[00168] **Calculated data saving in STP_5 (STP_6):** In case of insufficient accuracy (for at least one of the DEV_limit and R_0 criteria), the average P_avg and R_avg values are stored before starting with the second sequence of additional inrush steps and the corresponding detections and calculations.

[00169] **Linen agitation (STP_7):** Before starting the second sequence of inrush steps, redistribute the linen within the linen drum 5 and change the initial measurement position by rotating the linen drum 5 in the opposite direction to its rotation during the first sequence of inrush steps, e.g. for 10 seconds and e.g. with a rotational speed of the linen drum 5 between 40 rpm and 80 rpm.

[00170] **STP_8, STP_9, STP_10, STP_11 loop repetition:** The second sequence of additional inrush steps comprises a repetition of for example 6 iterations $m_{max} = 6$.

[00171] After m_{max} steps of additional inrush steps (i.e., m_{max} detections and calculations) as described above, the results are saved and a further statistical analysis is performed.

[00172] **Further statistical analysis (STP_12):** A total number of m_{max} results of additional rotational power parameter P_1 and additional ohmic resistance R_1 is

available. In this step of the algorithm, the average value P_{avg_1} of the calculated additional rotational power parameters P_1 is calculated. When calculating the average value, the minimum and maximum values were removed, based on the formula $P_{avg_1} = (\text{sum } P_1 - P_{1_min} - P_{1_max}) / (m_{max} - 2)$.

[00173] The average R_{avg_1} value of the detected additional ohmic resistances is also calculated. When calculating the average value, the minimum and maximum values were removed, based on the formula $R_{avg_1} = (\text{sum } R_1 - R_{1_min} - R_{1_max}) / (m_{max} - 2)$.

A total average rotational power value P_{tot_avg} and a total average ohmic resistance value R_{tot_avg} are then calculated from the partial average values P_{avg} , R_{avg} of the first sequence of inrush steps and P_{avg_1} , R_{avg_1} of the second sequence of additional inrush steps, weighted on the basis of the number of repetitions of the inrush steps n_{max} and the additional inrush steps m_{max} ,

for example through the equations:

$$[00174] \quad P_{tot_avg} = (n_{max} * P_{avg} + m_{max} * P_{avg_1}) / (n_{max} + m_{max})$$

$$[00175] \quad R_{tot_avg} = (n_{max} * R_{avg} + m_{max} * R_{avg_1}) / (n_{max} + m_{max})$$

[00176] **Linen mass M calculation (STP_13):**

[00177] To check whether the calculated results are excessively affected by high motor temperature 14, the total average value R_{tot_avg} of electrical resistance is compared with the threshold value of ohmic resistance R_0 , and two conditions can occur:

[00178] - the total average resistance value R_{tot_avg} is either equal to or less than the threshold value R_0 or, for example, $R_{tot_avg} - R_0 \leq \text{constant_comparison}$ (criterion indicative of a non-excessive electrical resistance),

[00179] - the total average resistance value R_{tot_avg} exceeds the threshold value R_0 or, e.g., $R_{tot_avg} - R_0 > \text{constant_comparison}$ (indicative of excessive electrical resistance).

[00180] For non-excessive electrical resistance, the linen mass M is calculated without applying a reduction for excessive electrical resistance, e.g., according to the equation: $M = (P_{tot_avg} - P_0) / A$, where A and P_0 are predetermined characterization parameters of the washing machine 1, which depend on the size and mass of the linen drum 5 as well as mechanical and electrical resistances and mechanical inertias of the entire moving system of the linen drum 5.

[00181] If the electrical resistance is not excessive, the linen mass M is calculated by

applying a reduction for excessive electrical resistance, e.g., according to the equation: $M = [(P_{\text{tot_avg}} - P_0) - B (R_{\text{tot_avg}} - R_0)] / A$, where A , P_0 , R_0 are predetermined characterization parameters of the washing machine 1, $R_{\text{tot_avg}}$ is the average total resistance value calculated in the STP_12 statistical analysis or, in the absence of the second sequence of additional inrush steps, the average resistance value R_{avg} calculated in the statistical analysis STP_5.

[00182] **Detergent notification generation (STP_14):** Based on the calculated (dry) linen mass M , the detergent suggestion notification described above is generated.

[00183] By way of example, the described predetermined constant parameters can have values in the following ranges:

[00184] DEV_limit can take a numeric value between 300 and 700.

[00185] The constant rotational acceleration can be 50rpm/sec.

[00186] The maximum rotational speed of drum 5 can be 80rpm.

[00187] The upper limit v_limit rotational speed of the linen drum 5 can be 60rpm.

[00188] The parameter A can be a numeric value between 0 and 10000.

[00189] The parameter B can be a numeric value between 0 and 10000.

[00190] The parameter R_0 can be an average ohmic resistance value measured during the characterization of the washing machine 1, e.g. in the order of magnitude of the detected ohmic resistance values.

[00191] The parameter P_0 can be a numeric value between 0 and 10000.

[00192] The features and method of the invention can also be implemented in a tumble dryer machine.

Claims

1. A washing machine (1) comprising:

- a housing (2),
- a linen drum (5) for containing the linen to be washed, supported rotatable about an axis of rotation (R-R), wherein the linen drum (5) delimits a loading opening, which is closable by means of a door (4) connected to the housing (2), for the loading and unloading of the linen to be washed,
- an electric motor (14) functionally connected to the linen drum (5) to rotate the linen drum (5) about the axis of rotation (R-R),
- a linen treatment system (3, 6, 7, 8, 9, 12, 13, 18, 20, 21) configured to perform, on the linen inside the linen drum (5), one or more treatment steps which are different from the rotation of the linen drum (5), comprising linen washing steps by means of soaking in water and detergent and/or linen drying steps by means of ventilation,
- an electronic control system (16) in signal connection with the electric motor (14), with 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 means of the user interface (17), wherein the electronic control system (16) comprises a module (26) for determining the mass (M) of the linen contained in the linen drum (5), wherein the user interface (17) is configured for the input of a command for determining the mass of the linen without performing said treatment steps, wherein, in response to the input of the command for determining the mass of the linen without performing a treatment program, the electronic control system (16):
 - carries out a procedure for determining the mass (M) of the linen contained in the linen drum,
 - elaborates, depending on the linen mass (M) determined, a suggestion for quantity and/or type of detergent,
 - generates, by means of the user interface (17), a notification containing said suggestion for quantity and/or type of detergent,
 - at the end of the procedure for determining the linen mass (M) contained in the linen drum (5), puts the washing machine (1) in a standby configuration in which:

- the user interface (17) may receive a command for starting a selected washing program,
- the washing machine (1) may receive a manual dosage of detergent or the user interface allows the selection of a quantity and/or type of detergent for the selected washing program.

2. A washing machine (1) according to claim 1, wherein the electronic control system (16) controls the user interface (17) to generate a request for the user to enter the command for determining the mass of the linen before entering a command to start any washing program.

3. A washing machine (1) according to claim 1 or 2, wherein the command for determining the mass of the linen is configured as a command for determining a quantity of detergent for the linen load in the linen drum (5).

4. A washing machine (1) according to any one of the preceding claims, wherein the electronic control system (16) is configured to complete the procedure for determining the mass of the linen and generating the notification containing the suggestion for quantity and/or type of detergent in less than two minutes, or in less than one minute from the entry of the command for determining the mass of the linen.

5. A washing machine (1) according to any one of the preceding claims, wherein the control system (16) generates a quantitative detergent indication depending on the determined linen mass and the user interface (17) displays said quantitative detergent indication.

6. A washing machine (1) according to claim 5, wherein the control system (16) generates the quantitative detergent indication also depending on technical detergent data, stored in a memory of the electronic control system (16), on water hardness data, which are pre-set or can be entered by the user by means of the user interface (17) and, optionally, on dirt intensity data which can be entered by the user by means of the user interface (17).

7. A washing machine (1) according to claim 5 or 6, wherein the control system (16):

- generates the quantitative detergent indication also depending on different types of detergent, including liquid detergent and powder detergent, which may be selected or set by the user, or
- generates and displays a plurality of detergent quantity indications in association with a plurality of different detergent types, including a powder detergent and a liquid detergent.

8. A washing machine (1) according to any one of claims 5 to 7, wherein the detergent quantity indication occurs by means of the indication of a plurality of, or of four, different detergent levels, non numerical or numerical.

9. A washing machine (1) according to any one of the preceding claims, wherein the electronic control system (16) is configured to:

- perform the determination of the linen mass (M), as a step preceding, and independent of, one or more linen treatment cycles which may be selected by the user, even if not requested by the user by means of a specific input of a command for determining the mass of the linen, and
- perform the linen treatment cycle selected by the user depending on the determined linen mass (M).

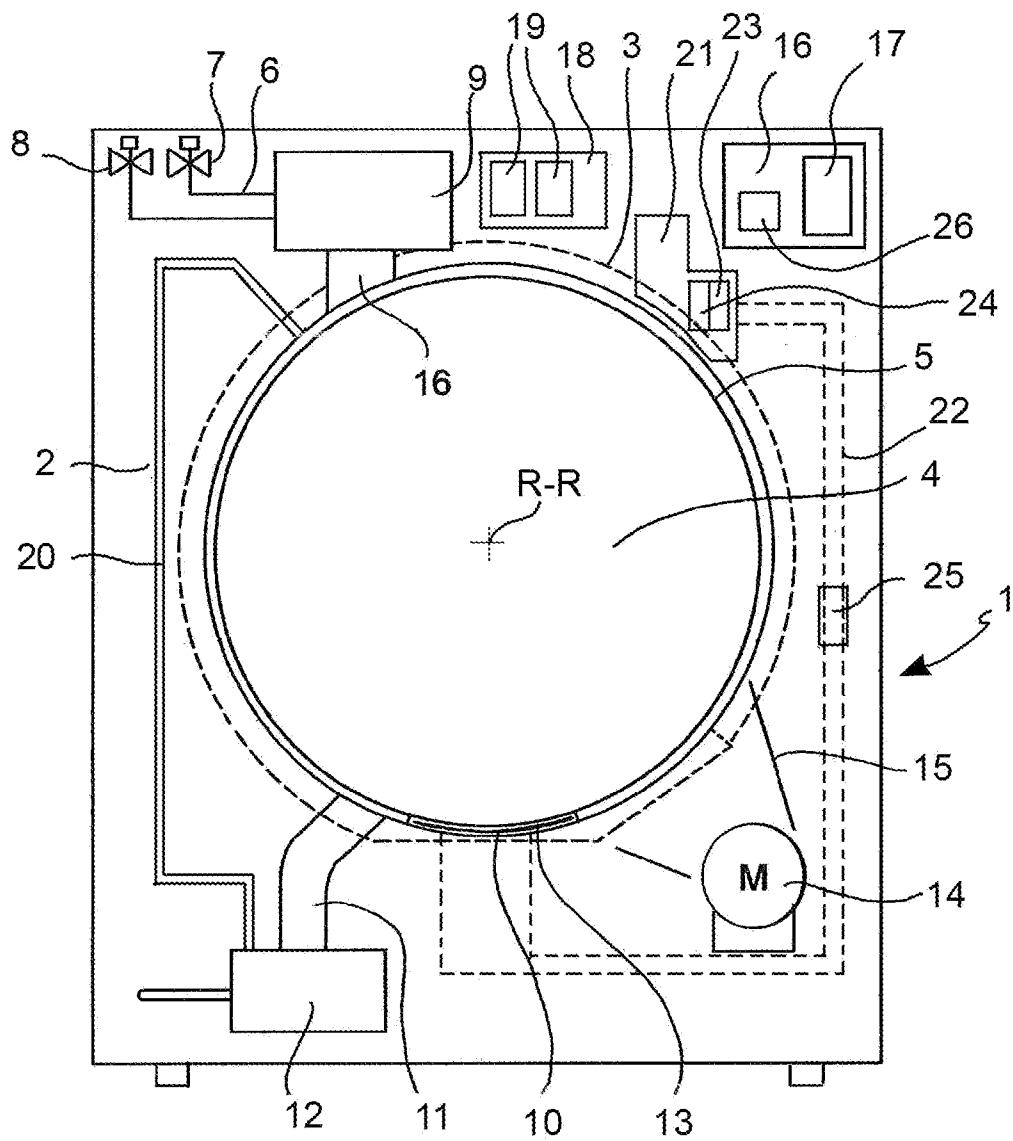
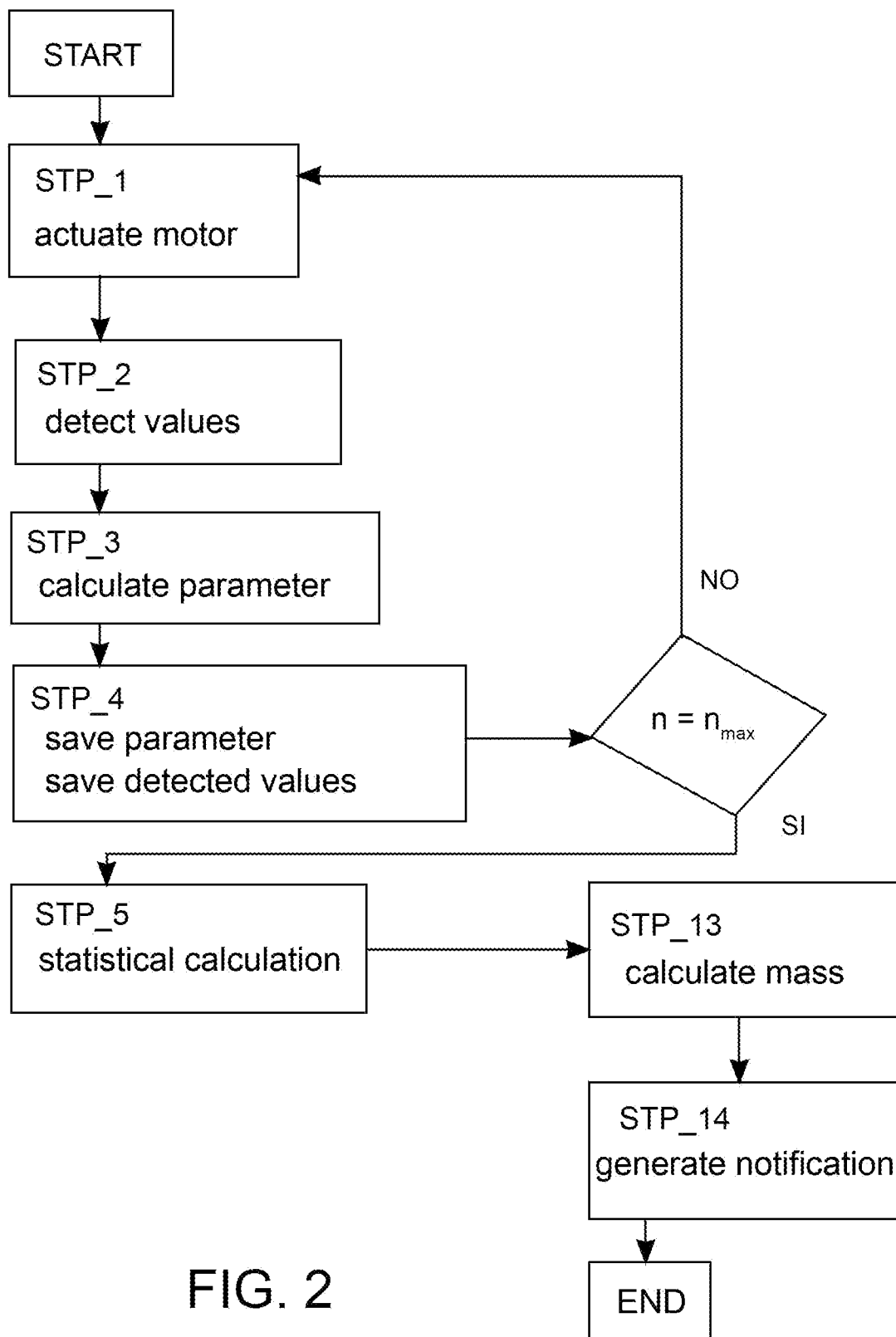


FIG. 1



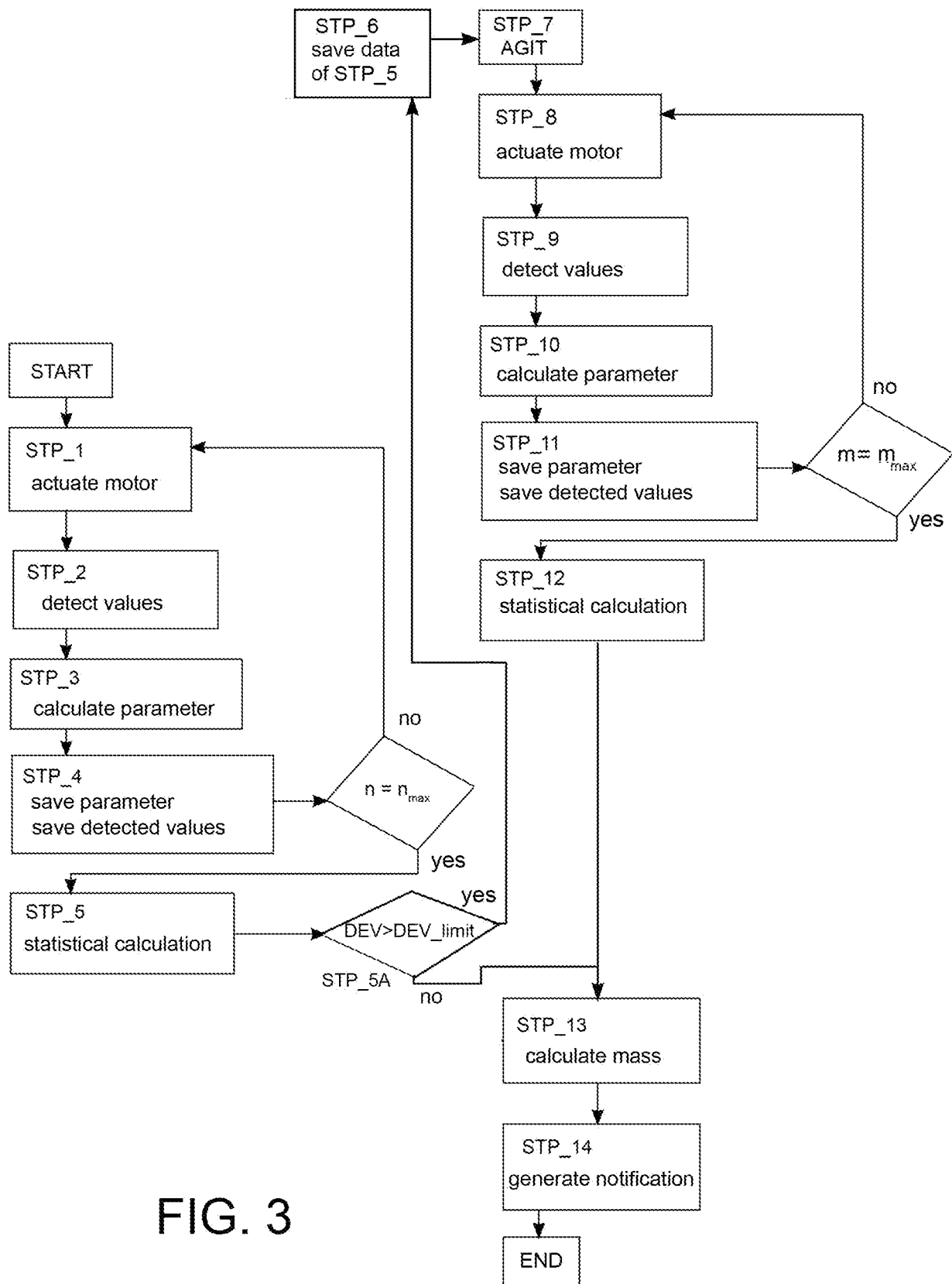


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER

INV. D06F33/37

ADD. D06F101/04 D06F105/42 D06F105/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

D06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	KR 100 624 795 B1 (LG ELECTRONICS INC [KR]) 18 September 2006 (2006-09-18) the whole document -----	1, 2, 4, 5, 9
X	DE 10 2008 005363 A1 (BSH BOSCH SIEMENS HAUSGERAETE [DE]) 23 October 2008 (2008-10-23) paragraph [0039]; claim 2; figures 1-2 -----	1, 2
X	US 2008/256723 A1 (KIM HYO-JIN [KR] ET AL) 23 October 2008 (2008-10-23)	1
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	-/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

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07/06/2022

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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

International application No

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