0005P00020

FLEXIBLE ASSEMBLY LINE FOR CUTLERY PACKAGING

[0001] The present application relates to a Flexible Assembly Line for Cutlery Packaging (FAL-CP). The application also relates to a method of using the Flexible Assembly Line.

[0002] In food catering business, cutleries, toothpicks and napkins are often provided in sets for sealing into flow wrap bags. Packing of these eating utensils is time consuming and labor intensive when these they are handled in large volumes. For example, in airline food catering business, since food is continuously supplied in trays to numerous flights, it is difficult to pack different sets of cutleries with large quantities that suit various types of food efficiently.

[0003] The present invention aims to provide a new and useful flexible assembly line for cutlery packaging. Essential features of the invention are provided in the independent claims, whilst advantageous features of the invention are given by the dependent claims.

[0004] According to one aspect of the invention, the application provides a flexible assembly line for cutlery packaging. The flexible assembly line includes a cutlery sorter for dispensing and spreading cutlery items, a transporting line connected to the cutlery sorter for receiving the scattered cutlery items and for moving them to a predetermined location, and a cutlery-packaging machine coupled to the transporting line at the predetermined location for wrapping the cutlery items together. Since the flexible assembly can sort the cutlery items and pack them automatically, cutlery packaging productivity and consistency of the flexible assembly line can be greatly increased, which is highly desired for catering business with large volumes. The cutlery packaging line can comprise a cutlery conveyor for transporting cutlery items.

[0005] The transporting line can comprise a toothpick and tissue assembly line for transporting serviettes and toothpicks to the cutlery-packaging machine. Thus, the flexible assembly line is able to seal the cutlery items, the serviette and a sachet of toothpicks into a single plastic bag in a tidy and convenient manner. The serviettes can be dispensed directly onto a conveyor of the toothpick and tissue assembly line.

[0006] The transporting line can further have a cutlery assembly line for transporting cutlery items to the cutlery-packaging machine. The cutlery assembly line can effectively move the cutlery items, which are separate from the sachet of toothpicks and the serviettes. The separation allows cutlery-handling machines with dedicated grasping mechanism to inspect and move the cutlery items effectively and efficiently.

[0007] The toothpick and tissue assembly line can comprise a vision inspection machine for checking the serviettes and the toothpicks before packaging. In production, serviettes or toothpicks can be missing from time to time. The vision inspection machine checks whether the serviettes are in order and whether the sachets are filled with toothpicks properly before allowing them to be packaged. The quality checking machine and procedure prevents poor packaging quality, which will to cause customer dissatisfaction.

[0008] The cutlery assembly line can have a vision inspector for checking quality of the cutlery items before packaging. Similar to the serviettes (tissue paper), some cutlery items can be stained, broken, bent or chipped off. The vision inspector scrutinizes whether the cutlery items are compliant with predetermined quality standards for avoiding cutlery packages of inferior quality.

[0009] The cutlery assembly line can further comprise a vision robot for bringing the cutlery items from the cutlery assembly line to the toothpick and tissue assembly line for packaging. The vision robots join the two dedicated lines together such that the flexible assembly line has the flexibility in packaging various types of cutlery items, chopsticks and serviettes. In fact, the vision robot makes the flexible assembly line so versatile that the vision robots can be programed for inspecting quality, assembling cutlery and packaging odd-shaped or special-purposed cutlery items to suit customers' changing requirements.

[0010] The vision robot can include a buffer station for storing cutlery items. There are times when a cutlery conveyor belt has shortage of cutlery items, the vision robot is thus able to pick suitable cutlery items from the buffer station to backup such that packaging production of the flexible assembly line will not be hampered in speed or

quality. In other words, the buffer station enables the flexible assembly line to run at its optimum efficiency.

[0011] The vision robot can be configured to check quality of a pile of cutlery items on the toothpick and tissue assembly line. For example, the vision robot can identify and count the number of cutlery items in the pile on a serviette for compliance with predetermined packaging instructions. If a duplicated cutlery item is identified, the vision robot will purge the faulty pile out of the toothpick and tissue assembly line. Alternatively, the vision robot will take the duplicated cutlery item away from the toothpick and tissue assembly line.

[0012] The transporting line can further comprise an auto tissue dispenser for distributing the serviettes in an orderly manner directly onto the flow-wrap machine conveyor belt. This arrangement allows one sachet of toothpicks and other cutlery items to be placed on top of a serviette easily for packing and inspection.

[0013] The transporting line can further comprise an auto toothpick dispenser for spreading the sachets of toothpicks onto the toothpick conveyor belt. Once the sachets of toothpicks are spread apart, each of them can be quickly picked up for placing on top of a serviette.

[0014] According to a further aspect of the invention, there is provided a flexible assembly line for cutlery packaging, which comprises a dispenser for dispensing or spreading cutlery items, a cutlery sorter for checking, orientating and assembling the cutlery items into sets; a transporting line for connecting to the cutlery sorter and transporting the cutlery items them to a predetermined location, and a cutlery packaging machine coupled to the transporting line at the predetermined location for wrapping the cutlery items together as cutlery package. The sorter can use machine vision to inspect integrity of the cutlery items and orientation of the cutlery items. For example, the sorter can purge a broken toothpick sachet into a reject bin. The sorter can also check incoming cutlery items and determine their orientations. A vision robot can pick a fork and rotate the fork according to a predetermined direction such that the fork can be later sealed into a plastic bag with the same orientation as other cutlery items (e.g. spoon, knife). In other words, the sorter can arrange handles of

cutlery items at a same end of the plastic bag, which form an orderly packaged cutlery set.

[0015] The flexible assembly line can comprise a machine vision system for visually inspect cutlery items. The machine vision system provides feedback such that the flexible assembly line becomes intelligent. For example, the machine vision system enables the cutlery sorter to recognize different types of cutlery items and place them to different places according to their nature. Segregated cutlery items can then individually inspected for quality compliance and packaging.

[0016] The flexible assembly line can be configured to sort cutlery items, to inspect the cutlery items, to assemble the cutlery items, to pack the cutlery items or to perform any combination of these tasks automatically. When required, the flexible assembly line can perform a combination of these tasks together. For example, the flexible assembly line can sort, inspect and assemble the cutlery items simultaneously because a vision robot can pick up a cutlery item (e.g. spoon) from a pile of cutlery items, inspect the cutlery item, change the cutlery item's orientation and place the cutlery items onto a serviette in forming a cutlery set.

[0017] Any stations 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 cutlery packaging. These stations, including vision robots, conveyors and vision inspectors can standalone or connect to the main Computer Monitoring System (CMS) for operation. Hence, the flexible assembly line can be configured to adapt to different production tasks easily.

[0018] 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 a bin full of collated cutlery sets to a warehouse and moves an empty bin to the collator of 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.

[0019] The cutlery sorter can comprise the top vision inspector, the flip over machine, the bottom vision inspector, the first vision robot, the second vision robot, the third vision robot. These machines can check finishing quality of the cutlery items, organize them following predetermined orientation and menu, and place them to designated places automatically. Hence, the sorter provides a feedback loop to the flexible assembly line for selecting quality compliant cutlery items and organizing them for packaging into cutlery sets automatically. The cutlery sorter, when equipped with machine vision, operates in a consistent, efficient and reliable manner, which is very suitable for long-term continuous catering service.

[0020] According to another aspect of the present invention, the application provides a method for packaging cutlery items. The method comprises a step of dispensing cutlery items onto a cutlery conveyor belt, a step of inspecting quality of the cutlery items automatically, and a step of packaging quality compliant cutlery items. The method has introduced automation to the cutlery packaging such that less labor or/and fewer operators are required. Packaging speed, accuracy and hygiene are improved due to the machine inspection, which provides a feedback loop for the packaging operation.

[0021] The method can include a step of taking the compliant cutlery items from the cutlery conveyor belt to a flow-wrap assembly line automatically for the packaging. Hence, the cutlery items are shifted between two production lines or belts, which offer flexibilities to the two lines. Each of these two lines can be programmed to handle different types of food utensils, and yet the two lines can be integrated for a single packaging production. Here, the toothpick assembly line can have a flow-wrap assembling machine.

[0022] The method may have a step of dispensing serviettes or sachets of toothpicks onto toothpick and tissue assembly line automatically. Automated toothpick or serviette dispensing avoids tedious and error-prone manual handling. Since the serviette and toothpick dispensing is done without human labor, the serviettes and the toothpicks can be orderly laid out during continuous packaging operations consistently. Speed and pattern of the automatic dispensing may be programmed to suit different types of food and packaging speed.

[0023] The method may still include a step of checking the quality of the serviettes and the sachets of toothpicks automatically for compliance. Machine vision is implemented for the quality checking such that non-compliant serviettes and toothpicks can be taken away from the flexible assembly line to avoid rejected packages appearing at the end of the flexible assembly line. In other words, packaging quality of the flexible assembly line is greatly enhanced by getting rid of rejected items at an early stage, which avoid the lost in motion for packaging.

[0024] The method can further include a step of checking quality of packaged cutlery items before collecting them orderly in a bin. The flexible assembly line is able to use its machine vision capability for counting items inside each package such that the flexible assembly line will take a rejected package into a bin for re-packaging. Quality-approved cutlery packages can be laid in an orderly manner for subsequent handlings.

[0025] 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.

[0026] Fig. 1 illustrates a first flexible assembly line for cutlery packaging;

[0027] Fig. 2 illustrates a perspective view of the first flexible assembly line in a simplified form;

[0028] Fig. 3 illustrates a flow chart for using the first flexible assembly line;

[0029] Fig. 4 illustrates a second flexible assembly line for cutlery packaging;

[0030] Fig. 5 illustrates a third flexible assembly line for cutlery packaging; and

[0031] Fig. 6 illustrates a fourth flexible assembly line for cutlery packaging.

[0032] Exemplary, non-limiting embodiments of the present application will now be described with references to the above-mentioned figures. In particular, Figs. 1-3 depict a first embodiment of the present invention.

[0033] Fig. 1 illustrates a first flexible assembly line 30 for cutlery packaging, which is first embodiment of the present invention. The first flexible assembly line 30 is

automated such that the first flexible assembly line 30 can package cutlery items together with folded tissue paper and toothpick. The first flexible assembly line 30 has a toothpick assembly line 32 at one side, and a cutlery assembly line 34 on the other side. Both lines 32, 34 extend longitudinally from left to right according to Fig. 1.

[0034] The toothpick assembly line 32 comprises an auto tissue dispenser 36, an auto toothpick dispenser 38, a vision inspection machine 40, a cutlery package machine 42, a cutlery inspection machine 44, a collator 46 and a toothpick conveyor belt 48. The auto tissue dispenser 36, the auto toothpick dispenser 38, the vision inspection machine 40, the cutlery package machine 42, the cutlery inspection machine 44 and the collator 46 are distributed along the toothpick conveyor belt 48 from left to right sequentially. In particular, the auto tissue dispenser 36, the auto toothpick dispenser 38 and the vision inspection machine 40 are closely laid at a left end 50 of the toothpick conveyor belt 48, whilst the cutlery package machine 42, the cutlery inspection machine 44 and the collator 46 reside near a right end 52 of the toothpick conveyor belt 48.

[0035] The cutlery package machine 42 is a horizontal flow wrap machine used for wrapping a cutlery package into a pillow pack using heat sealable films. Packaging speed of the cutlery package machine 42 is synchronized with the toothpick assembly line 32, as well as the cutlery assembly line 34.

[0036] Next to the toothpick assembly line 32, the cutlery assembly line 34 includes a cutlery sorter 54, a top vision inspector 56, a flip over machine, 58, a bottom vision inspector 60, a first vision robot 62, a second vision robot 64, a third vision robot 66, a cutlery reject bin 68 and a cutlery conveyer belt 70. Starting from a left end 72 to a right end 74 of the cutlery conveyer belt 70, the cutlery sorter 54, the top vision inspector 56, the flip over machine 58, the bottom vision inspector 60, the first vision robot 62, the second vision robot 64, the third vision robot 66 and the cutlery reject bin 68 are positioned along the cutlery conveyer belt 70 sequentially from a left end 72 to a right end 74.

[0037] The three vision robots 62, 64, 66 have three cutlery buffer stations 75, 77, 79 that are adjacent to the three vision robots 62, 64, 66 respectively. In other words, a

first buffer station 75 is placed near the first vision robot 62; a second buffer station 77 is positioned close to the second vision robot 64; whilst the third vision robot 66 has a third buffer station 79 next to it. Each of these buffer stations 75, 77, 79 has arrays of knife, fork, tablespoon and soupspoon so that their neighboring vision robots 62, 64, 66 can pick up a cutlery item (e.g. fork or knife) from respective buffer station onto a folded tissue paper when there is shortage of supply in cutlery items on the cutlery conveyor belt 70.

[0038] Each of these buffer stations 75, 77, 79 stores certain quantity and types of cutlery items for replenishment of cutlery items on the cutlery assembly line 34. The vision robots 62, 64, 66 are programmed to refill wherever there is a missing cutlery item or whenever there is "spare time" for replenishing.

[0039] The first vision robot 62 is located on top of the cutlery conveyer belt 70 and arms 76 of the first vision robot 62 can operate across both the toothpick conveyor belt 48 and the cutlery conveyer belt 70. Similarly, arms 78 of the second vision robot 64 and arms 80 of the third vision robot 66 can also reach both conveyer belts 48, 70 respectively.

[0040] When in use, parts of the first flexible assembly line 30 cooperate with each other for packaging cutleries, tissue paper and toothpicks into flow-wrap bags (not shown). Each of these flow-wrap bags contains a knife, a fork, a spoon, a toothpick, a tissue paper, a butter sachet, a jam sachet, a salt sachet and a milk sachet (not shown).

[0041] Fig. 2 illustrates a perspective view of the first flexible assembly line in a simplified form. Fig.2 depicts parts that are similar or identical to those of Fig. 1. The similar parts or steps are labeled with identical or similar reference numerals. Descriptions of the similar parts are therefore incorporated by reference where appropriate.

[0042] Fig. 3 illustrates a flow chart for explaining a method 100 of using the first flexible assembly line 30. The method 100 mainly comprises two process flows 102, 104 that interact via the three vision robots 62, 64, 66.

[0043] A first process flow 102 involves the toothpick assembly line 32. Initially, the auto tissue dispenser 36 receives a serviette pack of about fifty sheets per pack and the pack of serviette is manually open and placed into a hopper media of the auto tissue dispenser 36. The auto tissue dispenser 36 dispenses 106 folded tissue papers one at a time onto the toothpick conveyor belt 48. Bags of toothpicks are torn open and loose sachets of toothpicks are placed into a hopper media for being dispensed with a small quantity at a time onto the toothpick conveyor belt 48. The toothpick distribution precedes actions of vision robots 62, 64, 66 for picking these toothpicks and placing them into buckets of the flow wrap machine. The auto tissue dispenser 36 also checks 108 if the folded tissue papers are orderly laid out by using its machine vision. The auto tissue dispenser 36 will trigger 114 an alarm if a folded tissue paper is misaligned or a tissue paper is missing at an exit of the auto tissue dispenser 36. After hearing the alarm, an operator will rectify the discrepancies. Alternatively, the vision robot62, 64, 66 at downstream increase their operation speed to overcome shortage of properly aligned tissue papers.

[0044] . The auto toothpick dispenser will dispatch a small quantity of toothpick onto a toothpick conveyor where it will be mechanically spread across the conveyor to minimize toothpick stacking onto one another. Further down the stream, the vision robotic will be picking one toothpick at a time and orientate the toothpick before placing it into the Flow Wrap machine conveyor bucket. If the First Robotic missed the placement, the Second Robotic will take over and so on for the third Robotic. Unpicked toothpick will be transported to the end of the conveyor belt and dropped into the recycling bin whereby the operator will manually reload it into the hopper at the starting of the toothpick conveyor.

[0045] A second process flow 104 relates to the cutlery conveyor belt 70. At the left end 72 of the cutlery conveyor belt 70, washed cutlery items are poured 122 into a cutlery hopper (not shown) of the cutlery sorter 54, which is located above the cutlery conveyor belt 70.The hopper will dispense the cutlery in a small quantity at a time onto the cutlery conveyor belt whereby it is mechanically agitated to spread out to minimize cutlery stacking onto each other. The cutleries are then transported to the first top surface defect vision inspection system. Cutleries that failed the top surface

inspection will be transported to the end of the conveyor and dropped into the reject bin. Those cutleries that passed the top surface inspection will be pickup by the vision Robotic arms and be move across the vision camera for inspection of the bottom surface of the cutlery to ensure it meets the acceptance criteria. Then the vision robotic intelligent software will ensure each type of cutlery will be placed onto the Flow wrap conveyor bucket to assemble a set of cutlery pack. Those cutleries that failed the bottom inspection will be thrown into the reject bin and replaced via the buffer station.

[0046] The top vision inspector 56 examines 128 top surfaces of all incoming knives, forks, soupspoons and tablespoons. The top vision inspector 56 provides hygiene quality check to top surfaces of the cutlery items. The top surfaces are blown with pressurized filtered air to remove dust before the examination 128 to reduce vision inspection error. Unclean cutlery items are transported to the end of the conveyor belt 132 and casted 132 into a reject bin for rewash. The top vision inspector 56 also projects 134 ultraviolet light onto the cutlery items for further sanitizing.

[0047] Each of the cutlery items are flipped over 136 when passing through the next station, which is the flip over machine 58. The flip over machine 58 extends 138 its robotic arms (now shown), picks 140 each of these cutlery items up and rotates 142 these cutlery items for exposing bottom surfaces of the cutlery items toward top/ceiling/sky. Alternatively, the robotic arm will pick those cutlery items that passed the top surface inspection and move over a camera for “Fly-By” underside/bottom surface inspection.

[0048] The flipped cutlery items enter the bottom vision inspector 60 after departing from the flip over machine 58. The bottom vision inspector 60 discharges 144 pressurized air streams (i.e. air jet/blade) onto the bottom surfaces such that dirt on the bottom surfaces is blown off for avoiding possible error when undergoing vision inspection. The vision inspector 60 checks 146 the bottom surfaces of the cutlery items for hygiene quality control. Identified unclean cutlery items are rejected such that a robotic arm of the vision inspector 60 grasps 148 the unclean cutlery items and throw them into a reject bin for rewashing. Ultraviolet light of the bottom vision

inspector 60 is shined 150 onto the bottom surfaces too, which provides an additional cleaning action to the cutlery items.

[0049] Vision cameras of the two vision inspectors 56, 60 take continuous pictures of cutlery and/or toothpick on the cutlery conveyor belt 70, and the two vision inspectors 56, 60 communicate with the a quality control (QC) computer to decide which type of cutlery and toothpick to pick over for packaging. The QC computer sends analysis result to a main Computer Monitoring System (CMS) of the first flexible assembly line 30 to decide and synchronize the conveyor belts' speeds for proper load balancing.

[0050] The vision inspectors 56, 60 also inspect surface integrity of the cutlery items. Good cutlery items are allowed to proceed along the cutlery conveyor belt 70, whilst chipped/broken cutlery items are rejected and purged from the cutlery conveyor belt 70. The CMS is connected to the entire first flexible assembly line 30 such that the CMS can optimize cutlery packaging quantity and speed with crash-proof prevention mechanism.

[0051] As mentioned above, the three vision robots 62, 64, 66 bridge over between the toothpick line 32, and the cutlery assembly line 34. Each of these three vision robots 62, 64, 66 has a vision-picking module (not shown) for detecting shapes and locations of the cutlery items, the folded tissue papers and the sachets of toothpicks. When in action, the first vision robot 62, which stands next to the bottom vision inspector 60, takes 154 one knife and one fork onto a folded tissue paper upon noticing 152 the incoming cutlery items and the folded tissue paper by its sensors. The incoming folded tissue paper already has a sachet of toothpick on top. The second vision robot 64 grabs 156 a tablespoon and a soupspoon from the cutlery conveyor belt 70 and puts 158 them onto the folded tissue paper, together with knife and the fork.

[0052] The third vision robot 66 regulates 159 the toothpick and cutlery conveyor belt 48 at a downstream of the first and second vision robots 62, 64 for checking completeness of the cutlery items. In other words, the third vision robot 66 brings 160 a fork onto a folded tissue paper if the third vision robot 66 detects 162 a missing fork on the folded tissue paper. In fact, the third vision robot 66 will bring 160 any type(s)

of the cutlery items onto a folded tissue paper if the third vision robot 66 detects 162 a missing item.. For example, the third vision robot 66 will take 163 a pile of a folded tissue paper, a sachet of toothpick, a fork, a knife and a tablespoon away because a soupspoon is missing from the pile.

[0053] Alternatively, if the third vision robot 66 detects that one cutlery item (e.g. tablespoon) is missing from one of the folded tissue paper, the third vision robot 66 will pick up a tablespoon from the third buffer station 79 and deposit it onto the folded tissue paper. The third vision robot 66 will take a redundant cutlery item (e.g. fork) away from a folded tissue paper if the third vision robot 66 finds two forks on the folded tissue paper.

[0054] Piles of cutlery items, a folded paper and a sachet of toothpick are transported 164 to the cutlery-packaging machine 42. The cutlery-packaging machine 42 is flow-wrap type of packaging device that seals 166 each pile of the cutlery items, the folded paper and the sachet of toothpicks into transparent flow wrap bags separately. These piles, also known as cutlery packages, are illuminated 168 with ultraviolet light during the sealing.

[0055] At a downstream of the cutlery-packaging machine 42, the cutlery inspection machine 42 checks 170 the cutlery packages and ejects 172 rejected cutlery packages into a bin automatically. The collator 46, which is adjacent to the cutlery-packaging machine 42, places 174 approved cutlery packages in an orderly manner into a bin. The bin can store a predetermined quantity of cutlery packages.

[0056] Functionally, the auto tissue dispenser 36 allows the serviette to be placed directly into a magazine like holder. A loading & refilling height of the auto tissue dispenser 36 is about a table height, such as from 70 to 90 centimeters (cm). The auto tissue dispenser 36 also allows tissue refilling without stopping the dispenser 36, which is safe to operators. The auto tissue dispenser 36 can dispense one serviette in each flow-wrap pocket and has synchronized its dispensing speed with speeds of conveyor belts 48, 70. The auto tissue dispenser 36 has a sensor connected to an alarm for sounding a near-empty signal for refilling of tissue paper. The auto tissue dispenser 36 will stop autumnally and sound another signal if the auto tissue

dispenser 36 detects serviette jam. Once jammed serviettes is removed, the auto tissue dispenser 36 is resume its normal operation.

[0057] The auto toothpick dispenser 38 is configured to allow sachets of toothpicks placed directly into a magazine like holder/hopper. The holder/hopper is positioned at a table height (e.g. 70 to 80 cm) such that operators can refill the sachets of toothpicks with ease. The refilling can be performed without stopping the auto toothpick dispenser 38. At the auto toothpick dispenser 38, the toothpick dispensing and the tissue dispensing are synchronized with the conveyor belts 48, 70. The auto toothpick dispenser 38 has a near-empty-toothpick alarm to alert the operators for refilling the toothpick sachets. The auto toothpick dispenser 38 can stop automatically when it 38 detects toothpick jam and sends an alarm to the operators. Jammed toothpicks are removed such that the auto toothpick dispenser 38 can be re-started safely. Rejected toothpick sachets (e.g. sachet with no toothpick inside, or toothpick with damaged wrapping) are ejected and replaced with good toothpick sachets.

[0058] The cutlery sorter 54 allows assorted cutlery items to be poured directly into its hopper. A loading height of the cutlery sorter 54 is below a waist level of the operator (e.g. <70 cm). The cutlery sorter 54 also allows refilling without stopping the machine 54 and ensures operation safety. The cutlery sorter 54 can dispense cutlery items in small batches at regular interval onto cutlery conveyor belt 70. When dispensing the cutlery items, the cutlery sorter 54 prevents dispensed cutlery items from being stacked onto each other. The cutlery sorter 54 can sound an alarm if it 54 finds its cutlery items are almost depleted. Accordingly, an operator can refill the cutlery sorter 54 after hearing the alarm. The operator will also be prompted with an alarm if any cutlery items is jammed inside the cutlery sorter 54 and the jammed cutlery item can be safely removed by the operator.

[0059] The top vision inspector 56 blows off dust from the cutlery item prior to its vision inspection for reducing inspection error. The top vision inspector provides sterilization to the cutlery items by projecting ultraviolet light onto the top surfaces of the cutlery items. In contrast, the bottom vision inspector 60 shines ultraviolet light onto bottom surfaces of the cutlery items for further sterilization. Both the top and

bottom vision inspectors 56, 60 can eject dirty or chipped cutlery items into a bin for rewashing.

[0060] The three vision robots 62, 64, 66 are fully enclosed during operation. Each of these three vision robots 62, 64, 66 is equipped with safety interlock when opening. In other words, the three vision robots 62, 64, 66 will stop immediately of their covers are open. Each of the three vision robots 62, 64, 66 is installed with a HEPA type air purifier with anti-static ionic air for minimizing dust interference. Each of three vision robots 62, 64, 66 can be selected for synchronizing and communicating with other parts of the first flexible assembly line 30 for operation. The vision robots 62, 64, 66 are designed for food industry. For example, grease(s) used for the vision robots 62, 64, 66 is/are food grade. An operating system of the vision robots 62, 64, 66 allows the vision robots 62, 64, 66 to be configured to suit wide ranges of cutlery items and can work in wide spectrums of environments. Any of the vision robots 62, 64, 66 can automatically find its home position upon and return to its original or default position in case of power shut down. The vision robots 62, 64, 66 are able to be calibrated for their orientation, position and speed adjustments with precision. The vision robots 62, 64, 66 further have good repeatability and stability such that they 62, 64, 66 can operate reliably without human intervention for an extended period (e.g. 3 months).

[0061] The cutlery package machine 40 can blow air to cutlery items prior to its vision inspection. The cutlery package machine 40 eliminates dirty cutlery items, which include a stained knife, a cracked tablespoon, an exposed toothpick or a contaminated/darkened tissue paper. After packaging, the cutlery packaging machine 40 can perform a final quality inspection of a packaged cutlery items. Non-compliant packages are discarded to a reject bin, which an operator will clear.

[0062] The cutlery buffer stations 75, 77, 79 are platforms for temporarily holding sustainable quantities and various types of cutlery items. The cutlery buffer stations 75, 77, 79 are used as backups when certain cutlery items are not immediately available on the cutlery conveyor belt 70. The cutlery buffer stations 75, 77, 79 also store toothpicks and folded tissue papers. Hence, packaging of the first flexible assembly line 30 will not be delayed even if missing cutlery items are found on the cutlery conveyor belt 70.

[0063] The cutlery package machine 42 is a horizontal flow wrap machine that has four independent servomotors. These servomotors are suitable for high speed, continuously running with minimal noises (e.g. <70dB). The cutlery package machine 42 can package a cutlery set, which includes a serviette, a knife, a spoon, a fork, a teaspoon (magnetic or non-magnetic), pre-packed tooth picks and condiments. The cutlery package machine 42 can operate at about 10 to 60 packages per minute and each of its packages can range from 80 millimeters (mm) to 500 mm. The cutlery package machine 42 uses plastic films with a maximum width of about 350 mm. The plastic films are BOPP (biaxially oriented polypropylene film). The machine 42 can alternatively use laminated & heat-able plastic films. Programmable Logic Controller (PLC) of the machine 42 enables the communication with the CMS for regulating the toothpick assembly line 32, and the cutlery assembly line 34, such as pause, stop and start. The PLC is further responsive to jam or refilling situations of the cutlery items, the toothpicks and the folded tissue papers. The CMS has non-volatile memory (e.g. hard disk drive) for recording various production parameters, such as speed of conveyor belts 48, 70, flow wrap bags lengths, sealing temperatures, cutting positions, feeding positions and film tensions. The CMS has a touchscreen for intuitive display and further provides sets of memo pages for documenting bag former height, width, and angle positions. Malfunctions of the first flexible assembly line 30 are detected, displayed and recorded by the CMS. The touchscreen can show exact locations of the faults for speedy repair. The servomotors have overload protection that prevents parts of the first flexible assembly line 30 from wearing. When abnormal resistance is detected, the first flexible assembly line 30 will stop automatically. The CMS can be used to configure the first flexible assembly line 30 for quick product adjustments by entering bag length, product length, film tension, and sealing temperatures.

[0064] The cutlery package machine 42 has four sets of temperature controllers for regulating heating elements. The cutlery package machine 42 will stop automatically when detecting abnormal print registration on packaged cutlery items. The machine 42 also will stop automatically if the packaging film runs out. Transmissions of the cutlery package machine 42 are carried by timing belt with minimal noise and long life span. The cutlery package machine 42 is enclosed by a safety glass cover with polycarbonate (PC) material for having impact resistance. Automatic film shaft

positioning of the cutlery package machine 42 provides flexibility in changing different film width. All package contact areas of the cutlery package machine 42 are covered with stainless steel material. Sealing jaws of the cutlery package machine 42 will automatically move away when the machine 42 stops. Plastic films of the cutlery package machine 42 are fed from an underside of the machine 42. A discharging conveyor of the cutlery package machine 42 is integrated with the collator 46. The cutlery package machine 42 has production volume counter and a speed indicator. The cutlery package machine 42 is equipped with an overload cut-off device for preventing damaging sealing and cutting devices by misaligned cutlery packages. The cutlery package machine 42 has sensors for detecting and preventing empty cutlery packages. The cutlery package machine 42 is further suitable for food industries and allows ease of pest control activities.

[0065] The collator 46 can load packaged cutlery items automatically into the bin with a predetermined orientation. The bin for receiving the packaged cutlery items can be configured to accept various quantities. The collator 46 can automatically move a filled bin away and replace it with another empty bin without stopping first flexible assembly line 30. Loading and unloading of the bin are arranged at an ergonomically height such that no bending of waist or knee is required from an operator. Furthermore, the loading and unloading of bin are accessible without stopping the operation of the line 30 or violating any safety guideline.

[0066] The CMS of the first flexible assembly line 30 is machine-vision enabled and can be configured to accept any desirable quantity of production. Date and time of the production can also be inputted or selected. An operating system of the CMS is stored on the non-volatile memory which allows allow arrangements of loading, updating and deleting of production menus, as well as changing non-critical parameters. Password protection of different user levels is available, which allows at least 50 users to operate the first flexible assembly line 30 for production or maintenance. Users of the first flexible assembly line 30 can log onto the CMS by entering user names for production tracking and maintenance logging. The non-volatile memory can record different packaging types. The operating system is configured to release washing and maintenance reminders based on running hours of the first flexible assembly line 30. The main control can take photos of rejected cutlery

items/packages for analysis and demonstration. A typical record keeping period is about 90 days of accumulated production time. The CMS is enabled with online Production Performance KPI (Key Performance Indicator) management reporting and graphics. For example, the reporting includes basic reporting on productivity, reject quantity, types of the rejects, average production volumes, average time taken per package, delayed packaging time, auto maintenance planning, maintenance and breakdown time, types of breakdown, out-of-normal preset tolerance alert and alarm, frequent troubleshooting guide, show machine usage type (e.g. downtime, actual production, maintenance, standby time, building incoming supplies failure e.g. compressed air pressure, power, etc). The CMS allows viewing its recorded data by date, time, percentage, line, shift, menu, etc. Data captured by the CMS is more than one year. Production and maintenance reports are automatically generated at a pre-determine timings or shifts. The reports can be printed or saved as softcopies for backup. The CMS is connected to customer SAP terminals for direct on-line presentation. The CMS is further connected to a remote monitoring system in Technical Duty Control Room.

[0067] Faulty vision robot(s) 62, 64, 66 is/are bypassed or operate at a lower speed in a safe manner for repairing or checking. For example, the first vision robot 62 can be dismantled for repair, whilst the second vision robots 64 dispatches the cutlery items for production at a lower speed.

[0068] The flexible assembly line 30 can be modified for complying with different packaging requirements. For example, a vision camera can be installed between the Flow Wrap machine conveyor belt 48 and the cutlery conveyor belt 70 for vision inspection at bottom. The vision camera checks the bottom surfaces of the cutlery items whose top surfaces have already been checked by the top vision inspector 56.

[0069] Fig. 4 illustrates a second flexible assembly line 200 for cutlery packaging. The second flexible assembly line 200 has parts or steps that are similar to those of the first flexible assembly line 20. The similar parts or steps are labeled with identical or similar reference numerals. Descriptions of the similar parts or steps are hereby incorporated by reference where appropriate.

[0070] The second flexible assembly line 200 comprises a cutlery assembly line 34, a tissue assembly line 202 and a toothpick line 204. The cutlery assembly line 34 of the second flexible assembly line 200 has similar parts and operates similar to that 34 of the first flexible assembly line 200. However, the cutlery assembly line 34 of the second flexible assembly line 200 has three robots 62, 64, 66 that operate across three lines, namely the cutlery assembly line 34, the tissue assembly line 202 and the toothpick line 204.

[0071] The toothpick assembly line 202 comprises a toothpick dispenser 206, a toothpick conveyor belt 208 and a toothpick recycle bin 210, which are sequentially connected. The toothpick dispenser 206 has machine vision for guiding and inspecting toothpick allocation on the toothpick conveyor belt 208.

[0072] The tissue line 204 is located between the toothpick assembly line 202 and the cutlery assembly line 34. The tissue line 204 includes a tissue dispenser 214, a tissue conveyor belt 216, a cutlery package machine 42, a cutlery vision inspection machine 44 and a collator 46, which are sequentially connected. The conveyor belt 216 is substantially parallel to both the toothpick conveyor belt 208 and the cutlery conveyor belt 70 in their longitudinal directions respectively.

[0073] The three vision robots 62, 64, 66 of the second flexible assembly line 200 stand between the tissue conveyor belt 216 and the cutlery conveyor belt 70. The first vision robot 62 has arms 76 that extend over the toothpick conveyor belt 208, the tissue conveyor belt 216 and the cutlery conveyor belt 70. Similarly, the second vision robot 64 also has arms 78 extending over the toothpick conveyor belt 208, the tissue conveyor belt 216 and the cutlery conveyor belt 70. However, the third vision robot 66 only extends its arms 80 across the toothpick conveyor belt 48 and the cutlery conveyor belt 70.

[0074] When in use, in contrast to the first embodiment, the first vision robot 62 of the second flexible assembly line 200 of Fig. 4 operates with the toothpick line 204, the toothpick-tissue assembly line 32 (including a flow wrap machine conveyor) and the cutlery assembly line 34. In particular, the first vision robot 62 fetches a sachet of toothpicks (i.e. wrapped toothpicks) from the toothpick conveyor belt 208 and put the

sachet of toothpicks onto a folded tissue paper. Here, the folded tissue paper (serviettes) is kept in a magazine for dispensing onto the tissue conveyor belt 216. The first vision robot 62 further draws a butter knife and cutting knife from the cutlery conveyor belt 70 and puts them onto the folded tissue paper, together with the sachet of toothpicks. If there is shortage of butter knife or cutting knife at the cutlery conveyer belt 70, the first vision robot 62 takes a butter knife or a cutting knife from a first buffer station 75 to the folded tissue paper.

[0075] As the tissues-toothpick conveyor belt 48 progresses, the second vision robot 64 brings a spoon and a fork from the cutlery conveyor belt 70 and places them onto the folded paper. The second vision robot 64 will take a spoon or a fork from a second buffer station 77 instead if the second vision robot 64 finds a missing spoon or fork from the cutlery conveyor belt 70.

[0076] The second flexible assembly line 200 packages cutlery items, folded tissue papers, sachets of toothpicks and other items (e.g. butter, jam, salt, etc.) similar to that of the first flexible assembly line 30. Both flexible assembly lines 30, 200 can be reprogrammed to package different types, shape and quantity of food utensils.

[0077] In an alternative, the toothpick dispenser 206 can dispense the sachets of toothpicks with regular intervals onto the toothpick conveyor belt 208. The toothpick dispenser 206 can further disperse the sachets of toothpicks by employing a vibrator bowl for preventing the sachets of toothpicks from stacking onto each other. The vision robots 62, 64, 66 can thus easily pick and place the sachets of toothpicks for packaging. Stacked sachets of toothpicks, which the vision robots 62, 64, 66 do not pick up, will be dropped into a bin at the end 52 for reuse.

[0078] Fig. 5 illustrates a third flexible assembly line for cutlery packaging, which provides another embodiment of the invention. In the third flexible assembly line, a Vision System takes images of items, identify, analyze for shape and surfaces cleanliness, integrate the images with robotic to guide and command robotic arm to pick only the clean items and places the cutlery set (1 spoon, 1 knife, 1 teaspoon, 1 fork) into the respective pockets of the flow wrap machine in its designated orientation. The cutlery set includes tissue and toothpick items. The Vision System performs a

final check that all required items are in the pack. The Vision System further performs load balancing, job assignment and coordination between few robotic arms. The Vision System also adjusts the cutlery belt and flow wrap conveyors speed by sending signals to the machine main control PLC. The flexible assembly line further sends production statistic & KPIs (on-line) to mainframe for recording, analysis, monitoring, management reporting and abnormal process alarm. The Vision System also allows ease of updating of new cutlery types and deleting of obsolete layout. The Vision System is integrated with machine PLC and customer computer. The Vision System is also equipped with modem for remote troubleshooting.

[0079] Fig. 6 illustrates a fourth flexible assembly line for cutlery packaging, which provides another embodiment of the invention. In the fourth flexible assembly line, a Vision System takes image of items, identify, analyze for shape and surfaces cleanliness then to integrate with robotic to guide and command robotic arm to pick only the clean items and places the cutlery set (1 spoon, 1 knife, 1 teaspoon, 1 fork) into the respective pockets of the flow wrap machine in its designated orientation. This cutlery set includes tissue & toothpick items. The Vision System does a final check that all required items are in the pack. The Vision System also performs load balancing/job assignment and coordination between few robotic arms and adjust the cutlery belt and flow wrap conveyors speed by sending the signal to the machine main control PLC. The flexible assembly line further sends production statistic and KPIs (on-line) to mainframe for recording, analysis, monitoring, management reporting and abnormal process alarm. The Vision System allows ease of updating of new cutlery types and deleting of obsolete layout. The Vision System is integrated with machine PLC and customer computer. The Vision System is further equipped with modem for remote troubleshooting.

[0080] Any of the flexible assembly lines of Figs. 1-6 has incorporated modular design features. For example, in the first flexible assembly line 30 of Figs. 1-3, any of the stations can be individually installed onto removed from the flexible assembly line 30 independently, without affecting the operation of the flexible assembly line 30. The stations include the auto tissue dispenser 36, the auto toothpick dispenser 38, the vision inspection machine 40, the cutlery packaging machine 42 (i.e. flow wrap machine), the cutlery inspection machine 44, the collator 46, the toothpick conveyor

48, the cutlery sorter 54, the top vision inspector 56, the flip over machine 58 and the bottom vision inspector 60. The stations further include the first vision robot 62, the second vision robot 64, the third vision robot 66, the cutlery reject bin 68 and the cutlery conveyor belt 70. Any of these stations can be connected to the main Computer Monitoring System (CMS) for control and coordination.

[0081] Any of the flexible assembly lines, as shown in Figs. 1-6, has machine vision capability that can perform surface quality inspection on cutlery items. The flexible assembly lines further make decision for accepting or rejection based results of the vision inspection. Following the inspection, the flexible assembly lines can assemble the cutlery items by picking each type of cutlery items according to preloaded packaging instruction at the CMS. Here, the cutlery package includes toothpicks, tissues/serviettes and sugar packs. The flexible assembly lines can also pack the loose cutlery items into plastic bags. In short, the flexible assemble assembly lines according to Figs. 1-6 has 4-in-1 functions, which are auto-sorting, machine inspection, auto assembly and auto packaging.

[0082] Any of the flexible assembly lines (Figs. 1-6) can include an Automatically Guided Vehicle (i.e. AGV: automated guided vehicle or automatic guided vehicle). The AGV is a mobile robot that follows markers or wires on a floor of the in-flight center. The AGV moves between the collator and a warehouse of the in-flight center such that fully stacked cutlery bin is shipped to the warehouse, whilst a another empty bin is placed at the collator for collecting cutlery packages.

[0083] In the application, unless specified otherwise, the terms "comprising", "comprise", “have”, “include” 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.

[0084] 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.

[0085] 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.

[0086] 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.

0005P00020

Reference Numerals

30	first flexible assembly line
32	toothpick assembly line
34	cutlery assembly line
36	auto tissue dispenser
38	auto toothpick dispenser
40	vision inspection machine
42	cutlery package machine
44	cutlery inspection machine
46	collator
48	toothpick conveyor
50	left end
52	right end
54	cutlery sorter
56	top vision inspector
58	flip over machine
60	bottom vision inspector
62	first vision robot
64	second vision robot
66	third vision robot
68	cutlery reject bin
70	cutlery conveyer belt
72	left end
74	right end
75	first buffer station
76	arms
77	second buffer station
78	arms 80
79	third buffer station
80	arms
100	method
102	first process flow
104	second process flow

0005P00020

106 dispense
108 check
110 reposition
112 add
114 trigger
116 sort
118 allot
120 check
122 pour
124 sort
126 spread apart
127 process flow direction
128 examine
130 pick up
132 cast
134 project
136 flip over
138 extend
140 pick up
142 rotate
144 discharge
146 check
148 grasp
150 shine
152 take
154 notice
156 grab
158 put
159 regulate
160 bring
162 detect
163 take
164 transport
166 seal

168 illuminate

170 check

172 eject

174 place

176 provide

200 second flexible assembly line

202 tissue assembly line

204 toothpick line

206 toothpick dispenser

208 toothpick conveyor belt

210 toothpick recycle bin

212 toothpick dispenser

214 tissue dispenser

216 tissue conveyor belt

0005P00020

Claims

1. Flexible assembly line (30, 200) for cutlery packaging comprising:
   - a dispenser (36, 38, 54) for dispensing or spreading cutlery items,
   - a cutlery sorter (54, 56, 58, 60, 62, 64, 66) for checking, orientating and assembling the cutlery items into sets;
   - a transporting line (32, 34) for connecting to the cutlery sorter (54) and transporting the cutlery items them to a predetermined location, and
   - a cutlery packaging machine (42) coupled to the transporting line (32, 34) at the predetermined location for wrapping the cutlery items together as cutlery package.

2. Flexible assembly line (30, 200) of Claim 1, wherein
the transporting line (32, 34) comprises a toothpick and tissue assembly line (32) for transporting serviettes and toothpicks to the cutlery packaging machine (42).

3. Flexible assembly line (30, 200) of Claim 1 or 2, wherein
the transporting line (32, 34) further comprises a cutlery assembly line (34) for transporting cutlery items to the cutlery packaging machine (42).

4. Flexible assembly line (30, 200) of Claim 2 or 3, wherein
the toothpick and tissue assembly line (32) comprises a vision inspection machine (40) for checking the serviettes and the toothpicks before packaging.

5. Flexible assembly line (30, 200) of Claim 3 or 4, wherein
the cutlery assembly line (34) comprises a vision inspector (56, 60) for checking quality of the cutlery items before packaging.

6. Flexible assembly line (30, 200) of any of the claims 3 to 5, wherein
the cutlery assembly line (34) further comprises a vision robot (62, 64, 66) for bringing the cutlery items from the cutlery assembly line (34) to the toothpick and tissue assembly line (32) for packaging.

7. Flexible assembly line (30, 200) of Claim 6, wherein
the vision robot (62, 64, 66) comprises a buffer station for storing cutlery items.

8. Flexible assembly line (30, 200) of Claim 6 or 7, wherein
the vision robot (62, 64, 66) is configured to check quality of a pile of cutlery items on the toothpick and tissue assembly line.

9. Flexible assembly line (30, 200) of any of the preceding Claims, wherein
the transporting line (32, 34) further comprises an auto tissue dispenser (36) for distributing the serviettes in an orderly manner to a tissue-toothpick conveyor belt (48).

10. Flexible assembly line (30, 200) of any preceding Claims, wherein
the transporting line (32, 34) further comprises an auto toothpick dispenser for spreading sachets of toothpicks onto the toothpick conveyor (48).

11. Method for packaging cutlery items comprising:
- dispensing (126) cutlery items onto a cutlery conveyor belt (70),
- inspecting (128, 146) quality of the cutlery items automatically, and
- packaging (166) quality compliant cutlery items.

12. Method of Claim 11 further comprising
taking (148) the compliant cutlery items from the cutlery conveyor belt (70) to a toothpick and tissue assembly line (32) automatically for the packaging.

13. Method of Claim 11 or 12 further comprising
dispensing (106) serviettes or sachets of toothpicks onto toothpick and tissue assembly line (32) automatically.

14. Method of Claim 13 further comprising
checking (120) quality of the serviettes and the sachets of toothpicks automatically for quality compliance.

15. Method of any of the Claims 11 to 14 further comprising

checking (170) quality of packaged cutlery items before collecting them orderly in a bin.

16. Flexible assembly line (30, 200) according to any of the Claims 1 to 15, wherein the flexible assembly line (30, 200) comprises a machine vision system for visually inspect cutlery items.

17. Flexible assembly line (30, 200) according to any of the Claims 1 to 15 and Claim 16, wherein
the flexible assembly line (30, 200) is configured to sort cutlery items, to inspect the cutlery items, to assemble the cutlery items, to pack the cutlery items or to perform any combination of these tasks automatically.

18. Flexible assembly line (30, 200) according to any of the Claims 1 to 15 and Claims 16 to 17, wherein
any stations of the flexible assembly line (30, 200) is modularly designed such that the stations can be removed from or installed onto the flexible assembly line (30, 200) for cutlery packaging.

19. Flexible assembly line (30, 200) according to any of the Claims 1 to 15 and 16 to 18 further comprises
an Automatically Guided Vehicle for transporting objects from or to the flexible assembly line (30, 200).

20. Flexible assembly line (30, 200) according to any of the Claims 1 to 15 and 16 to 19, wherein
the cutlery sorter comprises the top vision inspector (56), the flip over machine (58), the bottom vision inspector (60), the first vision robot (62), the second vision robot (64), the third vision robot (66).