0005P00030

FLEXIBLE ASSEMBLY LINE FOR TRAY PACKAGING

[0001] The present application relates to a flexible assembly line for tray assembly, quality vision inspection and packaging. It also relates to a method of using the flexible assembly line for tray packaging.

[0002] In food catering business, food and cutleries are often served on trays. Moreover, each type of food is typically provided in separate containers, which are orderly placed in the trays. When food is supplied in larger volume with great diversity, such as in airline catering business, army or hospital, packaging the trays with the food and the cutleries becomes complex and labor-intensive. If the food has to be catered continuously around the clock, consistency, flexibility and efficiency become critical factors of high quality catering business.

[0003] The present invention aims to provide a new and useful flexible assembly line for tray assembly, quality inspection and packaging. The present invention also aims to provide a new and useful method for using the flexible assembly line. Essential features of the invention are provided by the independent claims, whilst other advantageous features of the invention are given by the dependent claims.

[0004] According to a first aspect of the present invention, the application provides a flexible assembly line for tray packaging. The flexible assembly line comprises a tray dispenser for providing an empty tray, a conveyor for transporting the empty tray, a loading station for placing food or non-food items onto the empty tray automatically. In contrast to manual loading, the flexible assembly line can package a tray loaded with food and non-food items automatically, and reduce significantly the labor. For example, the loading station can transfer an object onto an empty tray efficiently, accurately and repeatedly without failing in accuracy and speed. In airline catering industry, different tray assemblies with large volumes and great diversities have to be prepared quickly during flight turnovers. Caterers can reduce preparation time markedly by using the flexible assembly line for packaging the tray assemblies. When design and used correctly, the loading station offers high standard of hygiene for handling food, which food caterers desire to offer. The flexible assembly line can

incorporate intelligent vision inspection system for checking top and bottom surfaces of an object.

[0005] The flexible assembly line can also include a tray-to-cart loading station for removing a completed tray package away from the conveyor. The tray-to-cart loading station can efficiently take away a completed tray package such that the conveyor will not be jammed with completed tray packages, which may delay the speed of tray packaging.

[0006] The flexible assembly line may further have a vision inspection and rejection station for checking and rejecting food or non-food items. The vision inspection and rejection station makes the flexible assembly line to have a feedback loop for monitoring its operation. The vision inspection and rejection station prevents the flexible assembly line from packaging defective items, which cause loss of productivity and quality.

[0007] The flexible assembly line can include sorters or a sorter for organizing the food or non-food items for the loading station. The sorters are important for putting the food or non-food items in order such that the loading station can pick up a designated item efficiently. Properly organized food and non-food items allow the save of space on the sorter and enable the reduction of process time for the loading station.

[0008] The loading station or the tray dispenser can have a robot for picking food or non-food items, and for transferring them to the conveyor. The robot is versatile for picking and placing the food or non-food items efficiently such that the flexible assembly line is capable of handle wide variety of food and non-food items for tray packaging.

[0009] Any of the tray dispenser, the conveyor and the loading station may have vision component(s) for inspecting the food and non-food items. The vision components can inspect surface texture, shape and size of the food and non-food items for locating, checking and identifying these items. When connected with the robot, the flexible assembly line can handle different types of containers, trays and plates. The robot can further take an object away from the conveyor if the robot finds

any of these items do not comply with preloaded criteria. The preloaded criteria can govern the hygiene quality, tray floor plan, quantity of specific items, and others parameters.

[0010] The tray dispenser or the loading station can be configured to purge a rejected item from the conveyor after the vision inspection. If the vision components find a cup having a sharp edge, the loading station can lift the chipped cup off the conveyor and pick up a replacement for packaging.

[0011] The flexible assembly line can further comprise a manual loading station for manually loading or unloading food or non-food items onto the conveyor. The manual loading station can provide seats for operators so that the operators can put fragile and soft food items onto a tray for packaging. The manual loading station enables the flexible assembly line to handle almost all types of food or non-food items. Complimentary operations between robots and the operators make the flexible assembly line truly versatile for tray packaging. The manual loading station can have an Automated Storage and Retriever System (ASRS) whereby different food & non-food items can be distributed into designated containers respectively in advance. When a flight number is notified to the flexible assembly line, the preloaded items can be automatically rotated and stop next to an operator at the manual station for speedy loading.

[0012] The conveyor may have a belt that connects the tray dispenser and the loading station. An elongated and flat conveyor belt can support and transport trays steadily and efficiently between the stations. The belt is also easy to maintain and clean, making it almost ideal for transporting the trays, loaded or unloaded.

[0013] The loading station can comprise an automatic loading station for picking food items onto the conveyor. For handling food items, the loading station can have suction cup(s) or gripper(s) at an end of its arm for grasping the food items gently and steadily, without causing damage. The food loading station may further equipped with sanitizing tools, such as Ultraviolet lamps for killing germs on its arms.

[0014] Any station of the flexible assembly line can be modularly designed such that the stations can be removed from or installed onto the flexible assembly line for tray packaging. These stations, including the first loading station, the second loading station, the third loading station and the robots, can be connected to the main computer when required. Hence, the flexible assembly line can be configured to adapt to different production tasks easily.

[0015] The flexible assembly line can further comprise an Automatically Guided Vehicle (AGV) for transporting objects from or to the flexible assembly line. For example, The AGV transports carts fully loaded with tray assemblies to a warehouse of in-flight center and moves an empty cart to the flexible assembly line. The AGV can further carry food or non-food items to the flexible assembly line according to predetermined routes, which avoids using operators to move these items. The AVG is more reliable and cost effective for transporting regular items continuously.

[0016] The flexible assembly line can comprise an Automated Carousel for supplying food or non-food items. The Carousel can have parallel rollers and one or more of the rollers have pockets for receiving food or non-food items. Especially, the rollers can be installed on the same axis. An operator who stands next to the Automated Carousel can pick an item from the multiple pockets for assembling the trays. On an opposite side of the rollers, other operators can refill empty pockets without disrupting the tray packaging process. The Automated Carousel can either be supplied separately or in connection with the flexible assembly line. The Automated Carousel can also be propelled by the operator, or automatically. The Automated Carousel can further be connected to the main computer for controlling and communicating the loading information.

[0017] According to a second aspect of the present invention, the present application provides a method of using a flexible assembly line for tray packaging. The method comprises a step of putting a tray onto a conveyor, a step of loading a food or non-food item onto the tray automatically, and a step of transferring a loaded tray into a cart. Since the loading of food and non-food items is carried out by a machine, the loading speed, consistency and reliability are markedly improved, as compared to

manual operations. Optionally, the flexible assembly can put the tray or loading the food or non-food items after inspecting of top & bottom surfaces of the tray.

[0018] The method can further comprise a step of inspecting the tray automatically before or after the loading. The inspection can be carried out by visual checking, weighing, measuring, ultrasonic detecting or any suitable techniques such that the tray is checked for its shape, size, hygiene or any other relevant parameters against acceptance criteria. Hence, a quality control procedure is implemented by the flexible assembly line automatically for speedy operations.

[0019] The method may further comprise a step of inspecting the food and non-food items automatically before or after the loading. Since the entire tray assembly is inspected, including the tray and its contents, the tray assemblies can be made with good consistency and quality by automation. Intensive labor on inspection and loading can be greatly relieved.

[0020] The method may further comprise a step of sorting the food or non-food items for the loading. The sorting, which organizes the food and non-food items before the loading, provides convenience for picking and checking of these items. The method can thus be performed with great efficiency.

[0021] The step of inspecting may comprise machine vision inspection such that images or other data of the tray, the food items and the non-food items can be compared with preloaded criteria of acceptance and operators are relieved from intensively gazing at the flexible assembly line. The machine vision inspection provides great convenience, reliability, consistency and efficiency.

[0022] The accompanying figures (Figs.) illustrate embodiments and serve to explain principles of the disclosed embodiments. It is to be understood, however, that these figures are presented for purposes of illustration only, and not for defining limits of relevant inventions.

[0023] Fig. 1 illustrates a flexibly assembly line for tray packaging;

[0024] Fig. 2 illustrates the flexible assembly line by a process flow diagram;

[0025] Fig. 3 illustrates a second flexible assembly line for tray packaging;

[0026] Fig. 4 illustrates another view of the second flexible assembly line;

[0027] Fig. 5 illustrates a third flexible assembly line for tray packaging;

[0028] Fig. 6 illustrates another view of the third flexible assembly line;

[0029] Fig. 7 illustrates a non-food vision robotic module;

[0030] Fig. 8 illustrates another non-food vision robotic module;

[0031] Fig. 9 illustrates a food vision robotic module;

[0032] Fig. 10 illustrates another food vision robotic module;

[0033] Fig. 11 illustrates an automated carousel for the flexible assembly line;

[0034] Fig. 12 illustrates a part of the flexible assembly line;

[0035] Fig. 13 illustrates a fourth flexible assembly line for tray packaging; and

[0036] Fig. 14 illustrates a process flow chart of the fourth flexible assembly line.

[0037] Exemplary, non-limiting embodiments of the present application will now be described with references to the above-mentioned figures.

[0038] Both Fig. 1 and 2 relate to an embodiment of the present invention. In particular, Fig. 1 illustrates a flexible assembly line 30 for tray packaging. The flexible assembly line 30 comprises several stations 32-44, which are sequentially connected by a conveyor 46. These stations include a tray dispenser 32, a first robotic loading station 34, a second robotic food loading station 36, a third robotic food loading station 38, a manual food loading station 40, an inspection and rejection station 42 and a tray-to-cart loading station 44. However, the inspection and rejection station 42 and the tray-to-cart loading station 44 are placed together, on opposite sides of the conveyor 46. A main computer 48 controls the entire flexible assembly line 30 and the main computer 48 has two touch screen displays 50, 52, namely a first display 50 and a second display 52 at opposite ends of the conveyor 46. The loading stations 34, 36, 38 are also known as robotic modules such that they can be added or removed depending on working load. In other words, they are similar to a plug and play system that can selectively installed or removed for packaging different tray assemblies at various packaging speeds.

[0039] A first bin stacker 54 is positioned adjacent to the first loading station 34, and next to the conveyor 46. Alternatively, the first bin stacker 54 is placed on an opposite

side of the transport conveyor. A second bin stacker 56 is located close to the second loading station 36, and near the conveyor 46 too. The vibratory bowl sorter 58 is placed in close proximity with the third loading station 38, neighboring to the conveyor 46. In other words, the first bin stacker 54, the second bin stacker 56 and the third bin stacker 58 are consecutively arranged along the conveyor 46, which has a belt 60 with an elongated form.

[0040] Fig. 1 also shows objects that interact with the flexible assembly line 30. For example, a trolley 62 filled with trays is parked next to the tray dispenser 32 at a front end 64 of the belt 60. The trolley 62 is special designed with internal slots for receiving the trays. Once the trolley 62 is parked at a tray dispenser unit near the flexible assembly line 30, a fork mechanism (not shown) can incrementally lift/index the trolley 62 up vertically following gradual removal of trays. The trolley 62 is full of clean trays that are ready for receiving food and cutleries. At a back end 66 of the belt 60, the two carts 68 stand near the tray-to-cart station 44 for receiving completed tray assemblies. A first operator 68 and a second operator 70 are also depicted in Fig. 1. The first operator 68 stands near both the main computer 48 and the front end 64, whilst the second operator 70 stands adjacent the manual loading station 40.

[0041] The flexible assembly line 30 is designed to assemble many types of food and utensils onto trays. An assembled tray assembly may include but not limited to following food and non-food items with containers:

A. Trays
    i. Half tray
    ii. Small tray
    iii. Plastic long side plate
B. Cups
    i. Plastic tea cup
    ii. Drinking glass
    iii. Desert bowl with fruits
    iv. Pre-cupped water
    v. Pre-cupped yogurt
C. Cutlery pack
    i. Pepper sachet

ii. Salt sachet
iii. Sugar sachet

D. Condiments

i. Butter pack
ii. Jam pack
iii. Milk screamer
iv. Chili pack

E. Bakery items

i. Bread in wrapper
ii. Biscuit
iii. Cracker
iv. Muffin

[0042] According to Fig. 1, the tray dispenser 32 is a robot that has an arm 74 with a suction cup(s) or gripper(s)(s) or gripper(s) at its end (not shown). The tray dispenser 32 is fixed to the front end 64 such that its robotic arm 74 can pick an empty tray 76 from the trolley 62 to the belt 60. The robotic arm 74 is versatile in operation such that the arm 74 can reach an empty tray 76 of different height or distance. The robotic arm 74 further has an intelligent vision guided system (not shown) near the suction cup for checking the empty tray 76 before transferring it 76 onto the belt 60. The tray dispenser 32 will bring the empty tray 76 to a reject bin (not shown) if the intelligent vision guided system detects dirt, stain or defects on the tray 76. The arm 74 may also have gripper(s) or a combination of gripper(s) and suction cup(s).

[0043] The first loading station 34 has a first four-axis robot 78 for taking non-food items onto a clean empty tray 80. The clean empty tray 80 is transported to the first loading station 34 by the conveyor 46. The non-food items are picked up from the first bin stacker 54 where these non-food items are orderly stacked up. The first loading station 34 also has intelligent vision guided system (not shown) for inspecting incoming trays and the loaded non-food items. If a non-compliant item is found, such as a soiled teacup, the first four-axis robot 78 will seize the non-compliant item and transfer the con-compliant item into a reject bin (not shown). The robot 78 may alternatively be replaced by a five-axes or a six-axes robot.

[0044] The second loading station 36 also has a second four to six-axis robot 80 that is designed to take other non-food items onto a tray 84 from the first loading station 34. The other non-food items are stored at the second bin stacker 56. The second loading station 36 is equipped with intelligent vision guided system (not shown), which are used for checking the other non-food items. The second loading station 36 will bring non-conforming items to a reject bin (not shown). Similarly, the second robot 80 may alternatively be replaced by a five-axes or a six-axes robot.

[0045] In contrast, the third loading station 38 has a third four-axis robot 86 installed for picking food items from the vibratory bowl sorter 58 and placing them onto a tray 88 from the second loading station 36. An intelligent vision guided system (not shown) of the third loading station 38 examine a completed tray 90 of the third loading station 38 and the third four-axis robot 86 will replace non-conforming items with standard-conforming items. The second robot 80 may alternatively be replaced by a five-axis or a six-axes robot.

[0046] The manual loading station 40 provides seating positions to operators for loading fragile items, which the robots 78, 82, 86 find it difficult to handle. Especially, the manual loading station 40 offer seats next to the belt 60 for ease of loading. The operators place fragile items to the tray 90 from carousel shelves 91 of the third loading station 38. For example, the operators can pick soft rice packs and place them into the half trays. The carousel shelves 91 are placed next to the seats of the operators for easy access.

[0047] The inspection and rejection station 42 has several cameras, which are directed towards incoming trays from the manual loading station 40. The inspection and rejection station 42 presents final vision inspection to completed tray assemblies. Next to the inspection and rejection station 42, an auto rejection station 43 will take inspection-failed tray assemblies away from the belt 60.

[0048] In contrast, the tray-to-cart station 44 has an industrial robot (not shown) having an arm (not shown) for fetching the completed tray assemblies. The industrial robot can grab a completed tray assembly and insert it into a suitable slot of a cart,

which is parked next to the back end 66. An empty cart will be supplied after the cart 68 is completely filled with the completed tray assemblies and moved away.

[0049] Functionally, the tray dispenser 32 can automatically transfer empty trays sequentially from the trolley 62 to the conveyor 46. Clean and empty trays 76 are loaded into the trolley 62. Once trays on the trolley 62 are used up, another trolley 62 full of empty clean trays is supplied for replacing the empty trolley. The flexible assembly line 30 can operate without interruption when replacing the trolley 62.

[0050] The vibratory bowl/conveyor sorter 58 can sort food items laterally, which is perpendicular to the longitudinal direction of the belt 60. The vibratory bowl sorter 58 shakes selected food items (e.g. butter packs) such that the selected food items are automatically organized with uniform orientations for picking and placing.

[0051] Each of the three loading stations 34, 36, 38 can inspect objects for acceptance or rejection. Vision components of the three loading stations 34, 36, 38 inspect objects on possible stain, cracks, chips, foreign particles and other non-acceptable defects. Criteria of for the rejection and acceptance are stored in the three loading stations 34, 36, 38 for ensuring high quality and consistency of tray packaging. Items that fail to comply with the criteria are transferred to the reject bins by the corresponding robots 78, 82, 86. The three loading stations 34, 36, 38 have fly-by inspection functions such that bottom surfaces of their picked item are also checked before placing them onto the trays 84, 88, 90. The fly-by inspection functions are provided by the vision components.

[0052] The inspection and rejection station 42 not only screens completed tray assemblies in accordance with predetermined standard, the inspection and rejection station 42 also discharge compressed and filtered clean air onto the completed tray assemblies for cleaning.

[0053] The main computer 48 is connected to the vision stations and robots 32, 34, 36, 38, 42, 43, 44 for regulating workload and coordinating these stations/robots 32, 34, 36, 38, 42, 43, 44. The main computer 48 can also adjust speed of the conveyor 46 via PLCs (Programmable Logic Controllers) or Personal Computers (PCs). Together

with the loading stations 34, 36, 38, the inspection and rejection station takes images of defect objections for future analysis. The images and statistic data of the packaging production are kept for at least 30 days for reviewing. The statistic data is further made available online by the main computer 48 for Production Performance KPI (Key Performance Indicators), Management, text/table reporting and graphical representation and maintenance planning. The main computer 48 can further send Production statistic information and the KPIs to a mainframe computer (not shown) at a remote place for recording, analyzing, monitoring and reporting. The main computer 48 is equipped with a modem for remote communication, such as for troubleshooting. An alarm will be sent if an abnormal situation occurs in the flexibly assembly line 30. The two displays 50, 52, which are both connected to the main computer 48, have user-friendly interfaces for updating production menu, tray floor plan (tray layout).

[0054] The flexible assembly line 30 has features for maintaining high quality food hygiene of the tray packaging. For example, each of the loading stations 34, 36, 38 is enclosed with a HEPA (High-Efficiency Particulate Air) air purifier with static detection and anti-static ionic air blower for minimizing intrusion of foreign particles, such as dust and hair. The belt 60 is enclosed by a transparent cover for avoiding falling foreign particles. The belt 60 is further wiped down continually by a brush as the belt 60 moves. Each part of the flexibly assembly line 30 has a schedule of cleaning procedure for regular maintenance and cleaning. Warm and dark compartments of the flexible assembly line 30 have clear signs for indicating potential pest pockets for regular cleaning and inspection. The flexible assembly line 30 adopts lubrication-free design features for most machine components above the belt 60. Food-grade lubricant is used where lubrication is essential and the lubrication is above the height of the belt 60. Wetted areas of the flexible tray assembly line 30 are made to be of S/S316 material, whilst other areas are S/S304 compliant or has food grade. The flexible assembly line 30 has online bacteria count function for monitoring its hygiene quality.

[0055] The flexible assembly line 30 has numerous features that ensure safety. For example, robotic and moving parts are enclosed by shields or covers. Areas of machine movements that require operator’s access are installed with latched doors, safety interlocks and safety light curtain. Sensors are fitted near moving parts and

critical places that detects prohibited movements or contacts such that corresponding machine parts will be stopped if the sensors detect hazardous approaches. Safety and warning labels are affixed to the flexible assembly line 30 for alerting machine users. For electrical safety, the flexible assembly line 30 is securely earthed and its electrical wirings are connected to circuit breakers.

[0056] When in use, in a preparation stage according to a method of tray packaging 100, an operator enters 102 a flight number into the main computer 48 via the first display 50 which causes the main computer 48 to retrieve 104 corresponding meal menus, types and quantity of food utensils, cutleries requirements, and other relevant information. The main computer 48 further uploads 106 tray floor plans, specific shapes, sizes, hygiene criteria and weights of the food and non-food items to the robots 78, 82, 86. In an airline in-flight catering center or any catering operation, an authorized operator enters a flight number, desired production quantity, tray-packaging time, and other relevant data. The authorized operator has a user identification code and a password that allows him/her to set these production parameters. Different levels of user authorization are made available by the main computer 48 for maintenance, production control and other purposes. For example, the authorized user can upload, change and delete menus of tray packages according to flight numbers. In the meantime, the trolley filled empty trays 62, the bin stackers 54, 56 filled with non-food items, the vibratory bowl sorter 58 occupied with selected food items and the empty carts 68 are moved 108 to the flexible assembly line 30 when entering the production instruction.

[0057] Before picking up the empty tray 76 from the trolley 62, the trolley dispenser 32 inspects 110 the empty tray 76 and compare 112 images of the empty tray 76 with stored data. The stored data includes hygiene standard of the tray 76 and a standard 3-D image of the tray 76 (e.g. color, size, etc.). If the empty tray 76 passes the inspection, the trolley dispenser 32 uses its suction cup to catch 114 the tray 76 and move the empty tray 76 above a camera for inspecting its bottom surface. Accordingly, the trolley dispenser 32 will command and guide the robot to place 116 the empty tray 76 onto the front end 64 of the belt 60 with a predetermined orientation if the tray 76 meets all acceptance criteria. If the empty tray 76 does not meet the acceptance criteria, the tray 76 will dropped into a rejection bin for manual counter-checking. The

reason of the rejection and images of the rejected empty tray 76 will be recorded for further study.

[0058] The clean empty tray 80 progresses 120 along the belt 60 from the front end 64 towards the first loading station 34. The first loading station 34 identifies 122 location, speed (via encoder installed on the conveyor) and orientation of the clean empty tray 80 once detecting 124 the incoming clean empty tray 80. The vision system of the first robot 78 captures 126 a rectangular plate that was previously stored and stacked inside the first bin stacker 54. If the rectangular plate passes the vision (360 degrees around a vertical axis of the tableware) acceptance criteria, the first robot 78 will pick up and move the bottom surface of this rectangular plate above a vision camera for bottom inspection. If the rectangular plate passes the acceptance criteria, the first robot 78 will put 128 the rectangular plate onto the clean empty tray 80 according to a tray floor plan. If failed, the first robot 78 will reject the item to the reject station. The loading station comprises of a pre-inspected buffer station. This buffer station provides a backup during refilling for reducing downtime of the flexible assembly line 30. The buffer station stores plates for replacing rejected plates. Repeated rejection can possibly delay tray assembly packaging. The buffer station is refilled when the first robot 78 has idle/spare time.

[0059] The quality compliant tray 84 further progresses 120 to the second loading station 34. The second loading station 36 ascertains 136 travelling position, velocity and orientation of the tray 84 near its entrance. The second four-axis robot 82 stretches 138 its arms and seizes 140 a cutlery pack from the second bin stack 56. The cutlery pack is subsequently lifted 142 onto the tray 84 by the second four-axes robot 82. The second loading station 36 takes 144 images around the loaded tray 88 and compares 132 them against the preloaded criteria for quality check. The images are taken at 360 degrees around a vertical axis of the tray loaded 84. The loaded tray 88 will be permitted to proceed 120 on the belt 60 if the relevant criteria are met. If the loaded tray 88 does not fulfill the preloaded criteria, the cutlery pack will be replaced 148 by another cutlery pack from the second bin stacker 56. The second robot can alternatively be a five-axes robot or a six-axes robot.

[0060] The third loading station 38 senses 150 the tray 88 at its entrance. The third loading station 38 further examines 152 location, speed and orientation of the tray 88. The third four-axis robot 86 extends 154 its arms to the vibratory bowl sorter 58 and grabs 156 a fruit bowl. The fruit bowl is afterward deposited 160 onto the tray 88. Similar to the first and the second loading station 34, 36, the third loading station 38 shots 162 images on top of the tray 90, which has the fruit bowl. Cameras of the third loading station 38 shots the images on an upper hemisphere of the tray 90, around a vertical axis of the tray 90. The images are processed 164 by comparing to the preloaded criteria. The tray 90 is permitted to depart 166 from the third loading station 38 if all the criteria are met. However, the fruit bowl will be taken off 168 the tray 88 if the fruit bowl fails to fulfill the preloaded criteria. For example, the fruit bowl will be replaced 170 by another one if the fruit bowl is cracked with sharp edges. Types and sequences of tableware loaded at the loading stations 34, 36, 38 change according to catering requirements.

[0061] Several operators are seated at the manual loading station 40, which is immediately adjacent to the third loading station 38. The operators pick up 172 soft and fragile items from the manual loading station 40 and place 174 them to designated locations on the incoming tray 90. The soft and fragile items include chili packs, bread in wrapper, yogurt pack, and others. When placing 174 these items, the operators also scrutinize 176 if there is any broken, spilled or contaminated food or non-food items. Non-compliant items are taken off 178 the belt 60 for rework. The operators regularly look 180 at the second display 52 for regulating the speed and status of the tray packaging. If necessary, the operators may intervene 182 production of the flexible assembly line 30 for immediate repair or scheduled maintenance. The second display 52 provides an alternative to the first display 50 such that the operators can interact with the main computer 48 without leaving their seats.

[0062] The (final) inspection and rejection station 42 and the auto reject station 43 have machine vision capability for analyzing 182, 184 a completed tray assembly. The completed tray assembly includes food and non-food items for catering a meal. For example, the completed tray assembly has the food tray 76 as its base, the rectangular filled with a rice pack, the fruit bowl, a teacup holding a sealed yogurt cup,

the cutlery pack, a bowl of salad, a wrapped muffin, a cracker pack and others. When in operation, the inspection and rejection station 42 takes 184 continuous photos of the completed tray assembly and compares 186 the continuous photos with the preloaded criteria.

[0063] The reject station 43 will withhold 188 a completed tray assembly that does not fulfill the preloaded criteria and stack 190 the rejected tray assembly in a reject bin (not shown). In contrast, the reject station 43 will take no action to a completed tray assembly if the inspection and rejection station 42 is satisfied with the completed tray assembly because all preloaded criteria are complied with.

[0064] The auto tray-to-cart station 68 receives 192 completed tray assemblies at the back end 66 of the belt 60. The tray-to-cart station 68 is an industrial robot or mechanical tray pusher, similar to the tray dispenser 32. In operation, the auto tray-to-cart station 68 reaches 194 out to the belt 60 and holds 196 a completed tray assembly tightly. The auto tray-to-cart station 68 identify 198 a suitable slot in cart 68 neighboring to the back end 66, and insert 200 the completed tray into the slot fully. The auto tray-to-cart 68 will insert a subsequent completed tray assembly into a next available slot in the cart 68. The auto tray-to-cart station 68 transmits an alert signal to the main computer 48 if a cart 68 is almost full with the completed tray assemblies. The main computer 48 will show 204 messages on the displays 50, 52 for requesting empty carts 68. The empty carts 68 are supplied to the auto tray-to-cart station 68 following the request. The auto cart-to-tray station 68 will affix a label to a cart filled with the completed tray assembly for future identification. The label includes bar codes, Quick Response (QR) code, Radio-Frequency identification (RFID) code and texts for both human and machine interpretation. The tray-to-cart station 68 can alternatively be a mechanical tray pusher.

[0065] In the application, unless specified otherwise, the terms "comprising", "comprise", and grammatical variants thereof, intended to represent "open" or "inclusive" language such that they include recited elements but also permit inclusion of additional, non-explicitly recited elements.

[0066] As used herein, the term "about", in the context of concentrations of components of the formulations, typically means +/- 5% of the stated value, more typically +/- 4% of the stated value, more typically +/- 3% of the stated value, more typically, +/- 2% of the stated value, even more typically +/- 1% of the stated value, and even more typically +/- 0.5% of the stated value.

[0067] Throughout this disclosure, certain embodiments may be disclosed in a range format. The description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the disclosed ranges. Accordingly, the description of a range should be considered to have specifically disclosed all the possible sub-ranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed sub-ranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

[0068] It will be apparent that various other modifications and adaptations of the application will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the application and it is intended that all such modifications and adaptations come within the scope of the appended claims.

0005P00030

Reference Numerals

30	flexible assembly line
32	tray dispenser
34	first loading station
36	second loading station
38	third loading station
40	manual loading station
42	inspection and rejection station
43	auto reject station
44	tray-to-cart loading station
46	conveyor
48	main computer
50	first display
52	second display
54	first bin stacker
56	second bin stacker
58	vibratory bowl sorter
60	belt
62	trolley
64	front end
66	back end
68	carts
70	first operator
72	second operator
74	arm
76	empty tray
78	first four-axis robot
80	clean empty tray
82	second four-axis robot
84	tray
86	third four-axis robot
88	tray
90	tray

0005P00030

91 carousel shelves
100 method
102 enter
104 retrieve
106 upload
108 move
110 inspect
112 compare
114 catch
116 place
118 drop
119 allow
120 proceed
122 identify
124 detect
126 capture
128 put
130 scan
132 compare
134 replace
136 ascertain
138 stretch
140 seize
142 lift
144 take
146 move
148 replace
150 sense
152 examine
154 extend
156 grab
158 shifted
160 deposit
162 shot

0005P00030

164 process
166 depart
168 take off
170 replace
172 pick
174 place
176 scrutinize
178 take off
180 look
182 intervene
184 take
186 compare
188 withhold
190 stack
192 receive
194 reach
196 hold
198 identify
200 insert
202 transmit
204 shows
206 label

0005P00030

Claims

1. Flexible assembly line (30) for tray assembly, quality inspection and packaging comprising
a tray dispenser (32) for providing an empty tray (76),
a conveyor (46) for transporting the empty tray (76),
a loading station (34, 36, 38) for placing food or non-food items onto the empty tray (76) automatically.

2. The flexible assembly line (30) of Claim 1 further comprising
a tray-to-cart loading station (44) for removing a completed tray package away from the conveyor (46).

3. The flexible assembly line (30) of Claim 1 or 2 further comprising
a vision inspection and rejection station (32, 34, 36, 38) for checking and rejecting food or non-food items.

4. The flexible assembly line (30) of any of the preceding claims further comprising
sorters (54, 56, 58) for organizing the food or non-food items for the loading station (34, 36, 38).

5. The flexible assembly line (30) of any of the preceding claims, wherein
the loading station (34, 36, 38) or the tray dispenser (32) comprises a robot (32, 78, 82, 86) for picking food or non-food items or for transferring them to the conveyor (46).

6. The flexible assembly line (30) of any of the preceding claims, wherein
any of the tray dispenser (32), the conveyor (46) and the loading station (34, 36, 38) has vision components for inspecting the food and non-food items.

7. The flexible assembly line (30) of Claim 6, wherein
the tray dispenser (32) or the loading station (34, 36, 38) is configured to purge a rejected item from the conveyor (46) after the vision inspection.

8. The flexible assembly line (30) of any of the preceding claims further comprising
a manual loading station (40) for manually loading or unloading food or non-food items onto the conveyor (46).

9. The flexible assembly line (30) of any of the preceding claims, wherein
the conveyor (46) comprises a belt (60) that is connected to between the tray dispenser (32) and the loading station (34, 36, 38).

10. The flexible assembly line (30) of any of the preceding claims, wherein
the loading station (34, 36, 38) comprises an automatic loading station (32, 34, 36, 38) for picking food items onto the conveyor (46).

11. Method (100) of using a flexible assembly line for tray packaging comprising
putting a tray (76) onto a conveyor (46),
loading a food or non-food item onto the tray (76) automatically, and
transferring a loaded tray (84, 88, 90) into a cart (68).

12. Method (100) of Claim 11 further comprising
inspecting the tray (76) automatically before or after the loading.

13. Method (100) of preceding Claim 11 or 12 further comprising
inspecting the food and non-food items automatically before or after the loading.

14. Method (100) of any of the preceding claims 10 to 13 further comprising
sorting the food or non-food items for the loading.

15. Method (100) of Claim 12 or 13, wherein
the inspecting comprises machine vision inspection.

16. Flexible assembly line (30) according to any of the Claims 1 to 15, wherein

any stations of the flexible assembly line (30) is modularly designed such that the stations can be removed from or installed onto the flexible assembly line (30, 200) for tray packaging.

17. Flexible assembly line (30) according to any of the Claims 1 to 15 and 16 further comprises
an Automatically Guided Vehicle for transporting objects from or to the flexible assembly line (30).

18. Flexible assembly line (30) according to any of the Claims 1 to 15 and 16 to 17 further comprises
a Carousel that has parallel rollers, at least one of the rollers has pockets for receiving food or non-food items.