

METHODS AND ASSEMBLIES FOR EFFICIENTLY PACKING PHARMACEUTICAL PRODUCTS**FIELD OF DISCLOSURE**

[0001] The present disclosure is directed to methods and assemblies for efficiently packing pharmaceutical products. A vial packaging line is exemplified.

BACKGROUND

[0002] The complexity of packaging pharmaceutical products is significantly increasing due to targeted medicines for specific diseases and the increased variety of worldwide markets. The result is an increase in Stock Keeping Units (SKUs) with lower number of units per batch, which is what is known as High Mix Low Volume (HMLV) products. Having an increased number of batches with small number of units to be processed reduced efficiencies as it increases the number of changeovers on the packaging line, reducing the time available for actual packaging. The current state for packaging lines is either a highly manual packaging process with a capacity of 1 to 10 Units per Minute (UPMs) or a highly automated process with a capacity of 70 UPM's to 1,000 UPMs. The challenge is that manual packaging lines tend to have quick changeovers as there is little equipment setup required but lack the capacity to meet HMLV demand unless the manual packaging lines utilize an extensive number of operators and significant square footage within the facility, usually designed for productions of less than 100,000 units per year. On the other hand, highly automatic packaging lines tend to have complex changeovers with multiple change parts to accommodate different SKUs and significant layout required to accommodate the queues necessary to support a high-speed production. In many instances, the changeover time exceeds the time to pack the actual product.

SUMMARY

[0003] Thus, there is a need for a highly efficient pharmaceutical product packaging line that reduces changeover times and reduces if not eliminates waste related to work in process inventory, defects, motion, and transportation and waiting times, particularly for capacities ranging between 10 and 70 UPM (e.g., consider that a manual process at 10 UPMs requires a repetitive task to be performed consistently every 6 seconds, which is extremely challenging).

[0004] In order to address this (and other needs) and to maximize the efficiencies in the packaging of HMLV products, the inventors designed and implemented a highly efficient packaging line that generally uses advanced technologies related to Advanced Robotics, Digital Twins, Additive Manufacturing and Artificial Intelligence (AI). The highly efficient packaging line also utilizes Lean Manufacturing concepts such as a U-Shape layout, adherence to a Takt Time, no Work in Process (WIP) inventory, Single Piece Flow, and minimum to no change parts.

[0005] First, the inventors defined the problem statement the line was intended to solve and delineated a high-level diagram with the example process flow for a pharmaceutical product packaging line 100 shown in FIG. 1. In the example process flow shown in FIG. 1, the line 100 is configured to pack pharmaceutical products in vials ranging from 6cc to 50cc in a configuration with plastic trays in side-loading cartons including one or two inserts. The line 100 is also configured to apply the primary label to the vial prior to packaging and will apply a Carton Closure Label (CCL) at each end. The process flow has a "U" shape to minimize personnel movement within the line. The tasks were divided such that each one of them was consistently performed aligned with a Takt Time of 3 seconds for a design speed of 10 UPM's.

[0006] Next, the inventors refined the process line to visualize the required equipment. In particular, the inventors automated some of the process steps e.g., transfer and inspection using Collaborative Robots (COBOTs), while leaving more complex operations, e.g., loading, assembly, and packaging, to be performed manually. In turn, the inventors aimed to provide a line with at least an output of 10 UPM's and an overall equipment efficiency (OEE) of 40% to 60% for a throughput between 4 to 6 UPM.

[0007] Next, the inventors simulated the process line using Digital Twins in a computer model. The parameters used in the simulation were evaluated and optimized with Design of Experiment, varying operating parameters to determine impact in the OEE. The results of the simulation provided the design elements required to integrate the different elements and comply with the Takt Time. COBOTs were used for the handling and packaging of different components. An advance magnetic conveyor, essentially a 2D COBOT, was used to maintain a single piece flow with no WIP within stations. The information obtained from the Digital Twin also helped the inventors understand the headcount required for the line and defined the Standard Work they should follow.

[0008] Results from the simulation were challenged in a mock-up, where Additive Manufacturing concepts were applied, including the use of 3D printed components and rapid prototyping. Mockup studies revealed the feasibility of the design. The final design was completed, and the fabrication, integration and qualification phases started.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a high-level diagram of one example of a packaging assembly for efficiently packaging pharmaceutical products constructed in accordance with the teachings of the present disclosure;

[0010] FIG. 2 is a top view of the assembly, showing that the assembly including a product infeed and labeling system, a control and transport system, and a printing and aggregation system;

[0011] FIG. 3 is a close-up view of the components and operation of the product infeed and labeling system, the system including a product accumulator, a labeler and two collaborative robots ("COBOTS");

[0012] FIG. 4 is a close-up view of the components and operation of the control and transport system, and the printing and aggregation module, the transport system including a magnetic conveyor, a plurality of movers, a tray dispenser, and an insert dispenser;

[0013] FIG. 5 illustrates examples of different configurations of pharmaceutical products that can be assembled using the packaging assembly;

[0014] FIG. 6 is a perspective view of one example of the product accumulator that can be employed in the product infeed and labeling system;

[0015] FIG. 7 is a perspective view of one example of the labeler that can be employed in the product infeed and labeling system;

[0016] FIG. 8 is a plan view of examples of a stator and a mover that can be employed in the control and transport system;

[0017] FIG. 9 illustrates how the packaging assembly can be configured to at least partially automatically package vials in pre-formed trays into cartons;

[0018] FIG. 10 illustrates how the packaging assembly can be configured to at least partially package onbody injectors;

[0019] FIG. 11 illustrates how the packaging assembly can be configured to at least partially automatically package two-packs of syringes;

[0020] FIG. 12 illustrates how the packaging assembly can be configured to at least partially automatically package vials into cartons with labels thereon;

[0021] FIG. 13 illustrates how the packaging assembly can be configured to at least partially automatically package vial kits;

[0022] FIGS. 14-18 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and is configured to move vials from the product accumulator to a conveyor of the labeler;

[0023] FIGS. 19-22 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and is configured to move vials from the labeler to a multi-tray fixture coupled to one of the movers on the magnetic conveyor;

[0024] FIGS. 23-26 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and is configured to insert inserts from the insert dispenser into a respective tray on the magnetic conveyor;

[0025] FIGS. 27-30 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and is configured to remove packaged pharmaceutical products from a fixture on the magnetic conveyor and deposit the products onto a weight platform;

[0026] FIGS. 31-34 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a tray fixture for carrying a tray on the magnetic conveyor;

[0027] FIGS. 35-37 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a box fixture for carrying a box on the magnetic conveyor;

[0028] FIGS. 38-41 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a guard for the conveyor of the labeler;

[0029] FIGS. 42-44 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a gripper cover for a camera utilized in the packaging assembly;

[0030] FIGS. 45-47 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a sensor holder for a sensor for the labeler;

[0031] FIGS. 48-50 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a sensor holder for a sensor for verifying the presence of a tray in a tray fixture coupled to the magnetic conveyor prior to vial placement in the tray;

[0032] FIGS. 51-53 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a sensor holder for a sensor for verifying the presence of a tray in a tray fixture coupled to the magnetic conveyor prior to an insert being disposed in the tray;

[0033] FIGS. 54-56 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a sensor holder for a sensor for verifying the removal of the tray from the tray fixture;

[0034] FIGS. 57-62 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a hinge system for the tray dispenser;

[0035] FIGS. 63-65 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure, the accessory taking the form of adjustment tools for the labeler;

[0036] FIGS. 66-70 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure, the accessory taking the form of adjustment tools for the insert dispenser;

[0037] FIGS. 71-75 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure, the accessory taking the form of adjustment tools for the tray dispenser;

[0038] FIGS. 76 and 77 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure, the accessory taking the form of adjustment tools for the conveyor of the labeler;

[0039] FIGS. 78 and 79 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a pusher for the insert dispenser;

[0040] FIGS. 80 and 81 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a box for mounting a push button;

[0041] FIGS. 82 and 83 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a conveyor stop for the labeler;

[0042] FIGS. 84 and 85 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a handle for the insert dispenser;

[0043] FIGS. 86-89 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a vial gripper that is configured to move vials from the product accumulator to a conveyor of the labeler;

[0044] FIGS. 90-92 illustrate another example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a tray fixture for carrying a tray on the magnetic conveyor;

[0045] FIGS. 93 and 94 illustrate one example of an accessory that is constructed in accordance with the teachings of the present disclosure and takes the form of a mount for a vial sensor for detecting the presence of a vial at the entrance of the labeler.

DETAILED DESCRIPTION

[0046] Through the process briefly summarized above, the inventors developed the pharmaceutical product packaging line disclosed herein. The pharmaceutical product may be in liquid or solid form and is contained within a drug product storage device, such as a vial, or a drug delivery device, such as an injection device, for automatic administration or self-administration by the user or by trained healthcare professionals (e.g., caregivers, nurses, doctors). Such delivery devices include pre-filled syringes having components separate or together, single-use, disposable injectors, multiple-use reusable injectors, autoinjectors, pen-type injectors, and the like. Other components or materials useful or necessary for the use of the product by the patient or trained healthcare professional may be required to be included as well. These devices must be packaged to provide protection for the device and convenience for storage and transportation. A packaging line combines the pharmaceutical product in its device along with any additional components and packages them into trays, inserts, boxes, or other means to contain and protect the device and components.

[0047] The pharmaceutical product packaging line disclosed herein, one example of which is generally illustrated in FIGS. 2-4 as line 200, is a flexible packaging line that involves a semi-automatic configuration with both automated and manual stations. The packaging line 200 generally includes an assembly of different systems or modules, namely a Pharmaceutical Product Infeed and Labeling System 204, a Transport and Control System 208, a Carton Module, and a Carton Printing and Aggregation System 212, such that the packaging line 200 provides the flexibility to handle several variations of product containers, components, and packaging formats.

[0048] As best illustrated in FIG. 3, the Pharmaceutical Product Infeed and Labeling System 204 generally includes one (1) Pharmaceutical Product (e.g., Vial) Infeed Accumulator 300, one (1) Labeler 304, and two (2) Collaborative Robots (COBOTS) 308, 312. The Accumulator 300 is operated and loaded by the operator (Operator #1). The Labeling System is controlled by the

Control System 208. The Control System 208 directs the first Collaborative Robot (COBOT #1) 308 to transfer (pickup and loading) the pharmaceutical products from the Accumulator 300 to the Labeler 304. The Labeler 304 places the label onto each pharmaceutical product and a first Visual Inspection System 699 inspects the product for label presence. Optionally, the label may also be manually or automatically inspected for defects (e.g., to determine whether the proper label has been applied). The second Collaborative Robot (COBOT #2) 312 is directed by the Control Module 208 to transfer the pharmaceutical products from the Labeler outfeed area to the downstream process or to an eject bin in case of failed inspection results. The Labeler 304 within the Pharmaceutical Product Infeed and Labeling System 204 includes a local physical display, but controls of the interface are generally entirely handled by the Control Human Machine Interface (HMI) within the Base Frame of the Control System 208.

[0049] As best illustrated in FIG. 4, the Transport and Control System 208 generally includes one (1) Control Module (main HMI), two (2) Collaborative Robots (COBOTs) 400, 402, one (1) magnetic surface transport (magnetic conveyor) 404 including a plurality of stators 406 and a plurality of movers 408 for the products, one (1) tray dispenser (or feeder) 412, one (1) insert dispenser (or feeder) 416, and one (1) Weight Station 420. The Control Module manages the Labeling System 204 and the Transport System 208 to initiate production batches by, for example, downloading recipes / formats and displaying alarms. The Transport System 208 is designed to be adjusted automatically and/or mechanically, to different presentations / formats. Preferably, the Transport System 208 features identical modules of 4 stators 406 that can be arranged in any configuration as long as they are side by side. The Transport System 208 transports pre-formed trays dispensed to the movers 408 (e.g., by the tray dispenser 412, which receives a plurality of trays for the pharmaceutical products) to the next automated station. The Labeling System 204 is connected to the Transport System 208. The Collaborative Robot (COBOT#2) 312 from the Labeling System 204 loads the labeled pharmaceutical products into pre-formed trays at the loading position of the Transport System 208. Each pre-formed tray will be transported by the magnetic conveyor 404 to a second Visual Inspection System 701 whereby the labeled product in the tray will be inspected for label presence. In some examples, the second Visual Inspection System 701 is redundant to the first Visual Inspection System 699. The first Collaborative Robot (COBOT #3) 400 in the Transport System 208 retrieves inserts (e.g., leaflets) from the insert dispenser, inspects the retrieved inserts for conformation to the prescribed recipe (for example, leaflets/insert item number (No read / QA Lock)) using a third Visual Inspection System, and places the inserts that pass inspection into the pre-formed trays with the labeled pharmaceutical product. If the insert inspection fails (because, for example, the retrieved insert does not have the correct item number), the component is rejected. The system is preferably capable of placing up to two (2) inserts according to the packaging format, though it is possible that the system may place more than two inserts into each of the pre-formed trays. The pre-formed trays will in turn be transported by the magnetic conveyor 404 to a manual station 424 whereby dispensing cartons can be formed and the trays can be inserted into a respective dispensing carton by an operator (Operator #2).

[0050] In this example, one or more operators can perform one or more tasks at the manual station 424: (1) carton forming, which involves picking up flat cartons from a supply cart for individual cartons, verifying the cartons to confirm that the cartons are the correct cartons (e.g., using barcode or RFID scanners), and forming the dispensing carton by closing the bottom tab; (2) placing the formed dispensing carton in a work in process (WIP) area; (3) retrieving a carton from the WIP area, retrieving a tray assembly from one of the movers, and placing the tray assembly inside the carton; (4) closing the carton (e.g., by closing the top lip) and placing the closed carton on another one of the movers or at a closure label station; and (5) attaching the closure labels to the bottom and the top of the dispensing pack carton. The dispensing pack will remain sealed once closure labels are applied at the closure label station. After the closure labels are applied, the operator places the sealed dispensing cartons on the magnetic surface transport, which will transfer the components to the Weight Station 420.

[0051] In other examples, however, one or more of these steps can be automated. For example, carton closure can be achieved with the combination of an additional COBOT for carton handling and a 3D printed fixture to close the carton. In that example, the COBOT will pick up a flat carton, will open the flat carton, and will slide against the 3D printed fixture. As the COBOT slides the flat carton, the fixture will force the flaps and lid to close. The COBOT will keep the open box with a closed end in one arm. With the other arm, the COBOT will pick up the pharmaceutical product and the plastic tray with the inserts from the magnetic conveyor and will insert everything into the box. Carton formation can be similarly performed with a mirror image fixture. For example, flat cartons can be loaded onto a custom-made dispenser with 2 sides, such that new cartons can be loaded in one side while the COBOT picks up cartons from the other side without interruptions to the operation.

[0052] The Pharmaceutical Product and Labeling module 204 and the Transport System 208 shown in FIGS. 2-4 generally produce products at a capacity of ten (10) units per minute. The speed is set by mode of operation. At the same time, the packaging line 200 can handle more than 50 different product SKUs (e.g., vials ranging from 6cc to 50cc) with only two change parts, one at the labeler 304 and the other being a fixture coupled to the mover of the magnetic conveyor. The packaging line 200 is designed to run in a continuous motion to meet a product yield of 98% or higher. The equipment scrap rate for glass events is designed to run the lowest glass breakage / damage rate and false eject inspection.

[0053] The Transport System 208 has the capability to handle all types of different configurations of pharmaceutical products, trays, inserts/leaflets, and dispensing packs, for example, any of the vials, trays, inserts, and dispensing packs shown in FIG. 5. These components travel through packaging lines 200 via the movers 408 of the Transport System 208, which are movable in the x-direction and the y-direction and via the COBOTs, each of which preferably has seven (7) axes of motion (but may, in some cases, have less than six axes of motion or less than six (6) axes of motion).

[0054] In addition, the Transport System 208 may include a plurality of different fixtures that are removably coupled to the movers and are designed to handle different sizes and/or shapes of trays (or other pharmaceutical products).

[0055] All variable adjustments of the packaging line 200 are quantifiable and repeatable with the use of scales or digital indicators. These variables are controlled based on the system recipe obtained by the Control Module. The Control Module will also detect any abnormal conditions or movement, and the Control Module may trigger an alarm responsive to any detected abnormal conditions or movement. For example, the Control Module can detect movement changes in the Transport System 208 and monitor the temperature of the components in the Transport System 208.

[0056] Any required changeover (e.g., from one pharmaceutical product to another) in the packaging line 200 is generally designed to be performed by a trained operator (or two). The changeover time will generally be thirty (30) minutes or less for the Pharmaceutical Product Infeed and Labeling System 204, as the trained operator will only at a maximum need to change the drive roller for the Labeler 304 (e.g., when the packaging line 200 will run 6cc, 6 R, or 10cc EU vials) and to adjust the position of the upright post assembly, the conveyor, the turning roller, and the guide rail within the Pharmaceutical Product Infeed and Labeling System 204. Meanwhile, the changeover time will generally be fifteen (15) minutes or less for the Transport System 208, as the trained operator will at a maximum only need to change one of the fixtures (e.g., the multi-tray fixture illustrated in FIGS. 90-92 for recipes with 6cc or 6R vials with big trays) no parts will need to be changed in the Transport System 208. Setup parameters for the different pharmaceutical packaging line 200 configurations are stored in a configuration file (e.g., by the Control Module). Each recipe is unique and contains all electrical, mechanical, and pneumatic reference settings needed to set the equipment properly for each configuration.

[0057] Optionally, the packaging line 200 also includes two (2) water coolant systems coupled to (e.g., integrated with) the Transport System 208 in order to reduce heat generated by the magnetic conveyor 404 and the other components of the System

208. These water coolant systems are preferably located on the underside of the magnetic conveyor 404. As exemplified herein, each water coolant system preferably takes the form of an industrial four (4) gallon cooler designed for water-cooled torches rated up to 600 amps, (e.g. COOLMATE® Miller Welding, Appleton, WI). Factory-set pressure relief valves (60 psi) maintains consistent pressure during operation and thermally protected ¼ hp motor guards against overheating.

[0058] One example of the product accumulator 300 utilized in the packaging line 200 shown in FIGS. 2-4 is illustrated in FIG. 6. The product accumulator 300 in this example is configured to receive vials, so is alternatively referred to herein as a Vial Infeed. The Vial Infeed 300 has four (4) vial trays 600, which may be referred to as "shelves". Each shelf 600 holds twenty (20) vials and the shelves are numbered 1 - 4 from the bottom to top, such that the Vial Infeed in this example can receive up to eighty (80) vials. In other examples, the product accumulator 300 can be a commercially available machine that is configured to receive vials, syringes, on-body monitors, autoinjectors, other drug devices, or combinations thereof. The product accumulator 300 may be located in the same room as the equipment used to manufacture the drug device(s) or may be located in a different room as the equipment. For example, the product accumulator 300 may be configured to receive autoinjectors and may be located in the same room or a different room than the equipment used to manufacture the autoinjectors. The operator loads the shelves 600 from top to bottom; when a shelf 600 is loaded, the operator will press a button with a steady red light belonging to the filled shelf 600. This will cause the shelf 600 to move to the middle position, where the indicating light for that shelf 600 will flash green. The shelf 600 will only move towards the COBOT 312 tasked with unloading the Vial Infeed 300 if the COBOT 312 is clear from the area and the shelf 600 above is not currently being unloaded by the COBOT 312. When a shelf 600 is being unloaded by the COBOT 312, the indicating light for that shelf 600 will be steady green. When the COBOT 312 is finished unloading a shelf 600, the empty shelf 600 will be moved back to the middle position, where the indicating light will flash red. The shelf 600 will only move back to be reloaded when there are no shelves 600 underneath it that need reloading.

[0059] FIG. 7 illustrates the labeler 304 utilized in the packaging line 200 shown in FIGS. 2-4 as well as the first visual inspection system 699, which is used for the labeler 304. The labeler 300 is used to attach the primary label to a variety of containers for pharmaceutical products. The labeler 304 is generally positioned downstream of the Accumulator 300. Labelers that can be used to label pharmaceutical products are commercially available, for example a horizontal wrap labeling system, e.g., the Auto Label Automatic Tabletop Labeling System, Model 390S (Ft. Pierce, FL). This labeling system is designed to label an array of small glass vials ranging from 6cc to 50cc in size. The labeling system utilizes a compact cartridge-style conveyor transport assembly 700 utilizing a dual linked-chain system with machined acetal transport rollers 704 to carry the product. As briefly discussed above, the COBOT 308 loads and unloads products onto the conveyor transport assembly 700 of the labeler 304. A primary fiberoptic sensor threaded into the inboard side guide rail of the labeler 304 detects each transport roller 704 and is used to reference conveyor indexing movement. When the conveyor 700 is moving, it is always indexing the distance between rollers unless a stop is involved. Normal indexing occurs so quickly that it is barely noticeable. When running the 50cc vial, for example, indexing changes to every other roller and the indexing is noticeable. Roller indexing uses a single reference for all stop delays supporting the whole conveyor stops required during operation and increases stop position accuracy. Movement of the conveyor 700 is stopped to accomplish the product loading, product unloading, label application, and inspection functions. A sensor at the entrance to the conveyor 700 detects a product is present when it is placed on the conveyor 700. The presence of a product at the entrance permits the conveyor 700 to move. The product is transported to the label application station 712 and another sensor detects the product is present, causing the conveyor 700 to stop. During label application, a label is dispensed and wrapped around the product. After the label is applied, movement of the conveyor 700 resumes until another sensor detects the product is at the label inspection station, i.e., immediately adjacent the first visual inspection system 699. The conveyor 700 is stopped during the inspection function. The first visual inspection system 699 includes a camera 716 that performs the label

inspection (for example, while the product (e.g., vial) is rotated by a DC motor driven inspection turning roller). The inspection results are provided to the system HMI and displayed or recorded as required by the system recipe. The system tracks production count and inspection pass and fail results. When label inspection is complete, movement of the conveyor 700 resumes, and the product is moved to the exit end (or outflow area) of the conveyor 700 where another sensor detects the product. Again, movement of the conveyor 700 is stopped, and the product is removed from the conveyor 700 by COBOT #2 312 as discussed above. Depending upon the result of the inspection, the pharmaceutical product will either be directed downstream or removed from the packaging line 200. This cycle repeats when a product is placed at the entrance end (or inflow area) of the conveyor 700.

[0060] The labeler 304 is designed to handle back-to-back loading of products on the transport rollers 704. The labeler 304 employs three (3) stepper motors for conveyor movement, label web movement, and the label wrap rotation. Rotation during label inspection is performed by, for example, a DC motor. Operation is coordinated by, for example, a programmable logic controller (PLC) for precise label placement, and consistency in performance. The system HMI provides menu-style display pages for parameters and set points setup for the labeling step. Alternatively or additionally, the recipe / formats can be accessed and changed via the Control Module. In addition, memory locations are reserved for storage settings recipes for running multiple product / label applications.

[0061] The labeler 304 is generally designed to minimize the generation of pharmaceutical product or label defects. The labeler 300 provides the necessary engineering controls in order to prevent label absence (a defect), label flagging (a defect), misaligned labeling (a defect), and mechanical overload (failure mode). Beneficially, the labeler 304 does not have heat sources within the product path that could adversely impact product quality. The labeler 304 design allows application of the labels to the specified pharmaceutical product.

[0062] The first visual inspection system 699 is used in association with the labeler. Visual inspection systems are known in the art and available commercially, for example, the In-Sight D900 Vision System with In-Sight ViDi deep learning, Cognex, Natick, MA, the AE3 camera, Cognex, Natick, MA, or the IV3-500CA camera, Keyence, Osaka, Japan. As is known in the art, the In-Sight D900 camera uses the familiar and easy-to-use In-Sight spreadsheet platform which simplifies application development and factory integration. The camera is designed with commercial vision software and configured to inspect all formats. The camera is positioned in the packaging line 200 so as to ensure a proper field of view to guarantee an effective inspection process without affecting the quality of the product. In operation, the first visual inspection system 699 verifies label presence (i.e., whether the label has been properly applied to each vial) using the Deep Learning Classify tool "Vidi Blue" (also referred to as the Deep Learning tool "Vidi Green"). The live inspection images and results can be accessed through the main HMI. The inspection results will in turn be displayed on the HMI screen of the camera 716. At the beginning of each batch, the main PLC sends to the camera 716 the open job command and the job number to be loaded for the operation, then the camera 716 confirms to the main PLC the job loaded by sending back the job number. Once the job is loaded and the camera 716 is online, the line 200 can start. When the pharmaceutical product (e.g., vial) reaches the position of the camera 716, a sequence of inspection triggers in conjunction with the turning roller motor of the labeler 304 will allow the product to rotate. The camera 716 obtains images for a predetermined time (which can be defined in the PLC of the labeler). Before the product finishes rotating (or before the predetermined time expires), the camera 716 sends the inspection results to the main PLC, then the camera 716 sends the results to the labeler 304. The labeler 304 stores the inspection results. Later, when the product reaches the exit position of the labeler 304, the labeler communicates with the responsible COBOT (COBOT 312) to act and pick up that product and place it into the respective tray. If, during the process, the first visual inspection system 699 determines that the product does not meet

the established inspection requirements (e.g., no label has been applied to the vial), then the COBOT 312 will pick up the product and place it into the eject bin.

[0063] The second visual inspection system 701 is also used in association with the labeler. In this example, the second visual inspection system 701 is redundant to the first visual inspection system 699. In this example, the second visual inspection system 701 takes the form of the Keyence IV3-500CA camera mentioned above, as the Keyence IV3-500CA camera is equipped with built-in AI specifically designed for presence and difference checking. The Keyence IV3-500CA camera automatically determines imaging conditions and detection settings. The all-in-one design includes a lens and illumination, eliminating the need to rely on separate devices. The Keyence IV3-500CA camera is positioned in the packaging line 200 so as to ensure a proper field of view to guarantee an effective inspection process without affecting the quality of the product. In operation, the second visual inspection system 701 verifies label presence (i.e., whether the label has been properly applied to each product). The inspection results will in turn be displayed on the HMI Screen. At the beginning of each batch, the main PLC sends to the camera the job number to be loaded for the operation, then the camera confirms to the PLC the job loaded by sending back the job number. Once the job is loaded and the camera is online, the line 200 can start. When the pharmaceutical product (e.g., vials) reaches the position of the camera, the camera takes one image and sends the inspection result to the main PLC. If the inspection result is positive and the second visual inspection system 701 determines that the inspection result meets the established inspection requirements (e.g., a label has been applied to the product), the pharmaceutical product will continue to the next station. But, if the inspection result does not meet the established inspection requirements, an alarm will be activated (e.g., displayed on the HMI screen) and the line 200 will stop. Then the operator will remove the pharmaceutical product from the fixture (e.g., the multi-tray fixture illustrated in FIGS. 90-92) coupled to one of the movers 408 of the magnetic conveyor 404 and carrying the pharmaceutical product. In the event the operator does not remove the pharmaceutical product from the fixture coupled to the mover 408 of the magnetic conveyor 404, an alarm will be activated (e.g., displayed on the HMI screen) and the line 200 will be stopped once the pharmaceutical product arrives at the next station.

[0064] Techniques that facilitate the development and/or modification of automated visual inspection are also known in the art, see for example, WIPO Published Application No. WO2021/225876, the entirety being hereby incorporated herein by reference.

[0065] As discussed above, the packaging line 200 disclosed herein generally includes four collaborative robots or COBOTs (the COBOTs 308, 312, 400, 402), and it will be appreciated that at least in this example, each of the four COBOTs is identical. Generally speaking, the COBOT is a two-armed industrial robot with an integrated controller. Each arm has seven (7) axes of motion, which gives an extra degree of freedom compared to conventional robot arms having six (6) axes of motion. Such COBOTs are commercially available. For use in this example is the ABB IRB 14000 YuMi Dual Arm COBOT, Zurich, Switzerland. The integrated controller in this example takes the form of the IRB 14000 integrated controller, which is based on the Standard IRC5 controller and contains all of the functionality needed to move and control the robot arms.

[0066] Turning back to FIGS. 2-4, the arrangement and functionality of the four COBOTs will now be described in greater detail. The first COBOT (COBOT 308) is configured to pick up pharmaceutical products from the infeed Accumulator 300 and transport them to the labeler conveyor 700, as discussed above. The second COBOT (COBOT 312) is configured to pick up pharmaceutical products from the outfeed area of the labeler 304, as also discussed above. The third COBOT (COBOT 400), which is generally part of the Main Control and Transport System 208, retrieves inserts from the insert dispenser 416, inspects the inserts, and, when the inserts pass the inspection, places them into the trays. Finally, the fourth (or last) COBOT (COBOT 402), which is also generally part of the Main Control and Transport System 208, is designed to transfer the loaded dispensing

pack from the magnetic conveyor 404 to the weighing scale, then transfer that pack to the downstream process or to the eject bin based on the weight of the loaded pack as determined by the weighing scale.

[0067] Each of the four COBOTs is fully integrated with material handling functions. On the other hand, each of the COBOTs has a visual inspection system like the first inspection system 699 described above embedded therein in order to perform inspections. In other words, each of the COBOTs may include one of the cameras described above (e.g., the Insight D900 camera). The following inspections are performed by the COBOT cameras: the camera of the infeed COBOT (COBOT 308) is configured to verify that the pharmaceutical products are properly positioned at the infeed Accumulator 304 for the pharmaceutical products. The camera of the outfeed COBOT (COBOT 312) is configured to verify that the correct fixtures are coupled to the movers 408 of the magnetic conveyor 404. The camera of the insert COBOT (COBOT 400) is configured to inspect the retrieved insert(s) during the process to ensure that the insert(s) correspond(s) to the pharmaceutical product in the tray. And finally, the camera of the COBOT 402 at the Weight Station is configured to verify the dispensing carton orientation prior to picking up the carton and placing the carton onto the weight platform. Beneficially, the field of view of each of the cameras is not blocked when the COBOTs are in operation.

[0068] The tray dispenser 412 is positioned immediately adjacent the magnetic conveyor 404 at a position upstream of the loading area of the magnetic conveyor 404. The tray dispenser 412 is adapted to receive a plurality of trays for the pharmaceutical products (or other products), respectively. When the tray dispenser 412 includes one or more of these trays, the tray dispenser 412 is configured to dispense the plurality of trays, one at a time, onto the magnetic conveyor. The tray dispenser 412 is preferably automated such that the tray dispenser 412 automatically dispenses the plurality of trays onto the magnetic conveyor 404 when the packaging line 200 is in operation. To this end, the tray dispenser 412 generally includes actuators (e.g., motors) that drive movement of the plurality of trays within the tray dispenser 412 and onto the conveyor 404, as well as one or more sensors that can, for example, detect the availability (or lack thereof) of a tray within the dispenser, detect when a tray has been dispensed onto the conveyor 404, and detect the presence (or lack thereof) of a tray on the magnetic conveyor 404 immediately adjacent the tray dispenser 412 (so as to prevent a tray from being dispensed onto or into another tray).

[0069] The insert dispenser 416 is also positioned immediately adjacent the magnetic conveyor 404, but at a position between the loading area and an unloading area of the magnetic conveyor 404. The insert dispenser 416 is adapted to receive a plurality of inserts (e.g., leaflets) for the plurality of trays. When the insert dispenser includes these inserts, COBOT 400 is configured to retrieve one or more of these inserts (to be disposed in one of the trays) and to inspect the retrieved insert(s) as discussed above. Like the tray dispenser 412, the insert dispenser 416 generally includes actuators (e.g., motors), which generally drive the inserts in the insert dispenser 416 to the pick-up position of the insert dispenser 416, as well as one or more sensors that can, for example, detect the availability (or lack thereof) of inserts in the dispenser 416, detect when one or more inserts are retrieved by COBOT 400, and detect when the one or more inserts are disposed in the respective tray by COBOT 400.

[0070] The Control Module is communicatively connected to each of the components of the packaging line 200, namely the Accumulator 300, the Labeler 304, the four COBOTs 308, 312, 400, 402, the visual inspection systems 699, 712, the magnetic conveyor 404, the tray dispenser 412, the insert dispenser 416, and the Weight Station 420. In turn, the Control Module is able to control each of these components of the packaging line 200. The Control Module generally controls the components of the packaging line based on one or more parameters of the products, such as, for example, a type, a size, a shape, a number, or combinations thereof of the pharmaceutical products. In other words, the Control Module will control the components of the packaging line 200 differently based on the type of product to be packaged (e.g., a vial as opposed to an autoinjector), a size of the product to be packaged, a shape of the product to be packaged, and/or the number of products to be packaged. To this end,

the Control Module feeds production batch information to the components and receives information from the components. For example, the Control Module sends recipe parameters to each of the components and receives confirmation of the recipe parameters from each of the components. The Control Module can also receive inspection results from the various visual inspection systems (which perform different inspections). When appropriate, the Control Module displays alarms to the operators of the packaging line 200. For example, the Control Module may display an alarm to the operators when the insert(s) retrieved by the third COBOT 400 are not the correct inserts (i.e., do not correspond to the product in the tray). The Control Module in this example preferably takes the form of one of the computer systems disclosed in WIPO Published Application No. WO2021/225876.

[0071] The magnetic conveyor 404 utilized in the packaging line of FIG.2 is defined by the plurality of stators 406 and the plurality of movers 408 (Planor Motors, Richmond, BC) briefly discussed above. Each of the movers 408 is operatively coupled to a respective one of the stators 406 via a three-dimensional magnetic field, as illustrated in, for example, FIG. 8. More particularly, each stator includes a base plate and a coil array (having a plurality of coils) while each mover includes a yoke plate and a permanent magnet array for generating the respective magnetic field. A gap 409 is formed between each mover 408 and the stator 406 to which each mover 408 is operatively coupled via the magnetic field, and the magnetic field is confined to that gap 409. The gap 409 is preferably 1 mm, though the gap 409 can vary as needed. When the permanent magnet generates a magnetic field, the associated coils with current in them will generate electromagnetic force and electromagnetic torque. The electromagnetic force and torque in turn drives movement of the movers 408 relative to the stators 406. A controller (e.g., a planar motor controller) that is operatively connected to the plurality of stators can in turn independently adjust each of the magnetic fields, thereby allowing the controller to independently control the position of each of the plurality of movers 408 relative to the plurality of stators 406, respectively. It will be appreciated that each of the movers 408 is freely movable (relative to the respective stator 406 to which the mover 408 is coupled) in the x-direction, the y-direction, and the z-direction, such that each mover 408 can move in a free-form pattern that includes not only straight lines but also diagonals and curves in other words, each mover 408 has six degrees of freedom.

[0072] As such, the movers 408 can move in two (2) horizontal directions (X) and (Y) instead of moving only in straight lines and can freely move from one station in the packaging line 200 to another. The mover 408 arrives to the predetermined processing area according to the configured parameters established in the system recipe. The magnetic conveyor 404 is fully integrated with the material handling functions and aligns the mechanism with the automatic stations (e.g., the Accumulator 300, the Labeler 304, the tray feeder 412, the insert feeder 416, and the Weight Station 420) by configured parameters. In addition, the controller (e.g., an IP67 controller) is based on advanced edge computing technology and manages the whole magnetic conveyor and supports the communication interface. The controller also performs current overload monitoring. An operation error alarm will be triggered after a current overload detected by the controller.

[0073] The Transport System 208 uses weight detection as a trigger for movement. When, for example, one of the operators loads a dispensing carton (filled with a labeled pharmaceutical product and an insert) on one of the movers 408 downstream of the manual station, the Transport System 208 will use consecutive consistent readings, not deviating more than 0.2 grams from one another, for example, as a trigger for being picked up by the fourth COBOT(COBOT 402). The COBOT 402 will verify the dispensing carton orientation prior to pick up. The COBOT 402 will transfer the dispensing cartons from the magnetic conveyor 404 to a weight platform, then to the downstream process or to the eject bin according to the results produced by the weight platform.

[0074] In other examples, the Weight Station 420 can also be replaced, and weight verification can instead be performed by the magnetic conveyor 404, whereby the power consumption required to maintain the movers 408 in position is proportional to the weight of the mover 408. The space left available can be used to add a custom-made CCL applicator. An infinite screw controlled by a servomotor will control the position of the cartons which will be held by a custom-made 3D printed fixture which can handle all carton sizes in scope. CCL application will be controlled with servomotors and will be applied as the cartons in the 3D printed fixture are transported in the infinite screw. A Visual Inspection System, using, for example, Deep Learning with Cognex ViDi, will inspect for correct CCL label placement, eliminating the need for 200% manual visual inspection. The automatization of the manual components will increase the capacity of the line from 10 UPM's to 20 UPM's, maintaining an OEE between 40% to 60%.

[0075] It will be appreciated that eject / reject bins are located on, at, or immediately adjacent the Labeler 304, the insert feeder 412, and the Weight Station 420. The bins will collect pharmaceutical products as well as insert or dispensing packs with products that fail any inspection in the stations mentioned above. The first visual inspection system 699 located at the labeler 304 inspects the pharmaceutical product for defects as described above. If the inspection fails, the outfeed COBOT (COBOT 312) will pick up the pharmaceutical product and place the product in the eject bin. The second visual inspection system 701 also inspects the pharmaceutical product for defects as described above. If the inspection fails, the operator will remove the tray including the product. If the operator replaces the removed tray with another tray with a pharmaceutical product, an alarm will activate when that tray reaches the insert station. At the insert feeding station, the COBOT 400 will inspect the inserts and if the inspection fails (e.g., the insert is an unreadable insert material), then the COBOT 400 will pick up and place the inserts that fail the inspection into the reject bin. Alternatively, if the inspection fails, the line may be halted until the inserts that fail the inspection are manually removed by the operator. At the Weight Station 400, if the unit does not meet the weight specification or threshold, COBOT 402 will pick up the unit and place the packaged product into an eject bin. The eject process does not cause any damage to the pharmaceutical product, insert or dispensing pack. The eject bin preferably includes a lock system with a key, as applicable per line / equipment design. Ejected units are removed automatically out of the product flow.

[0076] The Carton Printing and Aggregation System 212 is grouped into two (2) different packaging stations: a Carton Serialization Printing and Inspection Station and a Manual Case Aggregation Station. The printing and inspection of serialized and non-serialized dispensing cartons is performed at the Carton Printing/Inspection Station, which may be configured to meet the packaging requirements. In one example, the station includes one (1) carton printing/inspection machine (Ultimate Solutions Corp., Caguas, Puerto Rico) containing a packaging execution system (PES) to monitor and control actions related to packaging identification and tracking. Such systems are commercially available, such as those provided by Systech International, Princeton, NJ). The station also includes a carton transportation system and a laser printing system to print identification information on the product carton (for example, Domino CO2 laser printer, Domino, Gurnee, Ill.). The station also includes an inspection camera to verify any printed text or code, an eject station, as well as any other features required for safety and to support proper machine functioning in the facility. For example, the line 200 can be halted if the inspection camera detects that the insert is an incorrect insert material. The inspection camera is generally a different camera than the cameras of the first and second visual inspection systems described above. For serialized products, the dispensing carton printed information may include a serialized 2D code, GTIN number, and/or the serial number in addition to any other required information (lot number, expiration date, etc.). The inspection camera verifies the printed information. The eject station is located downstream of the camera to eject dispensing cartons with printing defects or identified as eject by the inspection system.

[0077] The Manual Case Aggregation Station may be configured to meet the packaging and facility requirements. In one example, the station includes at least one (1) portable ergonomic working station containing the packaging execution system, a

station scanner (for dispensing cartons and shipper/pallet labels), shipper/pallet label printers, along with any additional equipment required to support proper equipment functioning and packaging process. shippers, and pallets.

[0078] FIGS. 9-13 illustrate how the packaging line 200 of FIGS. 2-4 can be configured to at least partially automatically package various pharmaceutical products. FIG. 9, for example, illustrates how the packaging line 200 can be configured to at least partially automatically package vials 900 in pre-formed trays 904 into cartons 908. FIG. 10 illustrates how the packaging line 200 can be configured to at least partially automatically package onbody injectors 1000. FIG. 11 illustrates how the packaging line 200 can be configured to at least partially automatically package two-packs of syringes 1100. FIG. 12 illustrates how the packaging line 200 can be configured to at least partially automatically package vials 1200 into cartons 1204 with labels 1208 thereon. And FIG. 13 illustrates how the packaging line 200 can be configured to at least partially automatically package vial kits 1300.

[0079] It will be appreciated that the packaging line 200 of FIGS. 2-4 also employs a plurality of accessories for facilitating the packaging process described herein. Generally speaking, the plurality of accessories are manufactured for use in mounting components of the packaging line 200, by the COBOTs 308, 312, 400, and 408, or by the magnetic conveyor 404. The plurality of accessories include, for example, grippers (e.g., product or insert grippers), fixtures, guards, sensor holders, and covers. Exemplary accessories are illustrated in FIGS. 14-94 and briefly described below.

[0080] The plurality of fixtures are generally coupled to and carried by the plurality of movers 408, respectively. When the plurality of fixtures are coupled to the plurality of movers 408, respectively, each of the plurality of fixtures is configured to receive a respective one of the products and to carry the product to the desired location. Beneficially, because the plurality of fixtures are removable from the plurality of movers 408, respectively, the plurality of fixtures are interchangeable with a second plurality of fixtures that can be removably coupled to and carried by the plurality of movers 408, respectively. The second plurality of fixtures generally have a different shape and/or size than each fixture of the plurality of fixtures, such that the second plurality of fixtures can transport different products (e.g., products that are larger or smaller) than the plurality of fixtures. When, for example, the packaging line 200 is used for packaging trays having a first size and/or first shape, a plurality of first fixtures having a first size and/or first shape can be employed, whereas when the packaging line is used for packaging trays having a second size and/or second shape different from the first size and/or first shape, a plurality of second fixtures having a second size and/or second shape different from the first size and/or first shape of the first fixtures can be employed, and with very little changeover time needed to switch between the first and second fixtures.

[0081] Preferably, the plurality of accessories are created for the packaging line 200 using an additive manufacturing technique. As such, the plurality of accessories can be created based on one or more parameters of the pharmaceutical products to be packaged using the packaging line, such as, for example, a type, a size, a shape, or a quantity of the pharmaceutical products to be packaged. Thus, the plurality of accessories can be customized, on the spot, to match the pharmaceutical products to be packaged using the packaging line 200. Moreover, the plurality of accessories can also be created a number of different materials. For example, the plurality of accessories can be manufactured with a base build material (e.g., nylon) and one or more reinforcement materials (e.g., carbon fiber, Fiberglass, HSHT, Kevlar), such that the plurality of fixtures are strong but at the same time can be quickly and easily manufactured.

[0082] The additive manufacturing technique may be any additive manufacturing technique or process that builds three-dimensional objects by adding successive layers of material on a material. The additive manufacturing technique may be performed by any suitable machine or combination of machines. The additive manufacturing technique may typically involve or use a computer, three-dimensional modeling software (e.g., Computer Aided Design, or CAD, software), machine equipment,

and layering material. Once a CAD model is produced, the machine equipment may read in data from the CAD file and layer or add successive layers of liquid, powder, sheet material (for example) in a layer-upon-layer fashion to fabricate a three-dimensional object. The additive manufacturing technique may include any of several techniques or processes, such as, for example, a stereolithography ("SLA") process, a fused deposition modeling ("FDM") process, multi-jet modeling ("MJM") process, and a selective laser sintering ("SLS") process. In some embodiments, the additive manufacturing process may include a directed energy laser deposition process. Such a directed energy laser deposition process may be performed by a multi-axis computer-numerically-controlled ("CNC") lathe with directed energy laser deposition capabilities.

[0083] FIGS. 14-18 illustrate an example of an accessory in the form of a vial gripper 1400 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The vial gripper 1400 is configured to move vials from the vial feeder 300 to the labeler conveyor 700. To this end, the vial gripper 1400 is specifically designed to be coupled to and carried by the COBOT 308, as illustrated in FIG. 14.

[0084] FIGS. 19-22 illustrate another example of an accessory in the form of a vial gripper 1900 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The vial gripper 1900 is, however, configured to move vials from the labeler 304 to a multi-tray fixture (e.g., the multi-tray fixture illustrated in FIGS. 90-92) coupled to one of the movers 408 on the magnetic conveyor 404. To this end, the vial gripper 1900 is designed to be coupled to and carried by the COBOT 312, as illustrated in FIG. 19.

[0085] FIGS. 23-26 illustrate another example of an accessory in the form of an insert gripper 2300 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The insert gripper 2300 is configured to insert inserts (e.g., leaflets) from the insert dispenser 416 into a respective tray on the magnetic conveyor 404. To this end, the insert gripper 2300 is designed to be coupled to and carried by the COBOT 400, as illustrated in FIG. 23.

[0086] FIGS. 27-30 illustrate another example of an accessory in the form of an outfeed gripper 2700 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The outfeed gripper 2700 is configured to remove packaged boxes from a fixture on the magnetic conveyor 404 and deposit the packaged boxes onto the weight platform 420. To this end, the outfeed gripper 2700 is designed to be coupled to and carried by the COBOT 402, as illustrated in FIG. 27.

[0087] FIGS. 31-34 illustrate another example of an accessory in the form of a tray fixture 3100 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The tray fixture 3100 is configured to be coupled to one of the movers 408 on the magnetic conveyor 404 and is configured to carry a tray (and components of the product to be packaged) throughout part of the packaging line 200. The tray fixture 3100 can carry a number of different types of trays (e.g., 6cc, 6R, 10cc, 20cc, 20 R, 30cc, 30 R, and 50cc trays) without change over.

[0088] FIGS. 35-37 illustrate another example of an accessory in the form of a box fixture 3500 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The box fixture 3500 is configured to be coupled to one of the movers 408 on the magnetic conveyor 404 and is configured to carry a box (including the product) throughout part of the packaging line 200. The box fixture 3500 can carry a number of different types of boxes or cartons without change over.

[0089] FIGS. 38-41 illustrate another example of an accessory in the form of a guard 3800 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The guard 3800 is

configured to serve as a guard for the conveyor 700 of the labeler 304 and a mount for a vial sensor (for detecting the position of the vial) as vials transition through the labeler 304. The guard 3800 is configured to fine tune the angle of the reflective sensor such that the sensor can perceive the vials more accurately.

[0090] FIGS. 42-44 illustrate another example of an accessory in the form of a gripper cover 4200 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The gripper cover 4200 is configured to accommodate an offset camera (of one of the visual inspection systems 699, 701) in order to prevent grippers from the COBOT 312, for example, from obstructing the camera.

[0091] FIGS. 45-47 illustrate another example of an accessory in the form of a sensor holder 4500 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The sensor holder 4500 is configured to receive a labeler web presence sensor and to hold the sensor in a position that increases the accuracy of the labeler 304.

[0092] FIGS. 48-50 illustrate another example of an accessory in the form of a sensor holder 4800 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The sensor holder 4800 is configured to receive a sensor for verifying the presence of a tray in a tray fixture prior to vial placement into the tray.

[0093] FIGS. 51-53 illustrate another example of an accessory in the form of a sensor holder 5100 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The sensor holder 5100 is configured to receive a sensor for verifying the presence of a tray in a tray fixture prior to an insert being disposed in the tray.

[0094] FIGS. 54-56 illustrate another example of an accessory in the form of a sensor holder 5400 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The sensor holder 5400 is configured to receive a sensor for verifying the removal of the tray from the tray fixture by the operator, thereby allowing the tray fixture to be recirculated by the magnetic conveyor 404.

[0095] FIGS. 57-62 illustrate another example of an accessory in the form of a hinge system 5700 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. In particular, the hinge system 5700 is for the tray feeder 412. The hinge system 5700 is configured to enable reloading of the tray feeder 412 without losing the convenience of having rods as stack guides. The rods minimize the contact surface with the tray stack.

[0096] FIGS. 63-65 illustrate other examples of accessories in the form of different adjustment tools 6300 constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. Each adjustment tool 6300 is configured to facilitate set-up of guides of the labeler 304 (depending upon the specific products to be packaged) and reduce the change over time.

[0097] FIGS. 66-70 illustrate other examples of accessories in the form of different adjustment tools 6600 constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. Each adjustment tool 6600 is configured to facilitate set-up of stack guides of the insert feeder 416 (depending upon the specific products to be packaged) and reduce the change over time.

[0098] FIGS. 71-75 illustrate other examples of accessories in the form of different adjustment tools 7100 constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. Each

adjustment tool 7100 is configured to facilitate set-up of the stack guides of the tray feeder 412 (depending upon the specific products to be packaged) and reduce the change over time.

[0099] FIGS. 76 and 77 illustrate other examples of accessories in the form of different adjustment tools 7600 constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. Each adjustment tool 7600 is configured to facilitate set-up of the labeler conveyor 700 and reduce the change over time.

[00100] FIGS. 78 and 79 illustrate another example of an accessory in the form of a pusher 7800 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The pusher 7800 is specifically configured to be coupled to the insert feeder 416 to eliminate bending of the inserts in the insert feeder 416 when running the long insert configuration.

[00101] FIGS. 80 and 81 illustrate another example of an accessory in the form of a customized box 8000 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The customized box 8000 is configured to mount a push button 8004, which can be used to cause one of the COBOTs (COBOT 402, e.g.) to repeat the sequence of verifying the dispensing carton orientation and placing the carton onto the weight platform 420 when, for example, it is necessary to re-orient the dispensing carton, and cover the wiring coupling.

[00102] FIGS. 82 and 83 illustrate another example of an accessory in the form of a conveyor stop 8200 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The conveyor stop 8200 is configured to rest on top of the walls of the conveyor 700 of the labeler 304 and to fit snugly into one roller 704 of the conveyor 700.

[00103] FIGS. 84 and 85 illustrate another example of an accessory in the form of a handle 8400 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The handle 8400 is specifically configured for the insert feeder 416. The handle 8400 is configured to facilitate entry to the adjustment area and to provide rigidity to the cover, which is preferably made using a polycarbonate such as Lexan that serves to protect the inserts in the insert feeder 416.

[00104] FIGS. 86-89 illustrate another example of an accessory in the form of a vial gripper 8600 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The vial gripper 8600 is similar to the vial gripper 1900 of FIGS. 19-22 but is modified to facilitate a better vial placement on the tray from the labeler 304 to a multi-tray fixture coupled to one of the movers 408 on the magnetic conveyor 404.

[00105] FIGS. 90-92 illustrate another example of an accessory in the form of a tray fixture 9000 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The tray fixture 9000 is similar to the tray fixture 3100, in that the tray fixture 9000 is configured to be coupled to one of the movers 408 on the magnetic conveyor 404 and is configured to carry a tray (and components of the product to be packaged) throughout part of the packaging line 200. However, the tray fixture 9000 is specifically designed to carry a big tray for 6cc and 6R vials.

[00106] FIGS. 93 and 94 illustrate another example of an accessory in the form of a mount 9300 that is constructed in accordance with the teachings of the present disclosure and is specifically configured for use in the packaging line 200. The mount 9300 is specifically configured to be coupled to the labeler 304 for locating a vial sensor for detecting the presence of a vial at the entrance of the labeler 304.

[00107] As used herein, "pharmaceutical product" refers to large molecule or a small molecule drug products for therapeutic use. "Drug product" refers to the finished dosage form that may contain one or more drug substances in association with one or

more pharmaceutically or physiologically acceptable carriers, diluents and/or excipients. Small molecule drug products are low molecular weight chemically derived therapeutics. Large molecule drug products are high molecular weight biologically derived from biological organisms. Such large molecule therapeutics include, but are not limited to, proteins, peptides, vaccines.

[00108] "Protein" refers to a molecule comprising two or more amino acid residues joined to each other by peptide bonds. Proteins also include macromolecules having one or more deletions from, insertions to, and/or substitutions of the amino acid residues of the native sequence, that is, a polypeptide or protein produced by a naturally-occurring and non-recombinant cell; or is produced by a genetically-engineered or recombinant cell, and comprise molecules having one or more deletions from, insertions to, and/or substitutions of the amino acid residues of the amino acid sequence of the native protein. Proteins also include amino acid polymers in which one or more amino acids are chemical analogs of a corresponding naturally occurring amino acid and polymers. Polypeptides and proteins are also inclusive of modifications including, but not limited to, glycosylation, lipid attachment, sulfation, gamma-carboxylation of glutamic acid residues, hydroxylation and ADP-ribosylation.

[00109] As used herein, the term "isolated" means (i) free of at least some other proteins or polynucleotides with which it would normally be found, (ii) is essentially free of other proteins or polynucleotides from the same source, e.g., from the same species, (iii) separated from at least about 50 percent of polypeptides, polynucleotides, lipids, carbohydrates, or other materials with which it is associated in nature, (iv) operably associated (by covalent or noncovalent interaction) with a polypeptide or polynucleotide with which it is not associated in nature, or (v) does not occur in nature. The terms "isolated protein", "isolated recombinant protein", or "purified recombinant protein" may be used interchangeably and refer to a polypeptide or protein of interest, that is purified away from proteins or polypeptides or other contaminants that would interfere with its therapeutic, diagnostic, prophylactic, research or other use. Drug substances and drug products made from proteins derived from recombinant animal cell lines and may be referred to as "recombinant protein drug products" or "recombinant biologic therapeutics".

[00110] Proteins include, among other things, secreted proteins, non-secreted proteins, intracellular proteins or membrane-bound proteins. The protein(s) may be produced intracellularly or secreted into the culture medium from which it can be recovered and/or collected. Proteins include those that exert a therapeutic effect, for example, by binding a target, particularly a target among those listed below, including targets derived therefrom, targets related thereto, and modifications thereof. Proteins may include "antigen-binding proteins". Antigen-binding protein refers to proteins or polypeptides that comprise an antigen-binding region or antigen-binding portion that has a strong affinity for another molecule to which it binds (antigen). Antigen-binding proteins encompass antibodies, peptibodies, antibody fragments, antibody derivatives, antibody analogs, fusion proteins, including single-chain variable fragments (scFvs) and double-chain (divalent) scFvs, DARPins®, muteins, multispecific proteins, bispecific proteins, proteins derived from the xMAb® process, and chimeric antigen receptors (CARs or CAR-Ts) and T cell receptors (TCRs) among others.

[00111] "Multispecific", "multispecific protein", and "multispecific antibody" are used herein to refer to proteins that are recombinantly engineered to simultaneously bind and neutralize at least two different antigens or at least two different epitopes on the same antigen. For example, multispecific proteins may be engineered to target immune effectors in combination with targeting cytotoxic agents to tumors or infectious agents. These multispecific proteins have been found useful for a variety of applications, such as in cancer immunotherapy, by redirecting immune effector cells to tumor cells, modifying cell signaling by blocking signaling pathways, targeting tumor angiogenesis, blocking cytokines, and as pre-targeted delivery vehicles for drugs, such as delivery of chemotherapeutic agents, radiolabels (to improve detection sensitivity) and nanoparticles (directed to specific cells/tissues, such as cancer cells).

[00112] The most common and most diverse group of multispecific proteins are those that bind two antigens, referred to herein as “bispecific”, “bispecific proteins”, and “bispecific antibodies”. Bispecific proteins can be grouped in two broad categories: immunoglobulin G (IgG)-like molecules and non-IgG-like molecules. IgG-like molecules retain Fc-mediated effector functions, such as antibody -dependent cell mediated cytotoxicity (ADCC), complement-dependent cytotoxicity (CDC), and antibody-dependent cellular phagocytosis (ADCP), the Fc region helps improve solubility and stability and facilitate some purification operations. Non-IgG-like molecules are smaller, enhancing tissue penetration (see Sedykh et al., *Drug Design, Development and Therapy* 18(12), 195-208, 2018; Fan et al., *J Hematol & Oncology* 8:130-143, 2015; Spiess et al., *Mol Immunol* 67, 95-106, 2015; Williams et al., Chapter 4 1 Process Design for Bispecific Antibodies in Biopharmaceutical Processing Development, Design and Implementation of Manufacturing Processes, Jagschies et al., eds., 2018, pages 837-855. Bispecific proteins are sometimes used as a framework for additional components having binding specificities to different antigens or numbers of epitopes, increasing the binding specificity of the molecule.

[00113] The formats for bispecific proteins, which include bispecific antibodies, are constantly evolving and include, but are not limited to, quadromas, knobs-in-holes, cross-Mabs, dual variable domains IgG (DVD-IgG), IgG-single chain Fv (scFv), scFv-CFG KIH, dual action Fab (DAF), half-molecule exchange, kl-bodies, tandem scFv, scFv-Fc, diabodies, single chain diabodies (scDiabodies), scDiabodies-CFG, triple body, miniantibody, minibody, TriBi minibody, tandem diabodies, scDiabody-HAS, Tandem scFv-toxin, dual-affinity retargeting molecules (DARTs), nanobody, nanobody-HSA, dock and lock (DNL), strand exchange engineered domain SEEDbody, Triomab, leucine zipper (LUZ-Y), XmAb®, Fab-arm exchange, DutaMab, DT-IgG, charged pair, Fcab, orthogonal Fab, IgG(H)-scFv, scFV-(H)IgG, IgG(F)-scFv, IgG(FIH)-Fv, IgG(H)-V, V(H)-IgG, IgG(F)-V V(F)-IgG, KIH IgG-scFab, 2scFv-IgG, IgG-2scFv, scFv4-Ig, Zyboby, DVI-Ig4 (four-in-one), Fab-scFv, scFv-CH-CF-scFv, F(ab')₂-scFv2, scFv-KIH, FabscFv-Fc, tetravalent HCAb, scDiabody-Fc, diabody-Fc, intrabody, ImmTAC, HSABody, IgG-IgG, Cov-XBody, scFv-PEG-scFv2, bi-specific T cell engager molecules (BiTEs®) and half-life extended bispecific T cell engager molecules (HFE BiTEs) (Fan *supra*; Spiess *supra*; Sedykh *supra*; Seimetz et al., *Cancer Treat Rev* 36(6) 458-67, 2010; Shulka and Norman, Chapter 26 Downstream Processing of Fc Fusion Proteins, Bispecific Antibodies, and Antibody-Drug Conjugates, in *Process Scale Purification of Antibodies Second Edition*, Uwe Gottschalk editor, p559-594, John Wiley & Sons, 2017; Moore et al., *MAbs* 3:6, 546-557, 2011).

[00114] In some embodiments are included bispecific T cell engager molecules (BiTE®), recombinant protein constructs made from two flexibly linked antibody derived binding domains (see WO 99/54440 and WO 2005/040220). One binding domain of the construct is specific for a selected tumor associated surface antigen on target cells, such as EGFRvIII, MSFN, CDH19, D 3, CD19, CD33, CD38, DDL3, FFT3, CDH3, BCMA, PSMA, MUC17, Claudin 6, CFDN18.2, or CD70; the second binding domain is specific for CD3, a subunit of the T cell receptor complex on T cells. The BiTE® molecules may also include the ability to bind to a context independent epitope at the N-terminus of the CD3s chain (WO 2008/119567) to more specifically activate T cells. Half-life extended BiTE® molecules are BiTE® molecule constructs that include fusion of the small bispecific antibody construct to larger proteins, which preferably do not interfere with the therapeutic effect of the BiTE® molecule construct. Examples include bispecific T cell engager molecules comprising bispecific Fc-molecules e.g. described in US Published Application Nos: US 2014/0302037 and US 2014/0308285, and WIPO Published Applications WO 2014/151910 and WO 2015/048272. An alternative strategy is the use of human serum albumin (HAS) fused to the bispecific molecule or the mere fusion of human albumin binding peptides (see e.g. WO2013/128027, WO2014/140358). Another HLE BiTE® molecule comprises fusing a first domain binding to a target cell surface antigen, a second domain binding to an extracellular epitope of the human and/or the Macaca CD3e chain and a third domain, which is the specific Fc modality (see e.g., WO 2017/134140). In particular, bispecific T cell engager molecules include anti-CD19 x anti-CD3 BiTE® molecules, MT1 11, Medi-1565 anti-cacinoembryonic antigen x anti-CD3 molecules, anti-

CD33 x anti-CD3 BiTE® molecules, anti-PSMA x anti-CD3 BiTE® molecules, anti-PSMA x anti-CD3 BiTE® molecules, anti-BCMA x anti-CD3 BiTE® molecules, AMG-110 (MT110), anti-CD19 x anti-CD3 BiTE® molecules, anti- delta-like ligand 3 (DLL3) x anti-CD3 BiTE® molecules, anti-EGFRvIII x anti-CD3 BiTE® molecules, half-life extended anti-FLT3 x anti-CD3 BiTE® molecules, half-life extended anti-CD33 x anti-CD3 BiTE® molecules, half-life extended anti-DLL3 x anti-CD3 BiTE® molecules, half-life extended anti-BCMA x anti-CD3 BiTE® molecules, and half-life extended anti-claudin 6 BiTE® molecules, for example.

[00115] In some embodiments, bispecific proteins may include blinatumomab, catumaxomab, ertumaxomab, solitomab, targomiRs, lutikizumab (ABT981), vanucizumab (RG7221), remtolumab (ABT122), ozoralixumab (ATN103), floteuzmab (MGD006), pasotuxizumab (AMG112, MT112), lymphomun (FBTA05), (ATN-103AMG 424 (anti-CD38 anti-CD3 Xmap), AMG 340 MDX-447, TF2, rM28, HER2Bi-aATC, GD2Bi-aATC, MGD006, MGD007, MGD009, MGD010, MGD011 (JNJ64052781), IMCgplOO, indium-labeled IMP-205, xm734, LY3164530, OMP-305BB3, REGN1979, COV322, ABT112, ABT165, RG-6013 (ACE910), RG7597 (MEDH7945A), RG7802, RG7813(R06895882), RG7386, BITS7201A (RG7990), RG7716, BFKF8488A (RG7992), MCFA-128, MM-111, MM141, MOR209/ES414, MSB0010841, AEX-0061, AEX0761, AEX0141; BII034020, AFM13, AFM11, SAR156597, FBTA05, PF06671008, GSK2434735, MEDI3902, MEDI0700, MEDI7352, as well as the molecules or variants or analogs thereof and biosimilars of any of the foregoing.

[00116] Multispecific proteins also include trispecific antibodies, tetravalent bispecific antibodies, multispecific proteins without antibody components such as dia-, tria- or tetrabodies, minibodies, and single chain proteins capable of binding multiple targets. Coloma, M.J., et. al., *Nature Biotech.* 15 (1997) 159-163.

[00117] An scFv is a single chain antibody fragment having the variable regions of the heavy and light chains of an antibody linked together. See U.S. Patent Nos. 7,741,465, and 6,319,494 as well as Eshhar *et al.*, *Cancer Immunol Immunotherapy* (1997) 45: 131-136. An scFv retains the parent antibody's ability to specifically interact with target antigen.

[00118] The term "antibody" includes reference to both glycosylated and non-glycosylated immunoglobulins of any isotype or subclass or to an antigen-binding region thereof that competes with the intact antibody for specific binding. Unless otherwise specified, antibodies include human, humanized, chimeric, multi-specific, monoclonal, polyclonal, heteroIgG, bispecific, and oligomers or antigen binding fragments thereof. Antibodies include the IgG1-, IgG2-, IgG3- or IgG4-type. Also included are proteins having an antigen binding fragment or region such as Fab, Fab', F(ab')₂, Fv, diabodies, Fd, dAb, maxibodies, single chain antibody molecules, single domain VHH, complementarity determining region (CDR) fragments, scFv, diabodies, triabodies, tetrabodies and polypeptides that contain at least a portion of an immunoglobulin that is sufficient to confer specific antigen binding to a target polypeptide.

[00119] Also included are human, humanized, and other antigen-binding proteins, such as human and humanized antibodies, that do not engender significantly deleterious immune responses when administered to a human.

[00120] Also included are modified proteins, such as are proteins modified chemically by a non-covalent bond, covalent bond, or both a covalent and non-covalent bond. Also included are proteins further comprising one or more post-translational modifications which may be made by cellular modification systems or modifications introduced *ex vivo* by enzymatic and/or chemical methods or introduced in other ways.

[00121] Proteins may also include recombinant fusion proteins comprising, for example, a multimerization domain, such as a leucine zipper, a coiled coil, an Fc portion of an immunoglobulin, and the like.

[00122] Also included are proteins comprising all or part of the amino acid sequences of differentiation antigens (referred to as CD proteins) or their ligands or proteins substantially similar to either of these. In some embodiments, proteins may include

colony stimulating factors, such as granulocyte colony-stimulating factor (G-CSF). Such G-CSF agents include, but are not limited to, Neupogen® (filgrastim) and Neulasta® (pegfilgrastim).

[00123] Also included are erythropoiesis stimulating agents (ESA), such as Epogen® (epoetin alfa), Aranesp® (darbepoetin alfa), Dynepo® (epoetin delta), Mircera® (methoxypolyethylene glycol-epoetin beta), Hematide®, MRK-2578, INS-22, Retacrit® (epoetin zeta), Neorecormon® (epoetin beta), Silapo® (epoetin zeta), Binocrit® (epoetin alfa), epoetin alfa Hexal, Abseamed® (epoetin alfa), Ratioepo® (epoetin theta), Eporatio® (epoetin theta), Biopoin® (epoetin theta), epoetin alfa, epoetin beta, epoetin zeta, epoetin theta, and epoetin delta, epoetin omega, epoetin iota, tissue plasminogen activator, GLP-1 receptor agonists, as well as the molecules or variants or analogs thereof and biosimilars of any of the foregoing.

[00124] In some embodiments, proteins may include proteins that bind specifically to one or more CD proteins, HER receptor family proteins, cell adhesion molecules, growth factors, nerve growth factors, fibroblast growth factors, transforming growth factors (TGF), insulin-like growth factors, osteoinductive factors, insulin and insulin-related proteins, coagulation and coagulation-related proteins, colony stimulating factors (CSFs), other blood and serum proteins blood group antigens; receptors, receptor associated proteins, growth hormones, growth hormone receptors, T-cell receptors; neurotrophic factors, neurotrophins, relaxins, interferons, interleukins, viral antigens, lipoproteins, integrins, rheumatoid factors, immunotoxins, surface membrane proteins, transport proteins, homing receptors, addressins, regulatory proteins, and immunoadhesins.

[00125] In some embodiments, products bind to one or more of the following, alone or in any combination: CD proteins including, but not limited to, CD3, CD4, CD5, CD7, CD8, CD19, CD20, CD22, CD25, CD30, CD33, CD34, CD38, CD40, CD70, CD123, CD133, CD138, CD171, and CD174, HER receptor family proteins, including, for instance, HER2, HER3, HER4, and the EGF receptor, EGFRvIII, cell adhesion molecules, for example, LFA-1, Mol, p150,95, VLA-4, ICAM-1, VCAM, and alpha v/beta 3 integrin, growth factors, including but not limited to, for example, vascular endothelial growth factor ("VEGF"); VEGFR2, growth hormone, thyroid stimulating hormone, follicle stimulating hormone, luteinizing hormone, growth hormone releasing factor, parathyroid hormone, mullerian-inhibiting substance, human macrophage inflammatory protein (MIP-1-alpha), erythropoietin (EPO), nerve growth factor, such as NGF-beta, platelet-derived growth factor (PDGF), fibroblast growth factors, including, for instance, aFGF and bFGF, epidermal growth factor (EGF), Cripto, transforming growth factors (TGF), including, among others, TGF- α and TGF- β , including TGF- β 1, TGF- β 2, TGF- β 3, TGF- β 4, or TGF- β 5, insulin-like growth factors-I and -II (IGF-I and IGF-II), des(1-3)-IGF-I (brain IGF-I), and osteoinductive factors, insulins and insulin-related proteins, including, but not limited to, insulin, insulin A-chain, insulin B-chain, proinsulin, and insulin-like growth factor binding proteins; (coagulation and coagulation-related proteins, such as, among others, factor VIII, tissue factor, von Willebrand factor, protein C, alpha-1-antitrypsin, plasminogen activators, such as urokinase and tissue plasminogen activator ("t-PA"), bombazine, thrombin, thrombopoietin, and thrombopoietin receptor, colony stimulating factors (CSFs), including the following, among others, M-CSF, GM-CSF, and G-CSF, other blood and serum proteins, including but not limited to albumin, IgE, and blood group antigens, receptors and receptor-associated proteins, including, for example, flk2/fit3 receptor, obesity (OB) receptor, growth hormone receptors, and T-cell receptors; neurotrophic factors, including but not limited to, bone-derived neurotrophic factor (BDNF) and neurotrophin-3, -4, -5, or -6 (NT-3, NT-4, NT-5, or NT-6); relaxin A-chain, relaxin B-chain, and prorelaxin, interferons, including for example, interferon-alpha, -beta, and -gamma, interleukins (ILs), e.g., IL-1 to IL-10, IL-12, IL-15, IL-17, IL-23, IL-12/IL-23, IL-2Ra, IL-1-R1, IL-6 receptor, IL-4 receptor and/or IL-13 to the receptor, IL-13RA2, or IL-17 receptor, IL-1RAP; viral antigens, including but not limited to, an AIDS envelope viral antigen, lipoproteins, calcitonin, glucagon, atrial natriuretic factor, lung surfactant, tumor necrosis factor-alpha and -beta, enkephalinase, BCMA, IgKappa, ROR-1, ERBB2, mesothelin, RANTES (regulated on activation normally T-cell expressed and secreted), mouse gonadotropin-associated peptide, DNase, FR-alpha, inhibin, and activin, integrin, protein A or D, rheumatoid factors, immunotoxins, bone morphogenetic protein (BMP), superoxide dismutase, surface membrane

proteins, decay accelerating factor (DAF), AIDS envelope, transport proteins, homing receptors, MIC (MIC-a, MIC-B), ULBP 1-6, EPCAM, addressins, regulatory proteins, immunoadhesins, antigen-binding proteins, somatropin, CTGF, CTLA4, eotaxin-1, MUC1, CEA, c-MET, Claudin-18, GPC-3, EPHA2, FPA, LMP1, MG7, NY-ESO-1, PSCA, ganglioside GD2, ganglioside GM2, BAFF, OPGL (RANKL), myostatin, Dickkopf-1 (DKK-1), Ang2, NGF, IGF-1 receptor, hepatocyte growth factor (HGF), TRAIL-R2, c-Kit, B7RP-1, PSMA, NKG2D-1, programmed cell death protein 1 and ligand, PD1 and PDL1, mannose receptor/hCG β , hepatitis-C virus, mesothelin dsFv[PE38] conjugate, Legionella pneumophila (lly), IFN gamma, interferon gamma induced protein 10 (IP10), IFNAR, TALL-1, thymic stromal lymphopoietin (TSLP), proprotein convertase subtilisin/Kexin Type 9 (PCSK9), stem cell factors, Flt-3, calcitonin gene-related peptide (CGRP), OX40L, α 4 β 7, platelet specific (platelet glycoprotein IIb/IIIb (PAC-1), transforming growth factor beta (TGF β), Zona pellucida sperm-binding protein 3 (ZP-3), TWEAK, platelet derived growth factor receptor alpha (PDGFR α), sclerostin, and biologically active fragments or variants of any of the foregoing.

[00126] In some embodiments, proteins include abciximab, acapatamab, adalimumab, adecatumumab, aflibercept, alemtuzumab, alirocicab, anakinra, atacicept, basiliximab, belimumab, bemarituzumab, bevacizumab, biosozumab, blinatumomab, brentuximab vedotin, brodalumab, cantuzumab mertansine, canakinumab, cetuximab, certolizumab pegol, conatumumab, daclizumab, denosumab, eculizumab, edrecolomab, efalizumab, efaveleukin alfa, epratuzumab, erenumab, etanercept, evolocumab, galiximab, ganitumab, gemtuzumab, golimumab, ibritumomab infliximab, ipilimumab, latikafusp, lerdelimumab, letikafusp, lumiliximab, lxdkizumab, mapatumumab, motesanib diphosphate, muromonab-CD3, natalizumab, nesiritide, nimotuzumab, nivolumab, ocrelizumab, ofatumumab, omalizumab, oprelvekin, ordesekimab, palivizumab, panitumumab, pembrolizumab, pertuzumab, pexelizumab, ranibizumab, rilatumumab, rituximab, rocatinlimab, romiplostim, romosozumab, rozibafusp alfa, sargamostim, tarlatamag, tezepelumab, tocilizumab, tositumomab, tiuxetan, trastuzumab, ustekinumab, vedolizumab, visilizumab, volociximab, zanolimumab, and zalutumumab, as well as biosimilars of any of the foregoing.

[00127] Proteins according to the invention encompass all of the foregoing and further include antibodies comprising 1, 2, 3, 4, 5, or 6 of the complementarity determining regions (CDRs) of any of the aforementioned antibodies. Also included are variants that comprise a region that is 70% or more, especially 80% or more, more especially 90% or more, yet more especially 95% or more, particularly 97% or more, more particularly 98% or more, yet more particularly 99% or more identical in amino acid sequence to a reference amino acid sequence of a protein of interest. Identity in this regard can be determined using a variety of well-known and readily available amino acid sequence analysis software.

[00128] The pharmaceutical product is in a drug storage device, such as a vial, or a drug delivery device, such as an injection device, for automatic administration or self-administration by the user or by trained healthcare professionals (nurses, doctors). Such devices include a pre-filled syringe having components separate or together, single-use, disposable injector, multiple-use reusable injector, autoinjector, pen-type injector. The pharmaceutical product can additionally include components or other materials useful or necessary for the use of the product by the patient.

CLAIMS

What is claimed is:

1. An assembly for at least partially automatically packaging pharmaceutical products, the assembly comprising:
 - a product accumulator configured to receive pharmaceutical products to be packaged;
 - a labeler positioned downstream of the product accumulator;
 - a first collaborative robot configured to transfer pharmaceutical products from the product accumulator to a labeler infeed area upstream of the labeler, the labeler configured to apply a label to each of the pharmaceutical products as the pharmaceutical products pass from the labeler infeed area to a labeler outfeed area downstream of the labeler;
 - a first visual inspection system positioned downstream of the labeler, the first visual inspection system configured to capture a first image of each of the pharmaceutical products after passing through the labeler, the first visual inspection system configured to determine whether the label is present on each of the pharmaceutical products based on the respective first image;
 - a second collaborative robot positioned downstream of the first visual inspection system;
 - a transport system comprising:
 - a conveyor having a loading area, an inspection area downstream of the loading area, and an unloading area downstream of the inspection area;
 - a tray dispenser positioned immediately adjacent the conveyor at a position upstream of the loading area, the tray dispenser adapted to receive a plurality of trays for the plurality of pharmaceutical products, respectively, the tray dispenser configured to singularly dispense the plurality of trays onto the conveyor, wherein the conveyor is configured to direct each of the trays from the tray dispenser to the loading area;
 - an insert dispenser positioned immediately adjacent the conveyor at a position between the loading area and the unloading area, the insert dispenser adapted to receive a plurality of inserts for the plurality of trays, respectively; and
 - a third collaborative robot positioned adjacent the insert dispenser,
 - wherein when the first visual inspection system determines that the label is present on a respective pharmaceutical product, the second collaborative robot is configured to transfer the respective pharmaceutical product from the labeler outfeed area to a respective tray in the loading area of the conveyor, wherein when the first visual inspection system determines that the label is not present on the respective pharmaceutical product, the first visual inspection system causes the respective pharmaceutical product to be removed from the assembly;
 - a second visual inspection system positioned immediately adjacent the inspection area of the conveyor, the second visual inspection system configured to capture a second image of each of the pharmaceutical products in the plurality of trays after the conveyor directs the plurality of trays from the loading area to the inspection area, the second visual inspection system configured to determine whether the label is present on each of the pharmaceutical products based on the respective second image,
 - wherein when the second visual inspection system determines that the label is present on the respective pharmaceutical product, the conveyor is configured to transfer the respective tray carrying the respective pharmaceutical product from inspection area to the unloading area, wherein when the second visual inspection system determines that the label is not present on the respective pharmaceutical product, the second visual inspection system generates a first alert to an operator of the assembly and causes the conveyor to stop until the respective pharmaceutical product is removed from the assembly;
 - wherein the third collaborative robot is configured to retrieve one or more inserts from the insert dispenser for each of the plurality of trays as the conveyor directs the plurality of trays from the inspection area to the unloading area; and

a third visual inspection system positioned immediately adjacent the conveyor, the third visual inspection system configured to capture a third image of each of the one or more inserts retrieved by the third collaborative robot, the third visual inspection system configured to determine whether each of the one or more inserts corresponds to the pharmaceutical product in the respective tray based on the respective third image,

wherein when the third visual inspection system determines that the respective one or more inserts correspond to the pharmaceutical product in the respective tray, the third collaborative robot disposes the respective one or more inserts into the respective tray on the conveyor, and wherein when the third visual inspection system determines that the respective one or more inserts do not correspond to the pharmaceutical product in the respective tray, the third visual inspection system causes the conveyor to stop and generates a second alert to the operator of the assembly.

2. The assembly of claim 1, wherein the transport system comprises a magnetic transport system such that the conveyor is a magnetic conveyor.

3. The assembly of claim 2, wherein the magnetic conveyor is defined by a plurality of stators and a plurality of movers, each mover of the plurality of movers operatively coupled to a stator of the plurality of stators via a magnetic field, the magnetic transport system further comprising a controller operatively connected to the plurality of stators and configured to adjust the magnetic field to independently control a position of each of the plurality of movers relative to the plurality of stators, respectively.

4. The assembly of claim 3, wherein the plurality of movers are movable in the x direction and the y direction.

5. The assembly of claim 3 or 4, further comprising a plurality of fixtures for the plurality of trays, the plurality of fixtures removably coupled to and carried by the plurality of movers, respectively, wherein when the plurality of fixtures are coupled to the plurality of movers, each of the plurality of fixtures is configured to receive a respective one of the plurality of trays from the tray dispenser, and to carry the respective one of the plurality of trays from the tray dispenser to the loading area and to the unloading area.

6. The assembly of claim 5, further comprising a fixture sensor configured to detect when each respective fixture is positioned to receive the respective one of the plurality of trays from the tray dispenser.

7. The assembly of claim 5 or 6, wherein the plurality of fixtures are removable from the plurality of movers, respectively, and interchangeable with a second plurality of fixtures to be removably coupled to and carried by the plurality of movers, respectively, wherein each fixture of the second plurality of fixtures has a different shape and/or size than each fixture of the plurality of fixtures.

8. The assembly of any one of claims 5-7, wherein the plurality of fixtures are manufactured using an additive manufacturing technique.

9. The assembly of claim 3 or 4, wherein when each of the trays has a first size and/or first shape, the plurality of fixtures comprise a plurality of first fixtures, each first fixture having a first size and/or first shape, and when each of the trays has a second size and/or second shape, the second size being different from the first size and the second shape being different from the first shape, the plurality of fixtures comprise a plurality of second fixtures, each second fixture having a second size and/or

second shape, the second size of the second fixture being different from the first size of the first fixture and the second shape of the second fixture being different from the first shape of the first fixture.

10. The assembly of any one of the preceding claims, further comprising a control system operatively connected to the labeler, the first and second collaborative robots, the first, second, and third visual inspection systems, and the transport system to control the labeler, the first, second, and third collaborative robots, the first, second, and third visual inspection systems, and the transport system based on one or more parameters of the pharmaceutical products.

11. The assembly of claim 9, wherein the parameters comprise a type, a size, a shape, a number, or combinations thereof of the pharmaceutical products.

12. The assembly of any one of the preceding claims, wherein each of the first, second, and third collaborative robots has 7 axes of motion.

13. The assembly of any one of the preceding claims, further comprising one or more water coolant systems coupled to the transport system and configured to reduce heat generated by the transport system.

14. The assembly of any one of the preceding claims, further comprising:

- a packaging station positioned downstream of the unloading area, the packaging station for forming a dispensing carton for each of the pharmaceutical products and inserting each of the plurality of trays into a respective dispensing carton;
- a weight station positioned downstream of the packaging station, the weight station configured to determine a weight of each of the pharmaceutical products; and
- a fourth collaborative robot configured to transfer each of the dispensing cartons to the weight station,

wherein the control system compares the determined weight of each of the pharmaceutical products to a weight threshold for the pharmaceutical products, and wherein the control system directs each of the pharmaceutical products to a downstream process or waste based on the comparison.

15. The assembly of claim 14, wherein the packaging station automatically forms the dispensing carton for each of the pharmaceutical products and/or automatically inserts each of the plurality of trays into the respective dispensing carton.

16. An assembly for automatically moving a plurality of pharmaceutical products through a packaging line for the pharmaceutical products, the assembly comprising:

- a magnetic transport system configured to transport the plurality of pharmaceutical products from a loading area of the packing line to an unloading area of the packaging line, the magnetic transport system comprising:
 - a magnetic conveyor defined by a plurality of stators and a plurality of movers, each mover of the plurality of movers operatively coupled to a stator of the plurality of stators via a magnetic field; and
 - a controller operatively connected to the plurality of stators and configured to adjust the magnetic field to independently control a position of each of the plurality of movers relative to the plurality of stators, respectively, and
 - a plurality of fixtures for carrying the pharmaceutical products through the packaging line, the plurality of fixtures removably coupled to and carried by the plurality of movers, respectively, wherein when the plurality of fixtures are coupled to the plurality of movers, each of the plurality of first fixtures is configured to receive a respective one of the plurality of pharmaceutical

products at the loading area and configured to carry the respective one of the plurality of pharmaceutical products from the loading area to the unloading area.

17. The assembly of claim 16, wherein the plurality of movers are movable in the x direction and the y direction.

18. The assembly of claim 16 or 17, wherein the plurality of fixtures are manufactured using an additive manufacturing technique.

19. The assembly of any one of claims 16-18, wherein the plurality of fixtures are removable from the plurality of movers, respectively, and interchangeable with a second plurality of fixtures to be removably coupled to and carried by the plurality of movers, respectively, wherein each fixture of the second plurality of fixtures has a different shape and/or size than each fixture of the plurality of fixtures.

20. The assembly of any one of claims 16-19, further comprising a control system operatively connected to the controller to control the magnetic transport system based on one or more parameters of the pharmaceutical products.

21. The assembly of claim 20, wherein the parameters comprise a type, a size, a shape, a number, or combinations thereof of the pharmaceutical products.

22. The assembly of any one of claims 16-21, further comprising one or more water coolant systems coupled to the magnetic transport system and configured to reduce heat generated by the magnetic transport system.

23. The assembly of any one of claims 16-22, wherein a gap is formed between the mover and the stator to which the mover is operatively coupled via the magnetic field, and wherein the magnetic field is confined to the gap.

24. A method of at least partially automatically packing pharmaceutical products, the method comprising:
providing a packaging line assembly, the packaging line assembly comprising: a product accumulator; a labeler positioned downstream of the product; a first collaborative robot; a first visual inspection system positioned downstream of the labeler; a second collaborative robot positioned downstream of the first visual inspection system; and a transport system, wherein the transport system comprises a conveyor having a loading area, an inspection area downstream of the loading area, and an unloading area downstream of the inspection area, a tray dispenser positioned immediately adjacent the conveyor at a position upstream of the loading area, and an insert dispenser positioned immediately adjacent the conveyor at a position between the loading area and the unloading area;
receiving, at the product accumulator, a first set of pharmaceutical products to be packaged;
transferring, via the first collaborative robot, the pharmaceutical products from the product accumulator to a labeler infeed area upstream of the labeler;
applying, via the labeler, a label to each of the pharmaceutical products as the pharmaceutical products pass from the labeler infeed area to a labeler outfeed area downstream of the labeler;
capturing, with the first visual inspection system, a first image of each of the pharmaceutical products after passing through the labeler;

determining, with the first visual inspection system, whether the label is present on each of the pharmaceutical products based on the respective captured first image;

receiving, at the tray dispenser, a plurality of trays for the pharmaceutical products, and singularly dispensing the plurality of trays from the tray dispenser onto the conveyor;

directing each of the trays from the tray dispenser to the loading area;

wherein when the first visual inspection system determines that the label is present on a respective pharmaceutical product, transferring, via the second collaborative robot, the respective pharmaceutical product from the labeler outfeed area to a respective tray in the loading area of the conveyor, wherein when the first visual inspection system determines that the label is not present on the respective pharmaceutical product, causing the respective pharmaceutical product to be removed from the assembly;

directing each of the trays from the loading area to the inspection area;

capturing, with a second visual inspection system positioned immediately adjacent the inspection area of the conveyor, a second image of each of the pharmaceutical products in the plurality of trays after the conveyor directs the plurality of trays from the loading area to the inspection area;

determining, with the second visual inspection system, whether the label is present on each of the pharmaceutical products based on the respective captured second image;

wherein when the second visual inspection system determines that the label is present on the respective pharmaceutical product, transferring, via the conveyor, the respective tray carrying the respective pharmaceutical product from the inspection area to the unloading area, wherein when the second visual inspection system determines that the label is not present on the respective pharmaceutical product, generating a first alert to an operator of the assembly and causing the conveyor to stop until the respective pharmaceutical product to be removed from the assembly;

receiving, at the insert dispenser, a plurality of inserts for the plurality of trays, respectively;

retrieving, via a third collaborative robot positioned adjacent the insert dispenser, one or more inserts from the insert dispenser for each of the plurality of trays as the conveyor directs the plurality of trays from the inspection area to the unloading area; and

capturing, with a third visual inspection system positioned immediately adjacent the conveyor, a third image of each of the one or more inserts retrieved by the third collaborative robot; and

determining, with the third visual inspection system, whether each of the one or more inserts corresponds to the pharmaceutical product in the respective tray based on the respective captured third image,

wherein when the third visual inspection system determines that the respective one or more inserts correspond to the pharmaceutical product in the respective tray, causing the third collaborative robot to dispose the respective one or more inserts into the respective tray, and wherein when the third visual inspection system determines that the one or more inserts do not correspond to the pharmaceutical product in the respective tray, causing the conveyor to stop and generating a second alert to the operator of the assembly.

25. The method of claim 24, further comprising creating one or more accessories for the packaging line assembly using an additive manufacturing technique, wherein the one or more accessories are created based on one or more parameters of the pharmaceutical products.

26. The method of claim 24 or 25, wherein the parameters comprise a type, a size, a shape, a number, or combinations thereof of the pharmaceutical products.

27. The method of claim 25 or 26, wherein the one or more accessories are manufactured with nylon and one or more reinforcement materials.

28. The method of any one of claims 25 to 27, wherein the one or more accessories comprise:
one or more product grippers for the first collaborative robot;
one or more product grippers for the second collaborative robot;
one or more insert grippers for the third collaborative robot;
one or more fixtures for the transport system; or
combinations thereof.

29. The method of any of claims 24-28, wherein the transport system comprises a magnetic transport system such that the conveyor is a magnetic conveyor.

30. The method of claim 29, wherein the magnetic conveyor is defined by a plurality of stators and a plurality of movers, each mover of the plurality of movers operatively coupled to a stator of the plurality of stators via a magnetic field, and wherein the magnetic transport system further comprises a controller operatively connected to the plurality of stators, the method further comprising adjusting the magnetic field to independently control a position of each of the plurality of movers relative to the plurality of stators, respectively.

31. The method of claim 30, wherein the plurality of movers are movable in the x direction and the y direction.

32. The method of claim 30 or 31, wherein the magnetic transport system further comprises a plurality of fixtures for the plurality of trays, the method further comprising removably coupling the plurality of fixtures to the plurality of movers, respectively, wherein when the plurality of fixtures are coupled to the plurality of movers, each of the plurality of fixtures is configured to receive a respective one of the plurality of trays from the tray dispenser, and to carry the respective one of the plurality of trays from the tray dispenser to the loading area and to the unloading area.

33. The method of claim 32, further comprising a fixture sensor configured to detect when each respective fixture is positioned to receive the respective one of the plurality of trays from the tray dispenser.

34. The method of claim 32 or 33, further comprising removing the plurality of fixtures from the plurality of movers, respectively, and removably coupling a second plurality of fixtures to the plurality of movers, respectively, wherein each fixture of the second plurality of fixtures has a different shape and/or size than each fixture of the plurality of fixtures.

35. The method of any one of claims 32-34, further comprising creating the plurality of fixtures using an additive manufacturing technique.

36. The method of claim 34 or 35, wherein when each of the trays has a first size and/or first shape, the plurality of fixtures comprise a plurality of first fixtures, each first fixture having a first size and/or first shape, and when each of the trays has a second size and/or second shape, the second size being different from the first size and the second shape being different from

the first shape, the plurality of fixtures comprise a plurality of second fixtures, each second fixture having a second size and/or second shape, the second size of the second fixture being different from the first size of the first fixture and the second shape of the second fixture being different from the first shape of the first fixture.

37. The method of any one of claims 24-36, wherein the packaging line assembly further comprises a control system operatively connected to the labeler, the first and second collaborative robots, the first, second, and third visual inspection systems, and the transport system, the method further comprising controlling, using the control system, the labeler, the first, second, and third collaborative robots, the first, second, and third visual inspection systems, and the transport system based on one or more parameters of the pharmaceutical products.

38. The method of claim 37, wherein the one or more parameters comprise a type, a size, a shape, a number, or combinations thereof of the pharmaceutical products.

39. The method of any one of claims 24-38, wherein each of the first, second, and third collaborative robots has 7 axes of motion.

40. The method of any one of claims 25-27, wherein the one or more accessories comprise one or more fixtures coupled to the conveyor, the method further comprising:

receiving, at the product accumulator, a second set of pharmaceutical products to be packaged, the pharmaceutical products in the second set being different from the pharmaceutical products in the first set; and

changing the one or more fixtures coupled to the conveyor to match the pharmaceutical products in the second set.