



(51) International Patent Classification:

B65B 57/02 (2006.01) *B65B 61/20* (2006.01)
B65B 57/08 (2006.01)

(21) International Application Number:

PCT/EP2017/079684

(22) International Filing Date:

17 November 2017 (17.11.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

16200089.7 22 November 2016 (22.11.2016) EP

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(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(54) Title: A METHOD OF OPERATING AN APPARATUS FOR FEEDING COMPONENTS TO BE APPLIED TO PACKAGING CONTAINERS

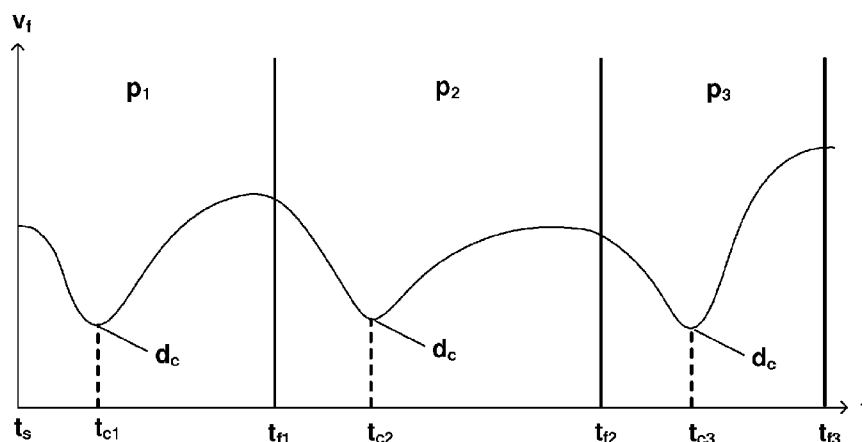


Fig. 4

(57) **Abstract:** A method of operating an apparatus for feeding components to be applied to packaging containers along a feed path is disclosed. The method comprises determining the distance from a start position to a collision point with an application path; calculating a clearance time being the amount of time required for a feed unit to move from the start position to the collision point to allow the application path to have passed the collision point; calculating a feed trajectory for the motion cycle from the start position to the collision point, and from the collision point to a final picking position, and performing the motion cycle comprising continuously moving the feed unit between the start position and the final picking position, via the collision point, at a velocity of the feed trajectory, the velocity being based on the clearance time and on a pitch distance between two successive packaging containers being conveyed.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

A METHOD OF OPERATING AN APPARATUS FOR FEEDING COMPONENTS TO BE APPLIED TO PACKAGING CONTAINERS

Field of the Invention

5

The present invention relates to a method of operating an apparatus for feeding components to be applied to packaging containers. More particularly, the present invention relates to a method for applying a component such as a drinking straw to a packaging container, a computer implemented method and
10 an apparatus.

Background of the Invention

Many packaging containers for liquid food are manufactured in so-called portion volumes, intended to be consumed direct from the package. The majority of these packages are provided with drinking straws which are secured to the side wall of the packaging container. Drinking straw applicators typically functions in that a belt of continuous drinking straw envelopes with drinking straws is provided in a feed unit that feeds the straws in a step wise manner to
15 an application means that picks each straw at a picking location and pushes the straw against the wall of a packaging container being advanced on a conveyor through the machine. Prior to the moment of application, the envelope of the drinking straw is provided with securement points for example consisting of glue which glues the drinking straw envelope in place.

25 In ultra high-speed production, the motions of the components of such straw applicator, in particular motions including considerable accelerations and decelerations, will cause substantial strain on the motors involved, and considerable vibrations will be created in the mechanics of the machine. A problem is also the varying load on the motors driving the apparatus, which will
30 lead to irregular service intervals. Further, in order to allow such high-speed production, it is necessary to have an optimized feed path of the straws to the application means, reducing the distances and tolerances, to decrease the time required for each step in the process. While pursuing such time optimization, a disadvantageous consequence is the difficulties in maintaining accelerations
35 and decelerations at a low level. A problem with previous solutions is also how to handle intersecting trajectories of several moving parts, which can also lead

to irregular start-stop operation, which again contribute to the strain of the machine.

The above problems may decrease the lifetime of the components in the machine, and further make the pursuit for the ultra high-speed production less feasible.

Hence, an improved method of operating an apparatus for feeding components to be applied to packaging containers in such high-speed applications would be advantageous and in particular allowing for avoiding more of the above mentioned problems and compromises.

Summary of the Invention

Accordingly, embodiments of the present invention preferably seeks to mitigate, alleviate or eliminate one or more deficiencies, disadvantages or issues in the art, such as the above-identified, singly or in any combination by providing a device according to the appended patent claims.

According to a first aspect a method of operating an apparatus for feeding components to be applied to packaging containers is provided. The apparatus comprising a feed unit adapted for conveying each of the components from a start position, at start time, to a final picking position, at end time, along a feed path, an application device which is movable along an application path to pick the component at the final picking position and transport the component to the packaging container, wherein the feed path cross the application path at a collision point. The method comprises determining the distance from the start position to the collision point; calculating a clearance time being the amount of time required for the feed unit to move from the start position to the collision point to allow the application path to have passed the collision point; calculating a feed trajectory having a first segment of a motion cycle of the feed unit from the start position to the collision point, and a second segment of the motion cycle of the feed unit from the collision point to the final picking position, and performing the first and second segment of the motion cycle comprising continuously moving the feed unit between the start position and the final picking position, via the collision point, at a velocity of the feed trajectory, the velocity being based on the clearance time and on a pitch distance between two successive packaging containers being conveyed.

According to a second aspect a computer-implemented method of operating an apparatus for feeding components to be applied to packaging

containers is provided. The apparatus comprising a feed unit adapted for conveying each of the components from a start position, at start time, to a final picking position, at end time, along a feed path. The apparatus comprises an application device which is movable along an application path to engage the component at the final picking position and transport the component to the packaging container, wherein the feed path cross the application path at a collision point. The computer-implemented method comprises determining the distance from the start position to the collision point; calculating a clearance time being the amount of time required for the feed unit to move from the start position to the collision point to allow the application path to have passed the collision point; calculating a feed trajectory having a first segment of a motion cycle of the feed unit from the start position to the collision point, and a second segment of the motion cycle of the feed unit from the collision point to the final picking position; and performing the first and second segment of the motion cycle comprising continuously moving the feed unit between the start position and the final picking position, via the collision point, at a velocity of the feed trajectory, the velocity being based on the clearance time and on a pitch distance between two successive packaging containers being conveyed.

According to a third aspect an apparatus for feeding components to be applied to packaging containers is provided. The apparatus comprising a feed unit adapted for conveying each of the components from a start position, at start time, to a final picking position, at end time, along a feed path. The apparatus comprises an application device which is movable along an application path to pick the component at the final picking position and transport the component to the packaging container, wherein the feed path cross the application path at a collision point; a control device for controlling the operation of the apparatus, which control device is connected to a drive unit driving the feed unit and the application device. The control device is adapted to determine the distance from the start position to the collision point; calculate a clearance time being the amount of time required for the feed unit to move from the start position to the collision point to allow the application path to have passed the collision point, calculate a feed trajectory having a first segment of a motion cycle of the feed unit from the start position to the collision point, and a second segment of the motion cycle of the feed unit from the collision point to the final picking position; and perform the first and second segment of the motion cycle comprising continuously moving the feed unit between the start position and the final picking position, via the collision point, at a velocity of the feed trajectory, the

velocity being based on the clearance time and on a pitch distance between two successive packaging containers being conveyed.

According to a fourth aspect, use of a method according to the first aspect for applying a component such as a drinking straw to a packaging container is provided.

According to a fifth aspect a computer program product comprising instructions which, when the program is executed by a computer, cause the computer to carry out the steps of the method according to the first aspect is provided.

Further examples of the disclosure are defined in the dependent claims, wherein features for the second and subsequent aspects are as for the first aspect *mutatis mutandis*.

Some examples of the disclosure provide for a decreased acceleration and/or deceleration of components in an apparatus for feeding components to be applied to packaging containers.

Some examples of the disclosure provide for a decreased acceleration and/or deceleration of components in a machine for applying drinking straws to packaging containers.

Some examples of the disclosure provide for a smoother operation of feed and application units having several interrelated and intersecting motion trajectories in an apparatus for feeding components to be applied to packaging containers, such as the application of drinking straws to packaging containers.

Some examples of the disclosure provide for increased lifetime of machine components in an apparatus for feeding components to be applied to packaging containers.

Some examples of the disclosure provide for increasing the throughput in ultra high-speed production lines.

Some examples of the disclosure provide for decreasing the forces, vibrations, and torques on the motors driving an apparatus for feeding components to be applied to packaging containers.

Some examples of the disclosure provide for avoiding interference of overlapping trajectories of a feed unit and an application device.

Some examples of the disclosure provide for an even load on the motors driving an apparatus for feeding components to be applied to packaging containers.

Some examples of the disclosure provide for increasing the robustness of an apparatus for feeding components to be applied to packaging containers.

Some examples of the disclosure provide for maintaining a more compact apparatus for feeding components to be applied to packaging containers.

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 but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

Brief Description of the Drawings

These and other aspects, features and advantages of which embodiments of the invention are capable of will be apparent and elucidated from the following description of embodiments of the present invention, reference being made to the accompanying drawings, in which

Fig. 1 is a schematic view of an apparatus for feeding components to be applied to packaging containers;

Figs. 2a-c are exemplary diagrams of motion trajectories of a feed unit in an apparatus for feeding components to be applied to packaging containers;

Figs. 3a-f are exemplary diagrams of motion trajectories of a feed unit in an apparatus for feeding components to be applied to packaging containers;

Fig. 4 is an exemplary diagram of motion trajectories of a feed unit in an apparatus for feeding components to be applied to packaging containers;

Fig. 5 are an exemplary diagrams of motion trajectories of a feed unit in an apparatus for feeding components to be applied to packaging containers;

Fig. 6 is a schematic of an apparatus for feeding components to be applied to packaging containers; and

Fig. 7 is a flowchart of a method of operating an apparatus for feeding components to be applied to packaging containers.

Description of embodiments

Specific embodiments of the invention will now be described with reference to the accompanying drawings. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. The terminology used in the detailed

description of the embodiments illustrated in the accompanying drawings is not intended to be limiting of the invention. In the drawings, like numbers refer to like elements.

Fig. 1a shows a schematic illustration of an apparatus 100 for feeding
5 components 101 to be applied to packaging containers 102. Fig. 1 illustrates five captions in time (I-V), of the movement of a feed unit 103 and an application device 104. Thus, the apparatus 100 comprises a feed unit 103 adapted for conveying each of the components 101 from a start position (d_s), at start time (t_s), which is illustrated in caption (I), to a final picking position (d_f), at end time
10 (t_f), which is illustrated in caption (V). The feed unit 103 conveys the components 101 along a feed path (d), which is vertically aligned in Fig. 1. The component 101 being located at the aforementioned start position and final picking position is illustrated in solid lines, whereas a preceding component 101', transported along the feed trajectory (d) is illustrated in dotted lines. The
15 apparatus 100 comprises an application device 104 which is movable along an application path (C) to pick or engage the component at the final picking position (d_f) and transport the component to a packaging container 102. The packaging containers 102, 102', are transported along a linear path (D) (vertically in Fig. 1) on a conveyer, passing the application device 104 one by one, where succeeding packaging containers are separated by a pitch distance
20 (p_1). The movements of the application device 104 are illustrated in the same schematic side views of captions (I-V) as the feed path (d), whereas the top part of Fig. 1 illustrates the application path (C) in a top-down view, which also indicates the location of the application device for each of the positions in the side-view captions (I-V). The application path (C) is circular and the feed path (d) can be approximated as a linear path adjacent the application path. The feed path cross the application path at a collision point (d_c), which is illustrated in caption (IV).

Starting at (I), the feed unit 103, holding the component 101 to be
30 conveyed to the final picking position (d_f), is located at the start position (d_s). Simultaneously, another component 101', which is located above the latter, is about to move into the final picking position (d_f) and be engaged by the application device 104. The components 101 and 101' are held in the feed unit at a distance apart, which is the feed pitch (P). The compartments of the feed
35 unit in which the components 101, 101', are held are thus separated by the feed pitch (P), and the feed unit 103 typically has a plurality of compartments, separated by the feed pitch (P), for conveying a series of components 101,

101', to be repeatedly picked by the application device 104 at the final picking position (d_f). Proceeding to (II), the application device 104 has moved further to the right, in the side-view in Fig. 1, which corresponds to the rotation to (II) in the top-down view of the application patch (C), in the top part of Fig. 1. In this position, the application device 104 starts to engage the first component 101', which is further pushed further to the right when proceeding to the next caption (III). The first component 101' is thus pushed against a first container 102 which is simultaneously conveyed to the application device 104. Proceeding to the next caption (IV), the succeeding component 101 has been conveyed to the collision point (d_c) where the feed path (d) cross the application path (C). The feed unit 103 can not pass the collision point (d_c) until the application device 104 has moved away from the intersecting trajectory, which is illustrated in the fourth position shown in caption (IV). Then, proceeding to caption (V), the feed unit 103 has moved to the final picking position (d_f) and is ready for being delivered to the next packaging container by the application device 104.

The apparatus 100 comprises a control device 105 (Fig. 6) for controlling the operation of the apparatus 100. The control device 105 is connected to a drive unit 106 driving the feed unit 103 and the application device 104. Reference is also made to a method 200 of operating an apparatus 100 for feeding components to be applied to packaging containers, Fig. 7. The order in which the steps of the method 200 are described and illustrated should not be construed as limiting and it is conceivable that the steps can be performed in varying order.

The control device 105 is adapted to determine the distance from the start position (d_s) to the collision point (d_c), and is further adapted to calculate a clearance time (t_c). The clearance time (t_c) is the amount of time required for the feed unit 103 to move from the start position (d_s) to the collision point (d_c) to allow the application path (C) to have passed the collision point (d_c). Thus, the feed unit 103 should not arrive at the collision point (d_c) before the clearance time (t_c) has lapsed, in order to not interfere with the application path (C) when moving towards the final picking position (d_f). The collision point (d_c) is in this example defined in relation to the feed unit 103. In practice, the collision would take place between the component 101, 101', and the application device 104, but in this example, it is assumed there is a fixed geometrical relationship between the component 101, 101', and the feed unit 103, so that the defined collision point (d_c) of the feed unit would correspond to the position of the feed unit 103 along the feed path (d) where the component 101, 101', would collide

with the application device 104. The control device 105 is adapted to calculate a feed trajectory having a first segment ($t_s \rightarrow t_c$) of a motion cycle of the feed unit 103 from the start position (d_s) to the collision point (d_c), and a second segment ($t_c \rightarrow t_f$) of the motion cycle of the feed unit 103 from the collision point (d_c) to the final picking position (d_f). An example of the feed trajectory is illustrated in Figs. 2a-c, where the y-axis is the distance moved along the feed path (d), the velocity (v_f), and acceleration (a_f) of the feed unit 103, respectively. The x-axis is the distance (D) a container package 102, 102', moves during a time unit in the direction of the container conveyer. For the purpose of the discussion, this axis can be seen as the progression of time units for the trajectory. The control device 105 is adapted to perform the first and second segment of the motion cycle. The control device 105 may thus instruct the drive unit 106 which drive the feed unit 103 and the application device 104. Performing the first and second segment of the trajectory comprises continuously moving the feed unit 103 between the start position (d_s) and the final picking position (d_f), via the collision point (d_c), at a velocity (v_f) of the feed trajectory. The velocity (v_f) is based on the clearance time (t_c) and on a pitch distance (p_1), which is the distance between two successive packaging containers 102, 102', being conveyed. By having a continuous motion at a velocity (v_f) which is calculated for the trajectory based on the determined collision criteria and on the pitch distance (p_1), the feed trajectory can smoothly complete the whole feed path (d) in the maximum available time, while correcting for the criteria determined at the collision point (d_c) to avoid interference with the crossing application path (C). This minimizes the acceleration and deceleration of the feed unit 103 since start and stop action is avoided, e.g. at the collision point (d_c), and the time available for the whole trajectory is synchronized with the pitch distance (p_1) which defines the maximum amount of time available for completing the feed path (d). This also provides for minimizing vibrations, since the motion is smooth and continuous also for the jerk, i.e. the acceleration derivative.

Fig. 7 illustrate a corresponding method 200 comprising determining 201 the distance from the start position to the collision point, calculating 202 a clearance time (t_c) being the amount of time required for the feed unit to move from the start position to the collision point to allow the application path to have passed the collision point, calculating 203 a feed trajectory having a first segment ($t_s \rightarrow t_c$) of a motion cycle of the feed unit from the start position to the collision point, and a second segment ($t_c \rightarrow t_f$) of the motion cycle of the feed unit from the collision point to the final picking position, and performing 204 the

first and second segment of the motion cycle comprising continuously moving the feed unit between the start position and the final picking position, via the collision point, at a velocity (v_f) of the feed trajectory, the velocity (v_f) being based on the clearance time and on a pitch distance (p_1) between two successive packaging containers being conveyed.

The feed velocity (v_f) of the feed trajectory (d) may be determined by polynomial interpolation between a start velocity (v_{fs}), the clearance time at the collision point (d_c), and a final velocity (v_{ff}). By interpolating the trajectory between the end values and the collision criteria, i.e. the clearance time and associated clearance velocity, the velocity (v_f) throughout the whole trajectory can be determined to move the feed unit 103 smoothly across the range, and maintaining a positive velocity during the whole time interval, while keeping the acceleration and deceleration at a minimum, even at the collision point (d_c). This provides for minimizing the acceleration, strain and vibrations in the drive unit 106 and maintaining a high throughput of the apparatus 100. The polynomial interpolation may comprise spline interpolation. The spline interpolation may be a high order spline.

Figs. 2a-b illustrate one example of a feed trajectory along a feed path (d), where the first and second segment of the trajectory is illustrated. The feed unit 103 starts to move from standstill and is accelerated to arrive at collision point (d_c) at the clearance time (t_c), with a clearance velocity (v_c), before being decelerated to arrive at the final position (d_f), at the end time (t_f), which corresponds to the time period the container 102, 102', move the full pitch distance (p_1) along the conveyor (D). In this example, there is only a single container and the feed unit reaches the end time (t_f) at a standstill. Since there is only one container, the pitch distance (p_1) has been set to a determined maximum value.

Figs. 3a-f illustrate another example of a feed trajectory along a feed path, showing a first feed trajectory (Figs. 3a-c) for a first container, and a second feed trajectory (Figs. 3d-f) for a subsequent second container, at a pitch distance (p_1) from the first container. As with the previous example, the feed unit 102 is accelerated to reach the collision point (d_c) at the clearance time (t_c), and in the second segment the end position (d_f) is reached at the end time (t_f), corresponding to the pitch (p_1). However, the end velocity (v_f) is not zero since a subsequent container 102 has been detected. The start velocity (v_s) for the next segment (Fig. 3e) thus substantially correspond to the previous end velocity (v_f), maintaining a low or zero acceleration (a_{fs}) between segments. Having

determined the interference condition at collision point (d_c), with the required interference time (t_c), the velocity (v_f) follows an interpolated decline of the feed trajectory in the first segment ($t_s - t_c$), Fig. 3e, to assume a clearance velocity (v_{fc}) at the transition to the second segment to avoid interference with the application trajectory (C). In this example, no further container 102, 102', is detected within a calculated maximum pitch distance (p_1), so the feed unit 103 follows an interpolated velocity (v_f) in the remaining second segment in order to reach the end condition, i.e. the end position (d_f) at a standstill, at the maximum duration of the trajectory in accordance with the maximum pitch distance (p_1).

The calculated feed trajectories thereby provide for a smooth continuous motion in the transition between the segments described, in the maximum amount of time, resulting in a minimal amount of acceleration and strain on the apparatus 100.

The step of performing the first segment ($t_s \rightarrow t_c$) of the motion cycle may thus comprise continuously moving 205 the feed unit 103 between the start position (d_s) to the collision point (d_c) during the clearance time (t_c). And further, performing the second segment of the motion cycle may comprise continuously moving 206 the feed unit 103 between the collision point (d_c) and the final picking position (d_f) during the time period of the second segment, which is the time available for a packaging container 102, 102', to complete its motion cycle for a determined pitch distance (p_1) between two successive packaging containers being conveyed. The time period or duration of the second segment may be determined as a total synch time (t_t) from which the clearance time (t_c) is subtracted. Thus, the total synch time (t_t) is the time period required for the packaging containers to be transported the pitch distance (p_1), and will thus vary depending on the pitch distance (p_1). Fig. 4 illustrates an example where different feed trajectories are calculated for pitch distances p_1 , p_2 , and p_3 , where p_2 is longer than p_1 , and p_3 is shorter than p_1 . The first trajectory is completed between start time (t_s) and first end time (t_{f1}), via first clearance time (t_{c1}). The total synch time is increased for the subsequent trajectory, given that the speed of the container conveyor is the same. Thus, interpolating the second trajectory with the new end condition, while also taking into account the new interference time (t_{c2}), the acceleration can be reduced in the second segment. This is also illustrated in Fig. 5, where the acceleration of the feed unit 103 is seen in the bottom diagram for the first pitch distance (p_1) and the longer pitch distance (p_2), which results in a lower acceleration than the first. The distance between two successive components 101, 101', being conveyed with the feed unit 103 may

be determined as the feed pitch (P), which typically has a constant value. Thus, the method 200 may comprise synchronizing 207 the feed pitch (P) with the pitch distance (p_1) of the packaging containers 102, 102', so that the period from the start time (t_s) to the end time (t_f) of the feed trajectory (d) corresponds to the time period required for the packaging containers 102, 102', to be transported the pitch distance (p_1).

The method 200 may comprise accelerating or decelerating 208 the feed unit 103 in the first segment of the feed trajectory for the collision point (d_c) to be reached at the clearance time (t_c), whereby the feed unit reach the collision point at a clearance acceleration (a_{fc}). Figs. 3c and 3f illustrate example of feed trajectories where the feed unit 103 is accelerated and decelerated, respectively, depending on the preceding feed trajectory. Determining the clearance acceleration (a_c) by polynomial interpolation between the first and second segment allows a gradual or minimal acceleration of the feed unit 103 in the transition between the first and the second segment. This may facilitate the synchronization with the application device 104, and accurately determining a clearance time (t_c) at the transition between the segments.

The method 200 may comprise synchronizing 209 the feed pitch (P) with the application path (C) of the application device 104 so that the period from the start time (t_s) to the end time (t_f) of the feed trajectory corresponds to the time period required for the application device 104 to complete its application trajectory. This may further limit start and stop behavior to reduce accelerations in the feed- and application trajectories.

The method 200 may comprise calculating 210 a new feed trajectory for each packaging container 102, 102', in a series of successive packaging containers, and determining 211 if a final packaging container in a series has been conveyed based on detecting a maximum pitch distance (p_1), upon which a closing feed trajectory is calculated to reach the end point (d_f) at a standstill. Continuous synchronization of the feed trajectories with the pitch proceeds if the pitch (p_1) is below a maximum determined pitch distance. Otherwise a stop trajectory is used to bring the feed unit 103 to a stop, as seen in Figs. 3d-f.

The method 200 may comprise accelerating or decelerating 212 the feed unit 103 in the second segment of the feed trajectory for the final picking position (d_f) to be reached with a final velocity (v_f) at the end time (t_f) corresponding to the total synch time (t_t). As mentioned, the total synch time is the time period required for the packaging containers to be transported the pitch distance (p_1). Figs. 3e-f illustrate for example maintaining an initial acceleration

for the first part of the second segment to increase the velocity (v_f) after having temporarily slowed down when passing the collision point (d_c), followed by a second segment of the trajectory with an interpolated deceleration to arrive at the end condition, i.e. the final position (d_f) when the total synch time (t_t) is reached. The final velocity (v_f) may be determined as the average velocity (v_{fa}) required for the feed unit 103 to move the feed pitch (P) during the total synch time (t_t). This is exemplified in Fig. 3b, where the end position (d_f) is reached with a final velocity (v_f), which is the average velocity (v_{fa}) of the whole trajectory. This may provide for further minimizing the overall acceleration (a_f) of the feed trajectory.

The clearance time (t_c) may be calculated by determining where the torque of the application device 104 is substantially equal to the torque of the feed unit 103. This will provide for an even load on the drive unit 106, which may comprise one motor for the application device 104 and another motor for the feed unit 103. Thus, the torque the respective motors will be subjected to, throughout the feed and application trajectories, will be substantially equal, by determining a clearance time (t_c) that balances the load on the respective motor. Such even load may provide for increasing the lifetime on the motors, and aligning the service intervals, since the strain is substantially equal throughout the time of operation. This may be done with an iterative calculation for various values on the clearance time, in order to arrive at a balanced value on t_c for which the maximum torque is substantially equal for both the application device 104 and the feed unit 103. A maximum torque for the feed unit 103 may correspond to the force required to stop the feed unit 103 from a maximum velocity (v_f), which it may have from a previous feed trajectory when it arrives the start position (d_s), until it reaches a standstill at the collision point (d_c). The previous feed trajectory may in this case correspond to a pitch distance (p_1) being substantially equal to the length (L) of a packaging container, i.e. having a minimal or no gap between successive packaging containers. Such minimal distance will give the minimal amount of time to complete the whole trajectory, thus resulting in the maximal velocity (v_f). By iteratively increasing the amount of time available to reach the collision point (d_c), i.e. the clearance time (t_c), the torque can be reduced while also approaching the level of torque on the application device 104. The torque on the application device 104 corresponds to the torque required to move the application device 104 to the collision point (d_c) during the same amount of time (t_c). The process of determining where the torque of the application device 104

is substantially equal to the torque of the feed unit 103 may be done for each trajectory, which varies depending on the current pitch value (p_1). This provides for further optimizing the trajectories to both minimize the acceleration throughout the motion cycle and provide an even load on the apparatus 100.

5 The control device 105 of the apparatus 100 is adapted to carry out the steps described above with respect to the method 200.

A computer-implemented method of operating an apparatus 100 for feeding components 101 to be applied to packaging containers 102, is also provided according to the present disclosure. The computer-implemented
10 method comprises the steps described above with respect to the method 200.

Use of the method 200 as described above for applying a component such as a drinking straw 101, 101', to a packaging container 102, 102', is also provided according to the present disclosure. The method 200 can be used in a filling machine where packaging containers 102, 102', are conveyed to the
15 application device 104 being fed by the feed unit 103.

A computer program product comprising instructions which, when the program is executed by a computer, cause the computer to carry out the steps of the method 200 described above is also provided according to the present disclosure.

20 It should be readily understood that the general principle of the above description is applicable to a variety of production processes, involving the interaction and intersection of several trajectories of moving components that benefit from being exposed to a minimal amount of accelerations and decelerations when being operated according to a set of instructions.

25 The present invention has been described above with reference to specific embodiments. However, other embodiments than the above described are equally possible within the scope of the invention. The different features and steps of the invention may be combined in other combinations than those described. The scope of the invention is only limited by the appended patent
30 claims.

More generally, those skilled in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications
35 for which the teachings of the present invention is/are used.

Claims

1. A method (200) of operating an apparatus (100) for feeding components (101) to be applied to packaging containers (102), said apparatus comprising;

5 a feed unit (103) adapted for conveying each of the components from a start position (d_s), at start time (t_s), to a final picking position (d_f), at end time (t_f), along a feed path (d),

an application device (104) which is movable along an application path (C) to pick the component at the final picking position (d_f) and transport the
10 component to the packaging container, wherein the feed path cross the application path at a collision point (d_c), the method comprising;

determining (201) the distance from the start position to the collision point,
calculating (202) a clearance time (t_c) being the amount of time required for the feed unit to move from the start position to the collision point to allow the
15 application path to have passed the collision point,

calculating (203) a feed trajectory having a first segment ($t_s \rightarrow t_c$) of a motion cycle of the feed unit from the start position to the collision point, and a second segment ($t_c \rightarrow t_f$) of the motion cycle of the feed unit from the collision point to the final picking position, and

20 performing (204) the first and second segment of the motion cycle comprising continuously moving the feed unit between the start position and the final picking position, via the collision point, at a velocity (v_f) of the feed trajectory, the velocity (v_f) being based on the clearance time and on a pitch distance (p_1) between two successive packaging containers being conveyed.

25 2. Method according to claim 1, wherein the feed velocity (v_f) of the feed trajectory is determined by polynomial interpolation between a start velocity (v_{fs}), the clearance time at the collision point, and a final velocity (v_{ff}).

30 3. Method according to claim 1 or 2, wherein performing the first segment of the motion cycle, comprises;

continuously moving (205) the feed unit between the start position to the collision point during the clearance time, and wherein performing the second segment of the motion cycle, comprises;

35 continuously moving (206) the feed unit between the collision point and the final picking position during the time of the second segment which is the time available for a packaging container to complete its motion cycle for a

determined pitch distance (p_1) between two successive packaging containers being conveyed.

5 4. Method according to claim 3, wherein the time of the second segment is a total synch time (t_t) from which the clearance time is subtracted, the total synch time being the time period required for the packaging containers to be transported the pitch distance (p_1).

10 5. Method according to any of claims 1-4, wherein the distance between two successive components conveyed with the feed unit is the feed pitch (P), the method comprising synchronizing (207) the feed pitch with the pitch distance of the packaging containers so that the period from the start time to the end time of the feed trajectory corresponds to the time period required for the packaging containers to be transported the pitch distance (p_1).

15 6. Method according to any of claims 1-5, comprising accelerating or decelerating (208) the feed unit in the first segment of the feed trajectory for the collision point to be reached at the clearance time, whereby the feed unit reaches the collision point at a clearance acceleration (a_{fc}).

20 7. Method according to claim 6, wherein the clearance acceleration is determined by polynomial interpolation of the feed trajectory into the second segment to have a gradual or minimal acceleration of the feed unit between the first and the second segment.

25 8. Method according to any of claims 1-7, comprising synchronizing (209) the feed pitch with the application path of the application device so that the period from the start time to the end time of the feed trajectory corresponds to the time period required for the application device to complete its application trajectory.

30 9. Method according to any of claims 1-8, comprising calculating (210) a new feed trajectory for each packaging container in a series of successive packaging containers, and determining (211) if a final packaging container in a series has been conveyed based on detecting a maximum pitch distance (p_1), upon which a closing feed trajectory is calculated to reach the end point at a standstill.

10. Method according to any of claims 1-9, comprising accelerating or decelerating (212) the feed unit in the second segment of the feed trajectory for the final picking position to be reached with a final velocity (v_f) at the end time (t_f) corresponding to the total synch time (t_t), the total synch time being the time period required for the packaging containers to be transported the pitch distance (p_1).

11. Method according to claim 10, wherein the final velocity is determined as the average velocity (v_{fa}) required for the feed unit to move the feed pitch (P) during the total synch time.

12. Method according to any of claims 1-11, wherein the clearance time is calculated by determining where the torque of the application device is substantially equal to the torque of the feed unit.

13. A computer-implemented method of operating an apparatus (100) for feeding components (101) to be applied to packaging containers (102), said apparatus comprising;

a feed unit (103) adapted for conveying each of the components from a start position (d_s), at start time (t_s), to a final picking position (d_f), at end time (t_f), along a feed path (d),

an application device (104) which is movable along an application path (C) to engage the component at the final picking position (d_f) and transport the component to the packaging container, wherein the feed path cross the application path at a collision point (d_c), the computer-implemented method comprising;

determining (201) the distance from the start position to the collision point,

calculating (202) a clearance time (t_c) being the amount of time required for the feed unit to move from the start position to the collision point to allow the application path to have passed the collision point,

calculating (203) a feed trajectory having a first segment ($t_s \rightarrow t_c$) of a motion cycle of the feed unit from the start position to the collision point, and a second segment ($t_c \rightarrow t_f$) of the motion cycle of the feed unit from the collision point to the final picking position, and

performing (204) the first and second segment of the motion cycle comprising continuously moving the feed unit between the start position and the

final picking position, via the collision point, at a velocity (v_f) of the feed trajectory, the velocity (v_f) being based on the clearance time and on a pitch distance (p_1) between two successive packaging containers being conveyed.

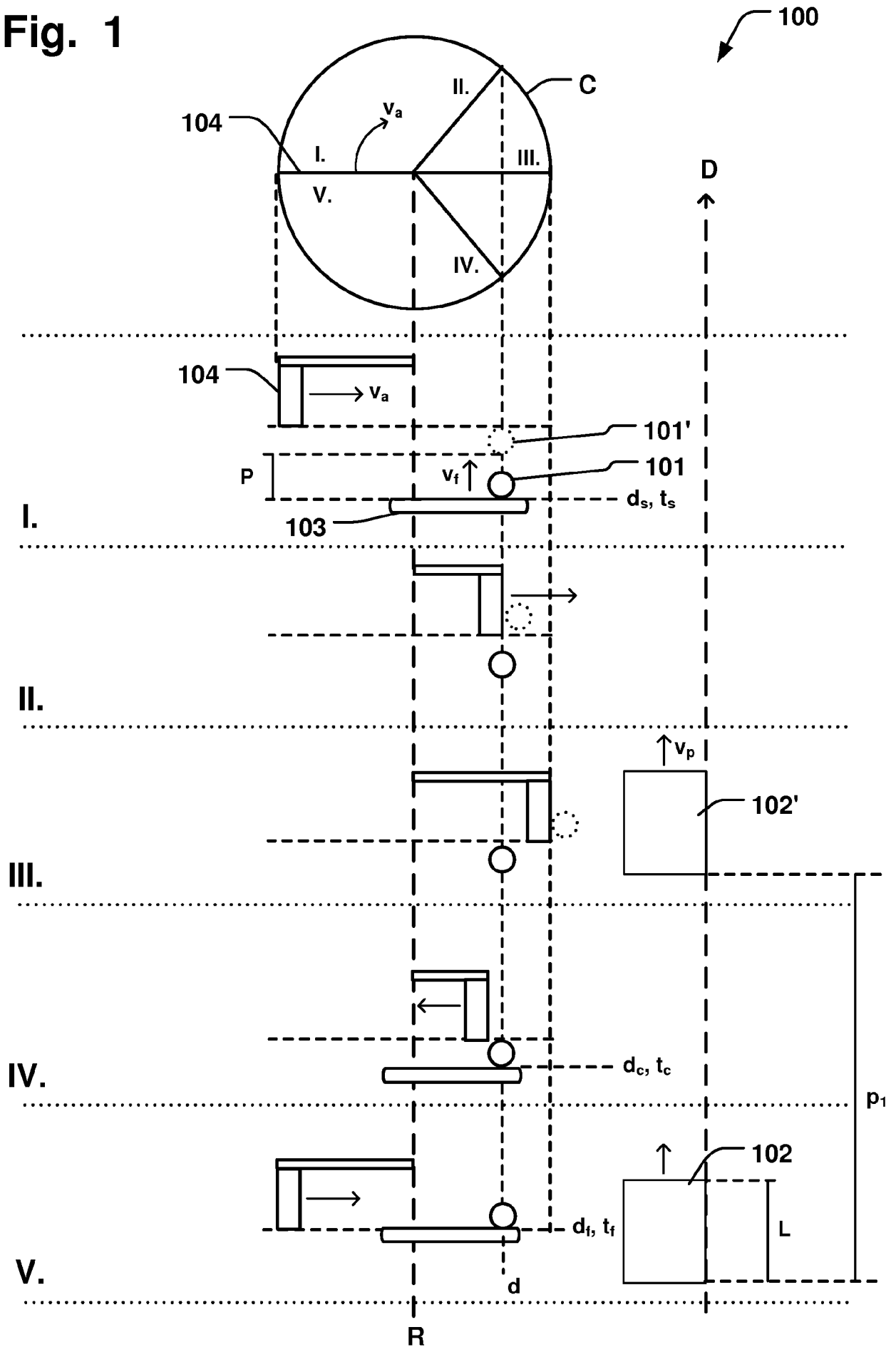
5 14. Use of a method according to any of claims 1-13, for applying a component such as a drinking straw to a packaging container.

15 15. A computer program product comprising instructions which, when the program is executed by a computer, cause the computer to carry out the steps
10 of the method according to any of claims 1-13.

16. Apparatus (100) for feeding components (101) to be applied to packaging containers (102), said apparatus comprising;
a feed unit (103) adapted for conveying each of the components from a
15 start position (d_s), at start time (t_s), to a final picking position (d_f), at end time (t_f), along a feed path (d),
an application device (104) which is movable along an application path (C) to pick the component at the final picking position (d_f) and transport the component to the packaging container, wherein the feed path cross the
20 application path at a collision point (d_c),
a control device (105) for controlling the operation of the apparatus, which control device is connected to a drive unit (106) driving the feed unit and the application device, wherein the control device is adapted to
determine (201) the distance from the start position to the collision point,
25 calculate (202) a clearance time (t_c) being the amount of time required for the feed unit to move from the start position to the collision point to allow the application path to have passed the collision point,
calculate (203) a feed trajectory having a first segment ($t_s \rightarrow t_c$) of a motion cycle of the feed unit from the start position to the collision point, and a second
30 segment ($t_c \rightarrow t_f$) of the motion cycle of the feed unit from the collision point to the final picking position, and
perform (204) the first and second segment of the motion cycle comprising continuously moving the feed unit between the start position and the final picking position, via the collision point, at a velocity (v_f) of the feed trajectory, the
35 velocity (v_f) being based on the clearance time and on a pitch distance (p_1) between two successive packaging containers being conveyed.

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Fig. 1



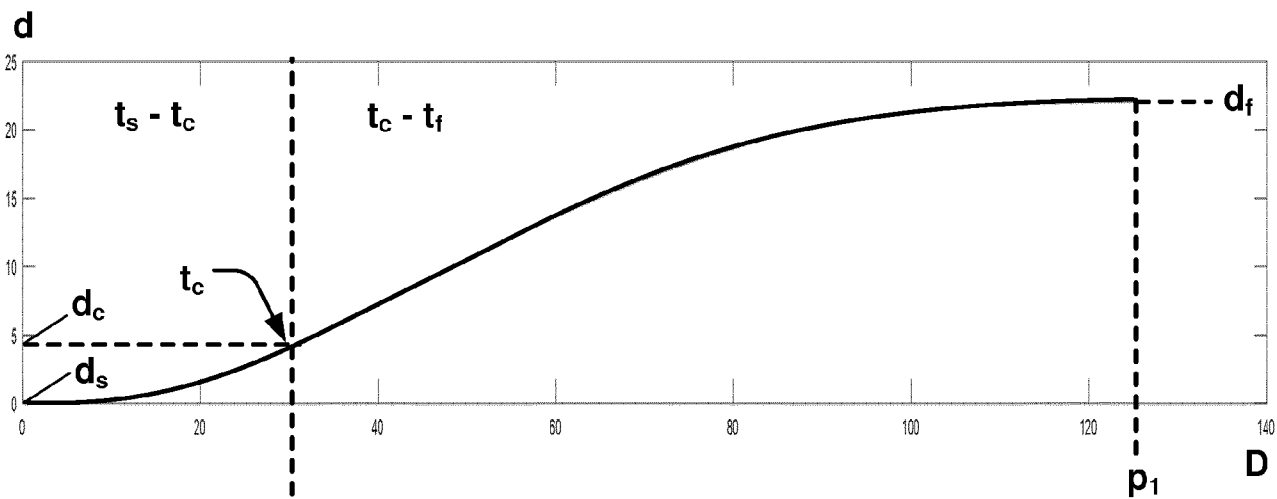


Fig. 2a

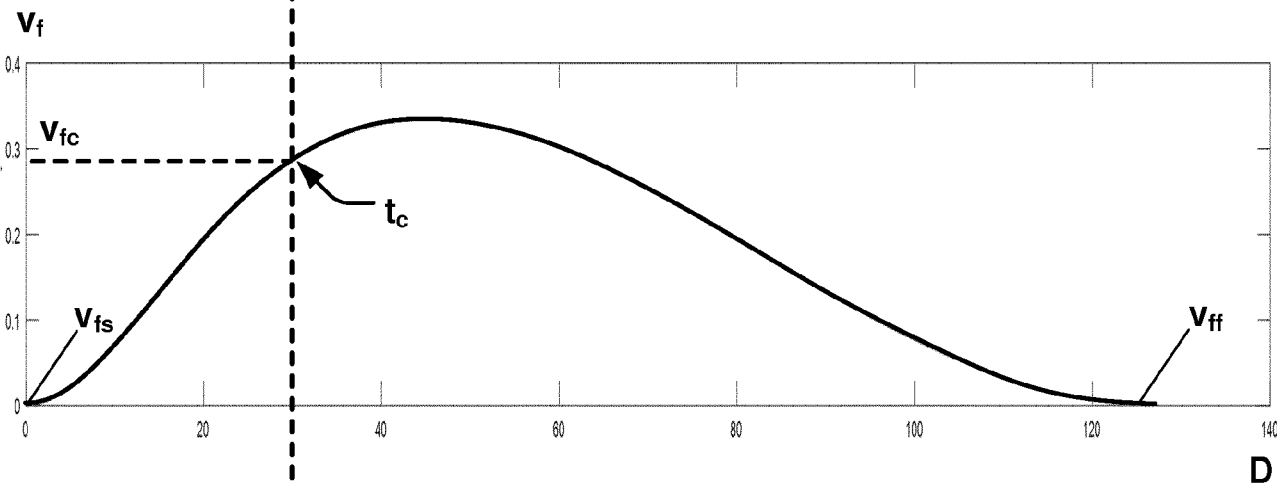


Fig. 2b

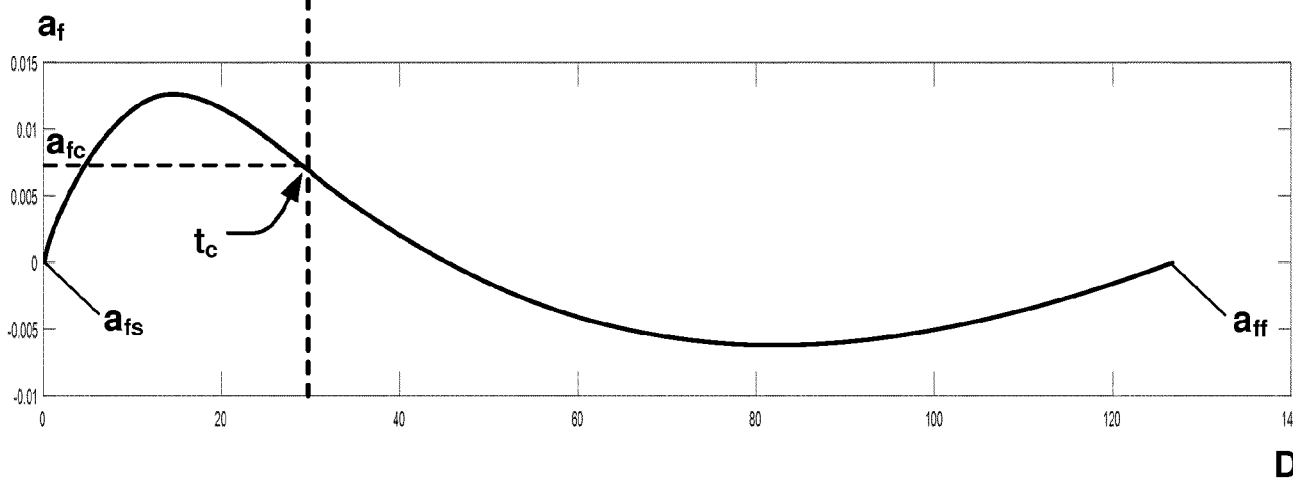


Fig. 2c

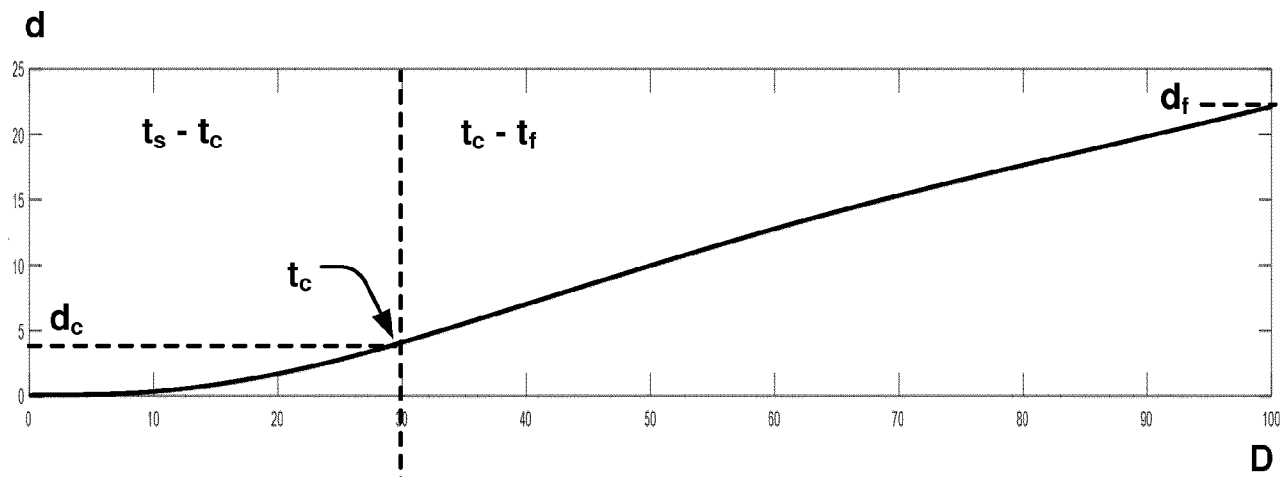


Fig. 3a

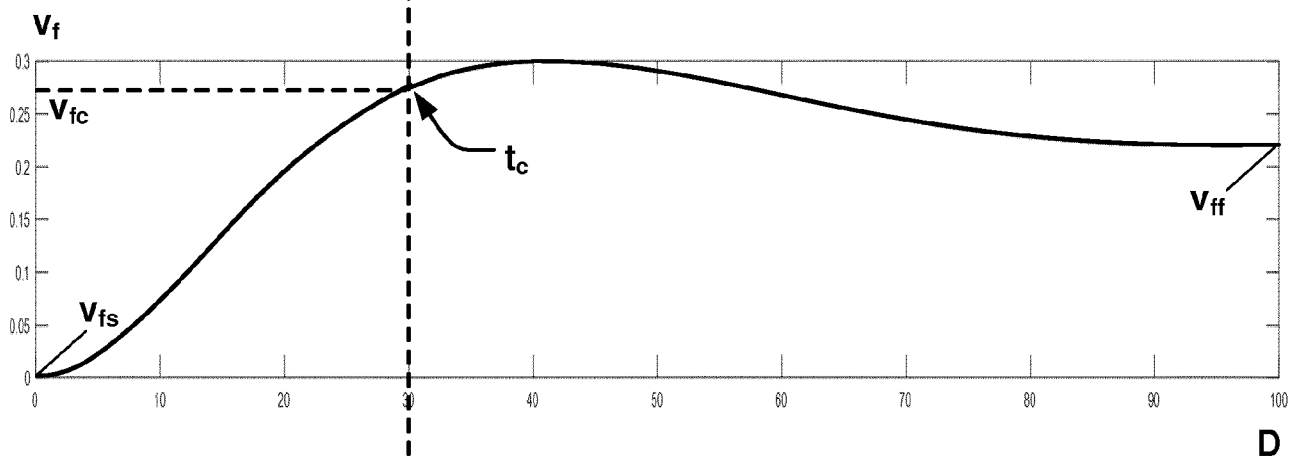


Fig. 3b

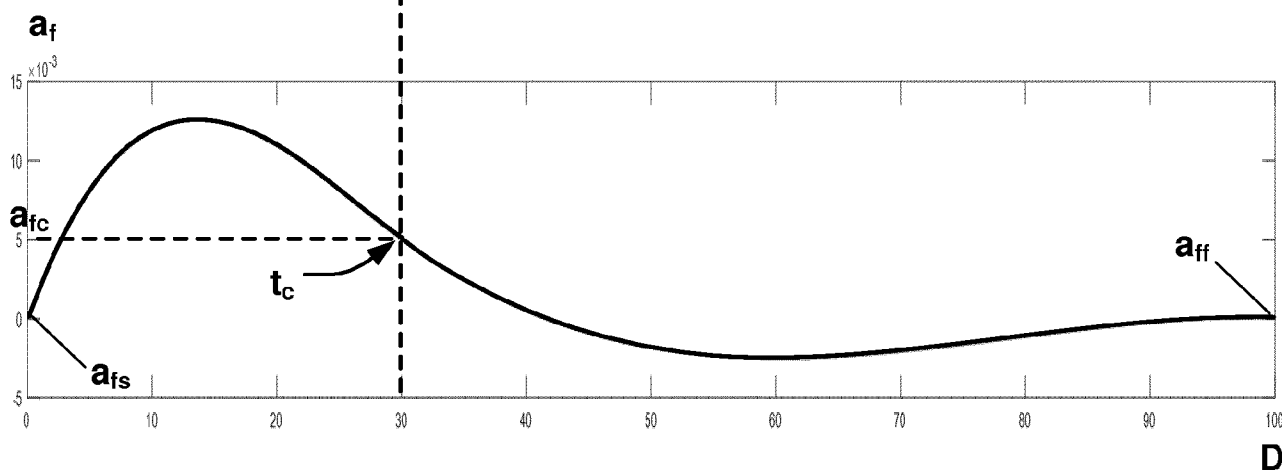


Fig. 3c

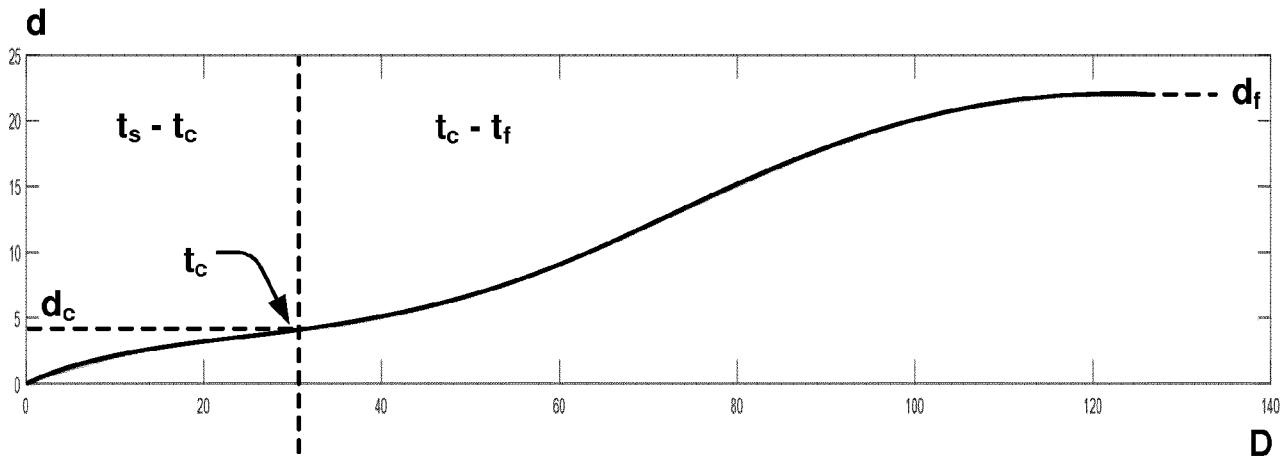


Fig. 3d

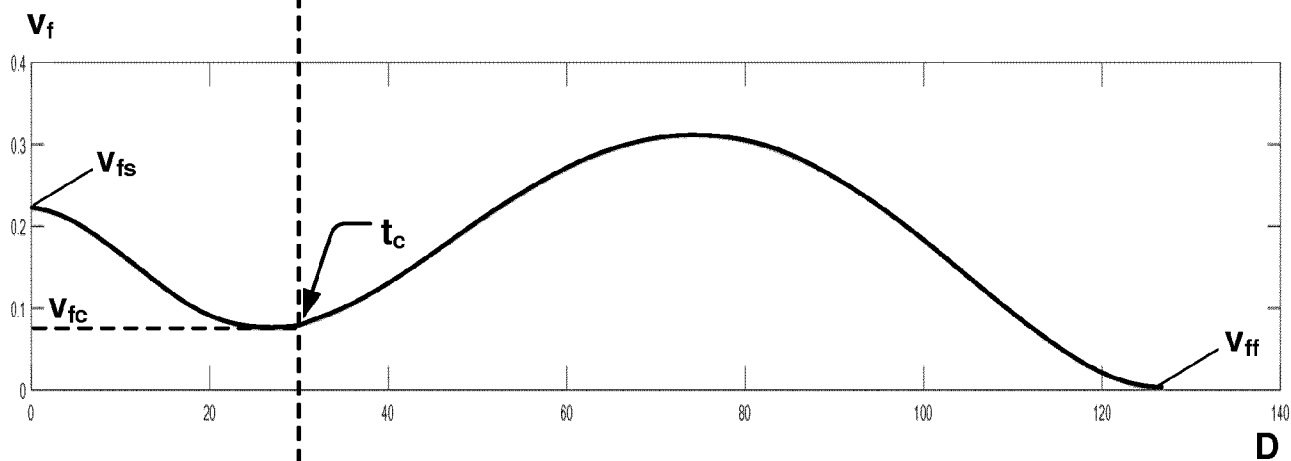


Fig. 3e

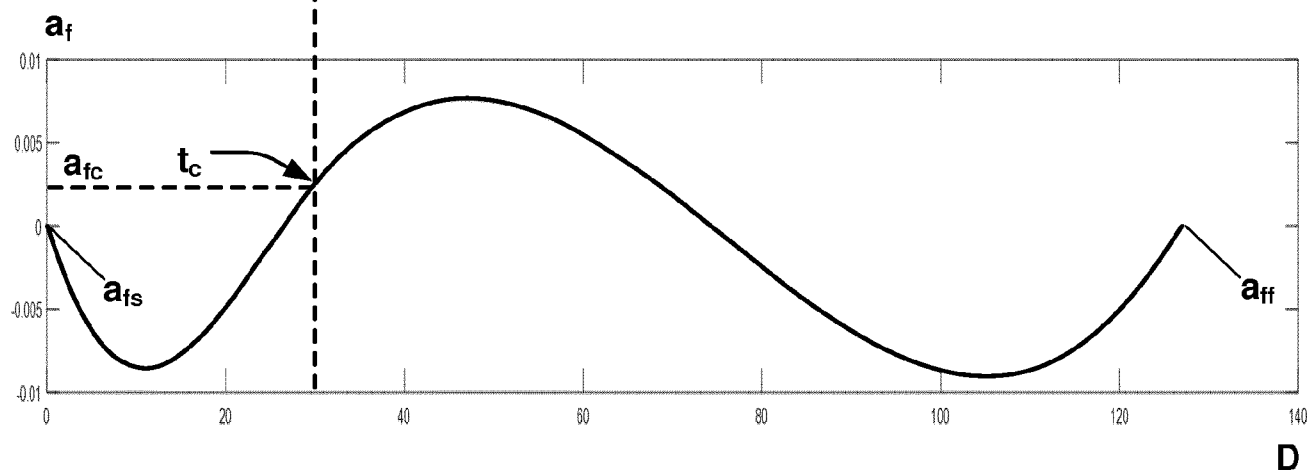


Fig. 3f

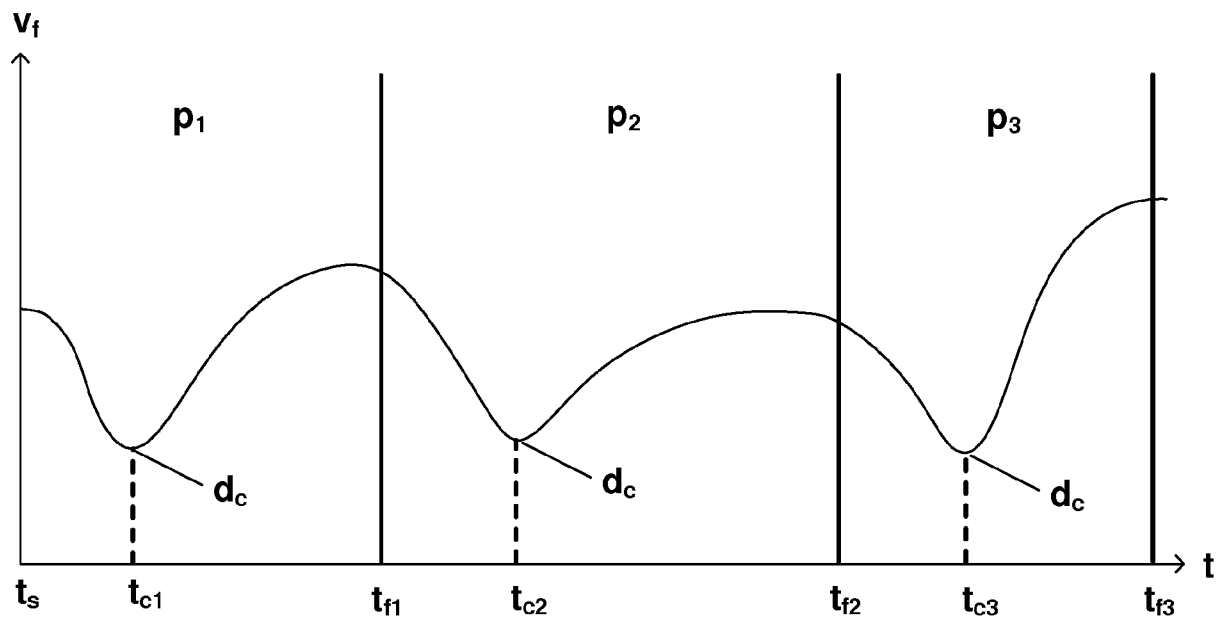


Fig. 4

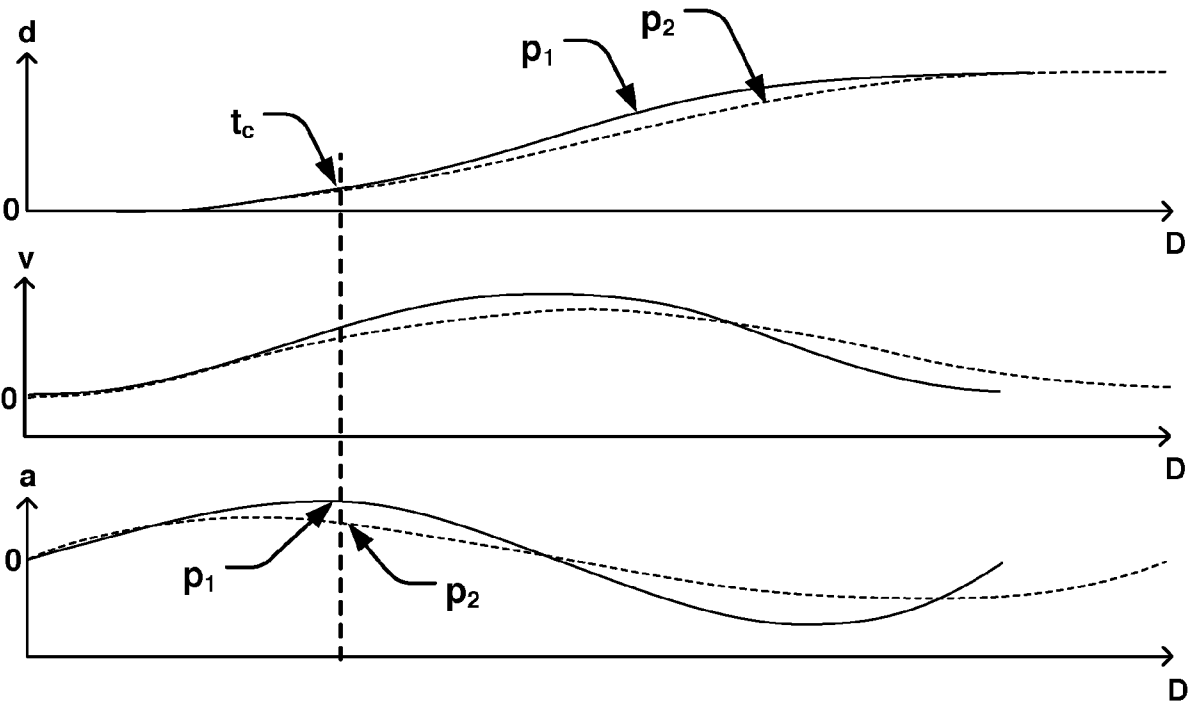
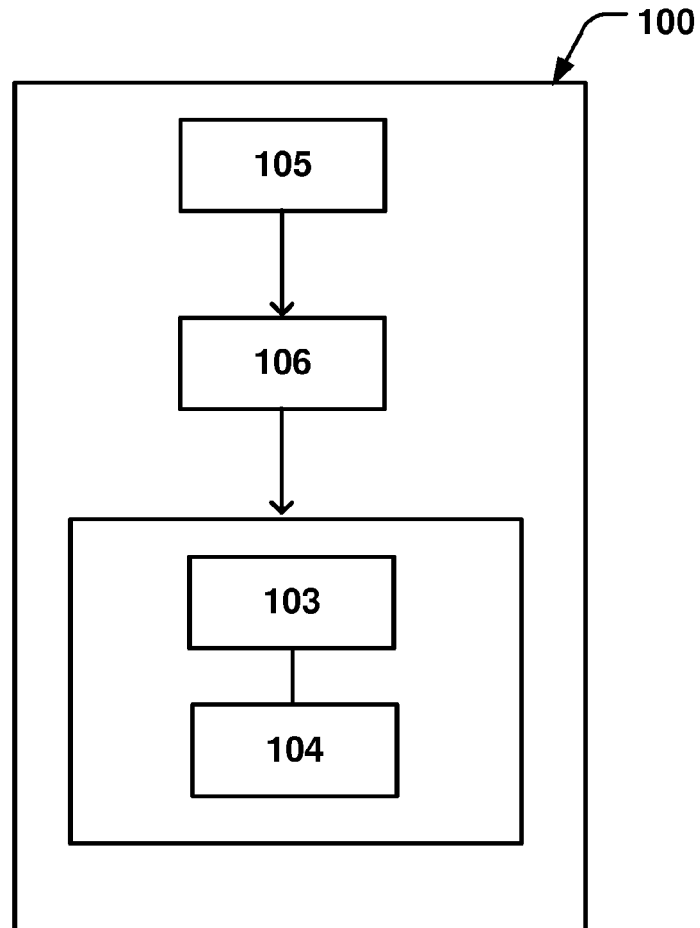
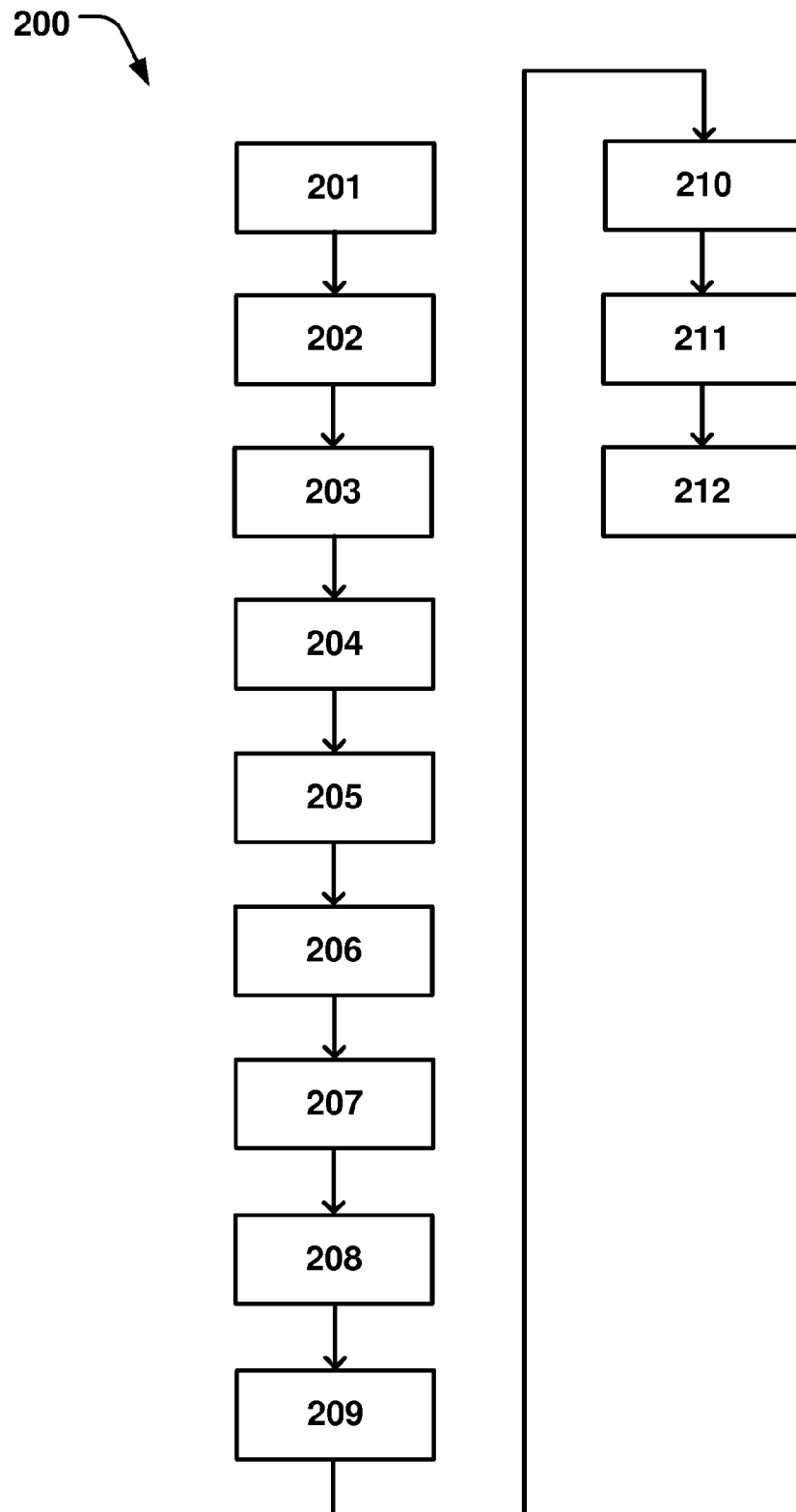


Fig. 5

**Fig. 6**

**Fig. 7**

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/079684

A. CLASSIFICATION OF SUBJECT MATTER
INV. B65B57/02 B65B57/08 B65B61/20
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B65B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2016/091622 A1 (TETRA LAVAL HOLDINGS & FINANCE [CH]) 16 June 2016 (2016-06-16) the whole document -----	1-16
A	WO 2016/096379 A1 (TETRA LAVAL HOLDINGS & FINANCE [CH]) 23 June 2016 (2016-06-23) the whole document -----	1-16
A	WO 2016/142104 A1 (TETRA LAVAL HOLDINGS & FINANCE [CH]) 15 September 2016 (2016-09-15) the whole document -----	1-16
A	WO 2016/096380 A1 (TETRA LAVAL HOLDINGS & FINANCE [CH]) 23 June 2016 (2016-06-23) the whole document -----	1-16



Further documents are listed in the continuation of Box C.



See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

18 December 2017

Date of mailing of the international search report

04/01/2018

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Authorized officer

Yazici, Baris

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/079684

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2016091622 A1	16-06-2016	CN 107000877 A EP 3230170 A1 US 2017334592 A1 WO 2016091622 A1	01-08-2017 18-10-2017 23-11-2017 16-06-2016
WO 2016096379 A1	23-06-2016	CN 107000874 A EP 3233641 A1 US 2017327261 A1 WO 2016096379 A1	01-08-2017 25-10-2017 16-11-2017 23-06-2016
WO 2016142104 A1	15-09-2016	CN 107207110 A WO 2016142104 A1	26-09-2017 15-09-2016
WO 2016096380 A1	23-06-2016	CN 107000875 A EP 3233642 A1 US 2017341793 A1 WO 2016096380 A1	01-08-2017 25-10-2017 30-11-2017 23-06-2016