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(54) A PACKAGING APPARATUS AND METHOD FOR FORMING A PLURALITY OF SEALED PACKAGES FILLED WITH A POURABLE PRODUCT

(57) A packaging machine (1) for forming a plurality of sealed packages (2) comprises: a conveying device (5), configured to advance a web (4) of packaging material; an isolation chamber (10); a tube forming device (13) configured to form a tube (3) from the advancing web (4) of packaging material; a delimiting element (40) arranged within the tube (3) and designed to divide the tube (3) in a first space (41) and a second space (42); a pressurizing device (43) configured to direct a flow of sterile gas into the second space (42) for obtaining a second gas pressure within the second space (42) ; a sealing device; a filling device (15); a package forming unit (16) configured to form and transversally seal the advancing tube (3); a control unit (17) configured to control the filling device (15) and the package forming unit (16) such that in a transient phase the filling device (15) is in an inactive configuration and the package forming unit (16) is in an active configuration.

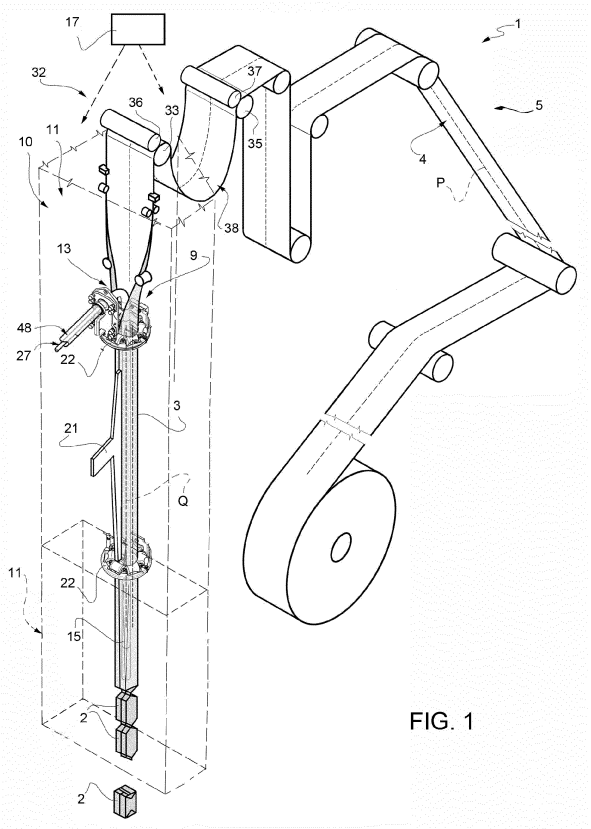

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a packaging machine for producing sealed packages of a pourable product, in particular a pourable food product.

[0002] The present invention also relates to a method for producing sealed packages of a pourable product, in particular a pourable food product.

BACKGROUND ART

[0003] Many liquid or pourable food products, such as fruit juice, UHT (ultra-high-temperature treated) milk, wine, tomato sauce, etc., are sold in packages made of sterilized packaging material.

[0004] A typical example is the parallelepiped-shaped package for liquid or pourable food products known as Tetra Brik Aseptic (registered trademark), which is made by sealing and folding laminated strip packaging material. The packaging material has a multilayer structure comprising a base layer, e.g. of paper, covered on both sides with layers of heat-seal plastic material, e.g. polyethylene. In the case of aseptic packages for long-storage products, such as UHT milk, the packaging material also comprises a layer of oxygen-barrier material (an oxygen-barrier layer), e.g. an aluminum foil, which is superimposed on a layer of heat-seal plastic material, and is in turn covered with another layer of heat-seal plastic material forming the inner face of the package eventually contacting the food product.

[0005] Packages of this sort are normally produced on fully automatic packaging machines, which advance a web of packaging material through a sterilization apparatus for sterilizing the web of packaging material at a sterilization station and an isolation chamber (a closed and sterile environment) in which the sterilized web of packaging material is maintained and advanced. During advancement of the web of packaging material through the isolation chamber, the web of packaging material is folded and sealed longitudinally at a tube forming station to form a tube having a longitudinal seam portion, the tube being further fed along a vertical advancing direction.

[0006] In order to complete the forming operations, the tube is filled with a sterilized or sterile-processed pourable product, in particular a pourable food product, and is transversally sealed and subsequently cut along equally spaced transversal cross sections within a package forming unit of the packaging machine during advancement along the vertical advancing direction.

[0007] Pillow packages are so obtained within the packaging machine, each pillow package having a longitudinal sealing band, a top transversal sealing band and a bottom transversal sealing band.

[0008] A typical packaging machine comprises a conveying device for advancing the web of packaging material along a web advancement path and a tube formed from the web of packaging material along a tube advancement path, the sterilization apparatus for sterilizing the web of packaging material prior to its formation into the tube, a tube forming and sealing device at least partially arranged within an isolation chamber and being configured to form the tube from the advancing web of packaging material and to longitudinally seal the tube, a filling device for filling the tube with the pourable product and a package forming unit adapted to form, transversally seal and cut the single packages from the tube of packaging material.

[0009] A typical packaging machine also comprises a tensioning device configured to control the tension of the tube, i.e. of the packaging material forming the tube. In particular, it is known to arrange the tensioning device between the sterilization station and the tube forming station for controlling the tension of the tube. Examples of a packaging machine comprising a tensioning device are disclosed in patent documents EP3725692B1 and EP3725689B1 in the name of the Applicant.

[0010] In order to correctly form the single packages, it is required that the hydrostatic pressure provided by the pourable product within the tube is sufficiently high as otherwise irregularly shaped packages might be obtained. Typically, the pourable product column present in the tube for providing for the required hydrostatic pressure extends at least 500 mm upwards from the hit position (i.e. the position at which the respective forming, sealing and cutting assemblies start to contact the advancing tube). As an alternative, patent document EP3456638B1 in the name of the Applicant proposes to provide a pressurizing device configured to direct, in use, a flow of sterile gas into the tube for obtaining a gas pressure within the tube providing a correct forming pressure. In such a way, the required hydrostatic pressure provided by the product column is reduced.

[0011] Despite this machine works satisfactorily, a need is felt to improve the behaviour of the machine during transient phases occurring before stop of the machine, namely in transient phases being after operational phases and before stop phases.

DISCLOSURE OF INVENTION

[0012] It is therefore an aim of the present invention to provide a packaging machine which overcomes at least one of the aforementioned drawbacks. It is also an aim of the present invention to provide a method for producing sealed packages which overcomes at least one of the aforementioned drawbacks.

[0013] These aims are fully achieved by the packaging machine and the method for producing sealed packages according to one or more of the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Two non-limiting embodiments of the present

invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a packaging machine according to the present invention, with parts removed for clarity;

Figure 2 is an enlarged view of a detail of the packaging machine of Figure 1, with parts removed for clarity;

Figure 3 schematically shows the behaviour of the machine of Figure 1 during a stop phase, a first transient phase, a second transient phase and an operational phase.

BEST MODES FOR CARRYING OUT THE INVENTION

[0015] Number 1 indicates as a whole a packaging machine for producing sealed packages 2 of a pourable food product, such as pasteurized milk or fruit juice, from a tube 3 of a web 4 of packaging material. In particular, in use, tube 3 extends along a longitudinal axis, in particular having a vertical orientation.

[0016] Web 4 of packaging material has a multilayer structure, and comprises a layer of fibrous material, normally paper, covered on both sides with respective layers of heat-seal plastic material, e.g. polyethylene.

[0017] Preferably, web 4 also comprises a layer of gas- and light-barrier material, e.g. aluminum foil or ethylene vinyl alcohol (EVOH) film, and at least a first and a second layer of heat-seal plastic material. The layer of gas- and light-barrier material is superimposed on the first layer of heat-seal plastic material, and is in turn covered with the second layer of heat-seal plastic material. The second layer of heat-seal plastic material forms the inner face of package 2 eventually contacting the food product.

[0018] A typical package 2 obtained by packaging apparatus 1 comprises a sealed longitudinal seam portion and a pair of transversal seal portions 66, in particular a pair of top and bottom transversal seal portions 66 (i.e. one seal portion 66 at an upper portion of package 2 and another seal portion 66 at a lower portion of package 2).

[0019] With particular reference to Figure 1, packaging machine 1 comprises a conveying device 5 for advancing in a known manner web 4 along a web advancement path P from a delivery station to a forming station 9, at which, in use, web 4 is formed into tube 3. Conveying device 5 is also configured to advance tube 3 along a tube advancement path Q.

[0020] Packaging machine 1 comprises an isolation chamber 10 having an inner environment 11, in particular an inner sterile environment 11, containing a sterile gas, in particular sterile air, and being separated from an outer environment 12.

[0021] Packaging machine 1 comprises a tube forming device 13 extending along a longitudinal axis, in particular having a vertical orientation, and being arranged, in particular at forming station 9, at least partially, preferably fully, within isolation chamber 10 and being adapted to form tube 3 from the, in use, advancing web 4.

[0022] Packaging machine 1 comprises a sealing device at least partially arranged within isolation chamber 10 and being adapted to longitudinally seal tube 3 formed by tube forming device 13.

[0023] Preferentially, tube forming device 13 is adapted to gradually fold web 4 into tube 3, in particular by overlapping with one another a first edge of web 4 and a second edge of web 4, opposite to first edge, for forming a longitudinal seam portion of tube 3, in particular the longitudinal seam portion being, in use, sealed by activation of sealing device.

[0024] Preferentially, conveying device 5 is adapted to advance tube 3 and any intermediate of tube 3 along a tube advancement path Q, in particular from forming station 9 to a package forming unit 16. In particular, with the wording intermediates of tube 3 any configuration of web 4 is meant prior to obtaining the tube structure and after folding of web 4 by tube forming device 13 has started. In other words, the intermediates of tube 3 are a result of the gradual folding of web 4 so as to obtain tube 3, in particular by overlapping with one another the first edge and the second edge.

[0025] Preferentially, tube forming device 13 comprises at least two forming ring assemblies 22, in particular arranged within isolation chamber 10 (in particular, within inner environment 11), being adapted to gradually fold in cooperation with one another web 4 into tube 3, in particular by overlapping the first edge and the second edge with one another for forming longitudinal seam portion. In the specific case shown, a first forming ring assembly 22 is arranged downstream of a second forming ring assembly 22 along path Q. In particular, first and second forming ring assemblies 22 are spaced apart from and parallel to one another. Furthermore, first and second forming ring assemblies 22 are arranged coaxial to one another and define longitudinal axis of tube forming device 13.

[0026] Preferentially, sealing device comprises a sealing head 21 adapted to interact with tube 3, for longitudinally sealing tube 3, in particular for sealing longitudinal seam portion. In particular, sealing head 21 is adapted to heat tube 3, in particular along seam portion. Sealing head 21 can be of the kind operating by means of induction heating or by a stream of heat or by means of ultrasound or other means.

[0027] Preferentially, sealing device comprises a pressuring assembly adapted to exert a mechanical force on tube 3, in particular on the substantially overlapping first edge and second edge so as to ensure sealing of tube 3 along seam portion. In particular, the pressuring assembly comprises an interaction roller and a counter-interaction roller adapted to exert a mechanical force onto seam portion from opposite sides thereof. In use, seam portion is interposed between the interaction roller and the counter-interaction roller. Preferentially, the interaction roller is supported by forming ring assembly 22.

[0028] Packaging machine 1 comprises a filling device

15 for (continuously) filling tube 3 with the pourable product.

[0029] With particular reference to Figures 1 and 2, filling device 15 comprise a filling pipe 27 being in fluid connection with a pourable product storage tank, which is adapted to store/provide for the pourable product to be packaged.

[0030] In particular, filling pipe 27 is adapted to direct, in use, the pourable product into tube 3. Preferentially, filling pipe 27 is, in use, at least partially placed within tube 3 for (continuously) feeding the pourable product into tube 3. In particular, filling pipe 27 includes a linear main pipe portion 28 extending within tube 3.

[0031] Even more particular, main pipe portion 28 comprises an upper section 29 and a lower section 30 coupled to one another (preferably, removably). In further detail, lower section 30 comprises an outlet opening from which the pourable product is fed, in use, into tube 3.

[0032] Packaging machine 1 comprises a package forming unit 16 which is adapted to shape, to transversally seal and to transversally cut the, in use, advancing tube 3 for forming packages 2. In particular, package forming unit 16 is arranged downstream of isolation chamber 10 and tube forming device 13 and sealing device along path Q.

[0033] With reference to Figure 2, package forming unit 16 comprises:

- a plurality of operative assemblies 61 (only one shown) and a plurality of counter-operative assemblies 62 (only one shown); and
- a track (not shown) adapted to advance the operative assemblies 61 and the counter-operative assemblies 62 along respective conveying paths. In particular, each of the operative assembly 61 and counter-operative assembly 62 advances cyclically along the respective conveying path. In even more particular, each of the operative assembly 61 and counter-operative assembly 62 is movable along said track independently from one another.

[0034] In more detail, each operative assembly 61 is adapted to cooperate, in use, with one respective counter-operative assembly 62 for forming a respective package 2 from tube 3. In particular, each operative assembly 61 and the respective counter-operative assembly 62 are adapted to shape, to transversally seal and, preferably also to transversally cut, tube 3 for forming packages 2.

[0035] In further detail, each operative assembly 61 and the respective counter-operative assembly 62 are adapted to cooperate with one another for forming a respective package 2 from tube 3 when advancing along a respective operative portion of the respective conveying path. In particular, during advancement along the respective conveying path each operative assembly 61 and the respective counter-operative assembly 62 advance parallel to and in the same direction as tube 3.

[0036] In more detail, each operative assembly 61 and the respective counter-operative assembly 62 are configured to contact tube 3 when advancing along the respective operative portion of the respective conveying path. In particular, each operative assembly 61 and the respective counter-operative assembly 62 are configured to start to contact tube 3 at a (fixed) hit position.

[0037] Furthermore, each operative assembly 61 and counter-operative assembly 62 comprises:

- a half-shell 63 adapted to contact tube 3 and to at least partially define the shape of packages 2;
- one of a sealing element 64 or a counter-sealing element 65, adapted to transversally seal tube 3 between adjacent packages 2 for obtaining transversal seal portions 66; and
- one of a cutting element (not shown and known as such) or a counter-cutting element (not shown and known as such) for transversally cutting tube 3 between adjacent packages 2, in particular between the respective seal portions 66.

[0038] In particular, each half-shell 63 is adapted to be controlled between a working position and a rest position by means of a driving assembly. In particular, each half-shell 63 is adapted to be controlled in the working position with the respective operative assembly 61 or the respective counter-operative assembly 62, in use, advancing along the respective operative portion.

[0039] It is noted that sealing element 64 and counter-sealing element 65 can be of the kind operating by means of induction heating or by a stream of heat or by means of ultrasound or other means.

[0040] According to a preferred non-limiting embodiment, package forming unit 16 is of the type described in any of patent documents EP3254980A1, EP3476751A1 in the name of the present Applicant. It is expressly understood that all the functional and structural features of the forming assembly of patent documents EP3254980A1, EP3476751A1 can be applied to package forming unit 16 described herein.

[0041] With particular reference to Figures 1 and 2, isolation chamber 10 comprises a housing 14 (only schematically shown) delimiting the inner environment 11 (i.e. housing 14 separates inner environment 11 from outer environment 12). In particular, inner environment 11 comprises (i.e. contains) the sterile gas, in particular the sterile air, at a given pressure. Preferentially, the given pressure is slightly above ambient pressure for reducing the risk of any contaminants entering inner environment 11. In particular, the given pressure is about 100 Pa to 500 Pa (0,001 bar to 0,005 bar) above ambient pressure.

[0042] Preferentially, packaging apparatus 1 comprises means (not shown and known as such) for feeding the sterile gas, in particular the sterile air, into isolation chamber 10, in particular inner environment 11.

[0043] According to one or more embodiments of the present invention and with particular reference to Figure 2, packaging apparatus 1 also comprises:

- a delimiting element 40 placed, in use, within tube 3 and designed to divide tube 3, in use, into a first space 41 and a second space 42; and
- a pressurizing device 43 adapted to direct, in particular to continuously direct, in use, a flow of sterile gas into second space 42 for obtaining a gas pressure within second space 42 that is higher than the gas pressure within first space 41.

[0044] In more detail, first space 41 is delimited by tube 3, in particular the walls of tube 3, and delimiting element 40. Furthermore, first space 41 opens up into inner environment 11. Even more particular, delimiting element 40 delimits first space 41 at a downstream portion, in particular a bottom portion, of first space 41 itself.

[0045] In more detail, second space 42 is delimited, in use, by tube 3, in particular the walls of tube 3, delimiting element 40 and transversal seal portion 66.

[0046] It is noted that said outlet opening of the lower section 30 of filling pipe 27 is open to the second space 42. Hence, said outlet opening of the lower section 30 is operatively positioned below the delimiting element 40.

[0047] In further detail, first space 41 is arranged upstream of second space 42 along tube advancement path Q. Even more particular, first space 41 is arranged upstream of delimiting element 40 along path Q. In the specific example shown, second space 42 is placed below first space 41.

[0048] In particular, as will become clear from the following description, second space 42 defines a high-pressure zone within tube 3 and first space 41 defines a low-pressure zone within tube 3.

[0049] In the context of the present application, high-pressure zone (i.e. second space 42) is to be understood such that the internal pressure lies in a range of about 5kPa to 40kPa (0,05 bar to 0,4 bar), in particular of about 10kPa to 30 kPa (0,10 bar to 0,30 bar) above ambient pressure (i.e. the pressure within second space 42 lies in a range of about 5kPa to 40kPa (0,05 bar to 0,4 bar), in particular of about 10kPa to 30 kPa (0,10 bar to 0,30 bar) above ambient pressure). In other words, second space 42 is overpressurized.

[0050] Low-pressure zone (i.e. first space 41) is to be understood such that the pressure is slightly higher than the ambient pressure. In particular, slightly higher than the ambient pressure means that the pressure lies in a range between 100 Pa to 500 Pa (0,001 bar to 0,005 bar) above ambient pressure.

[0051] In further detail, first space 41 is in (direct) fluidic connection with inner environment 11. Thus, sterile gas present in first space 41 can flow to inner environment 11.

[0052] In particular, tube 3 (and its intermediates) lie at least partially within isolation chamber 10 (in particular, within inner environment 11).

[0053] Preferentially, the pressure inside first space 41 (substantially) equals the given pressure present in isolation chamber 10, in particular in inner environment 11. Preferentially, the pressure inside first space 41 ranges between 100 Pa to 500 Pa (0,001 bar to 0,005 bar) above ambient pressure.

[0054] Filling device 15, in particular filling pipe 27, is adapted to direct the pourable product into second space 42. Thus, in use, second space 42 contains the pourable product and the pressurized sterile gas. The pressurized sterile gas provides for the required hydrostatic force needed for a correct forming of packages 2 (i.e. in other words, the sterile gas replaces the effect of the pourable product column within tube 3).

[0055] Advantageously, delimiting element 40 is designed to provide, in use, for at least one fluidic channel 44, in particular having an annular shape, for fluidically connecting second space 42 with first space 41 allowing for, in use, a leakage flow of sterile gas from second space 42 into first space 41. In particular, in use, the sterile gas leaks from second space 42 (the high-pressure zone) to first space 41 (the low-pressure zone) through fluidic channel 44. By providing for fluidic channel 44 it is possible to control the gas pressure within second space 42 with an increased accuracy. Preferentially delimiting element 40 is designed such that, in use, fluidic channel 44 is provided by a gap between the inner surface of tube 3 and delimiting element 40, in particular a peripheral portion 45 of delimiting element 40.

[0056] In particular, pressurizing means 43 are configured to provide for a variable flow of sterile gas of about 10 to 200 Nm3/h, in particular of 20 to 180 Nm3/h, even more particular of about 25 to 150 Nm3/h.

[0057] Preferentially, pressurizing means 43 are adapted to vary the flow of sterile gas in dependence of the sterile gas flowing from second space 42 to first space 41, in particular through at least fluidic channel 44.

[0058] Advantageously, pressurizing device 43 is designed such to provide for a closed sterile gas circuit from inner environment 11 into second space 42 and back into inner environment 11. In more detail, pressurizing device 43 is adapted to withdraw sterile gas from inner environment 11, to pressurize (to compress) the sterile gas and to direct the pressurized (compressed) sterile gas into second space 42.

[0059] Preferentially, pressurizing device 43 comprises a pumping device 46 adapted to withdraw sterile gas from inner environment 11, to pressurize (to compress) the sterile gas and to direct the pressurized sterile gas into second space 42. Preferentially, pumping device 46 is a rotary machine, even more particular a compressor.

[0060] Packaging machine 1 also comprises a control unit 17 for controlling operation of packaging machine 1.

[0061] Preferably, the rotary machine, in particular the compressor is configured to allow for a variable flow of sterile gas by maintaining a substantially constant gas pressure within second space 42, in particular as a function of the flow of gas from second space 42 to first space 41 (through fluidic channel 44).

[0062] Preferably, pressurizing device 43 comprise a gas feeding pipe 48 being at least indirectly fluidically connected with inner environment 11 and second space

42 for directing the sterile gas from inner environment 11 into second space 42. In particular, gas feeding pipe 48 is directly fluidically connected with second space 42. Preferentially, gas feeding pipe 48 is at least indirectly connected with pumping device 46, in particular the compressor.

[0063] In more detail, gas feeding pipe 48 comprises at least a main portion 49, which, in use, extends within tube 3. In particular, main portion 49 extends parallel to main pipe portion 28. Even more particular, at least main portion 49 and main pipe portion 28 are coaxial to one another.

[0064] In the specific example shown, filling pipe 27 extends at least partially within gas feeding pipe 48. Alternatively, gas feeding pipe 48 could at least partially extend within filling pipe 27.

[0065] In more detail, at least main pipe portion 28 of filling pipe extends at least partially within main portion 49 of gas feeding pipe.

[0066] In particular, the cross-sectional diameter of main pipe portion 28 of filling pipe is smaller than the cross-section diameter of main portion 49 of gas feeding pipe.

[0067] Preferentially, gas feeding pipe 48 and filling pipe 27 define/delimit an annular conduit 50 for the sterile gas to be fed into second space 42. In particular, annular conduit 50 is delimited by the inner surface of gas feeding pipe 48 and the outer surface of filling pipe 27.

[0068] In other words, in use, the sterile gas is directed into second space 42 through annular conduit 50.

[0069] Pressurizing means 43 also comprise:

- a first gas conduit 51 being in direct fluidic connection with pumping device 46, in particular the rotary machine, even more particular the compressor and the gas feeding pipe 48; and
- a second gas conduit 52 being in direct fluidic connection with inner environment 11 and pumping device 46, in particular the rotary machine, even more particular the compressor.

[0070] Thus, in use, sterile gas is withdrawn from inner environment 11 through gas conduit 52, is then pressurized (compressed) by pumping device 46, and is then directed into second space 42 through gas conduit 51 and gas feeding pipe 48.

[0071] Preferentially, delimiting element 40 is removably connected to at least a portion of filling pipe 27 and/or gas feeding pipe 48, in particular in a floating manner (i.e. with play). In other words, delimiting element 40 is adapted to (slightly) move parallel to the, in use, advancing tube 3.

[0072] With particular reference to Figure 1, packaging machine 1 also comprises a tensioning device 32 configured to control the tension of tube 3. In particular the tension of tube 3 may be controlled in dependence of cyclic advancement speed of web 4 and/or tube 3 and/or in dependence of the operation of package forming unit 11.

[0073] In particular, tensioning device 32 is arranged upstream of tube forming device 13 along web advancement path P and is configured to control the tension of tube 3, and in particular of the portion of web 4 extending between tensioning device 32 and tube forming device 13.

[0074] With particular reference to Figures 1, tensioning device 32 comprises:

- a main drive roller 33 rotatable around a main rotation axis; and a
- a main drive motor, in particular a servo motor, connected to main drive roller 33 and configured to actuate rotation of main drive roller 33 around main rotation axis.

[0075] According to a preferred non-limiting embodiment, tensioning device 32 further comprises:

- an auxiliary drive roller 35 rotatable around an auxiliary rotation axis; and
- an auxiliary drive motor, in particular an auxiliary servo motor, connected to auxiliary drive roller 35 and configured to actuate and/or control rotation of auxiliary drive roller 35 around auxiliary rotation axis.

[0076] According to a preferred non-limiting embodiment, auxiliary drive roller 35 and main drive roller 33 are spaced apart along web advancement path P, in particular with auxiliary drive roller 35 being arranged upstream of main drive roller 33.

[0077] According to a preferred non-limiting embodiment, tensioning device 32 further comprises:

- a main counter-roller 36 rotatable around a central axis and being arranged adjacent, in particular tangential, to main driver roller 33; and
- an auxiliary counter-roller 37 rotatable around a central axis and being arranged adjacent, in particular tangential, to auxiliary drive roller 35.

[0078] In particular, in use, web 4 is interposed and/or advances between main counter-roller 36 and main drive roller 33, and in particular between auxiliary counter-roller 37 and auxiliary drive roller 35.

[0079] Advantageously, control unit 17 is configured to control main drive motor such that an angular speed of main drive roller 33 is cyclically varied such to control the tension of tube 3, and in particular also of the portion of web 4 extending between main drive roller 33 and tube forming device 13.

[0080] According to a preferred non-limiting embodiment, control unit 17 is configured to control main drive motor such that the angular speed and/or the angular acceleration of main drive roller 33 is varied and/or controlled as a function of the operation of package forming unit 16 and/or as a function of the package forming cycle

and/or the forces acting on tube 3 and/or the operation of filling device 15 and the filling of tube 3.

[0081] According to a preferred non-limiting embodiment, control unit 17 is also configured to control the auxiliary drive motor and main drive motor such that a free loop 38 of web 4 expands and/or advances, in use, between auxiliary drive roller 35 and main drive roller 33. With respect to the present invention, the term free loop 38 indicates that the portion of web 4 expanding and/or advancing between auxiliary drive roller 35 and main drive roller 33 is not subjected to any tension and defines and/or forms free loop 38.

[0082] Preferentially, control unit 17 is configured to control the auxiliary drive motor such that an angular speed of auxiliary drive roller 35 is such to control, in particular the extension of, free loop 38 expanding and/or advancing between auxiliary drive roller 35 and main drive roller 33.

[0083] In particular, in use, the angular speed of auxiliary drive roller 35 substantially controls the extension of the free loop 38, the angular speed of main drive roller 33 substantially controls the tension of tube 3.

[0084] According to a preferred non-limiting embodiment, packaging machine 1 further comprises a sterilization apparatus for sterilizing at least a portion of web 4, preferentially at least a first face, even more preferentially the first face and a second face, in particular by directing a sterilizing irradiation onto at least the first face while, in use, advancing along a sterilization portion of the web advancement path. Preferentially, the sterilization apparatus is configured for sterilizing said at least a portion of web 4 at a sterilization station, arranged upstream of tube forming station along web advancement path P. Preferentially, the sterilization station is in fluid connection with the isolation chamber 10.

[0085] In particular, irradiation device comprises at least a first irradiation emitter, in particular a first electron beam emitter, configured to direct the sterilizing irradiation, in particular the electromagnetic irradiation, even more particular the electron beam irradiation on the first face of web 4 of packaging material. Preferentially irradiation device also comprises a second irradiation emitter, in particular a second electron beam emitter, configured to direct the sterilizing irradiation, in particular the electromagnetic irradiation, even more particular the electron beam irradiation, in use, on the second face of web 4 of packaging material.

[0086] Preferably, the irradiation device is of the type described in patent documents EP3549878A1 and EP3549613A1, in the name of the present Applicant. It is expressly understood that all the functional and structural features of the apparatus of patent documents EP3549878A1 and EP3549613A1 can be applied to the irradiation device of the machine described herein.

[0087] According to a preferred non-limiting embodiment, packaging machine 1 further comprises a folding unit configured to receive the sealed packages 2 from the package forming unit 16 and for producing folded packages.

[0088] It should be noted that each package 2 produced by the package forming unit 16 (so called "pillow package") comprises a main portion, a first end portion and a second end portion arranged on respective opposite sides of said main portion; said first end portion comprising a first fin and a pair of first flaps projecting laterally from said main portion; and said second end portion comprising a second fin and a pair of second flaps projecting laterally from said main portion. In particular, first fin has a rectangular shape and projects from an (upper) transversal seal portion 66 and second fin has a rectangular shape and projects from another (lower) transversal seal portion 66. First end portion tapers from the main portion towards first fin, and second end portion tapers from main portion towards second fin. First flaps have a substantially triangular shape and project from opposite sides of first end portion, and second flaps have a substantially triangular shape and project from opposite sides of second end portion.

[0089] Folding unit substantially comprises:

- an endless conveyor for feeding packages 2 continuously along a folding path from a supply station to an output station;
- first folding means which cooperate cyclically with each package 2 to flatten first end portion, fold relative first fin onto first end portion, and bend first flaps onto main portion towards the second end portion;
- second folding means for flattening second end portion, folding second fin onto second end portion and folding second flaps onto the second fin.

[0090] Preferably, folding unit further comprises a heating device acting on bent first and second flaps to melt the external layer of the packaging material and seal the flaps before they are pressed against main portion and second fin, respectively.

[0091] Preferably, folding unit further comprises a pressing device cooperating with each package 2 to hold flaps onto flattened fin as flaps cool. Heating device is, in particular, arranged between folding means and pressure device along folding path.

[0092] In particular, heating device comprises: an assembly air device; a pair of first nozzles connected to the assembly air device and adapted to direct hot air onto first flaps of each package before each package 2 reaches pressing device; and a pair of second nozzles connected to the assembly air device and adapted to direct hot air onto second flaps of each package 2.

[0093] Preferably, the folding unit is of the type described in patent document EP3549613A1, in the name of the present Applicant. It is expressly understood that all the functional and structural features of the apparatus of patent document EP3549613A1 can be applied to the folding unit described herein.

[0094] According to a preferred non-limiting embodiment, packaging machine 1 (in particular, tube forming

device 13) further comprises a strip applicator, configured to apply a sealing strip onto the web of packaging material. The strip applicator comprises an advancement device configured to advance the sealing strip along a strip advancement path and towards and onto the web 4 of packaging material, before formation of tube 3. The strip applicator comprises a heat distribution device configured to direct a stream of heated gas (in particular, air) onto the web 4 and/or onto the sealing strip. The strip applicator comprises an application device configured to apply the sealing strip onto the web 4.

[0095] Preferably, the strip applicator is of the type described in patent document EP4137295A1, in the name of the present Applicant. It is expressly understood that all the functional and structural features of the apparatus of patent document EP4137295A1 can be applied to the folding unit described herein.

[0096] The control unit 17 is configured to control operation of the filling device 15 and of the package forming unit 16 and, preferably, of the pressurizing device 43. In particular, the control unit 17 is configured to control the filling device 15 and the package forming unit 16 and, preferably, the pressurizing device 43 so to define an operational phase and a stop phase. In particular, in the operational phase, the machine 1 produces the sealed packages 2 filled with the pourable product. In the stop phase, the machine 1 is stopped, so that it does not produce any package 2.

[0097] In the operational phase, the filling device 15 is in a respective active configuration in which it (continuously) fills the tube 3 with the pourable product.

[0098] Also, in the operational phase, package forming unit 16 is in a respective active configuration in which it forms and transversally seals the packages 2 from the advancing tube 3.

[0099] Preferably, in the operational phase, the pressurizing device 43 is in a respective active configuration in which it directs the flow of sterile gas into the second space 42 for obtaining the second gas pressure within the second space 42.

[0100] In the stop phase, the filling device 15 is in a respective inactive configuration in which it does not fill the tube 3 with the pourable product.

[0101] Also, in the stop phase, the package forming unit 16 is in an inactive configuration in which it does not form and transversally seal the packages 2 from the advancing tube 3. Preferably, in the stop phase, the pressurizing device 43 is in the respective active configuration for maintaining an overpressure within the second space 42.

[0102] In particular, the filling device comprises a filling valve being coupled to the filling pipe 27 and being operable in an open position in which it allows the pourable product to flow through the filling pipe 27 (in particular, through the outlet of the lower section 30) and in a closed position in which it prevents the pourable product from flowing through the filling pipe 27 (in particular, through the outlet of the lower section 30). The control unit 17 is configured to control the filling valve for switching the filling device 15 in the respective active configuration and or in the respective inactive configuration.

[0103] According to the present disclosure, the control unit 17 is configured to control the filling device 15 and the package forming unit 16 and, preferably, the pressurizing device 43 such to define a transient phase. In particular, the transient phase is after the operational phase and before the stop phase. Hence, the transient phase occurs just before the machine is stopped.

[0104] In the transient phase, the filling device 15 is in the respective inactive configuration.

[0105] Also, in the transient phase, the package forming unit 16 is in the respective active configuration.

[0106] Preferably, in the transient phase, the pressurizing device 43 is in the respective active configuration.

[0107] In the transient phase, before the machine 1 is stopped, the filling device is inactive while the machine continues to produce packages. In such a way, it is possible to empty the tube 3 from the pourable product during the transient phase. Emptying the tube is particularly advantageous to prevent contaminations from the external environment during the subsequent stop phase. In particular, emptying the tube allows to also empty the filling pipe such that it is not exposed to negative pressures during the subsequent stop phases.

[0108] Also, in the transient phase, the tube 3 is filled with pressurized sterile gas coming from the pressurizing device 43, which allows to maintain the design in control despite the tube being emptied (as the pressurized sterile gas provides to the tube and packages the same internal pressure that the pourable product provides during operational phase). In particular, with expression "maintain the design in control", it is here meant that the crease pattern provided on the packaging material is maintained in alignment with the package forming unit.

[0109] In particular, in the transient the machine 1 produces packages that are in part filled with pressurized sterile gas and, possibly, in part filled with the residual pourable product. In such a way, in the subsequent stop phase, the tube 3 remains at a pressure higher than ambient pressure, so to prevent possible contaminations of the tube 3. Also, during the stop phase, the pressurizing device 43 is preferably kept in the active configuration so to ensure that the second space 42 is maintained at an overpressure with respect to the first space 41. Hence, during the stop phase, the outlet opening of the lower section 30 of the filling pipe 27 remains at a pressure higher than ambient pressure, and contaminations of the filling pipe 27 during the stop phase are prevented.

[0110] According to an aspect of the present disclosure, the package forming unit 16 is configured to release the sealed packages 2 according to a release speed. The control unit 17 is configured to control the package forming unit 16 such that in the transient phase the release speed decreases from an operational release speed to zero.

[0111] It is noted that during the operational phase, the

release speed is the operational release speed. In the stop phase the release speed is zero.

[0112] Also, the conveying device 5 is configured to advance the web 4 of packaging material according to a web advancement speed. The control unit 17 is configured to control the conveying device 5 such that in the transient phase the web advancement speed decreases from an operational web advancement speed to zero.

[0113] It is noted that during the operational phase, the web advancement speed is the operational web advancement speed. In the stop phase the web advancement speed is zero.

[0114] Also, the conveying device 5 and/or the tube forming device 13 and/or the package forming unit 16 are configured to advance the tube 3 according to a tube advancement speed. The control unit 17 is configured to control the conveying device 5 and/or the tube forming device 13 and/or the package forming unit 16 such that in the transient phase the tube advancement speed decreases from an operational tube advancement speed to zero.

[0115] It is noted that during the operational phase, the tube advancement speed is the operational tube advancement speed. In the stop phase the tube advancement speed is zero.

[0116] It is noted that the release speed, the web advancement speed and the tube advancement speed are substantially equal to each other. Hence, in the transient phase, the release speed, the web advancement speed and the tube advancement speed are simultaneously decreased to zero.

[0117] In fact, the control unit 17 is configured to control the conveying device 5 such that the tube advancement speed along the tube advancement path Q and/or the web advancement speed along the advancement path P substantially equal the release speed of the packages 2.

[0118] Preferably, the control unit 17 is configured to control the rotational speed of the compressor of the pressurizing device 43 as a function of the release speed and/or the tube advancement speed and/or the web advancement speed. In particular, in the operational phase the compressor operates at an operational rotational speed. In the transient phase the compressor has a rotational speed that decreases from the operational rotational speed to a base rotational speed. In the stop phase the compressor operates at the base rotational speed. Preferably, the base rotational speed is different, in particular greater, than zero.

[0119] Preferably, the control unit 17 is configured to control the package forming unit 16 and, preferably, the pressurizing device 43 such that the transient phase includes a first transient subphase and a second transient subphase, being after the first transient subphase. In particular, the transient phase consists in the first transient subphase and second transient subphase.

[0120] In the first transient subphase, the release speed equals the operational release speed. Also, in the first transient subphase, the web advancement speed equals the operational advancement speed and/or the tube advancement speed equals the operational tube advancement speed.

[0121] In the second transient subphase, the release speed decreases from the operational release speed to zero. Also, in the second transient subphase, the web advancement speed decreases from the operational advancement speed to zero and/or the tube advancement speed decreases from the operational tube advancement speed to zero.

[0122] Preferably, the control unit 17 is further configured to control the pressurizing device 43 such that in the first transient subphase the rotational speed of the compressor substantially equals the operational rotational speed, and in the second transient subphase the speed of the compressor gradually decreases from the operational rotational speed to the base rotational speed.

[0123] Figure 3 schematically illustrates such behavior. In particular, Figure 3 illustrates the trend over time of:

- second gas pressure P within the second space 42;
- pourable product flow F, flowing out of filling device 15;
- release speed S of sealed packages released by the package forming unit 16.

[0124] From time t_0 to time t_1, the machine 1 is in the operational phase. In such operational phase, the package forming unit 16 is in the active configuration, and the packages 2 are released according to the operational release speed. Also, in such operational phase, the second gas pressure P within the second space 42 is substantially constant, due to the compressor operating at the operational rotational speed. Also, in such operational phase, the flow F of pourable product flowing out of filling device 15 is substantially constant, due to the filling device 15 being in the active configuration.

[0125] At time t_1 the filling device 15 is switched to the inactive configuration. As a consequence, the tube 3 starts to empty. Also the filling pipe 27 starts to empty.

[0126] From time t_1 to time t_2, the machine 1 is in the first transient subphase. In such first transient subphase, the package forming unit 16 is still in the active configuration, and the packages 2 are still released according to the operational release speed. However, in such first transient subphase, the flow F of pourable product flowing out of filling device 15 rapidly decreases to zero, due to the filling device 15 having been switched to the inactive configuration. Moroever, in such in such first transient subphase, the second gas pressure P within the second space 42 remains approximately at the same level as in the operational phase, due to the compressor operating at the operational rotational speed. However, such second gas pressure P within the second space 42 may undergo fluctuations due to the emptying of the tube 3.

[0127] At time t_2, the emptying of tube 3 and filling pipe 27 is complete. Time t_2 is defined as the moment when

the tube 3 and the filling pipe 27 are completely emptied: in such a moment, the second transient phase begins.

[0128] From time t_2 to time t_3, the machine 1 is in the second transient subphase. In such second transient subphase, the release speed of the packages 2 and the tube advancement speed and the web advancement speed are gradually reduced until zero. Moreover, the operational speed of the compressor is reduced to the base rotational speed. As a consequence, during the second transient subphase, the second gas pressure P within the second space 42 decreases.

[0129] After time t_3, the machine is in the stop phase. During the stop phase, the second gas pressure P within the second space 42 remains stable (i.e. substantially constant), due to the pressurizing device still being active, in particular operating at the base rotational speed. So, the second gas pressure P within the second space 42 remains (slightly) above ambient pressure during the stop phase. In such a way, contaminations of the second space 42 and/or filling pipe 27 during the stop phase are prevented.

[0130] Preferably, the control unit 17 is configured to control the sealing device such that:

- in the operational phase the sealing device is in a respective active configuration in which it longitudinally seals the tube 3 formed by the tube forming device;
- in the stop phase the sealing device is in a respective inactive configuration in which it does not longitudinally seal the tube 3 formed by the tube forming device;
- in the transient phase the sealing device is in the respective active configuration.

[0131] In particular, during the first transient subphase, a sealing power delivered by the sealing head remains substantially constant, equating an operational sealing power it had during the operational phase. Then, during the second transient subphase the sealing power delivered by the sealing head decreases from the operational sealing power to zero.

[0132] Preferably, the control unit 17 is configured to control the sterilization apparatus such that:

- in the operational phase the sterilization apparatus is in a respective active configuration in which the sterilization apparatus directs the sterilizing irradiation onto at least the first face of packaging material;
- in the stop phase the sterilization apparatus is in a respective inactive configuration in which the sterilization apparatus does not direct the sterilizing irradiation onto at least the first face of packaging material;
- in the transient phase the sterilization apparatus is in the respective active configuration.

[0133] In particular, during the first transient subphase, an irradiation power delivered by the sterilizing irradiation remains substantially constant, equating an operational irradiation power it had during the operational phase. Then, during the second transient subphase the irradiation power delivered by the sterilizing irradiation decreases from the operational irradiation power to zero.

[0134] Preferably, the control unit 17 is further configured to control folding unit such that:

- in the operational phase the folding unit is in a respective active configuration in which the folding means perform at least one folding operation on the package 2;
- in the stop phase the folding unit is in a respective inactive configuration in which the folding means do not perform at least one folding operation on the package 2;
- in the transient phase the folding unit is in the respective active configuration.

[0135] In particular, during the first transient subphase, a speed of the endless conveyor of the folding unit remains substantially constant, equating an operational endless conveyor speed it had during the operational phase. Then, during the second transient subphase the speed of the endless conveyor of the folding unit decreases from the operational endless conveyor speed to zero.

[0136] Also, during the first transient subphase, a heating power delivered by the heating device of the folding unit remains substantially constant, equating an operational heating power it had during the operational phase. Then, during the second transient subphase the heating power delivered by the heating device of the folding unit decreases from the operational heating power to zero.

[0137] Preferably, the control unit 17 is further configured to control the strip applicator such that:

- in the operational phase the strip applicator is in a respective active configuration in which it applies the sealing strip onto the web 3 of packaging material;
- in the stop phase the strip applicator is in a respective inactive configuration in which it does not apply the sealing strip onto the web 3 of packaging material;
- in the transient phase the strip applicator is in the respective active configuration.

[0138] In particular, during the first transient subphase, a heating power delivered by the heat distribution device of the strip applicator remains substantially constant, equating an operational strip applicator heating power it had during the operational phase. Then, during the second transient subphase the heating power delivered by the heat distribution device of the strip applicator decreases from the operational strip applicator heating power to zero.

[0139] So, during the transient phase, before the machine 1 is stopped, the sealing device and/or the sterilization apparatus and/or the folding unit and/or the strip

applicator are still active so that the tube forming device 13 continues to form the tube 3 and the package forming unit 16 continues to produce sealed packages 2, while the tube 3 is being emptied as explained above. This configuration, in conjunction with the configuration of the package forming unit 16 detailed above, allows to use the sealed packages 2 that are produced to collect the residual pourable product in the tube 3 and discharge it.

[0140] According to an aspect of the present disclosure, the transient phase lasts at least 3 seconds and less than 25 seconds, in particular at least 5 seconds and less than 20 seconds, in even more particular at least 5 seconds and less than 15 seconds.

[0141] Preferably, the first transient subphase lasts at least 2 seconds and less than 20 seconds, in particular at least 3 seconds and less than 10 seconds. The second transient subphase lasts at least 1 second and less than 5 seconds, in particular less than 3 seconds.

[0142] The present disclosure also provides a method for forming a plurality of sealed packages 2 filled with a pourable product. Preferably, the method is carried out by the machine 1 which is the object of the present disclosure.

[0143] The method includes (in particular, during an operational phase) a step of advancing a web 4 of packaging material along a web advancement path P, through a conveying device 5.

[0144] The method includes (in particular, during the operational phase) a step of forming a tube 3 from the advancing web 4 of packaging material, through a tube forming device 13 extending along a longitudinal axis and being at least partially arranged within an inner environment 11 of an isolation chamber 10 containing a sterile gas.

[0145] The method includes (in particular, during the operational phase) a step of advancing the tube 3 along a tube advancement path Q. A delimiting element 40 is arranged within the tube and divides the tube 3 in a first space 41 being in fluidic connection with the inner environment 11 and a second space 42 being arranged downstream of the first space 41 along the tube advancement path Q.

[0146] The method includes (in particular, during the operational phase) a step of directing a variable flow of sterile gas into the second space 42, through a pressurizing device, for obtaining a second gas pressure within the second space 42, said second gas pressure being higher than a first gas pressure within the first space 41.

[0147] The method includes (in particular, during the operational phase) a step of longitudinally sealing the tube formed by the tube forming device 13, through a sealing device being at least partially arranged within the inner environment 11 of the isolation chamber 10.

[0148] The method includes (in particular, during the operational phase) a step of (continuously) filling the tube 3 with a pourable product, through a filling device 15.

[0149] The method includes a step of forming and transversally sealing (and cutting) the packages 2 from the advancing tube 3, through a package forming unit 16.

[0150] The method includes (in particular, during the operational phase) a step of controlling the tension of the web 4 of packaging material and/or of the tube 3, through a tensioning device 32.

[0151] In particular, the method includes the operational phase during which the filling device 15 is in a respective active configuration in which it (continuously) fills the tube 3 with the pourable product, and the package forming unit 16 is in a respective active configuration in which it forms and transversally seal the packages 2 from the advancing tube 3.

[0152] Also, during the operational phase the pressurizing device 43 is in an active configuration in which it directs the flow of sterile gas into the second space 42.

[0153] The method includes a stop phase during which the filling device 15 is in a respective inactive configuration in which it does not fill the tube 3 with the pourable product, and the package forming unit 16 is in a respective inactive configuration in which it does not form and transversally seal the packages 2 from the advancing tube 3.

[0154] Also, during the stop phase, the pressurizing device 43 is still in the active configuration in which it directs the flow of sterile gas into the second space 42. However, a rotational speed of the compressor of the pressurizing device 43 during the stop phase is lower than during the operational phase. As a consequence, the flow of sterile gas into the second space 42 during the stop phase is lower than during the operational phase.

[0155] Furthermore, during the stop phase, the conveying device 5 and/or the forming device 13 (in particular, the strip applicator) and/or the sealing device and/or the package forming unit 16 and/or the tensioning device 32 and/or the sterilization apparatus and/or the folding unit are in respective inactive configurations.

[0156] According to the present disclosure, the method includes a transient phase, during which the filling device 15 is in the respective inactive configuration and the package forming unit 16 is in the respective active configuration. Also, during the transient phase, the pressurizing device 43 is in the respective active configuration. The transient phase is after the operational phase and before the stop phase.

[0157] Preferably, the transient phase includes (or consists in) a first transient subphase and a second transient subphase, being after the first transient subphase.

[0158] Preferably, in the transient phase (in particular, in the second transient subphase) a release speed of the sealed packages 2 and/or an advancement speed of the tube 3 and/or an advancement speed of the web 4 of packaging material decreases to zero. Also, in the transient phase (in particular, in the second transient subphase) a rotational speed of a compressor of the pressurizing device 43 decreases from an operational rotational speed to a base rotational speed, in particular being greater than zero.

[0159] The advantages of the machine 1 according to

the present invention will be clear from the foregoing description.

[0160] During the operational phase the machine 1 produces sealed packages 2 sealed with the pourable product.

[0161] During the transient phase the tube 3 is being emptied from the pourable product and filled with sterile gas; so, the machine 1 produces packages that are at least in part filled with the sterile gas and, possibly, partly filled with the pourable product. Said transient phase serves to prepare the machine 1 and the tube 3 to the subsequent stop phase: in particular, as explained above, the tube 3 is emptied from residual pourable product and filled with pressurized gas, so that during the stop phase the tube 3 and the filling pipe 27 remain at pressures higher than ambient pressure and contaminations are prevented.

[0162] During the stop phase the machine 1 does not produce any package 2. Also, the pressure within the tube 3 is reduced during said stop phase due to the pressurizing device 43 working at the base rotational speed. However, said pressure within the tube 3 remains higher than ambient pressure, i.e. 0.01 bar above ambient pressure, due to the base rotational speed being greater than zero.

Claims

1. A packaging machine (1) for forming a plurality of sealed packages (2) filled with a pourable product, comprising:

- a conveying device (5), configured to advance a web (4) of packaging material along an advancement path (P);
- an isolation chamber (10) separating an inner environment (11) containing a sterile gas from an outer environment (12);
- a tube forming device (13) extending along a longitudinal axis, being at least partially arranged within the isolation chamber (10) and being configured to form a tube (3) from the, in use, advancing web (4) of packaging material;
- a delimiting element (40) arranged, in use, within the tube (3) and designed to divide the tube (3) in a first space (41) being in fluidic connection with the inner environment (11) and a second space (42) being arranged downstream of the first space (41) along the tube advancement path;
- a pressurizing device (43) configured to direct, in use, a flow of sterile gas into the second space (42) for obtaining a second gas pressure within the second space (42) that is higher than a first gas pressure within the first space (41);
- a sealing device, being at least partially arranged within the isolation chamber and being configured to longitudinally seal the tube formed by the tube forming device;
- a filling device (15) configured to continuously fill the tube (3) with the pourable product, wherein the filling device (15) is configured to direct the pourable product into the second space (42);
- a package forming unit (16) configured to form and transversally seal the packages (2) from the, in use, advancing tube (3);
- a control unit (17) configured to control operation of the packaging machine (1);

wherein the control unit (17) is configured to control the filling device (15) and the package forming unit (16) such that:

- in an operational phase, the filling device (15) is in a respective active configuration in which it fills the tube (3) with the pourable product, and the package forming unit (16) is in an active configuration in which it forms and transversally seals the advancing tube (3);
- in a stop phase, the filling device (15) is in a respective inactive configuration in which it does not fill the tube (3) with the pourable product, and the package forming unit (16) is in an inactive configuration in which it does not form and transversally seal the advancing tube (3);

characterized in that the control unit (17) is further configured to control the filling device (15) and the package forming unit (16) such that:
in a transient phase, being after the operational phase and before the stop phase, the filling device (15) is in the respective inactive configuration and the package forming unit (16) is in the respective active configuration.

2. The packaging machine (1) according to claim 1 wherein the package forming unit (16) is configured to release the sealed packages (2) according to a release speed, and wherein the control unit (17) is configured to control the package forming unit (16) such that in the transient phase the release speed decreases from an operational release speed to zero.

3. The packaging machine (1) according to claim 2, wherein the control unit (17) is configured to control the package forming unit (16) such that the transient phase includes a first transient subphase and a second transient subphase, being after the first transient subphase, wherein:

- in the first transient subphase the release speed equals the operational release speed;
- in the second transient subphase the release speed decreases from the operational release

speed to zero.

4. The packaging machine (1) according to any one of the previous claims, wherein the pressurizing device (43) comprises a compressor adapted to withdraw sterile gas from inner environment (11), to compress the sterile gas and to direct the pressurized sterile gas into the second space (42) wherein the control unit (17) is configured to control the pressurizing device (43) such that

- in the operational phase the compressor operates at an operational rotational speed;
- in the transient phase the compressor has a rotational speed that decreases from the operational rotational speed to a base rotational speed;
- in the stop phase the compressor operates at the base rotational speed;

wherein said base rotational speed is greater than zero.

5. The packaging machine (1) according to claim 3 or 4, wherein the control unit (17) is configured to control the pressurizing device (43) such that the transient phase includes a first transient subphase and a second transient subphase, being after the first transient subphase, wherein:

- in the first transient subphase the rotational speed of the compressor substantially equals the operational rotational speed;
- in the second transient subphase the speed of the compressor gradually decreases from the operational rotational speed to the base rotational speed.

6. The packaging machine (1) according to claim 5, wherein the control unit (17) is configured to control the package forming unit (16) and/or the conveying device (5) such that an advancement speed of the tube (3) along the tube advancement path (Q) substantially equals an operational advancement speed in the first transient subphase, and gradually decreases from the operational advancement speed to zero during the second transient subphase.

7. The packaging machine (1) according to claim 5 or 6, wherein in the second transient subphase the control unit (17) is configured to control the conveying device (5) such that an advancement speed of the web (4) of packaging material and/or of the tube (3) decreases to zero.

8. The packaging machine (1) according to any one of the previous claims, wherein the control unit (17) is configured to control the conveying device (5) such that:

- in the operational phase the conveying device (5) is in a respective active configuration in which it advances the web (4) of packaging material along the advancement path (P) ;
- in the stop phase the conveying device (5) is in a respective inactive configuration in which it does not advance the web (4) of packaging material along the advancement path (P);
- in the transient phase the conveying device (5) is in the active configuration.

9. The packaging machine (1) according to any one of the previous claims, wherein the control unit (17) is configured to control the sealing device such that:

- in the operational phase the sealing device is in a respective active configuration in which it longitudinally seals the tube (3);
- in the stop phase the sealing device is in a respective inactive configuration in which it does not longitudinally seal the tube (3);
- in the transient phase the sealing device is in the respective active configuration.

10. The packaging machine (1) according to any one of the previous claims, comprising a sterilization apparatus having an irradiation device configured to sterilize at least a first face of the advancing web (4) of packaging material by directing a sterilizing irradiation onto at least the first face while, in use, advancing along a sterilization portion of the web advancement path,
wherein the control unit (17) is configured to control the sterilization apparatus such that:

- in the operational phase the sterilization apparatus is in a respective active configuration in which the sterilization apparatus directs the sterilizing irradiation onto at least the first face of the web (4) of packaging material;
- in the stop phase the sterilization apparatus is in a respective inactive configuration in the sterilization apparatus does not direct the sterilizing irradiation onto at least the first face of the web (4) of packaging material;
- in the transient phase the sterilization apparatus is in the respective active configuration.

11. The packaging machine (1) according to any one of the previous claims, further comprising a folding unit configured to receive the sealed packages (2) from the package forming unit (16) and for producing folded packages, wherein the folding unit comprises an endless conveyor for feeding packages (2) continuously along a folding path from a supply station to an output station, and folding means which cooper-

ate, in use, with each package (2) to perform at least one folding operation on said package, wherein the control unit (17) is configured to control the folding unit such that:

- in the operational phase the folding unit is in a respective active configuration in which the folding means perform said at least one folding operation on said package (2) ;
- in the stop phase the folding unit is in a respective inactive configuration in which the folding means do not perform said at least one folding operation on said package (2) ;
- in the transient phase the folding unit is in the respective active configuration.

12. The packaging machine (1) according to any one of the previous claims, wherein the transient phase lasts at least 5 seconds and less than 20 seconds.

13. The packaging machine (1) according to any one of the previous claims, wherein the filling device comprises a filling pipe (27) and a filling valve being coupled to the filling pipe (27) and being operable in an open position in which it allows the pourable product to flow through the filling pipe (27) and in a closed position in which it prevents the pourable product from flowing through the filling pipe (27), wherein the control unit (17) is configured to control the filling valve for switching the filling device (15) in the respective active configuration and the respective inactive configuration.

14. A method for forming a plurality of sealed packages (2) filled with a pourable product, the method comprising the following steps:

- advancing a web (4) of packaging material along a web advancement path (P), through a conveying device (5);
- forming a tube (3) from the advancing web (4) of packaging material, through a tube forming device (13) extending along a longitudinal axis and being at least partially arranged within an inner environment (11) of an isolation chamber (10) containing a sterile gas;
- advancing the tube (3) along a tube advancement path (Q) ;

wherein a delimiting element (40) is arranged within the tube and divides the tube in a first space (41) being in fluidic connection with the inner environment (11) and a second space (42) being arranged downstream of the first space (41) along the tube advancement path (Q);

- directing a variable flow of sterile gas into the second space (42), through a pressurizing device, for obtaining a second gas pressure within the second space (42), said second gas pressure being higher than a first gas pressure within the first space (41);
- longitudinally sealing the tube formed by the tube forming device (13), through a sealing device being at least partially arranged within the inner environment (11) of the isolation chamber (10);
- continuously filling the tube (3) with a pourable product, through a filling device (15);
- form and transversally seal the packages (2) from the advancing tube (3), through a package forming unit (16);

wherein the method includes:

- an operational phase during which the filling device (15) is in a respective active configuration in which it fills the tube (3) with the pourable product, and the package forming unit (16) is in an active configuration in which it forms and transversally seals the advancing tube (3);
- a stop phase during which the filling device (15) is in a respective inactive configuration in which it does not fill the tube (3) with the pourable product, and the package forming unit (16) is in an inactive configuration in which it does not form and transversally seal the advancing tube (3) ;

characterized in that the method includes a transient phase, being after the operational phase and before the stop phase, during which the filling device (15) is in the respective inactive configuration and the package forming unit (16) is in the respective active configuration.

15. The method according to claim 14, wherein in the transient phase a release speed of the sealed packages (2) and/or an advancement speed of the tube (3) and/or an advancement speed of the web (4) of packaging material decreases to zero,
and a rotational speed of a compressor of the pressurizing device (43) decreases from an operational rotational speed to a base rotational speed, in particular being greater than zero.

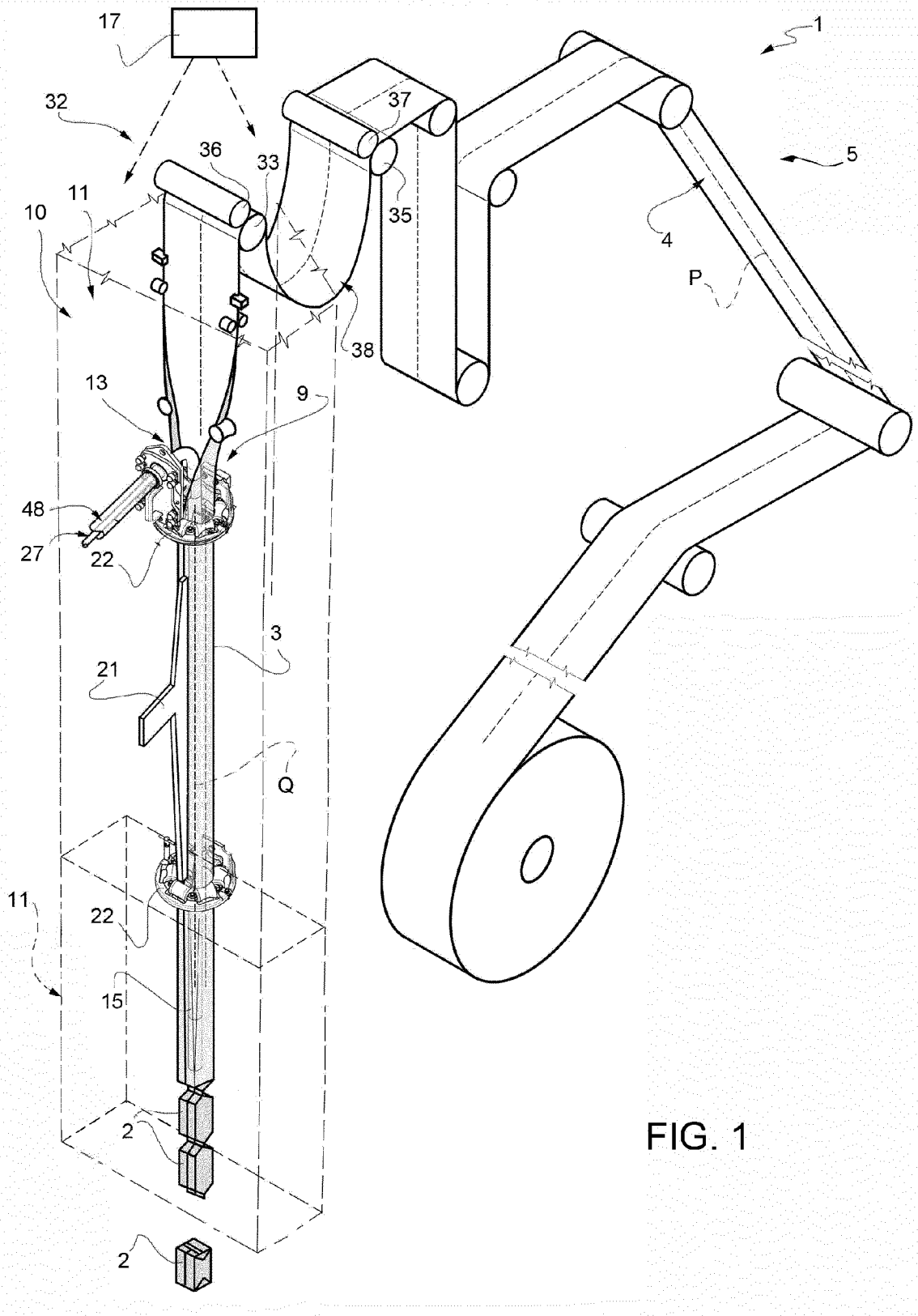

FIG. 1

FIG. 2

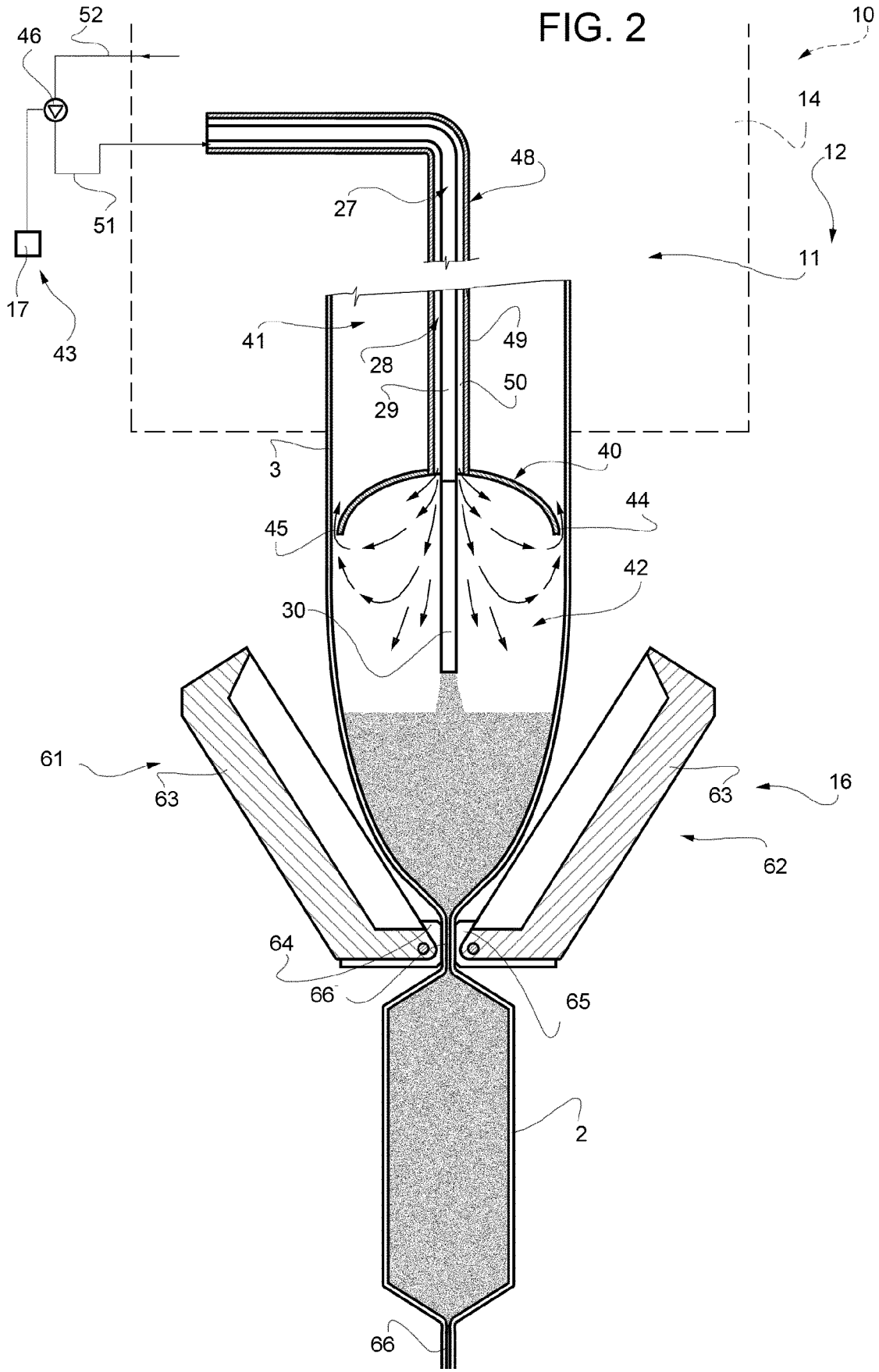
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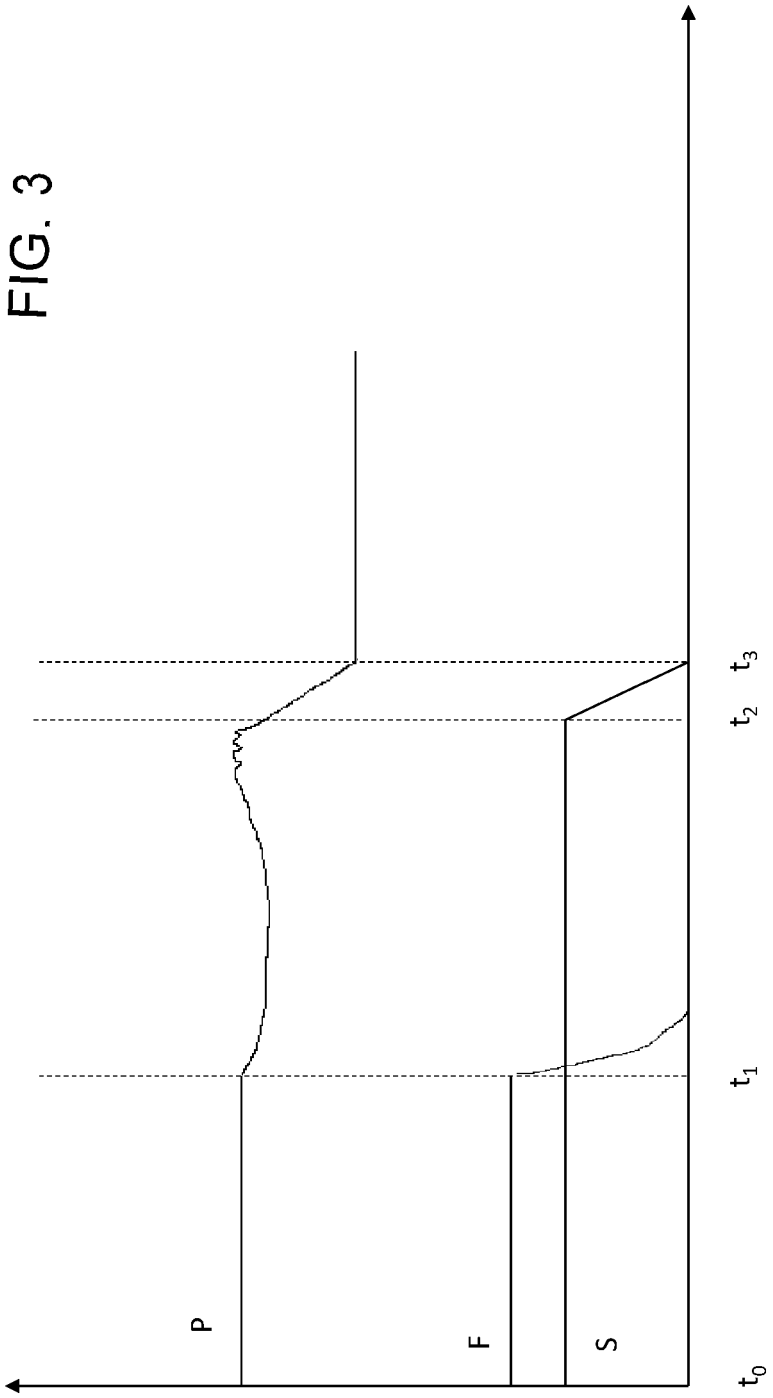
FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 24 17 5087

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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B65B

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Place of search	Date of completion of the search	Examiner
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