Description

Title of Invention

WASHING MACHINE

Technical Field

[0001]

The present invention relates to a washing machine which washes laundry.

Background Art

[0002]

A washing machine has been developed to wash laundry effectively under effective use of foam (c.f. Patent Document 1). Since a foam film includes surfactant at high concentration, the aforementioned washing machine may make the foam in contact with the laundry to effectively remove dirt from the laundry.

[0003]

A foam size affects cleaning efficiency. Large foam widely contacts laundry to achieve high cleaning efficiency.

[0004]

The washing machine in Patent Document 1 uses an air pump to blow air in liquid containing detergent and generate foam. However, sufficiently large foam is not generated under the techniques in Patent Document 1.

[0005]

Patent Document 1: JP 2010-172547 A

Summary of Invention

[0006]

Embodiments of the present invention provide a washing machine which uses large foam to clean laundry efficiently.

[0007]

A washing machine according to one aspect of the present invention includes a housing defining a generation space, in which foam is generated, a supply portion, which supplies liquid containing detergent to the housing to cause a boundary between a liquid layer and an air layer in the housing, and a blowing portion configured to send air toward the boundary through the air layer.

[0008]

The washing machine according to embodiments of the present invention may use large foam to clean laundry efficiently.

[0009]

Embodiments, features and advantages of the present invention will become clearer with the detailed description below and the accompanying drawings.

Brief Description of Drawings

[0010]

Fig. 1 is a schematic block diagram of an exemplary washing machine according to the first embodiment.

Fig. 2 is a schematic perspective view of the washing machine shown in Fig. 1.

Fig. 3 is a schematic sectional view of the washing machine shown in Fig. 1.

Fig. 4 is a schematic perspective view of the washing machine shown in Fig. 1.

Fig. 5 is a schematic perspective view of the washing machine shown in Fig. 1.

Fig. 6 is a schematic sectional view of a foam generator of the washing machine shown in Fig. 1.

Fig. 7 is a schematic sectional view of a housing of the foam generator shown in Fig. 6.

Fig. 8 is a schematic perspective sectional view of the housing shown in Fig. 7.

Fig. 9 is a schematic enlarged view of the housing shown in Fig. 7.

Fig. 10 is a schematic enlarged view of a guide cover of the washing machine shown in Fig. 1.

Fig. 11 is a schematic block diagram representing a control structure for a rotation speed of a circulatory pump of the washing machine shown in Fig. 1.

Fig. 12 is a schematic block diagram of the washing machine shown in Fig. 1.

Fig. 13 is a conceptual view of an exemplary operation program of the washing machine shown in Fig. 1.

Fig. 14 is a schematic flowchart representing an exemplary operation of the washing machine shown in Fig. 1.

Fig. 15A is a schematic sectional view of the foam generator shown in Fig. 6.

Fig. 15B is a schematic sectional view of the foam generator shown in Fig. 6.

Fig. 15C is a schematic sectional view of the foam generator shown in Fig. 6.

Fig. 16 is a schematic block diagram of an exemplary washing machine according to the second embodiment.

Fig. 17 is a conceptual view of a program about a washing operation cycle of the

washing machine shown in Fig. 16.

Description of Embodiments

[0011]

Exemplary washing machines are described below with reference to the drawings. Directional terms such as "up", "down", "left" or "right" used in the following description are merely for the purpose of clear explanation. Therefore, these terms do not limit the principles of the washing machines in any way. The following washing machines have not only a washing function of washing laundry but also a drying function of drying laundry. Alternatively, a laundry processing device may be a washing machine without a drying function.

[0012]

<First Embodiment>

<Washing Machine>

Fig. 1 is a schematic block diagram of a washing machine 100 according to the first embodiment. The washing machine 100 is described with reference to Fig. 1. A solid arrow shown in Fig. 1 represents a water flow. A dotted arrow shown in Fig. 1 represents an air flow. A dashed dotted arrow shown in Fig. 1 represents a transmission path of a control signal.

[0013]

The washing machine 100 includes a main housing 200, a controller 300, a watering mechanism 400, a washing mechanism 500, a circulatory mechanism 600 and a drying mechanism 700. The main housing 200 stores the controller 300, the watering mechanism 400, the washing mechanism 500, the circulatory mechanism 600 and the drying mechanism 700. The controller 300 controls the watering mechanism 400, the washing mechanism 500, the circulatory mechanism 600 and the drying mechanism 700.

[0014]

The washing machine 100 may sequentially execute a washing process of washing laundry, a rinsing process of rinsing the laundry, a spinning process of spin-drying the laundry, and a drying process of drying the laundry.

[0015]

The washing mechanism 500 includes a storage tub 510, in which laundry is stored, and a motor 520, which drives the storage tub 510. The motor 520 drives the storage tub 510 under control of the controller 300. In the washing process, the storage tub 510 agitates laundry in liquid containing detergent. Consequently, the laundry is cleaned appropriately. In the rinsing process, the storage tub 510 agitates the laundry in water at lower detergent concentration than

the washing process does. In the rinsing process, there is repetition of water supply to the storage tub 510 and drainage from the storage tub 510. Consequently, detergent is removed from the laundry appropriately. In the spinning process, the storage tub 510 spin-dries the laundry under a centrifugal force. Accordingly, it is facilitated to dry the laundry. In the drying process, dry air is supplied to the storage tub 510. Since the dry air is low in humidity and high in temperature, the laundry is dried appropriately in the storage tub 510. The storage tub 510 agitates the laundry during the dry air supply. Consequently, the laundry is dried appropriately.

[0016]

The watering mechanism 400 supplies water to the storage tub 510 in the aforementioned washing and rinsing processes. The watering mechanism 400 includes a watering port 410, which is connected to a tap, a switching valve 420 and a detergent storage portion 430, in which detergent is stored. Water supplied to the watering port 410 reaches the switching valve 420. The switching valve 420 switches a water supply route between a first water supply route 421, in which the water flows directly toward the storage tub 510, and a second water supply route 422, in which the water is supplied to the storage tub 510 through the detergent storage portion 430. For example, the first water supply route 421 may be used in the rinsing process. Consequently, tap water is supplied directly to the storage tub 510. For example, the second water supply route 422 may be used in the washing process. When the switching valve 420 opens the second water supply route 422, the water flows into the detergent storage portion 430. The water is mixed with the detergent in the detergent storage portion 430. Accordingly, water containing detergent flows into the storage tub 510. In this embodiment, the watering pipe is exemplified by a pipe conduit which defines the second water supply route 422. The watering portion is exemplified by the watering mechanism 400.

[0017]

The circulatory mechanism 600 includes a circulatory pump 610 and a foam generator 620. The circulatory mechanism 600 may circulate water between the circulatory pump 610 and the storage tub 510 in the aforementioned washing and rinsing processes. In this embodiment, the circulatory mechanism 600 includes a first circulation route 611 and a second circulation route 612 for the water circulation between the circulatory pump 610 and the storage tub 510. When the first circulation route 611 is used, the water flows into the storage tub 510 through the foam generator 620. When the second circulation route 612 is used, the water is sent directly from the circulatory pump 610 to the storage tub 510. Since the water is sent to the foam generator 620 and the storage tub 510 by the single circulatory pump 610, a space in the main housing 200 is used effectively, so that the washing machine 100 may be manufactured

at low cost. In addition, the use of the single circulatory pump 610 results in an increase in freedom of a layout design in the main housing 200.

[0018]

The foam generator 620 generates foam. The foam generated by the foam generator 620 is sent to the storage tub 510. Since a foam film forming the foam contains surfactant at high concentration, laundry in the storage tub 510 is cleaned effectively by contact with the foam.

[0019]

In this embodiment, the circulatory pump 610 changes a rotation speed under control of the controller 300. While the circulatory pump 610 operates at a high rotation speed, water flows into the storage tub 510 mainly through the first circulation route 611. While the circulatory pump 610 operates at a low rotation speed, the water flows into the storage tub 510 through the second circulation route 612. The circulation route between the first and second circulation routes 611, 612 is switched appropriately by the controller 300 adjusting a rotation speed of the circulatory pump 610 to change a pumping discharge. Alternatively, a switching valve or other components configured to selectively define a water flow direction may be used for switching the circulation route of water.

[0020]

The drying mechanism 700 includes an air filter 710, which receives air sent from the storage tub 510, a heat exchanger 720, which exchanges heat with the air passing through the air filter 710, a blower fan 730, which sends the air passing through the heat exchanger 720, and a switching valve 740, which switches an air flow direction from the blower fan 730. The air filter 710 removes lint from air sent from the storage tub 510. Therefore, the clean air flows into the heat exchanger 720. In the drying process, the controller 300 may actuate the heat exchanger 720. The heat exchanger 720 dehumidifies and heats the air. Consequently, the dry air suitable for drying laundry is generated. The controller 300 may stop the heat exchanger 720 from the washing process to the spinning process. Accordingly, the heat exchanger 720 does not consume power unnecessarily. Alternatively, the controller 300 may actuate the heat exchanger 720 in the washing process. Accordingly, the detergent may be activated by heat transmitted from the heat exchanger 720 to the air. In this embodiment, the blowing portion is exemplified by the drying mechanism 700.

[0021]

The controller 300 operates the blower fan 730 and the switching valve 740 in the washing and drying processes. In the washing process, the switching valve 740 sets an air flow route from the blower fan 730 to a first blow route 741 toward the foam generator 620. Since

the water containing detergent is sent into the foam generator 620 by the circulatory pump 610 as described above, large foam is generated in the foam generator 620 when the air flows from the blower fan 730 into the foam generator 620. The techniques for generating foam in this embodiment cause large foam in the size of about 5 mm to about 20 mm efficiently.

[0022]

In the drying process, the switching valve 740 sets an air flow route from the blower fan 730 to a second blow route 742 toward the storage tub 510. Accordingly, the aforementioned dry air flows into the storage tub 510 to dry the laundry. The dry air then flows into the air filter 710 through a return route 743 defined between the storage tub 510 and the air filter 710.

[0023]

Fig. 2 is a schematic perspective view of the washing machine 100. The washing machine 100 is further described with reference to Figs. 1 and 2.

[0024]

The main housing 200 includes a front wall 210, a rear wall 220 opposite to the front wall 210, a left wall 230, which stands between the front and rear walls 210, 220, a right wall 240 opposite to the left wall 230, a top wall 250 surrounded by the upper edges of the front, rear, left and right walls 210, 220, 230, 240 and a bottom wall 260 opposite to the top wall 250. The watering port 410 described with reference to Fig. 1 appears on the top wall 250. For example, a user may use a hose to connect the watering port 410 and a tap (not shown).

[0025]

The washing machine 100 further includes a door 101 attached to the front wall 210. The door 101 pivots between a closed position, at which the door 101 is leveled with the front wall 210, and an opened position, at which the door 101 protrudes from the front wall 210. The door 101 shown in Fig. 2 is in the opened position. When the door 101 is in the opened position, a feed opening 511 defined by the storage tub 510 is exposed. A user may rotate the door 101 to the opened position to feed laundry into the storage tub 510 through the feed opening 511.

[0026]

Fig. 3 is a schematic sectional view of the washing machine 100. The washing machine 100 is further described with reference to Figs. 1 and 3.

[0027]

The storage tub 510 includes a rotary drum 530, in which laundry is stored, and a water tub 540, in which the rotary drum 530 is stored. The rotary drum 530 includes an inner annular

wall 531, which defines the feed opening 511, an inner bottom wall 532 opposite to the inner annular wall 531, and a cylindrical inner circumferential wall 533 between the inner annular wall 531 and the inner bottom wall 532. The water tub 540 includes an outer annular wall 541, which is situated between the front wall 210 and the inner annular wall 531, an outer bottom wall 542, which is situated between the rear wall 220 and the inner bottom wall 532, and an outer circumferential wall 543, which surrounds the inner circumferential wall 533 between the outer annular wall 541 and the outer bottom wall 542. In this embodiment, the inner tub is exemplified by the rotary drum 530. The outer tub is exemplified by the water tub 540.

[0028]

The motor 520 includes a main body 521, which generates a driving force, and a drive shaft 522, which transmits the driving force to the rotary drum 530. The drive shaft 522 extends through the outer bottom wall 542 and is connected to the inner bottom wall 532.

[0029]

In addition to the circulatory pump 610 and the foam generator 620 (c.f. Fig. 1), the circulatory mechanism 600 includes a drain valve 690, an upstream circulation pipe 640, which defines a water flow route from the water tub 540 to the circulatory pump 610, a downstream circulation pipe 650, which defines a water flow route returning from the circulatory pump 610 to the water tub 540, and a drain pipe 660, which defines a drainage route from the main housing 200. The drain valve 690 is attached to the drain pipe 660. The controller 300 (c.f. Fig. 1) controls the drain valve 690. The controller 300 closes the drain valve 690 during water circulation between the storage tub 510 and the circulatory pump 610. The controller 300 opens the drain valve 690 to discharge redundant water.

[0030]

The downstream circulation pipe 650 includes a main pipe 659, into which water discharged by the circulatory pump 610 flows, a first branch pipe 651, which branches from the main pipe 659 and is connected to the foam generator 620, and a second branch pipe 652, which branches from the main pipe 659 and is connected to the outer annular wall 541. The first branch pipe 651 defines the first circulation route 611 described with reference to Fig. 1. The second branch pipe 652 defines the second circulation route 612 described with reference to Fig. 1. The controller 300 may control a pumping discharge from the circulatory pump 610 to selectively execute water circulation through the first branch pipe 651 and water circulation through the second branch pipe 652. In this embodiment, the branched pipe is exemplified by the downstream circulation pipe 650.

[0031]

In addition to the air filter 710, the heat exchanger 720, the blower fan 730 and the

switching valve 740, the drying mechanism 700 includes an air intake pipe 750, which defines an air flow route from the storage tub 510 to the blower fan 730, and an air sending pipe 760, which defines an air flow from the blower fan 730. The air filter 710 and the heat exchanger 720 are situated in the air intake pipe 750. The blower fan 730 is situated in the connection between the air intake pipe 750 and the air sending pipe 760. When the blower fan 730 rotates, a positive pressure environment is caused in the air sending pipe 760 whereas a negative pressure environment is caused in the air intake pipe 750.

[0032]

As shown in Fig. 3, the heat exchanger 720 includes a dehumidifier 721, which dehumidifies air discharged from the storage tub 510, and a heater 722, which heats the air passing through the dehumidifier 721. The dehumidifier 721 decreases humidity of the air. The heater 722 increases an amount of saturated water vapor in the air. Consequently, dry air suitable for drying laundry is generated. Known heat pump techniques may be applied to the heat exchanger 720.

[0033]

The air sending pipe 760 includes a main air sending pipe 769, which guides air sent by the blower fan 730, a first air guide pipe 761, which branches from the main air sending pipe 769 and guides the air to the foam generator 620, and a second air guide pipe 762, which branches from the main air sending pipe 769 and guides the air directly to the storage tub 510. Consequently, the air is blown to the foam generator 620 and the storage tub 510 by the single blower fan 730. Therefore, a space in the main housing 200 is used effectively. In addition, the washing machine 100 may be manufactured at low cost. The blower fan 730 may send a large volume of air into the foam generator 620. Therefore, foam generated in the foam generator 620 becomes large. In addition, it takes a short time to generate the foam.

[0034]

The switching valve 740 is situated at the bifurcation point, at which the first and second air guide pipes 761, 762 bifurcate from the main air sending pipe 769. During the washing process, the switching valve 740 closes the second air guide pipe 762 whereas the switching valve 740 opens the first air guide pipe 761. When the blower fan 730 sends dehumidified and heated air to the main air sending pipe 769 (i.e. during the drying process), the switching valve 740 opens the second air guide pipe 762 whereas the switching valve closes the first air guide pipe 761. The first air guide pipe 761 defines the first blow route 741 described with reference to Fig. 1. The second air guide pipe 762 defines the second blow route 742 described with reference to Fig. 1. The air intake pipe 750 defines the return route 743 described with reference to Fig. 1.

[0035]

Fig. 4 is a schematic perspective view of the washing machine 100. The washing machine 100 is further described with reference to Figs. 1, 3 and 4.

[0036]

The outer circumferential wall 543 of the water tub 540 includes a front circumferential wall 545, to which the outer annular wall 541 is attached, and a rear circumferential wall 546, which is situated between the outer bottom wall 542 and the front circumferential wall 545. The foam generator 620 is attached to the front circumferential wall 545. Figs. 3 and 4 show the rotational axis RX of the rotary drum 530 defined by the motor 520. In this embodiment, the foam generator 620 is situated above the rotational axis RX.

[0037]

The air intake pipe 750 includes a bellows pipe 751, which extends upward from the front circumferential wall 545, and a storage duct 752, in which the air filter 710 and the heat exchanger 720 are stored. The air filter 710 is removed from the storage duct 752 shown in Fig. 4, so that the heat exchanger 720 is exposed.

[0038]

When the blower fan 730 is operated, a negative pressure environment is caused in the bellows pipe 751 and the storage duct 752. Consequently, air in the storage tub 510 sequentially flows into the bellows pipe 751 and the storage duct 752.

[0039]

Fig. 5 is a schematic perspective view of the washing machine 100. The washing machine 100 is further described with reference to Figs. 2, 4 and 5.

[0040]

The air intake pipe 750 further includes a lid 753. The lid 753 is used for covering an ejection slot 754 (c.f. Fig. 4) formed on the storage duct 752, from which the air filter 710 is taken from the main housing 200. As shown in Fig. 2, the lid 753 appears on the top wall 250.

[0041]

The blower fan 730 is attached to the storage duct 752. The main air sending pipe 769 is connected to the blower fan 730 and the switching valve 740 which is situated below the blower fan 730. The first air guide pipe 761 extends from the switching valve 740 to the right along the outer bottom wall 542, and then extends forward along the outer circumferential wall 543. Eventually, the first air guide pipe 761 is connected to the foam generator 620. The second air guide pipe 762 extends downward from the switching valve 740 and is connected to

the outer circumferential wall 543.

[0042]

The detergent storage portion 430 is arranged on the left of the storage duct 752. The watering port 410 and the switching valve 420 are situated on the left of the blower fan 730. The switching valve 420 is situated between the watering port 410 and the blower fan 730.

[0043]

<Foam Generator>

Fig. 6 is a schematic sectional view of the foam generator 620. The foam generator 620 is described with reference to Figs. 3 and 6.

[0044]

The foam generator 620 includes a housing 621 defining a generation space 629, in which foam is generated, an upper cylinder 622, which protrudes upward from the housing 621, and a lower cylinder 623, which protrudes downward from the housing 621. The first branch pipe 651 described with reference to Fig. 3 is connected to the lower cylinder 623. When the circulatory pump 610 pumps water containing detergent to the foam generator 620, a boundary BD between a liquid layer WL and an air layer AL is formed in the housing 621. Since the lower cylinder 623 extends downward from the generation space 629, water is discharged appropriately from the housing 621 through the lower cylinder 623 when the blower fan 730 stops.

[0045]

The first air guide pipe 761 described with reference to Fig. 3 is connected to the upper cylinder 622. The upper cylinder 622 defines a blower port 624, which is in communication with the air layer AL above the boundary BD in the generation space 629. Air sent by the blower fan 730 flows into the generation space 629 through the blower port 624. Accordingly, the air directed downward by the first air guide pipe 761, the upper cylinder 622 and the blower port 624 is blown toward the boundary BD through the air layer AL when the blower fan 730 operates. Consequently, large foam is generated in the generation space 629. Since the blower port 624 exists above the boundary BD, water is less likely to flow toward the blower fan 730 through the blower port 624. Therefore, the blower fan 730 may blow air onto the liquid layer WL very reliably. Meanwhile, a rotation speed of the blower fan 730 may be set to a range from about 4,000 rpm to about 5,000 rpm. Consequently, an air amount passing through the liquid layer WL is ranged from about 0.1 m^3/min to about 0.3 m^3/min. In the drying process, a rotation speed of the blower fan 730 may be set to a range from about 4,000 rpm to about 6,000 rpm. Under this rotation speed range, the blower fan 730 may send about 2 m^3/min to 4 m^3/min

of air to the storage tub 510. In this embodiment, the supply portion is exemplified by the circulatory mechanism 600. The first guide pipe is exemplified by the first air guide pipe 761 and the upper cylinder 622. The pump is exemplified by the circulatory pump 610.

[0046]

The housing 621 includes a bottom wall 625, from which the lower cylinder 623 protrudes, a top wall 626, which lies above the bottom wall 625, a front wall 627, which is connected to the front ends of the bottom and top walls 625, 626, a rear wall 628 opposite to the front wall 627, and a slope wall 630 inclined downward from the rear end of the top wall 626 up to the upper end of the rear wall 628. The upper cylinder 622 protrudes from the slope wall 630.

[0047]

The housing 621 further includes an L-shaped plate 631. The L-shaped plate 631 includes a horizontal plate 632, which lies between the bottom and top walls 625, 626, and a vertical plate 633, which stands from the rear end of the horizontal plate 632 toward the blower port 624. A ventilation flue 634 is formed between the vertical plate 633 and the rear wall 628 and between the horizontal plate 632 and the bottom wall 625.

[0048]

The lower cylinder 623 includes a lower part 635, which protrudes downward from the bottom wall 625, and an upper part 636, which protrudes upward from the bottom wall 625. The lower cylinder 623 defines a flow route 637 of water containing detergent. The upper part 636 appearing in the ventilation flue 634 isolates the flow route 637 from the ventilation flue 634. Therefore, little water leaks into the ventilation flue 634. The upper part 636 defines an opening 638 on the horizontal plate 632. Water sent through the lower cylinder 623 overflows onto the L-shaped plate 631 from the opening 638, and then flows toward the generation space 629 over the horizontal plate 632. Accordingly, the liquid layer WL is formed. The horizontal plate 632 supports the liquid layer WL.

[0049]

The housing 621 further includes a control plate 641 which stands upward from the horizontal plate 632. The control plate 641 includes a connecting edge 642, which is connected with the horizontal plate 632, and a limit edge 643 opposite to the connecting edge 642. When a liquid level in the generation space 629 exceeds the limit edge 643, water flows over the limit edge 643, and then is discharged from the housing 621. Therefore, the control plate 641 may appropriately control a liquid level in the generation space 629.

[0050]

The foam generator 620 further includes a punching plate 670. The punching plate

670 is formed with a lot of punch holes 671. The punch holes 671 allow air passage. Accordingly, the air may be regulated by the punching plate to blow out substantially uniformly toward the boundary BD. The housing 621 includes a support plate 644 which extends downward from the top wall 626 between the vertical plate 633 and the control plate 641. The support plate 644 includes a rear support portion 645 which sandwiches the rear end of the punching plate 670. The control plate 641 includes a front support portion 646 which sandwiches the front end of the punching plate 670. The punching plate 670 is appropriately supported above the horizontal plate 632 by the front and rear support portions 646, 645.

[0051]

The housing 621 further includes a baffle plate 647 which extends from the support plate 644 toward the control plate 641 and lies above the opening 638. The baffle plate 647 lies between the punching plate 670 and the horizontal plate 632. The baffle plate 647 hits an upward water flow, which is defined by the lower cylinder 623, and guides the water to the generation space 629. The vertical plate 633 stands between the support plate 644 and the rear wall 628. A control flue 648 to guide air sent from the blower port 624 to the generation space 629 is formed between the vertical plate 633 and the support plate 644 and between the baffle plate 647 and the horizontal plate 632. The aforementioned opening 638 faces the control flue 648. The opening 638 faces the baffle plate 647. The baffle plate 647 is larger in area than the opening 638 is. Therefore, if the outer contour of the opening 638 is projected on the baffle plate 647, the projected outer contour of the opening 638 falls in a region defined by the outer contour of the baffle plate 647.

[0052]

The vertical plate 633 extends from the rear end of the horizontal plate 632 toward the blower port 624. The vertical plate 633 includes an upper edge 681 which faces the blower port 624. The upper edge 681 divides air flowing from the blower port 624 into air, which flows into the control flue 648, and air, which flows into the ventilation flue 634.

[0053]

The baffle plate 647 includes a distal edge 682 which faces the control plate 641. The control flue 648 includes an inflow end 683, which is defined between the upper edge 681 and the support plate 644, and an outflow end 684, which is defined between the distal edge 682 and the horizontal plate 632. Since the inflow end 683 is situated above the limit edge 643, the inflow end 683 is open in the air layer AL. Therefore, air may flow from the blower port 624 into the control flue 648 appropriately.

[0054]

Since the outflow end 684 is open toward the generation space 629, the outflow end 684

is situated in the liquid layer WL upon water supply to the foam generator 620 by the circulatory pump 610. Therefore, the boundary BD between the air layer AL and the liquid layer WL is formed not only in the generation space 629 but also in the control flue 648. When the blower fan 730 causes an air flow into the housing 621 through the blower port 624 above the boundary BD formed in the control flue 648, the air hits the boundary BD, and eventually reaches the generation space 629 beyond the outflow end 684. Accordingly, large foam is generated in the generation space 629.

[0055]

The blower fan 730 may send air into the generation space 629 and the lower cylinder 623 at high pressure when the circulatory pump 610 stops. When the blower fan 730 sends the air into the generation space 629 and the lower cylinder 623 at high pressure, water in the control flue 648 is pushed out. Accordingly, the control flue 648 is filled with the high-pressure air. Therefore, the control flue 648 is filled with the air layer AL whereas the liquid layer WL in the generation space 629 is away from the opening 638. The lower cylinder 623 which defines the opening 638 is connected to the horizontal plate 632 between the inflow and outflow ends 683, 684. Since the space between the inflow and outflow ends 683, 684 is filled with the air layer AL formed by the air blow from the blower fan 730, the liquid layer WL in the generation space 629 is away from the opening 638. While the liquid layer WL is away from the opening 638, water discharge through the opening 638 is stopped. The liquid layer WL may enter the control flue 648 when the blower fan 730 stops blowing air. Consequently, the liquid layer WL is drained through the opening 638. Thus, it is possible to use the control flue 648 for controlling drainage from the generation space 629. As described above, unintended discharge of the liquid layer WL from the opening 638 while the circulatory pump 610 is stopped is prevented without a control valve such as a check valve. Since a control valve such as an on-off valve is not necessary for drainage control of the liquid layer WL while the circulatory pump 610 is stopped, a space in the main housing 200 is used effectively, so that the washing machine 100 may be manufactured at low cost.

[0056]

Fig. 7 is a schematic sectional view of the housing 621. The housing 621 is described with reference to Figs. 4, 6 and 7.

[0057]

The housing 621 includes a left wall 661 which faces the front circumferential wall 545. An upper exhaust port 663 and a lower exhaust port 662 adjacent to the upper exhaust port 663 are formed in the left wall 661 between the control plate 641 and the front wall 627. The lower

exhaust port 662 is in communication with the ventilation flue 634. The control flue 648 and the generation space 629 are formed between the blower port 624 and the upper exhaust port 663. Air flowing from the blower port 624 into the control flue 648 enters the liquid layer WL in the generation space 629 to cause large foam. The foam generated in the generation space 629 flows over the control plate 641, and then is discharged from the upper exhaust port 663.

[0058]

The ventilation flue 634 is formed between the blower port 624 and the lower exhaust port 662. Since the L-shaped plate 631 partitions the generation space 629 on the horizontal plate 632 from the ventilation flue 634, little water enters into the ventilation flue 634. Therefore, air flowing into the ventilation flue 634 is discharged rapidly from the lower exhaust port 662 without being blocked by water.

[0059]

The housing 621 further includes a front attachment portion 664, which is formed on the left wall 661 along the lower and upper exhaust ports 662, 663, and a rear attachment portion 665 formed on the left wall 661 on the rear side from the front attachment portion 664. The front and rear attachment portions 664, 665 are used to attach the foam generator 620 to the front circumferential wall 545.

[0060]

Fig. 8 is a schematic perspective sectional view of the housing 621 attached to the front circumferential wall 545. Fig. 9 is a schematic enlarged view of the housing 621 around the front attachment portion 664. A connecting structure between the housing 621 and the front circumferential wall 545 is described with reference to Figs. 4, 8 and 9.

[0061]

The water tub 540 includes a guide cover 551, which is situated between the outer annular wall 541 and the front circumferential wall 545, and a connection duct 552, with which the housing 621 is connected to the guide cover 551. The front attachment portion 664 includes a facing wall 666, which faces the front circumferential wall 545. A seal groove 667 surrounding the upper exhaust port 663 and the lower exhaust ports 662 below the upper exhaust port 663 is formed in the facing wall 666. A seal member such as an O-ring is embedded in the seal groove 667. The connection duct 552 includes a first connecting end 562, which is connected to the facing wall 666, and a second connecting end 563, which is connected to the guide cover 551. The first connecting end 562 compresses the seal member arranged at the seal groove 667 to hold a connecting part between the connection duct 552 and the housing 621 airtight. The second connecting end 563 and the guide cover 551 may be connected so as to be

airtight by a structure similar to the connecting structure between the first connecting end 562 and the facing wall 666.

[0062]

Fig. 10 is a schematic enlarged view of the guide cover 551. The guide cover 551 is described with reference to Figs. 8 to 10.

[0063]

The guide cover 551 includes a guide region 553 for guiding foam and air discharged from the housing 621. The guide region 553 includes an inflow end 554, into which the foam and the air flows, and an outflow end 555 opposite to the inflow end 554. The outflow end 555 faces the feed opening 511 defined by the rotary drum 530. Therefore, the foam and the air are supplied to laundry through the feed opening 511.

[0064]

The guide region 553 includes a lower rib 556, which extends from the inflow end 554 to the outflow end 555, an upper rib 557, which extends above the lower rib 556 from the inflow end 554 to the outflow end 555, and an intermediate rib 561, which divides a space between the lower and upper ribs 556, 557 into an upper guide path 558 in communication with the upper exhaust port 663 and a lower guide path 559 in communication with the lower exhaust port 662. Like the guide region 553, the connection duct 552 is also segmented into the upper and lower guide paths 558, 559. Therefore, air guided from the first connecting end 562 up to the outflow end 555 by the lower guide path 559 is partitioned from air and foam which are guided by the upper guide path 558.

[0065]

An upper opening 568 is formed between the upper and intermediate ribs 557, 561. A lower opening 567 is formed between the lower and intermediate ribs 556, 561. The air and the foam from the upper opening 568 is discharged to the storage tub 510. The air is discharged from the lower opening 567.

[0066]

Air passes over the horizontal plate 632 after flowing into the control flue 648. Since water containing detergent exists over the horizontal plate 632, the air flowing over the horizontal plate 632 generates large foam. The air is then discharged from the upper exhaust port 663. The foam is discharged from the upper exhaust port 663 together with the air flowing toward the upper exhaust port 663. The foam then flows from the upper opening 568 into the rotary drum 530 through the upper guide path 558 formed in the connection duct 552 and the guide region 553. Accordingly, the foam directly contacts laundry in the rotary drum 530.

The laundry is cleaned effectively by a foam film including surfactant at high concentration. The principles of this embodiment contribute to generating large foam in the generation space 629. Therefore, the contact between the laundry and the foam is achieved over a wide region. Thus, the laundry is cleaned efficiently.

[0067]

As described above, little water exists in the ventilation flue 634. Therefore, air flowing into the ventilation flue 634 is discharged from the lower exhaust port 662 without little resistance of water. The air then flows at high speed from the lower opening 567 below the upper opening 568 into the rotary drum 530 through the lower guide path 559 formed in the connection duct 552 and the guide region 553. Foam discharged through the upper guide path 558 flows downward under the gravity. Since the lower guide path 559 is formed directly below the upper guide path 558, the foam is spread in a wide range in the rotary drum 530 by the air blown from the lower guide path 559. Accordingly, contact between laundry and foam is achieved over a wide region. Thus, laundry is cleaned efficiently. In this embodiment, the second guide pipe connected to the housing and the storage tub is exemplified by the connection duct 552, the upper rib 557 and the intermediate rib 561 which define the upper guide path 558. The discharge port is exemplified by the upper exhaust port 663.

[0068]

<Control for Water Supply to Foam Generator>

Water supply to the foam generator 620 is described with reference to Figs. 3, 4 and 6.

[0069]

As shown in Fig. 3, the circulatory pump 610 is situated below the storage tub 510. As shown in Fig. 4, the foam generator 620 is situated above the rotational axis RX of the rotary drum 530 (i.e. above the circulatory pump 610). When the circulatory pump 610 rotates at a high rotation speed, water is pumped toward the foam generator 620 through the first branch pipe 651 by the circulatory pump 610. The first branch pipe 651 is connected to the lower cylinder 623. Therefore, the water flows into the housing 621 through the lower cylinder 623.

[0070]

As shown in Fig. 3, the second branch pipe 652 is connected to the water tub 540 above the circulatory pump 610. The connecting position between the second branch pipe 652 and the water tub 540 is below the rotational axis RX. Therefore, the circulatory pump 610 may rotate at a relatively low rotation speed to send water into the water tub 540.

[0071]

When the circulatory pump 610 rotates at a high rotation speed, water is guided by the

main pipe 659 and then reaches the bifurcation between the first and second branch pipes 651, 652. The water then flows into the first and second branch pipes 651, 652. The first branch pipe 651 guides the water to the housing 621. Therefore, the water flowing into the first branch pipe 651 reaches the foam generator 620. Since air sent from the blower fan 730 also flows into the foam generator 620, large foam is generated in the foam generator 620. The foam generated in the foam generator 620 is then sent to the storage tub 510. The second branch pipe 652 guides water directly to the water tub 540. Therefore, the water flowing into the second branch pipe 652 flows directly into the water tub 540.

[0072]

Fig. 11 is a schematic block diagram representing a control structure for a rotation speed of the circulatory pump 610. The control for a rotation speed of the circulatory pump 610 is described with reference to Fig. 11.

[0073]

The circulatory pump 610 may adjust a rotation speed under control of the controller 300. When the circulatory pump 610 rotates at a first rotation speed (X1 rpm), the circulatory pump 610 may pump water to a first level PWL1. When the controller 300 rotates the circulatory pump 610 at a rotation speed no less than the first rotation speed, water containing detergent may flow into the first branch pipe 651, so that the water and the detergent are supplied to the foam generator 620. Therefore, the controller 300 may rotate the circulatory pump 610 at a rotation speed no less than the first rotation speed when laundry is cleaned by the foam. When the circulatory pump 610 rotates at a second rotation speed (X2 rpm) lower than the first rotation speed, the circulatory pump 610 may pump water to a second level PWL2 lower than the first level PWL1. When the controller 300 rotates the circulatory pump 610 at a rotation speed no less than the second rotation speed but less than the first rotation speed, the circulatory pump 610 may supply water only to the water tub 540 through the second branch pipe 652.

[0074]

The controller 300 may use the rotation speed of the circulatory pump 610 to adjust a flow rate of water in the first branch pipe 651. Therefore, the controller 300 may control the circulatory pump 610 to adjust a water supply rate to the foam generator 620.

[0075]

The controller 300 may use the rotation speed of the circulatory pump 610 to adjust a water flow rate in the second branch pipe 652. Therefore, the controller 300 may control the circulatory pump 610 to adjust a circulatory amount of water between the water tub 540 and the circulatory pump 610.

[0076]

Fig. 12 is a schematic block diagram of the washing machine 100. Control of the washing machine 100 is described with reference to Figs. 3, 6 and 12.

[0077]

The washing machine 100 further includes a level sensor 310 configured to detect a water level in the storage tub 510. Fig. 3 shows a water level DL in the storage tub 510, which is detected by the level sensor 310. The level sensor 310 is set to detect a level of water starting to enter the rotary drum 530. Meanwhile, the water level in the storage tub 510 may be above the lower end of the rotary drum 530. A detection signal representing the water entering into the rotary drum 530 is sent from the level sensor 310 to the controller 300 before laundry in the rotary drum 530 is buried under water. In this embodiment, the detector is exemplified by the level sensor 310.

[0078]

The controller 300 receiving the detection signal controls the circulatory pump 610 and sets a rotation speed of the circulatory pump 610 to be no less than the first rotation speed. Consequently, there is an increase in a flow rate of water in the first branch pipe 651. Water containing detergent is sent to the foam generator 620 through the first branch pipe 651.

[0079]

Simultaneously with the control for the circulatory pump 610, the controller 300 controls the switching valve 740 to close the second air guide pipe 762 whereas the switching valve 740 opens the first air guide pipe 761. Meanwhile, water supply into the storage tub 510 by the watering mechanism 400 may be stopped to maintain high detergent concentration. Accordingly, foam may be generated instantly in the foam generator 620. The controller 300 then actuates the blower fan 730. Consequently, air is sent from the blower fan 730 into the foam generator 620 through the first air guide pipe 761. Since the water containing detergent is supplied to the foam generator 620 as described above, large foam is generated in the foam generator 620. The foam is sent into the storage tub 510 together with the air and contacts laundry. Since the level sensor 310 sends a detection signal to the controller 300 before the laundry in the rotary drum 530 are buried under water as described above, the foam may contact the laundry directly without being blocked by water stored in the storage tub 510. Accordingly, the foam may clean the laundry effectively. Since detergent dissolves appropriately in water, water containing detergent is sent efficiently to the housing.

[0080]

The level sensor 310 may be set so that a volume of water in the storage tub 510

becomes greater than a capacity of the housing 621 when the level sensor 310 sends a detection signal to the controller 300. Accordingly, the circulatory pump 610 may continuously send water containing detergent to the foam generator 620.

[0081]

<Operation Control for Washing Machine>

Fig. 13 is a conceptual view of an exemplary operation program of the washing machine 100. An operation of the washing machine 100 is described with reference to Figs. 1 and 13.

[0082]

The operation of the washing machine 100 may be programmed with an operation cycle including a foam cleaning process, a shower process, a circulatory agitation process and a draining process. The controller 300 may control the watering mechanism 400, the washing mechanism 500, the circulatory mechanism 600 and the drying mechanism 700 in response to the set operation program. The washing machine 100 may repeat the programmed operation cycle a plurality of times in the washing process. Alternatively, the washing machine 100 may perform the programmed operation cycle only once in the washing process. It may be determined on the basis of a laundry amount stored in the storage tub 510, dirtiness of laundry or other parameters how many times the operation cycle is repeated.

[0083]

In the foam cleaning process, laundry is cleaned effectively by foam supplied from the foam generator 620. After the foam cleaning process, the shower process is performed. In the shower process, the watering mechanism 400 sprinkles water directly on the laundry in the rotary drum 530. Accordingly, the laundry is impregnated with surfactant contained at high concentration in a foam film adhered to the laundry. After the shower process, the circulatory agitation process is performed. In the circulatory agitation process, the laundry is agitated in water. The shower process and the circulatory agitation process may be executed in parallel. After the circulatory agitation process, the draining process is performed. Accordingly, dirty water is drained from the washing machine 100.

[0084]

In the washing operation cycle, the foam cleaning process is executed earlier. Accordingly, water containing little impurity (dirt) is supplied to the foam generator 620 in the foam cleaning process. Therefore, the foam generator 620 may generate large foam efficiently.

[0085]

Fig. 14 is a schematic flowchart representing an exemplary operation of the washing

machine 100 in the foam cleaning process. The operation of the washing machine 100 is described with reference to Figs. 1, 3, 12 to 14.

[0086]

(Step S110)

As shown in Fig. 13, the foam cleaning process is performed when the washing process is started or when the draining process in a previous operation cycle is completed. The foam cleaning process is started from step S110. In step S110, the controller 300 controls the watering mechanism 400 to open the watering port 410. Step S120 is then executed.

[0087]

(Step S120)

In step S120, the switching valve 420 opens a flow route of water to the detergent storage portion 430 under control of the controller 300. Accordingly, water flows into the detergent storage portion 430. Detergent in the detergent storage portion 430 dissolves into the water. The water containing detergent then flows into the storage tub 510. When a predetermined amount of the water is supplied to the storage tub 510 through the detergent storage portion 430, step S130 is then executed.

[0088]

(Step S130)

In step S130, the circulatory pump 610 operates under control of the controller 300 to increase a flow rate of water in the second branch pipe 652. For example, the circulatory pump 610 may rotate at a low rotation speed so that water flowing into the storage tub 510 through the second branch pipe 652 passes through a gap between the inner and outer circumferential walls 533, 543. As a result of water circulation between the circulatory pump 610 and the storage tub 510, there is uniform detergent concentration in water sent from the watering mechanism 400. After the actuation of the circulatory pump 610, step S140 is executed.

[0089]

(Step S140)

In step S140, the controller 300 determines whether or not a water level in the storage tub 510 exceeds the water level DL as the reference on the basis of a detection signal from the level sensor 310. If the water level in the storage tub 510 is below the water level DL, step S130 is executed. If the water level in the storage tub 510 is no less than the water level DL, the controller 300 stops the water supply from the watering mechanism 400. Step S150 is then executed.

[0090]

(Step S150)

In step S150, the controller 300 starts time keeping. Step S160 is then executed.

[0091]

(Step S160)

In step S160, the controller 300 sets a rotation speed of the circulatory pump 610 to be no less than the first rotation speed (X1 rpm) and increase a flow rate of water in the first branch pipe 651. Accordingly, the water containing detergent is supplied to the foam generator 620. Step S170 is then executed.

[0092]

(Step S170)

In step S170, the controller 300 controls the switching valve 740 to direct an air flow route toward the foam generator 620. The blower fan 730 then operates under control of the controller 300. Accordingly, not only the water containing detergent but also the air is sent to the foam generator 620. As a result of the air supply to the foam generator 620, large foam is generated in the foam generator 620. When the generated foam is supplied to the storage tub 510 along the air flow, step S180 is executed.

[0093]

(Step S180)

In step S180, the controller 300 controls the motor 520 to rotate the rotary drum 530. Accordingly, the laundry is agitated in the rotary drum 530. Therefore, the foam contacts the laundry entirely in the storage tub 510.

[0094]

As shown in Fig. 3, the rotational axis RX of the rotary drum 530 extends from the front wall 210 toward the rear wall 220. Therefore, the laundry moves upward due to the rotation of the rotary drum 530 and then falls due to the gravity. Accordingly, the laundry is slammed onto the inner surface of the inner circumferential wall 533. The colliding force which acts between the laundry and the inner circumferential wall 533 contributes to dirt removal from the laundry. Since foam produced according to the principles of this embodiment is greater than foam produced according to the principles of conventional techniques, a cushion effect of attenuating the colliding force between laundry and the inner circumferential wall 533 is less likely to happen, unlike foam used in the conventional foam cleaning process. Therefore, the laundry is cleaned efficiently.

[0095]

The washing machine 100 generates large foam. Since the large foam contacts laundry, a contact area on laundry per foam is large. Therefore, the principles of this embodiment make the foam cleaning process efficient.

[0096]

When agitation of the laundry in the storage tub 510 is started, step S190 is executed.

[0097]

(Step S190)

In step S190, the controller 300 compares the elapsed time from step S150 to a threshold period "Tth." If the elapsed time exceeds the threshold period "Tth," the foam cleaning process is terminated, and the next shower process is executed. Otherwise, step S160 is executed.

[0098]

<Drainage Control>

Figs. 15A to 15C are schematic sectional views of the foam generator 620. A method for controlling drainage from the foam generator 620 is described with reference to Figs. 1, 15A to 15C.

[0099]

(Filling Control)

As shown in Fig.15A, water flows into the housing 621 through the lower cylinder 623 when the controller 300 rotates the circulatory pump 610 at a high rotation speed and stops the blower fan 730. The water arriving at the opening 638 hits the baffle plate 647 and then flows substantially horizontally. Accordingly, the liquid layer WL and the air layer AL are formed in the generation space 629 and the control flue 648. Since the inflow end 683 is situated above the limit edge 643, the liquid level in the control flue 648 does not exceed the upper edge 681. Therefore, the boundary BD between the air layer AL and the liquid layer WL is situated between the inflow end 683 and the opening 638.

[0100]

(Generation Control)

As shown in Fig. 15B, air flows into the control flue 648 when the controller 300 operates the blower fan 730. Consequently, the control flue 648 is filled with the air layer AL. The boundary BD between the air layer AL and the liquid layer WL is situated near the outflow end 684. The air flows into the liquid layer WL in the generation space 629 beyond the outflow end 684. The air rises due to buoyancy and reaches the punching plate 670. The punching plate 670 causes a lot of bubbles. Consequently, foam is formed at high density in the generation space 629.

[0101]

As a result of the control flue 648 filled with the air layer AL, the liquid layer WL is apart from the opening 638. Therefore, little water flows from the housing 621 through the opening 638. Optionally, the controller 300 may rotate the circulatory pump 610 at a high rotation speed together with the blower fan 730 to supply water into the housing 621. Air flows substantially horizontally around the opening 638. In contrast, water supplied through the lower cylinder 623 flows upward. Therefore, the water may flow into the generation space 629 with little blockage by air.

[0102]

(Drainage Control)

As shown in Fig. 15C, the boundary BD between the liquid layer WL and the air layer AL is situated between the opening 638 and the inflow end 683 due to the hydraulic head of the liquid layer WL when the controller 300 reduces a rotation speed of the blower fan 730 and stops the circulatory pump 610. Since the space between the baffle plate 647 and the horizontal plate 632 is filled with the liquid layer WL, water is discharged from the foam generator 620 through the lower cylinder 623. Optionally, the controller 300 may then increase a rotation speed of the blower fan 730. Consequently, the boundary BD is displaced to a vicinity of the outflow end 684, so that drainage is stopped as described with reference to Fig. 15B.

[0103]

<Second Embodiment>

Fig. 16 is a schematic block diagram of an exemplary washing machine 100A according to the second embodiment. The washing machine 100A is described with reference to Figs. 1, 3, 13 to 16. With respect to the same components as the first embodiment, the same reference numerals are assigned. With respect to the components assigned with the same reference numerals, the description of the first embodiment is incorporated.

[0104]

Like the first embodiment, the washing machine 100A includes the main housing 200, the watering mechanism 400, the washing mechanism 500 and the drying mechanism 700. The washing machine 100A further includes a controller 300A and a circulatory mechanism 600A. The controller 300A performs control in a similar manner to the first embodiment for the watering mechanism 400, the washing mechanism 500 and the drying mechanism 700.

[0105]

The circulatory mechanism 600A may include all components of the circulatory mechanism 600 described in the context of the first embodiment. The circulatory mechanism

600A further includes a first valve 691, which opens or closes the first circulation route 611, and a second valve 692, which opens or closes the second circulation route 612. The first and second valves 691, 692 operate under control of the controller 300A.

[0106]

While the circulatory pump 610 operates in step S130 described with reference to Fig. 14, the controller 300A may open the second valve 692 whereas the controller 300A closes the first valve 691. Accordingly, water does not flow into the foam generator 620 unnecessarily during a process of causing uniform detergent concentration in circulated water.

[0107]

While the circulatory pump 610 operates in step S160 described with reference to Fig. 14, the controller 300A may close the second valve 692 whereas the controller 300A opens the first valve 691. Accordingly, water does not flow into the storage tub 510 unnecessarily through the second circulation route 612 while foam is supplied from the foam generator 620. Therefore, the foam may appropriately contact laundry without being blocked by water flowing from second circulation route 612.

[0108]

As described with reference to Fig. 13, the shower process may be performed after the foam cleaning process. In the shower process, the controller 300A may open the second valve 692 whereas the controller 300A closes the first valve 691. The controller 300A may set a rotation speed of the circulatory pump 610 to a value between the rotation speeds set in steps S130 and S160. Accordingly, the water flow rate in the second branch pipe 652 increases in comparison to the foam cleaning process. Since a relatively large amount of water flows into the water tub 540, the water is sprayed toward the feed opening 511. Therefore, the water falls upon the laundry in the rotary drum 530. Consequently, surfactant at high concentration contained in a foam film adhered to the laundry may appropriately seep into the laundry in the foam cleaning process. Accordingly, the laundry is cleaned effectively in the shower process.

[0109]

Fig. 17 is a conceptual view of a program for a washing operation cycle of the washing machine 100A. The washing operation cycle of the washing machine 100A is described with reference to Figs. 16 and 17.

[0110]

(Step S210)

The symbol "n" in Fig. 17 is a parameter about a count value representing how many times the foam cleaning process and the shower process are executed. In step S210, the

controller 300A sets the count value "n" to "0". Step S220 is then executed.

[0111]

(Step S220)

In step S220, the foam cleaning process is executed. The controller 300A closes the second valve 692 whereas the controller 300A opens the first valve 691. The controller 300A sets a rotation speed of the circulatory pump 610 to be higher than the rotation speed in the shower process. Accordingly, a water flow rate passing through the first circulation route 611 is increased in comparison to the shower process. On the other hand, a water flow rate passing through the second circulation route 612 is decreased in comparison to the shower process. When the foam cleaning process is complete, step S230 is executed.

[0112]

(Step S230)

In step S230, the shower process is executed. The controller 300A opens the second valve 692 whereas the controller 300A closes the first valve 691. The controller 300A may set a rotation speed of the circulatory pump 610 to be lower than the rotation speed in the foam cleaning process. Accordingly, a water flow rate passing through the first circulation route 611 is decreased in comparison to the foam cleaning process. On the other hand, the water flow rate passing through the second circulation route 612 is increased in comparison to the shower process. When the shower process is complete, step S240 is executed.

[0113]

(Step S240)

In step S240, the controller 300A increases the count value "n" by "1." Step S250 is then executed.

[0114]

(Step S250)

The symbol "N" in Fig. 17 is a threshold defined for the count value "n". In step S250, the controller 300A compares the count value "n" with the threshold "N". If the count value "n" is greater than the threshold "N," step S260 is executed. Accordingly, steps S220 and S230 are performed alternately until the count value "n" becomes greater than the threshold "N". Otherwise, step S220 is executed.

[0115]

(Step S260)

In step S260, the circulatory agitation process is executed. In the circulatory agitation process, the washing machine 100A may perform an operation in a similar manner to a general washing machine (washing machine not having a foam generating function) to clean laundry.

Step S270 is then executed.

[0116]

(Step S270)

In step S270, dirty water is drained from the washing machine 100A.

[0117]

The aforementioned washing machine 100 or 100A uses air not only for generating foam but also for drying laundry. Alternatively, air used for generating foam is utilized by a washing machine for applications other than drying laundry. For example, a washing machine may use air in order to stretch laundry. Therefore, it is possible to use the principles of this embodiment suitably not only in a washing machine having a drying function but also in a washing machine having other functions using air.

[0118]

The detailed designs or layouts of the aforementioned various components do not limit the principles of the present embodiments in any way. For example, flow rate control of water or air for the aforementioned foam generator is achievable with various known piping techniques. Therefore, a device or system resulting from a change, omission or addition in the aforementioned embodiments does not depart from the principles of the present embodiments in any way.

[0119]

The aforementioned embodiments mainly include the following features.

[0120]

A washing machine according to one aspect of the aforementioned embodiments includes a housing defining a generation space, in which foam is generated, a supply portion, which supplies liquid containing detergent to the housing to cause a boundary between a liquid layer and an air layer in the housing, and a blowing portion configured to send air to the boundary through the air layer.

[0121]

According to the aforementioned configuration, the liquid layer and the air layer are caused in the housing by liquid supply from the supply portion. Since the blowing portion sends air through the air layer to the boundary between the liquid layer and the air layer, large foam is formed in the housing. Accordingly, laundry is cleaned efficiently by the large foam.

[0122]

In the aforementioned configuration, the housing may be formed with a blower port in communication with the air layer. The blowing portion may include a blower fan and a first

guide pipe which guides the air from the blower fan to the blower port.

[0123]

According to the aforementioned configuration, the first guide pipe may appropriately guide air from the blower fan to the blower port. Since the blower port is in communication with the air layer, a large volume of the air passes through the air layer and hits the boundary between the liquid layer and the air layer. Accordingly, large foam is instantly formed in the housing. Therefore, laundry is cleaned efficiently by the large foam.

[0124]

In the aforementioned configuration, the housing may define the blower port above the liquid layer.

[0125]

According to the aforementioned configuration, liquid does not enter the blower port since the blower port is formed above the liquid layer. Accordingly, the blower fan may send air to the liquid layer very reliably.

[0126]

In the aforementioned configuration, the first guide pipe and the blower port may direct the air downward.

[0127]

According to the aforementioned configuration, air passes through the air layer and hits the boundary between the liquid layer and the air layer since the first guide pipe and the blower port direct air downward. Consequently, large foam is formed in the housing. Accordingly, laundry is cleaned efficiently by the large foam. Since liquid does not enter the blower port, the blower fan may send air to the liquid layer very reliably.

[0128]

In the aforementioned configuration, the washing machine may further include a storage tub, in which laundry is stored, and a second guide pipe, which is connected to the housing and the storage tub. The housing may be formed with a discharge port which is connected to the second guide pipe. The foam generated in the generation space may be supplied to the storage tub through the second guide pipe by the air which is supplied from the blower port.

[0129]

According to the aforementioned configuration, air flowing into the housing is discharged to the storage tub through the second guide pipe after foam generation. The foam generated in the generation space is supplied to laundry in the storage tub under an air flow from second guide pipe to the storage tub. Accordingly, the laundry is cleaned efficiently by large foam.

[0130]

In the aforementioned configuration, the washing machine may further includes a watering portion including a detergent storage portion, in which the detergent is stored, and a watering pipe, which guides water to the storage tub through the detergent storage portion. The supply portion may include a pump configured to send the water to the housing.

[0131]

According to the aforementioned configuration, water and detergent are guided by the watering pipe and reach the storage tub since the water passes through the detergent storage portion. Since the pump then sends the water and the detergent to the housing, the liquid layer and the air layer are formed in the housing. Since the blowing portion sends air to the boundary between the liquid layer and the liquid layer through the air layer, large foam is formed in the housing. Accordingly, laundry is cleaned efficiently by the large foam. Since the water and the detergent are sent from the storage tub to the housing, it is not necessary to add water containing detergent. Therefore, a space in the housing is used effectively, so that the washing machine is manufactured at low cost.

[0132]

In the aforementioned configuration, the housing may be arranged above the pump. The pump may pump the water to the housing.

[0133]

According to the aforementioned configuration, the liquid layer and the air layer are formed in the housing since the pump sends water and detergent in the storage tub to the housing. Since the blowing portion send air to the boundary between the liquid layer and the liquid layer through the air layer, large foam is formed in the housing. Therefore, laundry is cleaned efficiently by the large foam. Since the pump is used for pumping water, there is increased freedom of a layout design in the housing. Consequently, a space in the housing is used effectively, so that the washing machine is manufactured at low cost.

[0134]

In the aforementioned configuration, the supply portion may include a branched pipe including a main pipe, which guides the water pumped from the pump, a first branch pipe, which branches from the main pipe to guide the water to the housing, and a second branch pipe, which branches from the main pipe to guide the water directly to the storage tub.

[0135]

According to the aforementioned configuration, large foam is supplied to the storage tub if water flows into the housing through the first branch pipe. If water flows into the storage tub through the second branch pipe, laundry in the storage tub becomes wet appropriately.

Therefore, contact processes between foam and laundry and impregnation processes for laundry with detergent contained in foam are performed appropriately by the first and second branch pipes. Water supply to the housing and the storage tub may be achieved by one pump. Consequently, a space in the housing is used effectively, so that the washing machine is manufactured at low cost.

[0136]

In the aforementioned configuration, the washing machine may further include a controller which controls the pump to adjust a pumping discharge from the pump. A flow rate of the water in the first branch pipe may be adjusted in response to the pumping discharge from the pump.

[0137]

According to the aforementioned configuration, the controller may control the pump to appropriately adjust a flow rate of water in the first branch pipe. Therefore, the contact processes between foam and laundry and the impregnation processes for laundry with detergent contained in the foam are performed appropriately by the first and second branch pipes. Water supply to the housing and the storage tub may be achieved by one pump. Consequently, a space in the housing is used effectively, so that the washing machine is manufactured at low cost.

[0138]

In the aforementioned configuration, the washing machine may further include a detector configured to detect a liquid level in the storage tub. The storage tub may include an inner tub, in which the laundry is stored, and an outer tub, in which the inner tub is stored. The controller may increase a flow rate of the water in the first branch pipe when the detector detects the water entering into the inner tub.

[0139]

According to the aforementioned configuration, water in the storage tub is less likely to interfere with a contact between foam and laundry since the controller increases a flow rate of water in the first branch pipe when the detector detects water entering into the inner tub. Therefore, the laundry is cleaned efficiently by large foam. Since detergent is dissolved appropriately in water, the water containing detergent is supplied efficiently to the housing.

[0140]

In the aforementioned configuration, the inner tub may define a feed opening through which the laundry is fed, and the second guide pipe is formed so that the foam is supplied to the laundry through the feed opening.

[0141]

According to the aforementioned configuration, foam is supplied to the laundry through

the feed opening like water supplied through the second branch pipe. Therefore, the washing machine may impregnate the laundry efficiently with detergent contained in foam.

[0142]

In the aforementioned configuration, a liquid amount in the storage tub may be greater than a capacity of the housing when the detector detects the water entering into the inner tub.

[0143]

According to the aforementioned configuration, the pump may supply water to the housing continuously since a liquid amount in the storage tub is greater than a capacity of the housing when the detector detects the water entering into the inner tub.

[0144]

A washing machine according to another aspect of the aforementioned embodiments includes a cleaning tub, which uses liquid containing detergent to clean laundry, a foam generator including a housing defining a generation space for generating foam, a supply portion, which supplies the liquid to the foam generator, and a blowing portion configured to send air to the generation space. The housing defines an opening, through which the liquid flowing from the supply portion toward the generation space passes, and a flow path, which guides the air flowing from the blowing portion toward the generation space. The opening faces the flow path.

[0145]

In the aforementioned embodiments, the cleaning tube is exemplified by the storage tub 510. The flow path is exemplified by the control flue 648.

[0146]

According to the aforementioned configuration, liquid may contain dirt or lint which is separate from the laundry since the cleaning tub uses liquid containing detergent to clean the laundry. The liquid flows from the supply portion to the generation space through the opening defined by the housing. Since air flows from the blowing portion to the generation space through the flow path defined by the housing, foam is generated in the generation space. Since the opening faces the flow path through which the air passes, water stored in the generation space is reserved in the generation space by an air pressure of air supply. When there is a decrease in air supply amount, water is discharged from the housing through the opening by a water pressure in the generation space. Since the water storage in the generation space and the drainage from the generation space are controlled by the air supply amount, redundant water is discharged appropriately from the foam generator.

[0147]

In the aforementioned configuration, the housing may include a flow path wall which

defines the flow path. The flow path wall may include a facing wall which faces the opening.

[0148]

In the aforementioned embodiments, the flow path wall is exemplified by the support plate 644, the baffle plate 647 and the L-shaped plate 631. The facing wall is exemplified by the baffle plate 647.

[0149]

According to the aforementioned configuration, an air layer is formed between the opening and the facing wall while there is air supply from the blowing portion since the facing wall of the flow path wall defining the flow path faces the opening. Therefore, water stored in the generation space is reserved appropriately in the generation space. When there is a decrease in air supply amount, the water is discharged from the housing through the opening under a water pressure in the generation space. Since the water storage in the generation space and the drainage from the generation space are controlled by the air supply amount, redundant water is discharged appropriately from the foam generator.

[0150]

In the aforementioned configuration, the housing may include a connection pipe which connects the opening to the supply portion. The supply portion may supply the liquid to cause a liquid layer in the generation space. The blowing portion may guide the air to the connection pipe to make the liquid layer separate from the opening.

[0151]

In the aforementioned embodiments, the connection pipe is exemplified by the lower cylinder 623.

[0152]

According to the aforementioned configuration, water stored in the generation space is reserved appropriately in the generation space since the blowing portion guides air to the connection pipe connecting the opening to the supply portion to make the liquid layer separate from the opening. When there is a decrease in air supply amount, the water is discharged from the housing through the opening under a water pressure in the generation space. Since the water storage in the generation space and the drainage from the generation space are controlled by the air supply amount, redundant water is discharged appropriately from the foam generator.

[0153]

In the aforementioned configuration, the housing may include a support wall configured to support the liquid layer. The opening may be formed in the support wall.

[0154]

In the aforementioned embodiments, the support wall is exemplified by the horizontal

plate 632.

[0155]

According to the aforementioned configuration, the liquid layer is supported appropriately by the support wall. Since the opening is formed in the support wall, the air layer between the opening and the facing wall is adjacent to the liquid layer in the generation space. Therefore, the air layer between the opening and the facing wall may reserve liquid appropriately in the generation space. When there is a decrease in air supply amount, the water is discharged from the housing through the opening under a water pressure in the generation space. Since the water storage in the generation space and the drainage from the generation space are controlled by the air supply amount, redundant water is discharged appropriately from the foam generator.

[0156]

In the aforementioned configuration, the housing may define a blower port above the liquid layer, the air flowing into the blower port.

[0157]

According to the aforementioned configuration, air flowing from the blower port hits the liquid layer since the housing defines the blower port above the liquid layer. Consequently, large foam is generated in the housing.

[0158]

In the aforementioned configuration, the flow path may include a first end, which opens in the air layer above the liquid layer, and a second end, which opens in the liquid layer.

[0159]

In the aforementioned embodiments, the first end is exemplified by the inflow end 683. The second end is exemplified by the outflow end 684.

[0160]

According to the aforementioned configuration, air sent by the blowing portion may flow into the flow path appropriately through the first end since the first end is open in the air layer. Since the blowing portion sends the air beyond the second end, the air is supplied appropriately in the liquid layer. Consequently, large foam is generated in the generation space.

[0161]

In the aforementioned configuration, the connection pipe may extend from the opening downward below the generation space.

[0162]

According to the aforementioned configuration, liquid flows upward in the connection pipe while supply portion supplies the liquid. When there is a decrease in air supply amount, liquid flows downward in the connection pipe. Since a liquid flow in the connection pipe is

bidirectional, clogging is less likely to happen to the connection pipe. Therefore, redundant water is discharged appropriately from the foam generator.

[0163]

In the aforementioned configuration, the washing machine may further include a controller configured to control the blowing portion. The blowing portion may include a blower fan configured to send the air into the blower port. The controller may control a rotation speed of the blower fan to discharge the liquid in the generation space from the connection pipe.

[0164]

According to the aforementioned configuration, liquid in the foam generator is discharged from the connection pipe since the controller controls a rotation speed of the blower fan.

[0165]

In the aforementioned configuration, the housing may include an upright wall which stands on the support wall. The upright wall may include a limit edge which limits a liquid level in the generation space. The blower port may be formed above the limit edge.

[0166]

In the aforementioned embodiments, the upright wall is exemplified by the control plate 641.

[0167]

According to the aforementioned configuration, liquid is less likely to overflow from the blower port since the blower port is formed above the limit edge. Therefore, air may flow into the flow path appropriately from the blower port.

[0168]

In the aforementioned configuration, the flow path may guide air in a direction different from a guiding direction of the liquid which is defined by the connection pipe.

[0169]

According to the aforementioned configuration, liquid supply from the supply portion is less likely to be blocked by air flowing in the flow path since the flow path guides air in a direction different from the guiding direction of the liquid, which is defined by the connection pipe.

[0170]

In the aforementioned configuration, the washing machine may further include a storage tub, in which the laundry is stored, and a drying mechanism, which dries the laundry stored in the storage tub. The blowing portion may include a blower fan configured to send the air into

the blower port. The drying mechanism may include the blower fan.

[0171]

According to the aforementioned configuration, air supply to the storage tub and the foam generator is achieved by the common blower fan. Therefore, an internal space of the washing machine is used effectively. In addition, the washing machine may be manufactured at low cost.

[0172]

A washing machine according to yet another aspect of the aforementioned embodiments includes a blowing portion configured to send air, a foam generator including a housing defining a generation space, in which foam is generated, a storage tub, in which laundry is stored, a first flow route, which guides the air from the blowing portion to the housing, and a second flow route, which guides the air from the blowing portion to the storage tub.

[0173]

According to the aforementioned configuration, air flowing through the first flow route may generate foam in the generation space. Therefore, the washing machine may use foam to clean the laundry effectively. Air flowing through the second flow route is blown onto the laundry in the storage tub. Therefore, the washing machine may use the air to process the laundry appropriately. Since the air sent by the blowing portion is used for generating foam and processing the laundry, the washing machine may selectively perform cleaning the laundry with foam and processing the laundry with air, without requiring a lot of components. Accordingly, the washing machine may have a foam generating function without an unnecessary increase in size.

[0174]

In the aforementioned configuration, the washing machine may include a switcher configured to switch a flow route of the air between the first and second flow routes.

[0175]

In the aforementioned embodiments, the switcher is exemplified by the switching valve 740.

[0176]

According to the aforementioned configuration, the switcher generates foam in the generation space when a flow route of the air is set to the first flow route. Therefore, the washing machine may use foam to clean the laundry effectively. When the switcher sets a flow route of the air to the second flow route, the air is blown onto the laundry in the storage tub. Therefore, the washing machine may use the air to process the laundry appropriately. Since the air sent by the blowing portion is used for generating foam and processing the laundry, the

washing machine may selectively perform cleaning the laundry with foam and processing the laundry with air, without requiring a lot of components. Accordingly, the washing machine may include a foam generating function without an unnecessary increase in size.

[0177]

In the aforementioned configuration, the washing machine may include a supply portion which supplies liquid containing detergent to the housing to cause a liquid layer and an air layer in the housing. The air sent to the housing through the first flow route may flow into the liquid layer through the air layer.

[0178]

According to the aforementioned configuration, the liquid layer and the air layer are caused in the housing by liquid supply from the supply portion. Since the air sent to the housing through a first air guide pipe flows into the liquid layer through the air layer, large foam is formed in the housing. Therefore, the laundry is cleaned efficiently by the large foam.

[0179]

In the aforementioned configuration, the housing may be formed with a blower port in communication with the air layer. The blower port may direct the air sent by the first flow route downward.

[0180]

According to the aforementioned configuration, air passes through the air layer and hits the boundary between the liquid layer and the air layer since the blower port is in communication with the air layer and directs air downward. Consequently, large foam is formed in the housing. Therefore, laundry is cleaned efficiently by the large foam.

[0181]

In the aforementioned configuration, the washing machine may include a discharge pipe connected to the housing and the storage tub. The housing may be formed with a discharge port connected to the discharge pipe. Foam generated in the generation space may be supplied to the storage tub through the discharge pipe by the air sent to the housing.

[0182]

In the aforementioned embodiments, the discharge pipe is exemplified by the connection duct 552, the upper rib 557 and the intermediate rib 561 which form the upper guide path 558.

[0183]

According to the aforementioned configuration, the air flowing into the housing is discharged to the storage tub through the discharge pipe after generating foam. The foam generated in the generation space is supplied to the laundry in the storage tub by the air flow

from discharge pipe to the storage tub. Therefore, laundry is cleaned efficiently by the large foam.

Industrial Applicability

[0184]

The principles of the aforementioned embodiment are used suitably for a device having a function of cleaning laundry with foam.

Claims

1. A washing machine comprising:

a housing defining a generation space in which foam is generated;

a supply portion which supplies liquid containing detergent to the housing to cause a liquid layer and an air layer in the housing; and

a blowing portion configured to send air to the liquid layer through the air layer.

2. The washing machine according to claim 1,

wherein the housing is formed with a blower port in communication with the air layer, and

wherein the blowing portion includes a blower fan and a first guide pipe which guides the air from the blower fan to the blower port.

3. The washing machine according to claim 2,

wherein the housing defines the blower port above the liquid layer.

4. The washing machine according to claim 2 or 3,

wherein the first guide pipe and the blower port direct the air downward.

5. The washing machine according to any one of claims 2 to 4, further comprising:

a storage tub in which laundry is stored; and

a second guide pipe connected to the housing and the storage tub,

wherein the housing is formed with a discharge port which is connected to the second guide pipe, and

wherein the foam generated in the generation space is supplied to the storage tub through the second guide pipe by the air which is supplied from the blower port.

6. The washing machine according to claim 5, further comprising:

a watering portion including a detergent storage portion, in which the detergent is stored, and a watering pipe, which guides water to the storage tub through the detergent storage portion,

wherein the supply portion includes a pump which sends the water to the housing.

7. The washing machine according to claim 6,

wherein the housing is arranged above the pump, and

wherein the pump pumps the water toward the housing.

8. The washing machine according to claim 6 or 7,

wherein the supply portion includes a branched pipe including a main pipe, which guides the water pumped from the pump, a first branch pipe, which branches from the main pipe to guide the water to the housing, and a second branch pipe, which branches from the main pipe to guide the water directly to the storage tub.

9. The washing machine according to claim 8, further comprising:

a controller which controls the pump to adjust a pumping discharge from the pump,

wherein a flow rate of the water in the first branch pipe is adjusted in response to the pumping discharge from the pump.

10. The washing machine according to claim 9, further comprising:

a detector configured to detect a liquid level in the storage tub,

wherein the storage tub includes an inner tub, in which the laundry is stored, and an outer tub, in which the inner tub is stored, and

wherein the controller increases the flow rate of the water in the first branch pipe when the detector detects the water entering into the inner tub.

11. The washing machine according to claim 10,

wherein the inner tub defines a feed opening through which the laundry is fed, and

wherein the second guide pipe is formed so that the foam is supplied to the laundry through the feed opening.

12. The washing machine according to claim 10 or 11,

wherein a liquid amount in the storage tub is greater than a capacity of the housing when the detector detects the water entering into the inner tub.