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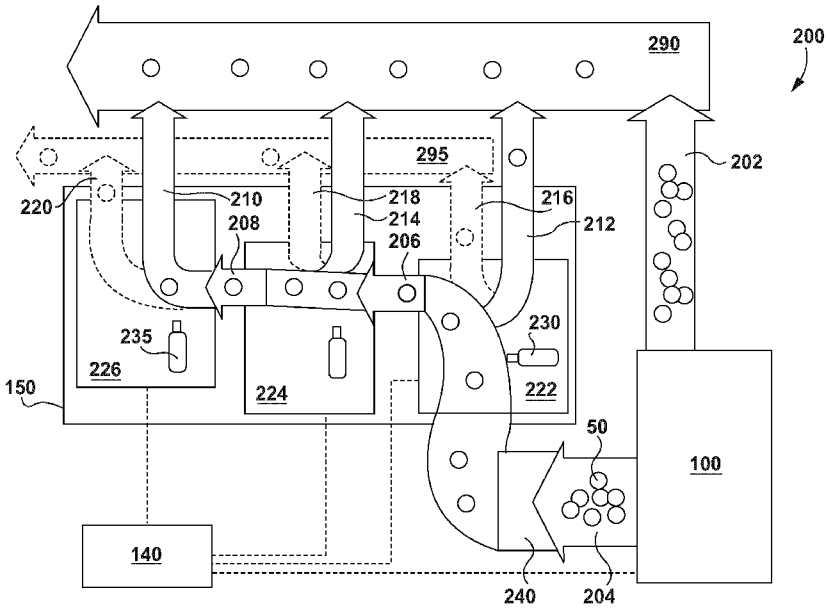


FIG. 3

(57) Abstract: A molding system comprises an inspection apparatus. The molding system comprises a molding machine for producing multilayer preforms having a core layer and a skin layer enveloping the core layer, a triage device configured to determine, for a portion of the multilayer preforms, at least one preform parameter, and to select at least one preform for inspection based at least in part on the preform parameter; and an inspection device configured to receive the selected multilayer preforms and to determine at least one attribute of the at least one of the plurality of multilayer preforms.

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MOLDING SYSTEM AND METHOD OF INSPECTING MULTILAYER PREFORMS

FIELD OF THE TECHNOLOGY

The present technology relates to a molding system and methods for using the molding system. More specifically the present technology relates to an injection molding system for producing and inspecting multilayer preforms, and a method of inspecting multilayer preforms, the injection molding system including at least a triage device and an inspection device.

BACKGROUND

Molding is a process by virtue of which a molded article can be formed from molding material by using a molding system. Various molded articles can be formed by using the molding process, such as an injection molding process. One example of a molded article that can be formed, for example, from polyethylene terephthalate (PET) material is a preform that is capable of being subsequently blown into a beverage container, such as, a bottle and the like.

Broadly speaking, the cost of producing a molded article is made up of the capital cost of the molding system itself, the cost of resin, and other overheads (electricity, water supply, labour costs, etc.). In order to garner the most profitability from the system, the molding system should be running as much as possible, and at full capacity. To extend the life of the molding system, regular inspection is important. One manner of inspecting machine is inspecting the preforms produced by the machine.

In order to minimize downtime, inspection should not impede operation of the molding system, and inspection of the molded articles should take place with a minimum of delay from when they are molded, to intercept issues as quickly as possible.

For multilayer preforms, where there are multiple layers of molded material together, has additional inspection challenges are presented. Inspection by hand of the different layers, as is commonly done in the art, is both time-consuming and difficult.

SUMMARY

It is an object of the present invention to ameliorate at least some of the inconveniences present in the prior art.

According to a first broad aspect of the present technology, there is provided a molding system, comprising a molding machine for producing a plurality of multilayer preforms, each of the plurality of multilayer preforms comprising a core layer and a skin layer enveloping the core layer; a triage device operatively connected to the molding machine, the triage device configured to receive at least a portion of the plurality of multilayer preforms from the molding machine, the triage device configured to determine, for each one of the at least the portion of the plurality of multilayer preforms, at least one preform parameter, and select at least one of the plurality of multilayer preforms for inspection based at least in part on the at least one preform parameter; and at least one inspection device operatively connected to the triage device, the at least one inspection device configured to receive the at least one of the plurality of multilayer preforms from the triage device, and to determine at least one attribute of the at least one of the plurality of multilayer preforms.

In some embodiments of the molding system, the system further comprises at least one conveyance device, the at least one conveyance device configured to transport a remainder of the plurality of multilayer preforms not having been selected by the triage device away from the molding machine.

In some embodiments of the molding system, the system further comprises a black speck inspection device configured to identify if a given preform of the plurality of multilayer preforms has a black speck defect, the molding system being configured to send the given preform to a rejection path if the given preform has the black speck defect.

In some embodiments of the molding system, the triage device comprises a machine vision device that is configured to determine the at least one preform parameter.

In some embodiments of the molding system, the system further comprises a singulator device for aligning and orienting the plurality of multilayer preforms; and wherein the singulator device is configured to create an order of the plurality of multilayer preforms prior to the triage device determining the at least one preform parameter; and the triage device is further configured to record the at least one preform parameter of each preform of the plurality of multilayer preforms according to the order.

In some embodiments of the molding system, the system further comprises a computer-implemented apparatus operatively connected to the triage device and the at least one inspection device; and wherein the triage device is configured to transmit the at least one preform parameter of the at least one of the plurality of multilayer preforms to the computer-implemented

apparatus; the at least one inspection device is configured to transmit the at least one attribute of the at least one of the plurality of multilayer preforms; the computer-implemented apparatus is further configured to correlate the at least one preform parameter of the at least one of the plurality of multilayer preforms with the at least one attribute.

In some embodiments of the molding system, the computer-implemented apparatus is further configured to determine if the at least one attribute falls outside a pre-determined range; and generate an alert for an operator that the at least one attribute falls outside the pre-determined range.

In some embodiments of the molding system, the computer-implemented apparatus is further configured to determine if the at least one attribute falls outside a pre-determined range; and adjust at least one operational setting of the molding system, based at least in part on the at least one attribute.

In some embodiments of the molding system, the at least one preform parameter is a cavity identification number, the cavity identification number being imprinted on each one of the plurality of multilayer preforms.

In some embodiments of the molding system, the at least one inspection device comprises a first inspection device and a second inspection device.

In some embodiments of the molding system, the at least one inspection device comprises an optical coherence tomography device for measuring a three-dimensional extent of the core layer; and the optical coherence tomography device is configured to determine a plurality of characteristics of the at least one of the plurality of multilayer preforms conveyed from the triage device, the plurality of characteristics including at least one characteristic of the core layer of the at least one of the plurality of multilayer preforms.

In some embodiments of the molding system, the optical coherence tomography device is configured to measure a three dimensional extent of the core layer of the at least one of the plurality of multilayer preforms conveyed from the triage device.

In some embodiments of the molding system, the optical coherence tomography device determines at least one of a thickness of the core layer, a volume of the core layer, a weight of the core layer, an extent of core layer coverage, presence of the core layer at an angle of a dome portion, an average core layer thickness around a circumference, a location of a leading edge of the core layer, and a location of a trailing edge of the core layer.

In some embodiments of the molding system, the at least one inspection device comprises at least one of an inspection device configured to determine a transparency parameter of the at least one of the plurality of multilayer preforms conveyed from the triage device; an inspection device configured to determine a weight of the at least one of the plurality of multilayer preforms conveyed from the triage device; and an inspection device configured to determine a color spectrum parameter of the at least one of the plurality of multilayer preforms conveyed from the triage device.

In some embodiments of the molding system, the preform parameter is related to a cavity of origin in the molding machine.

In some embodiments of the molding system, the at least one preform parameter is a coarse inspection parameter; and if the at least one attribute falls outside a pre-determined range, the triage device is further configured to select the at least one of the plurality of multilayer preforms for inspection based at least in part on the coarse inspection parameter.

In some embodiments of the molding system, the plurality of multilayer preforms comprises a plurality of shot groups, each shot group being a group of multilayer preforms produced during a single molding cycle; and the triage device is further configured to select a given shot group of the plurality of shot groups.

In some embodiments of the molding system, the plurality of multilayer preforms comprises a pre-determined group of multilayer preforms; and the triage device is further configured to select the pre-determined group from the plurality of multilayer preforms.

In some embodiments of the molding system, the triage device is further configured to select the pre-determined group every n^{th} cycles, the n^{th} cycles cycle being a pre-determined value.

In some embodiments of the molding system, the triage device is further configured to receive an instruction from an operator; and the triage device is configured to select the pre-determined group based at least in part on the instruction.

In some embodiments of the molding system, the molding machine is an injection molding machine.

According to another broad aspect of the present technology, there is provided a method of inspecting multilayer preforms by an molding apparatus, the molding apparatus comprising a triage device and at least one inspection device, the at least one inspection device being

operatively connected to the triage device by at least one conveyance device, the method comprising receiving a plurality of multilayer preforms at the triage device; determining, by the triage device, at least one preform parameter for each one of the plurality of multilayer preforms; selecting at least one of the plurality of multilayer preforms based at least in part on the at least one preform parameter; transporting, by the at least one conveyance device, the at least one of the plurality of multilayer preforms to the at least one inspection device; and determining, by the at least one inspection device, at least one attribute of the at least one multilayer preform.

In some embodiments of the method, the at least one preform parameter is a cavity identification number; and wherein the determining the at least one preform parameter for each one of the plurality of multilayer preforms comprises reading, by a machine vision device, the cavity identification number on the each one of the plurality of multilayer preforms; the selecting the at least one of the plurality of multilayer preforms comprises selecting a subgroup of the plurality of multilayer preforms; the transporting the at least one of the plurality of multilayer preforms comprises transporting the subgroup to the at least one inspection device; and wherein the method further comprises transporting a remainder of the plurality of multilayer preforms to a production path, the production path including at least one conveyance device for transporting the remainder of the plurality of multilayer preforms.

In some embodiments of the method, the plurality of multilayer preforms comprises a plurality of shot groups, each shot group being a group of multilayer preforms produced during a single molding cycle; and the selecting the subgroup comprises selecting a given shot group of the plurality of shot groups.

In some embodiments of the method, the given shot group is selected every n^{th} cycles, the n^{th} cycles cycle being a pre-determined value.

In some embodiments of the method, the selecting the subgroup comprises selecting a plurality of multilayer preforms having a same cavity identification number.

In some embodiments of the method, the selecting the subgroup comprises selecting a first subgroup having a first set of cavity identification numbers, the first subgroup being selected from multilayer preforms produced in a first molding cycle; selecting a second subgroup having a second set of cavity identification numbers, the second set of cavity identification numbers being different from the first set, the second subgroup being selected from multilayer preforms produced in a second molding cycle.

In some embodiments of the method, the method further comprises orienting, by a singulator device, the plurality of multilayer preforms, the singulator device creating an order of the plurality of multilayer preforms before the determining of the at least one preform parameter by the triage device; and recording, by the triage device, the at least one preform parameter of each preform of the plurality of multilayer preforms according to the order.

In some embodiments of the method, the at least one inspection device comprises an optical coherence tomography device; and the determining the at least one attribute of the at least one multilayer preform comprises determining a three-dimensional extent of a core layer of the at least one multilayer preform.

In some embodiments of the method, the at least one inspection device comprises an optical coherence tomography device; and the determining the at least one attribute comprises measuring layers of the at least one multilayer preform at a plurality of pre-determined points about the at least one multilayer preform.

In some embodiments of the method, the method further comprises determining, by a black speck inspection device of the apparatus, that at least one of the plurality of the multilayer preforms contains black speck defects; and transporting the at least one of the plurality of the multilayer preforms containing the black speck defects to a rejection path of the molding apparatus, the rejection path being configured for excluding multilayer preforms from a production path.

In some embodiments of the method, the molding apparatus further comprises a computer-implemented apparatus operatively connected to the triage device and the at least one inspection device; and the method further comprises receiving, by the computer-implemented apparatus, the at least one preform parameter of the at least one of the plurality of multilayer preforms from the triage device; receiving, by the computer-implemented apparatus, the at least one attribute of the at least one of the plurality of multilayer preforms from the at least one inspection device; and correlating, by the computer-implemented apparatus, the at least one preform parameter of the at least one of the plurality of multilayer preforms with the at least one attribute of the at least one of the plurality of multilayer preforms.

In some embodiments of the method, the method further comprises determining, by the computer-implemented apparatus, if the at least one attribute falls outside a pre-determined range; and generating, by the computer-implemented apparatus, an alert for an operator that the at least one attribute falls outside the pre-determined range.

In some embodiments of the method, the method further comprises determining, by the computer-implemented apparatus, if the at least one attribute falls outside a pre-determined range; and adjusting, by the computer-implemented apparatus, at least one operational setting of an molding machine, based at least in part on the at least one attribute.

In some embodiments of the method, the at least one preform parameter is a coarse inspection parameter; determining, by the computer-implemented apparatus, if the coarse inspection parameter falls outside a pre-determined range; and the selecting the at least one of the plurality of multilayer preforms comprises selecting the at least one of the plurality of multilayer preforms if the coarse inspection parameter falls outside the pre-determined range.

In the context of the present specification, the words "first", "second", "third", etc. have been used as adjectives only for the purpose of allowing for distinction between the nouns that they modify from one another, and not for the purpose of describing any particular relationship between those nouns. Further, as is discussed herein in other contexts, reference to a "first" element and a "second" element does not preclude the two elements from being the same actual real-world element.

These and other aspects and features of non-limiting embodiments of the present technology will now become apparent to those skilled in the art upon review of the following description of specific non-limiting embodiments of the technology in conjunction with the accompanying drawings.

Embodiments of the present technology each have at least one of the above-mentioned object and/or aspects, but do not necessarily have all of them. It should be understood that some aspects of the present technology that have resulted from attempting to attain the above-mentioned object may not satisfy this object and/or may satisfy other objects not specifically recited herein.

Additional and/or alternative features, aspects and advantages of embodiments of the present technology will become apparent from the following description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the embodiments of the present technology (including alternatives and/or variations thereof) may be obtained with reference to the detailed description of the non-limiting embodiments along with the following drawings, in which:

Figure 1 is a cross-sectional view of a multilayer preform, which can be inspected by non-limiting embodiments of the present technology;

Figure 2 is a plan view schematic diagram of an injection molding machine, which can be adapted for implementation of the non-limiting embodiments of the present technology;

Figure 3 is a plan view schematic diagram of a molding system, which can be adapted for implementation of the non-limiting embodiments of the present technology;

Figure 4 is a plan view schematic diagram of another embodiment of a molding system being implemented in accordance with another non-limiting embodiment of the present technology; and

Figure 5 depicts a block diagram of a method, the method executable in accordance with non-limiting embodiments of the present technology, the method executable within the system of Figures 3 or 4.

DETAILED DESCRIPTION

With reference to Fig. 1, there is depicted, in cross-section, a non-limiting embodiment of a multilayer preform 50. The multilayer preform 50 is produced by a molding machine. The illustrated preform 50 is produced by an injection molding machine 100, described below with reference to Fig. 2, but it is contemplated that preforms 50 could be produced by another type of molding machine in other non-limiting embodiments in accordance with the present technology. The multilayer preform 50 consists of a neck portion 32, a gate portion 36 and a body portion 34 extending between the neck portion 32 and the gate portion 36. The gate portion 36 is associated with a substantially spherical shape that terminates in a vestige portion 38.

The multilayer preform 50 is formed by at least two layers. On exterior sides, the multilayer preform 50 has a skin layer 20. The skin layer 20 can be made of various materials. For example, in multilayer preforms 50 for making beverage containers, the skin layer 20 is made of virgin polyethylene terephthalate (PET), which is approved by the FDA for use in contact with foodstuffs. It is contemplated that the skin layer 20 could be made of various other materials, including any appropriate polymer resins and thermoplastics, as will be appreciated by those skilled in the art. The multilayer preform 50 has a cavity identification number 25 imprinted in the skin layer 20. Even though the cavity identification number 25 is depicted to be located in the neck portion 32, this does not need to be so in alternative embodiments of the present

technology. In alternative embodiments, the cavity identification number 25 can be located anywhere within the gate portion 36 or the body portion 34.

As will be described below, each cavity 118 of one or more mold cavities 118 of the injection molding machine 100 has a cavity origin insert which imprints the cavity identification number 25 of each cavity 118, each cavity identification number 25 being unique to each cavity 118.

The skin layer 20 surrounds a core layer 40, the core layer 40 being generally made of a different material, or a different state of the same material, than the skin layer 20. At a top end of the preform 50, the core layer 40 begins at a leading edge 42. At a bottom end of the preform 50, the core layer 40 terminates at a trailing edge 44. In some embodiments, the core layer 40 is used to impart different properties to the preforms 50, such as increased rigidity. The core layer 40, in some embodiments, can act as a barrier layer in the eventual blow-molded container blown from the preform 50. In such cases, the barrier layer can help to prevent transmission of, for example, oxygen or light into an interior of the blow-molded container. The core layer 40 can also be made from any one of various appropriate thermoplastics and polymer resins as will be appreciated by those skilled in the art. It is contemplated that the core layer 40 could be also contain various additives, coloring, or property adjusting agents to affect different properties of the multilayer preform 50.

With reference to Fig. 2, there is depicted a non-limiting embodiment of the injection molding machine 100 which can be adapted to implement embodiments of the present technology. For illustration purposes only, it shall be assumed that the injection molding machine 100 makes the multilayer preforms 50 described above that are subsequently processed by a molding system 200 of the present technology. However, it should be understood that in alternative non-limiting embodiments, the injection molding machine 100 may comprise other types of molding systems, such as, but not limited to, compression molding systems, compression injection molding systems, transfer molding systems, metal molding systems and the like.

In the non-limiting embodiment of Fig. 2, the molding machine 100 comprises a fixed platen 102 and a movable platen 104. In some embodiments of the present technology, the molding machine 100 may include a third non-movable platen (not depicted). Alternatively or additionally, the molding machine 100 may include turret blocks, rotating cubes, turning tables and the like (all not depicted but known to those of skill in the art).

The injection molding machine 100 further comprises an injection unit 106 for plasticizing and injection of the molding material. The injection unit 106 can be implemented as a single stage or a two-stage injection unit.

In operation, the movable platen 104 is moved towards and away from the fixed platen 102 by means of stroke cylinders (not shown) or any other suitable means. Clamp force (also referred to as closure or mold closure tonnage) can be developed within the molding machine 100, for example, by using tie bars 108, 110 (typically, four tie bars 108, 110 are present in the molding machine 100) and a tie-bar clamping mechanism 112, as well as (typically) an associated hydraulic system (not depicted) that is usually associated with the tie-bar clamping mechanism 112. It will be appreciated that clamp tonnage can be generated using alternative means, such as, for example, using a column-based clamping mechanism, a toggle-clamp arrangement (not depicted) or the like.

A first mold half 114 can be associated with the fixed platen 102 and a second mold half 116 can be associated with the movable platen 104. In the non-limiting embodiment of Fig. 2, the first mold half 114 comprises the one or more mold cavities 118. As will be appreciated by those of skill in the art, the one or more mold cavities 118 may be formed by using suitable mold inserts (such as a cavity insert, a gate insert and the like) or any other suitable means. As such, the first mold half 114 can be generally thought of as a “mold cavity half”.

The second mold half 116 comprises one or more mold cores 120 complementary to the one or more mold cavities 118. As will be appreciated by those of skill in the art, the one or more mold cores 120 may be formed by using suitable mold inserts or any other suitable means. As such, the second mold half 116 can be generally thought of as a “mold core half”. Even though not depicted in Fig. 2, the first mold half 114 may be further associated with a melt distribution network, commonly known as a hot runner, for distributing molding material from the injection unit 106 to each of the one or more mold cavities 118. Also, the second mold half 116 is provided with neck rings (not depicted) produce preforms with the neck portions 32. The second mold half 116 is provided with the cavity origin insert for imprinting the cavity identification number 25 on the multilayer preforms 50.

The first mold half 114 can be coupled to the fixed platen 102 by any suitable means, such as a suitable fastener (not depicted) or the like. The second mold half 116 can be coupled to the movable platen 104 by any suitable means, such as a suitable fastener (not depicted) or the like. It should be understood that in an alternative non-limiting embodiment of the present

technology, the position of the first mold half 114 and the second mold half 116 can be reversed and, as such, the first mold half 114 can be associated with the movable platen 104 and the second mold half 116 can be associated with the fixed platen 102. In an alternative non-limiting embodiment of the present technology, the fixed platen 102 need not be stationary and may be movable in relation to other components of the molding machine 100.

Fig. 2 depicts the first mold half 114 and the second mold half 116 in a so-called "mold open position" where the movable platen 104 is positioned generally away from the fixed platen 102 and, accordingly, the first mold half 114 is positioned generally away from the second mold half 116. For example, in the mold open position, a molded article (not depicted) can be removed from the first mold half 114 and/or the second mold half 116. In a so-called "mold closed position" (not depicted), the first mold half 114 and the second mold half 116 are urged together (by means of movement of the movable platen 104 towards the fixed platen 102) and cooperate to define (at least in part) a molding cavity (not depicted) into which the molten plastic (or other suitable molding material) can be injected, as is known to those of skill in the art.

It should be appreciated that one of the first mold half 114 and the second mold half 116 can be associated with a number of additional mold elements, such as for example, one or more leader pins (not depicted) and one or more leader bushings (not depicted), the one or more leader pins cooperating with one more leader bushings to assist in alignment of the first mold half 114 with the second mold half 116 in the mold closed position, as is known to those of skill in the art.

The injection molding machine 100 can further comprise a robot 122 operatively coupled to the fixed platen 102. Those skilled in the art will readily appreciate how the robot 122 can be operatively coupled to the fixed platen 102 and, as such, it will not be described here in any detail. The robot 122 comprises a mounting structure 124, an actuating arm 126 coupled to the mounting structure 124 and a take-off plate 128 coupled to the actuating arm 126. The take-off plate 128 comprises a plurality of molded article receptacles 130.

Generally speaking, the purpose of the plurality of molded article receptacles 130 is to remove molded articles from the one or more mold cores 120 (or the one or more mold cavities 118) and/or to implement post mold cooling of the molded articles. In the non-limiting example illustrated herein, the plurality of molded article receptacles 130 comprises a plurality of cooling tubes for receiving a plurality of molded preforms. However, it should be expressly understood that the plurality of molded article receptacles 130 may have other configurations. The exact number of the plurality of molded article receptacles 130 is not particularly limited.

Schematically depicted in Fig. 2 is the robot 122 of a side-entry type. However, it should be understood that in alternative non-limiting embodiments of the present technology, the robot 122 can be of a top-entry type. It should also be expressly understood that the term "robot" is meant to encompass structures that perform a single operation, as well as structures that perform multiple operations.

The molding machine 100 further comprises a post-mold treatment device 132 operatively coupled to the movable platen 104. Those skilled in the art will readily appreciate how the post-mold treatment device 132 can be operatively coupled to the movable platen 104 and, as such, it will not be described here in any detail. The post-mold treatment device 132 comprises a mounting structure 134 used for coupling the post-mold treatment device 132 to the movable platen 104. The post-mold treatment device 132 further comprises a plenum 129 coupled to the mounting structure 134. Coupled to the plenum 129 is a plurality of treatment pins 133. The number of treatment pins within the plurality of treatment pins 133 generally corresponds to the number of receptacles within the plurality of molded article receptacles 130.

The molding machine 100 further comprises a computer-implemented apparatus 140, also referred to herein as a controller 140, configured to control one or more operations of the molding machine 100. The controller 140 is further configured to control one ore more operations of molding systems 200, 300, described below with respect to Figs. 3 and 4. As will be appreciated by those skilled in the art, the computer-implemented apparatus 140 may comprise a plurality of controllers 140 or computer-implemented apparatuses 140 operatively connected together.

The controller 140 includes a human-machine interface (not separately numbered) or an HMI, for short. The HMI of the controller 140 can be implemented in any suitable interface. As an example, the HMI of the controller 140 can be implemented in a multi-functional touch screen. An example of the HMI that can be used for implementing non-limiting embodiments of the present technology is disclosed in co-owned United States patent 6,684,264, content of which is incorporated herein by reference, in its entirety.

Those skilled in the art will appreciate that the controller 140 may be implemented using pre-programmed hardware or firmware elements (e.g., application specific integrated circuits (ASICs), electrically erasable programmable read-only memories (EEPROMs), etc.), or other related components. In other embodiments, the functionality of the controller 140 may be achieved using a processor that has access to a code memory (not shown) which stores

computer-readable program code for operation of the computing apparatus, in which case the computer-readable program code could be stored on a medium which is fixed, tangible and readable directly by the various network entities, (e.g., removable diskette, CD-ROM, ROM, fixed disk, USB drive), or the computer-readable program code could be stored remotely but transmittable to the controller 140 via a modem or other interface device (e.g., a communications adapter) connected to a network (including, without limitation, the Internet) over a transmission medium, which may be either a non-wireless medium (e.g., optical or analog communications lines) or a wireless medium (e.g., microwave, infrared or other transmission schemes) or a combination thereof.

In alternative non-limiting embodiments of the present technology, the HMI does not have to be physically attached to the controller 140. As a matter of fact, the HMI for the controller 140 can be implemented as a separate device. In some embodiments, the HMI can be implemented as a wireless communication device (such as a smartphone, for example) that is "paired" or otherwise communicatively coupled to the controller 140.

The controller 140 can perform several functions including, but not limited to, receiving from an operator control instructions, controlling the molding machine 100 based on the operator control instructions or a pre-set control sequence stored within the controller 140 or elsewhere within the molding machine 100, acquire one or more operational parameters associated with the molding system and the like. According to non-limiting embodiments of the present technology, the controller 140 is further configured to process one or more of the acquired operational parameters associated with the molding system 200, output information to the operator using the HMI and the like, as will be described herein below.

The injection molding machine 100 further includes a number of monitoring devices (not depicted), the monitoring devices being configured to acquire various operational parameters associated with the performance of the molding machine 100. Generally speaking, these monitoring devices are known in the art and, as such, will not be described here at any length.

Just as an example, the injection molding machine 100 may include a counter to count mold opening and closing to determine the number of cycles over a period of time and/or the cycle time of each cycle. The injection molding machine 100 may also include a number of pressure gauges to measure pressure within various components of the injection molding machine 100 (such as hydraulic fluid pressure or molding material pressure).

According to non-limiting embodiments of the present technology, the controller 140 is configured to acquire a plurality of operational parameters associated with the molding machine 100. The nature of the so-acquired plurality of operational parameters can vary. How the controller 140 acquires the plurality of operational parameters will depend, of course, on the nature of the so-acquired plurality of operational parameters.

The controller 140 can acquire machine variables by monitoring the operation of the molding machine 100. Just as an example, the controller 140 can acquire the cycle time by monitoring the performance of the molding machine 100. Naturally, the controller 140 can acquire some of the machine variables by either the operator entering them using the HMI or by reading a memory tag (not depicted) associated with the mold (i.e. the above described first mold half 114 and the second mold half 116) that is used in the molding machine 100. Various implementations of the memory tag (not depicted) are known in the art. Generally speaking, the memory tag (not depicted) may store information about the mold, the molded article to be produced, pre-defined control sequences, set-up sequences and the like.

For example, the operator may enter an indication of cavitation of the injection molding machine 100 using the HMI of the controller 140 (in which case, the cavitation can be considered to be an operational and supervisory variable). Alternatively, the mold (i.e. the above described first mold half 114 and the second mold half 116) may be equipped with the memory tag, which memory tag may for example store an indication of the cavitation of the mold. In those implementations, the controller 140 can acquire the cavitation by accessing the memory tag and reading the information therefrom (in which case, the cavitation can be considered to be a machine variable). In yet further embodiments, the memory tag may contain an indication of the mold cavitation of the mold (i.e. the above described first mold half 114 and the second mold half 116), but some of the mold cavities may not be operational at the time. Within those examples, the operator or the supervisor could enter the actual cavitation using the HMI (in which case, the cavitation could again be considered to be an operational and supervisory variable).

In some non-limiting embodiments of the present technology, the controller 140 can acquire the operational and supervisory variables by receiving an indication of those parameters from the operator. However, within some implementations of the molding machine 100, it is possible for the controller 140 to acquire some (or even all) of the operational and supervisory variables by monitoring performance of the molding machine 100. For example, some implementations of the molding machine 100 may include a device for weighing molded articles and/or a device to keep track of scrapped molded articles (for example, those molded articles that do not quality or

weight specifications). Within those embodiments, the controller 140 can acquire the part weight and/or scrap rates by monitoring the performance of the molding machine 100. Naturally, other ways for the controller 140 to acquire some or all of these or other operational parameters are possible, some of which will be described below.

With reference to Fig. 3, there is depicted a non-limiting embodiment of the molding system 200 which can be adapted to implement embodiments of the present technology. The molding system 200 comprises the injection molding machine 100 for making the multilayer preforms 50. The molding system 200 is illustrated and will be described herein with respect to the embodiment of the injection molding machine 100 described above. It is contemplated that different embodiments of the injection molding machine 100 could be included in the molding system 200. It is also contemplated that the molding system 200 could include different molding equipment, such as but not limited to: a compression molding machine, injection compression molding machine, extrusion blow molding machine, transfer molding machine and the like.

Along with the injection molding machine 100, the molding system 200 also comprises an inspection apparatus 150, which includes devices to perform an at least two step inspection process, as will be described below. Before, during and after the at least two step inspection, the multilayer preforms 50 produced by the injection molding machine 100 are sent either on to further production steps (such as preparation for blow-molding) or, if the preforms 50 are found to not meet some pre-determined parameters, they are sent to a pre-determined location for rejected preforms 50.

The molding system 200 comprises a production path 290 which receives multilayer preforms 50 from multiple points in the inspection apparatus 150, as will be described below. The production path 290 includes one or more conveyance devices (not separately depicted) to transport the multilayer preforms 50 delivered thereto. The production path 290 transports the multilayer preforms 50 from the molding system 200 to subsequent treatment systems, including but not limited to, cleaning systems, quality control systems, and packaging systems. It is also contemplated that the production path 290 could transport the multilayer preforms 50 to a blow-molding system for blowing the multilayer preforms 50 into blow-molded containers.

The molding system 200 comprises a rejection path 295 which similarly receives multilayer preforms 50 from multiple points in the inspection apparatus 150, as will be described below. The rejection path 295 includes one or more conveyance devices (not separately depicted) to transport the multilayer preforms 50 delivered thereto away from the molding system 200. The

rejection path 295 transports the multilayer preforms 50 to, in one non-limiting embodiment, a rejected parts bin (not shown) for recycling or destruction of preforms 50 that are found to not be of acceptable quality by the molding system 200. Generally, the rejection path 295 is configured for excluding some of the multilayer preforms 50 produced by the injection molding machine 100 from the production path 290, so that multilayer preforms 50 determined not to be acceptable do not continue onto the subsequent cleaning, packaging, and/or blow-molding systems to which the multilayer preforms 50 are transported by the production path 290.

Those skilled in the art will readily appreciate how production path 290 and the rejection path 295 can be operatively coupled to other portions of the molding system 200 and to subsequent treatment systems. As such, it will not be described here in any further detail.

The molding system 200 comprises several conveyance devices for transporting multilayer preforms 50 between different devices of the inspection apparatus 150. Many variations of conveyance devices can be implemented in non-limiting embodiments of the present technology, as will be appreciated by those skilled in the art. As such, specific implementation details need not be supplied here.

The molding system 200 comprises conveyance devices 202 and 204 for transporting multilayer preforms 50 from the injection molding machine 100. The conveyance device 204 receives a portion of the multilayer preforms 50 produced by the injection molding machine 100 and transports those preforms 50 to a triage device 222 of inspection apparatus 150, described in detail below. The conveyance device 202 receives the multilayer preforms 50 produced by the injection molding machine 100 which are not sent to the conveyance device 204. The conveyance device 202 transports those preforms 50 from the injection molding machine 100 directly to the production path 290.

The inspection apparatus 150 of the molding system 200 comprises the triage device 222 for selecting for inspection a portion of the multilayer preforms 50 delivered thereto. The triage device 222 is operatively connected to the injection molding machine 100 via at least the conveyance device 204. The triage device 222 is operatively connected to the controller 140 as well, such that information can be sent and received between the triage device 222 and the controller 140.

The triage device 222 is configured to determine at least one preform parameter for each multilayer preform 50 received at the triage device 222. Based on the at least one preform parameter determined by the triage device 222, the triage device 222 is configured to select at

least one of the multilayer preforms 50 for inspection. Only those preforms 50 selected by the triage device 222 are sent on toward an inspection device 226 via at least one conveyance device 206.

In the illustrated embodiment, the preform parameter is related to the cavity 118 of origin in the injection molding machine 100 of a given preform 50. Specifically, the triage device 222 comprises a machine vision device 230 that is configured to determine the preform parameter, where the preform parameter is the cavity identification number 25. The machine vision device 230 reads the cavity identification number 25 on each multilayer preform 50 received at the triage device 222. The machine vision device 230 operates with any suitable technology that will be known to those skilled in the art, and details of which need not be recited here.

In other non-limiting embodiments, the triage device 222 could comprise other or additional pre-inspection devices, including but not limited to: an optical inspection device and a picker device. It is also contemplated that the triage device 222 could receive the multilayer preforms 50 in a known order, and the triage device 222 could determine the preform parameter for each multilayer preform 50 based in part on information from the controller 140 with respect to the known order.

In some other non-limiting embodiments of the present technology, the preform parameter can be a coarse inspection parameter. In such a case, if the coarse inspection parameter of a given preform 50 falls outside a pre-determined range, the triage device 222 is further configured to select the given preform 50 for inspection based, at least in part, on the coarse inspection parameter. The coarse inspection parameter can be indicative of many variables of the given preform 50, including, but not limited to, visual appearance, overall thickness, color, and preform weight.

The plurality of multilayer preforms 50 produced by the molding machine 100 can comprise a plurality of shot groups, each shot group being a group of multilayer preforms 50 produced during a single injection molding cycle of the injection molding machine 100. In some cases, the triage device 222 can be configured to select one given shot group (based on a pre-determined schedule for example or a randomly picked given shot group). As such, an entire shot (all the preforms 50 produced during one cycle, one per cavity 118) can be chosen for inspection, allowing information on production from each cavity 118 to be gathered.

Similarly, in some non-limiting embodiments, the triage device 222 can be configured to select a pre-determined group of multilayer preforms 50. This group can be determined based on

previous inspection results, such as previous poor performance of certain cavities of the molding machine 100, or this group can be chosen by the operator, via the HMI and the controller 140. The triage device 222, being operatively connected to the controller 140, is further configured to receive an instruction from the operator and to select the pre-determined group based at least in part on the instruction.

The triage device 222 can be further configured to select the pre-determined group at regular intervals. Just as an example, it may be advantageous to select a few of the mold cavities 118 every 10 cycles, in order to monitor the cavity performance over time. As such, the triage device 222 can be further configured to select the pre-determined group every n^{th} cycles, where the n^{th} cycle is simply a pre-determined value.

Similarly, in some non-limiting embodiments, the triage device 222 can be configured to select pre-determined groups of preforms 50 on a rotating basis, also referred to as "rolling sub-groups". In such a case, the triage device 222 is configured to select a first subgroup having a first set of cavity identification numbers 25, the first subgroup being selected from multilayer preforms 50 produced in a first injection molding cycle. The triage device 222 then selects a second subgroup having a second set of cavity identification numbers 25, the second set of cavity identification numbers 25 being different from the first set, the second subgroup being selected from multilayer preforms produced in a second injection molding cycle of the injection molding machine 100. For example, during a first cycle, the triage device 222 selects the preforms 50 produced in the mold cavities 118 numbered 1 to 10, and then, during a second cycle, the triage device 222 selects the preforms 50 produced in the mold cavities 118 numbered 11 to 20.

As mentioned above, within some non-limiting embodiments of the molding machine 100, the controller 140 can be configured to acquire one or more of the operational and supervisory variables by monitoring performance of the molding machine 100. In such embodiments of the molding system 200, the triage device 222 can then be configured to select one or more multilayer preforms 50, in accordance with instructions from the controller 140, those instructions being based at least in part on those operational and supervisory variables. For example, the controller 140 could receive information from an external weight measuring device that preforms 50 coming from a given cavity 118 for one or more cycles weigh less than the other preforms 50. The controller 140 could, in such a case, send instructions to the triage device 222 to select the preforms 50 coming from that cavity 118 for further inspection with the inspection device 226, in order to more precisely identify the possible problem. In some non-

limiting embodiments, the operator could then be informed of the possible problem or situation with the injection molding machine 100, including in some cases those attributes determined by the inspection device 224. In some non-limiting embodiments, the controller 140 could, alternatively or additionally, directly adjust operational parameters of the injection molding machine. All of the above are simply examples of sub-groups of multilayer preforms 50 that can be selected by the triage device 222 for inspection. For any given embodiment of the present technology, all or none of the above example sub-groups can be chosen, either automatically according to inspection schedules for the injection molding machine 100 or as decided by the operator. It is also contemplated that different sub-groupings and pre-determined groups, not mentioned herein, may be chosen.

The molding system 200 comprises the conveyance device 206 for transporting the multilayer preforms 50 selected by the triage device 222 for inspection from the triage device 222 toward the inspection device 226 (described below). In this way, only those preforms 50 selected by the triage device 222 are more thoroughly inspected, rather than inspecting all preforms 50 that are sorted by the triage device 222. In the illustrated embodiment, the conveyance device 206 is a conveyer belt. It is contemplated that any suitable device or mechanism for selectively moving the selected preforms 50 from the triage device 222 to the black speck inspection device 224 and/or the inspection device 226.

The molding system 200 comprises a conveyance device 216 for transporting multilayer preforms 50 from the triage device 222 directly to the rejection path 295. In some non-limiting embodiments, the triage device 222 can be further configured to determine that a given preform 50 should not continue on to the production path 290. In some cases, this determination is based on the preform parameter determined by the triage device 222.

For example, if a given mold cavity 118 has been determined to be producing defective multilayer preforms 50, the triage device 222 can be used to detect the cavity identification number 25 of that defective mold cavity 118 and determine that those preforms 50 need to be sent directly to the rejection path 295, bypassing further inspection. In another non-limiting example, the machine vision device 230 could optically detect defects in a given multilayer preform 50, such as having an appearance or other quality specifications that fall outside of an allowed range of variation.

Generally, only a portion of the multilayer preforms 50 that is delivered to the triage device 222 are selected for inspection, for reasons that will become apparent. As such, a remainder of the

multilayer preforms 50, not selected by the triage device 222, need to be transported away from the triage device 222. The molding system 200 comprises a conveyance device 212 configured to transport multilayer preforms 50 from the triage device 222 directly to the production path 290, away from the injection molding machine 100.

In some embodiments of the present technology, the molding system 200 can comprise a singulator device 240 operatively connected between the injection molding machine 100 and the triage device 222. The singulator device 240 is configured for aligning and orienting the multilayer preforms 50 prior to arriving at the triage device 222. The singulator device 240 receives randomly oriented and grouped multilayer preforms 50 from the conveyance device 204, and aligns the preforms 50 in a single line, with all the preforms 50 all oriented in the same direction.

It is contemplated that the singulator device 240 could be replaced with other mechanisms or systems for orienting and aligning the multilayer preforms 50, as those skilled in the art will readily appreciate. It is also contemplated that other non-limiting embodiments of the molding system 200 could omit the singulator device 240. For example, the triage device 222 itself could include a mechanism for orienting and aligning the multilayer preforms 50 before the determining of the preform parameter by the triage device 222.

In some embodiments of the present technology, the inspection apparatus 150 can also comprise a black speck inspection device 224. The black speck inspection device 224 is configured to identify if a given multilayer preform 50 has one or more black speck defects. The black speck inspection device 224, as is commonly known in the art, is an optical detection device. The black speck inspection device 224 is operatively connected to the controller 140 such that information can be sent and received between the black speck inspection device 224 and the controller 140.

In some embodiments of the present technology, the inspection apparatus 150 can also comprise a conveyance device 208 for transporting the preforms 50 from the black speck inspection device 224 to the inspection device 226. In the illustrated embodiment, the conveyance device 206 is a conveyer belt. It is contemplated that any suitable device or mechanism for selectively moving the selected preforms 50 from the triage device 222 to the black speck inspection device 224 and/or the inspection device 226.

A conveyance device 218 is provided to transport any multilayer preforms 50 found to contain black speck defects from the black speck inspection device 224 to the rejection path 295. The molding system 200 is generally configured to send the given preform 50 to the rejection path

295, via the conveyance device 218, if the given preform 50 has a black speck defect. It should be noted that some or all of the multilayer preforms 50 found to have black speck defects may continue on to the inspection device 226, via the conveyance device 208, instead of being sent to the rejection path 295.

In some non-limiting embodiments of the present technology, the conveyance devices 216 and 218 could be combined, such that one conveyance device could transport multilayer preforms 50, selected for exclusion from the production path 290 from either the triage device 222 or the black speck inspection device 224, to the rejection path 295. Similarly, the conveyance devices 212 and 214 could be combined, such that one conveyance device could transport multilayer preforms 50 from either the triage device 222 or the black speck inspection device 224 to the production path 290.

Further, in some non-limiting embodiments of the present technology, the black speck inspection device 224 could be omitted from the inspection apparatus 150. In such a case, the conveyance devices 206 and 208 could be combined, such that one conveyance device could transport multilayer preforms 50 from the triage device 222 to an inspection device 226.

The inspection apparatus 150 of the molding system 200 further comprises the inspection device 226, mentioned above. The inspection device 226 is operatively connected to the triage device 222, via the conveyance devices 206 and 208. The inspection device 226 is also operatively connected to the controller 140 such that information can be sent and received between the inspection device 224 and the controller 140. The inspection device 226 is configured to receive the multilayer preforms 50 from the triage device 222 and to determine at least one attribute of the multilayer preforms 50 selected for inspection by the triage device 222.

In the illustrated embodiment, the inspection device 226 includes an optical coherence tomography (OCT) device 235. The OCT device 235 is a highly-repeatable, non-contact imaging technology which is used to determine cross-sectional thicknesses of layers of scattering materials. When scanning a given multilayer preform 50, a full three-dimensional extent of different layers can be determined, including a full three-dimensional extent of the core layer 40. As measurement of the core layer 40 of the multilayer preform 50 is non-destructive and non-contact, it does not require physical separation of the skin and core layers 20, 40 as is generally known in the art. In other non-limiting embodiments of the present technology, the inspection device 226 could include different technology to determine aspects of the core layer 40. These could include, but are not limited to a device using wave length based technologies, such as: an

X-ray imaging device, X-ray tomography device, an ultra-sound imaging device, a terahertz imaging device, and a terahertz tomography device.

In the illustrated embodiment, where the inspection device 226 comprises the optical coherence tomography device 235 for measuring the three-dimensional extent of the core layer 40, the optical coherence tomography device 235 is configured to determine a plurality of characteristics or attributes of the multilayer preforms 50 conveyed from the triage device 222. The plurality of characteristics and attributes can include, for example, characteristics of the core layer 40 of the selected multilayer preforms 50. In the illustrated embodiment, the optical coherence tomography device 235 can determine attributes including, but not limited to: thickness, volume, weight, and extent of the core layer 40, presence of the core layer 40 in a dome portion of the preform 50, and locations of the leading and trailing edges 42, 44.

In some non-limiting embodiments, these attributes can be statistically studied based on the groups or sub-groups chosen by the triage device 222, as described above. As one non-limiting example, the controller 140 could receive, from the inspection device 226, core layer 40 volume information for one entire shot group, as chosen by the triage device 222. In turn, the controller 140 could present, to the operator via the HMI, a distribution of volumes of the core layers 40 of the entire shot group. This is simply one example, as the attribute determined by the inspection device 226 and the preforms 50 selected by the triage device 222 will vary from embodiment to embodiment, as well as for different uses of any given embodiment.

In the illustrated embodiment, the inspection apparatus 150 includes a robotic arm (not separately illustrated) for handling and orienting the multilayer preforms 50 during their inspection at the OCT device 235. The robotic arm has four degrees of movement, specifically horizontal, vertical, tilting, and rotation, in order to properly align and orient each preform 50 for inspection by the OCT device 235 in order to determine the full three-dimensional extent of the layers 20, 40 of the preforms 50. It is contemplated that different devices and mechanisms could be implemented in order to achieve proper alignment and orientation of the multilayer preforms 50 for inspection by the OCT device 235.

The OCT device 235, in the illustrated embodiment, can measure the thickness of the core layer 40 by imaging the skin and core layers 20, 40 in a plurality of radial cross-sections at different distances from the neck portion 32, and at one or more positions around the circumference. The extent of the core layer 40 coverage is determined from these thickness measurements to ensure that the core layer 40 extends throughout portions of the preform 50 as desired.

Similarly, a maximum thickness, a minimum thickness and an average thickness of the core layer 40 at these points can be determined. It is also contemplated that the OCT device could determine the maximum thickness, the minimum thickness and the average thickness of the core layer 40 at any point can be determined from the measurement of the three-dimensional extent of the core layer 40. Similarly, the total volume of the core layer 40 could be determined from measuring the three-dimensional extent of the core layer 40. As the material density of the core layer 40 would be known, the weight of the core layer 40 could further be determined from the three-dimensional extent measured by the OCT device 235. Any of these measurements could be used, either in inspection by the operator or by the controller 140, to ensure that there are no unwanted gaps in the core layer 40. It is further contemplated that the OCT device 235 and/or the controller 140 could determine the average thickness of the core layer 40 around a given circumference.

In addition to determining the thickness of the core layer 40, in some non-limiting embodiments the OCT device 235 could be configured to determine a location of the leading edge 42 of the core layer 40 and a location of the trailing edge 44 of the core layer 40. This could be done by determining, by either the OCT device 235 or the controller 140, the point where the core layer 40 thins down to zero thickness at either a top or bottom end of a given multilayer preform 50. Similarly, the OCT device 235 and/or the controller 140 could be configured to determine an overall angle of the leading or trailing edge 42, 44, such that an irregularity in the core layer 40 edges could be determined.

The OCT device 235, in the illustrated embodiment, can also determine presence of the core layer at an angle 39 of the dome portion of the gate portion 36, as is illustrated in Fig. 1. The angle 39 refers to the angle of orientation of the preform 50 in front of a lens of the OCT device 235. The angle 39 could be pre-determined by the OCT device 235 in some embodiments. It is contemplated that the operator could set the angle 39, via the controller 140. For some preforms 50, the core layer 40 is intended to cover the entirety of the dome portion (an encapsulated core layer 40). In such a case, the preform 50 can be inspected at the angle 39 to verify the presence of the core layer 40. In different embodiments of the multilayer preforms 50, such as that illustrated in Fig. 1, the core layer 40 is not intended to extend into the dome portion. As such, the OCT device 235 can be configured to verify that there no part of the core layer 40 at the angle 39 around the dome portion. It is contemplated that in some non-limiting embodiments, the angle 39 could be greater or smaller than the angle 39 illustrated. It is also contemplated that the angle 39 could be a plurality of angles used to determine presence of the core layer 40 in the dome portion.

Upon determination of at least one of the attributes by the inspection device 226, the controller 140 receives and records the value of the attribute determined. In some embodiments, the controller 140 is configured to determine if the at least one attribute falls outside a pre-determined range, such as if the attribute falls outside of an acceptable range of values. In some embodiments, the controller 140 is further configured to generate an alert for the operator that the attribute falls outside the pre-determined range. For example, the operator may receive a visual or audio alert on the HMI that the preforms 50 being inspected have core layers 40 that are thinner than allowed. The controller 140 may also be configured to adjust at least one of the operational settings of the molding system 200, or specifically the injection molding machine 100, if the attribute falls outside the pre-determined range.

In some non-limiting embodiments, the inspection device 226 can be configured to perform a three-dimensional rendering of the core layer 40 based on the attributes. The controller 140 can also be configured to perform a three-dimensional rendering of the core layer 40 based on the attributes determined by the inspection device 226. The three-dimensional rendering and/or any of the attributes determined by the inspection device 226 may be presented to the operator on the HMI in some embodiments as well.

In some cases, the inspection device 226 comprises a first inspection device and a second inspection device. For example, in additional non-limiting embodiments of the present technology, the inspection device 226 can also, or alternatively, comprise one or more inspection devices 235 configured to: determine a thread acceptability parameter, determine a transparency parameter, determine a weight (either of the preform 50 or the core layer 40) , or determine a color spectrum parameter of the multilayer preforms 50 conveyed from the triage device 222. It is contemplated that in other non-limiting embodiments of the present technology, the inspection device 226 could be differently implemented, including as, but not limited to, a secondary or additional optical coherence tomography device, an optical transmission inspection device, an ultrasound device, and a gas perfusion device.

The optical coherence tomography device 235 of the illustrated embodiment generally inspects the preforms 50 at a speed of 100 preforms per hour, although the speed can vary from at least 75 preforms per hour, up to 240 preforms per hour. The speed of inspection can depend on many factors, including but not limited to: physical size of the preforms 50, material composition of the preforms 50, sampling parameters of the inspection, specifics of the inspection device 226, and instructions from the operator. It is contemplated that some embodiments within the present

technology could exhibit increased speeds of inspection, depending on the specific implementation.

The triage device 222 acts as an intermediary device between the injection molding machine 100 and the inspection device 226. The injection molding machine 100, as will be appreciated by those skilled in the art, generally produces multilayer preforms 50 at a rate which outpaces the inspection device 226 by orders of magnitude. As an example, one non-limiting embodiment of the injection molding machine 100, having 96 cavities and running at a cycle speed of 300 cycles per hour (one cycle every 12 seconds), can produce multilayer preforms 50 at a rate of 28,800 preforms per hour. This far out strips the maximum rate (120/hr) at which preforms 50 can be inspected by the inspection device 226.

A technical effect associated with embodiments of the present technology may include the ability to minimize down time of the injection molding machine 100 by performing regular, automated inspection of multilayer preforms 50, wherein the triage device 222 selects only certain preforms 50 to be inspected, according to either scheduled quality inspection schedules and/or operator instructions. Another technical effect associated with embodiments of the present technology may include the ability to minimize downtime, the inspection not impeding operation of the molding system, inspection of the molded articles taking place with a minimum of delay from when they are molded so as to intercept issues as quickly as possible, and inspection of the multilayer preforms requiring a minimum of operator interference.

In some non-limiting embodiments of the present technology, the singulator device 240 is configured to create an order of the multilayer preforms 50 prior to the triage device 222 determining the preform parameter. Then the triage device 222 is further configured to record, either within a computational device (not shown) within the triage device 222 itself or at the controller 140, the preform parameter of each multilayer preform 50 according to the order created by the singulator device 240.

In such a case, at least one of the triage device 222 and the inspection device 226 is configured to transmit an indication of the preform parameter of the multilayer preforms 50 sent to the inspection device 226 to the computer-implemented apparatus 140. The inspection device 226 is then configured to receive the multilayer preforms 50, selected by the triage device 222 for inspection, according to the order. For example, the inspection device 226 would receive the preforms 50 to be inspected in the same order as they have been through the triage device 222. In this way, the computer-implemented apparatus 140, being configured to correlate the preform

parameter with the at least one attribute determined by the inspection device 226, can connect a given inspection result with the originating mold cavity 118 of the multilayer preform 50.

Another embodiment of the molding system 300 in accordance with the present technology is illustrated in Fig. 4. The injection molding system 300 comprises the injection molding machine 100 and the controller 140 as before, although they have been omitted from Fig.4. In this embodiment, the molding system 300 also comprises an inspection apparatus 350. It should be noted that this is just one possible configuration of many non-limiting embodiments of the present technology.

In this configuration of the inspection apparatus 350, the black speck inspection device 224 is grouped with the triage device 222, with one combined conveyance path 306 for transporting the multilayer preforms 50 that have been selected for inspection by the triage device 222 on to the OCT device 235. These preforms 50 can be inspected by the black speck inspection device 224, either before or after being selected, although it is also contemplated that the selected preforms 50 may bypass the black speck inspection device 224 altogether.

Similarly, one conveyance path 316 is provided for transporting the multilayer preforms 50 which are determined to be rejected by the black speck inspection device 224 and/or the triage device 222 to the rejection path 295. One conveyance path 312 is provided for returning multilayer preforms 50, those that are not rejected by either of the devices 222 and 224 (but also not selected for inspection by the triage device 222), to the production path 290. The inspection apparatus 350 comprises a circular conveyance device 345 for handling and transporting multilayer preforms 50 between the conveyance devices 240, 316, 312, and 306, and the devices 222 and 224. The inspection apparatus 350 also comprises a circular conveyance device 347 for handling and transporting multilayer preforms 50 between the conveyance devices 306, 220, and 210, and the inspection device 226.

Specific details of the triage device 222, the black speck inspection device 224, the OCT device 235, the production path 290 and the rejection path 295 are similar or the same as those described above with respect to the molding system 200 and need not be repeated here.

With reference to Fig. 5, a non-limiting embodiment of a method 400 in accordance with the present technology will be discussed.

Fig. 5 depicts a block diagram of a method 400, the method 400 executable in accordance with non-limiting embodiments of the present technology. The method 400 will be described herein

with respect to the molding system 200, detailed above, but it is contemplated that the method applies equally to the molding system 300, as well as other non-limiting embodiments of an injection molding system according to the present technology.

Step 402 - receiving a plurality of multilayer preforms at the triage device

The method 400 begins at step 402, where a plurality of the multilayer preforms 50 produced by the injection molding machine 100 are received at the triage device 222.

Step 404 - determining, by the triage device, at least one preform parameter for each one of the plurality of multilayer preforms

At step 404, the triage device 222 determines at least one preform parameter for each one of the plurality of multilayer preforms 50 received at the triage device 222 at step 402.

As described above, the triage device 222 uses machine vision to the read the cavity identification number 25 of each multilayer preforms 50 in the illustrated embodiments of the molding systems 200 and 300.

In some non-limiting embodiments of the present technology, the method 400 also comprises steps of orienting, by the singulator device 240, the multilayer preforms 50, creating an order of the preforms 50 before the determining of the at least one preform parameter by the triage device 222. In such an embodiment, the method 400 further comprises recording, by the triage device 222, the at least one preform parameter of each preform 50 according to the order.

The method 400 then proceeds to execution of step 406.

Step 406 - selecting at least one of the plurality of multilayer preforms based at least in part on the at least one preform parameter

At step 406, at least one of the multilayer preforms 50 is selected for further inspection by the inspection device 226. In some embodiments, the selection is carried out by the controller 140. In some embodiments, the selection is carried out by the triage device 222 itself. As described above, the selection can be based on pre-determined groups or sub-groups.

In some non-limiting embodiments of the method 400, the selecting the subgroup comprises selecting a plurality of multilayer preforms 50 having a same cavity identification number 25. In some embodiments of the present technology, the given shot group is selected every n^{th} cycles, the n^{th} cycles cycle being a pre-determined value.

In some non-limiting embodiments of the method 400, the selecting the subgroup comprises selecting a rolling sub-group of the multilayer preforms 50. This comprises selecting a first subgroup having a first set of cavity identification numbers 25, the first subgroup being selected from multilayer preforms 50 produced in a first injection molding cycle and then selecting a second subgroup having a second set of cavity identification numbers 25, the second set of cavity identification numbers 25 being different from the first set, the second subgroup being selected from multilayer preforms 50 produced in a second injection molding cycle in the injection molding machine 100.

In some non-limiting embodiments of the present technology, the at least one preform parameter is a coarse inspection parameter. In such a case, the method 400 comprises determining, by the computer-implemented apparatus 140, if the coarse inspection parameter falls outside a pre-determined range and the selecting the multilayer preforms 50 comprises selecting the at least one of the plurality of multilayer preforms 50 if the coarse inspection parameter falls outside the pre-determined range.

The method 400 then proceeds to execution of step 408.

Step 408 - transporting, by the at least one conveyance device, the at least one of the plurality of multilayer preforms to the at least one inspection device

At step 408, the multilayer preforms 50 selected for further inspection in step 406 are transported by the conveyance devices 206 and 208 to the inspection device 226.

When implementing the molding system 200, the method 400 further optionally comprises, between step 408 and 410, determining, by the black speck inspection device 224, that at least one of the multilayer preforms 50 contains one or more black speck defects and transporting the multilayer preforms 50 containing the black speck defects to the rejection path 295.

The method 400 then proceeds to execution of step 410.

Step 410 – determining, by the at least one inspection device, at least one attribute of the at least one multilayer preform

At step 410, the method 400 continues with determining, by the inspection device 226, at least one attribute of the multilayer preform 50. As described above, in the molding system 200 implements the optical coherence tomography device 235 for determining the at least one attribute. The attributes to be determined in step 410 have been enumerated above, but include at

least determining the three-dimensional extent of the core layer 40 of the multilayer preform 50 under inspection.

In some non-limiting embodiments of the present technology, the determining the one or more attributes comprises measuring the layers 20, 40 of the multilayer preform 50 at a plurality of pre-determined points about the preform 50.

In embodiments of the present technology where the preform parameter is the cavity identification number 25 and the determining the preform parameter comprises reading the cavity identification number 25 by the machine vision device 230, the selecting the at least one of the plurality of multilayer preforms 50 comprises selecting a subgroup of the plurality of multilayer preforms 50, the transporting the at least one of the plurality of multilayer preforms 50 comprises transporting the subgroup to the at least one inspection device 226. The method 400 then further comprises transporting the remainder of the plurality of multilayer preforms 50 to the production path 290.

In some embodiments of the present technology, the plurality of multilayer preforms 50 comprises a plurality of shot groups, each shot group being a group of multilayer preforms 50 produced during a single injection molding cycle of the injection molding machine 100 and the selecting the subgroup comprises selecting a given shot group of the plurality of shot groups.

In some non-limiting embodiments of the present technology, the method 400 further comprises receiving, by the computer-implemented apparatus 140, the preform parameter from the triage device 222 and receiving, by the computer-implemented apparatus 140, the determined one or more attributes of the multilayer preforms 50 from the inspection device 226. Then the method 400 further comprises correlating, by the computer-implemented apparatus 140, the preform parameter with the attributes of the multilayer preforms 50.

In such an embodiment, the method 400 may further comprise determining, by the computer-implemented apparatus 140, if the one or more attributes fall outside a pre-determined range (such as an acceptable value range) and generating, by the computer-implemented apparatus 140, an alert for the operator that the attributes fall outside the pre-determined range.

In such an embodiment, the method 400 may further or alternatively comprise, if the attributes fall outside the pre-determined range, adjusting, by the computer-implemented apparatus 140, at least one of the operational settings of the injection molding machine 100, based at least in part on the one or more attributes.

As such, from one perspective, embodiments of the present technology can be summarized as follows, structured in numbered clauses.

CLAUSE 1. A molding system (200, 300), comprising:

a molding machine (100) for producing a plurality of multilayer preforms (50), each of the plurality of multilayer preforms (50) comprising a core layer (40) and a skin layer (20) enveloping the core layer (40);

a triage device (222) operatively connected to the molding machine (100), the triage device (222) configured to receive at least a portion of the plurality of multilayer preforms (50) from the molding machine (100), the triage device (222) configured to:

determine, for each one of the plurality of multilayer preforms (50), at least one preform parameter (25), and

select at least one of the plurality of multilayer preforms (50) for inspection based at least in part on the at least one preform parameter (25); and

at least one inspection device (226) operatively connected to the triage device (222), the at least one inspection device (226) configured to:

receive the at least one of the plurality of multilayer preforms (50) from the triage device (222), and to

determine at least one attribute of the at least one of the plurality of multilayer preforms (50).

CLAUSE 2. The molding system (200, 300) of CLAUSE 1, further comprising at least one conveyance device (212), the at least one conveyance device (212) configured to transport a remainder of the plurality of multilayer preforms (50) not having been selected by the triage device (222) away from the molding machine (100).

CLAUSE 3. The molding system (200, 300) of CLAUSE 1 or 2, further comprising a black speck inspection device (224) configured to identify if a given preform (50) of the plurality of multilayer preforms (50) has black speck defects, the molding system (200, 300) being configured to send the given preform (50) to a rejection path (295) if the given preform (50) has black speck defects.

CLAUSE 4. The molding system (200, 300) of any one of CLAUSES 1 to 3, wherein the triage device (222) comprises a machine vision device (230) that is configured to determine the at least one preform parameter (25).

CLAUSE 5. The molding system (200, 300) of any one of CLAUSES 1 to 4, further comprising:

a singulator device (240) for aligning and orienting the plurality of multilayer preforms (50); and wherein:

the singulator device (240) is configured to create an order of the plurality of multilayer preforms (50) prior to the triage device (222) determining the at least one preform parameter (25); and

the triage device (222) is further configured to record the at least one preform parameter (25) of each preform (50) of the plurality of multilayer preforms (50) according to the order.

CLAUSE 6. The molding system (200, 300) of CLAUSE 5, further comprising:

a computer-implemented apparatus (140) operatively connected to the triage device (222) and the at least one inspection device (226); and wherein:

the triage device (222) is configured to transmit the at least one preform parameter (25) of the at least one of the plurality of multilayer preforms (50) to the computer-implemented apparatus (140);

the at least one inspection device (226) is configured to transmit the at least one attribute of the at least one of the plurality of multilayer preforms (50);

the computer-implemented apparatus (140) is further configured to correlate the at least one preform parameter (25) of the at least one of the plurality of multilayer preforms (50) with the at least one attribute.

CLAUSE 7. The molding system (200, 300) of CLAUSE 6, wherein the computer-implemented apparatus (140) is further configured to:

determine if the at least one attribute falls outside a pre-determined range; and

generate an alert for an operator that the at least one attribute falls outside the pre-determined range.

CLAUSE 8. The molding system (200, 300) of CLAUSE 6, wherein the computer-implemented apparatus (140) is further configured to:

determine if the at least one attribute falls outside a pre-determined range; and

adjust at least one operational setting of the molding system (200, 300), based at least in part on the at least one attribute.

CLAUSE 9. The molding system (200, 300) of any one of CLAUSES 1 to 8, wherein the preform parameter (25) is related to a cavity (118) of origin in the molding machine (100).

CLAUSE 10. The molding system (200, 300) of any one of CLAUSES 1 to 9, wherein the at least one preform parameter (25) is a cavity identification number (25), the cavity identification number (25) being imprinted on each one of the plurality of multilayer preforms (50).

CLAUSE 11. The molding system (200, 300) of any one of CLAUSES 1 to 10, wherein the at least one inspection device (226) comprises a first inspection device (222) and a second inspection device (226).

CLAUSE 12. The molding system (200, 300) of any one of CLAUSES 1 to 11, wherein:

the at least one inspection device (226) comprises an optical coherence tomography device (235) for measuring three-dimensional extent of the core layer (40); and

the optical coherence tomography device (235) is configured to determine a plurality of characteristics of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222), the plurality of characteristics including at least one characteristic of the core layer (40) of the at least one of the plurality of multilayer preforms (50).

CLAUSE 13. The molding system (200, 300) of CLAUSE 12, wherein the optical coherence tomography device (235) is configured to measure a three dimensional extent of the core layer (40) of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222).

CLAUSE 14. The molding system (200, 300) of CLAUSE 12, wherein the optical coherence tomography device (235) determines at least one of:

a thickness of the core layer (40),

a volume of the core layer (40),

a weight of the core layer (40),

an extent of the core layer (40) coverage,

presence of the core layer (40) at an angle (39) of a dome portion,

an average core layer (40) thickness around a circumference,

a location of a leading edge (42) of the core layer (40), and

a location of a trailing edge (44) of the core layer (40).

CLAUSE 15. The molding system (200, 300) of any one of CLAUSES 1 to 14, wherein the at least one inspection device (226) comprises at least one of:

an inspection device configured to determine a thread acceptability parameter of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222);

an inspection device configured to determine a transparency parameter of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222);

an inspection device configured to determine a weight of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222); and

an inspection device configured to determine a color spectrum parameter of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222).

CLAUSE 16. The molding system (200, 300) of any one of CLAUSES 1 to 14, wherein:

the at least one preform parameter is a coarse inspection parameter; and

if the at least one attribute falls outside a pre-determined range, the triage device (222) is further configured to select the at least one of the plurality of multilayer preforms (50) for inspection based at least in part on the coarse inspection parameter.

CLAUSE 17. The molding system (200, 300) of any one of CLAUSES 1 to 14, wherein:

the plurality of multilayer preforms (50) comprises a plurality of shot groups, each shot group being a group of multilayer preforms (50) produced during a single molding cycle; and

the triage device (222) is further configured to select a given shot group of the plurality of shot groups.

CLAUSE 18. The molding system (200, 300) of any one of CLAUSES 1 to 14, wherein:

the plurality of multilayer preforms (50) comprises a pre-determined group of multilayer preforms (50); and

the triage device (222) is further configured to select the pre-determined group from the plurality of multilayer preforms (50).

CLAUSE 19. The molding system (200, 300) of CLAUSE 18, wherein the triage device (222) is further configured to select the pre-determined group every n^{th} cycles, the n^{th} cycles cycle being a pre-determined value.

CLAUSE 20. The molding system (200, 300) of CLAUSE 18, wherein:

the triage device (222) is further configured to receive an instruction from an operator; and

the triage device (222) is configured to select the pre-determined group based at least in part on the instruction.

CLAUSE 21. The molding system of any one of CLAUSES 1 to 20, wherein the molding machine is an injection molding machine.

CLAUSE 22. A method (400) of inspecting multilayer preforms (50) by a molding apparatus (200, 300), the molding apparatus (200, 300) comprising a triage device (222) and at least one inspection device (226), the at least one inspection device (226) being operatively connected to the triage device (222) by at least one conveyance device (206, 208), the method comprising:

receiving a plurality of multilayer preforms (50) at the triage device (222);

determining, by the triage device (222), at least one preform parameter (25) for each one of the plurality of multilayer preforms (50);

selecting at least one of the plurality of multilayer preforms (50) based at least in part on the at least one preform parameter (25);

transporting, by the at least one conveyance device (206, 208), the at least one of the plurality of multilayer preforms (50) to the at least one inspection device (226); and

determining, by the at least one inspection device (226), at least one attribute of the at least one multilayer preform (50).

CLAUSE 23. The method (400) of CLAUSE 22, wherein:

the at least one preform parameter (25) is a cavity identification number (25); and wherein

the determining the at least one preform parameter (25) for each one of the plurality of multilayer preforms (50) comprises reading, by a machine vision device (230), the cavity identification number (25) on the each one of the plurality of multilayer preforms (50);

the selecting the at least one of the plurality of multilayer preforms (50) comprises selecting a subgroup of the plurality of multilayer preforms (50);

the transporting the at least one of the plurality of multilayer preforms (50) comprises transporting the subgroup to the at least one inspection device (226); and wherein the method further comprises:

transporting a remainder of the plurality of multilayer preforms (50) to a production path (290), the production path (290) including at least one conveyance device for transporting the remainder of the plurality of multilayer preforms (50).

CLAUSE 24. The method (400) of CLAUSE 23, wherein:

the plurality of multilayer preforms (50) comprises a plurality of shot groups, each shot group being a group of multilayer preforms (50) produced during a single molding cycle; and

the selecting the subgroup comprises selecting a given shot group of the plurality of shot groups.

CLAUSE 25. The method (400) of CLAUSE 24, wherein the given shot group is selected every n^{th} cycles, the n^{th} cycles cycle being a pre-determined value.

CLAUSE 26. The method (400) of CLAUSE 23, wherein the selecting the subgroup comprises selecting a plurality of multilayer preforms (50) having a same cavity identification number (25).

CLAUSE 27. The method (400) of CLAUSE 23, wherein the selecting the subgroup comprises:

selecting a first subgroup having a first set of cavity identification numbers (25), the first subgroup being selected from multilayer preforms (50) produced in a first molding cycle; and

selecting a second subgroup having a second set of cavity identification numbers (25), the second set of cavity identification numbers (25) being different from the first set, the second subgroup being selected from multilayer preforms (50) produced in a second molding cycle.

CLAUSE 28. The method (400) of any one of CLAUSES 22 to 27, further comprising:

orienting, by a singulator device (240), the plurality of multilayer preforms (50), the singulator device (240) creating an order of the plurality of multilayer preforms (50) before the determining of the at least one preform parameter (25) by the triage device (222); and

recording, by the triage device (222), the at least one preform parameter (25) of each preform (50) of the plurality of multilayer preforms (50) according to the order.

CLAUSE 29. The method (400) of any one of CLAUSES 22 to 28, wherein:

the at least one inspection device (226) comprises an optical coherence tomography device (235); and

the determining the at least one attribute of the at least one multilayer preform (50) comprises determining a three-dimensional extent of a core layer (40) of the at least one multilayer preform (50).

CLAUSE 30. The method (400) of any one of CLAUSES 22 to 28, wherein:

the at least one inspection device (226) comprises an optical coherence tomography device (235); and

the determining the at least one attribute comprises measuring layers (20, 40) of the at least one multilayer preform (50) at a plurality of pre-determined points about the at least one multilayer preform (50).

CLAUSE 31. The method (400) of any one of CLAUSES 22 to 30, further comprising:

determining, by a black speck inspection device (224) of the apparatus (200, 300), that at least one of the plurality of the multilayer preforms (50) contains black speck defects; and

transporting the at least one of the plurality of the multilayer preforms (50) containing the black speck defects to a rejection path (295) of the molding apparatus (200, 300), the rejection path (295) being configured for excluding multilayer preforms (50) from a production path (290).

CLAUSE 32. The method (400) of any one of CLAUSES 22 to 31, wherein:

the molding apparatus (200, 300) further comprises a computer-implemented apparatus (140) operatively connected to the triage device (222) and the at least one inspection device (226); and wherein the method further comprises:

receiving, by the computer-implemented apparatus (140), the at least one preform parameter (25) of the at least one of the plurality of multilayer preforms (50) from the triage device (222);

receiving, by the computer-implemented apparatus (140), the at least one attribute of the at least one of the plurality of multilayer preforms (50) from the at least one inspection device (226); and

correlating, by the computer-implemented apparatus (140), the at least one preform parameter (25) of the at least one of the plurality of multilayer preforms (50) with the at least one attribute of the at least one of the plurality of multilayer preforms (50).

CLAUSE 33. The method (400) of CLAUSE 32, further comprising:

determining, by the computer-implemented apparatus (140), if the at least one attribute falls outside a pre-determined range; and

generating, by the computer-implemented apparatus (140), an alert for an operator that the at least one attribute falls outside the pre-determined range.

CLAUSE 34. The method (400) of CLAUSE 32, further comprising:

determining, by the computer-implemented apparatus (140), if the at least one attribute falls outside a pre-determined range; and

adjusting, by the computer-implemented apparatus (140), at least one operational setting of a molding machine (100), based at least in part on the at least one attribute.

CLAUSE 35. The method (400) of any one of CLAUSES 22 to 34, wherein:

the at least one preform parameter is a coarse inspection parameter;

determining, by the computer-implemented apparatus (140), if the coarse inspection parameter falls outside a pre-determined range; and

the selecting the at least one of the plurality of multilayer preforms (50) comprises selecting the at least one of the plurality of multilayer preforms (50) if the coarse inspection parameter falls outside the pre-determined range.

Modifications and improvements to the above-described embodiments of the present technology may become apparent to those skilled in the art. The foregoing description is intended to be exemplary rather than limiting. The scope of the present technology is therefore intended to be limited solely by the scope of the appended claims.

The description of the embodiments of the present technology provides only examples of the present technology, and these examples do not limit the scope of the present technology. It is to be expressly understood that the scope of the present technology is limited by the claims only. The concepts described above may be adapted for specific conditions and/or functions, and may be further extended to a variety of other applications that are within the scope of the present technology. Having thus described the embodiments of the present technology, it will be apparent that modifications and enhancements are possible without departing from the concepts as described.

CLAIMS

1. A molding system (200, 300), comprising:

a molding machine (100) for producing a plurality of multilayer preforms (50), each of the plurality of multilayer preforms (50) comprising a core layer (40) and a skin layer (20) enveloping the core layer (40);

a triage device (222) operatively connected to the molding machine (100), the triage device (222) configured to receive at least a portion of the plurality of multilayer preforms (50) from the molding machine (100), the triage device (222) configured to:

determine, for each one of the plurality of multilayer preforms (50), at least one preform parameter (25), and

select at least one of the plurality of multilayer preforms (50) for inspection based at least in part on the at least one preform parameter (25); and

at least one inspection device (226) operatively connected to the triage device (222), the at least one inspection device (226) configured to:

receive the at least one of the plurality of multilayer preforms (50) from the triage device (222), and to

determine at least one attribute of the at least one of the plurality of multilayer preforms (50).

2. The molding system (200, 300) of claim 1, further comprising at least one conveyance device (212), the at least one conveyance device (212) configured to transport a remainder of the plurality of multilayer preforms (50) not having been selected by the triage device (222) away from the molding machine (100).

3. The molding system (200, 300) of claim 1 or 2, further comprising a black speck inspection device (224) configured to identify if a given preform (50) of the plurality of multilayer preforms (50) has black speck defects, the molding system (200, 300) being configured to send the given preform (50) to a rejection path (295) if the given preform (50) has black speck defects.

4. The molding system (200, 300) of any one of claims 1 to 3, wherein the triage device (222) comprises a machine vision device (230) that is configured to determine the at least one preform parameter (25).

5. The molding system (200, 300) of any one of claims 1 to 4, further comprising:

a singulator device (240) for aligning and orienting the plurality of multilayer preforms (50); and wherein:

the singulator device (240) is configured to create an order of the plurality of multilayer preforms (50) prior to the triage device (222) determining the at least one preform parameter (25); and

the triage device (222) is further configured to record the at least one preform parameter (25) of each preform (50) of the plurality of multilayer preforms (50) according to the order.

6. The molding system (200, 300) of claim 5, further comprising:

a computer-implemented apparatus (140) operatively connected to the triage device (222) and the at least one inspection device (226); and wherein:

the triage device (222) is configured to transmit the at least one preform parameter (25) of the at least one of the plurality of multilayer preforms (50) to the computer-implemented apparatus (140);

the at least one inspection device (226) is configured to transmit the at least one attribute of the at least one of the plurality of multilayer preforms (50);

the computer-implemented apparatus (140) is further configured to correlate the at least one preform parameter (25) of the at least one of the plurality of multilayer preforms (50) with the at least one attribute.

7. The molding system (200, 300) of claim 6, wherein the computer-implemented apparatus (140) is further configured to:

determine if the at least one attribute falls outside a pre-determined range; and

generate an alert for an operator that the at least one attribute falls outside the pre-determined range.

8. The molding system (200, 300) of claim 6, wherein the computer-implemented apparatus (140) is further configured to:

determine if the at least one attribute falls outside a pre-determined range; and

adjust at least one operational setting of the molding system (200, 300), based at least in part on the at least one attribute.

9. The molding system (200, 300) of any one of claims 1 to 8, wherein the preform parameter (25) is related to a cavity (118) of origin in the molding machine (100).

10. The molding system (200, 300) of any one of claims 1 to 9, wherein the at least one preform parameter (25) is a cavity identification number (25), the cavity identification number (25) being imprinted on each one of the plurality of multilayer preforms (50).

11. The molding system (200, 300) of any one of claims 1 to 10, wherein the at least one inspection device (226) comprises a first inspection device (222) and a second inspection device (226).

12. The molding system (200, 300) of any one of claims 1 to 11, wherein:

the at least one inspection device (226) comprises an optical coherence tomography device (235) for measuring three-dimensional extent of the core layer (40); and

the optical coherence tomography device (235) is configured to determine a plurality of characteristics of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222), the plurality of characteristics including at least one characteristic of the core layer (40) of the at least one of the plurality of multilayer preforms (50).

13. The molding system (200, 300) of claim 12, wherein the optical coherence tomography device (235) is configured to measure a three dimensional extent of the core layer (40) of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222).

14. The molding system (200, 300) of claim 12, wherein the optical coherence tomography device (235) determines at least one of:

a thickness of the core layer (40),

a volume of the core layer (40),

a weight of the core layer (40),

an extent of the core layer (40) coverage,

presence of the core layer (40) at an angle (39) of a dome portion,

an average core layer (40) thickness around a circumference,

a location of a leading edge (42) of the core layer (40), and

a location of a trailing edge (44) of the core layer (40).

15. The molding system (200, 300) of any one of claims 1 to 14, wherein the at least one inspection device (226) comprises at least one of:

an inspection device configured to determine a thread acceptability parameter of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222);

an inspection device configured to determine a transparency parameter of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222);

an inspection device configured to determine a weight of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222); and

an inspection device configured to determine a color spectrum parameter of the at least one of the plurality of multilayer preforms (50) conveyed from the triage device (222).

16. The molding system (200, 300) of any one of claims 1 to 14, wherein:

the at least one preform parameter is a coarse inspection parameter; and

if the at least one attribute falls outside a pre-determined range, the triage device (222) is further configured to select the at least one of the plurality of multilayer preforms (50) for inspection based at least in part on the coarse inspection parameter.

17. The molding system (200, 300) of any one of claims 1 to 14, wherein:

the plurality of multilayer preforms (50) comprises a plurality of shot groups, each shot group being a group of multilayer preforms (50) produced during a single molding cycle; and

the triage device (222) is further configured to select a given shot group of the plurality of shot groups.

18. The molding system (200, 300) of any one of claims 1 to 14, wherein:

the plurality of multilayer preforms (50) comprises a pre-determined group of multilayer preforms (50); and

the triage device (222) is further configured to select the pre-determined group from the plurality of multilayer preforms (50).

19. The molding system (200, 300) of claim 18, wherein the triage device (222) is further configured to select the pre-determined group every n^{th} cycles, the n^{th} cycles cycle being a pre-determined value.

20. The molding system (200, 300) of claim 18, wherein:

the triage device (222) is further configured to receive an instruction from an operator; and

the triage device (222) is configured to select the pre-determined group based at least in part on the instruction.

21. The molding system (200, 300) of any one of claims 1 to 20, wherein the molding machine (100) is an injection molding machine (100).

22. A method (400) of inspecting multilayer preforms (50) by a molding apparatus (200, 300), the molding apparatus (200, 300) comprising a triage device (222) and at least one inspection device (226), the at least one inspection device (226) being operatively connected to the triage device (222) by at least one conveyance device (206, 208), the method comprising:

receiving a plurality of multilayer preforms (50) at the triage device (222);

determining, by the triage device (222), at least one preform parameter (25) for each one of the plurality of multilayer preforms (50);

selecting at least one of the plurality of multilayer preforms (50) based at least in part on the at least one preform parameter (25);

transporting, by the at least one conveyance device (206, 208), the at least one of the plurality of multilayer preforms (50) to the at least one inspection device (226); and

determining, by the at least one inspection device (226), at least one attribute of the at least one multilayer preform (50).

23. The method (400) of claim 22, wherein:

the at least one preform parameter (25) is a cavity identification number (25); and wherein

the determining the at least one preform parameter (25) for each one of the plurality of multilayer preforms (50) comprises reading, by a machine vision device (230), the

cavity identification number (25) on the each one of the plurality of multilayer preforms (50);

the selecting the at least one of the plurality of multilayer preforms (50) comprises selecting a subgroup of the plurality of multilayer preforms (50);

the transporting the at least one of the plurality of multilayer preforms (50) comprises transporting the subgroup to the at least one inspection device (226); and wherein the method further comprises:

transporting a remainder of the plurality of multilayer preforms (50) to a production path (290), the production path (290) including at least one conveyance device for transporting the remainder of the plurality of multilayer preforms (50).

24. The method (400) of claim 23, wherein:

the plurality of multilayer preforms (50) comprises a plurality of shot groups, each shot group being a group of multilayer preforms (50) produced during a single molding cycle; and

the selecting the subgroup comprises selecting a given shot group of the plurality of shot groups.

25. The method (400) of claim 24, wherein the given shot group is selected every n^{th} cycles, the n^{th} cycles cycle being a pre-determined value.

26. The method (400) of claim 23, wherein the selecting the subgroup comprises selecting a plurality of multilayer preforms (50) having a same cavity identification number (25).

27. The method (400) of claim 23, wherein the selecting the subgroup comprises:

selecting a first subgroup having a first set of cavity identification numbers (25), the first subgroup being selected from multilayer preforms (50) produced in a first molding cycle; and

selecting a second subgroup having a second set of cavity identification numbers (25), the second set of cavity identification numbers (25) being different from the first set, the second subgroup being selected from multilayer preforms (50) produced in a second molding cycle.

28. The method (400) of any one of claims 22 to 27, further comprising:

orienting, by a singulator device (240), the plurality of multilayer preforms (50), the singulator device (240) creating an order of the plurality of multilayer preforms (50) before the determining of the at least one preform parameter (25) by the triage device (222); and

recording, by the triage device (222), the at least one preform parameter (25) of each preform (50) of the plurality of multilayer preforms (50) according to the order.

29. The method (400) of any one of claims 22 to 28, wherein:

the at least one inspection device (226) comprises an optical coherence tomography device (235); and

the determining the at least one attribute of the at least one multilayer preform (50) comprises determining a three-dimensional extent of a core layer (40) of the at least one multilayer preform (50).

30. The method (400) of any one of claims 22 to 28, wherein:

the at least one inspection device (226) comprises an optical coherence tomography device (235); and

the determining the at least one attribute comprises measuring layers (20, 40) of the at least one multilayer preform (50) at a plurality of pre-determined points about the at least one multilayer preform (50).

31. The method (400) of any one of claims 22 to 30, further comprising:

determining, by a black speck inspection device (224) of the apparatus (200, 300), that at least one of the plurality of the multilayer preforms (50) contains black speck defects; and

transporting the at least one of the plurality of the multilayer preforms (50) containing the black speck defects to a rejection path (295) of the molding apparatus (200, 300), the rejection path (295) being configured for excluding multilayer preforms (50) from a production path (290).

32. The method (400) of any one of claims 22 to 31, wherein:

the molding apparatus (200, 300) further comprises a computer-implemented apparatus (140) operatively connected to the triage device (222) and the at least one inspection device (226); and wherein the method further comprises:

receiving, by the computer-implemented apparatus (140), the at least one preform parameter (25) of the at least one of the plurality of multilayer preforms (50) from the triage device (222);

receiving, by the computer-implemented apparatus (140), the at least one attribute of the at least one of the plurality of multilayer preforms (50) from the at least one inspection device (226); and

correlating, by the computer-implemented apparatus (140), the at least one preform parameter (25) of the at least one of the plurality of multilayer preforms (50) with the at least one attribute of the at least one of the plurality of multilayer preforms (50).

33. The method (400) of claim 32, further comprising:

determining, by the computer-implemented apparatus (140), if the at least one attribute falls outside a pre-determined range; and

generating, by the computer-implemented apparatus (140), an alert for an operator that the at least one attribute falls outside the pre-determined range.

34. The method (400) of claim 32, further comprising:

determining, by the computer-implemented apparatus (140), if the at least one attribute falls outside a pre-determined range; and

adjusting, by the computer-implemented apparatus (140), at least one operational setting of a molding machine (100), based at least in part on the at least one attribute.

35. The method (400) of any one of CLAUSES 22 to 34, wherein:

the at least one preform parameter is a coarse inspection parameter;

determining, by the computer-implemented apparatus (140), if the coarse inspection parameter falls outside a pre-determined range; and

the selecting the at least one of the plurality of multilayer preforms (50) comprises selecting the at least one of the plurality of multilayer preforms (50) if the coarse inspection parameter falls outside the pre-determined range.

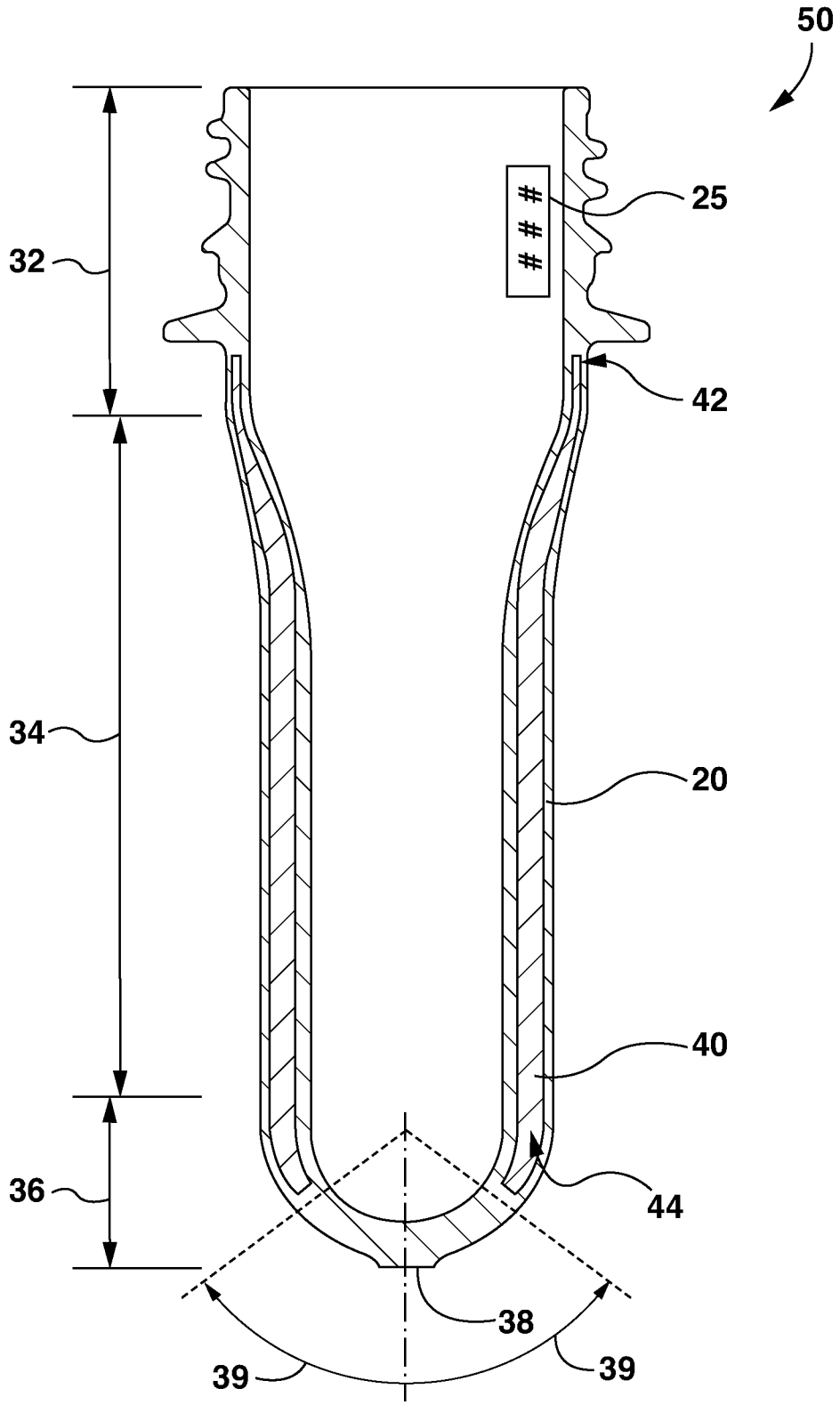


FIG. 1

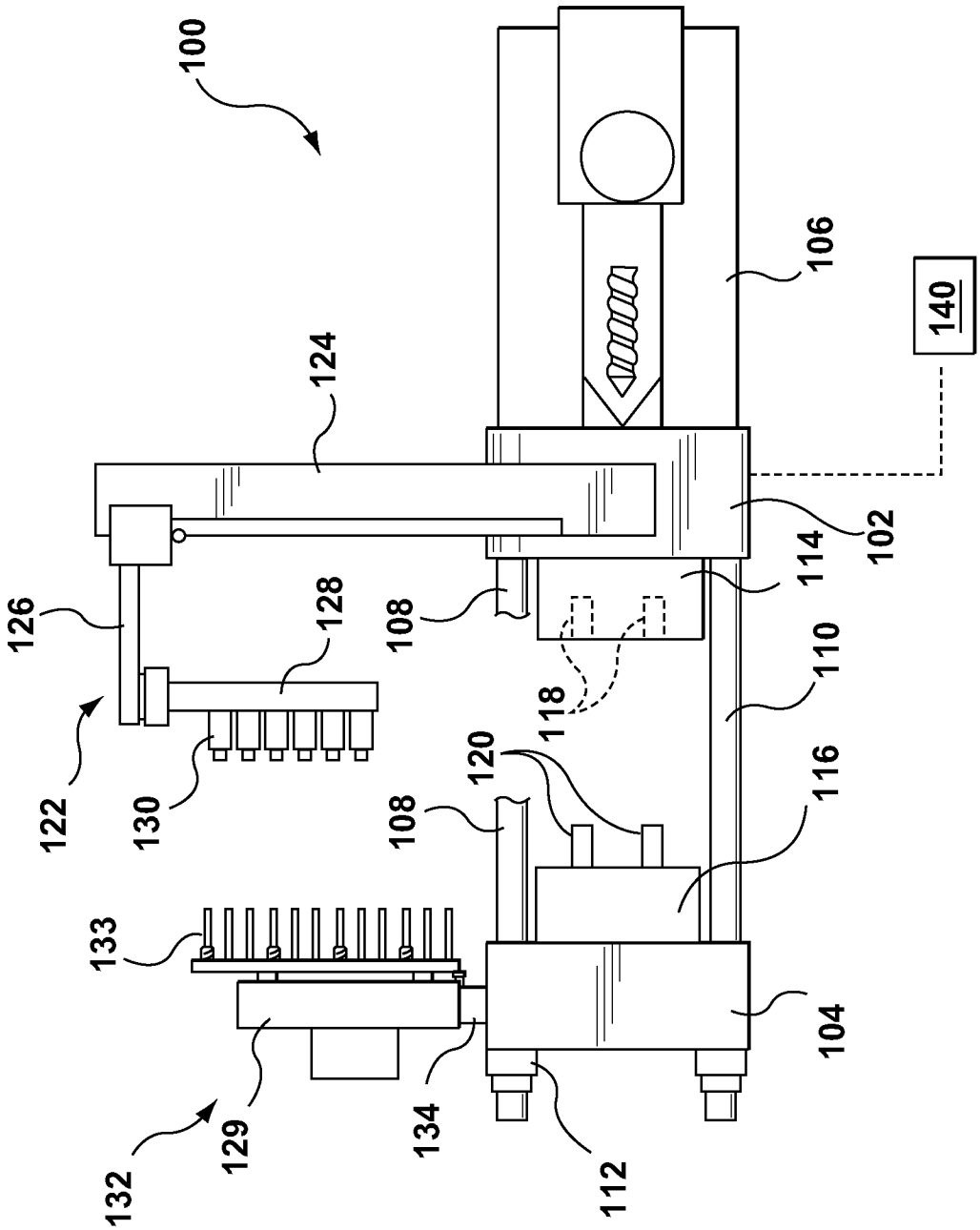

100
106
140
124
102
114
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118
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116
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132
112

FIG. 2

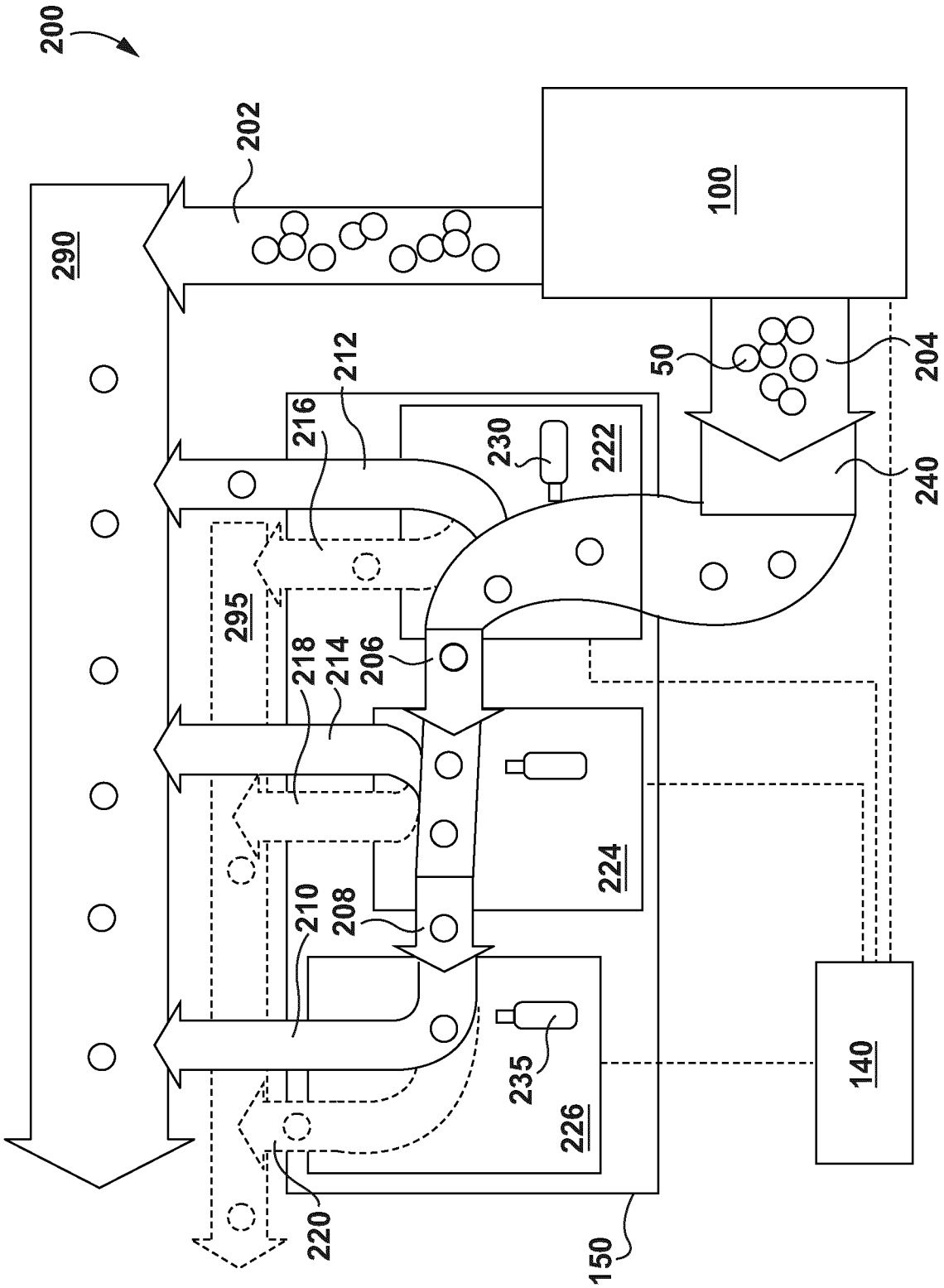

200
202
100
290
212
50
204
216
230
222
240
295
218
214
206
224
210
208
235
140
226
220
150

FIG. 3

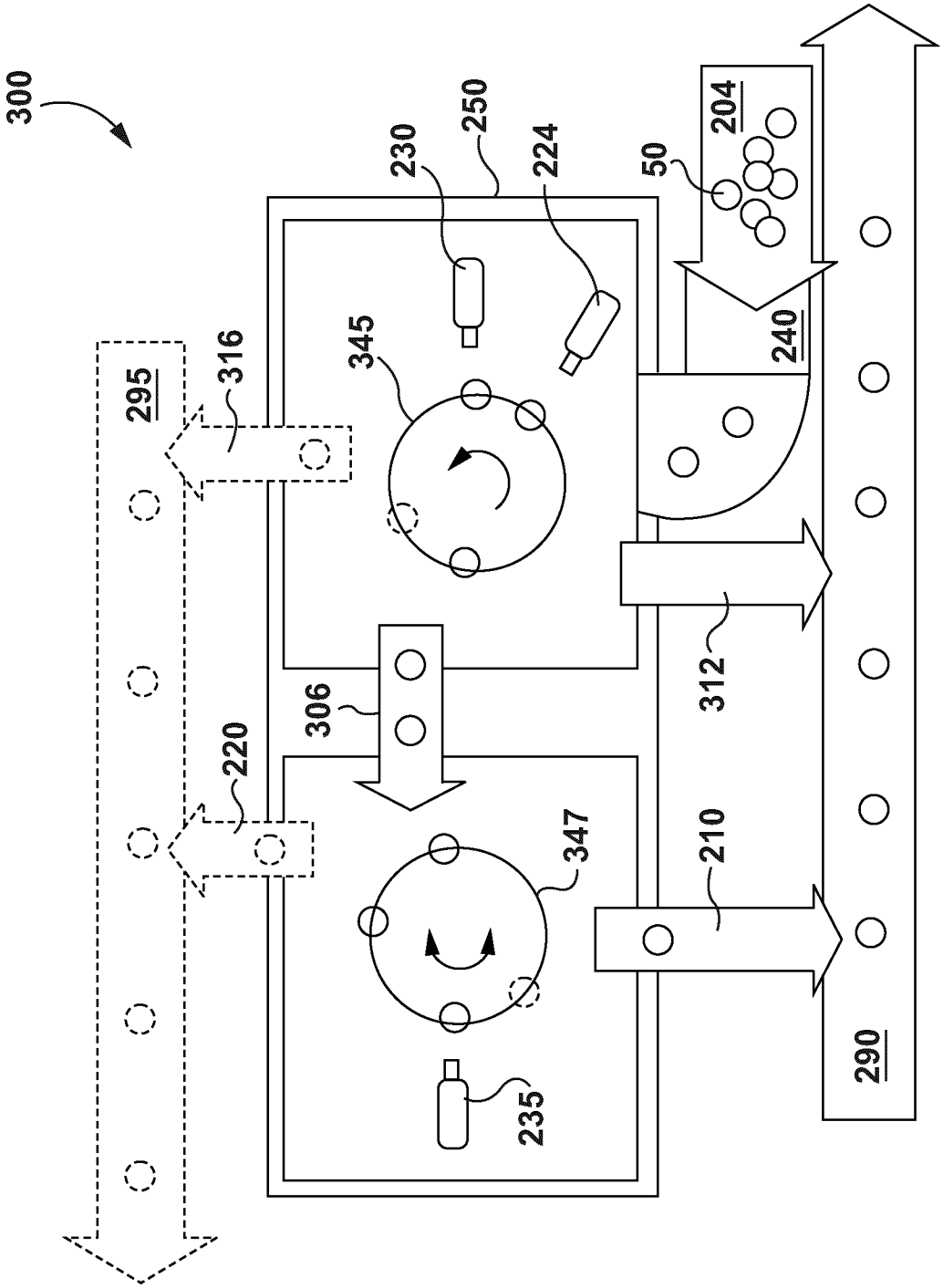

300
230
250
224
50
204
240
345
316
295
306
220
312
347
210
235
290

FIG. 4

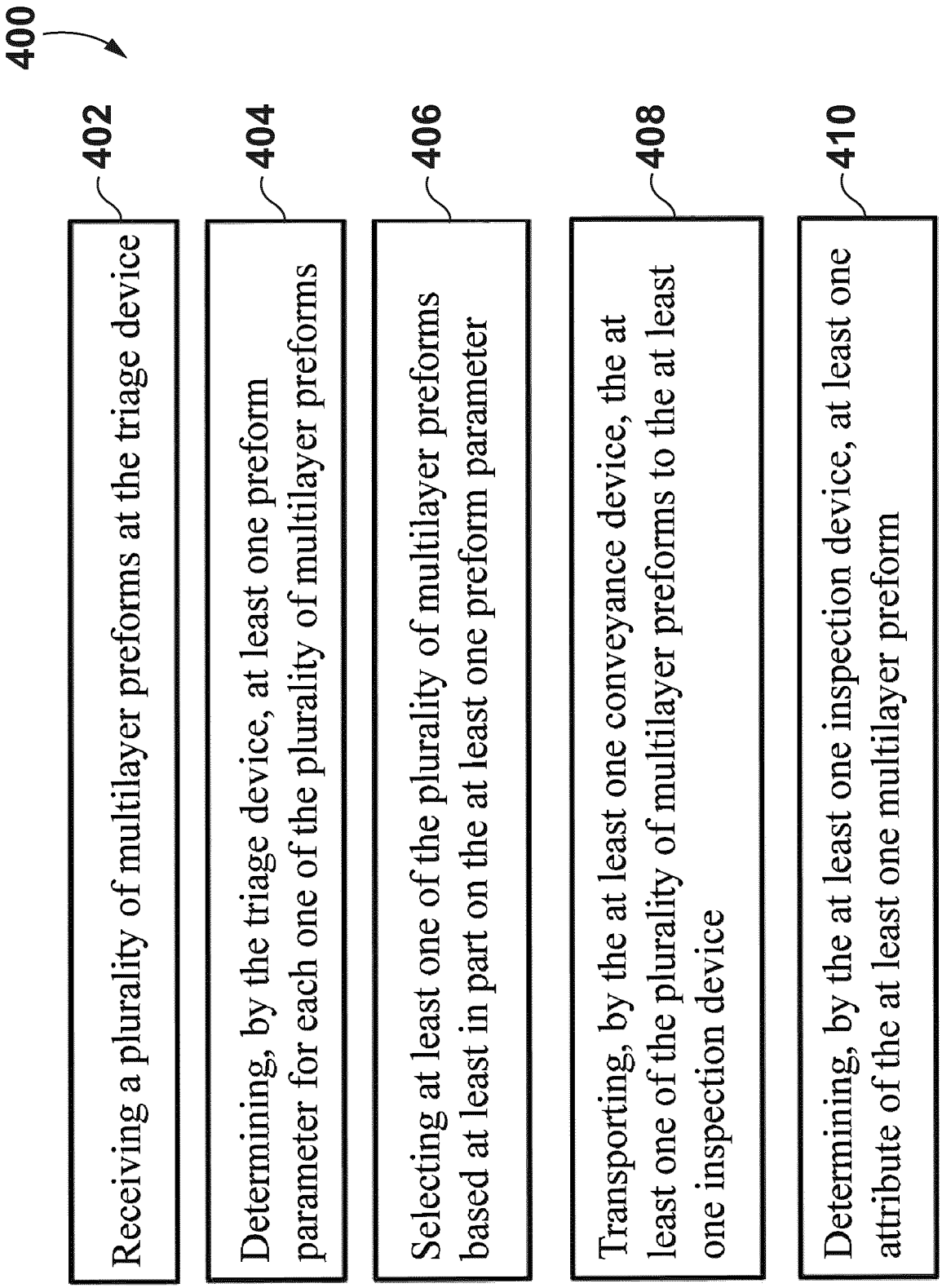

400
402
Receiving a plurality of multilayer preforms at the triage device
404
Determining, by the triage device, at least one preform parameter for each one of the plurality of multilayer preforms
406
Selecting at least one of the plurality of multilayer preforms based at least in part on the at least one preform parameter
408
Transporting, by the at least one conveyance device, the at least one of the plurality of multilayer preforms to the at least one inspection device
410
Determining, by the at least one inspection device, at least one attribute of the at least one multilayer preform

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2017/051066

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***B29B 11/14*** (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: ***B29B*** (2006.01); ***B29C*** (2006.01)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Questel-Orbit (FAMPAT) and Canadian Patent Database (Intellect) with key words such as: sort+, separat+, select+, inspect+, control, optical, reject, transport+, convey+, machine vision, molding or moulding, computer, triage, etc.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US7780898B2 (BIRCKBICHLER, C. A. et al.) 24 August 2010 (24-08-2010) *whole document*	1 - 35
A	US7204943B2 (COCHRAN, D. W. et al.) 17 April 2007 (17-04-2007) *whole document*	1 - 35
A	WO2014106297A1 (PANJWANI, V. G.) 10 July 2014 (10-07-2014) *whole document*	1 - 35
A	US5049750A (HOSHINO, m. ET AL.) 17 September 1991 (17-09-1991) *abstract; claims; Fig. 12*	1 - 35

☐ Further documents are listed in the continuation of Box C.

☑ See patent family annex.

*	Special categories of cited documents:
"A"	document defining the general state of the art which is not considered to be of particular relevance
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"O"	document referring to an oral disclosure, use, exhibition or other means
"P"	document published prior to the international filing date but later than the priority date claimed
"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&"	document member of the same patent family

Date of the actual completion of the international search 06 November 2017 (06-11-2017)	Date of mailing of the international search report 18 December 2017 (18-12-2017)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Authorized officer Julia Zhu (819) 639-7931

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2017/051066

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