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(71) Applicant: **BSH Hausgeräte GmbH**
81739 München (DE)

(72) Inventors:
• **Jakumeit, Rene**
13627 Berlin (DE)
• **Jänicke, Sven**
14641 Nauen (DE)
• **Shi, Yi-Chun**
13629 Berlin (DE)

(54) **PROCESS FOR THE OPERATION OF A WASHING MACHINE WITH FOAM DETECTION AND WASHING MACHINE SUITABLE FOR THIS PROCESS**

(57) The invention is directed to a process for the operation of a washing machine (1) with a tub (2) containing a drum (3) for receiving laundry (4) and a pressure sensor (6) in contact with an aqueous liquid, a drive motor (5) for the drum (3), a pump (18), and a control unit (8), wherein the presence of foam can be detected by a pressure change, characterized in that the following steps are carried out:

- (a) a washing phase is conducted with a suds containing water and detergent;
(b) water is added during or after the washing phase (a)

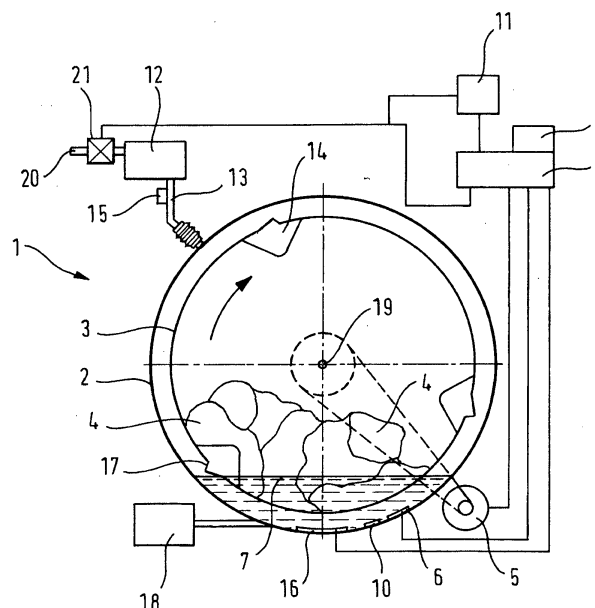
into the tub (2) in an amount $Q \leq Q_{\text{set}}$, wherein Q_{set} is a prescribed maximum quantity of water to be added in this step;

(c) a change of the pressure P is measured by the pressure sensor (6) upon the addition of the water in step (b); and

(d) the pressure change ΔP measured in step (c) is evaluated with respect to the presence of foam.

The invention is moreover directed to a washing machine (1) in which this process can be conducted.

Fig. 1



Description

[0001] The invention concerns a process for the operation of a washing machine with foam detection and a washing machine which is suitable for carrying out this process. More particularly, the invention concerns a process for the operation of a washing machine with a tub containing a drum for receiving laundry and a pressure sensor in contact with an aqueous liquid, a drive motor for the drum, a pump, and a control unit, wherein the presence of foam can be detected by a pressure change.

[0002] In a washing machine, laundry to be cleaned is treated in general in a washing phase with a detergent containing suds. After a rinsing phase with water in which suds and/or soil present in or on the laundry are removed, often a treatment of the laundry with a softening agent is conducted. It is useful with regard to costs and the environment to use an optimum amount of laundry treatment agent (in particular detergent and softening agent). Overdosing should be avoided since it may lead to an overflow in a washing machine.

[0003] In a washing machine often too much foam is produced because of an incorrect usage of detergents, in particular because of an overdosage of detergent, but also because of a wrong selection of a washing program. This is detrimental in various aspects. For example, an excessive amount of foam reduces the force that is acting on the laundry to be treated as well as the relative movement of laundry in the drum.

[0004] Moreover, the foam produced in a washing step has also a disadvantageous effect on the spinning phase, because it causes a slowdown between the drum and the tub. As a result, a spinning phase with a lower rotational speed shows an unsatisfactory performance or a drive motor for the tub is overloaded and perhaps even damaged during the spinning phase.

[0005] Incidentally, the suds pump does not transport a foam-suds mixture if during the course of a washing process too much foam is present in the tub or is produced during a spinning step. Spinning is thus not conducted if during a pumping-out the presence of foam is detected. Or, if foam is detected during spinning, the spinning is stopped. In a particularly unfavorable case, foam may exit from a washing machine during the exercise of a washing program which might damage mechanical or electronic components of the washing machine. Moreover, in a setup location furniture, the floor and the surrounding as such can be damaged. Altogether, the washing performance in a washing machine can decrease dramatically because of an excessive foam generation. An early detection of foam and efficient measures for the removal of foam are thus important.

[0006] In order to avoid the above mentioned disadvantages various possibilities for the recognition and removal of foam are known.

[0007] For the detection of foam formation in general the pressure inside a suds container (to be referred herein also as "tub") is measured by means of a suitable sen-

sor. Usually a pressure sensor that is also used for the determination of the water level in the tub is used. Often the presence of foam (mixture of liquid and air) is measured through the buildup of pressure during washing or spinning or through a strongly slowed down decrease of pressure during the pumping-out of the tub.

[0008] The publication DE 102 34 472 A1 discloses a method for eliminating foam in a tub of an electronically controlled drum washing machine as a consequence of a program step, which is provided for removal of water from the tub, with a solution drain system, which is arranged at the base of the tub, with a liquid pump and with a sensor for determination of the height of the liquid present in the solution container, the sensor signal of which sensor is recorded during operation of the solution pump, wherein the gradients of pressure vs. time which are successive in the course of the sensor signal are measured and a foam treatment measure is initiated in the case of constantly reducing gradients. Preferably, the foam treatment measure consists of the feed of a specific amount of cold and/or warm water.

[0009] The publication DE 36 38 498 A1 discloses a program-controlled washing machine with a laundry drum which is drivable by a motor in wash and spin gear, and which is located inside a wash container. A measuring device in the form of a sensor is provided for identifying foam in the wash container, whereby output signals of the measuring device are an index of foam formation during the spinning process and represent control quantities for the drive motor of the laundry drum and hence for the control of the spin revolution count.

[0010] The publication DE 10 2006 027 197 A1 describes a method of eliminating foam in a solution container of an electronically controlled drum washing machine with a solution drain system, which is arranged at the base of the solution container, with a solution pump, with a sensor for determining a height of the liquid present in the solution container, the sensor signal of which sensor is recorded during operation of the solution pump, and a drum, wherein after a main washing process and pumping out of the liquid the following steps are performed: a) alternating rotation of the drum at a low rotational speed U_1 and stopping of the drum as well as pumping out of the liquid during a time period t_1 of 30 seconds to 15 minutes, b) letting in water in an amount sufficient to cover all water paths and rinsing during a short time period t_2 , wherein a level regulation takes place over a very small hysteresis, and c) pumping out of the liquid while the drum is moved at a low rotational speed U_2 .

[0011] The publication EP 0 724 036 A1 describes a clothes washing machine comprising a washing tub, a drum rotatably arranged within said tub and adapted to hold the washload, a discharge conduit provided underneath said tub, a pressure sensor means installed in an air chamber whose open portion is connected with the lower portion of said discharge conduit, said sensor means being adapted to detect the pressure of the water column acting on said lower portion of the discharge con-

duit, wherein said machine is arranged to perform at least a washing cycle comprising at least a rinsing phase, wherein it is further provided with processing and control means arranged to receive from said pressure sensor a signal corresponding to the pressure detected in said air chamber, and to periodically work out the mean value thereof.

[0012] The publication EP 0 997 570 A2 describes a method for the computer-assisted determination of clusters for recognizing foam formation in a washing machine, comprising the steps of: measuring a set of quantities during a washing process, the set of quantities having at least the quantities of a pressure in the washing machine, a temperature in the washing machine, an amount of water in the washing machine; forming training data vectors from the measured quantities; and identifying, dependent on the training data vectors, clusters which indicate if a foam formation is to be anticipated for a set of measured quantities. The method preferably comprises utilizing a fuzzy clustering method for determining the clusters.

[0013] The publication DE 10 2010 028 614 A1 discloses a pump device for a water-bearing household appliance, in particular for a laundry treatment device for washing and/or drying laundry, comprising a discharge pump, a power stage connected to said discharge pump, at least one detection unit which is used to detect at least one electric parameter of the discharge pump, and a control unit which controls the discharge pump by means of the power stage. Said control unit evaluates the electric parameters detected by the detection unit and influences the control of the discharge pump in accordance with the result of the evaluation.

[0014] The publication DE 10 2011 052 619 A1 discloses a method for determining an over-sudsing condition in a laundry treating appliance comprising multiple components for implementing a washing cycle of operation including: a tub for holding liquid, a drum defining a treating chamber rotatably mounted within the tub, a pressure sensor fluidly coupled to the tub and outputting a signal indicative of an amount of water in the tub, and a controller coupled to and controlling the components, including receiving the signal and implementing the cycle of operation, the method comprising: rotating the drum while the tub contains a foamable liquid; determining, over time, a fluctuation in the signal from the pressure sensor while the drum is rotating; determining an over-sudsing condition when the fluctuation satisfies a predetermined threshold; and altering the cycle of operation in response to the determination of an over-sudsing condition.

[0015] The publication DE 10 2007 042 968 A1 describes a method for detecting foam in a drum washing machine having a program controller for controlling a program sequence, a drum which is mounted rotatably in a liquor container, a water inlet system, a liquor outflow system which is arranged on the liquor container, a drive motor for the drum, and a sensor for determining a signal

of a fluid which is situated in the liquor container and optionally contains foam, wherein, while the drum is rotating at a high rotational speed U_n , a signal S_n is measured by the sensor and is compared with a value W_n which is assigned to this rotational speed U_n and is stored in the program controller, and wherein value pairs U_n and W_n ($n \geq 1$) are stored for at least two rotational speeds in the program controller and the presence of foam is registered if the value W_n is reached or exceeded, that is to say if the condition $S_n \geq W_n$ is met.

[0016] There are a number of disadvantages with the known processes. There might be measurement errors because an imbalance of laundry and residual water that accrues during the spinning phase might simulate an apparent increase in pressure. Due to the occurrence of pressure peaks, a presence of foam might be indicated even if there is none. This might arise because of fluctuations during the pressure measurement with a sensor, whereby the errors during signal recording, transfer or processing will also depend on whether a digital or analogous controller is being used. Moreover, the pressure signals measured by the sensor tend to increase with the rotational speed such that a set pressure value for the determination of the existence of foam might be prematurely exceeded.

[0017] The detection of foam in a drum washing machine (herein also abbreviated as "washing machine") can also be effected by means of a conductivity measurement in the lower part of the tub.

[0018] The publication DE 41 04 151 A1 describes a laundry treating machine with a control device for controlling the program flow, a drum rotatably arranged in a tub, a drive motor for the drum, a heating device as well as a device for the detection of foam, which comprises switching equipment that cause a switching on of the heating and/or a slow rotation of the drum. The device for the detection of foam is in particular designed as a device for the measurement of conductivity, pressure or a light barrier configuration.

[0019] Moreover, the publication DE 10 2008 028 030 A1 describes a process for the determination of foam in a tub using electrodes.

[0020] Against this background it was an object of the present invention to provide an alternative process for the detection of foam during a washing program performed in a washing machine. The detection of foam should be preferably possible in a simple, but yet accurate manner. An object of the invention is furthermore to disclose a washing machine suitable for performing this method.

[0021] In accordance with the present invention, this object is achieved by a process for the operation of a washing machine and a washing machine suitable for carrying out this process with the features of the independent claims. Preferred embodiments of the invention are detailed in the respective dependent claims, in the subsequent description or in the figures of the attached drawing. Preferred embodiments of the process corre-

spond to preferred embodiments of the washing machine, even if they are not referred to herein in detail.

[0022] The invention is thus directed to a process for the operation of a washing machine with a tub containing a drum for receiving laundry and a pressure sensor in contact with an aqueous liquid, a drive motor for the drum, a pump, and a control unit, wherein the presence of foam can be detected by a pressure change, wherein the following steps are carried out:

- (a) a washing phase is conducted with a suds containing water and detergent;
- (b) water is added during or after the washing phase (a) into the tub in an amount $Q \leq Q_{\text{set}}$, wherein Q_{set} is a prescribed maximum quantity of water to be added in this step;
- (c) a change of the pressure P is measured by the pressure sensor upon the addition of the water in step (b); and
- (d) the pressure change ΔP measured in step (c) is evaluated with respect to the presence of foam.

[0023] Since the presence of a certain amount of foam can often be tolerated, "evaluated with respect to the presence of foam" means especially an evaluation with respect to the presence of a non-tolerable amount of foam.

[0024] In step (b), water is added during or after the washing phase (a). Preferably, step (b) is carried out after the completion of step (a), i.e. immediately before a pumping out of the aqueous liquid. It is however possible to carry out the process of the invention additionally or alternatively during the washing phase of step (a) as well as at a later stage, i.e. even after a pumping out of suds after the washing phase.

[0025] In a preferred process, the addition of the amount Q of water is however effected before a pumping out of the aqueous liquid, for example suds, with the pump.

[0026] It is moreover preferred in the process of the present invention that a rotating drum is stopped before the addition of the amount Q of water. This allows that the drum and laundry go into a still state which is favorable in that the movement of the drum and the laundry would interfere with the pressure measurement and the judgment of the foam evolution. Preferably, the rotating drum is stopped for a term Δt_{stop} of from 1 to 10 sec before the addition of the amount Q of water.

[0027] In the process of the present invention it is preferred that the prescribed quantity Q_{set} of water is in the range of from 0,5 L to 5 L, based on a volume of the drum in the range of from 6 to 20 L. In this range the sensitivity and accuracy of the present method is best.

[0028] Although not wanting to be bound by the following explanation, it is assumed that the addition of water leads to a reduction of the free space, i.e. the space that is not occupied by laundry, aqueous liquid or foam, in the drum, thus leading to an increased pressure which can

be detected by the pressure sensor. This can be understood in a first approximation by referring to the ideal gas law, $P \cdot V / T = \text{constant}$, according to which a decrease in the volume V would lead to an increase in the pressure P . The effect of the pressure increase will be more pronounced when the volume V is comparatively small, as is the case when the free space in the drum before the addition of water in step (b) is comparatively small because of the presence of foam. Accordingly, the amount of foam can be assessed. It is to be understood that the determination of foam is more precise when the amount of laundry and aqueous liquid is known.

[0029] There are various ways to define the pressure change ΔP to be measured by means of the pressure sensor.

[0030] In a preferred embodiment, the pressure P is measured during the addition of the amount Q of water. This can be done for example by measuring the pressure P at the very beginning of the addition of water in step (b) and by measuring the pressure P at the end of the addition of water. The pressure change ΔP would then be calculated as the difference between the two measured pressure values. Its ratio $(\Delta P / \Delta T)$, i.e. the pressure change in time, is according to the present invention a very preferred indicator for the presence of foam. It is to be noted that the pressure P can be measured also more or less continually during step (b), for example every 1 sec or even at shorter times. When more pressure values P , and thus pressure gradients $(\Delta P / \Delta T)$, are measured during step (b) it is possible to disregard specific values that might result because of a disturbing event in the drum.

[0031] In any way, in a preferred embodiment of the present invention, the pressure change ΔP measured in step (c) is evaluated in step (d) with respect to the presence of foam by reference to a relationship between the ratio $(\Delta P / \Delta T)$ and a free space stored in the control unit of the washing machine.

[0032] In a preferred alternative embodiment, the pressure P is measured before and after the addition of the prescribed quantity Q_{set} of water.

[0033] The aforementioned considerations regarding a change of the pressure P measured with the pressure sensor are based on the assumption that the effect of temperature, in particular of a temperature difference between the added water on one side and the laundry and aqueous liquid on the other side can be neglected. However, in order to increase the accuracy of the foam determination it is preferred to take a temperature difference between the aqueous liquid, for example suds, and the added water into account in that the measured pressure difference ΔP is corrected for the effect of the temperature difference. To this end either known temperature values may be considered or one or more temperature sensors might be present, preferably in the washing machine, to measure the temperature of the added water and of the laundry/aqueous liquid, respectively. The temperature signals would then be in general transmitted to the control

unit to be taken into account for the determination of the presence of foam.

[0034] It might be possible that a large amount of foam is present in the drum such that it is not necessary or even detrimental to add the preset quantity Q_{set} of water. Accordingly, in a preferred embodiment of the present process, the addition of water in step (b) is stopped when a pressure ratio $P_r = \Delta P/P_{\text{start}}$ is greater than a set ratio $P_{r,\text{set}1}$, wherein P_{start} is the pressure value before the addition of the amount Q of water. The set ratio $P_{r,\text{set}1}$ would in general correspond to the presence of an unacceptable large amount of foam.

[0035] In general, the process of the present invention is not limited to a mere detection of foam as such. Namely, the presence of foam might in preferred embodiment be indicated to a user on a display device that is usually present. In addition or alternatively, measures for the reduction of the amount of foam are initiated when foam, more particularly too much foam, is detected. Often only the control of a rinsing phase after a washing phase is adapted to a detected amount of foam.

[0036] In the process of the present invention, it is thus preferred to initiate a foam removal or reduction measure after the addition of water is stopped.

[0037] Measures for the reduction of the amount of foam can be started in the washing machine automatically or on demand by a user of the washing machine. A preferred foam reducing method is to dilute the aqueous liquid by the addition of water or by a combination of pumping out the aqueous liquid and adding water. After the completion of such a foam reducing method it is preferable to repeat the foam detection process of the present invention.

[0038] There are also other methods for the reduction of the amount of foam, for example a reduced rotation program and/or a cooling-down of the suds. Moreover, periods may be inserted where the drum stands still until the concentration of foam has fallen off to an acceptable extent. In embodiments of the invention, foam could be fought against by heating the foam vesicles such that they are caused to burst.

[0039] When no foam is present or when the amount of foam in the tub is acceptable, an aqueous liquid, preferably suds, can be pumped out. Accordingly, in a preferred embodiment of the process of the present invention, the pump is started to pump out aqueous liquid, when after the addition of water in the amount of Q_{set} a pressure ratio $P_r = \Delta P/P_{\text{start}}$ is smaller than a set ratio $P_{r,\text{set}2}$, wherein P_{start} is the pressure value P before the addition of the amount Q of water.

[0040] It might occur that the pressure values P obtained immediately and very shortly after the addition of water in step (b) are inaccurate or not sufficiently reliable due to fluctuations. Accordingly, in a preferred embodiment of the process of the present invention, a first pressure value P_1 is measured after a preset time Δt_{set} has elapsed after the beginning of the water addition in step (b) and the pressure difference ΔP is determined by com-

parison of P_1 with at least one later determined pressure value P_2 . Preferably, the later determined pressure value P_2 is determined at the end of step (b).

[0041] The process of the present invention can be conducted especially beneficial when the quantity Q of added water, but also the quantity of the aqueous liquid is known precisely. To this end, a measuring device for the quantity Q of water filled into the tub can be used.

[0042] It is to be noted moreover that the value Q_{set} is in general set while considering the selected washing program, the type and/or amount of laundry in the drum that is to be washed.

[0043] For the stipulation of a suitable value for Q_{set} the laundry load can be advantageously taken into account. Namely, the laundry in the drum occupies already a certain space. Accordingly, foam generated will have less space available which might lead to a much quicker filling of the entire drum with foam. In a preferred process, the maximum quantity of water Q_{set} is thus set in dependence of the laundry load L_L , whereby a correlation between the laundry load L_L and Q_{set} such that Q_{set} decreases when the laundry load L_L increases is stored in the control unit. The laundry load can be set by a user of the washing machine or preferably be determined automatically. For example, the weight of the drum containing dry laundry can be measured. However, the laundry load L_L can be suitably measured in the context of the present invention by analyzing the suction behavior of the laundry in that the change of the hydrostatic pressure when water is filled into the tub at the beginning of a washing phase, i.e. in a wetting phase, is analyzed. Namely, a pressure sensor is already present in the washing machine of the present invention. The pressure sensor will measure the free aqueous liquid. Accordingly, the water amount which is sucked in by the laundry can be calculated as the difference between the amount of water filled into the tub in the wetting phase and the free aqueous liquid. The sucked in amount of water should be proportional to the laundry load L_L . The corresponding relationships between the hydrostatic pressure and the laundry load L_L will be preferably stored in the control unit.

[0044] The invention is moreover directed to a washing machine with a tub containing a drum for receiving laundry and a pressure sensor in contact with an aqueous liquid, a drive motor for the drum, a pump, and a control unit, wherein the presence of foam can be detected by a pressure change, wherein the control unit is adapted to carry out the following steps:

- (a) a washing phase is conducted with a suds containing water and detergent;
- (b) water is added during or after the washing phase (a) into the tub in an amount $Q \leq Q_{\text{set}}$, wherein Q_{set} is a prescribed maximum quantity of water to be added in this step;
- (c) a change of the pressure P is measured by the pressure sensor upon the addition of the water; and
- (d) the pressure change ΔP measured in step (c) is

evaluated with respect to the presence of foam.

[0045] The washing machine of the present invention can be a washing machine as such or a washer dryer, i. e. a machine that combines the functions of a dryer and a washing machine.

[0046] A washing machine is preferred wherein at least one temperature sensor is present to allow for the measurement of the temperature of the aqueous liquid in the tub and the water to be added in step (b), respectively. Preferably, corrected pressure values P and/or corrected pressure difference values ΔP are then stored in the control unit for various temperature values.

[0047] The water to be added in step (b) is usually supplied by a domestic water supply. Accordingly, the washing machine of the present invention has in general a water inlet system. The water added in step (b) can be fed through a detergent dispenser tray that is usually present in a washing machine. It is however possible to use also a separate water inlet system.

[0048] A washing machine used herein comprises in general also a heating device as well as a suds discharge system placed at the bottom of the tub, wherein the pump used in the present invention is usually placed. Moreover, the washing machine used herein usually comprises laundry agitators and/or scooping devices.

[0049] The washing machine of the present invention comprises in general also an optical and/or acoustic display device which allows the user of the washing machine the display of for example operational parameters and/or the expected duration of a treatment process conducted therein. Preferably, an optical display device is used. For the present invention, the display device might advantageously provide information on the presence and amount of foam in the tub through the display of a text or the flashing of light emitting diodes (LEDs) which might have also different colours. For example, the fact that a detrimental amount of foam is present might be indicated, and it might be especially displayed whether a washing phase is proceeding at a not too high foam concentration or not.

[0050] For the process of the present invention, knowing the amount (quantity) of water Q flowing into the tub is of importance. In the washing machine of the present invention there is thus in general a measuring device for the determination of the amount of water Q filled in, for example a time measuring device for the determination of the opening time of a feed valve for the water or a liquid amount measuring device for the measurement of the filled in amount of water.

[0051] The invention has numerous advantages. The process of the present invention can be used when other methods for detecting foam do not work. Foam can be detected in an early stage, in particular before a pumping out of suds after a washing phase or even during a washing phase. A process for the operation of a washing machine is provided wherein the presence of foam can be determined qualitatively and quantitatively in a simple

manner. In doing so, the presence of foam can be in principle detected precisely. By determining the presence of foam more precisely and in embodiments of the invention of an actual amount of foam in a washing program it can be firstly avoided that it comes to an oversudsing condition, which might come with a damage in an apartment caused by water. On the other hand an excessive use of rinsing water can be avoided which would be required if a surplus of detergent were to be removed from the laundry. Namely, a rinsing phase can be adapted to the presence of foam. In addition, the invention allows the fast implementation of measures against the foam with respect to the combatting of foam as such or with respect to overdosage of detergents.

[0052] The process of the present invention allows moreover the operation of a washing machine in a tolerance range for the amount of foam, since it is possible in embodiments of the present invention to adjust precisely when the amount of foam is too high. In doing this, the type and amount of laundry as well as its soiling can in principle be taken into account. Namely, the washing machine might conduct an entire prescribed washing program without any disturbance or change in program parameters even in spite of the presence of foam, if the amount of foam remains within a tolerated range.

[0053] The invention will be described below by referring to preferred embodiments shown in the Figures 1 to 3 of the attached drawing.

Fig. 1 shows a cross-section of a washing machine according to a first embodiment. Other embodiments are conceivable.

Fig. 2 shows as cross-section parts of a washing machine according to a second embodiment that are important for the present invention, here two detergent dispenser trays and two valves.

Fig. 3 shows the two detergent dispenser trays and two valves including corresponding siphons to demonstrate the effect of water addition when too much foam is present in the tub.

[0054] Fig. 1 shows in a schematic view the parts which are important presently for a first embodiment of a washing machine, in which the novel process specified herein can be carried out.

[0055] The washing machine 1 of Fig. 1 comprises a tub 2 in which a drum 3 is rotatably mounted and can be driven by a drive motor 5. The rotary axis 19 of the drum 3 is directed forward and upward from the horizontal at a small angle (e.g. 13°), so that easier access and a view of the inside of the drum 3 are provided. Laundry agitators 14 enable a distribution of the laundry 4 when the drum 3 is rotating. Scooping devices 17 on the inner surface of the drum 3 enable an intensive rinsing of the laundry 4 with an aqueous liquid, i.e. detergent containing suds or water 7.

[0056] The washing machine 1 also has a suds supply system which includes a water connecting fitting for the domestic water supply system 20, an electrically controllable valve 21 and a supply pipe 13 to the tub 2. The supply pipe can be routed, as shown here, via a detergent dispenser tray 12, from which the supply water can transport a detergent contained therein into the tub 2. The tub 2 contains moreover a heating device 16 for the heating of water or suds 7. The valve 21, and also the heating device 16, can be controlled by a control unit 8 depending on a washing program, which can be based on a time program and/or the achievement of certain measured values of parameters within the washing machine such as the suds level, suds temperature, speed of the drum, etc. within the washing machine 1. 9 means a motor-drum control unit which may determine and store for example a drum rotation speed, a drive motor current value and a time span in which the drum is rotated.

[0057] 6 means a pressure sensor for measuring the hydrostatic pressure in the tub 2. The hydrostatic pressure P results from the fluid level of the aqueous liquid 7 in the tub 2. Moreover, the washing machine 1 comprises a measurement device 15 for determining the amount of water filled into the tub, for example a meter for the amount of water or a flow measuring device. In the case of a flow measuring device, the amount of water which has been filled in is calculated in connection with the determined filling time. The flow can moreover be determined by measuring the time until a specified level is reached that corresponds to a specific amount of water. The determination of the filled in amount Q of water or the amount of water used in a measure against foam, after the presence of foam has been detected, allows a more precise operation of the process of the present invention and in embodiments also foam reducing measures. 18 means a pump for the pumping out of an aqueous liquid, in particular suds or water 7. 10 means a temperature sensor in the tub 2.

[0058] 11 refers to a display device which allows to display the result of the detection of existing foam and possibly of automatically initiated measures or of measures that may be initiated by a user of the washing machine. In addition, process parameters regarding a washing process that is carried out in the washing machine can be displayed on the display device 11, in particular the course of a washing program under optimum detergent usage and foam avoidance (for example representable by means of a green light emitting diode (LED)) or under non-optimum detergent usage and foam avoidance (for example representable by means of a red light emitting diode (LED)).

[0059] Fig. 2 shows as cross-section parts of a washing machine according to a second embodiment that are important presently, here two detergent dispenser trays 25, 26 and two corresponding valves 22, 23. Detergent will be in general flushed into a tub (not shown here in detail) via detergent dispenser trays. As a result of a washing process in the drum 3, laundry 4 as well as foam and

aqueous liquid 7 will occupy a certain volume. However, the air in a free space 24 can be affected by the addition of water in that the volume of the free space 24 will be decreased.

[0060] In the washing machine of this embodiment, two detergent dispenser trays 25, 26 are used that can receive water from a domestic water supply, not shown, through valves 22, 23. The two dispenser trays 25, 26 are connected by means of two corresponding siphons 27 and 28 with the drum 3. In this configuration, i.e. with two siphons, a pressure change upon addition a quantity Q of water would be comparatively large when there is a large concentration of foam, i.e. in a situation where a free space 24 would be very small. The consequences are shown in Fig. 3.

[0061] Fig. 3 shows the two detergent dispenser trays 25, 26 and two valves 22, 23 including corresponding siphons 27, 28 to demonstrate the effect of water addition in step (b) when too much foam is present in the tub. Namely in a phenomenon called "siphon break" the addition of water via a first valve 22 into the first detergent dispenser tray 25 (as shown by the straight arrow) results in a flow of water into the first siphon 27. As a consequence thereof and of a very small free space 24, an overflow of siphon water through the second siphon 28 would occur. The pressure change ΔP upon the addition of a quantity Q of water into the tub and thus the drum would be therefore comparatively high. This means that with such a configuration the sensitivity of the process of the present invention would be high. 18 refers to a pump for the pumping out of an aqueous liquid.

LIST OF REFERENCE NUMERALS

[0062]

- | | |
|----|--|
| 1 | Washing machine |
| 2 | Tub, suds container |
| 3 | Drum |
| 4 | Laundry |
| 5 | Drive motor |
| 6 | Pressure sensor |
| 7 | Aqueous liquid, suds (and possibly foam) |
| 8 | Control unit |
| 9 | Motor-Drum-Control unit |
| 10 | Temperature sensor |
| 11 | Display device |
| 12 | (Single) Detergent dispenser tray |
| 13 | Supply pipe (to tub); tubing to tub |
| 14 | Laundry agitators |
| 15 | Measurement device for determining the amount of filled in water |
| 16 | Heating device |
| 17 | Scooping device |
| 18 | Pump, liquid pump |
| 19 | Rotational axis |
| 20 | Domestic water supply |
| 21 | (electrically controllable) Valve |

- 22 Valve
- 23 Valve
- 24 Free space (above laundry, aqueous liquid, foam)
- 25 First detergent dispenser tray
- 26 Second detergent dispenser tray
- 27 First siphon
- 28 Second siphon
- 29 Aqueous liquid, water (in siphon)

Claims

1. Process for the operation of a washing machine (1) with a tub (2) containing a drum (3) for receiving laundry (4) and a pressure sensor (6) in contact with an aqueous liquid (7), a drive motor (5) for the drum (3), a pump (18), and a control unit (8), wherein the presence of foam can be detected by a pressure change, **characterized in that** the following steps are carried out:

- (a) a washing phase is conducted with a suds containing water and detergent;
- (b) water is added during or after the washing phase (a) into the tub (2) in an amount $Q \leq Q_{\text{set}}$, wherein Q_{set} is a prescribed maximum quantity of water to be added in this step;
- (c) a change of the pressure P is measured by the pressure sensor (6) upon the addition of the water in step (b); and
- (d) the pressure change ΔP measured in step (c) is evaluated with respect to the presence of foam.

2. Process according to claim 1, wherein the addition of the amount Q of water is effected before a pumping off of the suds with the pump (18).
3. Process according to claim 1 or 2, wherein a rotating drum (3) is stopped before the addition of the amount Q of water.
4. Process according to claim 3, wherein the rotating drum (3) is stopped for a term Δt_{stop} of from 1 to 10 sec before the addition of the amount Q of water.
5. Process according to any of claims 1 to 4, wherein the prescribed quantity q_{set} of water is in the range of from 0,5 L to 5 L, based on a volume of the drum (3) in the range of from 6 to 20 L.
6. Process according to any of claims 1 to 5, wherein the pressure p is measured during the addition of the amount q of water.
7. Process according to any of claims 1 to 6 wherein the pressure p is measured before and after the addition of the prescribed quantity q_{set} of water.

8. Process according to any of claims 1 to 7, wherein a temperature difference between the aqueous liquid and the added water is taken into account in that the measured pressure difference ΔP is corrected for the effect of the temperature difference.

9. Process according to any of claims 1 to 8, wherein the addition of water in step (b) is stopped when a pressure ratio $P_r = \Delta P / P_{\text{start}}$ is greater than a set ratio P_r^{set1} , wherein P_{start} is the pressure value P before the addition of the amount q of water.

10. Process according to claim 9, wherein a foam removal or reduction measure is initiated after the addition of water is stopped.

11. Process according to any of claims 1 to 8, wherein after the addition of water in the amount of Q_{set} the pump (8) is started to pump out aqueous liquid when a pressure ratio $P_r = \Delta P / P_{\text{start}}$ is smaller than a set ratio P_r^{set2} , wherein P_{start} is the pressure value P before the addition of the amount q of water.

12. Process according to any of claims 1 to 11 wherein a first pressure value P_1 is measured after a preset time Δt_{set} has elapsed after the beginning of the water addition in step (b) and the pressure difference ΔP is determined by comparison of P_1 with at least one later determined pressure value P_2 .

13. Process according to claim 11, wherein the later determined pressure value P_2 is determined at the end of step (b).

14. Process according to any of claims 1 to 10 wherein the maximum quantity of water Q_{set} in step (b) is set in dependence of the laundry load L_L , whereby a correlation between the laundry load L_L and Q_{set} such that Q_{set} decreases when the laundry load L_L increases is stored in the control unit (8).

15. Washing machine (1) with a tub (2) containing a drum (3) for receiving laundry (4) and a pressure sensor (6) in contact with an aqueous liquid (7), a drive motor (5) for the drum (3), a pump (18), and a control unit (8), wherein the presence of foam can be detected by a pressure change, **characterized in that** the control unit (8) is adapted to carry out the following steps:

- (a) a washing phase is conducted with a suds containing water and detergent;
- (b) water is added during or after the washing phase (a) into the tub (2) in an amount $Q \leq Q_{\text{set}}$, wherein Q_{set} is a prescribed maximum quantity of water to be added in this step;
- (c) a change of the pressure P is measured by the pressure sensor (6) upon the addition of the

water; and

(d) the pressure change ΔP measured in step

(c) is evaluated with respect to the presence of foam.

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Fig. 1

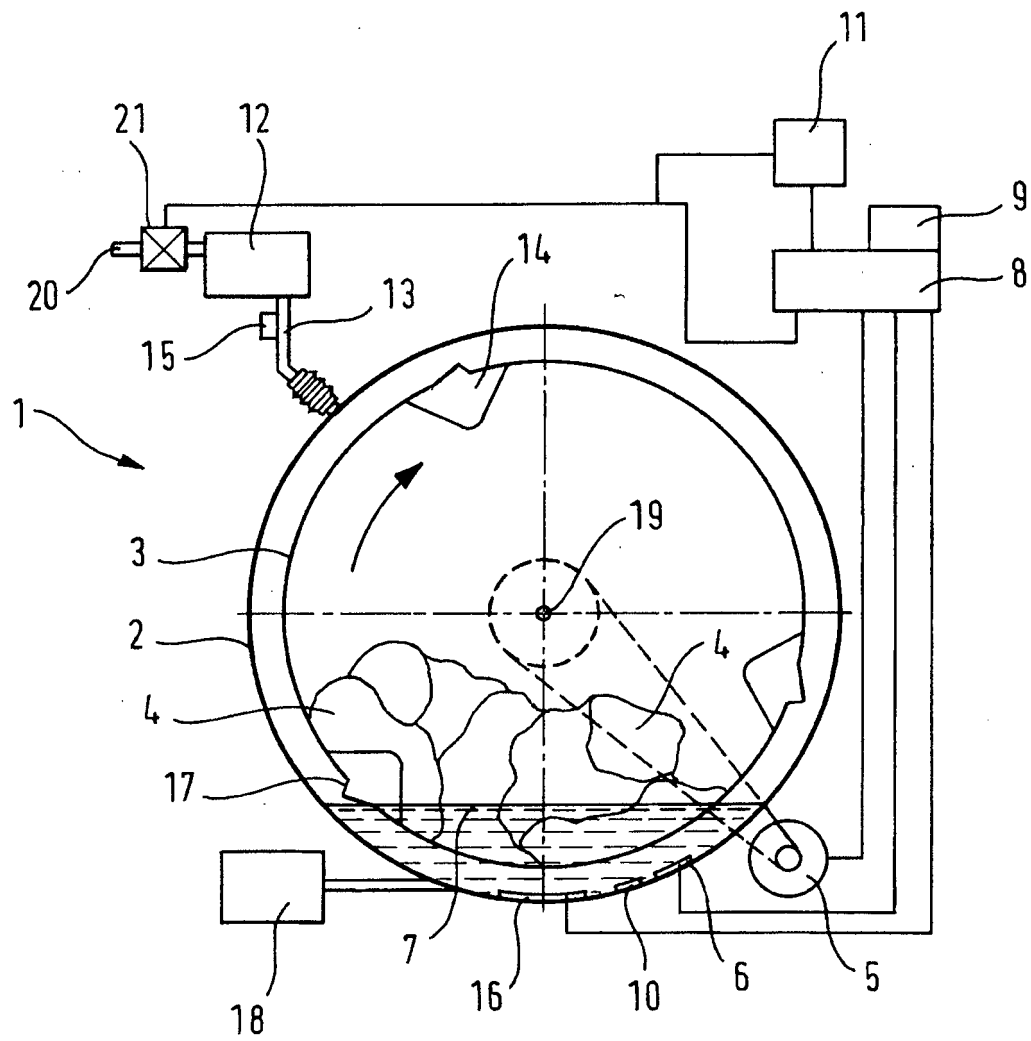


Fig. 2

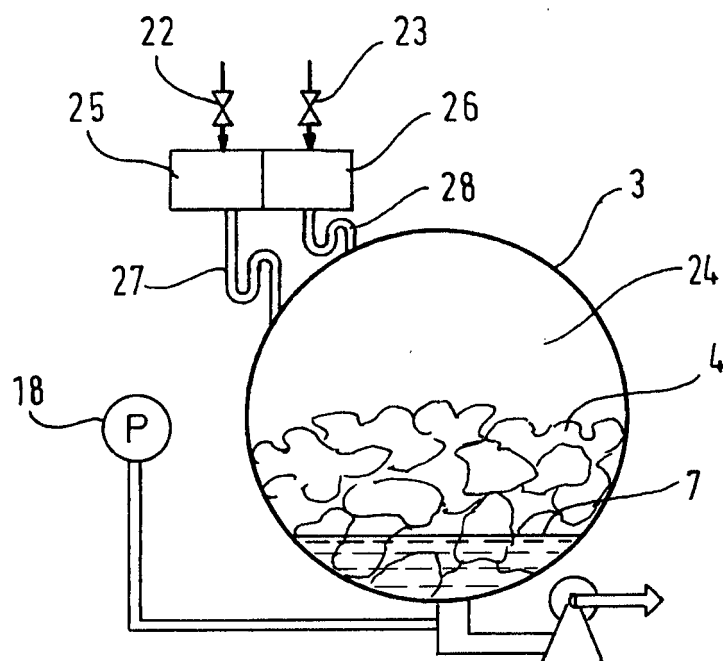
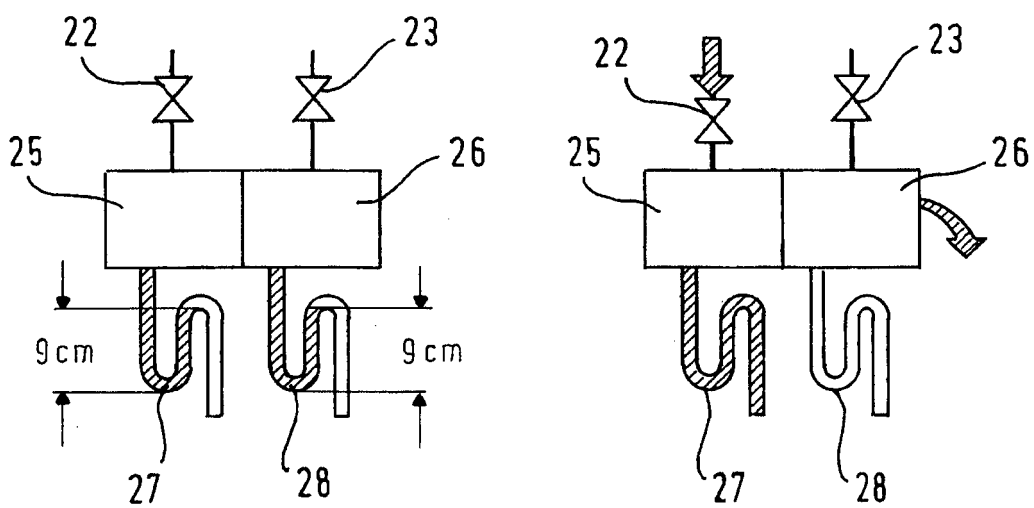


Fig. 3





EUROPEAN SEARCH REPORT

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