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(54) A METHOD FOR ADJUSTING PARAMETER SETTINGS FOR A FILLING STATION IN A PACKAGING MACHINE

(57) The present invention relates to a method (300) for adjusting parameter settings for a filling station (106) in a packaging machine (100), wherein the filling station (106) comprises: a pump (200) comprising a hollow body (202), an inlet valve (204a), an outlet valve (204b) and a piston (206). The method (300) comprising: obtaining (S302), via one or more sensors, sensor data relating to the inlet valve (204a) and the outlet valve (204b) respectively, wherein the sensor data is indicative of a position and/or speed of the inlet valve (204a) and the outlet valve (204b); identifying (S304) a first point in time at which the sensor data indicates that the position and/or speed of the inlet valve (204a) reaches a first threshold value; identifying (S306) a second point in time at which the sensor data indicates that the position and/or speed of the outlet valve (204b) reaches a second threshold value; identifying (S308) a third point in time at which a movement of the piston (106) between a volume-reducing position and a volume-increasing position is started; based on a comparison between the first and third point in time, and a comparison between the second and third point in time, determining (S310) an actuation time point of the inlet valve (204a) and/or an actuation time point of the outlet valve (204b); and updating (S312) the parameter settings used by a control unit (112) of the filling station (106) based on the actuation time point determined for the inlet valve (204a) and/or the actuation time point determined for the outlet valve (204b).

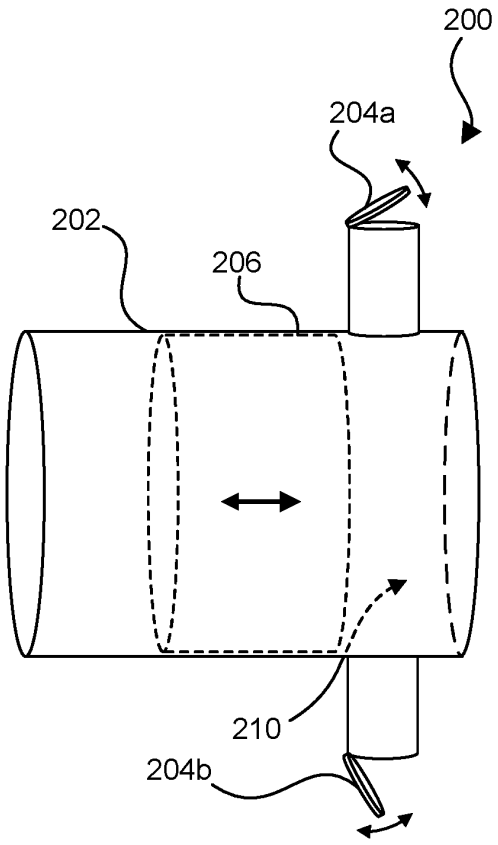

Fig. 2B

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Description

Technical field

[0001] The present invention relates to the field of packaging technology. More particularly, it is related to methods and apparatuses for adjusting parameter settings of a filling station in a packaging machine.

Background of the invention

[0002] Within the packaging industry, there is a constant demand for improvements. For example, sustainability (e.g. waste management and resource efficiency), product safety (e.g. contamination control and traceability), quality assurance (e.g. consistency, volume accuracy, shelf-life extension), and supply chain management (efficiency and transparency) are just a few examples of aspects that can be improved. As a result, packaging machines have become more and more automated which in turn has enabled significant increase in production rates. Today's state of the art packaging machines can produce several thousands of packages per hour. This puts high expectations on the control, design and functioning of different components of the packaging machine.

[0003] For instance, in the production of packages containing a liquid product, such as within the food industry, the process of filling the package has a significant effect on the above described aspects. As an example, mistiming in opening and closing of valves in relation to a pump piston or a position of the package to be filled can affect volume accuracy, integrity of the product or sealing of the package, or requiring the speed of the packaging machine to be reduced resulting in a lower production rate. It is therefore need for improving control of filling stations. A problem is however that there are a lot of parameters affecting the filling process, such as product properties (e.g. viscosity, density, presence of particles etc.), inherent inaccuracies, delay or moving time in components such as valves etc. In addition, these parameters may vary over time, such that any calibration made will deteriorate with time. It is therefore hard to maintain a high performance over time. Even further, what is an optimal control of one packaging machine may not be the same for a different packaging machine, since each mechanical component (such as valves, pumps, etc.) is unique, thus requiring an individualized calibration process. Present ways of controlling the filling process are insufficient in regard to many of the above mentioned aspects. It is therefore a need for improvements in this field.

Summary of the invention

[0004] The herein disclosed technology seeks to at least partly mitigate, alleviate or eliminate one or more of the above-mentioned deficiencies and disadvantages in the prior art. In particular, it is an object to provide a method for adjusting parameter settings for a filling station in a packaging machine.

[0005] The inventor of the present inventive concept has realized a new and improved way of controlling the filling process in the filling station. More specifically, the presently disclosed technology provides for an adaptive and dynamic way of adjusting the parameter settings for controlling the filling station in an improved way for increasing filling performance and package integrity, as well as reducing waste during production.

[0006] Various aspects and embodiments of the disclosed invention are defined below and in the accompanying independent and dependent claims.

[0007] According to a first aspect, there is provided a method for adjusting parameter settings for a filling station in a packaging machine. The filling station comprises: a pump comprising a hollow body, an inlet valve, an outlet valve and a piston. A cavity configured to hold a liquid product is formed by the hollow body, the inlet valve, and the outlet valve. The piston is movably arranged between a volume-reducing position, and a volume-increasing position. The pump is configured to be in a cavity filling state in which the inlet valve is open such that the liquid product is allowed to enter the cavity, or in a cavity emptying state in which the outlet valve is open such that the liquid product held in the cavity is allowed to be released into a package. The filling station further comprises a control unit configured to control opening and closing of the inlet and outlet valve, and to control movement of the piston. The filling station further comprises one or more sensors for providing sensor data relating to the inlet valve and outlet valve. The method comprises obtaining, via the one or more sensors, sensor data relating to the inlet valve and the outlet valve respectively, wherein the sensor data is indicative of a position and/or speed of the inlet valve and the outlet valve. The method further comprises identifying a first point in time at which the sensor data indicates that the position and/or speed of the inlet valve reaches a first threshold value. The method further comprises identifying a second point in time at which the sensor data indicates that the position and/or speed of the outlet valve reaches a second threshold value. The method further comprises identifying a third point in time at which a movement of the piston between the volume-reducing position and the volume-increasing position is started. The method further comprises, based on a comparison between the first and third point in time, and a comparison between the second and third point in time, determining an actuation time point of the inlet valve and/or an actuation time point of the outlet valve. The method further comprises updating the parameter settings used by the control unit based on the actuation time point determined for the inlet valve and/or the actuation time point determined for the outlet valve.

[0008] As mentioned above, the presently disclosed technology provides for an adaptive and dynamic way of adjusting the parameter settings used in controlling of a

filling process which may be associated with several advantages. Firstly, the method provides adjusted parameter settings which are individualized for the specific filling station, e.g. the specific inlet and outlet valves. This may yield improved production results as different filling machines may work in different ways. Furthermore, it may allow the control of the filling process (or more specifically the pump) to adapt to changes in properties of the product (such as variations in viscosity), filling conditions (such as varying filling volumes of the product which can affect the movement of the inlet and outlet valves), or other changes occurring over time.

[0009] By updating the parameter settings used by the control unit based on the determined actuation times, a risk of compromising package integrity e.g. due to product residues present at a sealing section of the package can be reduced. It may further improve volume accuracy of the filled packages.

[0010] Moreover, by employing the first and second threshold value for the position and/or speed of the inlet and outlet valve, the first and second point in time can be identified more reliably. More specifically, reaching the threshold value can give a more reliable indication on that the pump is changing from one state to another. Noise or other variations in the sensor data may otherwise give rise to erroneously identified point in times for opening or closing of the inlet and outlet valves. The point in time at which the inlet and outlet reaches the respective first and second threshold value may be seen as points in time when they are starting to open, or have almost closed.

[0011] The inlet valve and the outlet valve may be pneumatic valves. The one or more sensors may be arranged to measure a position and/or speed of a valve piston arranged in an air chamber of the pneumatic valve. Pneumatic valves are commonly used in filling machines for several reasons, such as their speed, durability etc. However, depending on the individual valve, there may be a delay between a requested opening/closing and an actual opening/closing. Furthermore, variations in pneumatic air pressure may further affect the timing of opening and closing. For example, if the air pressure is at a specified value, the valve may be expected to start to move (either from a closed to open state, or from an open to closed state) after a certain amount of time. However, some variations may exist which can cause the valve to start to move at an earlier or later time than expected. The presently disclosed technology may however provide for improvements in this regard, by allowing the actuation times to be determined dynamically to adjust and compensate for such variations.

[0012] The method may further comprise controlling a filling process of the filling station, using the control unit of the filling station, based on the updated parameter settings.

[0013] The obtained sensor data relating to the inlet valve and the outlet valve may pertain to a first filling cycle. The parameter settings may be updated for a second subsequent filling cycle.

[0014] The method may be performed iteratively for a number of subsequent filling cycles. By performing the method iteratively, more accurate actuation time points may be determined, since the determined actuation time points can be adjusted over a number of filling cycles. Furthermore, the determined actuation time points may be adjusted to take into account any changes happening over time, such as variation in product properties.

[0015] Determining the actuation time point of the inlet valve and the actuation time point of the outlet valve may be further based on a comparison between the first and second point in time.

[0016] By determining the actuation time points further based on the comparison between the first and second point in time may be advantageous in that it can reduce the risk of overlap of an open state of the inlet and outlet valve. Thereby, a volume accuracy can be increased.

[0017] In a case the third point in time indicates a start of a movement of the piston from the volume-reducing position to the volume-increasing position, the determined actuation time point of the inlet valve may be an opening initiation time point of the inlet valve, and the determined actuation time point of the outlet valve may be a closing initiation time point of the outlet valve.

[0018] In response to a difference between the first and third point in time being below a first reference value, the opening initiation time point of the inlet valve may be determined as an earlier point in time compared to a current opening initiation time point.

[0019] In response to a difference between the second and third point in time being below a second reference value, the closing initiation time point of the outlet valve may be determined as an earlier point in time compared to a current closing initiation time point. By adjusting the opening or closing initiation time point in accordance with above, the first or second point in time of a subsequent filling cycle may occur at an earlier point.

[0020] In response to a difference between the first and third point in time being greater than a difference between the second and third point in time, the opening initiation time point of the inlet valve may be determined as a later point in time compared to a current opening initiation time point, and/or the closing initiation time point of the outlet valve may be determined as an earlier point in time compared to a current closing initiation time point.

[0021] In case the third point in time indicates a start of a movement of the piston from the volume-increasing position to the volume-reducing position, the determined actuation time point of the inlet valve may be a closing initiation time point of the inlet valve, and the determined actuation time point of the outlet valve may be an opening initiation time point of the outlet valve.

[0022] In response to a difference between the first and third point in time being below a first reference value, the closing initiation time point of the inlet valve may be determined as an earlier point in time compared to a current closing initiation time point.

[0023] In response to a difference between the second

and third point in time being below a second reference value, the opening initiation time point of the outlet valve may be determined as an earlier point in time compared to a previous opening initiation time point.

[0024] In response to a difference between the first and third point in time being smaller than a difference between the second and third point in time, the closing initiation time point of the inlet valve may be determined as an earlier point in time compared to a current closing initiation time point, and/or the opening initiation time point of the outlet valve may be determined as a later point in time compared to a current opening initiation time point

[0025] According to a second aspect, there is provided a non-transitory computer-readable storage medium storing one or more programs configured to be executed by one or more processors of a processing system, the one or more programs comprising instructions for performing the method according to the first aspect.

[0026] The above-mentioned features and advantages of the first aspect, when applicable, apply to this second aspect as well. In order to avoid undue repetition, reference is made to the above.

[0027] According to a third aspect, there is provided a computer program product. The computer program product comprises instructions which, when the program is executed by a computer, cause the computer to carry out the steps of the method of the first aspect.

[0028] The above-mentioned features and advantages of the first and second aspect, when applicable, apply to this third aspect as well. In order to avoid undue repetition, reference is made to the above.

[0029] According to a fourth aspect, there is provided a method, performed in a packaging machine, for producing a package filled with a liquid product. The packaging machine comprises a filling station and a sealing station. The method comprises transferring a package with an open end to the filling station, wherein the package comprises a sealing section at the open end. The method further comprises filling, by the filling station, the package with the liquid product by controlling a pump of the filling station according to updated parameter settings obtained by the method according to the first aspect. The method further comprises transferring the package to the sealing station. The method further comprises sealing, by the sealing station, the open end of the package by: heating the sealing section such that a plastic foil layer of a packaging material of the package at least partly melts; and applying a pressure at the sealing section such that the plastic foil layer at the sealing section bonds and the open end is closed. Thereby, a filled and sealed package may be produced.

[0030] As explained in the foregoing, the filling process may have an impact on the results of the subsequent sealing process. In case the filling process is controlled in an undesirable way, there is a risk of product residue ending up on the sealing section of the package. By the presently disclosed technology, this risk may be reduces, resulting in an overall better production performance which involves also the sealing quality and integrity.

[0031] Moreover, the above-mentioned features and advantages of the first through third aspect, when applicable, apply to this fourth aspect as well. In order to avoid undue repetition, reference is made to the above. Additionally, the above-mentioned features and advantages of the fourth aspect, when applicable, apply to the other aspects as well.

[0032] According to a fifth aspect, there is provided a device for adjusting parameter settings for a filling station in a packaging machine. The filling station comprises: a pump comprising a hollow body, an inlet valve, an outlet valve and a piston. A cavity configured to hold a liquid product is formed by the hollow body, the inlet valve, and the outlet valve. The piston is movably arranged between a volume-reducing position and a volume-increasing position. The pump is configured to be in a cavity filling state in which the inlet valve is open such that the liquid product is allowed to enter the cavity, or in a cavity emptying state in which the outlet valve is open such that the liquid product held in the cavity is allowed to be released into a package. The filling station further comprises a control unit configured to control opening and closing of the inlet and outlet valve, and to control movement of the piston. The filling station further comprises one or more sensors for providing sensor data relating to the inlet valve and outlet valve. The device comprises control circuitry configured to obtain, via the one or more sensors, sensor data relating to the inlet valve and the outlet valve respectively, wherein the sensor data is indicative of a position and/or speed of the inlet valve and the outlet valve. The control circuitry is further configured to identify a first point in time at which the sensor data indicates that the position and/or speed of the inlet valve reaches a first threshold value. The control circuitry is further configured to identify a second point in time at which the sensor data indicates that the position and/or speed of the outlet valve reaches a second threshold value. The control circuitry is further configured to identify a third point in time at which a movement of the piston between the volume-reducing position and the volume-increasing position is started. The control circuitry is further configured to, based on a comparison between the first and third point in time, and a comparison between the second and third point in time, determine an actuation time point of the inlet valve and/or an actuation time point of the outlet valve. The control circuitry is further configured to update the parameter settings used by the control unit based on the actuation time point determined for the inlet valve and/or the actuation time point determined for the outlet valve.

[0033] The above-mentioned features and advantages of the first through fourth aspect, when applicable, apply to this fifth aspect as well. In order to avoid undue repetition, reference is made to the above.

[0034] According to a sixth aspect, there is provided a packaging machine comprising a filling station. The filling station comprises a pump comprising a hollow body, an

inlet valve, an outlet valve and a piston. A cavity configured to hold a liquid product is formed by the hollow body, the inlet valve, and the outlet valve. The piston is movably arranged between a volume-reducing position, and a volume-increasing position. The pump is configured to be in a cavity filling state in which the inlet valve is open such that the liquid product is allowed to enter the cavity, or in a cavity emptying state in which the outlet valve is open such that the liquid product held in the cavity is allowed to be released into a package. The filling station further comprises a control unit configured to control opening and closing of the inlet and outlet valve, and to control movement of the piston. The filling station further comprises one or more sensors for providing sensor data relating to the inlet valve and outlet valve. The packaging machine further comprises a sealing station. The packaging machine further comprises a device according to the fifth aspect.

[0035] The above-mentioned features and advantages of the first through fifth aspect, when applicable, apply to this sixth aspect as well. In order to avoid undue repetition, reference is made to the above.

[0036] A further scope of applicability of the present disclosure will become apparent from the detailed description given below. However, it should be understood that the detailed description and specific examples, while indicating preferred variants of the present inventive concept, are given by way of illustration only, since various changes and modifications within the scope of the inventive concept will become apparent to those skilled in the art from this detailed description.

[0037] Hence, it is to be understood that this inventive concept is not limited to the particular steps of the methods described or component parts of the systems described as such method and system may vary. It is also to be understood that the terminology used herein is for purpose of describing particular embodiments only and is not intended to be limiting. It must be noted that, as used in the specification and the appended claim, the articles "a", "an", "the", and "said" are intended to mean that there are one or more of the elements unless the context clearly dictates otherwise. Thus, for example, reference to "a device" or "the device" may include several devices, and the like. Furthermore, the words "comprising", "including", "containing" and similar wordings do not exclude other elements or steps.

[0038] The disclosed aspects and preferred embodiments may be suitably combined with each other in any manner apparent to anyone of ordinary skill in the art, such that one or more features or embodiments disclosed in relation to one aspect may also be considered to be disclosed in relation to another aspect or embodiment of another aspect.

Brief description of the drawings

[0039] The above and other aspects of the present inventive concept will now be described in more detail, with reference to appended drawings showing variants of the present inventive concept. The figures should not be considered limiting the invention to the specific variant; instead, they are used for explaining and understanding the inventive concept.

[0040] As illustrated in the figures, the sizes of layers and regions are exaggerated for illustrative purposes and, thus, are provided to illustrate the general structures of variants of the present inventive concept. Like reference numerals refer to like elements throughout.

Figure 1 schematically illustrates, by way of example, a packaging machine.

Figure 2A to 2C schematically illustrates, by way of example, a pump of a fillings station in different states.

Figure 3 is a flow chart illustrating the steps of a method for adjusting parameter settings for a filling station in a packaging machine.

Figure 4A and 4B are graphs illustrating, by way of example, a speed of an inlet valve, an outlet valve and a piston of a pump of a filling station.

Figure 5 schematically illustrates a device for adjusting parameter settings for a filling station in a packaging machine.

Figure 6 is a flow chart illustrating the steps of a method for producing a package.

Detailed description

[0041] The present inventive concept will now be described more fully hereinafter with reference to the accompanying drawings, in which currently preferred variants of the inventive concept are shown. This inventive concept may, however, be implemented in many different forms and should not be construed as limited to the variants set forth herein; rather, these variants are provided for thoroughness and completeness, and fully convey the scope of the present inventive concept to the skilled person.

[0042] It will also be appreciated that when the present disclosure is described in terms of a method, it may also be embodied in an apparatus or device comprising one or more processors, one or more memories coupled to the one or more processors, where computer code is loaded to implement the method. For example, the one or more memories may store one or more computer programs that perform the steps, services and functions disclosed herein when executed by the one or more processors in some embodiments.

[0043] It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting. It should be noted that, as used in the specification and the appended claim, the articles "a", "an", "the", and "said" are intended to mean that there are one or more of the elements unless the context clearly dictates otherwise. Thus, for example, reference to "a unit" or "the unit" may

refer to more than one unit in some contexts, and the like. Furthermore, the words "comprising", "including", "containing" do not exclude other elements or steps. It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps, or components. It does not preclude the presence or addition of one or more other features, integers, steps, components, or groups thereof. The term "and/or" is to be interpreted as meaning "both" as well and each as an alternative. The term "obtaining" is herein to be interpreted broadly and encompasses receiving, retrieving, collecting, acquiring, and so forth.

[0044] It will also be understood that, although the term first, second, etc. may be used herein to describe various elements or features, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first function could be termed a second function, and, similarly, a second function could be termed a first function, without departing from the scope of the embodiments. The first function and the second function are both functions, but they are not the same function.

[0045] A method for adjusting parameter settings for a filling station in a packaging machine, as well as other aspects thereof will now be described with reference to Fig. 1 to Fig. 6.

[0046] Figure 1 schematically illustrates, by way of example, a packaging machine 100. More specifically, Fig. 1 illustrates a packaging machine 100 for producing packages 102 filled with a liquid product 116 (herein illustrated by dashed lines). The packages 102 are herein provided having an open end (e.g. a top end). Thus, the packages 102 can be filled through the open end, before they are sealed. In some embodiments, the packaging machine 100 may be configured to produce so called gable top packages. An example of such a packaging machine 100 (sometimes referred to as filling machine) is marketed by Tetra Pak under the name Tetra Rex°. In this case, the liquid product typically is a food product such as dairy product, juice, or any other type of liquid food products. It is however to be noted that the presently disclosed technology is not limited to food products, as it may also be used in other types of liquid products. In some embodiments, the package 102 may be a carton based package. In other words, the package may be made of a packaging material comprising a carton layer. The packaging material may further comprise at least one plastic foil layer. In the following, the packaging machine 100 will be described in more detail.

[0047] The packages 102 are typically transported (also referred to as transferred) through the packaging machine 100 by a conveyor (belt) 104. Thus, the packages 102 move through the packaging machine 100 between different stations, along a feeding direction, herein indicated by the arrow denoted FD.

[0048] The packaging machine 100 comprises a filling station 106. The filling station 106 is configured to fill packages 102 with a liquid product 116. The filling station 106 comprises a pump 200. The pump comprises a hollow body 202, an inlet valve 204a, an outlet valve 204b and a piston 206. The hollow body 202, the inlet valve 204a and the outlet valve 204b forms a cavity 210 configured to hold the liquid product, at least temporarily. The piston 206 is movably arranged between a volume-reducing position and a volume-increasing position. Thereby, by moving the piston 206, the pump 200 can either pull in the liquid product through an inlet 208a to fill the cavity 210, or push out the liquid product held in the cavity through an outlet 208b. The former case may be referred to as a cavity filling state of the pump 200. In the cavity filling state, the inlet valve 204a is open such that the liquid product is allowed to enter the cavity 210. The latter case may be referred to as a cavity emptying state of the pump 200. In the cavity emptying state, the outlet valve 204b is open such that the liquid product held in the cavity 210 is allowed to be released into a package 102 to be filled. The pump 200 is further described in connection with Fig. 2A to 2C.

[0049] The filling station 106 further comprises a control unit 112 configured to control opening and closing of the inlet and outlet valve 204a, 204b. The control unit 112 are further configured to control movement of the piston 206. The control unit 112 may be provided as an integral unit of the filling station 106, communicatively connected to the pump 200, as indicated by the double arrow. Alternatively, the control unit 112 may be implemented as part of a control system of the packaging machine 100.

[0050] The filling station 106 further comprises one or more sensors (not show) for providing sensor data relating to the inlet valve 204a and outlet valve 204b. The one or more sensors will be further described in connection with Fig. 2A to 2C, and Fig. 4A to 4B.

[0051] The filling station 106 may further comprise a filling nozzle 108. The filling nozzle 108 herein refers to a component which serves as the interface between the filling station 106 and the package 102 to be filled. In other words, the filling nozzle 108 is configured to release the liquid product 108 into the package 102. The filling nozzle 108 may be a rubber nozzle. The filling nozzle 108 may be kept at a fixed position. During filling of the package (i.e. when the liquid product 116 is released into the package 102), the package 102 may be raised such that the filling nozzle 108 is arranged at a bottom region of the package 102. The liquid product may then be released into the package 102. As the level of the liquid product 116 rises in the package 102, the package 102 may be lowered such that the filling nozzle 108 is kept from being immersed in the liquid product. The raising and lowering of the package 102 (herein illustrated by a two-sided arrow, may be achieved e.g. by a lifting mechanism of the conveyor 104.

[0052] The packaging machine 100 further comprises a sealing station 114. The sealing station 114 is configured to seal the packages 102 filled with the liquid product. Sealing the packages may further involve folding of the package. More specifically, the sealing station 114 is

configured to seal the open end of the packages 102. The open end of the package 102 may comprise a sealing section, i.e. a section of the package intended to be sealed. Sealing the package 102 may comprise providing heat to the sealing section of the open end of the package 102 and applying a pressure to the sealing section such that the sealing section bonds to close the open end. In some examples, a plastic layer of the packaging material in the sealing section may at least partly melt due to the provided heat. By the applied pressure, the plastic foil layer of the sealing section may be bonded together. Thus, the plastic foil layer may constitute an adhesive. Alternatively, a different adhesive may be provided to the sealing section at the sealing station 114 to seal the package 102.

[0053] The sealing station 114 thus outputs finished packages 102 (i.e. packages that are filled and sealed) which may then be transported to a subsequent station, e.g. for packing and transport.

[0054] In view of the functioning of the packaging machine 100 as described above, the control of the inlet and outlet valve of the pump 200 is crucial for the filling performance. The filling performance can be formulized at least in three different aspects. The first aspect is volume accuracy. Volume accuracy herein refers to how accurate it is in filling the package with a certain volume. The volume accuracy may e.g. be affected by an overlap between the inlet and outlet valve (i.e. both valves being open at the same time), and by inlet and/or outlet valve leakage (i.e. one or both valve not being sufficiently closed).

[0055] The second aspect is product splash. Product splash herein refers to the movement of the liquid product as it is released into the package. The product splash may be affected by pressure build-up in the pump before the outlet valve is opened, resulting is a burst of product, or by inlet and outlet valve overlap. Product splash may lead to product accumulation on the filling nozzle 108. Product accumulation may in turn affect the cleanliness and integrity of the product. Furthermore, there is a risk of the accumulated product dripping onto the sealing section of a package being filled, having a negative effect on the subsequent sealing process.

[0056] The third aspect is after dripping. After dripping herein refers to drips of the liquid product after the filling has ended. This may be caused e.g. by the outlet valve not being fully closed at the right time, or by inlet and outlet valve overlap. As with the accumulated product, after dripping risks resulting in product at the sealing section of the package, thereby affecting the sealing performance.

[0057] The herein disclosed technology provides a way of mitigating these problems by adjusting parameter settings for the filling station 106. This may e.g. be achieved by the packaging machine 100 being provided with a device 500 (as further described below in connection with Fig. 5) for performing the method 300 as described in connection with Fig. 3. The control unit 112 of the filling station 106 may constitute such a device 500.

[0058] It is to be noted that the herein illustrated packaging machine 100 is a simplified version for illustrative purposes. The sizes and shapes of the different components are not to be treated as limiting in any way, as they are not to be seen as a real-life example. Further, as is readily understood, the packaging machine 100 may comprise additional stations and components not shown herein. For example, the packaging machine 100 may further comprise a station for providing the packages with open top, and a sterilization station for sterilizing the package.

[0059] Figure 2A to 2C schematically illustrates, by way of example, a pump 200 of a filling station in three different states. The pump 200 may be a pump of a filling station 106 as described above in connection with Fig. 1. As explained in the foregoing, the pump comprises a hollow body 202, an inlet valve 204a, an outlet valve 204b and a piston 206. A cavity 210 configured to hold a liquid product 116 is formed by the hollow body 202, the inlet valve 204a, and the outlet valve 204b. A volume of the cavity 210 may be adjusted based on a position of the piston 206. More specifically, the piston 206 is movably arranged between a volume-reducing position and a volume-increasing position. The volume-reducing position may be seen as an end position in which the volume of the cavity is as small as possible. Correspondingly, the volume-increasing position may be seen as an end position in which the volume of the cavity is as large as possible.

[0060] By increasing the volume (i.e. by moving the piston towards the volume-increasing position) the pump 200 can achieve a suction or pulling effect of liquid into the cavity through the inlet 208a. This may also be referred to as a refill stroke of the pump 200. Fig. 2C may be seen as a representation of the piston 206 moving towards the volume-increasing position (as indicated by the arrow on the piston 206). Fig. 2C may be further representative of the pump 200 being in a cavity filling state. The cavity filling state refers to a state in which the pump 200 is configured to fill the cavity with the liquid product. Thus, in the cavity filling state, the inlet valve 204a is open such that the liquid product 116 is allowed to enter the cavity 210. The cavity filling state may be further defined by the piston 206 moving from the volume-reducing position to the volume-increasing position to suck in the liquid product. As illustrated herein, the outlet valve 204b may be closed when the pump 200 is in the cavity filling state.

[0061] By instead reducing the volume (i.e. by moving the piston towards the volume-reducing position), the pump 200 can achieve a pushing or delivery effect of liquid in the cavity through the outlet 208b. This may also be referred to as a delivery stroke. Fig. 2A may be seen as a representation of the piston 206 moving towards the volume-reducing position (as indicated by the arrow on the piston 206). Fig. 2A may be further representative of the pump 200 being in a cavity emptying state. The cavity emptying state refers to a state in which the pump 200 is

configured to empty the cavity with the liquid product (i.e. by releasing the liquid product held therein). Thus, in the cavity emptying state, the outlet valve 204b is open such that the liquid product 116 is allowed to be released into the package 102. The cavity emptying state may be further defined by the piston 206 moving from the volume-increasing position to the volume-reducing position to push out the liquid product. As illustrated herein, the inlet valve 204a may be closed when the pump 200 is in the cavity emptying state.

[0062] Fig. 2B is shown to illustrate an intermediate state in which positions of the inlet valve 204a, outlet valve 204b and piston 206 are adjusted, as indicated by the arrows. It is however to be noted that the positions of the inlet valve 204a, the outlet valve 204b and the piston 206 as illustrated in the intermediate state, may not be representative of simultaneous positions in an actual case. For example, the position (or state) of the inlet and outlet valve 204a, 204b may be adjusted before adjusting the piston 206. Moreover, the inlet valve 204b may be adjusted before the outlet valve 204b, and vice versa, depending on whether the pump 200 transfers from the cavity filling state to the cavity emptying state or vice versa.

[0063] As explained in the foregoing, the fillings station 106 of the packaging machine 100 comprises one or more sensors for providing sensor data relating to the inlet valve 204a and the outlet valve 204b. In some embodiments, a first sensor may be arranged to provide sensor data relating to the inlet valve 204a. Further, a second sensor may be arranged to provide sensor data relating to the outlet valve 204. The first and second sensor may be position sensors configured to provide sensor data indicative of a position of the inlet and outlet valve 204a, 204b respectively. More specifically, in case the inlet and outlet valve 204a, 204b are pneumatic valves, the first and second sensor may be arranged to measure a position of a valve piston of the respective valve, the valve piston being arranged inside an air chamber of the valve. Put differently, the first and second sensor may be configured to sense the position of the valve piston located inside the respective valve. Alternatively, the first and second sensor may be velocity sensors, measuring a speed of the inlet and outlet valve 204a, 204b respectively. Thus, the first and second sensor may be arranged to measure a speed of the valve piston. By valve piston is herein meant a part of the pneumatic valve which movement (which can be controlled by pneumatic pressure) causes the valve to open or close.

[0064] In addition, a third sensor may be arranged to provide sensor data (either positional or speed data) relating to the piston 206.

[0065] The pump 200 as shown herein is merely for illustrative purposes for illustrating the interaction between the inlet and outlet valve 204a, 204b and the piston 206 of the pump 200, and should not be taken as representative of an actual physical pump. As is readily understood, the pump 200 may be any suitable pump as commonly used in filling stations of packaging machines. Moreover, the inlet and outlet valve 204a, 204b are herein illustrated simply as adjustable lids of a respective inlet 208a and outlet 208b of the hollow body 202. It is however to be noted that the inlet and outlet valve 204a, 204b may be any kind of pneumatically controlled valve. Such valves are commonly found in filling stations of packaging machines today.

[0066] Figure 3 is a flow chart illustrating the steps of a method 300 for adjusting parameter settings for a filling station 106 in a packaging machine 100. The filling station and packaging machine 100 have been described above in connection with Fig. 1 to 2C. In order to avoid undue repetition, reference is made to above.

[0067] Below, the different steps of the method 300 are described in more detail with reference to Fig. 3. Even though illustrated in a specific order, the steps of the method 300 may be performed in any suitable order, in parallel, as well as multiple times. Thus, although Fig. 3 may show a specific order of method steps, the order of the steps may differ from what is depicted. In addition, two or more steps may be performed concurrently or with partial concurrence. For example, the steps denoted S304, S306 and S308 may be performed in any order, at any point in time, or in parallel, based on a specific realization. Such variation will depend on the software and hardware systems chosen and on designer choice. All such variations are within the scope of the invention. Likewise, software implementations could be accomplished with standard programming techniques with rule-based logic and other logic to accomplish the various steps.

[0068] In some embodiments, the method 300 is performed iteratively for a number of subsequent filling cycles. The wording "filling cycle" herein refers to the filling process associated with filling of one package. In broad terms, a filling cycle may comprise the steps of receiving a package, opening the inlet valve, filling the cavity of the pump with the liquid product, closing the inlet valve, opening the outlet valve, and releasing the liquid product in the pump into the package. As an example, after two filling cycles, the steps required for filling a package has been performed twice, which results in two filled packages. Performing the method 300 over the number of subsequent filling cycles therefore provides for an iterative adjustment of the parameter settings, which are allowed to converge around any suitable values.

[0069] The method 300 comprises obtaining S302, via the one or more sensors, sensor data relating to the inlet valve 204a and the outlet valve 204b respectively. The sensor data is indicative of a position and/or speed of the inlet valve 204a and the outlet valve 204b. The sensor data may be indicative of the position and/or speed over time. The sensor data may e.g. be obtained continuously, or at discrete points in time over a filling cycle, or around a transition from one filling cycle to another. The sensor

data may be obtained S302 until the below described first to third points in time have been identified. Put differently, the sensor data may be obtained until the points in time have been detected.

[0070] Sensor data indicative of a position of the inlet and outlet valve 204a, 204b may be obtained directly by using position sensors. Sensor data indicative of a speed of the inlet and outlet valve 204a, 204b may be obtained directly by using speed sensors. Alternatively, the sensor data indicative of the speed of the inlet and outlet valve 204a, 204b, may be obtained as a derivative of sensor data indicative of the position. Using speed data obtained from position data may be advantageous in that the position data, which can be readily obtained through position sensors need not to be calibrated so as to output the actual position. Since the speed data effectively is a change in position data, stationary points (i.e. where the valves are not moving) can be determined regardless of what position the positional sensor actually outputs. Moreover, the transition points between the two different scenarios (further described below) can more easily be identified in the derivative of the positional data compared to the unprocessed positional data.

[0071] The method 300 further comprises identifying S304 a first point in time at which the sensor data indicates that the position and/or speed of the inlet valve 204a reaches a first threshold value. Put differently, the step denoted S304 may be formulated as detecting when (i.e. at what point in time) the position and/or speed of the inlet valve 204a reaches the first threshold value.

[0072] The method 300 further comprises identifying S306 a second point in time at which the sensor data indicates that the position and/or speed of the outlet valve 204b reaches a second threshold value. Put differently, the step denoted S306 may be formulated as detecting when (i.e. at what point in time) the position and/or speed of the outlet valve 204b reaches the second threshold value. The first and second threshold value may be the same or different threshold value(s).

[0073] In some embodiments, the first and second point in time are identified as points in time when the speed of the inlet and outlet valve reaches the first and second threshold value, respectively. In a case where both the position and speed of the inlet and outlet valve 204a, 204b are monitored to identify the first and second point in time, the first and second point in time may be identified as point in times of whichever (i.e. either the position and speed fulfilling the respective threshold value) happens later. Alternatively, the first and second point in time may be identified as point in times of whichever happens earlier. Further, the threshold values for the speed and position may be different threshold values.

[0074] The method 300 further comprises identifying S308 a third point in time at which a movement of the piston 206 between the volume-reducing position and the volume-increasing position is started. In other words, the third point in time is either a point in time where the piston starts to move from the volume-reducing position towards the volume-increasing position, or vice versa. Put differently, the third point in time may be a point in time at which the piston 206 starts its delivery stroke, or its refill stroke. Moreover, the third point in time may be defined as a point in time when a speed of the piston 206 reaches a third threshold value. The speed of the piston 206 may be a measured speed of the piston 206, e.g. as measured by a sensor. Alternatively, the speed of the piston 206 may be a command signal value for the speed of the piston 106. In other words, the command signal of the pump may be monitored in order to identify the third point in time. The command signal should herein be understood as a signal to the pump defining what position and/or speed the piston 206 should have.

[0075] The method 300 further comprises, based on a comparison between the first and third point in time, and a comparison between the second and third point in time, determining S310 an actuation time point of the inlet valve 204a and/or an actuation time point of the outlet valve 204b. Put differently, the comparison between the first and third point in time can be formulated as determining a difference between the first and third point in time, and comparing said difference to a certain reference value. The same holds for the comparison between the second and third point in time. Depending on the outcome of the respective comparison, actuation time points of either one or both of the inlet and outlet valve may be determined.

[0076] The wording "actuation time point" of the inlet and outlet valve 204a, 204b should herein be understood as a point in time of putting the respective valve into motion, i.e. either activating or deactivating the respective valve. Put differently, the actuation time point may be seen as a point in time of performing a mechanical action of the inlet or outlet valve. In other words, the actuation time point may refer to a point in time at which the closing or opening of the valve is initiated, e.g. by sending a request signal for closing or opening to the inlet or outlet valve.

[0077] Determining S310 the actuation time point(s) may be understood as determining an adjusted actuation time point, or determining an actuation point adjustment. In other words, determining S310 the actuation time point may be further based on a current (or previous) actuation time point. The determined actuation point adjustment may e.g. be applied to the current actuation time point to obtain an adjusted actuation time point. How the adjusted actuation time points of the inlet and outlet valve can be determined S310 based on the comparisons will be further described below.

[0078] As an example, if it was found that the first point in time occurred X amount of seconds too early, compared to the third point in time, the new actuation time point of the inlet valve may be determined as a later point in time compared to a current actuation time point of the inlet valve. More specifically, the new actuation time point may be determined as a point in time X amount of seconds later than the current actuation time point. Si-

milarly, if it was found that the second point in time occurred Y amount of seconds too late, compared to the third point in time, the new actuation time point of the outlet valve may be determined as an earlier point in time compared to a current actuation time point of the outlet valve. More specifically, the new actuation time point may be determined as a point in time Y amount of seconds earlier than the current actuation time point.

[0079] The method 300 further comprises updating S312 the parameter settings used by the control unit 112 based on the actuation time point determined for the inlet valve 204a and/or the actuation time point determined for the outlet valve 204b. In other words, control settings for the filling process may be adjusted by setting the determined actuation time point(s) as new actuation time point(s) for the control unit 112. The actuation time point (of the inlet and/or outlet valve) may be updated by being set to the determined actuation time point of the respective valve. However, in case the method is performed iteratively, the actuation time point (of the inlet and/or outlet valve) may be updated gradually over a number of filling cycles. If for example, it has been determined that the actuation time point should be adjusted by 8 ms, the actuation time point may be updated e.g. by 2 ms over four filling cycles. At each filling cycle, the updated actuation time points may be evaluated to see that it leads to an improvement of the filling process. By doing this, the procedure can be made more robust in that any incorrectly determined adjustments can be captured, such that they don't cause any significant deterioration of the filling performance.

[0080] The method 300 may further comprise controlling the filling station, by the control unit of the filling station, based on the updated parameter settings. In other words, a filling process of the filling station may be controlled based on the updated parameter settings.

[0081] The obtained sensor data relating to the inlet valve 204a and the outlet valve 204b may pertain to a first filling cycle. The parameter settings may be updated S312 for a second subsequent filling cycle. In other words, the updated parameter settings determined based on one filling cycle may be used in the control of a subsequent filling cycle. Repeating the above mentioned method steps for a number of filing cycles can therefore provide for continuous and dynamic adjustment of the parameter settings over a plurality of filling cycles. This may be advantageous both in that the parameter settings can be continuously calibrated and improved over time, and in that they can be adjusted to compensate for any changes in the filling process, such as variations in properties of the liquid product (e.g. variations in viscosity), or other changes over time.

[0082] Determining S310 the actuation time point of the inlet valve 204a and the actuation time point of the outlet valve 204b may be further based on a comparison between the first and second point in time. By comparing the first and second point in time of the inlet valve and outlet valve gives signal of any potential overlap between the inlet and outlet valves (i.e. both valves being at least partly open at the same time). Thereby, the updated parameter settings can be determine to reduce the risk of this overlap.

[0083] Hereinafter, distinction will be made between two different scenarios (may also be referred to as cases or events). As mentioned above, the pump 200 is configured to be in a cavity filling state (in which the cavity of the pump is filled with the product) or in a cavity emptying state (in which the package is filled with the product). The first scenario herein corresponds to when the pump 200 transitions from the cavity emptying state to the cavity filling state. In such case, the third point in time indicates a start of a movement of the piston 206 from the volume-reducing position to the volume-increasing position. This may also be referred to as an end of package filling state. The second scenario corresponds to when the pump 200 transitions from the cavity filling state to the cavity emptying state. In such case, the third point in time indicates a start of a movement of the piston 206 from the volume-increasing position to the volume-reducing position. This may also be referred to as a start of package filling state.

[0084] Looking first at the first scenario. The determined actuation time point of the inlet valve 204a is then an opening initiation time point of the inlet valve 204a, and the determined actuation time point of the outlet valve 204b is a closing initiation time point of the outlet valve 204b. The wording "opening initiation time point" should be construed as a point in time at which the valve receives a command signal which indicates that it should open. In other words, the opening initiation time point refers to the point in time at which the valve starts to open. Correspondingly, the "closing initiation time point" should be construed as a point in time at which the valve receives a command signal which indicates that is should close. In other words, the closing initiation time point refers to the point in time at which the valve starts to close.

[0085] In response to a difference between the first and third point in time being below a first reference value, the opening initiation time point of the inlet valve 204a may be determined S310 as an earlier point in time compared to a current opening initiation time point. Put differently, if the comparison between the first and third point in time yields that the difference is below the first reference value, the opening initiation time point of the inlet valve may be adjusted to an earlier point in time. Thus, the determined actuation time point for the inlet valve is then an earlier point in time compared to the current actuation time point. Similarly, if the difference between the first and third point in time is above the first reference value, the opening initiation time point of the inlet valve 204a may be determined as a later point in time.

[0086] Moreover, in response to a difference between the second and third point in time being below a second reference value, the closing initiation time point of the outlet valve 204b may be determined S310 as an earlier point in time compared to a current closing initiation time point. Put differently, if the comparison between the sec-

ond and third point in time yields that the difference is below the second reference value, the closing initiation time point of the outlet valve may be adjusted to an earlier point in time. Thus, the determined actuation time point for the outlet valve is then an earlier point in time compared to the current actuation time point. Similarly, if the difference between the second and third point in time is above the second reference value, the closing initiation time point of the outlet valve 204b may be determined as a later point in time.

[0087] Moreover, to avoid overlap between the inlet and outlet valve in the first scenario, the outlet valve should be more or less closed before the inlet valve starts to open. This may be achieved by the opening initiation time point of the inlet valve being at a later point in time than the closing initiation time point of the outlet valve. Thus, in response to the difference between the first and third point in time being greater than the difference between the second and third point in time, the opening initiation time point of the inlet valve may be determined as a later point in time compared to a current opening initiation time point. Alternatively, or in combination, the closing initiation time point of the outlet valve may be determined as an earlier point in time compared to a current closing initiation time point.

[0088] Moving on to the second scenario, the determined actuation time point of the inlet valve 204a is then a closing initiation time point of the inlet valve 204a, and the determined actuation time point of the outlet valve 204b is an opening initiation time point of the outlet valve 204b.

[0089] In response to a difference between the first and third point in time being below a first reference value, the closing initiation time point of the inlet valve 204a may be determined S310 as an earlier point in time compared to a current closing initiation time point. Put differently, if the comparison between the first and third point in time yields that the difference is below the first reference value, the closing initiation time point of the inlet valve may be adjusted to an earlier point in time. Thus, the determined actuation time point for the inlet valve is then an earlier point in time compared to the current actuation time point. Similarly, if the difference between the first and third point in time is above the first reference value, the closing initiation time point of the inlet valve 204a may be determined as a later point in time. It is to be noted that the first reference value used in the second scenario may be a different value than the first reference value used in the first scenario.

[0090] Moreover, in response to a difference between the second and third point in time being below a second reference value, the opening initiation time point of the outlet valve 204b may be determined S310 as an earlier point in time compared to a previous opening initiation time point. Put differently, if the comparison between the second and third point in time yields that the difference is below the second reference value, the opening initiation time point of the outlet valve may be adjusted to an earlier point in time. Thus, the determined actuation time point for the outlet valve is then an earlier point in time compared to the current actuation time point. Similarly, if the difference between the second and third point in time is above the second reference value, the opening initiation time point of the outlet valve 204b may be determined as a later point in time. It is to be noted that the second reference value used in the second scenario may be a different value than the second reference value used in the first scenario.

[0091] Moreover, to avoid overlap between the inlet and outlet valve in the second scenario, the inlet valve should be more or less closed before the outlet valve starts to open. This may be achieved by the closing initiation time point of the inlet valve being at an earlier point in time than the opening initiation time point of the outlet valve. Thus, in response to the difference between the first and third point in time being smaller than the difference between the second and third point in time, the closing initiation time point of the inlet valve may be determined as an earlier point in time compared to a current closing initiation time point. Alternatively, or in combination, the opening initiation time point of the outlet valve may be determined as a later point in time compared to a current opening initiation time point.

[0092] For further details of the different points in time and the relationship between then, reference is made to Fig. 4A and 4B below, in which an illustrative example is presented.

[0093] Further variants of the method 300 will become apparent from the present disclosure. The above mentioned and described embodiments are only given as examples and should not be limiting to the present invention. Other solutions, uses, objectives, and functions within the scope of the invention as claimed below described patent claims should be apparent for the person skilled in the art.

[0094] The above described method 300 will be further exemplified by way of example as described below in connection with Fig. 4A and 4B.

[0095] Executable instructions for performing these functions are, optionally, included in a non-transitory computer-readable storage medium or other computer program product configured for execution by one or more processors.

[0096] Generally speaking, a computer-accessible medium may include any tangible or non-transitory storage media or memory media such as electronic, magnetic, or optical media-e.g., disk or CD/DVD-ROM coupled to computer system via bus. The terms "tangible" and "non-transitory," as used herein, are intended to describe a computer-readable storage medium (or "memory") excluding propagating electromagnetic signals, but are not intended to otherwise limit the type of physical computer-readable storage device that is encompassed by the phrase computer-readable medium or memory. For instance, the terms "non-transitory computer-readable medium" or "tangible memory" are intended to encompass types of storage devices that do not ne-

cessarily store information permanently, including for example, random access memory (RAM). Program instructions and data stored on a tangible computer-accessible storage medium in non-transitory form may further be transmitted by transmission media or signals such as electrical, electromagnetic, or digital signals, which may be conveyed via a communication medium such as a network and/or a wireless link.

[0097] Figure 4A and 4B are graphs illustrating, by way of example, a speed of the inlet valve, the outlet valve and the piston of the pump in the first and second scenario respectively, over time. More specifically, the graph denoted 402 is an interpolation of measured speed readings (represented by circles) of the inlet valve, and the graph denoted 404 is an interpolation of measured speed readings (represented by diamonds) of the outlet valve. These graphs may thus represent the obtained sensor data relating to the inlet and outlet valve. In the present example, the speed readings has been obtained by derivation of position readings of the inlet and outlet valve. The graph denoted 406 represents a command signal for a speed of the piston 206 of the pump 200. Further shown in Fig. 4A and 4B is a threshold value, V1, V2 (indicated by the dashed line 408) which in the illustrated example serves as the first and second threshold value used in identifying the first and second point in time. It is however to be noted that the first and second threshold value may be different values. In addition, the first and second threshold value of the first scenario (herein V1) may be different from the first and second threshold value of the second scenario (herein V2).

[0098] Fig. 4A illustrates the case which above has been described as the first scenario, i.e. where the inlet valve 204a should open, and the outlet valve 204b should close for allowing the cavity of the pump 200 to be refilled.

[0099] A point in time at which the speed of the inlet valve reaches the threshold value V1 (indicated by a star) is herein identified as the first point in time T1, as has been described in the foregoing. Correspondingly, a point in time at which the speed of the outlet valve reaches the threshold value V1 is identified as the second point in time T2. Moreover, the above described third point in time is herein indicated as the point in time denoted T3 at which the piston starts to move. More specifically, the third point in time T3 may be identified as the point in time at which the speed command signal of the piston transitions from zero to a non-zero value. Further illustrated in Fig. 4A is a fourth point in time T4 which indicates a point in time at which the piston stops.

[0100] In accordance with the above described method 300, the actuation point (in this case an opening initiation time point) of the inlet valve can be determined based on a comparison between the first point in time T1 and the third point in time T3. The comparison may comprise comparing a first distance (herein denoted D1) between the first and third point in time against a reference value. In other words, the actuation time point can be adjusted by the presently disclosed technology such that the first point in time T1 occurs at a certain amount of time before the third point in time T3.

[0101] The actuation point (in this case a closing initiation time point) of the outlet valve can be determined based on a comparison between the second point in time T2 and the third point in time T3. The comparison may comprise comparing a second distance (herein denoted D2) between the second and third point in time against a reference value. In other words, the actuation time point can be adjusted by the presently disclosed technology such that the second point in time T2 occurs at a certain amount of time before the third point in time T3. The reference values to which the first and second distance are compared may be between 1 and 5 milliseconds (ms). More specifically, the reference values may be between 2 and 4ms. The reference value to which the first distance D1 is compared may, in the present case, be smaller than the reference value to which the second distance D2 is compared. It is however to be appreciated that the reference values may vary depending on a specific scenario. As an example, the reference values may be dependent on a type of valve used, a type of liquid product that is to be filled in the packages, other components of the filing station or packaging machine, etc.

[0102] Fig. 4B illustrates the case which above has been described as the second scenario, i.e. where the inlet valve 204a should close, and the outlet valve 204b should open for allowing the liquid product in the cavity of the pump 200 to be emptied into the package.

[0103] A point in time at which the speed of the inlet valve reaches the threshold value V2 (indicated by a star) is herein identified as the first point in time T1, as has been described in the foregoing. Correspondingly, a point in time at which the speed of the outlet valve reaches the threshold value V2 is identified as the second point in time T2. Moreover, the above described third point in time is herein indicated as the point in time denoted T3 at which the piston starts to move. More specifically, the third point in time T3 may be identified as the point in time at which the speed command signal of the piston increases from zero to a non-zero value.

[0104] In accordance with the above described method 300, the actuation point (in this case a closing initiation time point) of the inlet valve can be determined based on a comparison between the first point in time T1 and the third point in time T3. The comparison may comprise comparing the first distance (herein denoted by D1) between the first and third point in time against a reference value. In other words, the actuation time point can be adjusted in accordance with the presently disclosed technology such that the first point in time T1 occurs at a certain amount of time before the third point in time T3.

[0105] The actuation point (in this case an opening initiation time point) of the outlet valve can be determined based on a comparison between the second point in time T2 and the third point in time T3. The comparison may comprise comparing a second distance (herein denoted by D2) between the second and third point in time against

a reference value. In other words, the actuation time point can be adjusted by the presently disclosed technology such that the second point in time T2 occurs at a certain amount of time before the third point in time T3. The reference value to which the first distance D1 is compared may, in the present case, be greater than the reference value to which the second distance D2 is compared, thereby allowing the closing of the inlet valve to happen before the opening of the outlet valve. The reference value to which the first distance D1 in the second scenario are compared may be the same reference value to which the second distance D2 in the first scenario is compared. Moreover, the reference value to which the second distance D2 in the second scenario are compared may be the same reference value to which the first distance D1 in the first scenario is compared.

[0106] Figure 5 schematically illustrates a device 500 for adjusting parameter settings for a filling station in a packaging machine. In particular, the device 500 is configured to perform the method 300 as described above in connection with Fig. 3. Any aspects, principles or advantages described above in connection with the method 300 applies to the device 500 as described below, and vice versa. The device 500 may also be referred to as control device or control apparatus. The device 500 may be provided as an integral part of the packaging machine, such as the packaging machine 100 described in connection with Fig. 1. More specifically, the device 500 may be part of a control system of the packaging machine 100. Alternatively, the device 500 may be provided externally to the packaging machine 100. In such case, the device 500 may be communicatively connected to the packaging machine 100, either wirelessly (e.g. Bluetooth, Wi-Fi, cellular communication etc.) or through wired connection.

[0107] The device 500 comprises circuitry 502. The circuitry 502 may physically comprise one single circuitry device. Alternatively, the circuitry 502 may be distributed over several circuitry devices. As shown in the example of Fig. 5, the device 500 may further comprise a transceiver 506 and a memory 508. The circuitry 502 being communicatively connected to the transceiver 506 and the memory 508. The circuitry 502 may comprise a data bus (not illustrated in Fig. 5), and the circuitry 502 may communicate with the transceiver 506 and/or the memory 508 via the data bus.

[0108] The circuitry 502 may be configured to carry out overall control of functions and operations of the device 500. The circuitry 502 may include a processor 504, such as a central processing unit (CPU), microcontroller, or microprocessor. The processor 504 may be configured to execute program code stored in the memory 508, in order to carry out functions and operations of the device 500.

[0109] The transceiver 506 may be configured to enable the device 500 to communicate with other devices or apparatuses. As in the example given above, the device 500 may be communicatively connected to a control system of the packaging machine 100, e.g. through the transceiver 506. The transceiver 506 may both transmit data from and receive data to the device 500. The transceiver 506 may communicate over wired or wireless communication protocols (e.g. Bluetooth, Wi-Fi, cellular communication etc.).

[0110] The memory 508 may be a non-transitory computer-readable storage medium. The memory 508 may be one or more of a buffer, a flash memory, a hard drive, a removable media, a volatile memory, a non-volatile memory, a random access memory (RAM), or another suitable device. In a typical arrangement, the memory 508 may include a non-volatile memory for long term data storage and a volatile memory that functions as system memory for the device 500. The memory 508 may exchange data with the circuitry 502 over the data bus. Accompanying control lines and an address bus between the memory 508 and the circuitry 502 also may be present.

[0111] Even though not explicitly illustrated in Fig. 5, the device 500 may comprise input devices such as one or more of a keyboard, a mouse, and a touchscreen. The device 500 may further comprise a display for providing output to the user (e.g. a machine operator).

[0112] Functions and operations of the device 500 may be implemented in the form of executable logic routines (e.g., lines of code, software programs, etc.) that are stored on a non-transitory computer readable recording medium (e.g., the memory 508) of the device 500 and are executed by the circuitry 502 (e.g. using the processor 504). Put differently, when it is stated that the circuitry 502 is configured to perform a specific operation, or execute a specific function, the processor 504 of the circuitry 502 may be configured execute program code portions stored on the memory 508, wherein the stored program code portions correspond to the specific operation or function. Furthermore, the functions and operations of the circuitry 502 may be a stand-alone software application or form a part of a software application that carries out additional tasks related to the circuitry 502. The described functions and operations may be considered a method that the corresponding device is configured to carry out, such as the method 300 discussed above in connection with Fig. 3. Also, while the described functions and operations may be implemented in software, such functionality may as well be carried out via dedicated hardware or firmware, or some combination of one or more of hardware, firmware, and software. The following operations may be performed by the device 500, and may be stored as functions on a non-transitory computer readable recording medium.

[0113] The control circuitry 502 is configured to obtain, via the one or more sensors, sensor data relating to the inlet valve 204a and the outlet valve 204b respectively. The sensor data is indicative of a position and/or speed of the inlet valve 204a and the outlet valve 204b. This may e.g. be performed by execution of an obtaining function.

[0114] The control circuitry 502 is further configured to identify a first point in time at which the sensor data indicates that the position and/or speed of the inlet valve

204a reaches a first threshold value. This may be performed e.g. by execution of a first identifying function.

[0115] The control circuitry 502 is further configured to identify a second point in time at which the sensor data indicates that the position and/or speed of the outlet valve 204b reaches a second threshold value. This may be performed e.g. by execution of a second identifying function.

[0116] The control circuitry 502 is further configured to identify a third point in time at which a movement of the piston 206 between the volume-reducing position and the volume-increasing position is started. This may be performed e.g. by execution of a third identifying function. It is to be noted that the first, second, and third identifying function may be implemented as one or more common identifying functions.

[0117] The control circuitry 502 is further configured to, based on a comparison between the first and third point in time, and a comparison between the second and third point in time, determine an actuation time point of the inlet valve 204a and/or an actuation time point of the outlet valve 204b. This may be performed e.g. by execution of a determining function.

[0118] The control circuitry 502 is further configured to update the parameter settings used by the control unit 112 based on the actuation time point determined for the inlet valve 204a and/or the actuation time point determined for the outlet valve 204b. This may be performed e.g. by execution of an updating function.

[0119] It should be noted that features, aspects and advantages of the method 300 as described above in connection with Fig. 3, are applicable also to the device 500 described herein. To avoid undue repetition, reference is made to the above.

[0120] Figure 6 is a flow chart illustrating the steps of a method 600, performed in a packaging machine 100, for producing a package 102 filled with a liquid product 116. The packaging machine 100 comprises a filling station 106 and a sealing station 114. An example of such a packaging machine 100 has been described in the foregoing. For further details, reference is made to the above.

[0121] Below, the different steps of the method 600 are described in more detail with reference to Fig. 6. Even though illustrated in a specific order, the steps of the method 600 may be performed in any suitable order, in parallel, as well as multiple times. Thus, although Fig. 6 may show a specific order of method steps, the order of the steps may differ from what is depicted. In addition, two or more steps may be performed concurrently or with partial concurrence. For example, the steps denoted S610 and S612 may be performed at least partly in parallel.

[0122] The method 600 comprises transferring S602 a package 102 with an open end to the filling station 106. The package 102 may be transferred S692 by a conveyor 104 of the packaging machine 100. The open end package 102 thus allows for being filled with the liquid product from the top. The package 102 comprises a sealing section at the open end. The sealing section is a section of the package 102 adapted to be sealed after the package 102 has been filled. The package may be a so-called gable top package.

[0123] The method 600 further comprises filling S604, by the filling station 106, the package 102 with the liquid product 116 by controlling a pump 200 of the filling station 106 according to updated parameter settings obtained by the method 300 as described above in connection with Fig. 3.

[0124] The method 600 further comprises transferring S606 the package 102 to the sealing station 114. Transferring the package 102 to the sealing station 114 may be performed by the conveyor 104 of the packaging machine 100.

[0125] The method 600 further comprises sealing S608, by the sealing station 114, the open end of the package 102. The open end of the package 102 is sealed by heating S610 the sealing section such that a plastic foil layer of a packaging material of the package 102at least partly melts. Sealing S608 the open end further comprises applying S612 a pressure at the sealing section such that the plastic foil layer at the sealing section bonds and the open end is closed. As has been explained in the foregoing, controlling the pump 200 of the filling station 106 according to the updated parameter settings determined according to the presently disclosed technology may reduce a risk of the subsequent sealing S608 of the package 102 resulting in an deficient sealing of the package 102 due to product residue at the sealing section.

[0126] Further variants of the method 600 will become apparent from the present disclosure. The above mentioned and described embodiments are only given as examples and should not be limiting to the present invention. Other solutions, uses, objectives, and functions within the scope of the invention as claimed below described patent claims should be apparent for the person skilled in the art.

[0127] The present invention has been presented above with reference to specific embodiments. However, other embodiments than the above described are possible and within the scope of the invention. Different method steps than those described above, performing the methods by hardware or software, may be provided within the scope of the invention. Thus, according to an exemplary embodiment, there is provided a non-transitory computer-readable storage medium storing one or more programs configured to be executed by one or more processors of a vehicle control system, the one or more programs comprising instructions for performing the methods according to any one of the above-discussed embodiments. Alternatively, according to another exemplary embodiment a cloud computing system can be configured to perform any of the methods presented herein. The cloud computing system may comprise distributed cloud computing resources that jointly perform the methods presented herein under control of one or

more computer program products.

[0128] Additionally, variations to the disclosed variants can be understood and effected by the skilled person in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

[0129] It should be noted that any reference signs do not limit the scope of the claims, that the invention may be at least in part implemented by means of both hardware and software, and that the same item of hardware may represent several "means" or "units".

Claims

1. A method (300) for adjusting parameter settings for a filling station (106) in a packaging machine (100), wherein the filling station (106) comprises:

   a pump (200) comprising a hollow body (202), an inlet valve (204a), an outlet valve (204b) and a piston (206),
   wherein a cavity (210) configured to hold a liquid product (116) is formed by the hollow body (202), the inlet valve (204a), and the outlet valve (204b);
   wherein the piston (206) is movably arranged between a volume-reducing position and a volume-increasing position;
   wherein the pump (200) is configured to be in a cavity filling state in which the inlet valve (204a) is open such that the liquid product (116) is allowed to enter the cavity (210), or in a cavity emptying state in which the outlet valve (204b) is open such that the liquid product (116) held in the cavity (210) is allowed to be released into a package (102);
   a control unit (112) configured to control opening and closing of the inlet and outlet valve (204a, 204b), and to control movement of the piston (206); and
   one or more sensors for providing sensor data relating to the inlet valve (204a) and outlet valve (204b);
   the method (300) comprising:

      obtaining (S302), via the one or more sensors, sensor data relating to the inlet valve (204a) and the outlet valve (204b) respectively, wherein the sensor data is indicative of a position and/or speed of the inlet valve (204a) and the outlet valve (204b);
      identifying (S304) a first point in time at which the sensor data indicates that the position and/or speed of the inlet valve (204a) reaches a first threshold value;
      identifying (S306) a second point in time at which the sensor data indicates that the position and/or speed of the outlet valve (204b) reaches a second threshold value;
      identifying (S308) a third point in time at which a movement of the piston (106) between the volume-reducing position and the volume-increasing position is started;
      based on a comparison between the first and third point in time, and a comparison between the second and third point in time, determining (S310) an actuation time point of the inlet valve (204a) and/or an actuation time point of the outlet valve (204b); and
      updating (S312) the parameter settings used by the control unit (112) based on the actuation time point determined for the inlet valve (204a) and/or the actuation time point determined for the outlet valve (204b).

2. The method (300) according to claim 1, wherein the inlet valve (204a) and the outlet valve (204b) are pneumatic valves, and wherein the one or more sensors are arranged to measure a position and/or speed of a valve piston arranged in an air chamber of the respective pneumatic valve.

3. The method (300) according to claim 1 or 2, wherein the obtained sensor data relating to the inlet valve (204a) and the outlet valve (204b) pertains to a first filling cycle, and wherein the parameter settings are updated (S312) for a second subsequent filling cycle.

4. The method (300) according to any one of the claims 1 to 3, wherein the method (300) is performed iteratively for a number of subsequent filling cycles.

5. The method (300) according to any one of the claims 1 to 4, wherein determining (S310) the actuation time point of the inlet valve (204a) and the actuation time point of the outlet valve (204b) is further based on a comparison between the first and second point in time.

6. The method (300) according to any one of the claims 1 to 5, wherein, in a case the third point in time indicates a start of a movement of the piston (206) from the volume-reducing position to the volume-increasing position, the determined actuation time point of the inlet valve (204a) is an opening initiation time point of the inlet valve (204a), and the determined actuation time point of the outlet valve (204b) is a closing initiation time point of the outlet valve (204b).

7. The method (300) according to claim 6, wherein, in response to a difference between the first and third point in time being below a first reference value, the opening initiation time point of the inlet valve (204a)

is determined (S310) as an earlier point in time compared to a current opening initiation time point.

8. The method (300) according to claim 6 or 7, wherein, in response to a difference between the second and third point in time being below a second reference value, the closing initiation time point of the outlet valve (204b) is determined (S310) as an earlier point in time compared to a current closing initiation time point.

9. The method (300) according to any one of the claims 1 to 8, wherein, in a case the third point in time indicates a start of a movement of the piston (206) from the volume-increasing position to the volume-reducing position, the determined actuation time point of the inlet valve (204a) is a closing initiation time point of the inlet valve (204a), and the determined actuation time point of the outlet valve (204b) is an opening initiation time point of the outlet valve (204b).

10. The method (300) according to claim 9, wherein, in response to a difference between the first and third point in time being below a first reference value, the closing initiation time point of the inlet valve (204a) is determined (S310) as an earlier point in time compared to a current closing initiation time point.

11. The method (300) according to claim 10 or 11, wherein, in response to a difference between the second and third point in time being below a second reference value, the opening initiation time point of the outlet valve (204b) is determined (S310) as an earlier point in time compared to a previous opening initiation time point.

12. A non-transitory computer-readable storage medium storing one or more programs configured to be executed by one or more processors of a processing system, the one or more programs comprising instructions for performing the method (300) according to any one of claims 1-11.

13. A method (600), performed in a packaging machine (100), for producing a package (102) filled with a liquid product (116), wherein the packaging machine (100) comprises a filling station (106) and a sealing station (114), the method (600) comprising:

transferring (S602) a package (102) with an open end to the filling station (106), wherein the package (102) comprises a sealing section at the open end;
filling (S604), by the filling station (106), the package (102) with the liquid product (116) by controlling a pump (200) of the filling station (106) according to updated parameter settings obtained by the method (300) according to any one of the claims 1 to 11;
transferring (S606) the package (102) to the sealing station (114);
sealing (S608), by the sealing station (114), the open end of the package (102) by:

heating (S610) the sealing section such that a plastic foil layer of a packaging material of the package (102) at least partly melts; and
applying (S612) a pressure at the sealing section such that the plastic foil layer at the sealing section bonds and the open end is closed.

14. A device (500) for adjusting parameter settings for a filling station (106) in a packaging machine (100), wherein the filling station (106) comprises:

a pump (200) comprising a hollow body (202), an inlet valve (204a), an outlet valve (204b) and a piston (206),
wherein a cavity (210) configured to hold a liquid product is formed by the hollow body (202), the inlet valve (204a), and the outlet valve (204b);
wherein the piston (206) is movably arranged between a volume-reducing position and a volume-increasing position;
wherein the pump (200) is configured to be in a cavity filling state in which the inlet valve (204a) is open such that the liquid product is allowed to enter the cavity (210), or in a cavity emptying state in which the outlet valve (204b) is open such that the liquid product held in the cavity (210) is allowed to be released into a package (102);
a control unit (112) configured to control opening and closing of the inlet and outlet valve (204a, 204b), and to control movement of the piston (206); and
one or more sensors for providing sensor data relating to the inlet valve (204a) and outlet valve (204b);
the device (500) comprising control circuitry (502) configured to:

obtain, via the one or more sensors, sensor data relating to the inlet valve (204a) and the outlet valve (204b) respectively, wherein the sensor data is indicative of a position and/or speed of the inlet valve (204a) and the outlet valve (204b);
identify a first point in time at which the sensor data indicates that the position and/or speed of the inlet valve (204a) reaches a first threshold value;
identify a second point in time at which the sensor data indicates that the position an-

d/or speed of the outlet valve (204b) reaches a second threshold value;
identify a third point in time at which a movement of the piston (206) between the volume-reducing position and the volume-increasing position is started;
based on a comparison between the first and third point in time, and a comparison between the second and third point in time, determine an actuation time point of the inlet valve (204a) and/or an actuation time point of the outlet valve (204b); and
update the parameter settings used by the control unit (112) based on the actuation time point determined for the inlet valve (204a) and/or the actuation time point determined for the outlet valve (204b).

15. A packaging machine (100) comprising:

a filling station (106), wherein the filling station (106) comprises:

a pump (200) comprising a hollow body (202), an inlet valve (204a), an outlet valve (204b) and a piston (206),
wherein a cavity (210) configured to hold a liquid product is formed by the hollow body (202), the inlet valve (204a), and the outlet valve (204b);
wherein the piston (206) is movably arranged between a volume-reducing position and a volume-increasing position;
wherein the pump (200) is configured to be in a cavity filling state in which the inlet valve (204a) is open such that the liquid product is allowed to enter the cavity (210), or in a cavity emptying state in which the outlet valve (204b) is open such that the liquid product held in the cavity (210) is allowed to be released into a package (102);
a control unit (112) configured to control opening and closing of the inlet and outlet valve (204a, 204b), and to control movement of the piston (206); and
one or more sensors for providing sensor data relating to the inlet valve (204a) and outlet valve (204b);

a sealing station (114); and
a device (500) according to claim 14.

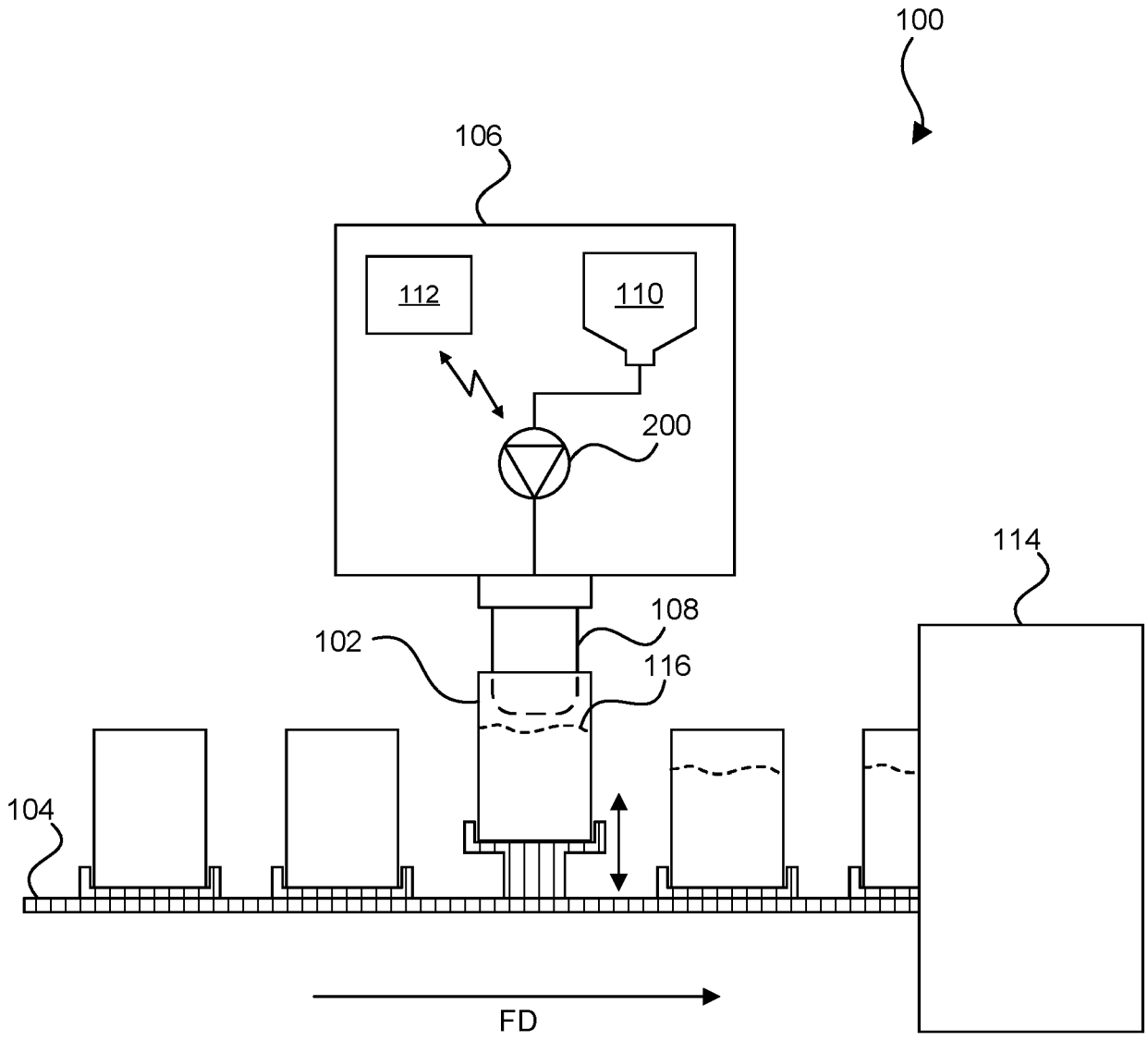


Fig. 1

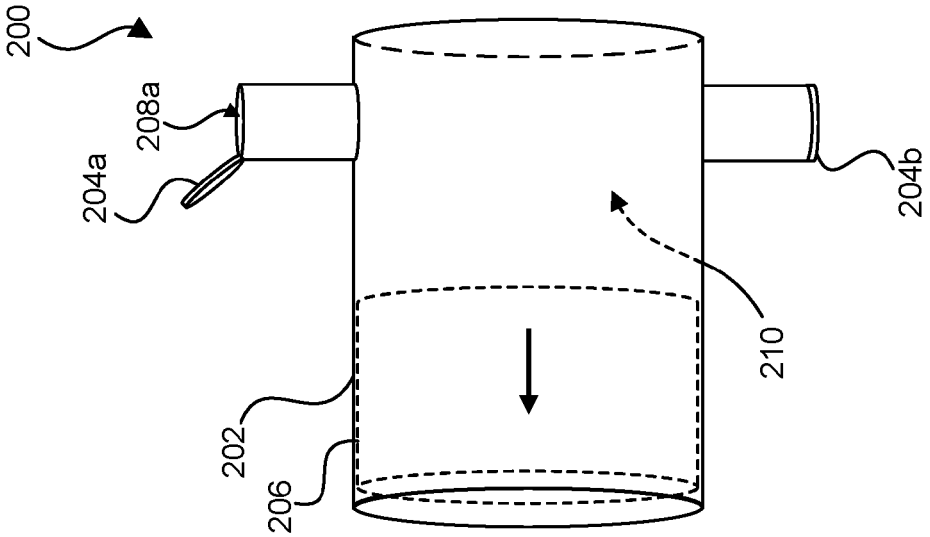


Fig. 2C

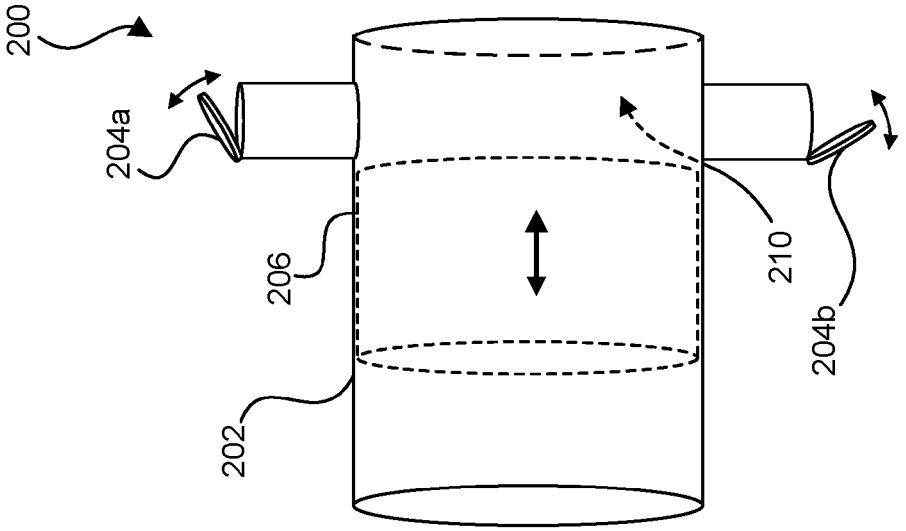


Fig. 2B

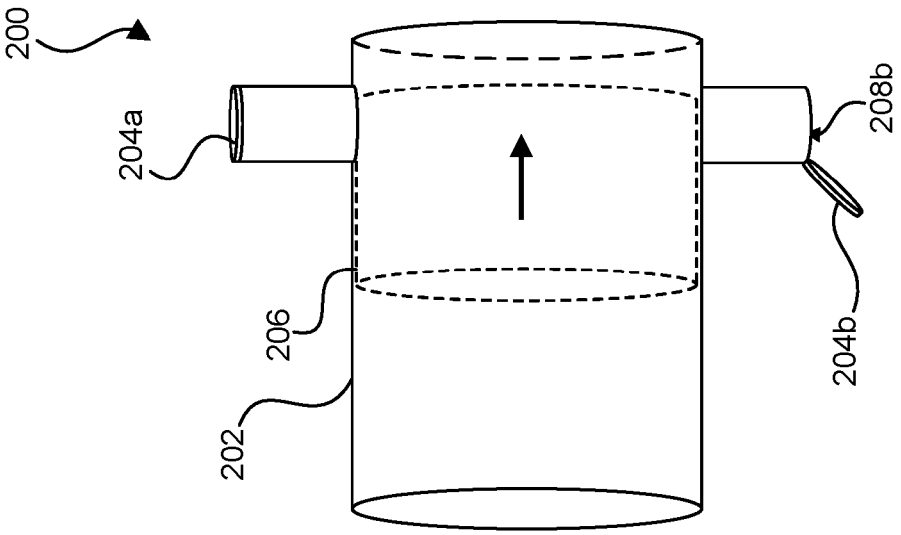


Fig. 2A

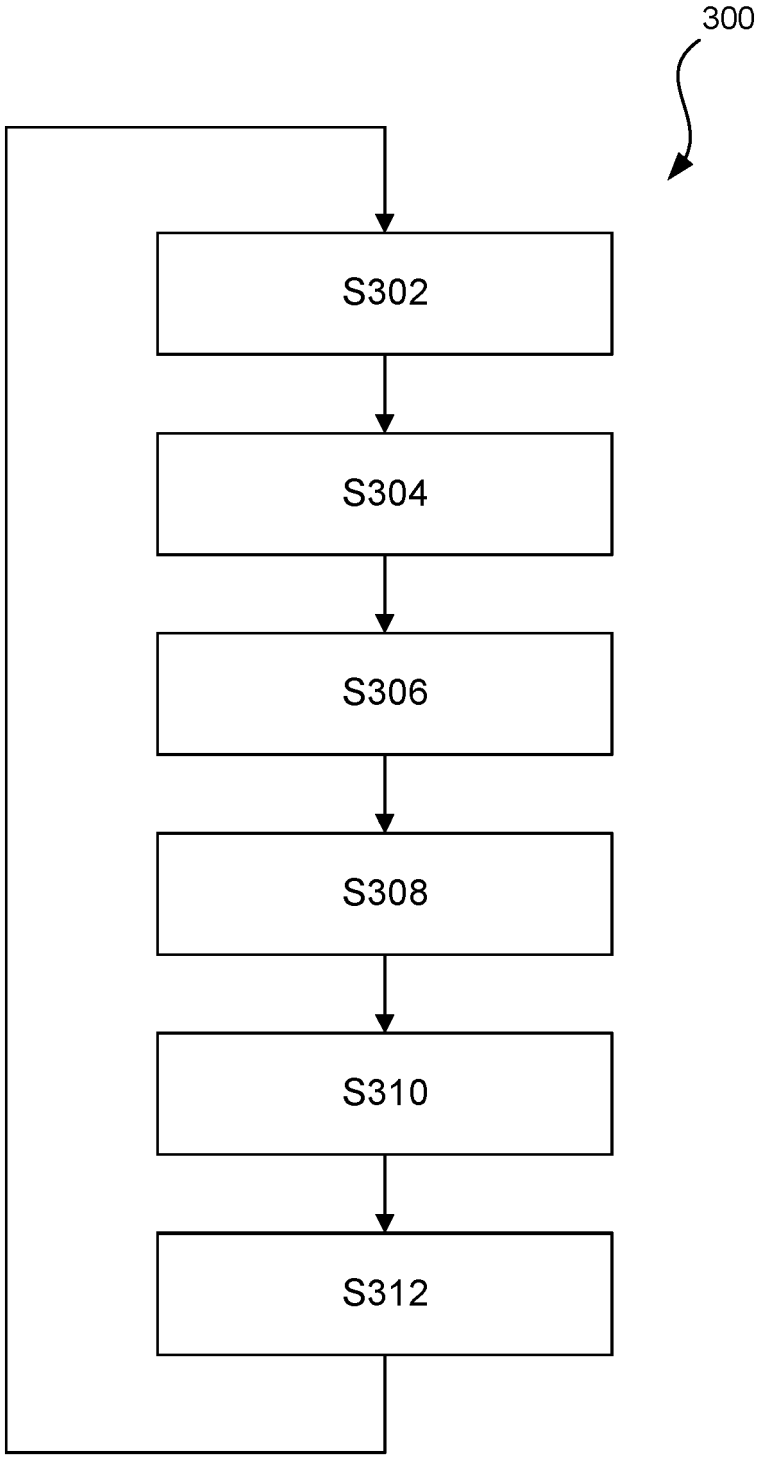
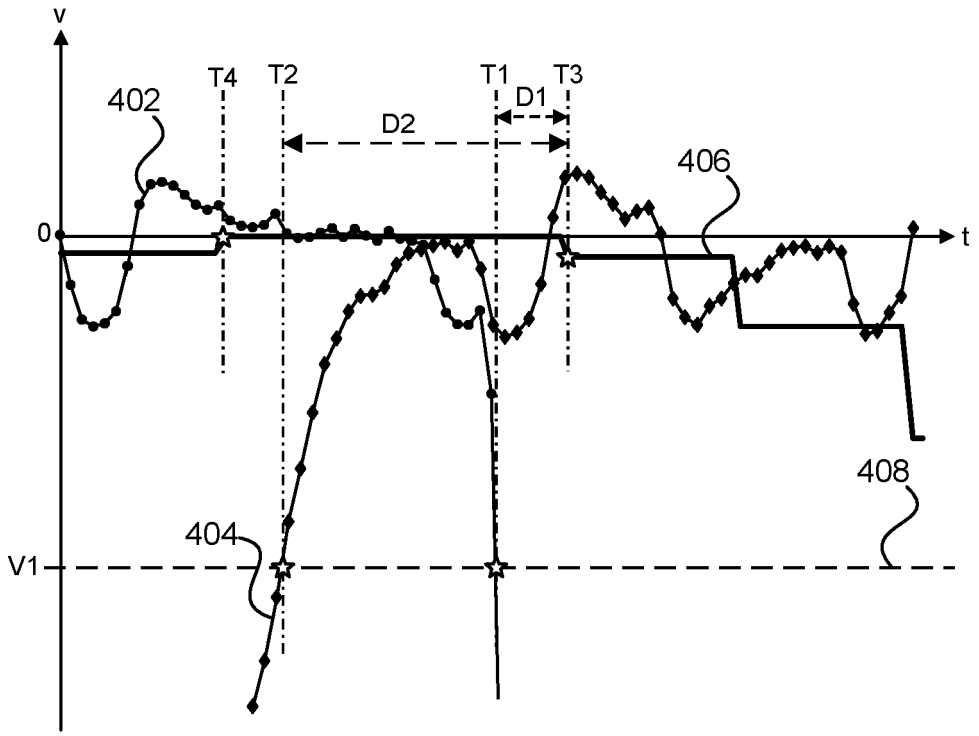


Fig. 3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V1

Fig. 4A

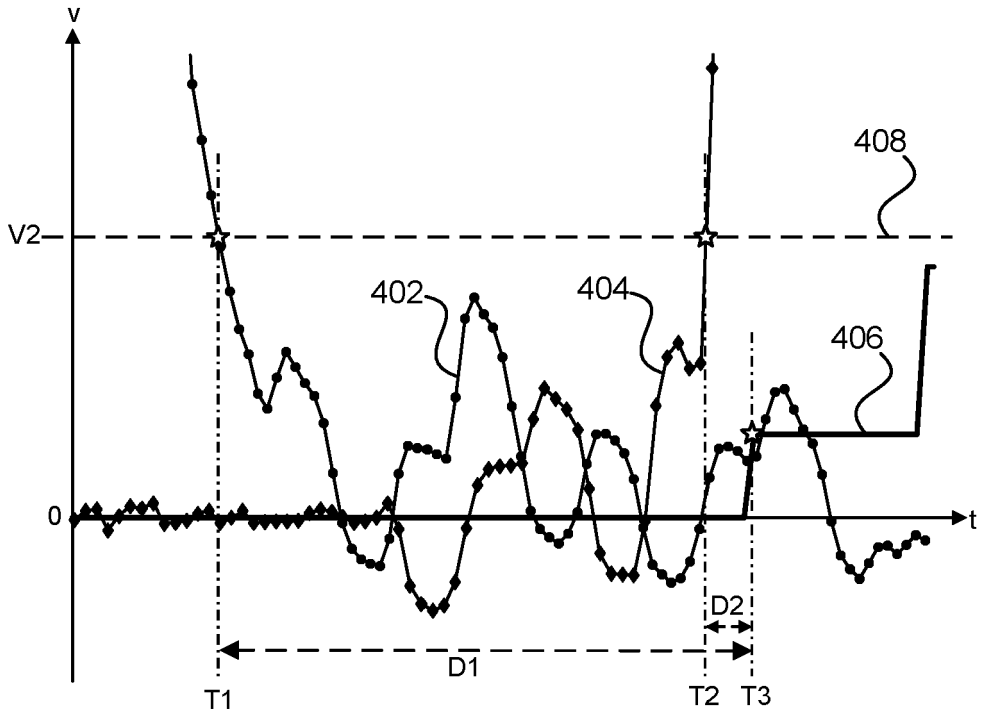
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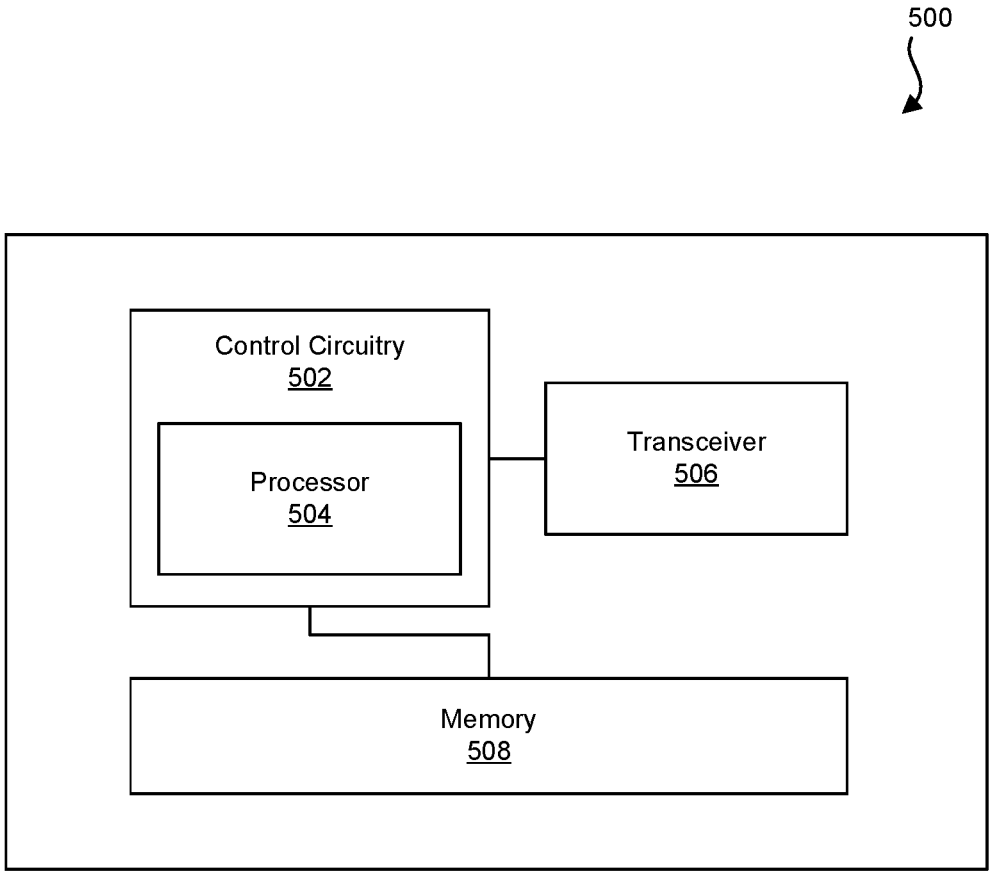
Fig. 4B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Control Circuitry
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Processor
504
Transceiver
506
Memory
508

Fig. 5

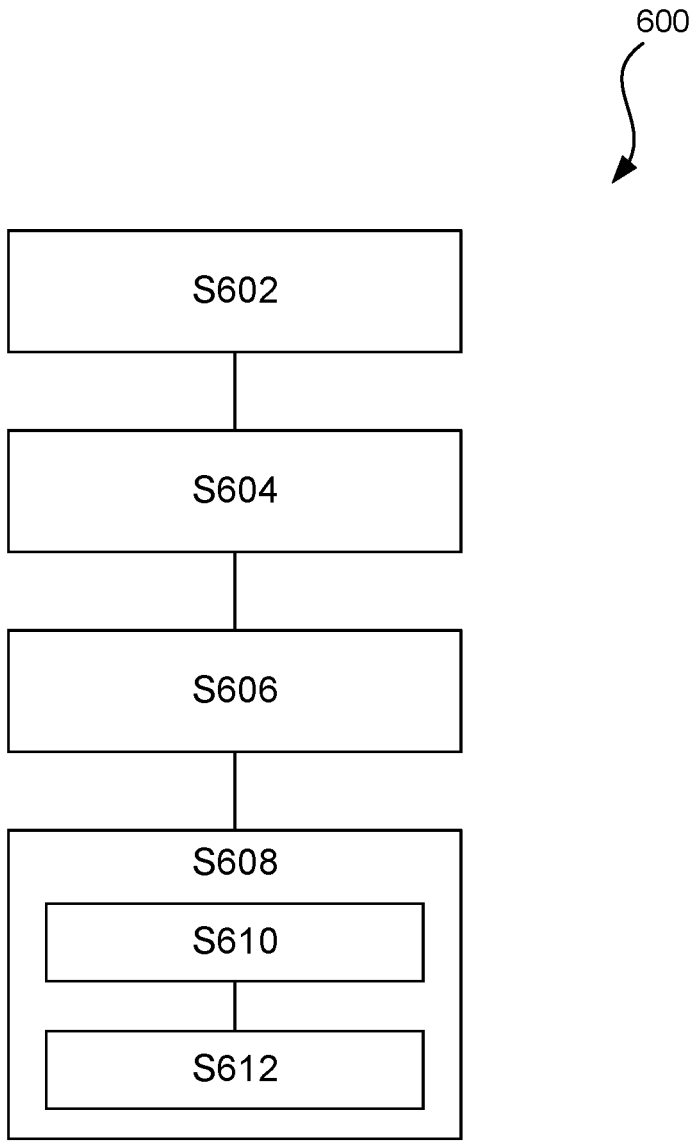

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 24 20 5174

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B65B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 February 2025	Paetzke, Uwe

CATEGORY OF CITED DOCUMENTS

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