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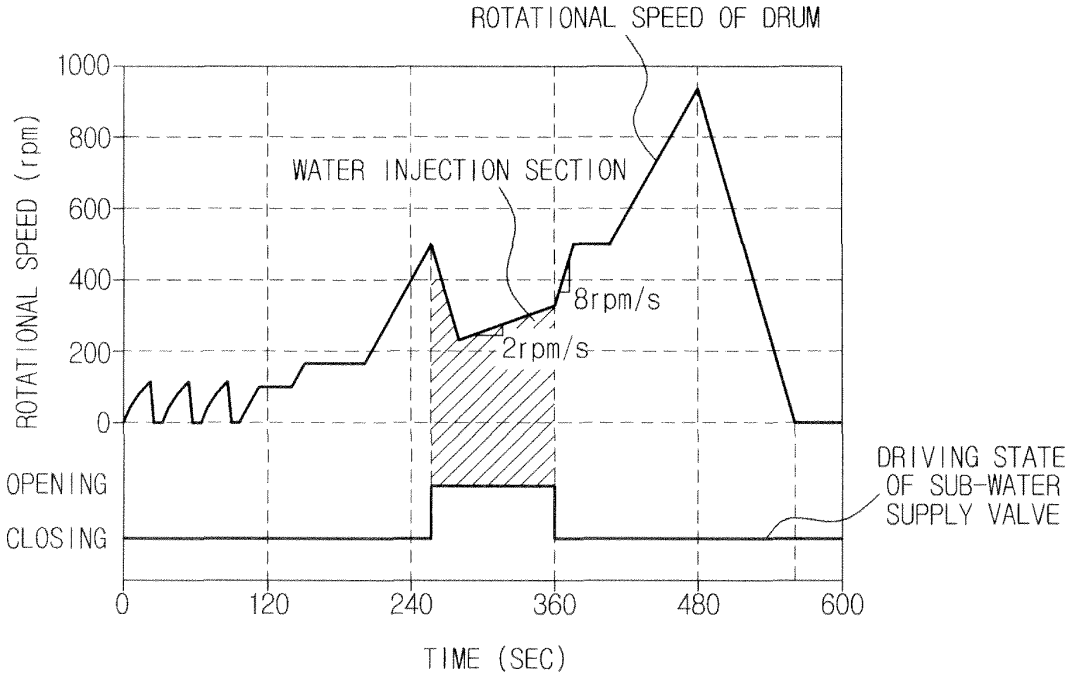
(54) **Washing machine and control method thereof**

(57) A washing machine (1) includes a drum (20), a water supply device (40), and a controller (120). The drum (20) accommodates laundry, and the water supply device (40) supplies water to the inside of the drum (20). The controller (120) controls supply of water so that water is supplied into the drum (20) from when rotational speed of the drum (20) reaches a first predetermined speed, is decelerated and reaches a second predetermined speed, to when the rotational speed of the drum (20) reaches to a third speed more than the second speed and less than the first speed, in a spin-drying cycle.

FIG. 5



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Description

BACKGROUND

1. Field

[0001] Embodiments of the present disclosure relate to a washing machine which executes a spin-drying cycle by rotating a drum accommodating laundry and using centrifugal force applied to the laundry, and a control method thereof.

2. Description of the Related Art

[0002] In general, a washing machine includes a tub to contain water (wash water or rinse water), a drum rotatably installed in the tub and accommodating laundry, and a motor generating driving force to rotate the drum, and achieves washing of the laundry through an operation of raising and then dropping the laundry in the drum when the cylindrical drum is rotated.

[0003] Such a washing machine executes washing of laundry through a series of cycles, such as a washing cycle of separating contaminants from the laundry using water containing detergent (wash water), a rinsing cycle of removing foam or remaining detergent from the laundry using water not containing detergent (rinse water), and a spin-drying cycle of dehydrating the laundry. Prior to execution of washing of the laundry through such a series of cycles, a user places the laundry in the washing machine.

[0004] The conventional washing machine rinses the laundry and separates contaminants from the laundry by repeating an operation including water supply, rinse and drainage while executing the rinsing cycle. Further, when the rinsing cycle has been completed, the washing machine separates remaining contaminants from the laundry by rotating the drum and using centrifugal force applied to the laundry within the drum while executing the spin-drying cycle. Therefore, the conventional washing machine requires a long time and a large amount of water (wash water or rinse water) to execute such an operation.

SUMMARY

[0005] Therefore, it is an aspect of the present disclosure to provide a washing machine which injects water into a drum when the rotational speed of the drum reaches a designated speed and then is reduced while executing the spin-drying cycle of the washing machine, and a control method thereof.

[0006] It is another aspect of the present disclosure to provide a washing machine which stops injection of water into a drum when the rotational acceleration of the drum is greater than a designated acceleration, and a control method thereof.

[0007] Additional aspects of the disclosure will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the disclosure.

[0008] In accordance with one aspect of the present disclosure, a washing machine includes a drum accommodating laundry, a water supply device supplying water to the inside of the drum, and a controller controlling supply of water so that water is supplied into the drum from when the rotational speed of the drum reaches a first predetermined speed, to when the rotational speed of the drum is decelerated, reaches a second predetermined speed and then reaches a third speed more than the second speed and less than the first speed, in a spin-drying cycle.

[0009] The water supply device may include an injection nozzle injecting water into the drum and a water supply valve adjusting supply of water from the outside of the washing machine to the injection nozzle.

[0010] The first speed may be a rotational speed greater than the second speed, and the second speed may be a resonant speed.

[0011] The controller may adjust at least one of an opening and closing time and an opening and closing degree of the water supply valve.

[0012] The controller may stop injection of water into the drum by closing the water supply valve if the rotational acceleration of the drum is greater than a predetermined acceleration while the rotational speed of the drum reaches the second speed and then reaches the third speed.

[0013] The controller may cause water to be supplied to the inside of the drum until the rotational speed of the drum reaches the second speed, maintains the second speed and then reaches the third speed.

[0014] The first speed may be a rotational speed greater than the second speed, and the second speed may be a rotational speed less than a resonant speed.

[0015] The controller may adjust at least one of an opening and closing time and an opening and closing degree of the water supply valve.

[0016] The controller may stop injection of water into the drum by closing the water supply valve if the rotational acceleration of the drum is greater than a predetermined acceleration while the rotational speed of the drum reaches the second speed and then reaches the third speed.

[0017] In accordance with another aspect of the present disclosure, a control method of a washing machine includes injecting water into a drum accommodating laundry using an injection nozzle from when the rotational speed of the drum reaches a first predetermined speed in a spin-drying cycle, and stopping injection of water into the drum when the rotational speed of the drum is decelerated and reaches a second predetermined speed and then the rotational speed of the drum reaches to a third speed more than the second speed and less than the first speed.

[0018] The first speed may be a rotational speed greater than the second speed, and the second speed may be a resonant speed.

[0019] The injection of water into the drum using the

injection nozzle may include injecting water into the drum by adjusting at least one of an opening and closing time and an opening and closing degree of a water supply valve adjusting supply of water to the injection nozzle.

[0020] The stoppage of injection of water into the drum may include stopping injection of water into the drum if the rotational acceleration of the drum is greater than a predetermined acceleration while the rotational speed of the drum reaches the second speed and then reaches the third speed.

[0021] The stoppage of injection of water into the drum may include stopping injection of water into the drum when the rotational speed of the drum reaches the second speed, maintains the second speed and then reaches the third speed.

[0022] The first speed may be a rotational speed greater than the second speed, and the second speed may be a rotational speed smaller than a resonant speed.

[0023] The injection of water into the drum using the injection nozzle may include injecting water into the drum by adjusting at least one of an opening and closing time and an opening and closing degree of a water supply valve adjusting supply of water to the injection nozzle.

[0024] The stoppage of injection of water into the drum may include stopping injection of water into the drum if the rotational acceleration of the drum is greater than a predetermined acceleration while the rotational speed of the drum reaches the second speed, maintains the second speed and then reaches the third speed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] These and/or other aspects of the disclosure will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a perspective view schematically illustrating the external appearance of a washing machine in accordance with one embodiment of the present disclosure;

FIG. 2 is a cross-sectional view schematically illustrating the configuration of the washing machine in accordance with the embodiment of the present disclosure;

FIG. 3 is a block diagram schematically illustrating a control system of the washing machine in accordance with the embodiment of the present disclosure;

FIG. 4 is a flowchart schematically illustrating a control method of a washing machine in accordance with one embodiment of the present disclosure;

FIG. 5 is a graph schematically illustrating the operating state of a sub-water supply valve of the washing machine according to time in the control method of FIG. 4;

FIG. 6 is a flowchart schematically illustrating a control method of a washing machine in accordance with another embodiment of the present disclosure;

FIG. 7 is a graph schematically illustrating the operating state of a sub-water supply valve of the washing machine according to time in the control method of FIG. 6;

FIG. 8 is a flowchart schematically illustrating a control method of a washing machine in accordance with a further embodiment of the present disclosure; and

FIG. 9 is a graph schematically illustrating the operating state of a sub-water supply valve of the washing machine according to time in the control method of FIG. 8.

DETAILED DESCRIPTION

[0026] Reference will now be made in detail to the embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

[0027] FIG. 1 is a perspective view schematically illustrating the external appearance of a washing machine in accordance with one embodiment of the present disclosure, and FIG. 2 is a cross-sectional view schematically illustrating the configuration of the washing machine in accordance with the embodiment of the present disclosure.

[0028] With reference to FIGS. 1 and 2, a washing machine 1 includes a main body 10 forming the external appearance of the washing machine 1, a drum-type tub 11 installed in the main body 10 and storing water (wash water or rinse water), and a cylindrical drum 20 rotatably installed in the tub 11 and provided with a plurality of holes 24.

[0029] A motor 30 serving as a drive device to rotate a rotary shaft 31 connected to the drum 20 so as to execute washing, rinsing and spin-drying cycles is installed at the outside of the rear surface of the tub 11.

[0030] The drum 20 includes a cylindrical part 21, a front panel 22 arranged at the front portion of the cylindrical part 21, and a rear panel 23 arranged at the rear portion of the cylindrical part 21. An opening 26 through which laundry is put into and taken out of the drum 20 is formed on the front panel 22, and the rotary shaft 31 to transmit the driving force of the motor 30 is connected to the rear panel 23.

[0031] The rotary shaft 31 is disposed between the drum 20 and the motor 30. One end of the rotary shaft 31 is connected to the rear panel 23 of the drum 20, and the other end of the rotary shaft 31 is extended to the outside of the rear wall of the tub 11. When the motor 30 drives the rotary shaft 31, the drum 20 connected to the

rotary shaft 31 is rotated about the rotary shaft 31.

[0032] A bearing housing 33 rotatably supporting the rotary shaft 31 is installed on the rear wall of the tub 11. The bearing housing 33 may be formed of an aluminum alloy, and may be inserted into the rear wall of the tub 11 when the tub 11 is formed through injection molding. Bearings 32 are installed between the bearing housing 33 and the rotary shaft 31 so as to effectively rotate the rotary shaft 31

[0033] During the washing cycle, the motor 30 rotates the drum 20 at a low speed in regular and reverse directions and thereby, contaminants are removed from the laundry in the drum 20 through repetition of raising and dropping of the laundry. During the spin-drying cycle, when the motor rotates the drum 20 at a high speed in one direction, water is separated from the laundry by centrifugal force applied to the laundry.

[0034] A plurality of holes 24 for circulation of wash water is formed through the circumferential surface of the drum 20, and a plurality of lifters 25 is installed on the inner circumferential surface of the drum 20 so as to raise and drop the laundry when the drum 20 is rotated.

[0035] A balancer 15 formed in a disc shape and being concentric with the center of rotation of the drum 20 is installed on each of the front and rear surfaces of the drum 20. Such a balancer 15 may reduce vibration generated due to the unbalanced eccentric structure of the drum 20 and eccentricity of the laundry within the drum 20 when the drum 20 is rotated.

[0036] The motor 30 may employ a universal motor including a field coil and an armature or a brushless direct (BLDC) motor including permanent magnets and electric magnets, or may employ any motor which may be applied to small and medium-sized drums. Here, the RPM and rotating direction of the motor 30 are controlled according to the intensity and direction of current supplied to the motor 30.

[0037] A water level sensor 13 detecting a frequency varied according to the water level so as to detect the amount (level) of water within the tub 11 and a washing heater 12 heating water within the tub 11 are installed in the lower portion of the tub 11.

[0038] Vibration sensors 14 are installed on the upper surface of the tub 11. The vibration sensors 14 are installed at front and rear ends of the tub 11 and detect vibration of the tub 11.

[0039] A door 17 opening and closing an inlet 27 through which laundry is put into and taken out of the inside of the drum 20 is installed on the front surface of the main body 10.

[0040] A detergent supply device 61 to supply detergents (for example, a synthetic detergent or a natural soap detergent) and a water supply device 40 to supply water (wash water or rinse water) are installed above the tub 11.

[0041] The inside of the detergent supply device 61 is divided into plural spaces, and the detergent supply device 61 is installed on the front surface of the main body 10 so that a user easily puts detergents and a fabric rinse into the respective spaces.

[0042] The water supply device 40 includes a main water supply pipe 43 connecting an external water supply pipe and the detergent supply device 61 to supply water (wash water or rinse water) to the inside of the tub 11, a main water supply valve 41 installed on the main water supply pipe 43 and controlling supply of water, and a connection pipe 46 connecting the detergent supply device 61 and the tub 11. Such configuration allows water to be supplied to the inside of the tub 11 via the detergent supply device 61, thereby allowing the detergent within the detergent supply device 61 together with water to be supplied to the inside of the tub 11.

[0043] Further, the water supply device 40 includes a sub-water supply pipe 44 provided with one end branching off from the main water supply pipe 43 to supply water directly to the inside of the drum 20, and an injection nozzle 45 installed at the other end of the sub-water supply pipe 44 and injecting water of a high pressure into the drum 20. A sub-water supply valve 42 is installed on the sub-water supply pipe 44 and controls water supply through the sub-water supply pipe 44. Such configuration allows water to be supplied directly to the injection nozzle 45 not via the detergent supply device 61. Thereby, water not mixed with detergent is injected into the drum 20.

[0044] A control panel 70 on which various buttons to control the washing machine 1 and a display unit are arranged is provided at the upper portion of the front surface of the main body 10, and a detergent feeding part 60 connected to the detergent supply device 61 so that detergent for washing machines is fed to the detergent supply device 61 through the detergent feeding part 60 is provided at one side of the control panel 70.

[0045] Various buttons to receive instructions from a user so as to control the operation of the washing machine 1 and the display unit to display the operating state of the washing machine 1 and the manipulating state of the user are arranged on the control panel 70.

[0046] Further, the washing machine 1 in accordance with this embodiment of the present disclosure includes a drain device 50 to drain water from the inside of the tub 11, and the drain device 50 includes a first drain pipe 51 connected to the lower portion of the tub 11 so as to drain water from the inside of the tub 11 to the outside, a drain pump 52 installed on the first drain pipe 51, and a second drain pipe 53 connected to the outlet of the drain pimp 52.

[0047] Further, the washing machine 1 in accordance with this embodiment of the present disclosure includes a damper 16 reducing vibration under the tub 11 to damp vibration generated during the operating process of the washing machine 1. The damper 16 is provided under the tub 11 and movably supports the tub 11. That is, the tub 11 is excited by vibration exciting force generated while rotating the drum 20 and is thus vibrated in all directions, namely, forward and backward, leftward and rightward, and upward and backward directions. Such vibration of the tub 11 is reduced by the damper 16.

[0048] FIG. 3 is a block diagram schematically illustrating a control system of the washing machine in accordance with the embodiment of the present disclosure.

[0049] With reference to FIG. 3, the washing machine includes an input unit 111, a water level sensing unit 112, a vibration sensing unit 113, an RPM sensing unit 114, a controller 120, and a driving unit 130.

[0050] The input unit 111 serves to input driving information, such as the washing cycle, the rinsing cycle and the spin-drying cycle of the washing machine, by user manipulation, and may include keys, buttons, switches, a touch pad, etc. The input unit 111 includes any device which generates designated input data by manipulation, such as push, contact, pressure, and rotation.

[0051] Further, the input unit 111 is provided on the control panel 70, and includes plural buttons to input driving information regarding the operation of the washing machine (buttons to select power, a reservation function, a wash water temperature, soaking, washing, rinsing, spin-drying and a detergent kind, etc.)

[0052] The water level sensing unit 112 senses the level of water supplied to the tub using water level sensor 13, the vibration sensing unit 113 senses vibration of the tub using vibration sensors 14, and the RPM sensing unit 114 senses the RPM of the motor 30. Then, the water level sensing unit 112, the vibration sensing unit 113 and the RPM sensing unit 114 input the sensed water level, vibration and RPM to the controller 120.

[0053] The controller 120 is a microcomputer controlling the overall operation of the washing machine, such as washing, rinsing and spin-drying, according to input information, and sets amounts of wash water and rinse water, a motor RPM and a motor operation factor (motor on/off time), washing time and rinsing time according to the weight of laundry (load) in a selected washing course.

[0054] The driving unit 130 drives the motor 30, the washing heater 12, water supply valves 140, and the drain pump 52, regarding the operation of the washing machine according to a driving control signal from the controller 120. Here, the water supply valves 140 include the main water supply valve 41 and the sub-water supply valve 42.

[0055] Hereinafter, a control method of a washing machine and a driving state of a sub-water supply valve in accordance with one embodiment of the present disclosure will be described in detail.

[0056] FIG. 4 is a flowchart schematically illustrating a control method of a washing machine in accordance with one embodiment of the present disclosure.

[0057] With reference to FIG. 4, the controller 120 drives the drain pump 52 through the driving unit 130 to drain water from the tub 11 to the outside (Operation S41 0). Thereby, water in the tub 11 is drained to the outside via the first drain pipe 51 and the second drain pipe 53.

[0058] Further, the controller 120 drives the motor 30 through the driving unit 130 to rotate the drum 20 at an accelerated speed (Operation S411). Then, the RPM sensing unit 114 senses the RPM of the motor 30. Here, since the RPM of the motor 30 corresponds to the RPM of the drum 20, the controller 120 may calculate the rotational speed and the rotational acceleration of the drum 20 through the RPM of the motor 30 sensed by the RPM sensing unit 114.

[0059] Thereafter, the controller 120 judges whether or not the rotational speed of the drum 20 reaches a first predetermined reference speed, and stops driving of the motor 30 through the driving unit 130 upon judging that the rotational speed of the drum 20 reaches the first predetermined reference speed (Operation S412).

[0060] The first predetermined reference speed may be greater than the resonant speed of the washing machine 1. This is to resolve eccentricity of laundry within the drum 20 while adjusting the rotational speed of the drum 20, and to pass through the resonant speed. Here, the resonant speed means the rotational speed of the drum 20 at the moment when vibration is rapidly generated due to properties of the washing machine 1.

[0061] Further, when the rotational speed of the drum 20 reaches the first predetermined reference speed and then is decelerated, the controller 120 causes water to be injected into the drum 20 by opening the sub-water supply valve 42 through the driving unit 130 (Operation S413). Although driving of the motor 30 is stopped, the rotational speed of the drum 20 is decelerated by frictional force while maintaining rotation of the drum 20 due to rotational inertia of the drum 20. Here, the controller 120 causes water to be injected into the drum 20 by opening the sub-water supply valve 42 through the driving unit 130. Further, the controller 120 may cause water to be injected into the drum 20 for a designated time by adjusting the opening and closing time of the sub-water supply valve 42, and cause a designated amount of water to be injected into the drum 20 by adjusting the opening and closing degree of the sub-water supply valve 4.

[0062] Thereby, since water of a high pressure injected into the drum 20 passes through laundry and thus separates remaining contaminants from the laundry, the laundry is cleanly rinsed in a short time.

[0063] Thereafter, the controller 120 judges whether or not a designated time after deceleration of the rotational speed of the drum 20 has elapsed, and rotates the drum 20 at an accelerated speed by re-driving the motor 30 through the driving unit 130 upon judging that the designated time has elapsed (Operation S414). For example, the designated time may be about 20 seconds.

[0064] As described above, although driving of the motor 30 is stopped based on whether or not the rotational speed of the drum 20 reaches the first predetermined reference speed, driving of the motor 30 may be stopped based on other criteria. For example, the controller 120 may stop driving of the motor 30 through the driving unit 130 by judging the degree of eccentricity of laundry. For this purpose, the controller 120 may judge the degree of eccentricity of laundry from the degree of vibration of the tub 11 sensed by the vibration sensing unit 113, and stop driving of the motor 30 through the driving unit 130 when

the degree of eccentricity of laundry is greater than a predetermined reference degree of eccentricity.

[0065] Further, when a designated time after stoppage of driving of the motor 30 has elapsed, when the degree of eccentricity of laundry is smaller than the reference degree of eccentricity, or when the rotational speed of the drum 20 reaches a second reference speed, the controller 120 causes the balancer to reach a position reducing excessive vibration of the tub 11 while rotating the drum 20 at an accelerated speed by re-driving the motor 30 through the driving unit 130. Here, the second reference speed may be the resonant speed.

[0066] During such a process, the controller 120 may accelerate the rotational speed of the drum 20 according to predetermined section or predetermined time.

[0067] Further, the controller 120 judges whether or not the rotational acceleration of the drum 20 is greater than a predetermined reference acceleration (Operation S415). Upon judging that the rotational acceleration of the drum 20 is greater than the predetermined reference acceleration, the controller 120 stops injection of water into the drum 20 by closing the sub-water supply valve 42 through the driving unit 130 (Operation S416). On the other hand, upon judging that the rotational acceleration of the drum 20 is not greater than the predetermined reference acceleration, the controller 120 maintains the open state of the sub-water supply valve 42 through the driving unit 130 so as to continuously inject water into the drum 20.

[0068] With reference to FIG. 5, when the rotational speed of the drum 20 reaches the first predetermined reference speed, driving of the motor 30 is stopped and thus the rotational speed of the drum 20 is decelerated, and the sub-water supply valve 42 is opened and thus water is injected into the drum 20.

[0069] Further, when the designated time after deceleration of the rotational speed of the drum 20 has elapsed or when the rotational speed of the drum 20 reaches the second reference speed, the motor 30 is re-driven and thus the drum 20 is rotated at an accelerated speed. Here, the rotational speed of the drum 20 is accelerated according to predetermined section or predetermined time, as described above. On the assumption that the predetermined reference acceleration is 6 rpm/s, in a section where the rotational acceleration of the drum 20 is 2 rpm/s, the rotational acceleration of the drum 20 is not greater than the reference acceleration, and thus the open state of the sub-water supply valve 42 is maintained and water is continuously injected into the drum 20. However, in a section where the rotational acceleration of the drum 20 is 8 rpm/s, the rotational acceleration of the drum is greater than the reference acceleration, and thus the sub-water supply valve 42 is closed and injection of water into the drum 20 is stopped.

[0070] On the other hand, when the rotational acceleration of the drum 20 is not greater than the reference acceleration while the drum 20 is rotated at an accelerated speed by re-driving the motor 30, in a section where the rotational speed of the drum 20 reaches a third reference speed, the open state of the sub-water supply valve 42 is maintained and water is continuously injected into the drum 20. Here, the third reference speed may be more than the second reference speed and be less than the first reference speed. Hereinafter, for convenience of description, the third reference speed will be described as being the first reference speed.

[0071] The reason for the above operation is that if the rotational acceleration of the drum 20 is greater than the reference acceleration, the amount of water discharged from laundry during the spin-drying cycle is increased, and at this time, when water is injected into the drum 20, the amount of water discharged from the laundry is more increased, and as a result, water in the tub 11 is not discharged to the outside by the drain pump and remains between the tub 11 and the rotating drum 20. In order to prevent such a drawback, in the control method of the washing machine in accordance with this embodiment of the present disclosure, injection of water into the drum 20 is stopped when the rotational acceleration of the drum 20 is greater than the reference acceleration.

[0072] When the rotational speed of the drum 20 is gradually accelerated and reaches the third reference speed, the controller 120 maintains the rotational speed of the drum 20 by adjusting the RPM of the motor 30 through the driving unit 130 (Operation S417). While the rotational speed of the drum 20 maintains the third reference speed, water in the tub 11 is continuously discharged to the outside by the drain pump 52, and thus water discharged from the laundry to the tub 11 does not remain between the tub 11 and the drum 20 and is effectively drained.

[0073] Thereafter, the controller 120 judges whether or not a designated time has elapsed, and rotates the drum 20 at an accelerated speed by re-driving the motor 30 through the driving unit 130 upon judging that the designated time has elapsed (Operation S418).

[0074] Further, the controller 120 judges whether or not the rotational speed of the drum 20 sensed by the RPM sensing unit 114 reaches the maximum speed, and stops driving of the motor 30 through the driving unit 130 upon judging that the rotational speed of the drum 20 reaches the maximum speed (Operation S419). Although driving of the motor 30 is stopped, the rotational speed of the drum 20 is decelerated by frictional force while maintaining rotation of the drum 20 due to rotational inertia of the drum 20.

[0075] Thereafter, the controller 120 judges whether or not the drum 20 is stopped (Operation S420). Upon judging that the drum 20 is stopped, the controller 120 stops driving of the drain pump 52 through the driving unit 130 (Operation S421).

[0076] The spin-drying cycles of the washing machine may be divided into an intermediate spin-drying cycle and a final spin-drying cycle. Here, the intermediate spin-drying cycle means the spin-drying cycle in which the drum 20 is rotated while draining wash water from the

tub 11 after the washing operation has been completed, or means the spin-drying cycle in which, if plural rinsing operations are executed, the drum 20 is rotated while draining rinse water from the tub 11 between the respective rinsing operations. Further, the final rinsing operation means the spin-drying cycle in which the drum 20 is rotated to drain remaining water from the tub 11 and to separate remaining water from the laundry after the washing operation and the rinsing operation have been completed.

[0077] The controller 120 may cause water to be injected into the drum 20 by opening the sub-water supply valve 42 through the driving unit 130, even while the rotational speed of the drum 20 reaches the maximum speed and is then decelerated, in case of the intermediate spin-drying cycle. Thereby, the amount of water consumed in the rinsing operation may be reduced while increasing the rinsing effect of the laundry. Further, the controller 120 causes water not to be injected into the drum 20 while the rotational speed of the drum 20 reaches the maximum speed and is then decelerated, in order to minimize the amount of water remaining in the laundry, in case of the final spin-drying cycle.

[0078] FIG. 6 is a flowchart schematically illustrating a control method of a washing machine in accordance with another embodiment of the present disclosure. Hereinafter, a detailed description of a process from Operation S610 to Operation S617 of FIG. 6 which is the same as the process of FIG. 4 will be omitted.

[0079] With reference to FIG. 6, the controller 120 judges whether or not a designated time has elapsed, and rotates the drum 20 at an accelerated speed by re-driving the motor 30 through the driving unit 130 upon that the designated time has elapsed (Operation S618). Here, the controller 120 executes high-speed spin-drying of laundry by driving the motor 30 to the maximum RPM.

[0080] During such a process, the controller 120 does not continuously accelerate the motor 30 through the driving unit 130. When the motor 30 is continuously accelerated, water between the tub 11 and the drum 20 is not discharged by the drain pump 52 and remains, and vibration and noise of the tub 11 is more increased due to remaining water. Therefore, the controller 120 divides the high-speed spin-drying process into plural sections, judges the level of eccentricity of laundry from the level of vibration of the tub 11 sensed by the vibration sensing unit 113 when the RPM of the motor 30 reaches a predetermined RPM in each section, and drives the motor 30 through the driving unit 130 according to the judged level of eccentricity so as to gently increase the rotational speed of the drum 20.

[0081] Thereafter, the controller 120 judges whether or not the rotational speed of the drum 20 reaches the maximum speed, and maintains the rotational speed of the drum 20 by adjusting the RPM of the motor 30 through the driving unit 130 upon judging that the rotational speed of the drum 20 reaches the maximum speed (Operation S619). The controller 120 judges whether or not a designated time has elapsed, and stops driving of the motor 30 through the driving unit 130 upon judging that the designated time has elapsed (Operation S620). Although driving of the motor 30 is stopped, the rotational speed of the drum 20 is decelerated by frictional force while maintaining rotation of the drum 20 due to rotational inertia of the drum 20. Thereafter, the controller 120 judges whether or not the drum 20 is stopped (Operation S621). Then, upon judging that the drum 20 is stopped, the controller 120 stops driving of the drain pump 52 thorough the driving unit 130.

[0082] With reference to FIG. 7, when the rotational speed of the drum 20 reaches the first predetermined reference speed, driving of the motor 30 is stopped and thus the rotational speed of the drum 20 is decelerated, and the sub-water supply valve 42 is opened and thus water is injected into the drum 20. Further, when the designated time after deceleration of the rotational speed of the drum 20 has elapsed or when the rotational speed of the drum 20 reaches the second reference speed, the motor 30 is re-driven and thus the drum 20 is rotated at an accelerated speed. Here, the rotational speed of the drum 20 is accelerated according to predetermined section or predetermined time, as described above. Here, maintaining of the open state of the sub-water supply valve 42 or closing of the sub-water supply valve 42 by comparing the rotational acceleration of the drum 20 with the predetermined reference acceleration is the same as that of FIG. 5.

[0083] FIG. 8 is a flowchart schematically illustrating a control method of a washing machine in accordance with a further embodiment of the present disclosure. Hereinafter, a detailed description of a process of Operation S810 and Operation S811 of FIG. 8 which is the same as the processes of FIG. 4 and FIG. 6 will be omitted.

[0084] With reference to FIG. 8, the controller 120 judges whether or not the rotational speed of the drum 20 reaches a first predetermined reference speed, and maintains the rotational speed of the drum 20 by adjusting the RPM of the motor 30 through the driving unit 130 upon judging that the rotational speed of the drum 20 reaches the first predetermined reference speed (Operation S812).

[0085] The controller 120 judges whether or not a designated time after maintenance of the rotational speed of the drum 20 has elapsed, and stops driving of the motor 30 through the driving unit 130 upon judging that the designated time has elapsed (Operation S813). Then, when the rotational speed of the drum 20 is decelerated, the controller 120 causes water to be injected into the drum 20 by opening the sub-water supply valve 42 through the driving unit 130 (Operation S814).

[0086] Thereafter, the controller 120 judges whether or not a designated time after deceleration of the rotational speed of the drum 20 has elapsed, and maintains the rotational speed of the drum 20 by adjusting the RPM of the motor 30 while re-driving the motor 30 through the driving unit 130 when the designated time has elapsed

or when the rotational speed of the drum 20 reaches a second reference speed (Operation S815).

[0087] The controller 120 judges whether or not a designated time after maintenance of the rotational speed of the drum 20 has elapsed, and rotates the drum 20 at an accelerated speed by re-driving the motor 30 through the driving unit 130 upon judging that the designated time has elapsed (Operation S816). Such control of driving of the motor 30 may serve to cause the balancer to reach a position reducing excessive vibration of the tub 11, in order to resolve eccentricity of laundry in the same manner as in FIG. 4.

[0088] Thereafter, the controller 120 judges whether or not the rotational acceleration of the drum 20 is greater than a predetermined reference acceleration (Operation S817). Upon judging that the rotational acceleration of the drum 20 is greater than the predetermined reference acceleration, the controller 120 stops injection of water into the drum 20 by closing the sub-water supply valve 42 through the driving unit 130 (Operation S818). On the other hand, upon judging that the rotational acceleration of the drum 20 is not greater than the predetermined reference acceleration, the controller 120 maintains the open state of the sub-water supply valve 42 through the driving unit 130 so as to continuously inject water into the drum 20.

[0089] With reference to FIG. 9, when the designated time from maintenance of the first predetermined reference speed of the drum 20 has elapsed, driving of the motor 30 is stopped and thus the rotational speed of the drum 20 is decelerated, and the sub-water supply valve 42 is opened and thus water is injected into the drum 20. Further, when the designated time after deceleration of the rotational speed of the drum 20 has elapsed or when the rotational speed of the drum 20 reaches the second reference speed, the rotational speed of the drum 20 is maintained by adjusting the RPM of the motor 30.

[0090] The controller 120 judges the level of eccentricity of laundry from the level of vibration of the tub 11 sensed by the vibration sensing unit 113 while the rotational speed of the drum is uniformly maintained. Further, the controller 120 judges the position of the balancer based on the level of eccentricity of the laundry, and rotates the drum 20 at an accelerated speed by re-driving the motor 30 when the balancer is located at a position reducing the excessive vibration of the tub 11.

[0091] On the assumption that the predetermined reference acceleration is 6 rpm/s, in a section where the rotational acceleration of the drum 20 is 0 rpm/s, the rotational acceleration of the drum 20 is not greater than the reference acceleration, and thus the open state of the sub-water supply valve 42 is maintained and water is continuously injected into the drum 20. However, in a section where the drum 20 is rotated at an accelerated speed, i.e., where the rotational acceleration of the drum 20 is 8 rpm/s, the rotational acceleration of the drum is greater than the reference acceleration, and thus the sub-water supply valve 42 is closed and injection of water into the drum 20 is stopped.

[0092] When the rotational speed of the drum 20 is gradually accelerated and reaches a third reference speed, the controller 120 maintains the rotational speed of the drum 20 by adjusting the RPM of the motor 30 through the driving unit 130 (Operation S819). Thereafter, the controller 120 judges whether or not a designated time has elapsed, and rotates the drum 20 at an accelerated speed by re-driving the motor 30 through the driving unit 130 upon judging that the designated time has elapsed (Operation S820).

[0093] Further, the controller 120 judges whether or not the rotational speed of the drum 20 sensed by the RPM sensing unit 114 reaches the maximum speed, and maintains the rotational speed of the drum 20 by adjusting the RPM of the motor 30 through the driving unit 130 upon judging that the rotational speed of the drum 20 reaches the maximum speed (Operation S821). Thereafter, the controller 120 judges whether or not a designated time has elapsed, and stops driving of the motor 30 through the driving unit 130 upon judging that the designated time has elapsed (Operation S822). Although driving of the motor 30 is stopped, the rotational speed of the drum 20 is decelerated by frictional force while maintaining rotation of the drum 20 due to rotational inertia of the drum 20. Thereafter, the controller 120 judges whether or not the drum 20 is stopped (Operation S823). Upon judging that the drum 20 is stopped, the controller 120 stops driving of the drain pump 52 through the driving unit 130 (Operation S824).

[0094] Although one embodiment of the present disclosure sets the maximum speed of the drum 20 at about 1,000 rpm, the rotational speed of the drum 20 may be changed according to the capacity or structure of the washing machine.

[0095] As is apparent from the above description, in a washing machine and a control method thereof in accordance with one embodiment of the present disclosure, when the rotational speed of a drum reaches a designated speed and is then decelerated while executing the spin-drying cycle of the washing machine, water is injected into a drum. Therefore, a contact time of water with laundry is secured, the injected water separates remaining contaminants from the laundry while passing through the laundry, and thus the laundry may be rinsed in a short time. Further, since injection of water into the drum is stopped when the rotational acceleration of the drum is greater than a designated acceleration, thus a phenomenon in which the amount of water discharged to a tub is increased and water in the tub is not discharged to the outside and remains between the tub and the rotating drum may be prevented.

[0096] Although a few embodiments of the present disclosure have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents.

Claims

1. A washing machine (1) comprising:

   a drum (20) accommodating laundry;
   a water supply device (40) supplying water to the inside of the drum (20); and
   a controller (120) control adapted to supply of water so that water is supplied into the drum (20) from when the rotational speed of the drum reaches a first predetermined speed, to when the rotational speed of the drum is decelerated, reaches a second predetermined speed and then reaches a third speed more than the second speed and less than the first speed, in a spin-drying cycle.

2. The washing machine according to claim 1, wherein the water supply device (40) includes:

   an injection nozzle (45) injecting water into the drum (20); and
   a water supply valve (42) adjusting supply of water from the outside of the washing machine (1) to the injection nozzle.

3. The washing machine according to claim 2, wherein the first speed is a rotational speed greater than the second speed, and the second speed is a resonant speed.

4. The washing machine according to claim 3, wherein the controller (120) is adapted to adjust at least one of an opening and closing time and an opening and closing degree of the water supply valve (42).

5. The washing machine according to claim 3, wherein the controller (120) is adapted to stop injection of water into the drum (20) by closing the water supply valve (42) if the rotational acceleration of the drum is greater than a predetermined acceleration while the rotational speed of the drum reaches the second speed and then reaches the third speed.

6. The washing machine according to claim 2, wherein the controller (120) is adapted to cause water to be supplied to the inside of the drum (20) until the rotational speed of the drum reaches the second speed, maintains the second speed and then reaches the third speed.

7. The washing machine according to claim 6, wherein the first speed is a rotational speed greater than the second speed, and the second speed is a rotational speed smaller than a resonant speed.

8. The washing machine according to claim 7, wherein the controller (120) is adapted to adjust at least one of an opening and closing time and an opening and closing degree of the water supply valve (42).

9. The washing machine according to claim 8, wherein the controller (120) is adapted to stop injection of water into the drum (20) by closing the water supply valve (42) if the rotational acceleration of the drum is greater than a predetermined acceleration while the rotational speed of the drum reaches the second speed and then reaches the third speed.

10. A control method of a washing machine (1) comprising:

    injecting water into a drum (20) accommodating laundry using an injection nozzle (45) from when the rotational speed of the drum reaches a first predetermined speed in a spin-drying cycle; and stopping injection of water into the drum (20) when the rotational speed of the drum is decelerated and reaches a second predetermined speed and then the rotational speed of the drum reaches to a third speed more than the second speed and less than the first speed.

11. The control method according to claim 10, wherein the first speed is a rotational speed greater than the second speed, and the second speed is a resonant speed.

12. The control method according to claim 11, wherein the injection of water into the drum using the injection nozzle (45) includes injecting water into the drum (20) by adjusting at least one of an opening and closing time and an opening and closing degree of a water supply valve (42) adjusting supply of water to the injection nozzle.

13. The control method according to claim 11, wherein the stoppage of injection of water into the drum (20) includes stopping injection of water into the drum if the rotational acceleration of the drum is greater than a predetermined acceleration while the rotational speed of the drum reaches the second speed and then reaches the third speed.

14. The control method according to claim 10, wherein the stoppage of injection of water into the drum (20) includes stopping injection of water into the drum when the rotational speed of the drum reaches the second speed, maintains the second speed and then reaches the third speed.

15. The control method according to claim 14, wherein the first speed is a rotational speed greater than the second speed, and the second speed is a rotational speed smaller than a resonant speed.

16. The control method according to claim 15, wherein the injection of water into the drum using the injection nozzle (45) includes injecting water into the drum (20) by adjusting at least one of an opening and closing time and an opening and closing degree of a water supply valve adjusting supply of water to the injection nozzle.

17. The control method according to claim 15, wherein the stoppage of injection of water into the drum (20) includes stopping injection of water into the drum if the rotational acceleration of the drum is greater than a predetermined acceleration while the rotational speed of the drum reaches the second speed, maintains the second speed and then reaches the third speed.

18. A control method of a washing machine (1), comprising:

draining water from a tub (11) to outside the washing machine;
driving a drum (20) of the washing machine at an accelerated speed;
sensing an RPM of the drum (20);
judging whether or not the rotational speed of the drum reaches a first reference speed, and stop driving the drum upon judging that the rotational speed of the drum reaches the first predetermined reference speed;
during deceleration of the drum after stopping the driving of the drum, injecting water into the drum;
re-driving the drum motor (30) to a second reference speed;
judging whether or not the rotational acceleration of the drum (20) is greater than a predetermined reference acceleration;
upon judging that the rotational acceleration of the drum is greater than the predetermined reference acceleration, stopping injection of water into the drum;
accelerating the drum to a maximum speed; and
stopping the driving of the drum.

19. The control method according to claim 18, wherein the first predetermined reference speed is greater than a resonant speed of the washing machine (1).

20. The control method according to claim 19, where the resonant speed is a rotational speed of the drum (20) at the moment when vibration is rapidly generated due to properties of the washing machine (1).

21. The control method according claim 20, wherein the second reference speed is the resonant speed.

22. The control method according claim 18, wherein injecting water into the drum (20) comprises injecting water into the drum for a designated time.

23. The control method according claim 22, wherein the designated time is about 20 seconds.

24. The control method according claim 18, wherein injecting water into the drum (20) comprises injecting a designated amount of water into the drum.

25. The control method according claim 18, wherein the predetermined reference acceleration is 6 rpm/s.

FIG. 1

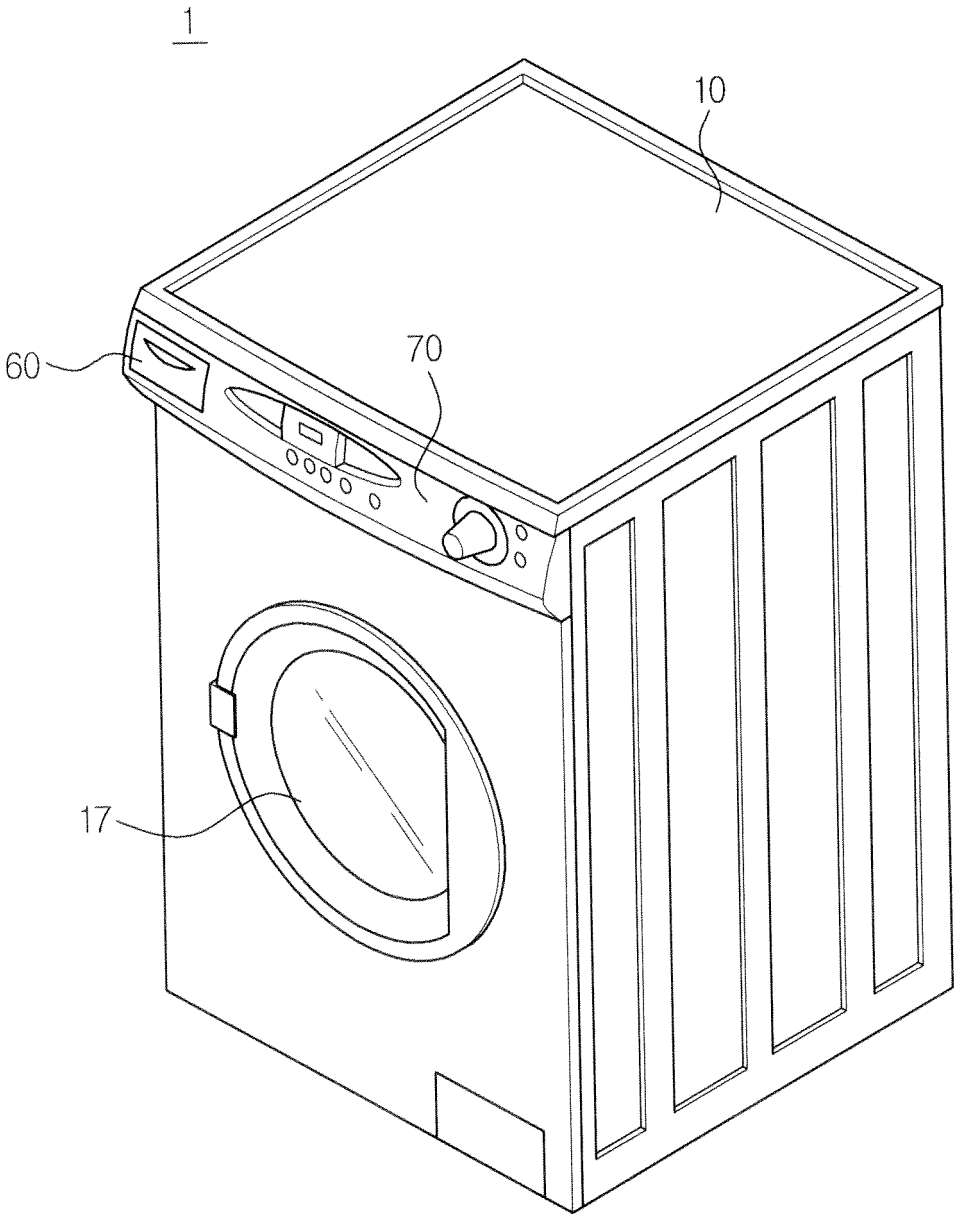
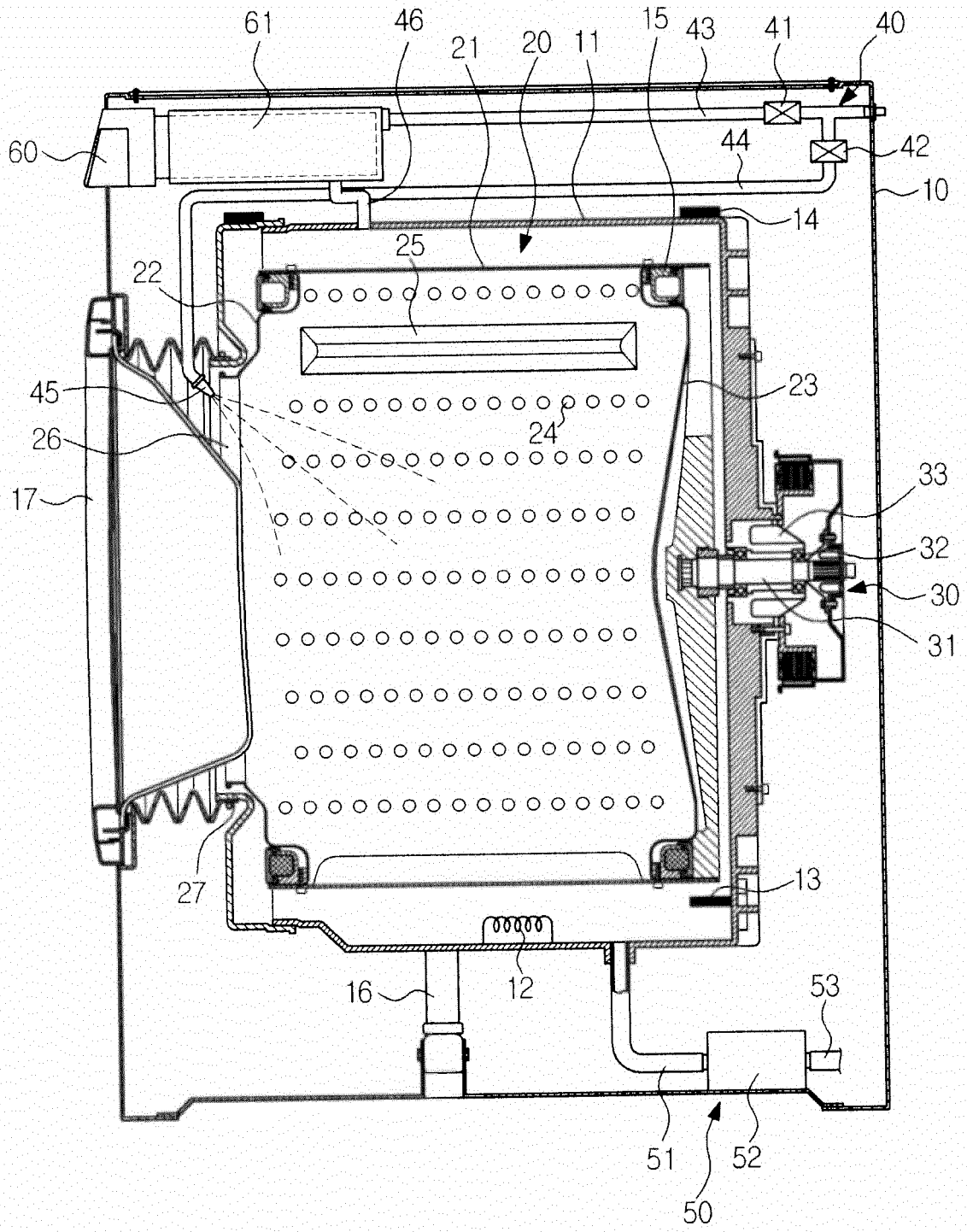


FIG.2


61
46
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42
10
14
25
22
45
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24
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27
13
16
12
53
51
52
50

FIG.3

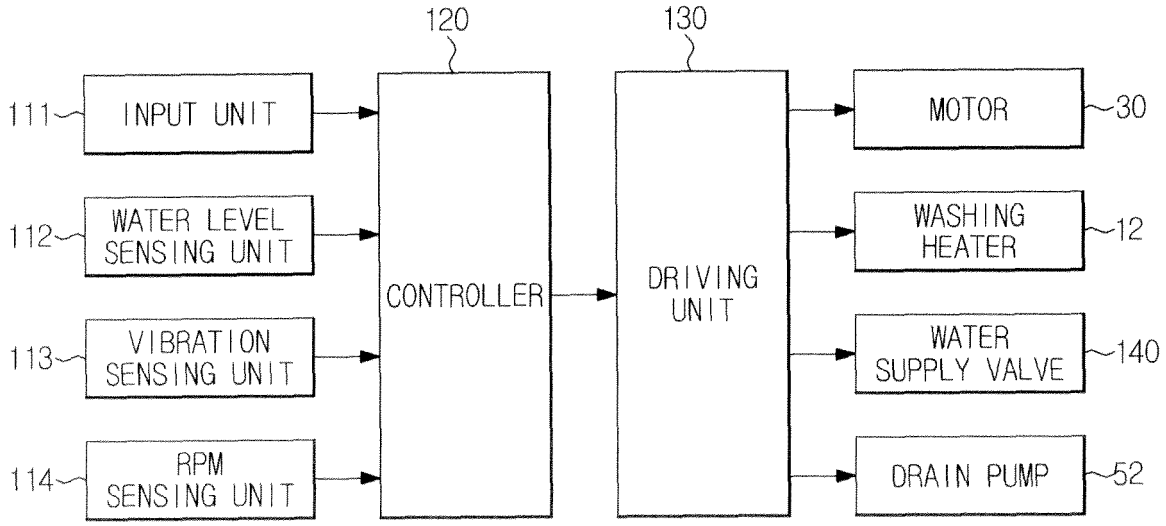

120
130
111
INPUT UNIT
112
WATER LEVEL SENSING UNIT
113
VIBRATION SENSING UNIT
114
RPM SENSING UNIT
CONTROLLER
DRIVING UNIT
MOTOR
30
WASHING HEATER
12
WATER SUPPLY VALVE
140
DRAIN PUMP
52

FIG.4

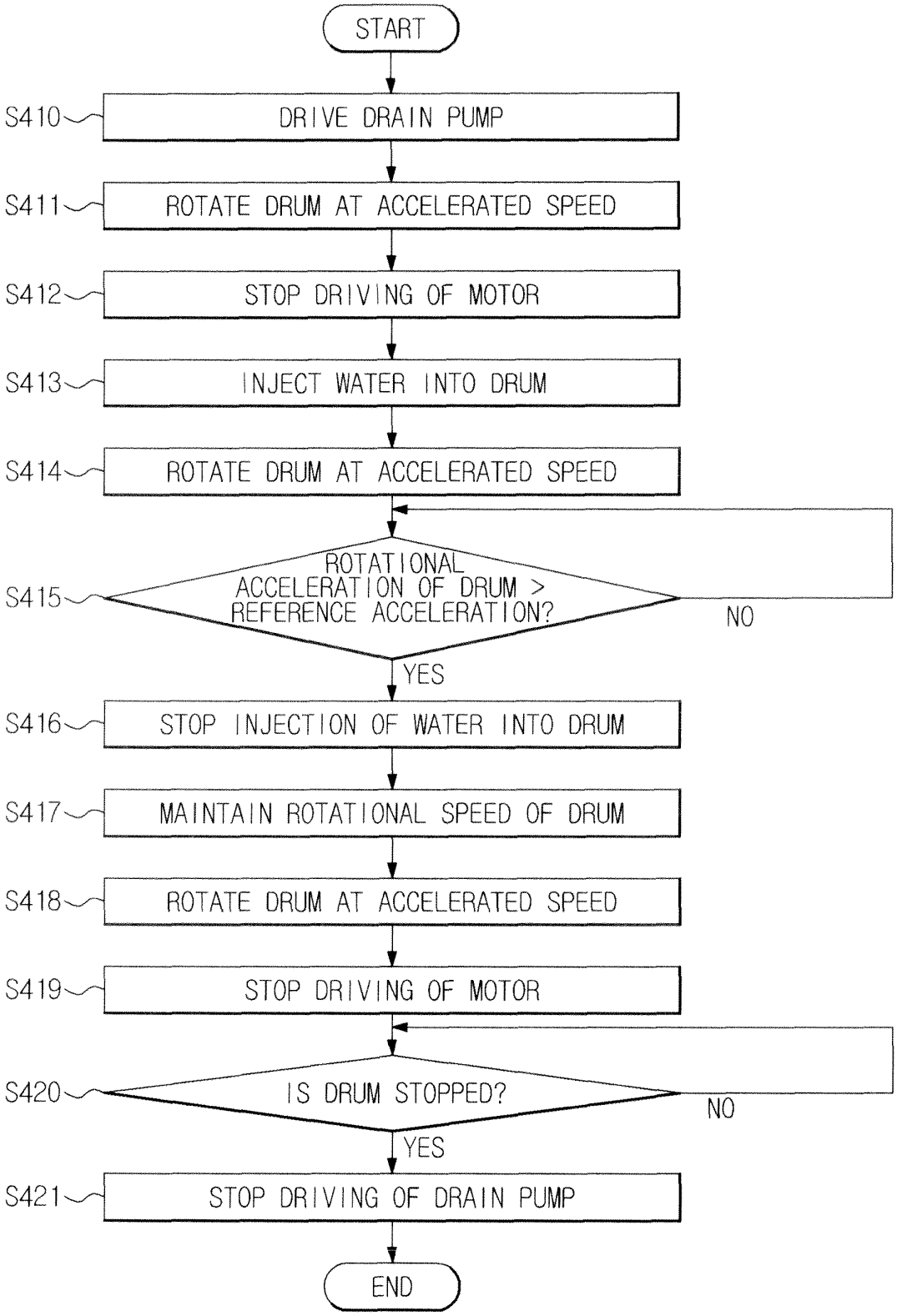

START
S410
DRIVE DRAIN PUMP
S411
ROTATE DRUM AT ACCELERATED SPEED
S412
STOP DRIVING OF MOTOR
S413
INJECT WATER INTO DRUM
S414
ROTATE DRUM AT ACCELERATED SPEED
S415
ROTATIONAL ACCELERATION OF DRUM > REFERENCE ACCELERATION?
NO
YES
S416
STOP INJECTION OF WATER INTO DRUM
S417
MAINTAIN ROTATIONAL SPEED OF DRUM
S418
ROTATE DRUM AT ACCELERATED SPEED
S419
STOP DRIVING OF MOTOR
S420
IS DRUM STOPPED?
NO
YES
S421
STOP DRIVING OF DRAIN PUMP
END

FIG. 5

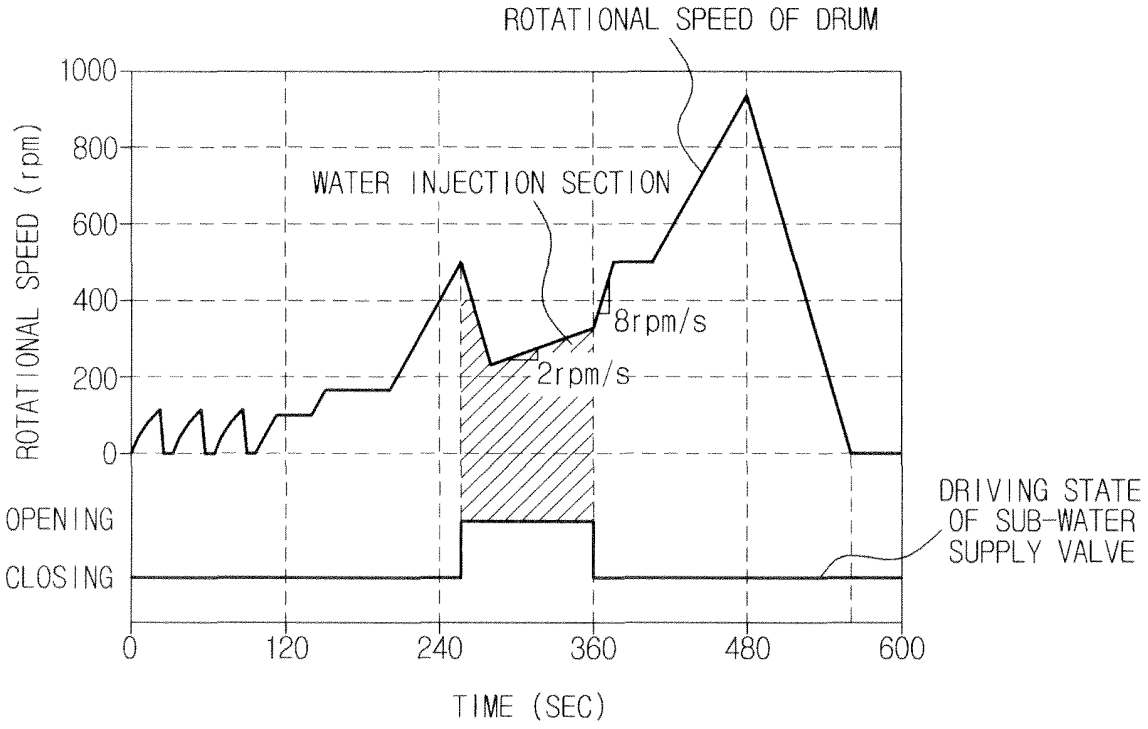

ROTATIONAL SPEED OF DRUM
1000
800
600
400
200
0
ROTATIONAL SPEED (rpm)
WATER INJECTION SECTION
8rpm/s
2rpm/s
OPENING
CLOSING
DRIVING STATE OF SUB-WATER SUPPLY VALVE
0
120
240
360
480
600
TIME (SEC)

FIG.6

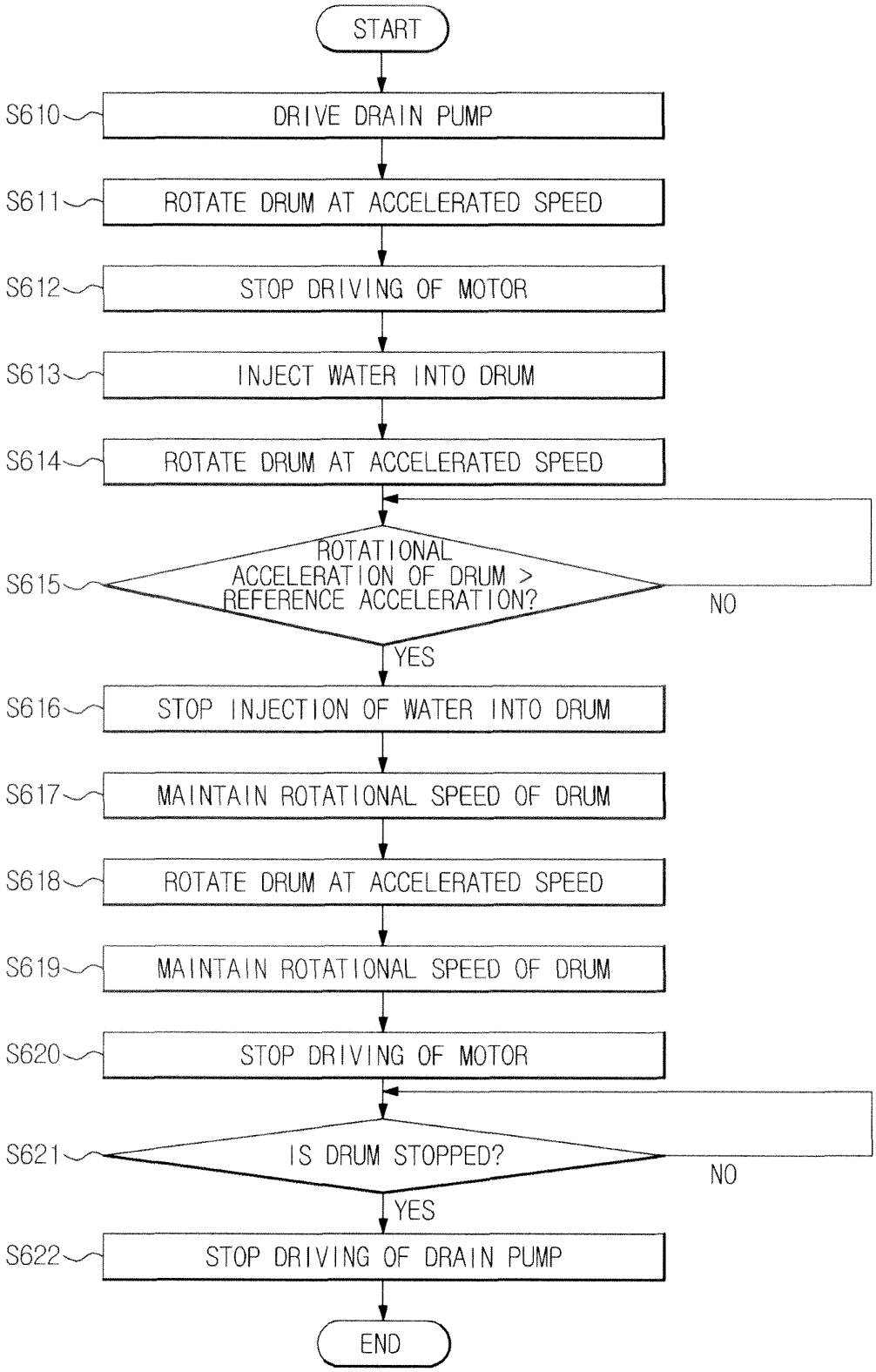

START
S610
DRIVE DRAIN PUMP
S611
ROTATE DRUM AT ACCELERATED SPEED
S612
STOP DRIVING OF MOTOR
S613
INJECT WATER INTO DRUM
S614
ROTATE DRUM AT ACCELERATED SPEED
S615
ROTATIONAL ACCELERATION OF DRUM > REFERENCE ACCELERATION?
NO
YES
S616
STOP INJECTION OF WATER INTO DRUM
S617
MAINTAIN ROTATIONAL SPEED OF DRUM
S618
ROTATE DRUM AT ACCELERATED SPEED
S619
MAINTAIN ROTATIONAL SPEED OF DRUM
S620
STOP DRIVING OF MOTOR
S621
IS DRUM STOPPED?
NO
YES
S622
STOP DRIVING OF DRAIN PUMP
END

FIG.7

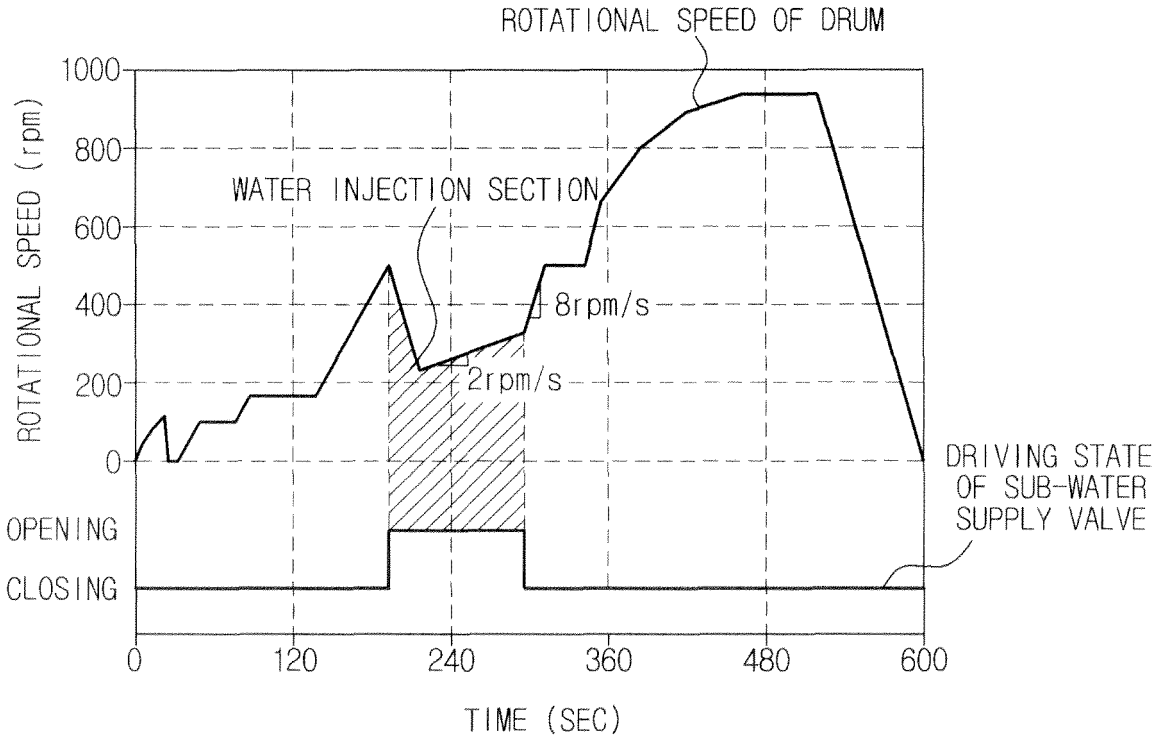

ROTATIONAL SPEED OF DRUM
1000
800
600
400
200
0
ROTATIONAL SPEED (rpm)
WATER INJECTION SECTION
8rpm/s
2rpm/s
OPENING
CLOSING
DRIVING STATE OF SUB-WATER SUPPLY VALVE
0
120
240
360
480
600
TIME (SEC)

FIG.8

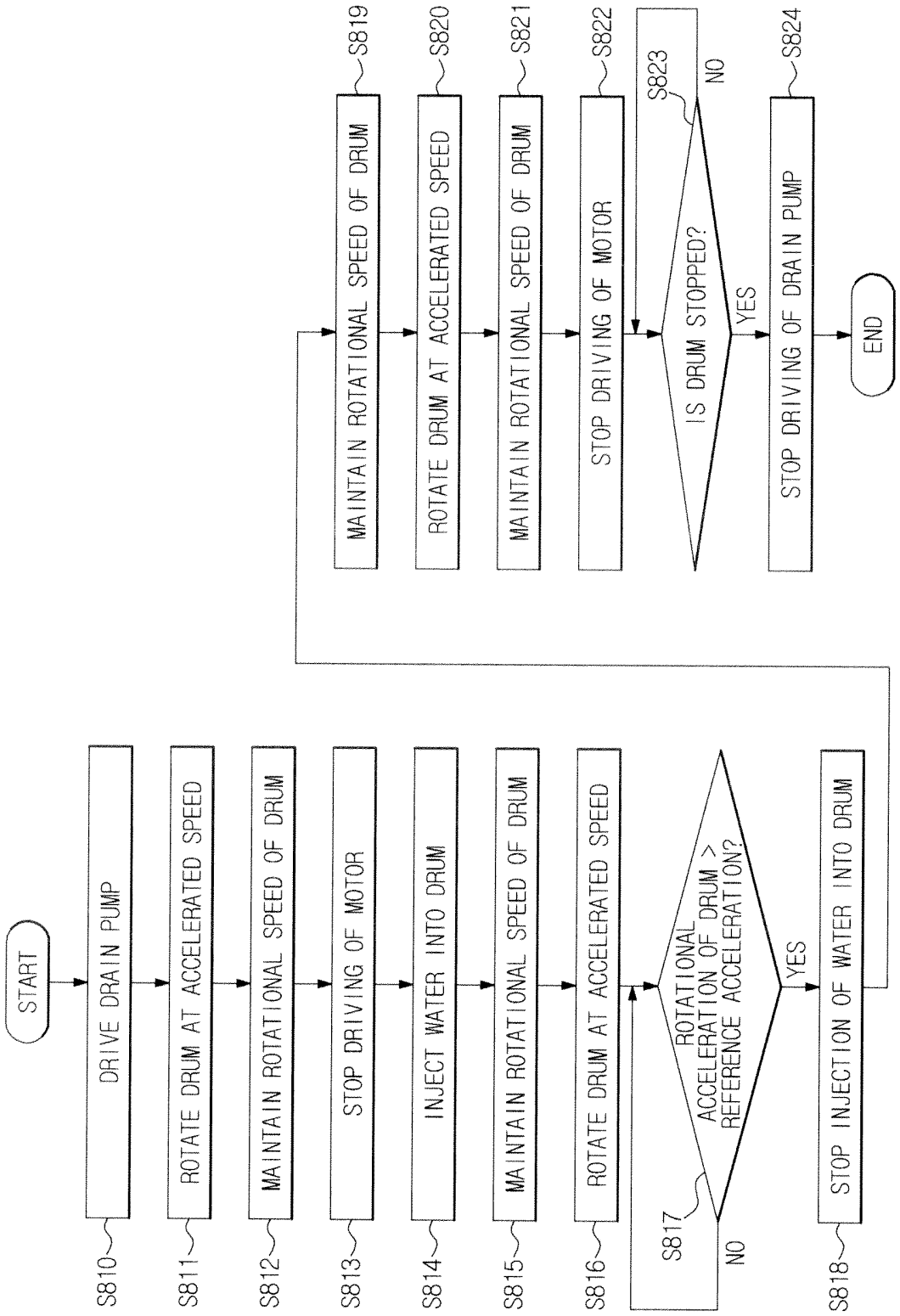
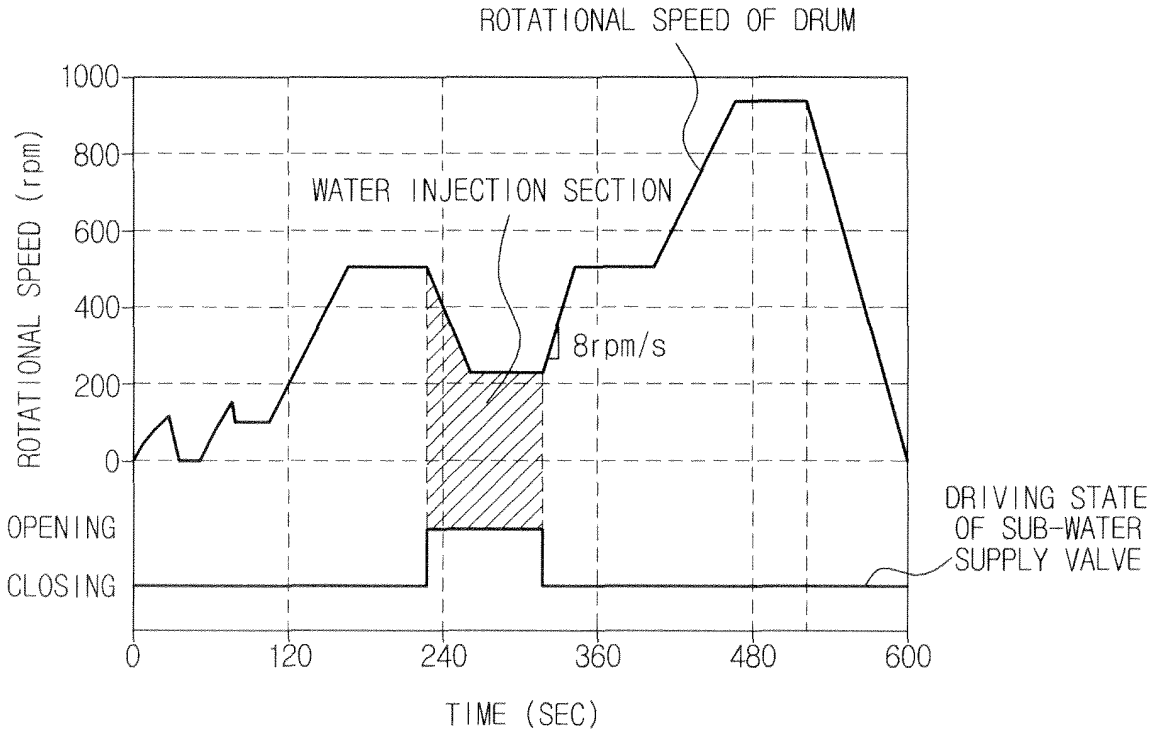

START
DRIVE DRAIN PUMP
S810
ROTATE DRUM AT ACCELERATED SPEED
S811
MAINTAIN ROTATIONAL SPEED OF DRUM
S812
STOP DRIVING OF MOTOR
S813
INJECT WATER INTO DRUM
S814
MAINTAIN ROTATIONAL SPEED OF DRUM
S815
ROTATE DRUM AT ACCELERATED SPEED
S816
S817
ROTATIONAL ACCELERATION OF DRUM > REFERENCE ACCELERATION?
NO
YES
STOP INJECTION OF WATER INTO DRUM
S818
MAINTAIN ROTATIONAL SPEED OF DRUM
S819
ROTATE DRUM AT ACCELERATED SPEED
S820
MAINTAIN ROTATIONAL SPEED OF DRUM
S821
STOP DRIVING OF MOTOR
S822
S823
IS DRUM STOPPED?
NO
YES
STOP DRIVING OF DRAIN PUMP
S824
END

FIG.9


ROTATIONAL SPEED OF DRUM
1000
800
600
400
200
0
ROTATIONAL SPEED (rpm)
WATER INJECTION SECTION
8rpm/s
OPENING
CLOSING
DRIVING STATE OF SUB-WATER SUPPLY VALVE
0
120
240
360
480
600
TIME (SEC)