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(54) **Method for operating a washing appliance and washing appliance implementing the same**

(57) A first aspect of the present invention is relative to a method for operating a washing appliance, such as a washing machine or a combined washer-dryer, comprising a washing chamber (12) to wash goods according to a wash program selected by a user including at least a washing cycle, wherein the method includes adding (110,120) a detergent to a washing liquor (15) which is circulating within the washing chamber (12) during a washing phase of the washing cycle; performing (130) a plurality of measurements ($C_1, C_2, C_3 \dots C_n$) of the conductivity of the washing liquor (15) in order to collect a set of conductivity measurements ($C_1, C_2, C_3 \dots C_n$); analyzing (150) at least part of the set of conductivity measurements ($C_1, C_2, C_3 \dots C_n$) in order to determine if a condition of substantial invariability of the conductivity measurements ($C_1, C_2, C_3 \dots C_n$) is reached; and starting to heat (170) the washing liquor (15) when said condition of substantial invariability of the conductivity measurements ($C_1, C_2, C_3 \dots C_n$) has been reached.

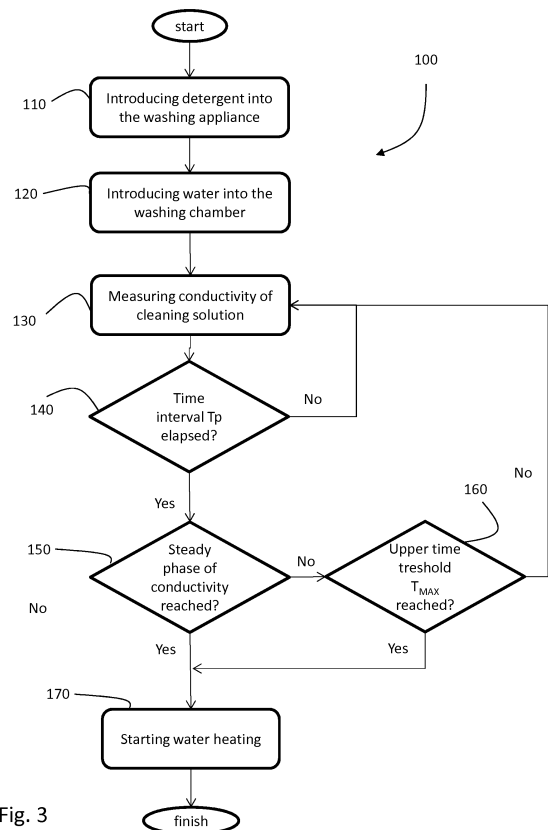


Fig. 3

Description

[0001] The present invention is relative to a method for operating a laundry washing appliance, such as a washing machine or a combined washer-dryer, apt to wash goods in one or more washing cycles, and to a laundry washing appliance implementing the same.

[0002] A washing cycle of laundry as performed by a laundry washing appliance generally comprises two phases: a washing phase and a rinse phase.

[0003] A wash program or process comprises one or more washing cycles and is terminated by a final spinning phase. Additional spinning steps might be present between consecutive rinsing steps during the rinsing phase.

[0004] The washing phase represents the portion of each washing cycle during which water is supplied into the appliance possibly together with the detergent to form a washing liquor (wetting step), the washing liquor is possibly heated (heating step), the laundry to be washed is subjected to tumbling of the drum in order to repeatedly expose it to mechanical action and to the washing liquor, so that dirt is removed from the laundry and stabilized in the washing liquor (tumbling step) and finally the washing liquor in which dirt is stabilized, is drained from the washing chamber (draining step).

[0005] The rinsing phase aims to remove the residuals of dirt and detergent coming from the washing phase. In many appliances, the rinsing phase is performed stepwise, e.g. generally two or three rinsing steps are performed.

[0006] In current laundry washing appliances, timing between subsequent steps of a washing phase are preset without taking into account the effective water and/or laundry conditions. In other words, each next step starts independent of the completion degree of the previous one. By way of an example, the heating of the washing liquor is usually started a preset time period from the beginning of the washing phase, independent of other conditions.

[0007] In the present description and in the following claims, with "the beginning of the washing phase" it is meant the moment when the water inlet is opened for the first time during a washing cycle and fresh water is introduced into the washing chamber.

[0008] One exception is found with regard to the method for controlling a cycle of operation in a laundry treating appliance described in document EP 2 441 875 which provides for a pre-heating step, a subsequent measurement and analysis step in which the amount of at least one constituent product of the reaction of one or more enzymes contained in the detergent with the soils and stains in the laundry is measured and analyzed for determining if it has reached a plateau and, once the amount of constituent product is determined to reach a plateau, the effective heating step is started.

[0009] In other words, the above control method monitors the constituent products deriving from the reaction of the stains in the laundry with one or more enzymes contained in the detergent introduced into the washing liquor. The heating of the washing liquor is started when a plateau of the amount of constituent products is reached.

[0010] This method provides for a correlation of the heater ignition with the water and/or laundry conditions. However, the control method described in EP 2 441 875 cannot be considered to be fully reliable.

[0011] In fact, in many cases the amount of constituent products deriving from the reaction of the stains in the laundry with one or more enzymes does not grow at all or it grows so less that it becomes extremely difficult to detect if a plateau has been reached. In such cases, a control based on that condition is not feasible.

[0012] For example, if the stains in the laundry are not of the types reacting with enzymes (e.g. protein stains, triglyceride-based fatty stains, starch stains, guar gum stains etc.) or if the detergent contains just a low portion of enzymatic components (like e.g. powder detergents), then there will be just a very little amount of reaction constituent products and it will be not easily possible to identify a plateau in the related development.

[0013] In order to find an alternative and more reliable way to correlate the heater ignition with the water and/or laundry conditions, Applicant has made the following observations.

[0014] Applicant has noticed that liquid or gel detergents, due to their high content of enzymatic components, are better active during detergent dissolution in cold water, when these components are active on a multiplicity of stain types, such as e.g. protein stains as blood, eggs etc.

[0015] This implies that in case the washing liquor is heated before the detergent is fully dissolved, the enzymatic components of non-dissolved detergent is partially or completely deactivated before having had the chance to act on these kind of stains. Thus, a too early heater ignition could worsen the washing performances on these stain types.

[0016] Detergents in powder form, containing a much lower portion of enzymatic components, suffer less from this inconvenient. However, the bleaching components of powder detergents give their best performances in warm/hot water. Applicant has thus also realized that best washing performances are reached if all bleaching components are already dissolved in water when heating begins. In fact, if part of the detergent dissolves only after the water has been heated, its bleaching components will have less time for acting on the load. Also in this case, a too early heater ignition is likely to worsen the washing performances.

[0017] The above considered, Applicant has realized that, ideally, the heater ignition should take place when a substantially full detergent dissolution degree is reached in order to maximize the washing performances.

[0018] Furthermore, Applicant has noted that the time required to reach a full dissolution condition varies from detergent type to detergent type.

[0019] Applicant has considered that setting a very long washing phase duration corresponding to the feasible longest detergent dissolution would imply, in most cases, an unnecessary extension of the overall wash program duration which could make the user believe that a deficiency is present in the washing apparatus itself, which is, in his/her opinion, not performing properly.

[0020] Applicant has thus understood that a modification in the washing appliance has to be made in order to establish a tuning between the heater ignition and the water and/or laundry conditions which offers high reliability irrespective of the detergent type used or the kind and quantity of dirt of the laundry, thereby optimizing the washing performances while keeping short the overall washing cycle duration. According to a first aspect, the invention relates to a method for operating a washing appliance comprising a washing chamber to wash goods according to a wash program selected by a user including at least a washing cycle, the method including:

- Adding a detergent to a washing liquor which is circulating within the washing chamber during a washing phase of the washing cycle;
- Performing a plurality of measurements of the conductivity of the washing liquor in order to collect a set of conductivity measurements;
- Analyzing at least part of the set of conductivity measurements in order to determine if a condition of substantial invariability of the conductivity measurements is reached; and
- Starting to heat the washing liquor when said condition of substantial invariability of the conductivity measurements has been reached.

[0021] The present invention is applicable to laundry washing appliances, such as for example a washing machine or combined washer-dryer, apt to wash goods in one or more washing cycles.

[0022] The washing appliance generally includes a washing chamber where the laundry to be washed is loaded and then removed, after the wash program has finished.

[0023] In the washing chamber, water and detergent are introduced at the beginning of the washing phase of each washing cycle of the wash program selected by the user, in order to form the washing liquor which is used to wash the laundry loaded into the washing chamber.

[0024] In the present description and in the following claims, with "washing cycle" it is meant the portion of a washing program comprising a washing phase, a rinse phase and possibly a spinning step.

[0025] In the present description and in the following claims, with "washing phase" it is meant the portion of each washing cycle during which water is supplied into the appliance possibly together with the detergent to form a washing liquor (wetting step), the washing liquor is possibly heated (heating step), the laundry to be washed is subjected to tumbling of the drum (tumbling step) and finally the washing liquor is drained from the washing chamber (draining step).

[0026] When detergent is added to the washing liquor, it starts to dissolve into the water-based solution thereby increasing the detergent concentration of the washing liquor until all detergent is gone into solution and the detergent concentration does not grow anymore.

[0027] Applicant has identified the necessity of a tuning between the detergent dissolution and the heating of the washing liquor so as to link the heater ignition to the real dissolution level of the detergent. As said above, ideally, the heating of the washing liquor should start only after all the detergent has dissolved into the same. In order to achieve this object, Applicant has had the idea of identifying the condition of detergent full dissolution and making the heater ignition dependent on the reaching of the said condition.

[0028] Applicant has considered that there is a correlation between detergent concentration and conductivity of water. Thus, an analysis of the washing liquor conductivity, leads to information on the detergent concentration and thus on the detergent dissolution degree into the washing liquor.

[0029] Applicant has also considered that through the measurement of the washing liquor conductivity and an appropriate analysis of the related curve, it is possible to determine if a condition of detergent full dissolution has been reached.

[0030] The condition of full dissolution of the detergent is considered to be optimal for the heater to be turned on. In fact, if the detergent is fully dissolved before heating of the washing liquor is started, it is assured that the action of the detergent enzymatic and bleaching components can be maxed out.

[0031] In detail, the condition of the conductivity course identifying a condition of full dissolution of the detergent is a condition of substantial invariability of the conductivity measurements.

[0032] Applicant has noticed that, when adding detergent to the washing liquor, its conductivity always grows rapidly as detergent dissolves into the same, until a steady condition is reached ("plateau") in which the conductivity value substantially does not vary anymore and keeps a high level. This development is independent from the specific load conditions (kind of stains, dirt degree etc.)

[0033] Applicant has recognized that reaching of the above substantially steady condition of the conductivity identifies a substantially complete dissolution of detergent into the washing liquor.

[0034] Thus, according to the invention, a plurality of measurements of the conductivity of the washing liquor is per-

formed and the measured conductivity values are analysed in order to detect if the condition of substantial invariability of the conductivity measurements is reached.

[0035] Not least, Applicant considered that, in case a washing appliance already comprised a conductivity sensor, said washing appliances could be easily modified in order to implement the method for operating a washing appliance according to the invention.

[0036] The invention, according to the above described aspect, may include, alternatively or in combination, one of the following features.

[0037] Preferably, determining the condition of substantial invariability of the conductivity measurements ($C_1, C_2, C_3 \dots C_n$) includes comparing relative variations of successive conductivity measurements ($C_1, C_2, C_3 \dots C_n$) according to the formula

$$\sum_{k=0}^m |c_{n-k} - c_{n-k-1}| > [Threshold > 0]$$

and identifying a condition of substantial invariability of the washing liquor conductivity when the sum of the relative variations keeps staying below the threshold.

[0038] Even more preferably, the number m of subsequent conductivity measurements to be taken into consideration for the evaluation of the steady condition is equal to or greater than two.

[0039] This particular way of analyzing the conductivity measurements leads to an accurate detection of the steadiness condition with lower possibility to fail. In fact, this formula advantageously assures that the conductivity variations are considered over a longer time thereby taking into account both signal noise and variance and excluding accidental fulfillment of the condition set.

[0040] Preferably, analyzing at least part of the set of conductivity measurements is performed after a first time interval from the beginning of the washing phase, namely from the moment when the water inlet is opened for the first time during a washing cycle and fresh water is introduced into the washing chamber.

[0041] This conditions assures a preset time interval for the detergent to dissolve into the washing liquor before the conductimetric signals are analyzed in order to determine a condition of full dissolution.

[0042] Preferably, the analysis step of the conductivity measurements is repeated until either the steadiness condition is reached or an upper time limit has been exceeded.

[0043] This further condition avoids the washing cycle to last excessively in case the detection of a full dissolution condition fails.

[0044] More preferably, after one analysis step of the conductivity measurements a second time interval is waited before a subsequent analysis steps is performed. This conditions allows to reduce the total number of analysis steps necessary before complete dissolution is reached and the related condition of full dissolution is detected.

[0045] Preferably, the washing appliance is a washing machine or a washer-dryer.

[0046] A second aspect of the present invention relates to a washing appliance comprising a washing chamber apt to receive a washing liquor used to wash goods loaded into the washing chamber and a conductivity sensor apt to be immersed in the washing liquor for performing conductivity measurements of the same, characterized in that the conductivity sensor is connected to processing and control means for the implementation of the method for operating a washing appliance as described above.

[0047] With reference to the attached drawings, further features and advantages of the present invention will be shown by means of the following detailed description of some of its preferred embodiments. According to the above description, the several features of each embodiment can be unrestrictedly and independently combined with each other in order to achieve the advantages specifically deriving from a certain combination of the same.

[0048] In the said drawings,

- figure 1 is a schematic view of a washing appliance operating according to the method of the invention;
- figure 2 is a graph showing the typical curve progression of the detergent concentration of the washing liquor during the dissolution phase;
- figure 3 is a flowchart of the method according to the invention.

[0049] In the following description, the discussion of the figures will be made by means of reference signs which will be the same for constructional elements having the same function.

[0050] With reference to figure 1, a laundry washing appliance operating according to the method of the invention is globally indicated with reference number 10.

[0051] The washing appliance 10, depicted here as the preferred embodiment, not limiting the scope and applicability

of the invention, is a washing machine.

[0052] The washing machine 10 includes a washing chamber 12, inside of which laundry is placed before a washing program starts and removed after the washing program has completed.

[0053] The washing chamber 12 is preferably contained in a casing 13 having an aperture closed by a door 14 pivotably mounted on the casing 13.

[0054] The washing machine 10 further includes a conductivity sensor 11, preferably placed inside the washing chamber 12 or within a recirculating circuit (not shown) of the washing appliance in order to be or come in direct contact with a washing liquor 15 for performing conductivity measurements of the same.

[0055] With washing liquor 15, a water-based solution is meant, in which detergent is dissolved and in which the laundry is at least partially immersed or soaked during a washing cycle. The washing liquor 15 is used to wash the laundry loaded into the washing chamber.

[0056] The conductivity sensor 11 is connected to a processing and/or control device (not shown in the drawings) which executes the method for operating a washing appliance 100 according to the invention.

[0057] In order to operate the washing appliance 10, the user loads the washing chamber 12 with laundry to be washed and inserts (step 110) a detergent of a given type for example into a detergent dispenser, drawer, compartment (not shown in the drawings) or directly into the washing chamber 12.

[0058] The user then selects a washing program among a plurality of predefined washing programs which include at least a washing cycle.

[0059] At the beginning of a washing phase of the washing cycle, the water inlet is opened and fresh water is introduced 120 into the washing chamber 12 (wetting step).

[0060] If the detergent is already present in the washing chamber, the introduction of fresh water 100 directly starts to form the washing liquor 15.

[0061] Otherwise, if the detergent is not present at this stage, it is flushed into the washing chamber 12 during the introduction of fresh water so as to form the washing liquor 15.

[0062] Starting from the beginning of the water introduction (step 120), namely from the beginning of the washing phase, the conductivity of the washing liquor (water and detergent solution) is repeatedly measured (step 130), e.g. by means of the conductivity sensor 11.

[0063] The conductivity measurement is repeated at given time intervals (e.g. equal to 5 s), thereby obtaining a plurality of conductivity measured values $C_1, C_2, C_3 \dots C_n$. While detergent is dissolving, the conductivity measurements $C_1, C_2, C_3 \dots C_n$ are supposed to increase continuously until all detergent is gone into solution.

[0064] When all detergent is dissolved, namely when the highest detergent concentration level is reached, water conductivity will not further increase over time, that is, subsequent conductivity readings will give similar results.

[0065] In other words, a steady condition of the conductimetric signal indicates that an almost full dissolution of the detergent into the washing liquor 15 has been reached.

[0066] By way of a non limiting example, figure 2 plots an ideal trend of conductivity over time after detergent dissolution begins. The signal initially grows (up to point (C_{10}, T_{10})), then a steady condition is reached where the conductivity values do not substantially vary, also called "plateau".

[0067] Thus, after a given first time interval T_p (step 140) from the beginning of the washing phase, namely the beginning of the water introduction (step 120), the collected measured conductivity values $C_1, C_2, C_3 \dots C_n$ are analyzed to understand whether an almost steady condition has been reached (step 150).

[0068] By way of a non limiting example, the analysis (step 150) of the collected measured conductivity values $C_1, C_2, C_3 \dots C_n$ is done by comparing relative variations of the same according to the following formula:

$$\sum_{k=0}^m |c_{n-k} - c_{n-k-1}| > [Threshold > 0]$$

with m and the threshold to be defined based on experimental data.

[0069] This formula takes into account m subsequent conductivity readings, namely a variation over a time period is considered.

[0070] The number m of subsequent measurements to be taken into consideration for the evaluation of the steady condition is preferably higher than two.

[0071] It is clear that the longer the time period of consideration is, the greater is the accuracy of the steadiness detection and the lower is the possibility to fail.

[0072] If the sum of the relative variations keeps staying below the given threshold, then the conductivity is considered to be steady, namely the detergent is almost fully dissolved into the cleaning solution.

[0073] The heating of the washing liquor 15 is then started. (step 170)

[0074] The analysis step 150 of the collected measured conductivity values $C_1, C_2, C_3 \dots C_n$ is repeated until either the steadiness condition is reached or an upper time limit T_{MAX} has been exceeded (step 160).

[0075] In other words, if conductivity steadiness is not detected after water and detergent have being mixed for a time period coinciding with the upper time limit T_{MAX} , the heating phase (step 170) is started and the washing cycle is carried on without further delay. This avoids the washing cycle to last excessively in case the signal steadiness detection fails.

[0076] Preferably, the analysis step 150 is done stepwise, namely if after a first analysis step 150 the steadiness condition has not been reached, further conductivity measurements (step 130) are preformed and the analysis step 150 is repeated on the newly collected set of conductivity values.

[0077] More preferably, the subsequent analysis step 150 is delayed of a second time interval T_d with respect to the previous analysis step 150, in order to reduce the total number of analysis steps necessary before complete dissolution is reached.

[0078] From the above description the features of the method for operating a washing appliance according to the present invention so as its related advantages are clear. Further alternatives of the above described embodiment are still possible without departing from the teachings of the invention.

[0079] It is finally clear that the so designed method for operating a washing appliance and related washing appliance can undergo many changes and variations all within the invention; furthermore all the details of the washing appliance can be replaced with technically equivalent elements. In practice, all the used materials and the dimensions can be varied according to the technical requirements without departing from the invention.

Claims

1. A method (100) for operating a washing appliance (10) comprising a washing chamber (12) to wash goods according to a wash program selected by a user including at least a washing cycle, said method including:

- Adding (110,120) a detergent to a washing liquor (15) which is circulating within the washing chamber (12) during a washing phase of the washing cycle;
- Performing (130) a plurality of measurements ($C_1, C_2, C_3 \dots C_n$) of the conductivity of the washing liquor (15) in order to collect a set of conductivity measurements ($C_1, C_2, C_3 \dots C_n$);
- Analyzing (150) at least part of the set of conductivity measurements ($C_1, C_2, C_3 \dots C_n$) in order to determine if a condition of substantial invariability of the conductivity measurements ($C_1, C_2, C_3 \dots C_n$) is reached; and
- Starting to heat (170) the washing liquor (15) when said condition of substantial invariability of the conductivity measurements ($C_1, C_2, C_3 \dots C_n$) has been reached.

2. The method (100) for operating a washing appliance (10) according to claim 1, wherein said determining the condition of substantial invariability of the conductivity measurements ($C_1, C_2, C_3 \dots C_n$) includes:

- comparing relative variations of successive conductivity measurements ($C_1, C_2, C_3 \dots C_n$) according to the formula:

$$\sum_{k=0}^m |C_{n-k} - C_{n-1-k}| < [Threshold > 0]$$

- identifying a condition of substantial invariability of the washing liquor conductivity when the sum of the relative variations keeps staying below the threshold.

3. The method (100) for operating a washing appliance (10) according to claim 2, wherein the number (m) of subsequent conductivity measurements ($C_1, C_2, C_3 \dots C_n$) to be taken into consideration for the evaluation of the steady condition is equal to or greater than two.

4. The method (100) for operating a washing appliance (10) according to any of claims 1 to 3, wherein said analyzing at least part of the set of conductivity measurements ($C_1, C_2, C_3 \dots C_n$) is performed after a first time interval (T_p) from the beginning of the washing phase.

5. The method (100) for operating a washing appliance (10) according to any of the preceding claims, wherein the

analysis step (150) of at least part of the set of conductivity measurements ($C_1, C_2, C_3 \dots C_n$) is repeated until either the steadiness condition is reached or an upper time limit (T_{MAX}) has been exceeded.

6. The method (100) for operating a washing appliance (10) according to claim 5, wherein after one analysis step (150) of the conductivity measurements ($C_1, C_2, C_3 \dots C_n$) a second time interval (T_d) is waited before a subsequent analysis steps (150) is performed.
7. The method according to any of the preceding claims, wherein said washing appliance is a washing machine or a washer-dryer.
8. Washing appliance (10) comprising a washing chamber (12) apt to receive a washing liquor (15) used to wash goods loaded into the washing chamber (12), heating means apt to heat the washing liquor (15) comprised in the washing chamber (12) and a conductivity sensor (11) apt to be immersed in the washing liquor (15) for performing conductivity measurements of the same (15), **characterized in that** it further comprises a processing and/or control device for the implementation of the method (100) for operating a washing appliance according to any of the preceding claims.

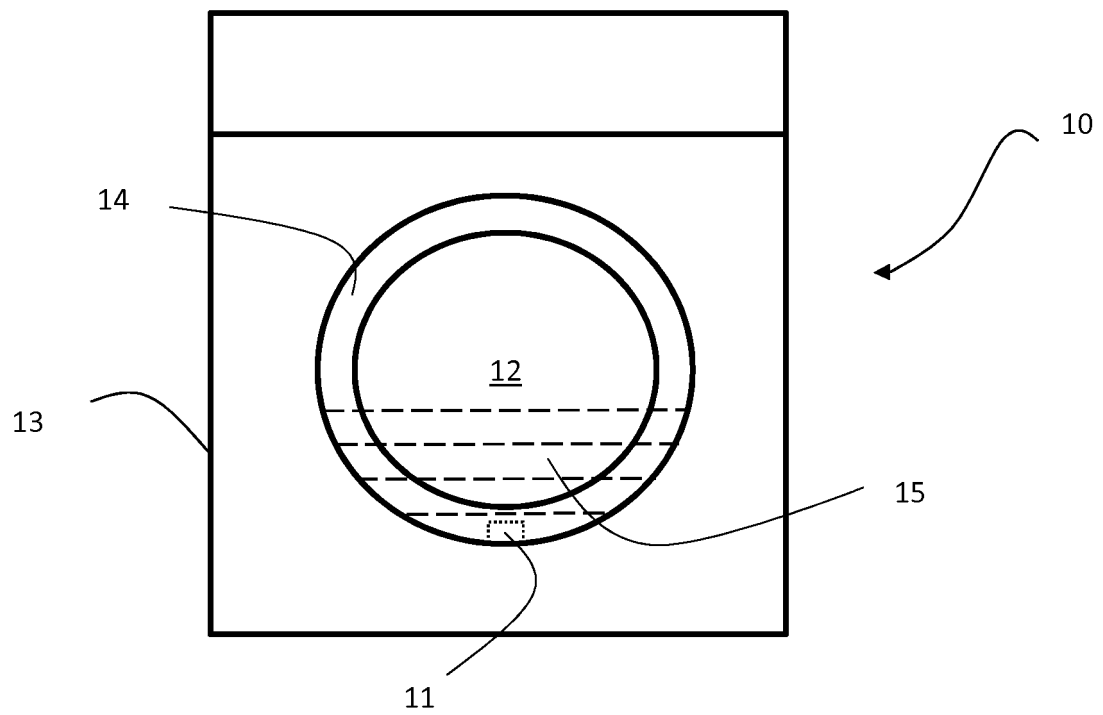


Fig. 1

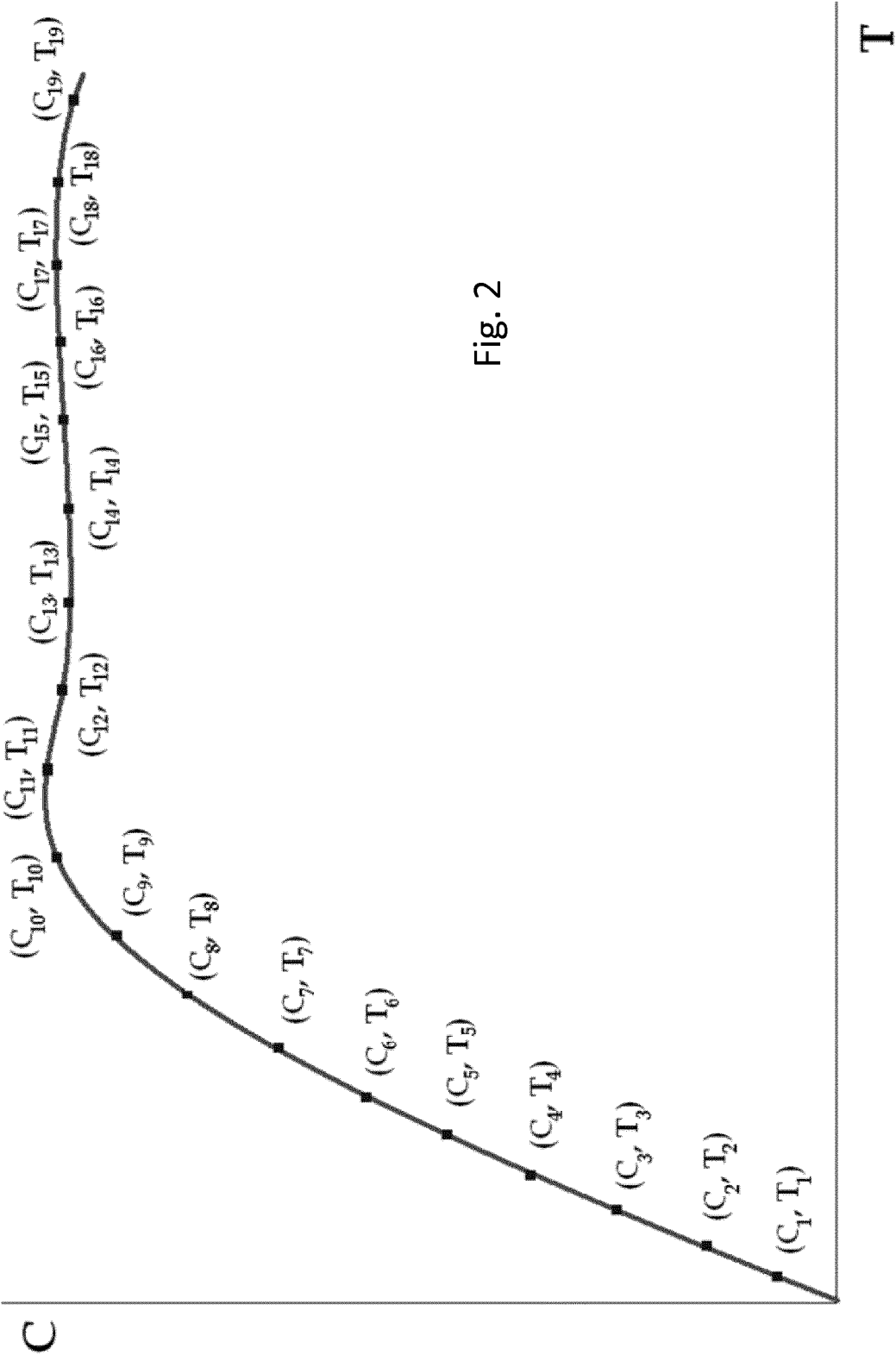


Fig. 2

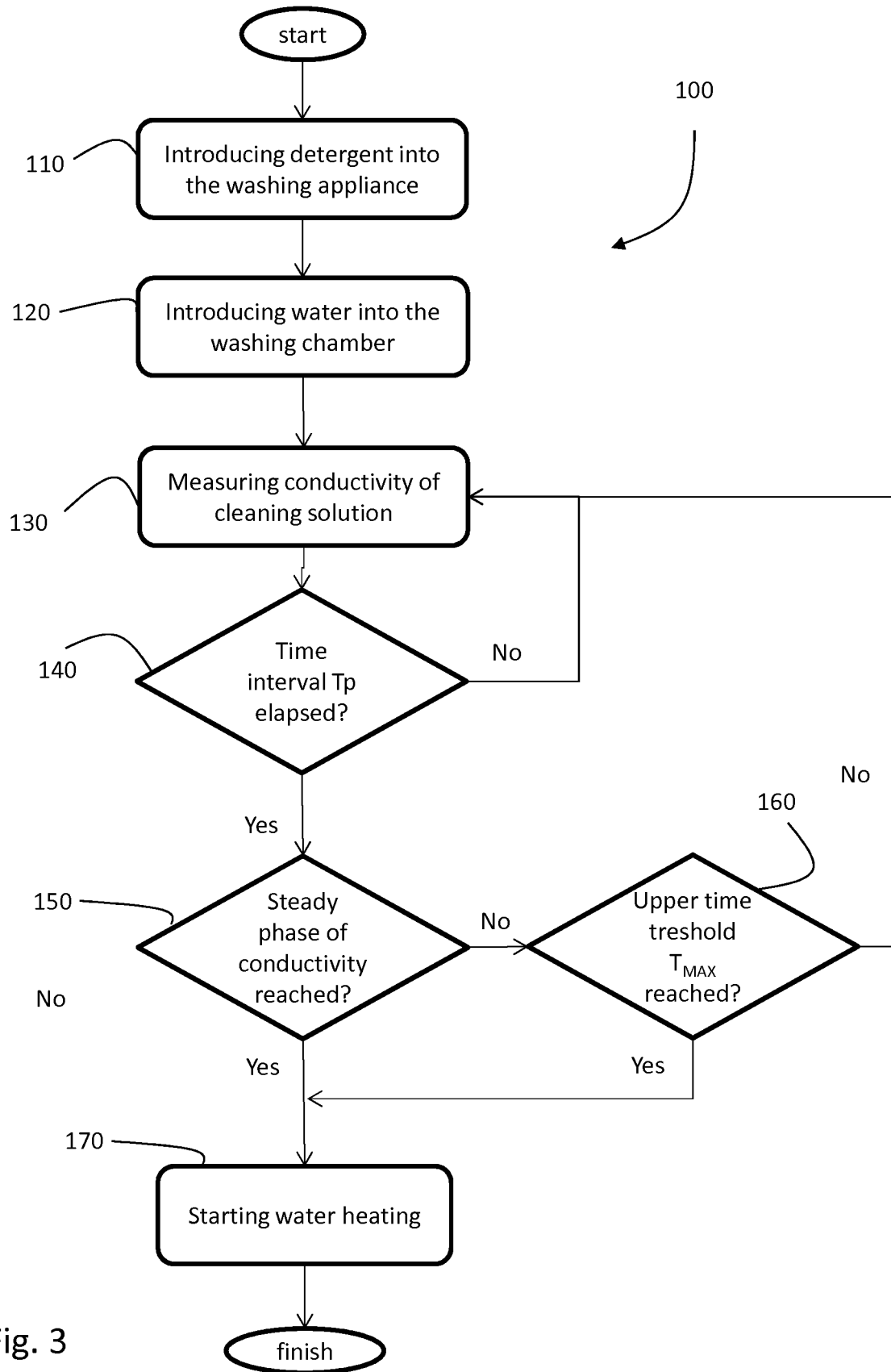


Fig. 3



EUROPEAN SEARCH REPORT

Application Number
EP 14 17 3587

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 January 2015	Examiner Weidner, Maximilian
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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REFERENCES CITED IN THE DESCRIPTION

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