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(54) **A METHOD OF OPERATING AN APPARATUS FOR APPLYING COMPONENTS TO PACKAGING CONTAINERS**

(57) A method of operating an apparatus for applying components to packaging containers is disclosed. The method comprises determining the distance from an application start position to at least one collision point with a feed path; calculating an interference time being the amount of time required for the application device to complete an overlap path where the application device overlaps with the feed path; calculating an application trajectory of a motion cycle from a start position, to the at least one collision point, and to an end position; and performing the motion cycle, comprising continuously moving the application device between the start position and the end position, via the at least one collision point, at a velocity of the application trajectory determined by polynomial interpolation between a start velocity, an interference velocity, and a final velocity.

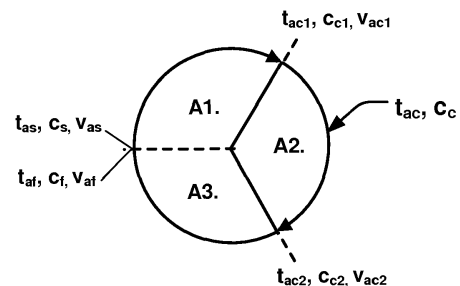


Fig. 3

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Description

Field of the Invention

[0001] The present invention relates to a method of operating an apparatus for applying components 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 an apparatus.

Background of the Invention

[0002] 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 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.

[0003] 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 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 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.

[0004] 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.

[0005] Hence, an improved method of operating an apparatus for applying components 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

[0006] 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.

[0007] According to a first aspect a method of operating an apparatus for applying components to packaging containers is provided. The apparatus comprising an application device which is movable along an circumferential application path from an application start position, at an application start time, to an application end position, at an application end time, the application path overlaps with a feed path of a feed unit at at least one application collision point, the feed unit being adapted for conveying each of the components to the at least one application collision point, the circumferential application path having a center of rotation around a rotational axis, wherein the feed unit feeds the component in a longitudinal feed direction adjacent the at least one application collision point, wherein the longitudinal feed direction is substantially parallel to said rotational axis and substantially perpendicular to said conveyor direction. The method comprises determining the distance from the application start position to the at least one collision point; determining the distance from the at least one collision point to the application end position; calculating an interference time being the amount of time required for the application device to complete an overlap path, being the portion of the application path where the application path overlaps with the feed path; calculating an application trajectory having a first segment of a motion cycle of the application device from the start position to the at least one collision point, a second segment of the motion cycle of the application device for the overlap path, and a third segment of the motion cycle of the application device from the at least one collision point to the end position; performing the first, second and third segment of the motion cycle, comprising continuously moving the application device between the start position and the end position, via the at least one collision point, at a velocity of the application trajectory determined by polynomial interpolation between a start velocity, an interference velocity based on the interference time at the at least one collision point, and a final velocity.

[0008] According to a second aspect a computer-implemented method of operating an apparatus for applying components to packaging containers is provided. The apparatus comprises an application device which is movable along an circumferential application path from an application start position, at an application start time, to an application end position, at an application end time. The application path overlaps with a feed path of a feed unit at at least one application collision point, the feed unit being adapted for conveying each of the components to the at least one application collision point. The circum-

ferential application path has a center of rotation around a rotational axis, and the feed unit feeds the component in a longitudinal feed direction adjacent the at least one application collision point, and a longitudinal feed direction is substantially parallel to the rotational axis and substantially perpendicular to the conveyor direction. The computer-implemented method comprises determining the distance from the application start position to the at least one collision point; determining the distance from the at least one collision point to the application end position; calculating an interference time being the amount of time required for the application device to complete an overlap path, being the portion of the application path where the application path overlaps with the feed path. The method further comprising calculating an application trajectory having a first segment of a motion cycle of the application device from the start position to the at least one collision point, a second segment of the motion cycle of the application device for the overlap path, and a third segment of the motion cycle of the application device from the at least one collision point to the end position; performing the first, second and third segment of the motion cycle, comprising continuously moving the application device between the start position and the end position, via the at least one collision point, at a velocity of the application trajectory determined by polynomial interpolation between a start velocity, an interference velocity based on the interference time at the at least one collision point, and a final velocity.

[0009] According to a third aspect an apparatus for applying components to packaging containers is provided. The apparatus comprises an application device which is movable along an circumferential application path from an application start position, at an application start time, to an application end position, at an application end time. The application path overlaps with a feed path of a feed unit at at least one application collision point, and the feed unit is adapted for conveying each of the components to the at least one application collision point. The circumferential application path has a center of rotation around a rotational axis. The feed unit feeds the component in a longitudinal feed direction adjacent the at least one application collision point, and the longitudinal feed direction is substantially parallel to the rotational axis and substantially perpendicular to a conveyor direction in which the packaging containers are conveyed. The apparatus comprises 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 application start position to the at least one collision point; determine the distance from the at least one collision point to the application end position; calculate an interference time being the amount of time required for the application device to complete an overlap path, being the portion of the application path where the application path overlaps with the feed path; calculate an application trajectory having a first segment of a motion

cycle of the application device from the start position to the at least one collision point, a second segment of the motion cycle of the application device for the overlap path, and a third segment of the motion cycle of the application device from the at least one collision point to the end position; perform the first, second and third segment of the motion cycle, comprising continuously moving the application device between the start position and the end position, via the at least one collision point, at a velocity of the application trajectory determined by polynomial interpolation between a start velocity, an interference velocity based on the interference time at the at least one collision point, and a final velocity.

[0010] 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.

[0011] 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.

[0012] 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.

[0013] 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.

[0014] 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.

[0015] 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 applying components to packaging containers, such as the application of drinking straws to packaging containers.

[0016] Some examples of the disclosure provide for increased lifetime of machine components in an apparatus for applying components to packaging containers.

[0017] Some examples of the disclosure provide for increasing the throughput in ultra high-speed production lines.

[0018] Some examples of the disclosure provide for decreasing the forces, vibrations, and torques on the motors driving an apparatus for applying components to packaging containers.

[0019] Some examples of the disclosure provide for avoiding interference of overlapping trajectories of a feed unit and an application device.

[0020] Some examples of the disclosure provide for an even load on the motors driving an apparatus for applying components to packaging containers.

[0021] Some examples of the disclosure provide for increasing the robustness of an apparatus for applying

components to packaging containers.

[0022] Some examples of the disclosure provide for maintaining a more compact apparatus for applying components to packaging containers.

[0023] 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

[0024] 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 applying components to packaging containers;

Fig. 2 is a schematic view an application device for applying components to packaging containers;

Fig. 3 is a schematic view of the application path of an application device for applying components to packaging containers;

Figs. 4a-c are exemplary diagrams of motion trajectories of an application device in an apparatus for applying components to packaging containers;

Fig. 5 is a schematic of an apparatus for applying components to packaging containers; and

Fig. 6 is a flowchart of a method of operating an apparatus for applying components to packaging containers.

Description of embodiments

[0025] 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.

[0026] Fig. 1 a shows a schematic illustration of an apparatus 100 for applying components 101 to packaging containers 102, being conveyed in a longitudinal conveyor direction (D). Fig. 1 illustrates five captions in time (I-V), of the movement of the application device 104 and a feed unit 103. Thus, the apparatus 100 comprises an application device 104 which is movable along an circumferential application path (C) from an application start

position (c_s), at an application start time (t_{as}), to an application end position (c_f), at an application end time (t_{af}), further illustrated in Figs. 2-3. The circumferential application path (C) has a center of rotation around the rotational axis (R), illustrated in Fig. 1.

[0027] The application path (C) overlaps with a feed path (d) of the feed unit 103 at at least one application collision point (c_{c1} , C_{c2}). The feed unit 103 is adapted for conveying each of the components 101, 101', to the at least one application collision point (c_{c1} , c_{c2}), where the application device 104 can engage the component 101, 101', and push it towards and against a packaging container 102, 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 (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 104 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. Thus, the feed unit 103 feeds the component 101 in a longitudinal feed direction (d) adjacent the at least one application collision point (c_{c1} , C_{c2}). The longitudinal feed direction (d) is substantially parallel to the rotational axis (R) of the application device 104, and substantially perpendicular to the conveyor direction (D). The conveyor direction (D) is aligned along the feed path (d) in Fig. 1 in order to schematically illustrate the events in time. In the apparatus 100 the conveyor direction (D) is rather substantially perpendicular to the rotational axis (R) of the application device 104 as illustrated in Fig. 2. In case of having components 101 that are of elongated shape, e.g. drinking straws, it is advantageous to have their longitudinal direction aligned perpendicular to the feed direction, in order to advance a new drinking straw in the shortest amount of time and spatial distance. Then, by having the feed path (d) aligned perpendicular to the conveyor direction (D) of the packages, it is possible to get the longitudinal direction of the straws aligned with the conveyor direction (D). This advantageously allows more time to apply the straw 101 to the package, when the package passes the application device 104 since the overlap in the direction of motion is maximized (Fig. 2). This also entails different considerations with respect to the intersecting motion trajectories of the application device 104 and the feed unit 103, compared to the case where the feed path is parallel with the conveyor direction.

[0028] Further with respect to Fig. 1, the feed unit 103 is 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 (t_f), which is illustrated in caption (V). The final pick-

ing position (d_f) corresponds to the location of the at least one application collision point (c_{c1} , c_{c2}). The feed unit 103 conveys the components 101, 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. Starting at (I), the feed unit 103, holding the component 101 to be 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), or collision point (c_{c1} , c_{c2}), 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 unit in which the components 101, 101', are held are thus separated by the feed pitch (P). 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 position (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', also illustrated in Fig. 2. The first component 101' is 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), (c_{c1} , c_{c2}), where the feed path (d) cross the application path (C). The feed unit 103 can not pass the collision point (d_c), (c_{c1} , c_{c2}), 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.

[0029] The apparatus 100 comprises a control device 105 (Fig. 5) 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 300 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 300 are described and illustrated should not be construed as limiting and it is conceivable that the steps can be performed in varying order.

[0030] The control device 105 is adapted to determine 301 the distance from the application start position (c_s) to the at least one collision point (c_{c1} , c_{c2}), and is adapted to determine 302 the distance from the at least one collision point (c_{c1} , c_{c2}) to the application end position (c_f).

The control device 105 is further adapted to calculate 303 an interference time (t_{ac}) being the amount of time required for the application device 104 to complete an overlap path (c_c), see Fig. 3, which is the portion of the application path (C) where the application path (C) overlaps with the feed path (d). It should be noted that the least one collision point (c_{c1} , c_{c2}) is defined in relation to the application path (C) which is substantially perpendicular to the feed path (d). Thus, with respect to the mentioned collision point denoted d_c , being defined in relation to the feed path (d), there can be one or more collision point (c_{c1} , c_{c2}) along the application path (C). Also, the collision point (d_c), (c_{c1} , c_{c2}), is in this example defined in relation to the feed unit 103 and application device 104. In practice, the collision would take place with the component 101, 101', 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), (c_{c1} , c_{c2}), with 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.

[0031] The control device 105 is further adapted to calculate 304 an application trajectory having a first segment (A1) of a motion cycle of the application device 104 from the start position (c_s) to the at least one collision point (c_{c1} , c_{c2}), to calculate a second segment (A2) of the motion cycle of the application device 104 for the overlap path (c_c), and to calculate a third segment (A3) of the motion cycle of the application device 104 from the at least one collision point (c_{c1} , c_{c2}) to the end position (c_f). See Fig. 3 for a schematic illustration of segments A1-A3. An example of the application trajectory is illustrated in Figs. 4a-c, where the y-axis is the distance moved along the application path (C), the velocity (v_a), and acceleration (a_a) of the application unit 104, respectively. The x-axis is the distance (D) a container package 102, 102', moves during a time unit in the direction of the container conveyor. For the purpose of the discussion, this axis can be seen as the progression of time units for the trajectory. In this example, the overlap path (c_c), which is associated with the application trajectory in the second segment (A2), corresponds to the distance between a collision start point (c_{c1}) and collision end point (c_{c2}), at an interference start time (t_{ac1}) and interference end time (t_{ac2}), respectively.

[0032] The control device 105 is further adapted to perform 305 the first, second and third segment (A1, A2, A3) 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 second and third segment (A1, A2, A3) of the motion cycle comprises continuously moving the application device 104 between the start position (c_s) and the end position (c_f), via the at least one collision point (c_{c1} , c_{c2}), at a velocity (v_a) of the application trajectory determined by polynomial interpolation between a start velocity (v_{as}), an interference velocity (v_{ac1} , v_{ac2}) based on the inter-

ference time at the at least one collision point (c_{c1} , c_{c2}), and a final velocity (v_{af}). By interpolating the application trajectory between the end values and the collision criteria, i.e. the interference time and associated interference velocity, the velocity (v_a) throughout the whole trajectory can be determined to move the application unit 104 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 at least one collision point (c_{c1} , c_{c2}). 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. By having a continuous motion at a velocity (v_a) which is calculated for the trajectory based on polynomial interpolation between the start velocity (v_{as}), the determined interference criteria, and the final velocity (v_{af}), the application trajectory can smoothly complete the whole application path (C) in the maximum available time, while correcting for the criteria determined at the at least one collision point (c_{c1} , c_{c2}) to avoid interference with the crossing feed path (d). This minimizes the acceleration and deceleration of the application device 104 since start and stop action is avoided, e.g. at the at least one collision point (c_{c1} , c_{c2}).

[0033] Fig. 6 illustrate a corresponding method 300 comprising determining 301 the distance from the application start position (c_s) to the at least one collision point (c_{c1} , c_{c2}), determining 302 the distance from the at least one collision point to the application end position (c_f), calculating 303 an interference time (t_{ac}) being the amount of time required for the application device 104 to complete an overlap path (c_c), being the portion of the application path (C) where the application path (d) overlaps with the feed path. The method comprising calculating 304 an application trajectory having a first segment (A1) of a motion cycle of the application device 104 from the start position (c_s) to the at least one collision point (c_{c1} , c_{c2}), a second segment (A2) of the motion cycle of the application device for the overlap path (c_c), and a third segment (A3) of the motion cycle of the application device 104 from the at least one collision point (c_{c1} , c_{c2}), to the end position (c_f). The method 300 comprising performing 305 the first, second and third segment of the motion cycle, comprising continuously moving the application device 104 between the start position (c_s) and the end position (c_f), via the at least one collision point (c_{c1} , c_{c2}), at a velocity (v_a) of the application trajectory determined by polynomial interpolation between a start velocity (v_{as}), an interference velocity (v_{ac1} , v_{ac2}) based on the interference time at the at least one collision point, and a final velocity (v_{af}).

[0034] With reference to Fig. 3, the method 300 may comprising accelerating or decelerating 306 the application device 104 in the first segment (A1), and/or in the second segment (A2), and/or in the third segment (A3) of the application trajectory so that, for a determined interference time (t_{ac}), the application device 104 reach the

end position (c_f) at an application end time (t_{af}) which corresponds to a total synch time (t_t). The total synch time (t_t) is the time period required for the packaging containers 102, 102', to be transported a pitch distance (p_1), which is the distance between two successive packaging containers being conveyed, as illustrated in Fig. 1. By using the full synch time for completing the application trajectory, the acceleration is kept at a minimum throughout the application path (C). Turning to Fig. 4c, the application device 104 is accelerated from a standstill to reach the collision start point (c_{c1}) at the interference start time (t_{ac1}), followed by acceleration and subsequent deceleration over the second segment (A2) to reach the collision end point (c_{c2}) at the interference end time (t_{ac2}). Deceleration to reach a standstill at end point (c_f) concludes the third segment (A3) of the application trajectory, in a first example, with zero end velocity (v_{af}). In another example, the application device is decelerated to reach a positive end velocity (v'_{af}), if the application device 104 proceeds directly to another trajectory, as indicated in Fig. 4b.

[0035] The method 300 may comprise determining 307 the current total synch time (t_t) for each subsequent application trajectory (C) calculated for a corresponding package container 102, 102', being conveyed. With reference to Fig. 3, the time available for the first (A1) and third (A3) segment of the application trajectory is determined by subtracting the interference time (t_{ac}) from the current total synch time (t_t). This provides for continuously adapting the trajectory to the maximum amount of time available to complete the segments. The length of the application path (C) in the first segment (A1) may be the same as the length of the application path (C) in the third segment (A3). The symmetry of the first and third segment provides for an advantageous feed trajectory where the available time, less the interference time (t_c) can be divided equal between the first segment (A1) and the second (A3) to achieve a corresponding acceleration or deceleration in these segments.

[0036] The method 300 may comprise the step of, within the period of the interference time (t_c), move 308 the application device 104 along the application path (C) to engage a component 101, conveyed by the feed unit (103) to the at least one collision point (c_{c1} , c_{c2}), and apply the component to a packaging container 102'. This is schematically illustrated in Fig. 2, where the application device 104 start to engage the component 101 at an interference start time (t_{c1}), at collision start point (c_{c1}), to push the component 101 radially outwards in the direction of packaging container 102', and apply it to the latter. The application step is completed during the period of completing the rotation until the interference end time (t_{c2}) is reached at the collision end point (c_{c2}). The interference time (t_{ac}) may be calculated to minimize the acceleration and torque on the application device 104, and the feed unit 103, as explained further below, while allowing for the necessary amount of time to apply the component 101 to the packaging container 102.

[0037] As exemplified with respect to e.g. Figs. 3-4, the at least one collision point may comprises a collision start point (c_{c1}) and a collision end point (c_{c2}) at opposite ends of the overlap path (c_o). It is also conceivable that the application path (C) may interfere with an intersecting feed path (d) along a different overlap path (c_o) that entails a different set of collision points (c_{c1} , c_{c2}). In this example, the collision points (c_{c1} , c_{c2}) are separated by the interference time in the second segment of the application trajectory. Thus, the application device 104 reaches the collision start point at an interference start time (t_{ac1}), and the collision end point at an interference end time (t_{ac2}). The method 300 may comprise synchronizing 309 the application trajectory with the feed path (d) so that a component 101 is conveyed by the feed unit 103 to the collision end point (c_{c2}) at the interference end time (t_{ac2}). Since the feed path (d) is perpendicular to the plane of the application path (C), i.e. parallel to rotational axis (R), the coordination of the intersecting trajectories is facilitated and it is possible let the collision end point (c_{c2}) and the associated interference end time (t_{ac2}) to define the synchronization with the feed trajectory (d). It is thus possible to let the application device 104 to proceed along its trajectory (C) until the collision end point (c_{c2}) is reached, at the interference end time (t_{ac2}), before proceeding with moving the feed unit 103 to the end point (c_{c2}), which maximizes the amount of time for the movement of the latter, thereby reducing the acceleration or deceleration, while providing for the synchronization of the application device 104 and feed unit 103.

[0038] As elucidated above, performing the first segment (A1) of the motion cycle may comprise continuously moving 310 the application device 104 between the start position (c_s) and the collision start point (c_{c1}), during a start period, until reaching the interference start time (t_{c1}). Performing the second segment (A2) of the motion cycle may comprise continuously moving 311 the application device 104 between the collision start point (c_{c1}) and the collision end point (c_{c2}) during the interference time (t_{ac}). Performing the third segment (A3) of the motion cycle may comprise continuously moving 312 the application device 104 between the collision end point (c_{c2}) and the end position (c_f), during a stop period, before reaching the end time (c_f), where the total time for the first, second and third segment is a total synch time (t_f). The total synch time (t_f) is the time period required for the packaging container 102 to be transported a pitch distance (p_1), which is the distance between two successive packaging containers 102, 102', being conveyed. 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. Figs. 4a-c illustrates an example where the overlap path is represented by the second segment (A2) of the trajectory. A trajectory is calculated by interpolation to achieve a continuous motion during the time available for reaching the start of the overlap path (c_{c1}), during the interfer-

ence time (t_{ac}), when moving along the overlap path (c_o), and during the period to reach the final position (c_f) at end time (t_f). If a successive packaging container is detected, the trajectory will proceed with a non-zero velocity (v'_{af}) into the next trajectory. The trajectory will in that case be determined from the collision end point (c_{c2}) to the next collision start point (c_{c1}), and the velocity v'_{af} will be calculated by the interpolation of the trajectory, given the conditions at the respective collision points (c_{c1} , c_{c2}), dictated by the respective distances and the amount of time available given the current pitch distance (p_1).

[0039] The acceleration of the application trajectory (C) may be interpolated to reach a gradual or minimal acceleration in the transition from the first (A1) to the second (A2) segment, and in the transition from the second to the third (A3) segment. Fig. 4b illustrates the case where the acceleration (a_a) assumes a zero or minimal value in the transition between the aforesaid segments of the trajectory. This may facilitate the synchronization with the feed unit 103, and facilitate determining an interference time (t_{ac1} , t_{ac2}) at the transition between the segments.

[0040] The velocity (v_f) of the application device 104 in the first (A1), second (A2) and third (A3) segment may always be positive. The strain on the drive unit 106 is minimized by calculating an application trajectory where the velocity is positive throughout the motion cycle, since start-, stop- and reverse action is avoided.

[0041] The method 300 may comprise calculating 312 a new application trajectory for each packaging container 102, 102', in a series of successive packaging containers, and determining 313 if a final packaging container in a series has been conveyed based on detecting a maximum pitch distance (p_1), upon which a closing application trajectory is calculated 314 to reach the end point (c_f) at a standstill. Continuous synchronization of the application trajectories with the pitch may proceed if the pitch (p_1) is below a maximum determined pitch distance. E.g. as explained above where the trajectory is calculated from the collision end point (c_{c2}) to the next collision start point (c_{c1}). Otherwise a stop trajectory is used bring the application device 104 to a stop, as seen in Fig. 4b for end velocity (v_{af}).

[0042] The interference time (t_{ac}) 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 an interference time (t_{ac}) 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 bal-

anced value on t_{ac} 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 for the feed unit 103 to reach its collision point (d_c), and the amount of time available for the application device 104 to reach the end of the overlap path (c_c), i.e. the collision end point (c_{c1}), the torque can be reduced while also approaching the same level of torque on both the application device 104 and the feed unit 103. 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.

[0043] The control device 105 of the apparatus 100 is adapted to carry out the steps described above with respect to the method 300.

[0044] A computer-implemented method of operating an apparatus 100 for applying components 101 to packaging containers 102, 102', is also provided according to the present disclosure. The computer-implemented method comprises the steps described above with respect to the method 300.

[0045] Use of the method 300 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 300 can be used in a filling machine where packaging containers 102, 102', are conveyed to the application device 104.

[0046] 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 300 described above is also provided according to the present disclosure.

[0047] 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.

[0048] 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 claims.

[0049] 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 for which the teachings of the present invention is/are used.

Claims

1. A method (300) of operating an apparatus (100) for applying components (101) to packaging containers (102) being conveyed in a longitudinal conveyor direction (D), said apparatus comprising; an application device (104) which is movable along an circumferential application path (C) from an application start position (c_s), at an application start time (t_{as}), to an application end position (c_f), at an application end time (t_{af}), the application path overlaps with a feed path (d) of a feed unit (103) at at least one application collision point (c_{c1} , c_{c2}), the feed unit (103) being adapted for conveying each of the components to the at least one application collision point, the circumferential application path having a center of rotation around a rotational axis (R), wherein the feed unit feeds the component in a longitudinal feed direction (d) adjacent the at least one application collision point, wherein the longitudinal feed direction is substantially parallel to said rotational axis and substantially perpendicular to said conveyor direction, the method comprising; determining (301) the distance from the application start position to the at least one collision point, determining (302) the distance from the at least one collision point to the application end position, calculating (303) an interference time (t_{ac}) being the amount of time required for the application device to complete an overlap path (c_c), being the portion of the application path where the application path overlaps with the feed path, calculating (304) an application trajectory having a first segment (A1) of a motion cycle of the application device from the start position to the at least one collision point, a second segment (A2) of the motion cycle of the application device for the overlap path, and a third segment (A3) of the motion cycle of the application device from the at least one collision point to the end position, performing (305) the first, second and third segment of the motion cycle, comprising continuously moving the application device between the start position and the end position, via the at least one collision point,

at a velocity (v_a) of the application trajectory determined by polynomial interpolation between a start velocity (v_{as}), an interference velocity (v_{ac1} , v_{ac2}) based on the interference time at the at least one collision point, and a final velocity (v_{af}).

2. Method according to claim 1, comprising accelerating or decelerating (306) the application device in the first segment, and/or in the second segment, and/or in the third segment of the application trajectory so that, for a determined interference time, the application device reach the end position at an application end time which corresponds to a total synch time (t_t), the total synch time being the time period required for the packaging containers to be transported a pitch distance (p_1).
3. Method according to claim 2, comprising determining (307) the current total synch time for each subsequent application trajectory calculated for a corresponding package container being conveyed, wherein the time available for the first and third segment of the application trajectory is determined by subtracting the interference time from the current total synch time.
4. Method according to any of claims 1 - 3, wherein the length of the application path in the first segment is the same as the length of the application path in the third segment.
5. Method according to any of claims 1 - 4, comprising the step of, within the period of the interference time, move (308) the application device along the application path to engage a component, conveyed by the feed unit to the at least one collision point, and apply the component to a packaging container.
6. Method according to any of claims 1 - 5, wherein the at least one collision point comprises a collision start point (c_{c1}) and a collision end point (c_{c2}) at opposite ends of the overlap path, separated by the interference time in the second segment of the application trajectory, whereby the application device reach the collision start point at an interference start time (t_{ac1}), and the collision end point at an interference end time (t_{ac2}), the method comprising synchronizing (309) the application trajectory with the feed path (d) so that a component is conveyed by the feed unit to the collision end point (c_{c2}) at the interference end time (t_{ac2}).
7. Method according to claim 6, wherein performing the first segment of the motion cycle, comprises; continuously moving (310) the application device between the start position and the collision start point, during a start period, until reaching the interference start time, and wherein performing the second seg-

ment of the motion cycle, comprises;

continuously moving (311) the application device between the collision start point and the collision end point during the interference time, and wherein performing the third segment of the motion cycle, comprises;

continuously moving (312) the application device between the collision end point and the end position, during a stop period, until reaching the end time, wherein the total time for the first, second and third segment is a total synch time (t_t), the total synch time being the time period required for the packaging container to be transported a pitch distance (p_1), which is the distance between two successive packaging containers being conveyed.

8. Method according to any of claims 1 - 7, wherein the acceleration of the application trajectory is interpolated to reach a gradual or minimal acceleration in the transition from the first to the second segment, and in the transition from the second to the third segment.
9. Method according to any of claims 1 - 8, wherein the velocity (v_f) of the application device in the first, second and third segment is always positive.
10. Method according to any of claims 1-9, comprising calculating (312) a new application trajectory for each packaging container in a series of successive packaging containers, and determining (313) if a final packaging container in a series has been conveyed based on detecting a maximum pitch distance (p_1), upon which a closing application trajectory is calculated (314) to reach the end point at a standstill.
11. Method according to any of claims 1-10, wherein the interference time is calculated by determining where the torque of the application device is substantially equal to the torque of the feed unit.
12. A computer-implemented method of operating an apparatus (100) for applying components (101) to packaging containers (102) being conveyed in a longitudinal conveyor direction (D), said apparatus comprising; an application device (104) which is movable along an circumferential application path (C) from an application start position (c_s), at an application start time (t_{as}), to an application end position (c_f), at an application end time (t_{af}), the application path overlaps with a feed path (d) of a feed unit (103) at at least one application collision point (c_{c1} , c_{c2}), the feed unit (103) being adapted for conveying each of the components to the at least one application collision point, the circumferential application path having a center of rotation around a rotational axis (R), the feed unit feeds the component in a longitudinal

- feed direction (d) adjacent the at least one application collision point, wherein the longitudinal feed direction is substantially parallel to said rotational axis and substantially perpendicular to said conveyor direction, the computer-implemented method comprising;
- determining (301) the distance from the application start position to the at least one collision point,
- determining (302) the distance from the at least one collision point to the application end position,
- calculating (303) an interference time (t_{ac}) being the amount of time required for the application device to complete an overlap path (c_c), being the portion of the application path where the application path overlaps with the feed path,
- calculating (304) an application trajectory having a first segment (A1) of a motion cycle of the application device from the start position to the at least one collision point, a second segment (A2) of the motion cycle of the application device for the overlap path, and a third segment (A3) of the motion cycle of the application device from the at least one collision point to the end position,
- performing (305) the first, second and third segment of the motion cycle, comprising continuously moving the application device between the start position and the end position, via the at least one collision point, at a velocity (v_a) of the application trajectory determined by polynomial interpolation between a start velocity (v_{as}), an interference velocity (v_{ac1} , v_{ac2}) based on the interference time at the at least one collision point, and a final velocity (v_{af}).
13. Use of a method according to any of claims 1-12, for applying a component such as a drinking straw to a packaging container.
14. 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 any of claims 1-12.
15. Apparatus (100) for feeding components (101) to packaging containers (102) being conveyed in a longitudinal conveyor direction (D), said apparatus comprising;
- an application device (104) which is movable along an circumferential application path (C) from an application start position (c_s), at an application start time (t_{as}), to an application end position (c_f), at an application end time (t_{af}), the application path overlaps with a feed path (d) of a feed unit (103) at at least one application collision point (c_{c1} , c_{c2}), the feed unit (103) being adapted for conveying each of the components to the at least one application collision point, the circumferential application path having a center of rotation around a rotational axis (R), the feed unit feeds the component in a longitudinal

feed direction (d) adjacent the at least one application collision point, wherein the longitudinal feed direction is substantially parallel to said rotational axis and substantially perpendicular to said conveyor direction,

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 (301) the distance from the application start position to the at least one collision point,

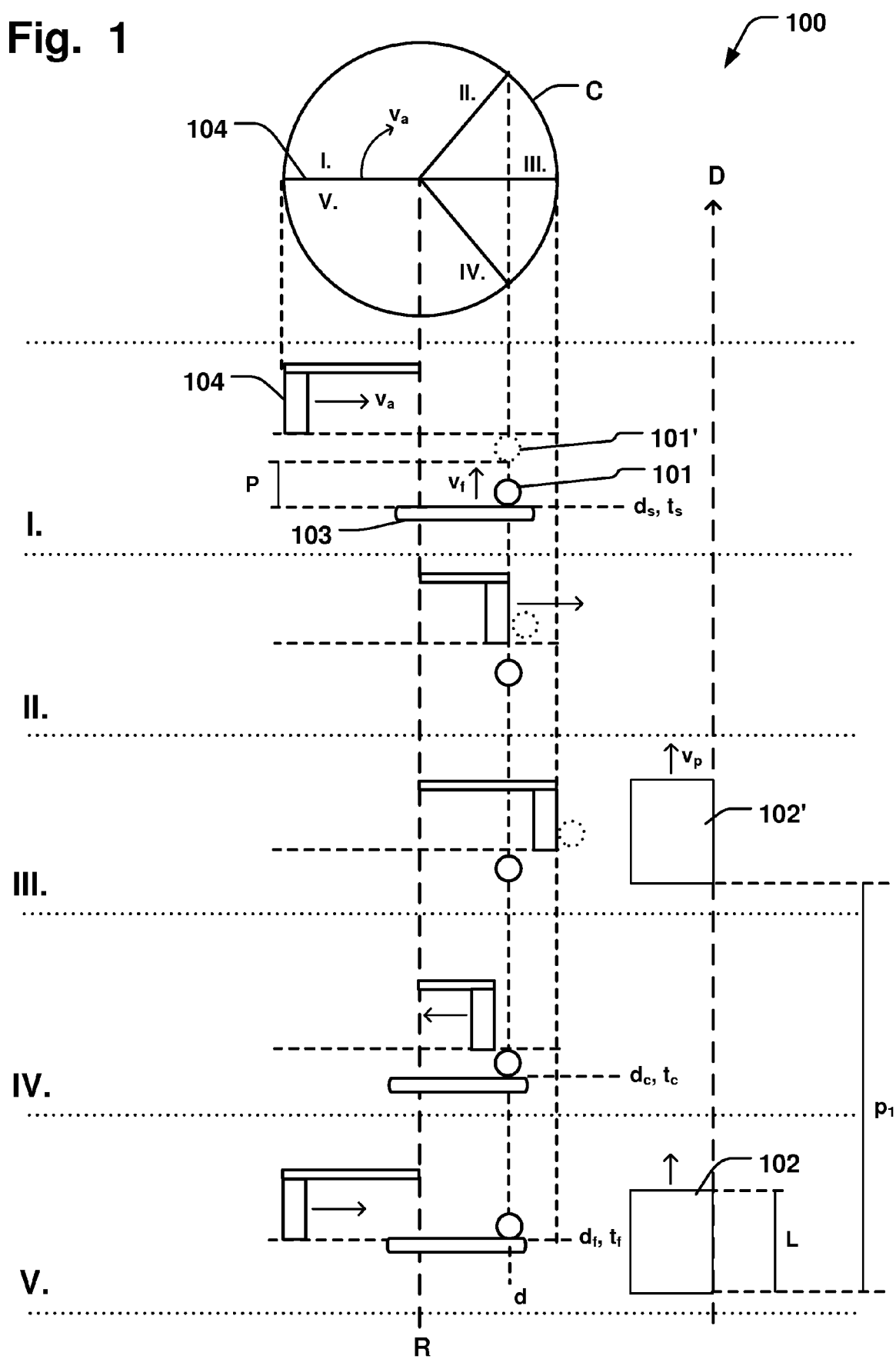
determine (302) the distance from the at least one collision point to the application end position,

calculate (303) an interference time (t_{ac}) being the amount of time required for the application device to complete an overlap path (c_c), being the portion of the application path where the application path overlaps with the feed path,

calculate (304) an application trajectory having a first segment (A1) of a motion cycle of the application device from the start position to the at least one collision point, a second segment (A2) of the motion cycle of the application device for the overlap path, and a third segment (A3) of the motion cycle of the application device from the at least one collision point to the end position,

perform (305) the first, second and third segment of the motion cycle, comprising continuously moving the application device between the start position and the end position, via the at least one collision point, at a velocity (v_a) of the application trajectory determined by polynomial interpolation between a start velocity (v_{as}), an interference velocity (v_{ac1} , v_{ac2}) based on the interference time at the at least one collision point, and a final velocity (v_{af}).

Fig. 1



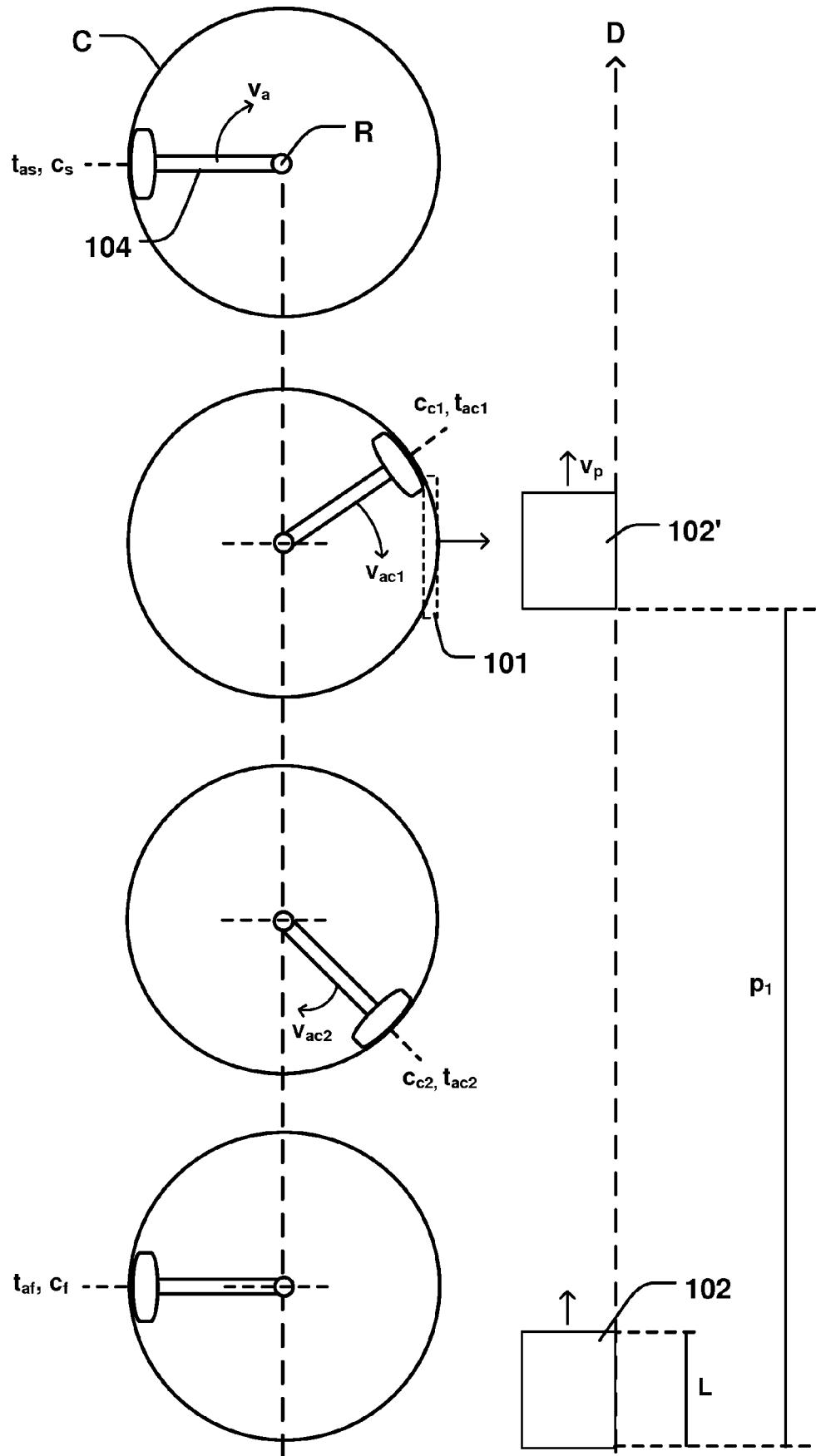


Fig. 2

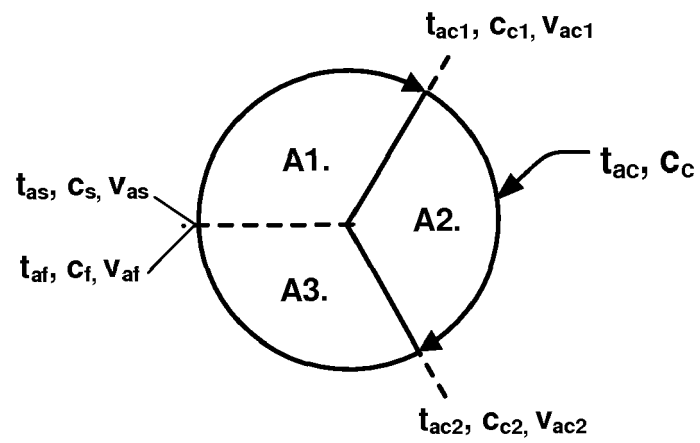


Fig. 3

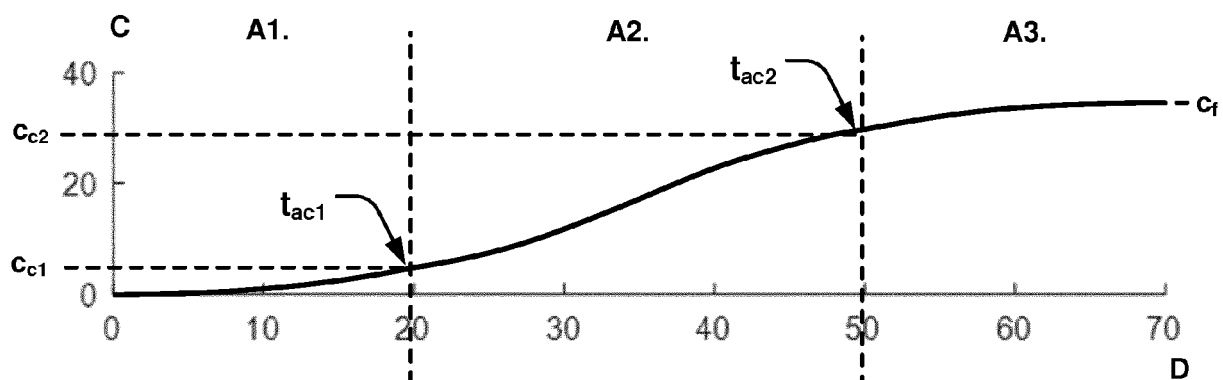


Fig. 4a

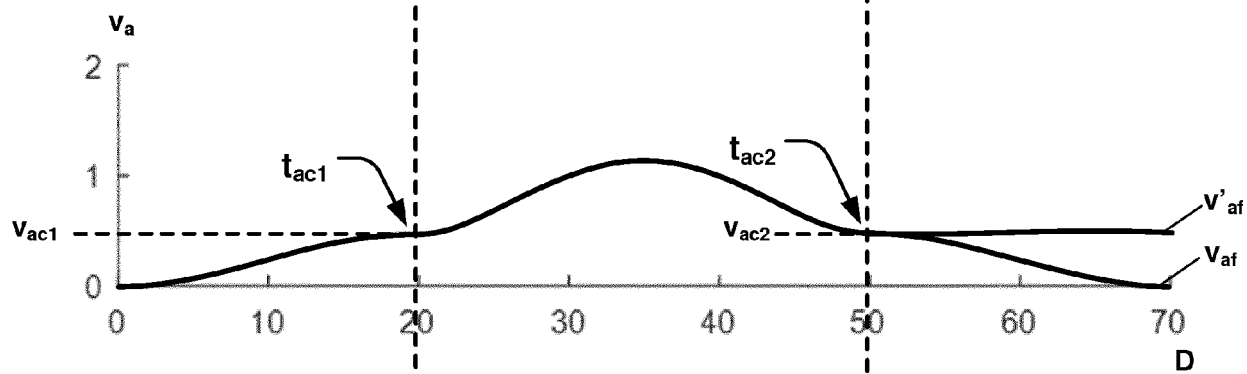


Fig. 4b

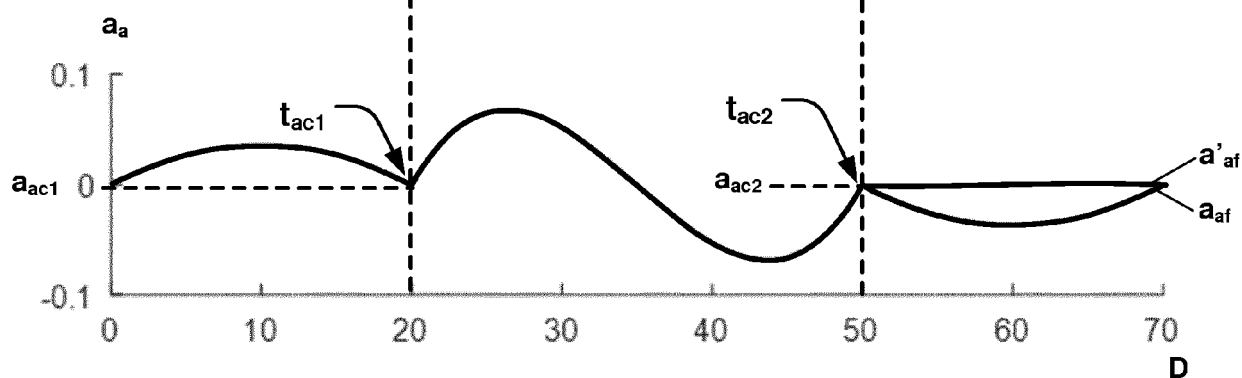


Fig. 4c

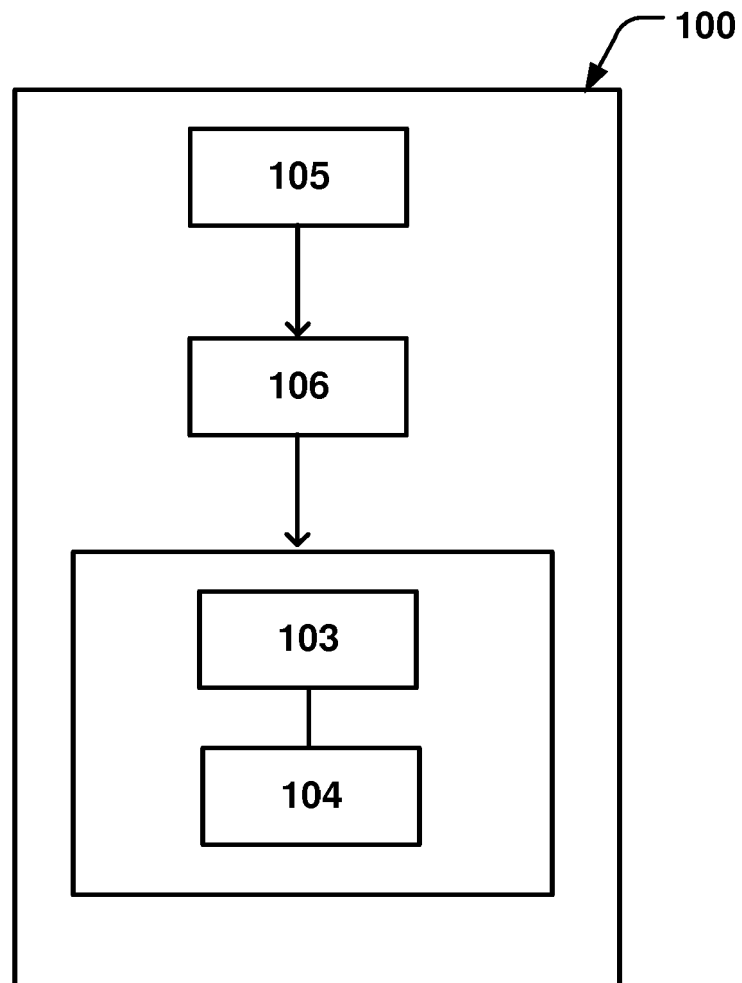
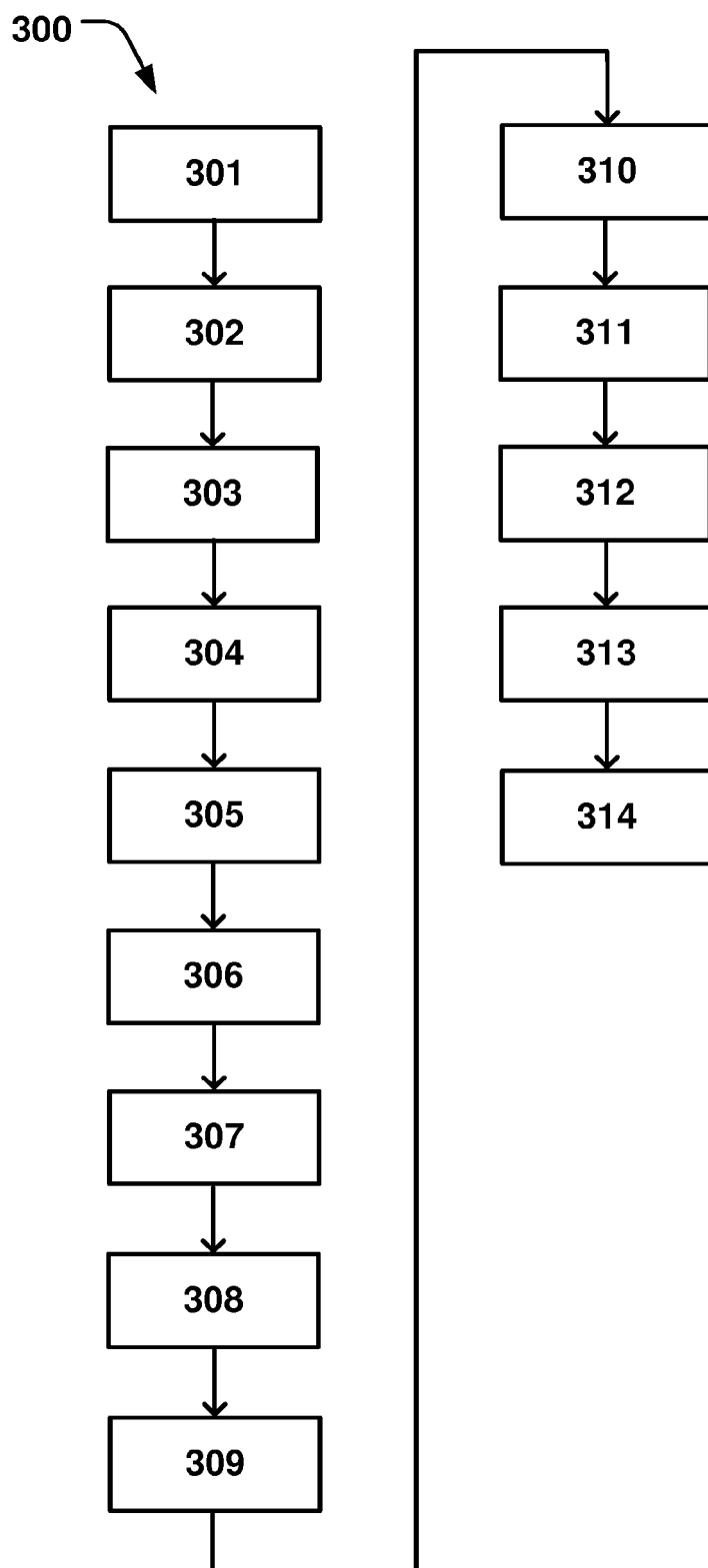


Fig. 5

**Fig. 6**



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