A METHOD TO CONTROL A WASHING MACHINE AND A WASHING MACHINE

The present invention relates to a method to control a washing machine (1), the washing machine including a tub (5) and a drum (6), the drum (6) being rotatably mounted inside the tub (5) and apt to contain laundry to be washed, the method comprising:

- setting a washing cycle among a plurality of washing cycles;
- calculating a first weight of the laundry in the drum before water is supplied to the drum and/or tub;
- comparing the first weight to a first threshold (T1);
- if said first weight is above the first threshold (T1), then the method further includes:
  i. introducing water into the tub;
  ii. calculating a second weight of the laundry present into the drum;
  iii. determining a parameter of the set washing cycle on the basis of said second weight, independently from the first weight;
  iv. washing and/or rinsing said laundry.

![Diagram](image-url)
The present invention relates to a method to control a washing machine and to a washing machine.

Commonly, a washing machine includes a tub where water is introduced, a drum which is rotatably mounted inside the tub to receive laundry, such as clothes, shoes, accessories etc., and a motor which generates a drive force to rotate the drum, thereby allowing washing to be performed via tumbling of laundry in the drum. For example, the laundry is tumbled along an inner wall of the drum during rotation of the drum.

Further, in such washing machines, a plurality of washing programs or washing cycles are generally available. Commonly, washing programs or cycles include a washing step to eliminate stains on laundry using water and preferably also a detergent, and a rinsing step to rinse the laundry.

The weight of the load which is introduced in a washing machine, that is, the weight of the laundry introduced in a drum of a washing machine, is a relevant parameter for the correct operations of the washing machine in a washing cycle. The weight of the laundry indeed may determine the correct amount of water and/or detergent which needs to be introduced inside the tub or drum during a washing step or the speed at which the drum should be rotated in order to wash the laundry properly or not to create imbalances and noises. Further, it may influence the overall duration time of the washing cycle.

On the other side, weighting the laundry with a weighing scale or the like is not a feasible step to be achieved in a washing machine, due to its construction and the presence of water. Further, the weighting of the laundry should not increase the costs of production of the washing machine in such a way that it may change the overall apparatus cost noticeably.

The problem to determine a correct weight of the laundry in a washing machine has been already considered in the prior art.

EP1423563 discloses a method for washing in a washing machine, which can measure an accurate washing load before actual washing is carried out. To do this, the present invention provides a method for controlling washing in a washing machine, including (a) introducing laundry into a drum of the washing machine, (b) measuring an initial washing load caused by the introduced laundry, (c) repeating water supply to the drum for a fixed time period for maintaining a minimum water level determined by the initial washing load, taking water absorbed to the laundry into account, (d) after the preset water supply time period, determining a final washing load in the drum based on a number of water resupply times for an elapsed time from the initial water supply, and (e) washing the laundry by a washing method preset according to the determined final washing load.

EP2871274 Describes a washing machine and control method thereof capable of accurately detecting the weight of laundry received in the washing machine by primarily detecting the weight of the laundry according to the driving of a motor before the beginning of a washing process and correcting the primary detected weight of laundry according to the number of supplies of water which is additionally supplied within a given time after main water supply is completed during the washing process.

However, there is a need of a method to control a washing machine, and a washing machine in which the weight determination is rather easy, realized in a relatively quick way and performed only when needed.

According to a first aspect of the invention, the invention relates to a method to control a washing machine, the washing machine including a tub and a drum, the drum being rotatably mounted inside the tub and apt to contain laundry to be washed, the method comprising:

- setting a washing cycle among a plurality of washing cycles;
- calculating a first weight of the laundry in the drum before water is supplied to the drum and/or tub;
- comparing the first weight to a first threshold;
- if said first weight is above the first threshold, then the method further includes:
  - introducing water into the tub;
  - calculating a second weight of the laundry present into the drum;
  - determining a parameter of the set washing cycle on the basis of said second weight, independently from the first weight;
  - washing and/or rinsing said laundry.

In the present context, a washing machine may indicate a "simple" washing machine where the washing of laundry is performed, or a combined washer dryer, where, in addition to the washing, drying of the laundry is performed.

The washing machine includes a drum where laundry is located, which can rotate around an axis by means of a motor. The axis of rotation of the drum can be horizontal, that is, substantially parallel to a surface where the appliance is located or slightly tilted to it, or vertical. Therefore, the washing machine might be a front loading washing machine or a top loading washing machine as well.

The washing machine further preferably comprises a casing, preferably but not necessarily parallelepiped-shaped, on which a door is advantageously hinged to access and close the drum in order to load or unload the laundry to be washed. The door is preferably hinged
on a front wall of the casing in case of a front loading washing machine, while it is hinged on a top wall of the casing in case of a top loading washing machine. [0014] Further, the washing machine is connected to a water supply, for example to the water mains, by means of suitable pipes which can be opened or closed, for example by a valve, in order to introduce water to the drum. One or more discharge pipes can be present as well in order to discharge water from the drum.

[0015] A drawer or other container is also preferably present and fluidly connected to the drum in order to introduce detergent into the drum itself, if needed during the laundry washing.

[0016] The washing machine may further include a control panel, for example located in an upper portion of the casing, where inputs or commands can be selected by an user, and/or information about the status of the washing machine can be displayed, for example by means of a display or one or more light indicators.

[0017] In operation, a washing machine include a plurality of washing programs or cycles. Each washing program preferably includes a washing step where the laundry is washed, such as tumbled, and a rinsing step, where the laundry is rinsed. The washing program may also include a spinning step where the drum is rotated at relatively high velocity. Further steps may be present as well, for example a pre-washing or others.

[0018] The various cycles may differ one from the others for the duration of the same, for the number or rinsing steps, for the temperature of the washing water, for the amount of detergent and so on.

[0019] The washing programs are preferably designed to treat laundry made of a specific textile type or composition or type of dirt or stain. For example, in a washing machine, a cotton cycle program at high temperature is generally present, as well as a delicate cycle program for delicate textiles (e.g. silk) at lower temperatures.

[0020] According to the invention, a washing program or cycle is set. The washing program or cycle is generally set either by a user operating on the control panel, for example by means of a switch, button, knobs and the like, or automatically, that is, a predefined washing program is stored on a memory of the washing machine and automatically selected when the appliance is switched on. Alternatively, the washing machine may “auto-select” the washing program among the available ones, for example all stored in a memory, depending on one or more characteristics of the laundry inserted in the drum, which are automatically detected.

[0021] The setting of a washing cycle predefines one or more of a plurality of parameters, that is, given the washing program, for example the duration of the same may be defined, as well as the type and quantity of detergent to be used, the temperature of the water, the amount of water to be used in washing, the amount of water to be used in rinsing, the revolution per minute of the drum, and others.

[0022] According to the invention, before water is introduced inside the drum and/or tub to wash the laundry, for example before the beginning of the washing cycle which has been set, a calculation of a first weight of the laundry introduced into the drum is performed. Such calculation takes place in any known manner, by means of a first weight sensor.

[0023] For example, the first weight sensor may be a mechanical sensor of the weight of the laundry, but it may also be a predictive algorithm calculating the first weight by statistical methods. This first weight calculation determines a certain value of the weight of the laundry introduced in the drum which is compared with a first threshold.

[0024] Preferably, the calculation of the first weight is relatively “rough”, that is, with a relatively low precision, and performed in a rather fast manner.

[0025] The first threshold is preferably comprised in a range between about from 1/5 to 3/5 of the maximum admissible laundry load. More preferably it is of about 2 kg. The first threshold therefore may depend on the type of washing machine, because not all washing machines have the same maximum load. Commonly, washing machines having a maximum load of 5 kg, 8 kg or 4 kg are known for household uses.

[0026] The first threshold is used to discern between a “heavy load”, that is, when the first weight is above the first threshold means that the laundry which is present inside the drum of the washing machine is “heavy”, or a “light load”, that is, when the first weight is below the first threshold then the laundry present inside the drum is “light”.

[0027] Relatively light loads, that is, loads that are below the first threshold, are not a big concern to be washed. Generally, if the weight of the laundry is not very high, the laundry can be relatively easily washed in a “standard” washing program cycle. Indeed, a good washing quality is generally achieved for light loads.

[0028] However, high loads may affect the functioning of the washing machine and pre-set washing programs may not be ideal for the correct washing of the laundry.

[0029] Changing all washing programs to be optimal in case of high loads would however create an excessive waste of resources or of time. Thus having all washing cycles optimized for high load is not preferred.

[0030] Therefore, according to the invention, only when the first weight is above the first threshold, a second weight of the laundry is calculated. This second weight is calculated after water has been introduced into the tub and/or drum. Dependingly from the second weight, and regardless of the value of the first weight, a parameter of the washing cycle which has been set is determined. Such parameter could be any, and it is chosen so as to optimize the set washing cycle when the load is “heavy”, that is, when the weight of the laundry is high. The parameter could be at the beginning set according to “standards”, for example according to a memorized value stored in a memory of the washing machine, and then updated as soon as the second weight is calculated and
In this way, the set washing cycle is adapted to

terminated.

ducing water in the tub:

threshold, then the method further includes, after intro-

ding water in the tub:

checking a level of water inside the drum; and

calculating a second weight of the laundry present

into the drum on the basis of the amount of water

needed to maintain a pre-set level of water in the

drum.

5

[0031] In this way, the set washing cycle is adapted to

the needs of the high load cycles, for example making

the cycle longer (adapted parameter = duration), or per-

forming more rinsing steps (adapted parameter = number

of rinsing steps). The parameter which is changed in the

washing cycle may vary and may depend on the cycle

itself.

[0032] In all cases, however, for the determination

of the parameter, only the second weight is taken into ac-

count, and not on the first weight. Thus errors in the first

weight calculation do not propagate.

[0033] In this way, a more accurate "investigation" of

the weight of the laundry is performed only when there

is a hint from the first weight calculation that the weight

is above the first threshold. If the weight is above such a

first threshold, the weight is calculated again, for example

preferably in a longer and/or more precise manner, and

the result of this second calculation is used to determine

a parameter of the washing cycle. Thus, before varying

a parameter of the washing cycle, it is determined wheth-

er the load is really "heavy", so that extra energy is used

only if needed. Further, the amount of data processing

is also minimized. The second weight is calculated only

when necessary and therefore when the first weight is

below the first threshold further calculations are avoided.

The washing cycle of heavy loads is therefore optimized

and a better quality is achieved.

[0034] Preferably, if said first weight is below or equal

to the first threshold, then the method further includes:

- determining a parameter of the set washing cycle

  on the basis of said first weight; and

- washing and/or rinsing said laundry.

[0035] If the weight of the laundry is not very high, that

is, if it is below the first threshold, no further investigation

of the weight are made and the initial, preferably "rough"

calculation is used to set for example one or more pa-

parameter of the washing cycle. The cycle in this way is

simpler because no further - preferably longer - second

calculation of the weight is needed and the initial, pref-

erably rapid, first calculation is enough. Indeed, light laun-

dry poses less problems, in general, than the heavy one

during the washing cycle.

[0036] Preferably, if said first weight is above the first

threshold, then the method further includes, after intro-

ducing water in the tub:

- determining an amount of water to be loaded into

  the drum during the set washing cycle.

[0037] The second weight calculation is preferably an

accurate calculation, that is, preferably more accurate

than the first calculation, and also it may last longer than

the first calculation in order to obtain the second weight

value. The second calculation is performed after the wa-

ter has been allowed into the drum, for example via an

inlet pipe, and it uses the amount of water introduced as

an indicator of the weight of the laundry. The level of the

water in the drum is thus checked as a measure of the

amount of water in it and of the amount of water absorbed

by the laundry. The variations of the water level due to

the absorbance of the water introduced in the drum by

the laundry are monitored and when these variations re-

main below a certain value, that is, when these variations

are "small", then the second weight is calculated.

[0038] Preferably, determining a parameter of the set

washing cycle on the basis of said second weight, inde-

pendently from the first weight, includes:

- determining the time duration of the set washing

  cycle.

[0039] One of the parameter of the set washing cycle

that is preferably influenced by the weight of the laundry

is for example the length or duration of the whole set

washing cycle. Therefore, if the first weight is above the

first threshold, the duration of the cycle is determined on

the basis of the second weight. Generally, the higher the

weight, the longer the duration of the set washing cycle.

[0040] Preferably, determining a parameter of the set

washing cycle on the basis of said first weight includes:

- determining the time duration of the set washing

  cycle.

[0041] As mentioned above, the weight of the laundry

may influence the optimal duration of the cycle, thus a

"pre-set" duration, such as the one stored in the memory

of the appliance might not be the optimal one for such a

high load. However in case of a light load, there is no

need to perform a second calculation of the weight and

thus the duration of the laundry is calculated on the basis

of the first weight only.

[0042] Advantageously, determining a parameter of

the set washing cycle on the basis of said first weight

includes:

- determining an amount of water to be loaded into

  the drum during the set washing cycle.

[0043] Depending on the weight, also the amount of

water to be introduced in the drum may vary. Preferably

the amount of water which depends on the weight of the

laundry is the water during the rinsing step. More prefer-

ably, the number of rinsing steps depend on the weight

of the laundry.

[0044] Preferably, if said first weight is below or equal

to the first threshold, then the method further includes:
The quantity of water which is introduced is preferably dependent on the set washing cycle. After the water has been introduced into the drum, in an amount which implies that the water is in contact with the laundry, variations of the level of the water inside the drums are calculated. The water inside the drum changes its level with time due to the fact that the laundry absorbs at least part of the introduced water. Thus, the level of the water changes from its initial level to a lower level after a certain time period. If the variations of the level are "small", that is, if the difference between the initial water level and a level after a predetermined amount of time are below a given value called second threshold, then the water introduction is stopped. However the variations are above such a second threshold, then the water is again introduced inside the drum and the level of the same is again monitored. If the variations of the level of the water remain below the above mentioned second threshold, then the water introduction is stopped, otherwise the cycle is again repeated. The variation of the water level is preferably calculated subtracting from the level of the water at the beginning of the pre-determined time interval, the water level at the end of the predetermined time interval. Preferably, during the water level monitoring the drum remains still, that is, it does not rotate. However, in a different embodiment of the invention, in order to monitor the water level, the drum is rotated during water introduction. The drum is rotated so that the water may be better absorbed by the whole laundry present in the drum.

Preferably, if said first weight is above the first threshold, the method includes the steps of:

- introducing in the drum a pre-determined amount of water;
- waiting a predetermined time interval;
- stopping water introduction if after said predetermined time interval a water level variation within said predetermined interval is below or equal to a second threshold;
- calculating a second weight of the laundry present into the drum on the basis of the amount of water added in the drum up to the stopping of water introduction.

In order to calculate the second weight, preferably a predefined amount of water is introduced in the drum. This amount is predefined and preferably depends on the set washing cycle. After the water introduction, the water level in the drum is checked, it is waited for a given time interval and after this time interval has elapsed, the level of water in the drum is checked again. A variation of the water level can be thus calculated, subtracting from the initial water level the end water level. If the laundry has absorbed so much water that the variation of the water level is above a third threshold, more water is introduced, again in a pre-defined amount, and the steps above are repeated, to check whether the water level variations are still "big", i.e. above the third threshold limit. As above, the water level may be monitored with or without drum rotations.

The time interval is set so that generally the laundry has absorbed all the water it can absorb within it, so that the level of water into the drum cannot get lower than a given value even if more time than the pre-set one elapses. In this way, the second weight can be determined on the basis of the amount of water absorbed by the laundry.

Preferably, said washing machine includes a motor driving the drum in rotation and calculating a first weight of the laundry in the drum before water is supplied to the drum and/or tub includes:

- calculating the first weight by detecting one or more parameters of the motor while the drum is rotating.

The drum is rotated by means of a motor, which may also control the drum velocity and the reversal of rotations, if needed. In order to calculate the first weight, which is calculated without the introduction of water into the drum, preferably parameters of the motor while it rotates the drum are calculated, for example sensed or detected by suitable sensor(s) which are commonly present in a washing machine for other purposes. One of these parameters can be for example the torque of the motor. However, one or more of the following can be used as well:

- Parameters indicative of the operating conditions of the motor driving the drum in rotation, such as a motor torque value and/or a power absorbed by the motor and/or a current absorbed by the motor;
- Speed or acceleration of the drum or number of times in which the drum reverses its rotation direction;
- Speed or acceleration of an agitator located in the drum to move the laundry located therein;
- Humidity of the laundry and variations thereof;
- Time from the beginning of the selected program and/or phase of the program which is taking place;
- Parameters indicative of operating conditions of mechanical elements of the appliance, like the opening or closing of valves, the activations of alarms and so on;
Preferably, said washing machine includes a motor driving the drum in rotation and calculating a first weight of the laundry in the drum before water is supplied to the drum and/or tub includes:

- Sensing a plurality of parameters concerning operating conditions of the washing machine; and
- Predicting a weight of the laundry present within the washing machine based on said plurality of parameters by means of a data-driven soft sensor.

The weight of the laundry in a laundry treatment appliance is a quantity that is either unmeasurable or costly/time-consuming to obtain. Therefore in the present invention a statistical model-based technology addressed to industrial environments that provide an estimate of such quantity is used. The primary purpose of sensors is to deliver data for process monitoring and control. In the context of process industry, predictive models are called Soft Sensors: term is a combination of the words "software", because the models are usually - but not necessarily - computer programs, and "sensors", because the models are delivering similar information as their hardware counterparts. Other common terms for predictive sensors in the process industry are inferential sensors, virtual sensor or on-line analyser and observer-based sensors.

Two different classes of Soft Sensors, namely model-driven and data-driven, can be distinguished. Model-driven models are also called white-box models because they have full phenomenological knowledge about the process background. In contrast to this purely, data-driven models are called black-box techniques because the model itself has no knowledge about the process and is based on empirical observations of the process. In between the two extremes there are many combinations of these two major types of models possible. A typical example of such a combination is a model-driven Soft Sensor making use of data-driven methods for the modelling of fractions which can not be modelled easily in terms of phenomenological models.

The present invention preferably uses a data driven model, being based on empirical data. Therefore a data-driven soft sensor is an inferential statistical model developed from process observations. The soft sensor, which normally operates using a software, might be embedded in the control unit of the appliance. The same control unit - as already stated - preferably controls also the appliance during its functioning, that is, during the execution of the selected laundry program, for example sending command signals to the motor of the drum and to the other components participating in the correct functioning of the appliance. For example, in a heat pump dryer, the control unit sends command signals to the heat pump. In this way, making use of values from sensors which are already available in the appliance for other purposes, and the same processor already used to control the proper functioning of the appliance, the weight of the laundry introduced inside the washing machine is predicted. This prediction is obtained by means of a statistical method by means of a soft sensor which is data driven. The operation of "training" the soft sensor is preferably performed in the production site. Without adding further elements (such as a new sensor) to the appliance, a prediction of the weight of the laundry is obtained.

Preferably, said step of predicting a weight of the laundry by means of a data driven soft sensor includes a step of predicting a weight of the laundry by means of a supervised learning prediction.

In supervised learning, from input data (in this case the values of the operating conditions of the appliance) are used to predict an output value (in this case the weight of the laundry).

In supervised learning, input data is called training data. A model is prepared through a training process where it is required to make predictions and is corrected when those predictions are wrong. The training process continues until the model achieves a desired level of accuracy on the training data. Preferably, the soft sensor of the invention uses a supervised learning method, that is a learning task of inferring a function from labelled training data. The training data consist of a set of training examples. In supervised learning, each example is a pair consisting of an input object (typically a vector) and a desired output value (also called the supervisory signal). A supervised learning algorithm analyses the training data and produces an inferred function, which can be used for mapping new examples.

In the present invention therefore, preferably the soft sensor uses the operating conditions of the appliance during the selected program and the output value includes the weight of the laundry present in the drum of the laundry treatment appliance. This is done after the algorithm had been properly trained by the training examples which are data collected in field tests of the appliance.

Preferably, determining a parameter of the set washing cycle on the basis of said second weight, independently from the first weight, includes one or more:

- determining said parameter also on the basis of a selected washing and program;
- determining said parameter also on the basis of a hardness of introduced water in the washing;
- determining said parameter also based on an amount of dirt included in the laundry;
- determining said parameter also based on a colour of the laundry;
- determining said parameter also based on a fabric type of said laundry.

The parameter of the set washing cycle which is determined using the value of the second weight may
It is known that a user prefers to receive information about the status of the washing cycle. One of these desired information is the duration of the washing cycle. So, if the first weight is below the first threshold, the duration of the washing cycle is determined by the first weight (the second weight is not calculated) and thus such information is visualized to the user, for example by means of a display.

Preferably, if said first weight is above the first threshold, then the method further includes:
- determining a parameter of the set washing cycle on the basis of said first weight; and
- displaying said first duration on a display.

More preferably, if said first weight is above the first threshold, then determining a parameter of the set washing cycle on the basis of said first weight includes
- determining a first duration of said selected washing cycle on the basis of said first weight;
- displaying said first duration on a display;
and updating said parameter on the basis of said second weight, independently from said first weight.

More preferably, if said first weight is above the first threshold, then determining a parameter of the set washing cycle on the basis of said first weight includes
- determining a second duration of said set washing cycle on the basis of said second weight;
- updating said display displaying said second duration.

Due to the fact that the first weight calculation is performed rather fast, while the second weight calculation is relatively slow, in order to give immediately some feedback to the user, some parameters of the washing cycle are already calculated just after the first weight calculation and for example displayed. One of such parameters could be for example the duration of the washing cycle. When the more accurate weight calculation is obtained so that the value of the second weight is available, then the parameter is updated so that the user can see the correct parameter and rely on it.

The update could also result in keeping the parameter equal to what it had been determined using the first weight. For example, the duration calculated using the first weight could be identical to the duration calculated using the second weight.

Preferably, the method according to the invention includes:
- inputting a preferred duration of the set washing cycle;
- determining a duration of said set washing cycle on the basis of the first or second weight and on the basis of the preferred inputted duration.

In an embodiment, the user may introduce some constraints to the set washing cycle, that is, it may determine the "wished value" of certain parameters of the set washing cycle. One of such parameters can be for example the duration of the washing cycle.

If the duration of the washing cycle as determined using the first or second weight is longer than what has been inputted by the user, then preferably the "wish duration" inputted overrides the calculated duration determined using the first or second weight. If the duration of the washing cycle as determined using the first or second weight is shorter than what has been inputted by the user, then preferably the duration which has been calculated using the first or the second weight overrides what it has been inputted and it will be the real duration of the washing cycle. In other words, the real duration is preferably the shorter between the inputted and the calculated ones.

Preferably, said washing machine is a front loading washing machine.

Preferably, the step of calculating the first weight lasts less than 1 minute.

The first weight calculation, from its beginning to its end, that is, till the results is outputted, lasts less than a minute, for example about 30 seconds. Preferably, the first weight calculation is performed before the washing cycle starts. It is a relatively "fast calculation", where speed prevails preferably over accuracy.

Preferably, the step of calculating the second weight lasts less than 30 minutes.

The second weight calculation lasts generally longer than the first weight calculation, and it is also preferably more accurate. The second weight calculation has a duration which may also depends on the type of laundry, that is for example the longest duration calculated is for a cotton washing cycle.

According to a further aspect, the invention relates to a washing machine including:
- a tub;
The present invention will now be described with reference to the accompanying drawings that illustrate non-limiting embodiments thereof, wherein:

- a drum, the drum being rotatably mounted inside the tub and apt to contain laundry to be washed;
- a water inlet apt to introduce water into the tub and/or the drum;
- a first weigh sensor apt to calculate a first weight of the laundry;
- a second weight sensor apt to calculate a second weight of the laundry;
- a control panel;
- a memory storing information about one or more washing cycles;
- a control unit programmed for
  - obtaining a value of the first weight of the laundry from the first sensor before water is supplied to the drum and/or tub through said water inlet;
  - comparing the first weight to a first threshold;
  - if said first weight is above the first threshold, then obtaining the second weight of the laundry present into the drum from the second sensor after water has been introduced into the drum;
  - determining a parameter of the selected washing cycle on the basis of said second weight, independently from the first weight.

The advantages of this aspect of the invention have been already described with reference to the first aspect and they are not herein repeated.

Preferably said first weight sensor is a soft sensor.

Preferably said first sensor includes a motor torque sensor.

The present invention will now be described with reference to the accompanying drawings that illustrate non-limiting embodiments thereof, wherein:

- Fig. 1 is an isometric view of the washing machine of the invention;
- Fig. 2 is a further isometric view of the washing machine of figure 1 with the casing made transparent in order to show its inner components;
- Fig. 3 is an isometric view of the washing machine of figure 2; and
- Fig. 4 is a flow chart of the various steps of the method of the invention.

The following description refers to an advantageous embodiment of the invention in which the washing machine 1 is a "standard washing machine" with no drying functionality (i.e. a washing machine which can only wash and rinse the laundry).

However it is clear that the invention can be applied as well to washer - dryers (i.e. a washing machine which can also dry the laundry), not illustrated.

The washing machine 1 according to the invention which is schematically illustrated in the enclosed Figures is advantageously of the front-loading type; it is however clear that the invention is applicable, substantially without any crucial modification, to a top-loading washing machine.

With reference to Figures 1 to 3, the washing machine 1 comprises an external casing 2 in which frontal wall 2a an access opening 3 is obtained, provided with a loading/unloading door 4, which allows the access to a washing tub 5 contained in the external casing 2; the washing tub 5 contains a rotatable perforated drum 6 in which the laundry to be washed, not depicted in the drawings, can be loaded and unloaded. In this advantageous embodiment the drum 6 embodies, therefore, a treating chamber in which one or more items (pieces of laundry in this advantageous embodiment) can be loaded and treated with water and one or more additives (washing/rinsing products in this advantageous embodiment). The rotational axis of the drum 6 is substantially horizontal.

The washing tub 5 is connected to the external casing 2 preferably via a flexible bellows, not represented, connected between the frontal, opened, surface of the washing tub 5 facing the access opening 3, and the border of the latter.

In the example illustrated, the washing tub 5 is advantageously elastically supported by the external casing 2 via a suitable resilient support system, comprising, for example, springs 8; preferably the oscillations of the washing tub 5 are damped by suitable shock-absorbing devices or dampers 9, interposed between the washing tub 5 and the bottom of the casing 2.

Clearly, the washing tub 5 may be associated to the casing 2 in any other suitable way.

Advantageously, the washing machine 1 comprises a water inlet circuit, not visible in the figures, adapted for feeding water and washing/rinsing products, into the washing tub 5; the water inlet circuit comprises, for example, a removable drawer 19, adapted to be filled with washing and/or rinsing products, e.g. liquid or concentrate or gel detergent, or powder detergent, or softer, an inlet duct, also not represented, connectable to water delivery means present outside the washing machine 1 and adapted to deliver fresh water to the drawer 19 and/or to the tub, and an outlet duct, fluidly connecting the drawer 19 and the washing tub 5 and adapted to deliver water and washing/rinsing products into the washing tub 5.

The washing machine 1 also advantageously
The washing machine 1 advantageously comprises an electric motor 11 for rotating the rotatable drum 6, a valve (not shown) adapted to deliver the washing/rinsing liquid into the washing tub 5, an electric pump (not shown) adapted to drain and/or to recirculate the washing/rinsing liquid from the washing tub 5, an electric heater (also not shown) adapted to heat the washing/rinsing liquid, etc.

[0093] The drum 6 is advantageously rotated by the electric motor 11 which preferably transmits the rotational motion from a motor shaft 24 to the drum 6, advantageously by means of a belt/pulley system 29. In a different embodiment of the invention, the motor 11 can be directly associated with the shaft 24 of the drum 6.

[0094] The washing machine 1 advantageously comprises a logic unit (for example an electronic board, a microcontroller, a microprocessor, or any other similar electronic control unit/device), schematically indicated in Figure 1 with the block numbered 12, configured to control the electric and/or electronic components of the washing machine 1, so as to make the washing machine 1 to perform a washing cycle, advantageously comprising one or more phases; for example the washing cycle may comprise a prewash phase, a soaking phase, a main washing phase (comprising, for example, the addition into the washing tub 5 of water mixed with detergent and the rotation of the drum 6, so as to apply a mechanical action on the laundry), a steam supplying phase, a rinsing phase, a spinning phase, etc. The washing cycle may comprise one or more of the above mentioned phases (or also other phases well known in the art) adapted to apply to the laundry to be washed a specific chemical and/or physical action. A phase of the washing cycle may be performed, during a single washing cycle, only once or also two or more times. Clearly the duration of the overall washing cycle depends on the kind, on the number, and on the duration of its phases.

[0095] Each washing cycle is defined by a plurality of parameters, which are for example stored in a memory of the control unit 12. These parameters may include the duration of the cycle, the water temperature during the main washing phase, the number of rinsing phases, and so on. Thus, when a program among the plurality is set, a plurality of parameters is set as well.

[0096] The washing machine 1 is also provided with a first weight sensor, schematically represented in Figure 1 with the block numbered 13, which is configured to detect/measure the weight of the laundry loaded in the rotatable drum 6. For example, the weight sensor 13 may comprise one or more transducers, operatively connected to the logic unit 12; the transducers may comprise, for example, a load cell or a strain gauge and can be associated with the resilient support system 8, 9 supporting the washing tub 5, as for example depicted in figure 2. More preferably, the first weight sensor 13 is a soft sensor measuring the weight of the laundry by means of an algorithm. Most preferably, it is part of the control unit 12.

[0097] However, it is underlined that the use of a particular first weight sensor 13 is not critical for the invention, and therefore substantially any device adapted to measure the weight of the laundry loaded into the rotatable drum 6 may be used. In all cases, the first weight sensor 13 is apt to measure a weight of the laundry when the laundry is in a dry state, that is, before water is introduced inside the drum 6.

[0098] The washing machine 1 comprises an user interface 14, which is operatively connected to the logic unit 12 and is configured to allow the user to manually set a washing cycle to be performed. Alternatively, the washing cycle can be set automatically.

[0099] User interface 14 may comprise, for example, a touch screen display, adapted to display information and to receive inputs from the user, and or it may comprise a one or more buttons, and/or switches, and/or knobs, and/or displays, etc. allowing the user to receive information and to input instructions/commands directed to the logic unit 12.

[0100] The user, by means of the user interface 14, may program the washing machine 1 with one or more parameters indicating his/her "wish values" for them. That is, when the washing program or cycle is set, the user may change some of the pre-memorized values of these parameters by inputting its wished value from the user interface 14. These user's inputs overrule the standard memorized values for the parameters.

[0101] User interface 14 may be further configured to display user information; this information may comprise the name of a particular washing cycle, the weight of the loaded laundry, the duration of the washing cycle, the temperature of the washing/rinsing liquid, the rotating speed of the spinning, etc. More in general the user interface 14 is designed to present information related to the washing cycle and/or the status of the washing machine 1 and even more preferably it is designed to display the duration of the washing cycle.

[0102] In the embodiment illustrated in the enclosed Figures, the user interface 14 advantageously comprises a display device, preferably a LCD or a LED display, designed to present user information, and a separated input device, not illustrated, comprising for example a keyboard, and/or a set of keys or knobs, and/or one or more touch-sensitive input devices, etc., adapted for setting a
washing cycle and washing-product information.

[0103] In another embodiment, not illustrated, the logic unit 12 may be advantageously integrated in the user interface 14.

[0104] Further, the washing machine includes a second weight sensor 16 apt to measure a weight of the laundry in the wet state. As for the first weight sensor, this second weight sensor 16 can be any as long as it is apt to measure the weight of the laundry when it is wet. This second weight sensor 16 can also be a soft sensor, that is, an algorithm, and can be part of the logic unit 12, as depicted in figure 2.

[0105] A method of controlling the washing machine 1 will be described in more detail as follows, with reference to figure 4. First, a washing program or cycle among the stored plurality is set in the washing machine in step 1F. Such program or cycle may be inputted by the user. Given the set washing cycle, a plurality of parameters of the same is set, the values of which may be changed according to the method of the invention. The user may also indicate a value of one or more of these parameters of the washing cycle in step 2F, such as "washing parameters values". The inputs of the user therefore may change in step 2F the initially pre-determined memorized values of the parameters of the set washing cycle. Parameters relative to the set washing cycle may be displayed on the display of the control panel 14 in the step 3F, such as for example the duration of the set washing cycle. The value displayed is either the "standard" value, that is, the value as stored in the memory and considered to be the default value for the set washing program, or the value of the parameter as modified by the user in step 2F. In case the parameter displayed is the duration of the cycle, from this moment for example the countdown of the visualized value begins so at any point in time the user is aware of the remaining duration of the washing cycle watching the display of the user interface 14.

[0106] Further, the weight of laundry is detected, before the water is introduced into the drum, by means of the first weight sensor 13 in step 4F. For example, the first weight value can be calculated driving the motor 11 to accelerate the drum 6 accommodating laundry to a certain speed and then measuring the torque and using a predictive algorithm.

[0107] The value of the first weight is used to calculate a parameter of the washing cycle, for example the parameter visualized in the display of the user interface 14, for example the duration of the washing cycle. In case the first weight calculation gives a result which is already indicated that the parameter which has been visualized in phase 3F needs to be modified by the new value calculated on the basis of the first weight, the value on the display can be updated in phase 5F. The visualized parameter(s) therefore may have a "sudden jump" from one value to the other, that is, from the pre-set memorized value that the set program cycle refers to in a memory of the washing machine, to a new value which is based on the first weight value.

[0108] Then, preferably still before water is admitted into the drum 6, it is checked whether the first weight value is above or below a given threshold T1 in phase 6F.

[0109] In case the first weight is below threshold T1, a "light" load is present in the drum 6 and no need for other weight calculation is present. The washing process begins, main water supply is executed to supply water into the drum 6 (wash water) until a target water amount for washing set according to the set washing cycle. The amount of water is preferably big enough that the laundry is in contact to the water. A first level of water inside the drum is reached and it is measured. However, this first water level is lowered as laundry absorbs water in the drum 6. If after a pre-determined time interval, the laundry has absorbed so much water that the difference between the new - second - water level at the end of the predetermined time interval and the first water level is above a given value considered as a threshold, water supply to additionally supply water is executed accordingly. The water is not supplied anymore if after the pre-determined time interval the difference between the first level and the second level water is below the selected threshold. The water amount which is introduced in the laundry at the beginning preferably depends on the set washing program or cycle.

[0110] After the introduction of the water loading in 7F, the washing and/or rinsing process can proceed in step 8F. The parameter displayed may slowly change as the washing process proceeds, for example in case of a display of the duration of the cycle, the remaining time till the end of the cycle is continuously updated in a countdown manner.

[0111] If the first weight is above the first threshold T1, then a "heavy load" is present inside the drum and a more accurate evaluation of the weight of the laundry is performed by means of the second weight sensor 16 in step 9F. To perform this calculation, a pre-defined amount of water is preferably introduced into the drum 6. The water level is lowered as laundry absorbs water. If after a pre-determined time interval, the laundry has absorbed so much water that the difference between a first water level at the beginning of the predetermined time interval and a second water level at the end of the predetermined time interval is above a given value considered as a threshold, water supply to additionally supply water is executed accordingly. The water is not supplied any more if after the pre-determined time interval the difference between the first and second level is below the threshold.

[0112] Since weight of laundry is proportional to an amount of absorbing water from laundry, the weight of laundry may be determined according to the number of water resupplies, in each of which a known amount of water is introduced in the drum. That is, since the number of water resupplies varies according to weight of laundry, the second weight of the laundry can be calculated in a more precise manner. Alternatively, not only the number of water resupplies is used to calculate the load of the laundry, but also the time the water takes to maintain the
desired water level.

[0113] The same parameter which has been determined using the first weight is then recalculated, for example the duration of the washing cycle. The second calculation of the same parameter is totally independent from the previously obtained value of the first weight. The value of the parameter of the washing cycle, not re-calculated, may remain the same or may change. In case it changes, then also the display is updated with the new value of the parameter, which is optimized for washing cycles in which there is a heavy load. For example, the display may show a new time duration of the cycle, and the visualized value may perform a non-continuous "jump" from the previously displayed value obtained on the basis of the first weight to a new value obtained on the basis of the second weight. This takes place in step 10F. After the second weigh calculation and the determination of the parameter, the washing and rinsing of the laundry takes place in step 11F.

[0114] The value of the same parameter which has been determined using the first and the second weight may also be modified by other information regarding the washing cycle or the operative condition of the washing machine 1, or by the "wished value" inputted by the user.

[0115] The invention thus conceived can be subjected to numerous modifications and variants all falling within the scope of the inventive concept. In addition, all details can be replaced by other technically equivalent elements. In practice, the disclosed method, as well as the components of the washing machine may vary depending on the requirements without departing from the scope of protection of the following claims.

Claims

1. A method to control a washing machine (1), the washing machine including a tub (5) and a drum (6), the drum being rotatably mounted inside the tub and apt to contain laundry to be washed, the method comprising:

- setting a washing cycle among a plurality of washing cycles;
- calculating a first weight of the laundry in the drum before water is supplied to the drum and/or tub;
- comparing the first weight to a first threshold (T1);
- if said first weight is above the first threshold, then the method further includes:

• introducing water into the tub;
• calculating a second weight of the laundry present into the drum;
• determining a parameter of the set washing cycle on the basis of said second weight, independently from the first weight;

• washing and/or rinsing said laundry.

2. The method according to claim 1, wherein, if said first weight is below or equal to the first threshold, then the method further includes:

- determining a parameter of the set washing cycle on the basis of said first weight;
- washing and/or rinsing said laundry.

3. The method according to claim 1 or 2, wherein if said first weight is above the first threshold, then the method further includes, after introducing water in the tub:

- checking a level of water inside the drum; and
- calculating a second weight of the laundry present into the drum on the basis of the amount of water needed to maintain a preset level of water in the drum.

4. The method according to any of the preceding claims, wherein determining a parameter of the set washing cycle on the basis of said second weight, independently from the first weight, includes:

- determining the time duration of the selected washing cycle.

5. The method according to any of the preceding claims, wherein determining a parameter of the selected washing cycle on the basis of said first weight includes:

- determining the time duration of the set washing cycle.

6. The method according to any of the preceding claims when dependent on claim 2, wherein determining a parameter of the set washing cycle on the basis of said first weight includes:

- determining an amount of water to be loaded into the drum during the set washing cycle.

7. The method according to any of the preceding claims, wherein, if said first weight is below or equal to the first threshold, then the method further includes:

- introducing in the drum a predetermined amount of water;
- waiting a predetermined time interval; and
- stopping water introduction if after said predetermined time interval a water level variation within said predetermined interval is below or equal to a second threshold.

8. The method according to any of the preceding claims
when dependent on claim 3, wherein, if said first weight is above the first threshold, the steps of:

- introducing water into the tub;
- checking a level of water inside the drum;
- calculating a second weight of the laundry present into the drum on the basis of the amount of water needed to maintain the level of water in the drum;

include:

- introducing in the drum a predetermined amount of water;
- waiting a predetermined time interval;
- stopping water introduction if after said predetermined time interval a water level variation within said predetermined interval is below or equal to a third threshold;
- calculating a second weight of the laundry present into the drum on the basis of the amount of water added in the drum up to the stopping of water introduction.

9. The method according to any of the preceding claims, wherein said washing machine includes a motor driving the drum in rotation and calculating a first weight of the laundry in the drum before water is supplied to the drum and/or tub includes:

- calculating the first weight by detecting one or more parameters of the motor while the drum is rotating.

10. The method according to any of the preceding claims, wherein said washing machine includes a motor driving the drum in rotation and calculating a first weight of the laundry in the drum before water is supplied to the drum and/or tub includes:

- sensing a plurality of parameters concerning operating conditions of the washing machine; and
- predicting a weight of the laundry present within the washing machine based on said plurality of parameters by means of a data-driven soft sensor.

11. The method according to one or more of the preceding claims, wherein determining a parameter of the selected washing cycle on the basis of said second weight, independently from the first weight, includes one or more:

- determining said parameter also based on a characteristic of the set washing cycle;
- determining said parameter also based on a hardness of introduced water in the washing;
- determining said parameter also based on an amount of dirt present in the laundry;
- determining said parameter also based on a colour of the laundry;
- determining said parameter also based on a fabric type of said laundry.

12. The method according to any of the preceding claims when dependent on claim 2, wherein, if said first weight is below or equal to the first threshold, determining a parameter of the selected washing cycle on the basis of said first weight further includes:

- determining a duration of said set washing cycle on the basis of said first weight; and
- displaying said duration on a display.

13. The method according to any of the preceding claims, wherein, if said first weight is above the first threshold, then the method further includes:

- determining a parameter of the set washing cycle on the basis of said first weight; and
- updating said parameter on the basis of said second weight, independently of said first weight.

14. The method according to claim 13, wherein, if said first weight is above the first threshold, then determining a parameter of the set washing cycle on the basis of said first weight includes

- determining a first duration of said selected washing cycle on the basis of said first weight; and
- displaying said first duration on a display;

and updating said parameter on the basis of said second weight, independently of said first weight, includes

- determining a second duration of said set washing cycle on the basis of said second weight, independently of said first weight; and
- updating said display displaying said second duration.

15. A washing machine including:

- a tub;
- a drum, the drum being rotatably mounted inside the tub and apt to contain laundry to be washed;
- a water inlet apt to introduce water into the tub and/or the drum;
- a first weigh sensor apt to calculate a first weight of the laundry;
a second weight sensor apt to calculate a second weight of the laundry;
• a control panel;
• a memory storing information about one or more washing cycles;
• a control unit programmed for
  • receiving information about a set washing cycle;
  • obtaining a value of the first weight of the laundry from the first sensor before water is supplied to the drum and/or tub through said water inlet;
  • comparing the first weight to a first threshold;
  • if said first weight is above the first threshold, then obtaining the second weight of the laundry present into the drum from the second sensor after water has been introduced into the drum;
  • determining a parameter of the set washing cycle on the basis of said second weight, independently from the first weight.
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