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(54) **METHOD AND APPARATUS FOR CONTROLLING DISHWASHER**

(57) Disclosed is a method for controlling a dishwasher, the method comprising: triggering a water-softening apparatus to be in a softening working state during a water intake stage of a working stage during which soft water is needed for washing, so as to introduce water produced when the water-softening apparatus is in the softening working state into a washing cavity of a dishwasher; and after the water-softening apparatus is in the softening working state during the working stage, if at least one of the number of instances and duration of the water-softening apparatus being in the softening working state and the amount of water produced by the water-softening apparatus in the softening working state reaches a corresponding preset value, the water-softening apparatus being in a recycling working state before the water intake stage of the next working stage during which the soft water is needed for washing. The water-softening apparatus comprises several first electrodes and several second electrodes, which are arranged in a stacked manner, wherein the first electrodes and the second electrodes are arranged alternately, and the polarities thereof are opposite. A water flow channel is formed between the first electrode and the second electrode adjacent

thereto, wherein the side of one of the two electrodes that faces the channel is provided with an adsorption layer which is used for adsorbing target cations. The water-softening apparatus implements the switching of a softening function and a recycling function by means of converting the polarity of the first electrode and the polarity of the second electrode.

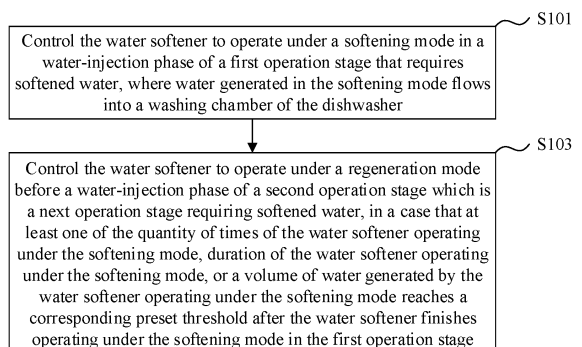


Figure 3

Description

[0001] This application claims priority to Chinese Patent Application No. 202010363845.2, titled "METHOD AND APPARATUS FOR CONTROLLING DISHWASHER", filed on April 30, 2020 with the China National Intellectual Property Administration, which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates to the field of household electrical appliances, and in particular, to a method and an apparatus for controlling a dishwasher.

BACKGROUND

[0003] In conventional technology, a water softener of a capacitive deionization type utilizes its electrode material to adsorb metal cations, such as calcium ions and magnesium ions in the water. In a case the metal cations saturate the adsorption capability, the water softener needs to regenerate, so as release the adsorbed calcium ions and magnesium ions into the water and therefore restore the adsorption capability. The water softeners of such type are mainly applied to professional equipment for large-scale water treatment. In a case that a dishwasher utilizes the capacitive-deionization water softener, an urgent problem to be solved is how to control the capacitive-deionization water softener to perform softening and regeneration.

SUMMARY

[0004] A method for controlling a dishwasher is provided according to an embodiment of the present disclosure. The dishwasher includes a water softener, where the water softener includes multiple first electrodes and multiple second electrodes that are alternately staked, water is capable to flow through a channel, the channel is located between each pair of a first electrode of the multiple first electrodes and a second electrode of the multiple second electrodes, the second electrode is adjacent to the first electrode, and a surface of the first electrode facing the channel is provided with an adsorption layer for adsorbing target cations. A single washing cycle of the dishwasher includes at least one operation stage, and each operation stage includes a water-injection phase and a washing phase. The method includes: controlling the water softener to operate under a softening mode in the water-injection phase of a first operation stage that requires softened water, where water generated in the softening mode flows into a washing chamber of the dishwasher, and where the first electrodes are connected to a negative terminal of a power source and the second electrodes are connected to a positive terminal of the power source when the water softener is under the softening mode; determining whether to trigger a regener-

ation mode of the water softener; and in response to determining to trigger the regeneration mode, controlling the water softener to operate under the regeneration mode before the water-injection phase of a second operation stage, which is a next operation stage requiring softened water, where the first electrode is connected to the positive terminal of the power source and the second electrode is connected to the negative terminal of the power source when the water softener is under the regeneration mode.

[0005] An apparatus for controlling a dishwasher is further provided according to an embodiment of the present disclosure. The dishwasher includes a water softener, where the water softener includes multiple first electrodes and multiple second electrodes that are alternately staked, water is capable to flow through a channel, the channel is located between each pair of a first electrode of the multiple first electrodes and a second electrode of the multiple second electrodes, the second electrode is adjacent to the first electrode, and a surface of the first electrode facing the channel is provided with an adsorption layer for adsorbing target cations. A single washing cycle of the dishwasher includes at least one operation stage, and each operation stage includes a water-injection phase and a washing phase. The apparatus includes: a softening control module, configured to control the water softener to operate under softening mode in the water-injection phase of a first operation stage that requires softened water, where water generated in the softening mode flows into a washing chamber of the dishwasher, and where the first electrodes are connected to a negative terminal of a power source and the second electrodes are connected to a positive terminal of the power source when the water softener is under the softening mode; a determination module, configured to determine whether at least one of: a quantity of times of the water softener operating under the softening mode reaching a preset quantity, duration of the water softener operating under the softening mode reaching a preset duration, or a volume of water generated by the water softener operating under the softening mode reaching a preset volume, is true after the water softener finishes operating under the softening mode in the first operation stage; and a regeneration control module, configured to control the water softener to operate under a regeneration mode before the water-injection phase of a second operation stage, which is a next operation stage requiring softened water, in response the at least one being true, where the first electrode is connected to the positive terminal of the power source and the second electrode is connected to the negative terminal of the power source when the water softener is under the regeneration mode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

Figure 1 is a schematic structural diagram of a water

softener according to an embodiment of the present disclosure.

Figure 2 is a cross-sectional view of a water softener as shown in Figure 1.

Figure 3 is a flowchart of a method for controlling a dishwasher according to an embodiment of the present disclosure.

Figure 4 is a flowchart of a method for controlling a dishwasher according to another embodiment of the present disclosure.

Figure 5 is a flowchart of a method for controlling a dishwasher according to another embodiment of the present disclosure.

Figure 6 is a flowchart of a method for controlling a dishwasher according to another embodiment of the present disclosure.

Figure 7 is a flowchart of a method for controlling a dishwasher according to another embodiment of the present disclosure.

Figure 8 is a flowchart of a method for controlling a dishwasher according to another embodiment of the present disclosure.

Figure 9 is a schematic structural diagram of an apparatus for controlling a dishwasher according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0007] Embodiments are described in detail herein, and examples thereof are shown in the drawings. Unless indicated otherwise, identical reference numerals in different drawings represent the same or similar elements when following description makes references to the drawings. Implementations described in following embodiments do not represent all implementations that are consistent with the present disclosure. Rather, they are merely examples of apparatuses and methods that are consistent with what is described in detail in the appended claims and in some aspects of the present disclosure.

[0008] The terminology used in this specification is for the purpose of describing particular embodiments only and is not intended to limit the present disclosure. Unless clearly indicated otherwise in the context, singular forms such as "a", "the", and "such" in this specification and the appended claims are intended to include plural forms as well.

[0009] "First", "second", and similar terms used in the description and claims of the present disclosure do not indicate any order, quantity, or degree of importance, and are only configured to distinguish different components.

Likewise, the terms such as "a(n)" or "one" do not indicate a quantitative limitation, but rather indicate presence of at least one. Similarly, terms such as "multiple" or "multiple layers of" indicates a quantity of two or more. Unless otherwise indicated, terms such as "front", "rear", "lower," and "upper" are intended for facilitating description, rather than being limited to a designated location or a designated spatial orientation. A term such as "include" or "comprise" is intended to indicate that a subject previous to such term encompasses an element, an item, or an equivalent of the element or the item, which is listed subsequent to such term, and is not intended to exclude another element or another item.

[0010] Hereinafter embodiments of the present disclosure are described in detail in conjunction with the drawings. Features in following embodiments and implementations may be mutually complementary and may be combined when there is no conflict.

[0011] A method for controlling a dishwasher according to embodiments of the present disclosure is applicable to a dishwasher having a capacitive-deionization water softener. The dishwasher may include the water softener, a washing chamber, a drain pipe, a connecting valve (such as a three-way valve), a switching valve, and the like. Each of the water softener and the washing chamber has a water inlet and a water outlet. The connecting valve may be a three-way valve having a first port, a second port, and a third port, or may be a multi-way valve having additional ports besides those of the three-way valve. The first port of the connecting valve is connected to the water outlet of the water softener, the second port of the connecting valve is connected to the water inlet of the washing chamber, and the third port of the connecting valve is connected to the drain pipe. Connections between the water softener and the washing chamber and between the water softener and the drain pipe are blocked or unblocked through closing or opening different ports of the connecting valve. That is, the water outlet of the water softener and the washing chamber of the dishwasher communicate via the connecting valve in some operating situations, while the water outlet of the water softener and the water inlet of the water tank communicate via the connecting valve in other operating situations. The switching valve is connected between the washing chamber and the drain pipe, and is configured to block and unblock connection between the washing chamber and the drain pipe.

[0012] The water softener may include a first electrode and a second electrode connecting to opposite polarities. The water softener swaps the polarities connected to the first electrode and the second electrode, so as to switch between a softening mode and a regeneration mode. The dishwasher is provided with a controller, such as a control circuit board. The controller is electrically connected to the water softener, a washing apparatus, and other components, so as to control operation of these apparatuses and components.

[0013] Reference is made to Figure 1 and Figure 2. In

some embodiments, the capacitive-deionization water softener 300 includes multiple first electrode sheets 1 and multiple second electrode sheets 2. The multiple first electrode sheets 1 and the multiple second electrode sheets 2 are stacked in an interleaved manner, and a channel through which water is capable to flow is formed between each pair of the first electrode sheet 1 and the second electrode sheet 2 that are adjacent. Specifically, the channel may be implemented by filling an insulating filter or the like between the first electrode sheet 1 and the second electrode sheet 2. The insulating filter may have a mesh structure. After the first electrode sheets 1 and the second electrode sheets 2 are fixed under a certain pressure, the insulating filter is filled between the first electrode sheet 1 and the second electrode sheet 2 that are adjacent. Thereby, the channel through which water is capable to flow is formed between the first electrode sheet 1 and the second electrode sheet 2 is formed.

[0014] The first electrode sheets 1 and the second electrode sheets 2 may be thin graphite electrode sheets, or made of another conductive material. The first electrode sheets 1 and the second electrode sheets 2 are connected to positive and negative terminals of a power source, so that an electric field can be formed among the first electrode sheets 1 and the second electrode sheets 2.

[0015] The first electrode sheet 1 is provided with a first adsorption layer (not depicted) for adsorbing target cations (such as calcium ions and magnesium ions in water). The second electrode sheet 2 may be provided with a second adsorption layer (not depicted) for adsorbing target anions.

[0016] When the water softener 300 is powered, the first electrode sheets 1 are connected to a negative terminal of the direct-current (DC) power source, and the second electrode sheets 2 are connected to a positive terminal of the DC power source. Thereby, when water flows among the first electrode sheets 1 and the second electrode sheets 2, cations in the water are adsorbed by the first adsorption layer, anions in the water are adsorbed by the second adsorption layer, and hence the water is softened.

[0017] When the adsorption capacities of the first adsorption layer and the second adsorption layer are saturated, the first electrode sheet 1 and the second electrode sheet 2 may swap their connections to the terminals of the power source. That is, the first electrode sheet 1 is connected to the positive terminal of the DC power source, and the second electrode sheet 2 is connected to the negative terminal of the DC power source. In such case, the first adsorption layer releases the cations adsorbed on it under the electric field. Few cations are adsorbed by the second adsorption layer because the second adsorption layer has a poor capability of adsorbing the cations. Therefore, the cations return to the water, and the adsorption capability of the first adsorption layer is restored. Similarly, the second adsorption layer releases the anions adsorbed on it under the electric field, and

the adsorption capability of the second adsorption layer is restored. Thereby, regeneration is implemented.

[0018] In some embodiments, a forward voltage applied between the first electrode and the second electrode refers to that the first electrode sheets 1 are connected to the negative terminal of the DC power source while and the second electrode sheets 2 are connected to the positive terminal of the DC power source. Correspondingly, a backward voltage applied between the first electrode and the second electrode refers to that the first electrodes 1 are connected to the positive terminal of the DC power source and the second electrodes 2 are connected to the negative terminal of the DC power source.

[0019] Reference is made to Figure 3, in conjunction with Figure 4 to Figure 5 when necessary. A method for controlling a dishwasher according to an embodiment of the present disclosure may include following steps S101 and S103.

[0020] In step S101, the water softener is controlled to operate under a softening mode in a water-injection phase of a first operation stage requiring softened water, where water generated in the softening mode flows into a washing chamber of the dishwasher.

[0021] In step S103, the water softener is controlled to operate under a regeneration mode before the water-injection phase of a second operation stage, which is a next operation stage requiring softened water, in a case that after the water softener finishes operating under the softening mode in the first operation stage, a quantity of times of the water softener operating under the softening mode reaches a preset quantity, and/or duration of the water softener operating under the softening mode reaching a preset duration, and/or a volume of water generated by the water softener operating under the softening mode reaching a preset volume.

[0022] The second operation stage and the first operation stage may belong to a same washing cycle, and the second operation stage is the next operation stage which requires softened water after the first operation stage. For example, in a washing cycle, the second operation stage may be immediately after the first operation stage, or there may be another operation stage after the first operation stage and before the second operation stage. Alternatively, the second operation stage and the first operation stage may belong to different washing cycles. For example, the first operation stage belongs to the first full washing cycle, and the second operation stage belongs to the second full washing cycle.

[0023] It may be preset in a program of the dishwasher, or selected by a user based on an actual situation, whether softened water is required in a certain operation stage. Washing with heated water is more apt to convert metal cations into insoluble substances such as calcium carbonate, magnesium hydroxide, or the like, than washing with unheated water, and hence is more apt to generate lime scale. Therefore, in some embodiments, an operation stage requiring water heating may be determined as the operation stage requiring softened water. Corre-

spondingly, it may be first determined whether a certain operation stage requires using heated water, and when positive, such operation stage is determined to require softened water.

[0024] A single washing cycle of the dishwasher includes at least one operation stage, and each operation stage includes a water-injection phase and a washing phase. Specifically, the operation stage of the dishwasher may include prewash, wash, rinse, or a combination thereof. Correspondingly, the prewash includes a prewash water-injection phase and a prewash washing phase, the wash includes a wash water-injection phase and a wash washing phase, and the rinse includes a rinse water-injection phase and a rinse washing phase.

[0025] A full cycle of washing dishes includes only the wash stage in some dishwashers, includes the wash stage and then the rinse stage in some dishwashers, while includes the prewash stage, then the wash stage, and then the rinse stage in some dishwashers. A dishwasher having two or more of the prewash, the wash, and the rinse may provide multiple washing modes. For example, a dishwasher having the prewash and the wash may be controlled to operate under multiple selectable washing modes. The full washing cycle may include only the wash in one mode, include the wash and the rinse in another mode, and include the prewash, the wash, and the rinse in a third mode. Some dishwashers further have a drying function after the washing cycle.

[0026] A detergent may or may not be used in each washing phase of the dishwasher. Softened water may or may not (for example, using tap water or water generated by the regenerating water softener) be used in each washing phase of the dishwasher. Correspondingly, heated water or unheated water may be used in each operation stage of the dishwasher. For example, the rinse may include a warm-rinse, in which dishes are washed with heated water, or a cold-rinse, in which dishes are washed with unheated water (such as tap water). In an operation stage requiring water heating, the water is generally heated during the washing phase.

[0027] In some embodiments, it is taken as an example that the operation stages in a washing cycle of the dishwasher includes the wash and the rinse. In the wash, heated water added with a detergent is used to wash dishes. The rinse refers to the warm-rinse in which heated water is used to wash dishes. In some scenarios, a brightener or a rinse agent may be applied for washing the dishes in the rinse. Correspondingly, the wash is a first operation stage and the warm-rinse is a second operation stage. The first operation stage and the second operation stage belong to a same washing cycle. In another embodiment, there is another operation stage requiring no water heating between the wash and the warm-rinse. For example, tap water is directly used to wash dishes in the other operation stage.

[0028] In step S101, the first port and the second port of the connecting valve may be opened, so that the water outlet of the water softener and the water inlet of the

washing chamber communicate. Thereby, water generated by the water softener under the softening mode is capable to flow into the washing chamber of the dishwasher.

[0029] Reference is made to Figure 4. In an embodiment, the method further includes S102 after the step S101 and before step S103. In step S102, it is determined whether at least one of: a quantity of times of the water softener operating under the softening mode, duration of the water softener operating under the softening mode, or a volume of water generated by the water softener operating under the softening mode, reaches a corresponding preset threshold after the water softener finishes operating under the softening mode in the first operation stage. For example, it is determined whether the quantity of times of the water softener operating under the softening mode reaches a preset quantity, whether the duration of the water softener operating under the softening mode reaches a preset duration, or whether the volume of water obtained by the water softener operating under the softening mode reaches a preset volume.

[0030] Herein the quantity of times of the water softener operating under the softening mode may be understood as how many times the water softener has operated under the softening mode since the softening capability of the water softener is fully restored. In a specific embodiment, the preset quantity may be preset based on a specific condition, such as the softening capability of the water softener or a volume of softened water required in an operation stage of the dishwasher. The preset duration may be preset based on a specific condition such as the softening capability of the water softener. Similarly, the preset volume may be preset based on a specific condition such as the softening capability of the water softener.

[0031] In some embodiments, the preset quantity for times of the water softener performing the softening (i.e., the preset quantity for the times of the water softener operating under the softening mode) may be 1. Hence, the preset quantity is reached as soon as the water softener finishes operating under the softening mode in the first operation stage, and the water softener needs to operate under the regeneration mode before a next operation stage that requires softened water, i.e., before the second operation stage. In other embodiments, the preset quantity may have another value, such as 2 or 3, which is not limited herein.

[0032] In some embodiments, the quantity of times of the water softener operating under the softening mode is increased by 1 when the water-injection phase of the operation stage requiring softened water ends.

[0033] For example, the quantity of times of the water softener operating under the softening mode is increased by 1 when the water-injection phase of the first operation stage ends. Correspondingly, the method may include a following step in a case that the water softener needs to operate under the regeneration mode before the water-

injection phase of the second operation stage that requires softened water. After the water softener is under the regeneration mode, the quantity of times of the water softener operating under the softening mode is reset to zero. Hence, next time the water softener starts the softening, the quantity of times of the water softener operating under the softening mode would be counted from zero.

[0034] In some embodiments, the volume of water generated by the water softener operating under the softening mode may be acquired through detecting a volume of water in the washing chamber. In a case that the water softener is capable to operate under the softening mode for multiple times before regeneration (for example, the preset quantity is two or more), since the water softener operates under the water softening mode for the second time, a volume of water in the washing chamber, which is generated by the water softener operating under the softening mode in the current operation stage, is added to the total volume of water generated by the water softener operating under the softening mode before the current operation stage. For example, the preset quantity is 3. In such case, when the water softener is operating under the softening mode for the second time, the volume of water generated by the water softener operating under the softening mode is equal to a sum of a volume of water which has been generated by the water softener operating in the softening mode for the second time and a volume of water generated by the water softener operating in the softening mode for the first time.

[0035] In an embodiment, the determination in the step S102 may not be skipped, and the process proceeds to the step S103 directly when one of: the quantity of times of the water softener operating under the softening mode, the duration of the water softener operating under the softening mode, and the volume of water generated by the water softener operating under the softening mode, reaches the corresponding preset threshold.

[0036] In step S103, the water softener is controlled to operate under the regeneration mode before the water-injection phase of the second operation stage, which is a next operation stage that requires softened water. In an embodiment, the step S103 is implemented through following step S1031.

[0037] In step S1031, the water softener is controlled to operate under the regeneration mode during at least a part of the washing phase of the first operation stage.

[0038] During the washing, the step S1031 is capable to reduce duration in which the dishwasher operates, and hence improves an operation efficiency of the dishwasher.

[0039] In an embodiment, the second operation stage is immediately after the first operation stage, and the water softener may be controlled to regenerate during the washing phase of the first operation stage. For example, the regeneration of the water softener may start when the washing phase of the first operation stage starts. Additionally or alternatively, the regeneration of the water

softener may stop when the washing phase of the first operation stops. Additionally or alternatively, duration of the regeneration of the water softener and the washing phase of the first operation stage may overlap partially. Specific configurations may be based on time consumption of the regeneration of the water softener, time consumption of the washing phase of the first operation stage, or the like, which is not limited herein.

[0040] In an embodiment, the regeneration of the water softener has not finished when the washing phase of the first operation stage ends, and the method may further include a following step. Water generated by the water softener under the regeneration mode is controlled to be drained through the drain pipe, such that operation after the washing-injection phase of the first operation stage is not affected.

[0041] In an embodiment, a water tank may be provided in the dishwasher, and is configured to store the excess water generated by the water softener in the regeneration mode. Hence, such water can be used in an operation stage not requiring softened water, saving water resources. Specifically, the water outlet of the water softener may be connected to the washing chamber of the dishwasher and a water inlet of the water tank via a three-way valve or another component. The water outlet of the water softener and the washing chamber of the dishwasher communicate via the three-way valve in some operating situations, while the water outlet of the water softener and the water inlet of the water tank communicate via the three-way valve in other operating situations. A water outlet of the water tank and the washing chamber may communicate under control of a switching valve. The water tank being capable to store the water generated from the regeneration renders the regeneration of the water softener more temporally flexible. Moreover, the water tank may have an outlet flow rate greater than that of the water softener, which can reduce time consumed by filling the dishwasher with water. Hence, the fully washing cycle of the dishwasher is shortened.

[0042] In some embodiments, there is another operation stage between the first operation stage and the second operation stage. The method may include step S104 after the step S101 or after the step S102.

[0043] In step S104, the water softener is controlled to operate under the regeneration mode in the water-injection phase of a third operation stage, where water generated under the regeneration mode is controlled to flow into the washing chamber of the dishwasher.

[0044] The step S104 is capable to achieve effective usage of hard water generated by the water softener under the regeneration mode, which reduces a waste of water resources.

[0045] Additionally or alternatively, in some embodiments, the water generated by the water softener under the regeneration mode is drained through the drain pipe. In such case, water not processed by the water softener, such as tap water, is used in the third operation stage.

[0046] In an embodiment, a water outlet of the water

softener and the washing chamber may communicate via a pipe, and the water outlet and the drain pipe may communicate via another pipe. For example, valves may be provided at a water inlet of the washing chamber and a water inlet of the drain pipe, may be provided in the pipes, or may be provided at the water outlet of the water softener. Thereby, the pipe connecting the water outlet of the water softener and the washing chamber and the pipe connecting the water outlet of the water softener and the drain pipe may be unblocked or blocked by opening or closing corresponding valves. Correspondingly, in a case that the operation stage which the dishwasher is to enter is the prewash, the valves may be controlled to unblock the pipe connecting the water outlet of the water softener and the washing chamber, and block the pipe connecting the water outlet of the water softener and the drain pipe. Hence, the water generated by the water softener under the regeneration mode flows into the washing chamber of the dishwasher. Water generated by the water softener under the softening mode may be controlled in a similar manner to flow into the washing chamber, which is not described in detail herein.

[0047] In another embodiment, the water outlet of the water softener, the washing chamber, and the drain pipe communicate in series via pipes. That is, the water outlet of the water softener and the drain pipe communicate via the washing chamber. Valves may be provided at a water inlet of the washing chamber and a water inlet of the drain pipe, or may be provided in the pipes, or may be provided at the water outlet of the water softener. Thereby, the pipe connecting the water outlet of the water softener and the washing chamber and the pipe connecting an outlet of the washing chamber and the drain pipe may be unblocked or blocked by opening or closing of the corresponding valves. Correspondingly, in a case that the operation stage which the dishwasher is to enter is the prewash, the valves may be controlled to unblock the pipe connecting the water outlet of the water softener and the washing chamber, and block the pipe connecting the water outlet of the washing chamber and the drain pipe. Hence, the water generated by the water softener under the regeneration mode flows into the washing chamber of the dishwasher. When draining water, the pipe connecting the water outlet of the washing chamber and the drain pipe is unblocked, so that water in the washing chamber of the dishwasher is drained through the drain pipe. Water generated by the water softener under a softening mode may be controlled in a similar manner to flow into the washing chamber, which is not described in detail herein.

[0048] In some embodiments, the method may further include step S105 before the step S104.

[0049] In step S105, it is determined whether there is the third operation stage which does not requiring softened water between the first operation stage and the second operation stage. The process proceeds to the S104 in a case that the determination in the step S105 is positive. Otherwise, the process may proceed to the

step S103, for example, to the step S1031.

[0050] In some embodiments, the first operation stage and the second operation stage belong to different washing cycles. For example, the first operation stage is the final washing phase of a single washing cycle. In such case, controlling the water softener to operate under the regeneration mode before the water-injection phase of the second operation stage that requires softened water may include following steps S1035 and S1036.

[0051] In step S1035, the water softener is controlled to not operate under the regeneration mode before a current washing cycle ends.

[0052] In step S1036, in a case that a next washing cycle is detected to start, the water softener is controlled to operate under the regeneration mode before the water-injection phase of the second operation stage, which is the earliest operation stage that requires softened water in the next washing cycle.

[0053] As an example, the washing cycle of the dishwasher includes the prewash, the wash, and the rinse in some embodiments. It is necessary to use softened water in the wash and the rinse, while it is not necessary to use softened in the prewash. Hence, after the water-injection phase of the rinse, the water softener of the dishwasher may be controlled to not operate under the regeneration mode before the current washing cycle ends, in a case that at least one of the quantity of times of the water softener operating under the softening mode, the duration of the water softener operating under the softening mode, or the volume of water generated by the water softener operating under the softening mode reaches a corresponding preset threshold. In a case that the next washing cycle also includes the prewash, the wash, and the rinse, the water softener of the dishwasher may be controlled to operate under the regeneration mode before or during the prewash of the next washing cycle. Before the prewash, hard water generated under the regeneration mode may be controlled to flow into the washing chamber, such that the hard water can be used in the prewash.

[0054] In some embodiments, each time the water softener performs the softening, a volume of the generated softened water is only sufficient for a single washing phase. Reference is made to Figure 6. The single washing cycle of the dishwasher includes the prewash, the wash, and the rinse, and softened water is required in all of the three stages. As shown in Figure 6, the water softener operates under the softening mode during the water-injection phase of the prewash, the water-injection phase of the wash, and the water-injection phase of the rinse, and water generated under the softening mode flows into the washing chamber. The water softener operates under the regeneration mode during the washing phase of the prewash, the washing phase of the wash, and the washing phase of the rinse. Hence, a washing efficiency of the dishwasher is effectively improved.

[0055] Reference is made to Figure 7 and Figure 8. The single washing cycle of a dishwasher includes the

prewash, the wash, and the rinse. Softened water is required in the wash and the rinse, and may be unnecessary in the prewash. Figure 7 and Figure 8 illustrate two brief processes for controlling a dishwasher. In an embodiment as shown in Figure 7, the water softener operates under the softening mode during the water-injection phase of the wash and the water-injection phase of the rinse, and operates under the regeneration mode during the water-injection phase of the prewash and the washing phase of the wash. In an embodiment as shown in Figure 8, the water softener under the softening mode during the water-injection phase of the wash and the water-injection phase of the rinse, and operates under the regeneration mode in the washing phase of the wash and the washing phase of the rinse.

[0056] An apparatus for controlling a dishwasher is further provided according to an embodiment of the present disclosure. A single washing cycle of the dishwasher includes at least one operation stage, and each operation stage includes a water-injection phase and a washing phase. As shown in Figure 9, the apparatus includes a softening control module 100, a determination module 200, and a regeneration control module 300.

[0057] The softening control module 100 is configured to control the water softener to operate under a softening mode in a water-injection phase of a first operation stage that requires softened water. Water generated in the softening mode flows into a washing chamber of the dishwasher.

[0058] The determination module 200 is configured to determine whether a quantity of times of the water softener operating under the softening mode reaches a preset quantity, and/or duration of the water softener operating under the softening mode reaches a preset duration, and/or a volume of water generated by the water softener operating under the softening mode reaches a preset volume, after the water softener finishes operating under the softening mode in the first operation stage.

[0059] The regeneration control module 300 is configured to control the water softener to operate under a regeneration mode before the water-injection phase of a second operation stage, which is a next operation stage requiring softened water, in a case that to a result of the determining of the determination module is positive.

[0060] The water softener includes multiple first electrodes and multiple second electrodes that are alternately stacked, and the first electrodes and the second electrodes have opposite polarities. Water is capable to flow through a channel formed between each pair of the first electrode and the second electrode that are adjacent. A surface of the first electrode facing the channel is provided with an adsorption layer for adsorbing target cations. Polarities of the first electrode and the second electrode are swapped such that the water softener can switch between a softening mode and a regeneration mode.

[0061] In embodiments of the present disclosure, the water softener is controlled to operate under the softening mode in the water-injection phase of the first operation

stage requiring softened water, and the water generated under the softening mode is controlled to flow into the washing chamber of the dishwasher, so as to provide water for washing in the first operation stage. After the first operation stage, the water softener is controlled to operate under the regeneration mode before the water-injection phase of the second operation stage, which is a next operation stage that requires softened water, in a case that at least one of the quantity of times of the water softener operating under the softening mode, duration of the water softener operating under the softening mode, or a volume of water generated by the water softener operating under the softening mode reaches a corresponding preset threshold. Thereby, the softening capability of the water softener can be restored in time and effectively utilized.

[0062] A non-transitory computer-readable storage medium is further provided according to an embodiment of the present disclosure. The storage medium stores a computer program, and the computer program when executed by a processor implements the method for controlling the dishwasher provided according to embodiments of the present disclosure.

Claims

1. A method for controlling a dishwasher, wherein:

the dishwasher comprises a water softener, the water softener comprises a plurality of first electrodes and a plurality of second electrodes, the first electrodes and the second electrodes alternately stacked, water is capable to flow through a channel, the channel is located between each pair of a first electrode of the plurality of first electrodes and a second electrode of the plurality of second electrodes, the second electrode is adjacent to the first electrode, and a surface of the first electrode facing the channel is provided with an adsorption layer for adsorbing target cations;

a single washing cycle of the dishwasher comprises at least one operation stage, each of which comprises a water-injection phase and a washing phase; and

the method comprises:

controlling the water softener to operate under a softening mode in the water-injection phase of a first operation stage that requires softened water, wherein water generated in the softening mode flows into a washing chamber of the dishwasher, and wherein the first electrode is connected to a negative terminal of a power source and the second electrode is connected to a positive terminal of the power source when the water softener

- is under the softening mode;
determining whether to trigger a regeneration mode of the water softener; and
controlling the water softener to operate under the regeneration mode before the water-injection phase of a second operation stage, which is a next operation stage requiring softened water, in response to determining to trigger the regeneration mode, wherein the plurality of first electrodes is connected to the positive terminal of the power source and the plurality of second electrodes is connected to the negative terminal of the power source when the water softener is under the regeneration mode.
2. The method according to claim 1, wherein determining whether to trigger the regeneration mode of the water softener comprises:
- determining whether at least one of:
- a quantity of times of the water softener operating under the softening mode reaching a preset quantity,
 - duration of the water softener operating under the softening mode reaching a preset duration, or
 - a volume of water generated by the water softener operating under the softening mode reaching a preset volume,
- is true after the water softener finishes operating under the softening mode in the first operation stage.
3. The method according to claim 1, wherein controlling the water softener to operate under the regeneration mode before the water-injection phase of the second operation stage, comprises:
- controlling the water softener to operate under the regeneration mode in the water-injection phase of a third operation stage not requiring softened water, and controlling water generated in the regeneration mode to flow into the washing chamber of the dishwasher, in response to there being the third operation stage between the first operation stage and the second operation stage.
4. The method according to claim 1, wherein controlling the water softener to operate under the regeneration mode before the water-injection phase of the second operation stage, comprises:
- controlling the water softener to operate under the regeneration mode during at least a part of the washing phase of the first operation stage.
5. The method according to any one of claims 1 to 3,

wherein:

the dishwasher determines that the water softener is to operate under the regeneration mode before the water-injection phase of the second operation stage, in response to the quantity of times of the water softener operating under the regeneration mode reaching the preset quantity; and
the preset quantity is 1.

6. The method according to claim 5, wherein the first operation stage and the second operation stage belong to different washing cycles.
7. The method according to claim 6, wherein controlling the water softener to operate under the regeneration mode before the water-injection phase of the second operation stage comprises:

controlling the water softener to not operate under the regeneration mode before the current washing cycle ends, in response to a washing phase of the first operation stage a final washing phase of a current washing cycle; and
controlling the water softener to operate under the regeneration mode before the water-injection phase of the second operation stage, in response to detecting that a next washing cycle starts, wherein the second operation stage is an earliest operation stage requiring softened water in the next washing cycle.

8. The method according to any one of claims 1 to 3, wherein:

the dishwasher determines that the water softener is to operate under the regeneration mode before the water-injection phase of the second operation stage, in response to the quantity of times of the water softener operating under the regeneration mode reaching the preset quantity; and
after controlling the water softener to operate under the softening mode in the water-injection phase of the first operation stage, the method further comprises:
increasing the quantity of times of the water softener operating under the softening mode by 1 after the water-injection phase of the first operation stage ends.

9. The method according to claim 8, wherein after controlling the water softener to operate under the regeneration mode before the water-injection phase of the second operation stage, the method further comprises:
resetting the quantity of times of the water softener

operating under the softening mode to zero, after the water softener is under the regeneration mode.

10. The method according to claim 1, wherein whether an operation stage requires softened water is determined by:
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determining whether the operation stage requires water heating; and
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determining that the operation stage requires softened water in response to determining that the operation stage requires water heating.
11. The method according to claim 4, wherein after controlling the water softener to operate under the regeneration mode during at least the part of the washing phase of the first operation stage, the method further comprises:
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draining, through a drain pipe, water generated by the water softener under the regeneration mode. 20
12. The method according to claim 4, wherein the dishwasher comprises a water tank, and after controlling the water softener to operate under the regeneration mode during at least the part of the washing phase of the first operation stage, the method further comprises:
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controlling water generated by the water softener under the regeneration mode to flow into the water tank for storage. 30
13. The method according to claim 12, wherein there is a third operation stage not requiring softened water between the first operation stage and the second operation stage, and controlling the water softener to operate under the regeneration mode before the water-injection phase of the second operation stage comprises:
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controlling water stored in the water tank to flow into the washing chamber of the dishwasher in the water-injection phase of the third operation stage. 40
14. The method according to claim 1, wherein the single washing cycle of the dishwasher comprises a pre-wash, a wash, and a rinse, and the wash and the rinse both require softened water. 45
15. An apparatus for controlling a dishwasher, wherein:
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the dishwasher comprises a water softener, the water softener comprises a plurality of first electrodes and a plurality of second electrodes, the first electrodes and the second electrodes are alternately stacked, water is capable to flow through a channel, the channel is located between each pair of a first electrode of the plurality of first electrodes and a second electrode of the plurality of second electrodes, the second elec-

trode is adjacent to the first electrode, and a surface of the first electrode facing the channel is provided with an adsorption layer for adsorbing target cations;

a single washing cycle of the dishwasher comprises at least one operation stage, each of which comprises a water-injection phase and a washing phase; and
the apparatus comprises:

a softening control module, configured to control the water softener to operate under softening mode in the water-injection phase of a first operation stage that requires softened water, wherein water generated in the softening mode flows into a washing chamber of the dishwasher, and wherein the plurality of first electrodes is connected to a negative terminal of a power source and the plurality of second electrodes is connected to a positive terminal of the power source when the water softener is under the softening mode;

a determination module, configured to determine whether at least one of:

a quantity of times of the water softener operating under the softening mode reaching a preset quantity,
duration of the water softener operating under the softening mode reaching a preset duration, or
a volume of water generated by the water softener operating under the softening mode reaching a preset volume,

is true after the water softener finishes operating under the softening mode in the first operation stage; and

a regeneration control module, configured to control the water softener to operate under a regeneration mode before the water-injection phase of a second operation stage, which is a next operation stage requiring softened water, in response the at least one being true, wherein the plurality of first electrodes is connected to the positive terminal of the power source and the plurality of second electrodes is connected to the negative terminal of the power source when the water softener is under the regeneration mode.

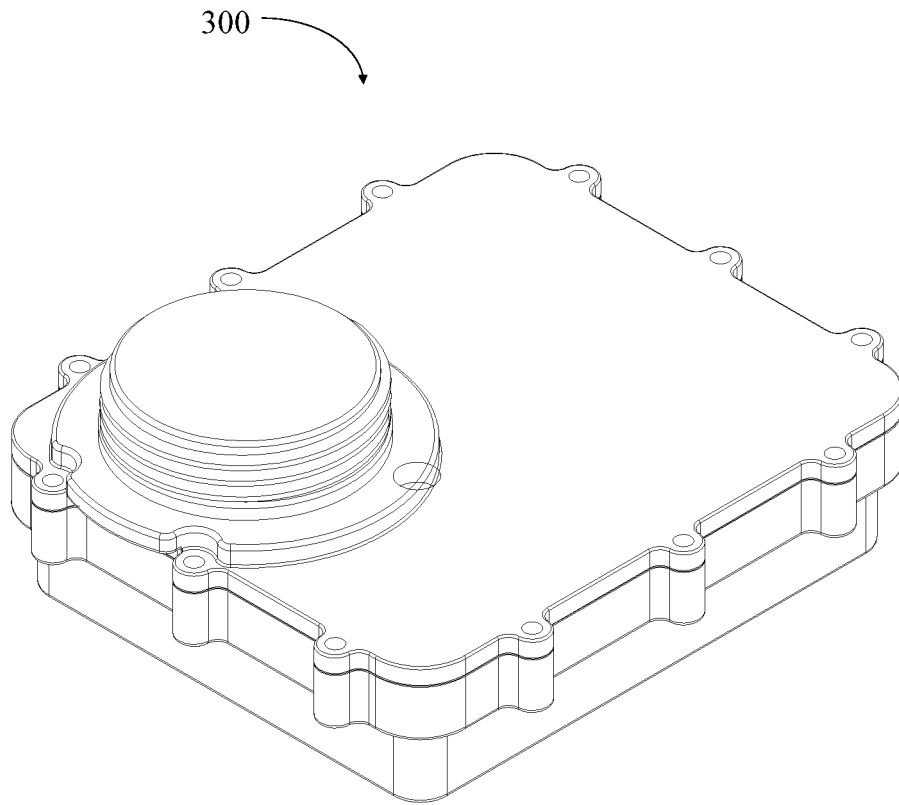


Figure 1

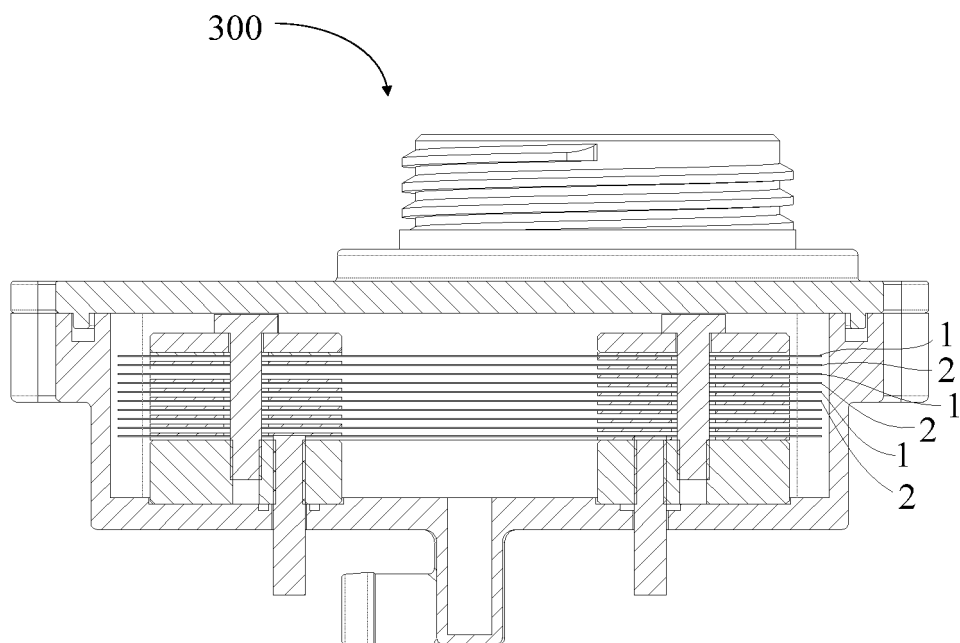
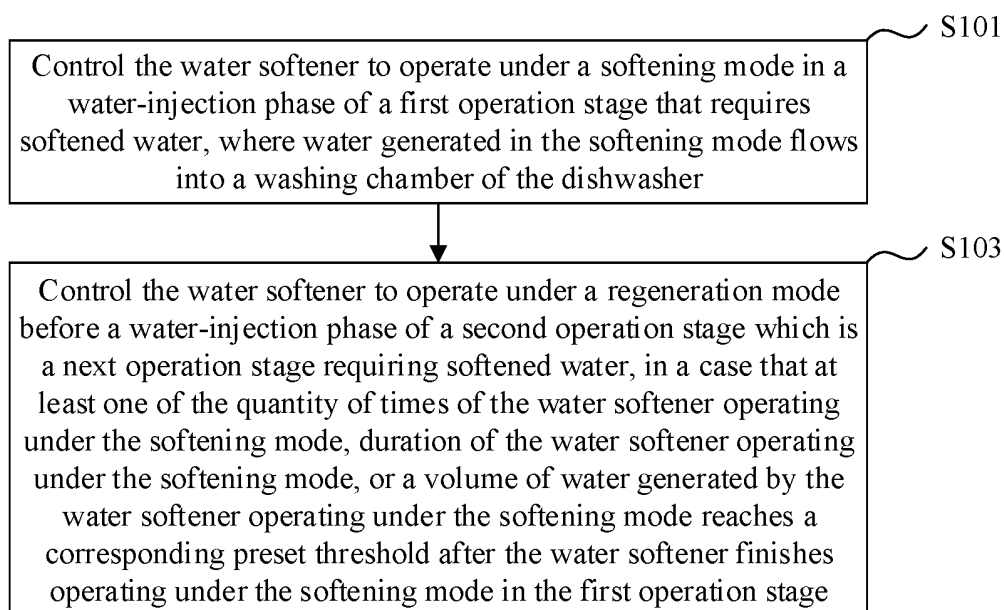
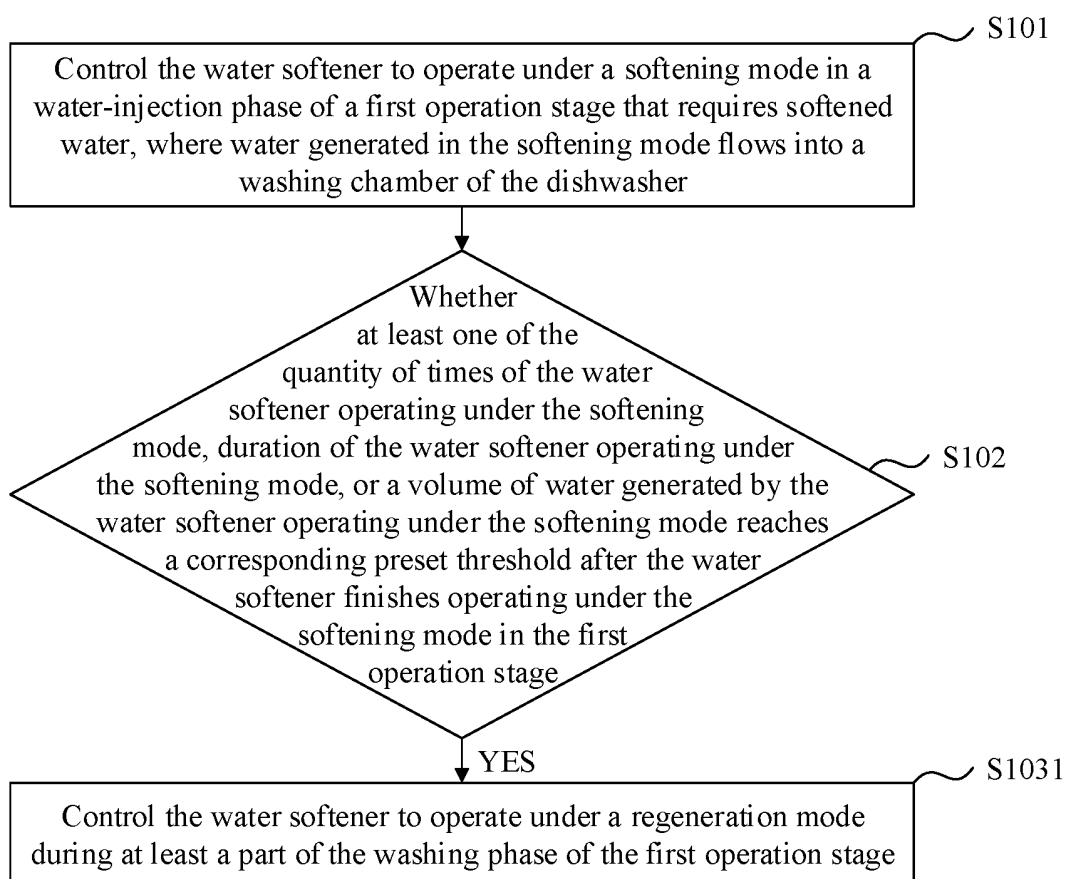
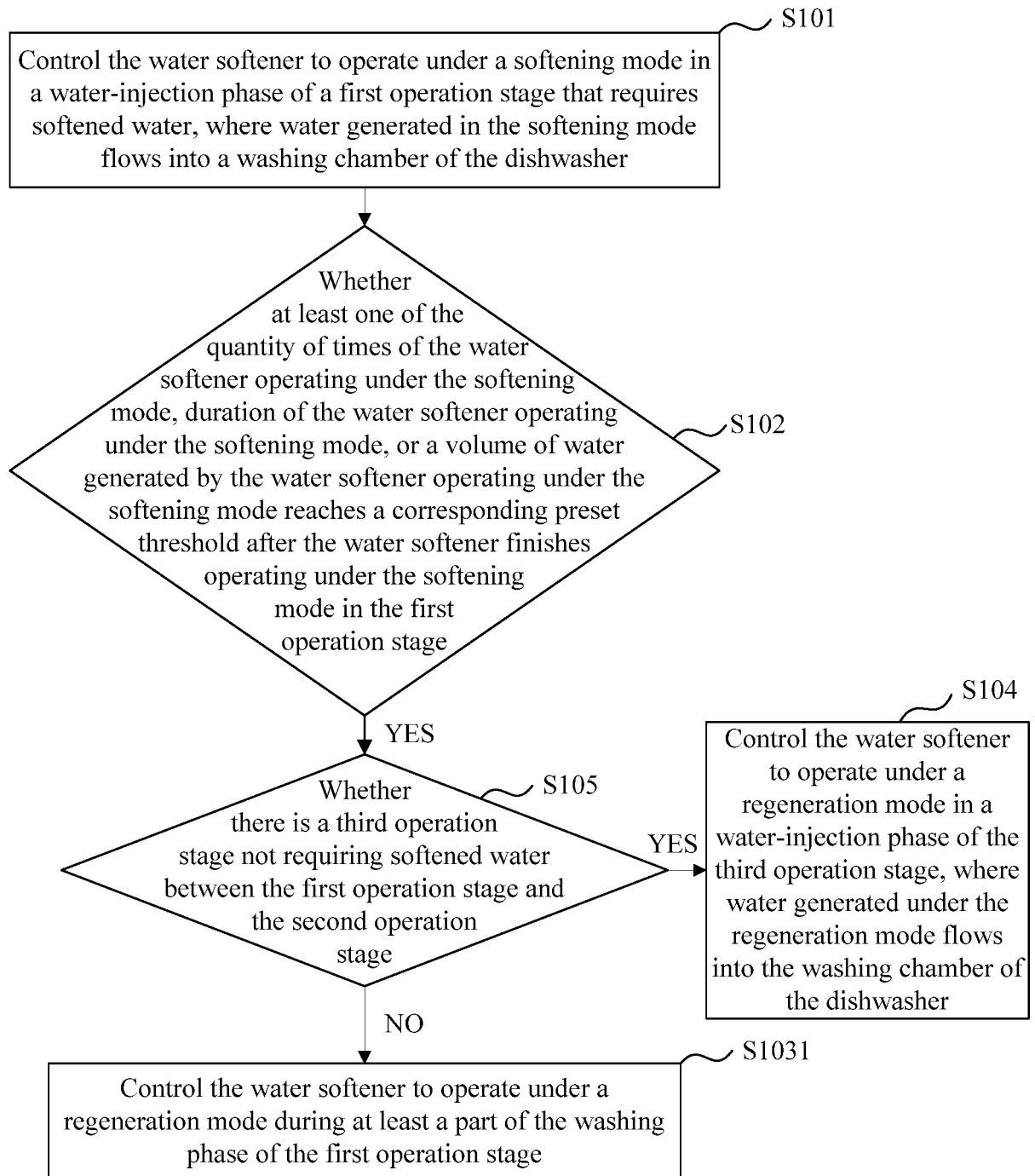
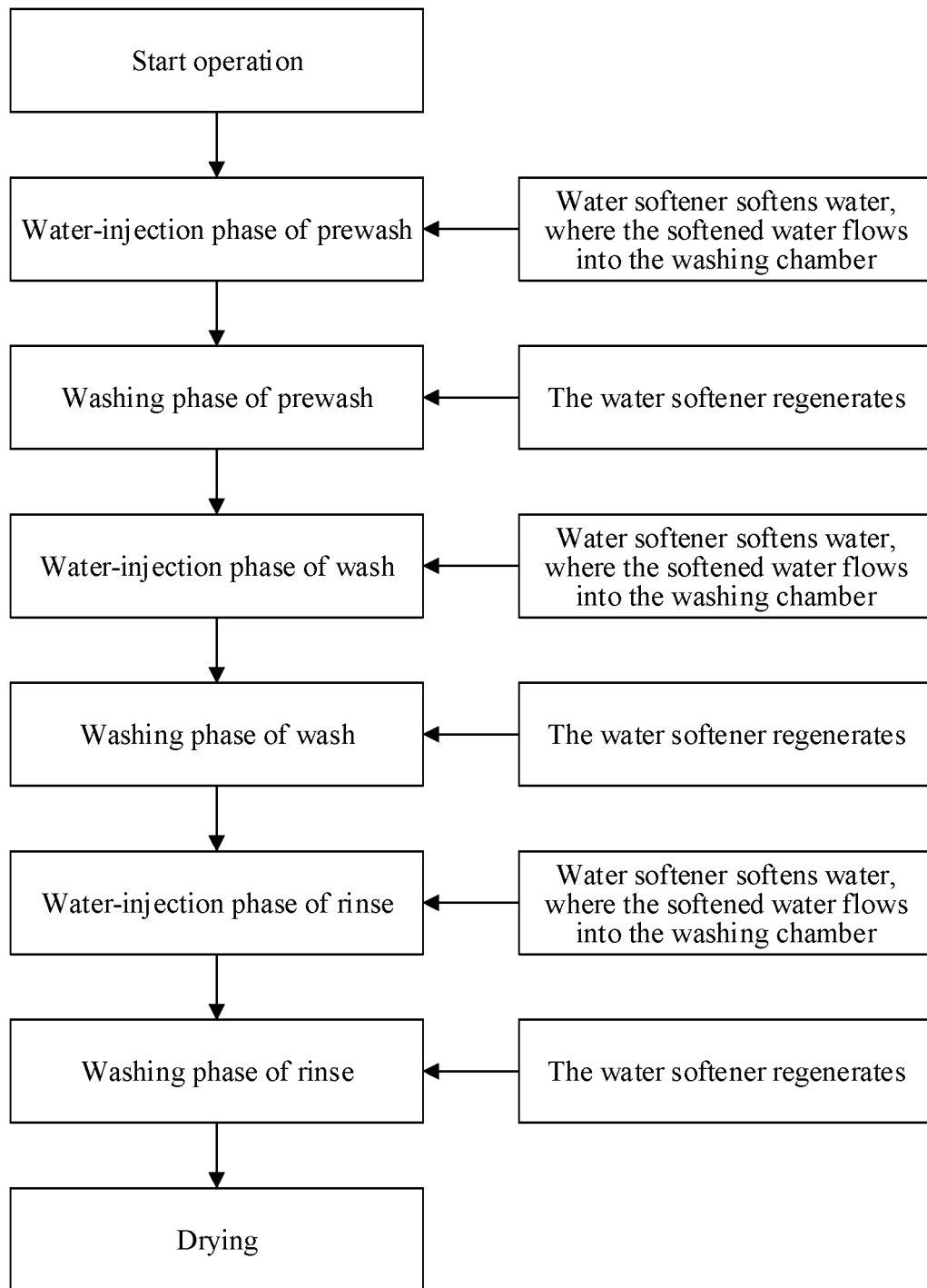
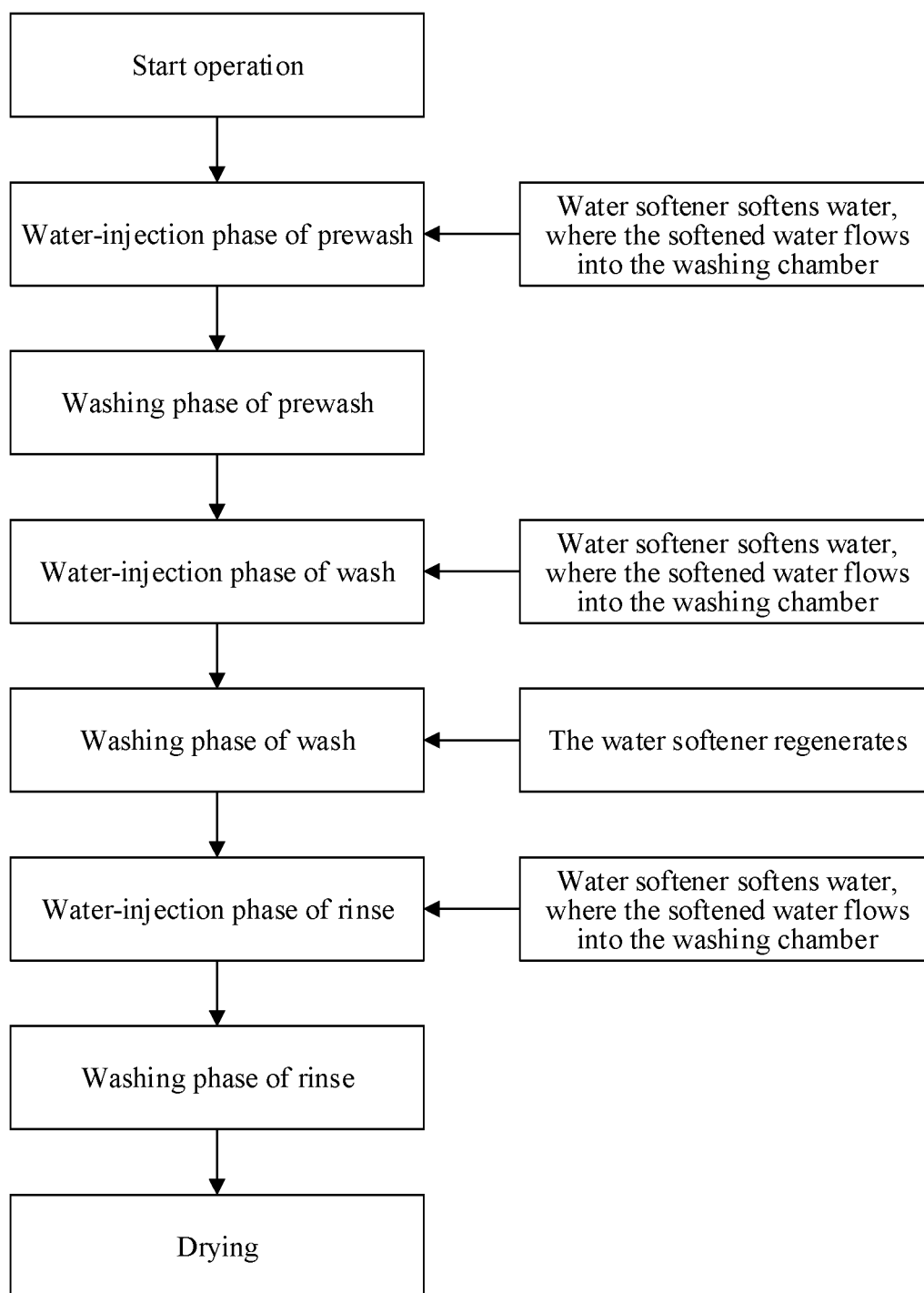


Figure 2

**Figure 3****Figure 4**

**Figure 5**

**Figure 6**

**Figure 7**

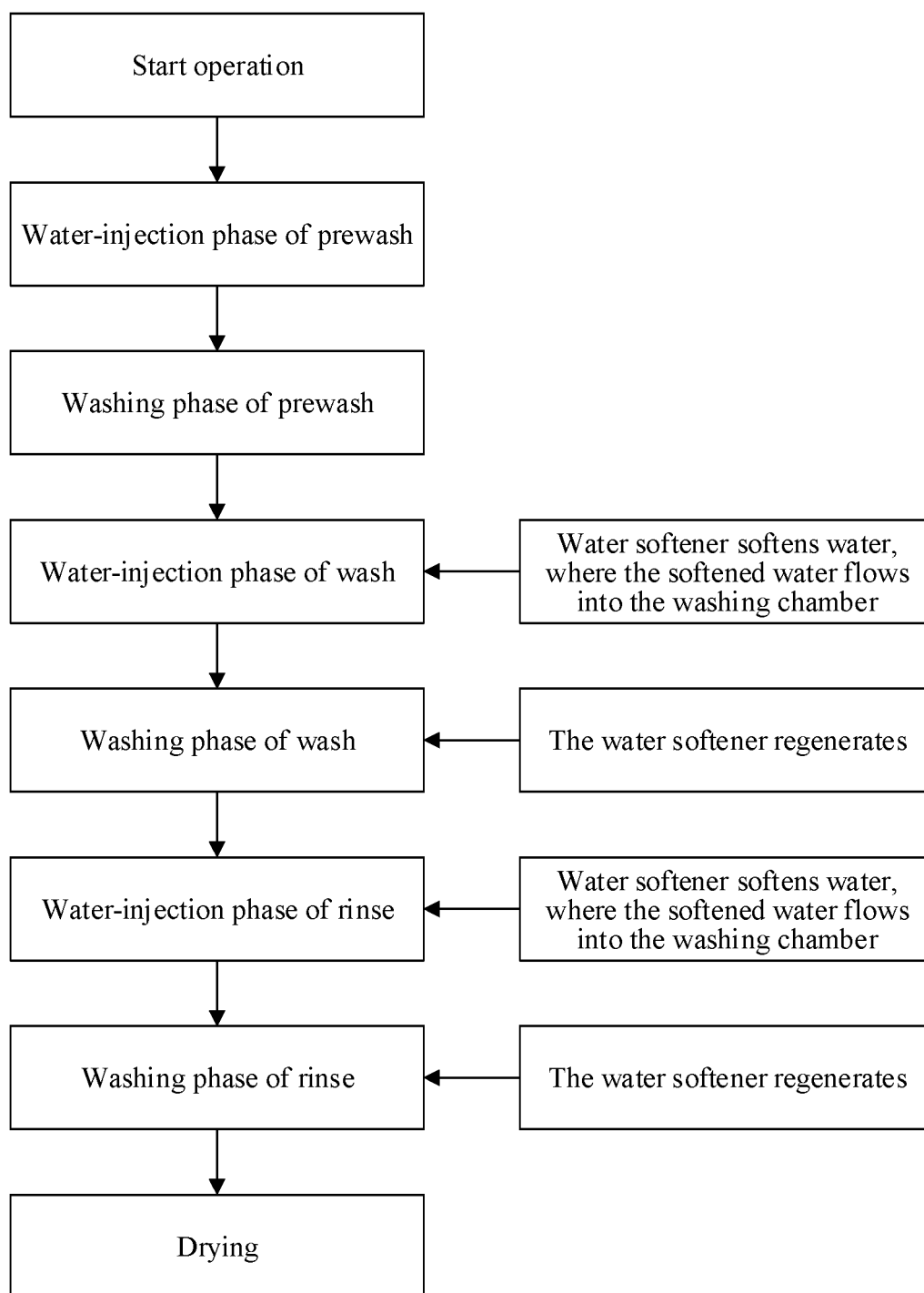


Figure 8

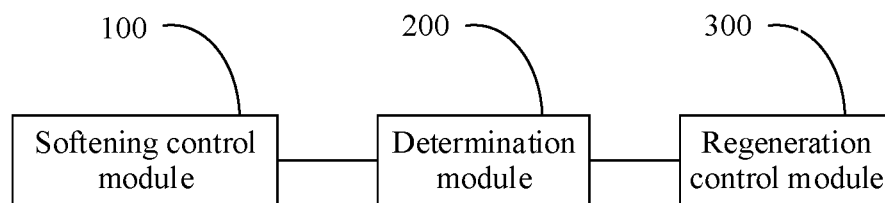


Figure 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2021/088878

A. CLASSIFICATION OF SUBJECT MATTER

A47L 15/00(2006.01)i; A47L 15/42(2006.01)i; A47L 15/46(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A47L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS; CNTXT; CNKI; VEN; USTXT; WOTXT; EPTXT; GBTXT; IEEE: 三花, 亚威科, 黄隆重, 徐伟, 周静, 黄海, 许伟东, 黄宇杰, 水, 软化, 再生, 软水, 电容, 电极, 正极, 负极, 预洗, 主洗, 漂洗, 废水, 浓水, 再生水, 箱, 盒, 存, 蓄, water, soft+, regenerat+, electrode?, capacit+, positive, negative, prewash+, mainwash+, rins+, waste, box+, case?, stor+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 111685678 A (ZHEJIANG SANHUA INTELLIGENT CONTROLS CO., LTD.) 22 September 2020 (2020-09-22) description, paragraphs [0016]-[0065], and figures 1-8	1-15
PX	CN 111685702 A (ZHEJIANG SANHUA INTELLIGENT CONTROLS CO., LTD.) 22 September 2020 (2020-09-22) description, paragraphs [0016]-[0078], and figures 1-7	1-15
PX	CN 111685679 A (ZHEJIANG SANHUA INTELLIGENT CONTROLS CO., LTD.) 22 September 2020 (2020-09-22) description, paragraphs [0018]-[0087], and figures 1-6	1-15
Y	CN 104487623 A (ELECTROLUX HOME PRODUCTS CORP. N.V.) 01 April 2015 (2015-04-01) description paragraphs [0033]-[0162]	1-15
Y	CN 109965808 A (FOSHAN YUNMI ELECTRICAL APPLIANCE SCIENCE & TECHNOLOGY CO., LTD. et al.) 05 July 2019 (2019-07-05) description, paragraphs [0031]-[0060], figure 1	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

09 June 2021

Date of mailing of the international search report

08 July 2021

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2021/088878

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2021/088878

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CN	111685679	A	22 September 2020		None				
CN	104487623	A	01 April 2015		EP	2867398	A1	06 May 2015	
					AU	2013283242	B2	02 February 2017	
					US	9422660	B2	23 August 2016	
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REFERENCES CITED IN THE DESCRIPTION

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