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DRUM TYPE WASHING MACHINE



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Field of the Invention

5 The present invention relates to a drum type washing machine for washing laundry accommodated in a rotary drum by rotating the rotary drum disposed in a water tub.

Background of the invention

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 A conventional drum type washing machine is shown in Fig. 7. As shown therein, housing 57 of the washing machine includes water tub 53 installed via a suspension structure. Accommodated in water tub 53 is rotary drum 51 which is
15 provided with a number of drum perforations 52 on its cylindrical surface. Rotary drum 51 is driven to rotate by drum driving motor 55. Further, by opening door 54, which is installed at the front portion of housing 57 and can be opened and closed freely, laundry can be loaded into or
20 unloaded from rotary drum 51 via respective openings formed at the front portions of water tub 53 and rotary drum 51.

 After opening door 54, laundry and detergent are added in rotary drum 51, and the operation of the washing machine is initiated thereafter. Water is fed into water tub 53 and
25 the amount of water required for washing the laundry is supplied into rotary drum 51 through drum perforations 52.

Then, when rotary drum 51 is driven to rotate at a predetermined rotational speed by drum driving motor 55, the laundry accommodated in rotary drum 51 is lifted up in the rotational direction by being caught on agitation blades 56 provided on the inner cylindrical surface of rotary drum 51 and is dropped upon reaching a specific height, thereby undergoing pounding motions. After completion of the washing process, soiled wash water is drained, and a rinsing process is carried out in fresh water. Then, when the rinsing process is finished, a water-extracting process is performed by way of spinning rotary drum 51 at a high rotational speed. The series of processes described are automatically performed according to a preset control sequence (see Japanese Patent Laid-Open Application No. H10-201985, pp. 3 to 5, Fig. 1).

When rotary drum 51 of the drum type washing machine is not rotating, laundry tends to clump in the lower portion of rotary drum 51. When wash water is drained from rotary drum 51 and water-extracting process for the laundry is performed by centrifugal force generated by spinning rotary drum 51 at a high rotational after a washing and rinsing process, if the laundry is clumped at one side of rotary drum 51, rotary drum 51 becomes unbalanced, thereby causing a high level of vibration and making it impossible to carry out a normal water-extracting process. To solve this problem, the above-described conventional drum type washing

machine executes the water-extracting process after performing a laundry untangling step which entails rotating rotary drum 51 at a first rotational speed; a laundry balancing step which entails increasing the rotational speed
5 of rotary drum 51 up to a second rotational speed; a preliminary water-extracting process which entails rotating rotary drum 51 at a third rotational speed; and a laundry balance monitoring step for motoring the balanced state of laundry by rotating rotary drum 51 at the second rotational
10 speed sequentially .

However, such conventional control operation is complicated and it takes a considerable amount of time prior to starting the water-extracting process, causing an increase in cost and extending the overall time required
15 time for washing laundry unreasonably.

Further, if laundry contains any articles with string-like piece attached thereto or are band-shaped themselves, the laundry may get entangled during the washing and/or the rinsing process; this condition can not be improved by the
20 above control operation. In such a case, since user has no means to facilitate the separation of entangled laundry, the water-extracting process is suspended, so that the washing machine stops while the laundry remains unbalanced inside.

Summary of the Invention

It is, therefore, an object of the present invention to provide a drum type washing machine capable of
5 effectively performing a water-extracting process after the completion of a washing and rinsing process; and capable of carrying out an alternative control operation when laundry inside the machine remains unbalanced.

In accordance with a preferred embodiment of the
10 present invention, there is provided a drum type washing machine including: a housing; a water tub elastically supported in the housing; a rotary drum accommodated in the water tub and having an approximately horizontal or a slanted rotational axis; a drum driving motor for rotating
15 the rotary drum; and a controller for controlling a rotation of the drum driving motor, wherein with respect to water extracting processes following each operational stage of the washing machine, the controller is capable of rotating the rotary drum up to a first rotational speed which makes
20 laundry in the rotary drum cling to an inner surface of the rotary drum; performing a laundry balance determining operation for determining whether the laundry is evenly distributed and clung on the inner surface of the rotary drum by using an initial reference value; repeating the
25 laundry balance determining operation if a balanced state of the laundry is found to be unacceptable by using the initial

reference value; updating the initial reference value to a value having a wider range of tolerance when the number of repetitions of the laundry balance determining operation reaches a predetermined value; repeating the laundry balance
5 determining operation by using the updated reference value; and rotating the rotary drum at a rotational speed required for a water-extracting operation when the balanced state of the laundry is found to be acceptable based on either one of the initial reference value or the updated reference value.

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Brief Description of the Drawings

The above and other objects and features of the present invention will become apparent from the following
15 description of a preferred embodiment given in conjunction with the accompanying drawing, in which:

Fig. 1 shows a cross sectional view describing a configuration of main components of a drum type washing machine in accordance with a preferred embodiment of the
20 present invention;

Fig. 2 illustrates a circuit diagram of a control unit of the drum type washing machine in accordance with the preferred embodiment of the present invention;

Fig. 3 is a front view of a control panel of the
25 washing machine in accordance with the preferred embodiment of the present invention;

Fig. 4 describes a washing process, a rinsing process and a water-extracting process of the washing machine;

Fig. 5 shows a flowchart illustrating a control sequence for a water-extracting process;

5 Figs. 6A and 6B are time charts that outline the rotational speed of a rotary drum in the water-extracting process of the washing machine; and

Fig. 7 shows a cross sectional view illustrating a configuration of a conventional drum type washing machine.

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Detailed Description of the Preferred Embodiments

Fig. 1 shows a configuration of the main components of a drum type washing machine in accordance with a preferred
15 embodiment of the present invention. Housing 9 includes therein water tub 3 supported by a suspension structure (not shown), and cylindrical rotary drum 1 having a bottom surface is disposed in water tub 3 such that the direction of its rotational axis is slanted with respect to the
20 horizontal direction.

Specifically, rotary drum 1 is installed in water tub 3 such that its opening is positioned at the front portion of housing 9 while the bottom surface of rotary drum 1 is disposed at the rear portion of housing 9. Furthermore,
25 rotary drum 1 is slanted such that the direction of the rotational axis thereof is slanted toward the rear portion

of housing 9. Rotary drum 1 is driven to rotate by drum driving motor 5 installed at the rear portion of water tub 3. Formed at the front portion of water tub 3 is opening 8 through which laundry is loaded into or unloaded from rotary drum 1. Further, door 7 is installed at a sloped surface formed at the front surface portion of housing 9 such that it faces opening 8 and can be freely opened and closed. Since laundry loading/unloading opening 8 faces upward and door 7 is installed at the sloped surface which faces upward, laundry can be loaded into or unloaded from rotary drum 1 conveniently after door 7 is opened. Further, by forming door 7 partially or entirely with a transparent material, the inside of rotary drum 1 can be viewed from outside.

Although slanted rotary drum 1 described above offers advantages such that it facilitates loading and unloading of laundry and that allows water supplied in rotary drum 1 to collect in the rear portion thereof so that a higher water depth level can be obtained even with a small quantity of water, the drum design also has a disadvantage such that laundry in rotary drum 1 would gather at the lowest point of the lower rear portion of rotary drum 1. As a result, it is problematic because it is not possible to achieve a satisfactory degree of cleaning for all laundry articles by alternating their positions in rotary drum 1 and to make laundry articles to stick to the inner cylindrical surface of rotary drum 1 evenly during a water-extracting operation.

In the preferred embodiment of the present invention, however, this problem is solved by alternating the positions of laundry articles in rotary drum 1 by way of controlling the rotation of rotary drum 1 driven by drum driving motor 5 and by way of one or more agitation blades 6 provided on the inner cylindrical surface of rotary drum 1.

Each of agitation blades 6 has a ridge elongated at a specific angle of inclination with respect to the direction of the rotational axis of rotary drum 1. When rotary drum 1 rotates, by agitation blades 6, it is possible to effectively transfer laundry articles from the lower position of rotary drum 1 to a higher position thereof. Thus, if ridges are formed at an angle of inclination capable of creating the effect of transferring laundry articles from the lower position to the higher position of rotary drum 1, the laundry articles, which tend to gather at the lower position of rotary drum 1, can be dispersed in rotary drum 1 more efficiently. Accordingly, if rotary drum 1 having agitation blades 6 at multiple locations on the inner cylindrical surface thereof is rotated, laundry articles, which tend to gather at the lower position of slanted rotary drum 1, are picked up from the rear portion to the higher position of the front portion of rotary drum 1. Therefore, the laundry articles can be sufficiently agitated while alternating positions in rotary drum 1 without falling toward the lower position of the rear portion of rotary drum

1. As a result, the efficiency of washing is not deteriorated. Further, in washing a small amount of laundry, the amount of wash water is also small so that the laundry may not be completely soaked in wash water. In such cases, typically it becomes necessary to agitate laundry in rotary drum 1 sufficiently to alternate the positions of laundry articles in rotary drum 1 so that they can be fully soaked in wash water. However, in rotary drum 1 having agitation blades 6 in accordance with the present invention, alternating the positions of laundry articles is sufficiently performed so that cleaning effect reaches every laundry article thereby enhancing the overall cleaning efficiency.

Fig. 2 shows the arrangement of a control unit, which includes controller 16 for controlling the operation of the drum type washing machine configured as described above. Controller 16 controls the operations of drum driving motor 5, water supply valve 12 and water drain valve 11. Further, input setting unit 17 and display unit 18 are installed in a control panel disposed on the surface of housing 9. When an operation course is selected from input setting unit 17, the selected course option to be performed and an operational state are displayed on display unit 18, and controller 16 controls drum driving motor 5, water supply valve 12 and water drain valve 11 according to an operational sequence selected. Hereinafter, the operation of the drum type

washing machine using controller 16 will be described with reference to Figs. 1 to 3.

After opening door 7, laundry is loaded into rotary drum 1 and detergent is also added from a detergent dispenser disposed in water supply unit 15. Then, power-on switch 17f is turned on from the control panel shown in Fig. 3, and an operation course corresponding to the type of laundry is selected from course setting switch 17d. Thereafter, an operation start input is generated by pressing start/pause switch 17e, so that an operation control by controller 16 is started. The drum type washing machine basically performs in order a washing process, a rinsing process and a water-extracting process. If a drying function is also available, a drying process can be performed if selected.

First, in order to detect the amount of laundry accommodated in rotary drum 1, controller 16 transmits a control command to driving circuit 22 to activate drum driving motor 5 to rotate rotary drum 1 at a predetermined rotational speed. Then, drum driving motor 5 which is triggered by driving circuit 22 is driven to rotate rotary drum 1, and laundry amount detector 27 detects the amount of the laundry based on a load exerted on drum driving motor 5 from the laundry.

Namely, drum driving motor 5 is a brushless DC motor. As shown in Fig. 2, driving circuit 22 controls the on-off

operations of switching devices 23a to 23f of inverter 23 which controls the supply of electric power to three-phase windings 5a to 5c of a stator of drum driving motor 5. DC power supplied to inverter 23 is obtained by rectifying a power from commercial power source 28 through diode bridge 29, choke coil 30 and smoothing capacitor 31. The load exerted on drum driving motor 5 is substantially proportional to an input current. Thus, load detecting unit 24 detects the value of the input current of inverter 23 from voltages at the both ends of resistor 25, which is connected in series to a DC power supply circuit for supplying the DC power to inverter 23, by way of current detecting circuit 26, and laundry amount detector 27 detects the amount of laundry loaded into rotary drum 1 based on the detected value of the input current. The amount of laundry detected by laundry amount detector 27 is stored in a memory of controller 16 to be used in a control operation to be described hereinafter.

Next, controller 16 transmits to load driving unit 20 a control command for opening water supply valve 12, and water supply valve 12 is opened, so that fresh water is fed into water tub 3 from a water supply hose connected to water supply unit 15. At this time, detergent supplied in water supply unit 15 is also added into water tub 3 while being dissolved in the water. At this point, the operating time of water supply valve 12 is determined based on the amount

of laundry detected by laundry amount detector 27. Further, the water level in water tub 3 is detected by water level detector 19 installed in water tub 3. When the water level reaches a specific level, a water level detection signal is transmitted to controller 16 from water level detector 19, and controller 16 transmits a control command for closing water supply valve 12 to load driving unit 20 to thereby stop the supply of water. Since the water supplied in water tub 3 is partially absorbed by the laundry in rotary drum 1 through drum perforations 2 formed on rotary drum 1, the water level in water tub 3 becomes lower. Thus, water tub 3 is supplied with additional water through the same process as described above.

Washing of laundry can be initiated through the above-described control operations. Controller 16 transmits a control command to driving circuit 22 to activate drum driving motor 5 to rotate rotary drum 1. Then, a first agitation control operation is performed initially as follows. Repeatedly executed in the first agitation control operation is a first agitation cycle, which includes a series of stages of forwardly rotating rotary drum 1 at a preset rotational speed for a first preset period of time; stopping rotary drum 1 for a second preset period of time; reversibly rotating rotary drum 1 at, e.g., the preset rotational speed for the first preset period of time; and then stopping rotary drum 1 for the second preset period of

time. The first agitation control operation is performed for a first predetermined period of time. The preset rotational speed is a rotational speed allowing laundry accommodated in rotary drum 1 to be lifted up in the rotational direction of rotary drum 1 and dropped upon reaching a position where the weight of the laundry becomes greater than the centrifugal force exerted on them by the rotation of rotary drum 1. Since the laundry is lifted up and dropped, an effect of pounding motion is thereby provided, and repeating such pounding motions facilitate cleaning process for removing dirt from the laundry soaked in wash water containing detergent dissolved therein. Further, since only the laundry contacting agitation blades 6 is picked up among laundry articles piled on top of each other, the effect of alternating the respective positions of laundry articles can be obtained. If the rotational speed is slower than the preset rotational speed, laundry cannot be picked up by agitation blades 6. In contrast, laundry would not drop at a rotational speed greater than the preset rotational speed because the influence of centrifugal force would become greater than the weight of the laundry. Furthermore, by reversing the rotational direction of rotary drum 1, laundry articles can be prevented from being entangled so that positions of laundry articles in rotary drum 1 can be more effectively alternated.

The effect of pounding motions, i.e., lifting up and

then dropping laundry, is affected by the amount of laundry accommodated in rotary drum 1. Therefore, it is preferable that the preset rotational speed is adjusted depending on the amount of laundry. As described earlier, the amount of laundry is detected by laundry amount detector 27 and the detected laundry amount is stored. When the measured amount of laundry is greater than a preset amount, controller 16 sets the preset rotational speed to a slower speed. In contrast, if the stored amount of laundry is smaller than the preset value, controller 16 increases the preset rotational speed. Although it is possible to obtain a cleaning effect of laundry articles while alternating their positions by way of repeating only the first agitation control operation for a specific washing period, it is more preferable to execute a second agitation control operation after the first agitation control operation.

Repeatedly performed in the second agitation control operation is a second agitation cycle including a series of stages of forwardly rotating rotary drum 1 at a predetermined rotational speed higher than that of the first agitation control operation for a third preset period of time; stopping rotary drum 1 for a fourth preset period of time; reversibly rotating rotary drum 1 at the predetermined rotational speed for the third preset time period; and then stopping rotary drum 1 for the fourth preset time period. The second agitation cycle is repeated for a second

predetermined period of time. The predetermined rotational speed represents a rotational speed which does not allow laundry to drop but instead to cling onto the inner cylindrical surface of rotary drum 1 by the centrifugal force produced by the rotation of rotary drum 1. The laundry articles' tendency to cling to the inner cylindrical surface of rotary drum 1 leads to separating and spreading out clumped up laundry articles. Furthermore, when rotary drum 1 is stopped for the fourth preset time period, the laundry articles lifted up to the upper portion of rotary drum 1 are detached from the inner cylindrical surface and dropped by the effect of inertia. By the unfolding and dropping movements of laundry articles, their positions are alternated while their forms are changed as well, thereby leading to more effective pounding motions.

By performing the first and the second agitation control operations alternately for a third predetermined period of time, alternating the positions of laundry articles in rotary drum 1 can be sufficiently performed and different pounding motions in the two agitation control operations can be obtained so that it is possible to provide substantially the same degree of cleaning to all laundry articles even in slanted rotary drum 1 without reducing the cleaning efficiency.

Upon completion of the washing process described above, controller 16 transmits a control command to load driving

unit 20 to open water drain valve 11, so that a water drain control operation for discharging soiled water from water tub 3 is executed. Moreover, controller 16 transmits a control command to driving circuit 22 to extract water from laundry by rotating drum driving motor 5, whereby water-extraction from the laundry is performed after the washing process.

After a predetermined time for water-extraction from the laundry, controller 16 closes water drain valve 11 but opens water supply valve 12, so that fresh water is fed into water tub 3 and a rinsing process is started. In the rinsing process, the laundry in rotary drum 1 are subject to agitating motions by alternately rotating rotary drum 1 forwardly and reversibly. For instance, if the first and/or the second agitation control operation as in the washing process are executed in the rinsing process, the positions of the laundry articles in rotary drum 1 are alternated and the effect of pounding motions can reach all laundry articles, so that a substantially uniform rinsing process can be obtained.

As shown in Fig. 4, after the washing process, rinsing processes are usually performed twice and a water-extracting operation is carried out after each rinsing process to extract water from the laundry. The water-extracting operation after the second rinsing process is identified as the water-extracting process. That is, a water-extracting

operation herein refers to an operation for spinning rotary drum 1 at a high rotational speed after draining water from rotary drum 1 during various processes including the washing process. In order to perform a water-extracting operation effectively during each process, laundry should be stuck on the inner cylindrical surface of rotary drum 1 uniformly such that water absorbed in the laundry is dispersed out into water tub 3 through drum perforations 2 by centrifugal force. If the laundry is unevenly balanced toward one portion of rotary drum 1, water-extraction of the laundry cannot be performed smoothly, and rotary drum 1 would shake or vibrate considerably because its center of gravity is offset toward one side. Therefore, a laundry balancing operation for balancing the laundry is performed when starting the water-extracting operation. Hereinafter, a control sequence for the laundry balancing operation and the water-extracting operation will be described in order.

Fig. 5 is a flowchart describing the control sequence performed by controller 16 in order to carry out the laundry balancing operation and the water-extracting operation. Reference numerals S1 to S14 represent step numbers of the control sequence.

When a water-extraction is started, an initial reference value for determining the balanced state of laundry is set (S1), and initialization (N=1) of the number of repetitions of laundry balance determining operation is

performed (S2). Then, drum driving motor 5 is driven at a first predetermined rotational speed (for example, 90 rpm) (S3). The time period required for increasing the rotational speed of drum driving motor 5 up to the first rotational speed is controlled based on the data which is obtained by laundry amount detector 27 and stored in controller 16. As shown in Fig. 6A, when the amount of laundry is large, drum driving motor 5 is driven to rotate rotary drum 1 such that the rotational speed of rotary drum 1 reaches a second rotational speed (for example, 40 rpm) at time t1 and then keeps rotating rotary drum 1 at the second rotational speed during the time period from t1 through t2. During the subsequent time period from t2 through t3, motor 5 is driven to rotate rotary drum 1 such that the rotational speed of rotary drum 1 reaches the first rotational speed at time t3. When the laundry amount is small, on the other hand, rotary drum 1 is rotated such that the rotational speed thereof reaches a third rotational speed (for example, 50 rpm) at time t1, and the time period from t2 to t3' during which the rotational speed of rotary drum 1 is increased up to the first rotational speed is shortened, as shown in Fig. 6B. By this control, centrifugal force becomes greater than the gravity exerted on the laundry so that the laundry would stay stuck to the inner cylindrical surface of rotary drum 1.

If the laundry stuck to the cylindrical surface of

rotary drum 1 distributed evenly, rotary drum 1 rotates normally without experiencing irregular rotation, so that the balanced state is found to be good in the laundry balance monitoring step (S4). Thereafter, controller 16
5 spins drum driving motor 5 at a high rotational speed, so that water can be extracted from the laundry (S14).

The balanced state of laundry is monitored by detecting irregular rotation of rotary drum 1. As shown in Fig. 2, drum driving motor 5 is a brushless DC motor
10 including the stator and a rotor, wherein position detectors 21a to 21c made of hall IC's are disposed at the stator by an interval of an electrical angle of 120 degrees to face a permanent magnet provided in the rotor. While the rotor makes one revolution, the magnetic field of the permanent
15 magnet is detected by position detectors 21a to 21c, and a pulse is inputted to controller 16 by the interval of the electrical angle of 120 degrees. Based on the pulse inputs, controller 16 changes the on-off status of switching devices 23a to 23f and supplies thus controlled electric power to
20 first, second and third windings 5a to 5c of the stator. As a result, a magnetic field is formed by first to third windings 5a to 5c, thereby rotating the rotor. Further, each of switching devices 23a, 23c and 23e is subjected to pulse width modification (PWM), and the number of rotations
25 (rotational speed) of the rotor is controlled by repeatedly controlling a duty ratio at a predetermined frequency.

Controller 16 calculates the number of rotations of the rotor based on the period of the pulses outputted from three position detectors 21a to 21c and then performs the PWM control of switching devices 23a, 23c and 23e such that the rotor makes as many rotations as a set rotation number. Accordingly, if it is detected that the pulses from position detectors 21a to 21c are not outputted at a specific interval even though the rotational number of rotary drum 1 is maintained at a predetermined value, it would be determined that irregular rotation problem of rotary drum 1 exists; namely, it would be interpreted as having the problem of poor and uneven distribution of laundry stuck on the inner surface of rotary drum 1. Therefore, by setting the variation in rotational speed of drum driving motor 5 as a reference value for determining the balanced state of laundry, uneven distribution of laundry in rotary drum 1 can be detected. At this point, switching devices 23b, 23d and 23f are not subjected to the PWM control.

If irregular rotation of rotary drum 1 is detected in step S4, i.e., if laundry is found to be unevenly balanced toward one portion of rotary drum 1, controller 16 stops the rotation of rotary drum 1 (S5) and determines whether N equals a first predetermined value (for example, 16) (S6). If N is less than the first predetermined value, it is then determined whether N equals a second predetermined value (for example, 8) (S7). If N is smaller than the second

predetermined value, 1 is added to N (S9) and the process is returned to step S3 and the driving operations from steps S3 through S7 are repeated. Here, if N is found to reach the second predetermined value in step S7, the reference value
5 for use in determining the balance state of laundry is changed (S8). Then, by adding 1 to N (S9), the process goes back to step S3 and the above-described laundry balancing operation is repeated.

When the number of repetitions of laundry balance
10 determining operation reaches the second predetermined value, the reference value for determining the balanced state of laundry is updated such that a tolerance range for laundry balance determination is expanded, whereby water-extraction
15 of laundry can be started even if laundry is unevenly balanced to some extent, so that the water-extraction of laundry is not interrupted in the middle of the process.

If it is determined in step S4 that the balanced state of laundry is good, it is then determined whether N is equal to or greater than 9 (S11). If N is less than 9, the
20 reference value for determining the balance state of laundry is not updated. In such case, since it is not considered to be at a state where rotary drum 1 would vibrate because of unbalanced laundry therein, the water-extraction of laundry is performed by spinning rotary drum 1 at a fourth
25 rotational speed (for example, 900 rpm)

If N is equal to or greater than 9 in step S11, on the

other hand, the reference value is updated such that the tolerance range for laundry balance determination is expanded, and it is considered to be at a state where rotary drum 1 would vibrate considerably because of unbalanced laundry therein. Therefore, the rotational speed of rotary drum 1 is set to be of a value (for example, 800 rpm) smaller than the fourth rotational speed (S12), and the time period for the water-extracting operation of laundry is extended to compensate for the reduction in water-extracting ability (S13). Thereafter, the water-extraction of laundry is performed (S14).

Moreover, if laundry is found to be in an unbalanced state in step S4 even after the reference value is updated such that the tolerance range for the laundry balance determination is expanded, that is, if N reaches the first predetermined value (for example, 16) in step S6, it is interpreted as being in a state wherein the unbalanced state of laundry cannot be improved by repeating the laundry balancing operations because the laundry is entangled in a complicated manner. In such a case, the process proceeds to step S10 and alerts an abnormality to user by way of making, for example, an electronic sound or a synthetic sound to prompt the user to untangle the laundry. Although not shown in Fig. 5, since whether the user finished untangling the laundry can be detected by the opening and closing of door 7, N is initialized when the opening and closing of door 7 is

detected, thereby re-performing the above-described operations.

Further, since monitoring of the balanced state of laundry is performed when conducting every water-extracting operation in each of washing, rinsing and water-extracting processes as shown in Fig. 4, the monitoring procedure is performed in water extracting steps for each of the processes.

Further, it may be preferable that the rotational direction of rotary drum 1 is repeatedly, periodically reversed until the rotational speed of rotary drum 1 reaches the first rotational speed. In this case, the forces to the laundry are applied in different directions, thereby facilitating the separation of entangled laundry articles.

In accordance with the present invention described above, the state of laundry distribution in the rotary drum is detected based on the balanced state of laundry during a water-extracting operation which is performed after each of a washing and a rinsing process. If the laundry is found to be in an unbalance state, the laundry balancing operation is repeated several times prior to starting the water-extracting operation, so that the state of the laundry in the rotary drum can be readily changed and entangled laundry articles can be separated. If the laundry articles are entangled in such a complicated manner that a balanced state thereof cannot be reached by using an initial reference

value, the initial reference value is updated to a value having a wider range of tolerance, so that the water-extracting operation can be started even in case the laundry is unbalanced to some extent and an interruption of the water-extracting operation can be prevented. Furthermore, by alerting abnormality to user by means of an abnormality notification unit when the entangled state of laundry cannot be improved by control operations, the user can be prompted to take a measure to separate the entangled laundry articles. Further, even when the laundry is entangled, the water-extracting operation can be performed by way of rotating the rotary drum at a rotational speed lower than that for a normal water-extracting operation. As a result, a drum type washing machine can be configured to perform water-extracting operations after each of the washing and the rinsing process multiple times.

While the invention has been shown and described with respect to the preferred embodiment, it will be understood by those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A drum type washing machine comprising:

a housing;

5 a water tub elastically supported in the housing;

a rotary drum accommodated in the water tub and having
an approximately horizontal or a slanted rotational axis;

a drum driving motor for rotating the rotary drum; and

a controller for controlling a rotation of the drum
10 driving motor,

wherein with respect to water extracting processes
following each operational stage of the washing machine, the
controller is capable of rotating the rotary drum up to a
first rotational speed which makes laundry in the rotary
15 drum cling to an inner surface of the rotary drum;
performing a laundry balance determining operation for
determining whether the laundry is evenly distributed and
clung on the inner surface of the rotary drum by using an
initial reference value; repeating the laundry balance
20 determining operation if a balanced state of the laundry is
found to be unacceptable by using the initial reference
value; updating the initial reference value to a value
having a wider range of tolerance when the number of
repetitions of the laundry balance determining operation
25 reaches a predetermined value; repeating the laundry balance
determining operation by using the updated reference value;

and rotating the rotary drum at a rotational speed required for a water-extracting operation when the balanced state of the laundry is found to be acceptable based on either one of the initial reference value or the updated reference value.

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2. The washing machine of claim 1, further comprising an abnormality notification unit wherein the controller controls the abnormality notification unit to report abnormality when the number of repetitions of the laundry balance determining operation reaches a preset value by
10 using the updated reference value.

3. The washing machine of claim 1, wherein the controller executes a water-extracting operation by using a second
15 rotational speed when the balanced state of the laundry is found to be acceptable based on the updated reference value, the second rotational speed being lower than a rotational speed for performing a water-extraction of the laundry after the balanced state of the laundry is found to be acceptable
20 based on the initial reference value.

4. The washing machine of claim 3, wherein the controller extends a time period for the water-extracting operation when the water-extracting operation is performed at the
25 second rotational speed.

5. The washing machine of any one of claims 1 to 4,
wherein the controller controls the rotational direction of
the rotary drum to be repeatedly, periodically reversed
until the rotational speed of the rotary drum reaches the
5 first rotational speed.