

## FLEXIBLE ASSEMBLY LINE FOR CUTLERY PACKAGING

[0001] The present application relates to a flexible assembly line for cutlery packaging. The application also relates to methods of making, installing and 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 and inflight 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. It also intends to offer new and useful methods for making, installing and using the flexible assembly line in order to package cutlery items. Essential features of the invention are provided in the independent claims, whilst advantageous features of the invention are given by the dependent claims. The present application claims the priority of Singapore Patent Application SG201200198-8 that was filed on 10 January 2012. The entire content of the earlier application is hereby incorporated by reference.

[0004] According to a first aspect of the invention, the flexible assembly line comprises a cutlery assembly line for receiving and dispensing cutlery items. The cutlery assembly line further comprises an automatic organizer on the cutlery assembly line for picking, organizing or arranging the cutlery items in forming one or more sets of eating utensils. A set of cutlery items often includes a knife, a fork, a spoon, a serviette, a sachet of toothpicks, a packet of pepper and a packet of table salt. The cutlery items may either be orderly separated according to their categories, or randomly distributed/scattered. Picking one or more cutlery items from one of the categories can possibly be done via jigs designed to filter through their corresponding cutlery items. For example, cutlery items can be transported by conveyor belts for passing through suitable orifices of their corresponding jigs for the picking.

[0005] The flexible assembly line for cutlery packaging is also known as an automatic assembly line for packaging cutlery items, or simply an assembly line for packaging cutlery items. The cutlery or cutlery items include hand implements (tools) used in preparing, serving, and especially eating food, which are known as eating utensils.

5 For example, the cutlery items include chop sticks for eating noodles.

[0006] The flexible assembly line can automatically select a cutlery item from a pool of randomly scattered cutlery items and put the selected cutlery item onto a serviette for making one or more sets of eating/dinning utensils. The automatic selection is performed repeatedly by preloaded computer programs of the automatic organizer.

10 The function of automatic selection integrates functions of sorting and assembling cutlery items together such that the timing consuming sorting process of cutlery items can be avoided. As a result, the flexible assembly line can receive washed cutlery items of random types and automatic organizer can pick a suitable cutlery item from scattered cutlery items and deposit the selected cutlery items at another place for making a set of eating utensils.

[0007] The flexible assembly line can further comprise a toothpick and tissue assembly line adjacent to the cutlery assembly line for providing serviettes and/or sachets of toothpicks in forming the one or more sets of eating utensils. For example, a set of eating/dinning utensils includes a spoon, a fork, a knife, a serviette and a sachet of toothpick. The assembly lines can be synchronized and coordinated by a computer for providing suitable amount of eating utensils continuously.

20 [0008] The flexible assembly line may further comprise a cutlery packaging machine coupled to both the cutlery assembly line and the toothpick and tissue assembly line for wrapping selected cutlery items, a serviette and a sachet of toothpick together in forming the at least one set of eating utensils. The packaging machine may be a flow wrap type of machine that can seal individual sets of eating utensils continuously.

25 Additionally, the packaging machine may include disinfecting mechanism for treating the cutlery items before or after packaging. For example, the packaging machine can illuminate the cutlery items with ultraviolet light for killing germs.

30

[0009] The automatic organizer can comprise an industrial robot on one of the cutlery assembly line and the toothpick and tissue assembly line. The industrial robot is configured to recognize and choose different types of cutlery items from scattered cutlery items in forming the one or more sets of eating utensils. For example, the industrial robot has some jigs that can accept designated type of cutlery items respectively. Accepted cutlery items can be automatically transported by conveyor belts to a cutlery packaging machine for sealing with plastic bags. Since the jogs can be altered to suit cutlery items, the industrial robot offers flexibility in packaging various types of cutlery items. A new jig may be manufactured and installed to receive a cutlery item of new type or new size. The industrial robot thus enables the automatic organizer or the assembly line to be adaptable or flexible.

[0010] The industrial robot can have a camera for machine vision capability in order to pick or check the cutlery items, the serviette or the sachet of toothpick for providing quality compliant eating utensils. The camera or machine vision not only enables the industrial robot to find the cutlery items, it also guides movements of the industrial robot such that the industrial robot can pick a cutlery item from a pile/pool of randomly scattered cutlery items, and move the selected cutlery item onto a serviette in forming a set of eating utensil.

[0011] The industrial robot may be configured to scan profiles of the cutlery items for recognizing different patterns of the cutlery items. In other words, the industrial robot can recognize patterns, shapes or edges of cutlery items for matching preloaded images of cutlery items. Only image-matched cutlery items can be selected and moved onto a serviette for providing a set of eating utensils.

[0012] The industrial robot can be figured to scan surface texture of the cutlery items for quality inspection. The industrial robot is programmed or trained to differentiate shallow or typically scratches from deep cuts or food residues on surfaces of the cutlery items. In one execution, the industrial robot counts the number of light or dark pixels of captured images from the cutlery items in order to recognize the food residues on the surfaces of the cutlery items. Washed cutlery items with food debris attached, which are considered be quality or hygiene non-complaint, will be rejected by the industrial robot.

[0013] The cutlery assembly line further comprises a spreader at an end for scattering the cutlery items randomly. The spreader may include a hopper that shakes a pile of cutlery items and scattered them onto a cutlery conveyor belt for the convenience of picking by the industrial robot. Instead of sorting the cutlery items, the spreader facilitates the application of machine vision by the industrial robot.

[0014] The toothpick and tissue assembly line may further comprise a sorter at an end for disseminating sachets of toothpicks, serviettes or both. The sorter can lay the serviettes in an orderly manner (e.g. linearly distributed on a toothpick conveyor) such that the industrial robot can place selected/picked cutlery item onto it. Often, the sorter scatters sachets of toothpick apart such that an end effector of the industrial robot can grasp one sachet for depositing it onto a serviette.

[0015] The flexible assembly line can further comprise a transporting line connected to the spreader, the sorter or both to the cutlery packaging machine. In an embodiment, the transporting line includes a toothpick conveyor and a cutlery conveyor belt such that multiple industrial robots can be distributed over the conveyors for simultaneous operations. Packaging speeding of the flexible assembly line can be greatly enhanced accordingly.

[0016] The automatic organizer may comprise a vision inspector adjacent to one of the toothpick and tissue assembly line and the cutlery assembly line for recognizing patterns, surface texture or quantity of the cutlery items, the serviettes and the toothpicks before their packaging. The vision inspector can operate independently or be a part of the industrial robot such that other functions can be implemented onto the flexible assembly line. For example, the vision inspector is connected to a blower such that the blower will discharge pressurized air onto passing cutlery items upon receiving alert from the vision inspector. In a further example, the vision inspector is linked to a collator such that an alarm will be sent to an operator if a bin of the collator is full of packaged cutlery items.

[0017] The automatic organizer can further comprise a blower next to the vision inspector for discharging air onto the cutlery items. Air of high speed from the blower can remove dirt on the cutlery items, which may interfere with vision inspection.

5 [0018] The industrial robot may comprise a buffer station for storing cutlery items. The buffer station may have stacks of cutlery items. The industrial robot will pick a cutlery item (e.g. a fork) from the buffer station if the industrial robot cannot locate this type of cutlery item (e.g. the fork) from the cutlery assembly line. The buffer station may sound an alarm or message to an operator of any type of the cutlery items is running  
10 short.

[0019] An end effector of the industrial robot can comprise a suction cup for grabbing a cutlery item. The suction cup is powered by a negative pressure or vacuum such that cutlery items with smooth surfaces (e.g. a knife) can be easily picked up and  
15 transported.

[0020] The automatic organizer may comprise an auto tissue dispenser for laying folded tissue paper onto a toothpick conveyor in an orderly manner. For example, the folded tissue papers are linearly distributed with gaps in-between. The auto tissue  
20 dispenser may further examine quality/hygiene of the folded tissue paper (i.e. serviette) and discard non-compliant serviettes.

[0021] The cutlery assembly line can comprise an upstream conveyor belt, an inspection station and a downstream conveyor belt that are sequentially laid out  
25 following a process flow direction or in a longitudinal direction. The inspection station further comprises a top vision camera at the upstream conveyor belt and a bottom vision camera at the downstream conveyor belt for checking opposite surfaces of a cutlery item. A cutlery item carried by the upstream conveyor belt and the downstream conveyor belt are not required to be flipped over for checking its two  
30 opposite surfaces. A flip-over motion is avoided, whilst vision inspections of the two opposite surfaces are performed on moving belts continuously. Efficiency of the vision inspection is markedly improved.

[0022] The cutlery assembly line may further comprise a reject bin between the upstream conveyor belt and the downstream conveyor belt for collecting quality non-complaint cutlery items. If a cutlery item is found to be dirty (quality non-compliant), the cutlery item is directly dropped into the reject bin by the upstream conveyor belt, without being picked up by the inspection station. In other words, the inspection station does not check an opposite surface of the cutlery item if one surface of the cutlery item is found to be quality non-complaint.

[0023] Machine stations of the automatic organizer and the vision inspection station can be electrically connected in forming an artificial neural network for adaptive control. The artificial neural network can perform cutlery pattern recognition, image analysis and adaptive control, which enables some of machine stations to be autonomous. The artificial neural network for artificial intelligence is based on statistical estimations, classification optimization and control theory.

[0024] The flexible assembly line may comprise a flip over machine for turning over a cutlery item before or after its machine vision inspection. The flip over machine may be installed between two cameras of a vision inspection station such that opposite surfaces of a cutlery item progressing below the two cameras are examined with the action of flipping over the cutlery item by the flip over machine.

[0025] The flexible assembly line can further comprise an automatically guided vehicle for transporting packaged cutlery items to or from the flexible assembly line. A bin full of packaged cutlery items will be transported to a warehouse, whilst an empty bin will be located at an end of the flexible assembly line for receiving freshly packaged cutlery items. The flexible assembly can be less dependent on human intervention, such as taking away packaged cutlery items.

[0026] According to a second aspect of the invention, the application provides a method for packaging cutlery items. The method comprises a first step of dispensing cutlery items onto a cutlery conveyor belt, and a second step of automatically picking up the cutlery items in forming one or more eating utensil set. The method avoids sorting cutlery items into piles of distinctive types such that the packaging can be done more efficiently.

[0027] The method can further comprise a step of inspecting the cutlery items by machine vision for picking quality complaint cutlery items. The machine vision comprises steps of capturing images of cutlery items, processing the captured images and making decisions for an industrial robot. Machine image processing techniques includes pixel counting, thresholding, segmentation, blob discovery, pattern recognition, gauging, edge recognition and filtering. The machine vision makes the flexible assembly line to be adaptive for packaging changing types of cutlery items.

[0028] The method may also comprise a step of automatically packaging quality compliant cutlery items in forming sets of eating utensils. For example, the automatic packaging can be performed by a flow wrap machine that can seal a set of cutlery items into a transparent plastic bag. The packages of cutlery items can be labeled or tagged with barcode for logistic control.

[0029] According to a third aspect of the invention, the application provides a method for making or installing a flexible assembly line. The method comprises a step of providing a cutlery assembly line and another step of presenting a toothpick and tissue assembly line, and a further step of connecting the cutlery assembly line and the toothpick and tissue assembly line together for packaging sets of eating utensils. The flexible assembly line may be installed on a factory floor for flight catering, banquet catering or food distribution.

[0030] The method of making or installing can further comprise a step of installing one or more industrial robots at the flexible assembly line for picking or moving various types or shapes of cutlery items adaptably. Some of the industrial robots may be removed, duplicated or reprogrammed for enhancing productivity and flexibility of the flexible assembly line.

[0031] 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.

[0032] Fig. 1 illustrates a first flexible assembly line for cutlery packaging;

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

Fig. 3 illustrates a flow chart on a method for using the first flexible assembly line;

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

Fig. 5 illustrates a third flexible assembly line for cutlery packaging;

Fig. 6 illustrates a fourth flexible assembly line for cutlery packaging;

Fig. 7 illustrates a side view of an inspection station for checking quality compliance of cutlery items; and

Fig. 8 illustrates a top view of the inspection station according to Fig. 7.

[0033] 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.

[0034] 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 automatic assembly line such that the first flexible assembly line 30 can package cutlery items 31 together with folded tissue papers and toothpick sachets 33. 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.

[0035] The toothpick assembly line 32 comprises an auto tissue dispenser 36, an auto toothpick dispenser 38, a vision inspection machine 40, a toothpick vision robot 41, 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 toothpick vision robot 41, 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, the vision inspection machine 40 and the toothpick vision robot 41 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. A cutlery reject bin 68 is further placed next to the right end 52.

- 5 [0036] The toothpick vision robot 41 has machine vision for checking incoming tissue papers on the toothpick conveyor 48. The machine vision is enabled by an imaging capturing device (smart camera, smart sensor or image sensor) and an imaging processing device (not shown) that are connected together. When in use, the toothpick conveyor 48 carries stacks of folded tissue papers moving from the left end
- 10 50 to the right end 52, which defines a process flow direction 127. The imaging processing device (computer) analyses moving object images from the imaging capturing device such that the toothpick vision robot 41 dispenses two toothpick sachets 33 onto each stack of incoming folded tissue paper.
- 15 [0037] 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 other stations/parts of the toothpick assembly line 32, as well as the neighboring cutlery assembly line 34.
- 20 [0038] 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
- 25 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.
- 30 [0039] The three vision robots 62, 64, 66 have three cutlery buffer stations 75, 77, 79 that are adjacent to them 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 soup spoon such that their neighboring vision robots 62, 64, 66 can pick up a

cutlery item (e.g. a fork) from respective buffer stations 75, 77, 79 onto a folded tissue paper (i.e. serviette) if there is shortage of supply in cutlery items 31 on the cutlery conveyor belt 70.

- 5 [0040] Each of these buffer stations 75, 77, 79 stores certain quantity and types of cutlery items 31 for replenishing cutlery items 31 onto the cutlery assembly line 34. In other words, the vision robots 62, 64, 66 are programmed to take cutlery items 31 from the buffer stations 75, 77, 79 if the vision robots 62, 64, 66 discover missing cutlery items 31 from piles/sets of cutlery items 31 on the cutlery conveyor belt 70, which is also known as refilling.
- 10

- [0041] 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 the conveyer belts 48, 70 respectively.
- 15

- [0042] When in use, parts of the first flexible assembly line 30 cooperate with each other for packaging cutleries, tissue papers 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), which is collectively known as a cutlery package.
- 20

- [0043] Fig. 2 illustrates a perspective view of the first flexible assembly line 30 in a simplified form. Fig.2 depicts parts that are similar or identical to those of Fig. 1. The similar parts or process steps are labeled with identical or similar reference numerals. Descriptions of the similar parts are therefore incorporated by reference where appropriate.
- 25

- [0044] 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.
- 30

[0045] A first process flow 102 involves the toothpick assembly line 32. Initially, the auto tissue dispenser 36 receives a serviette 37 (folded tissue paper) of about fifty sheets per pack and the pack of serviette 37 is manually open and placed into a hopper media (not shown) of the auto tissue dispenser 36. The auto tissue dispenser 5 36 dispenses 106 folded serviettes 37 one at a time onto the toothpick conveyor belt 48. Bags of toothpicks (not shown) are torn open and loose sachets 33 of toothpicks are placed into another hopper media for being dispensed with a small quantity at a time onto the toothpick conveyor belt 48. The toothpick distribution precedes actions of the vision robots 62, 64, 66 for picking these toothpicks and placing them into 10 buckets of the flow wrap machine 42. The auto tissue dispenser 36 also checks 108 if the folded tissue papers are orderly laid out by using its machine vision capability. 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 115 will rectify the discrepancies. Alternatively, 15 the vision robot 62, 64, 66 at downstream will increase their operation speed for taking serviettes 37 and sachets 33 from the buffer stations 75, 77, 79 to overcome shortage of properly aligned tissue papers.

[0046] The auto toothpick dispenser 38 will dispatch a small quantity of toothpick onto 20 the toothpick conveyor 48 where it will be mechanically spread across the conveyor 48 to minimize toothpick stacking onto one another. Further down the stream, the vision robots 62, 64, 66 pick one toothpick sachet at a time and orientate the toothpick sachets 33 before placing it into the collator (conveyor bucket) 46 of the flow wrap machine 42. If the first vision robot 62 misses a placement (e.g. putting a fork) onto a 25 serviette 37, the second vision robot 64 will examines a pile of cutlery items 31 on the serviette 37, and take a replenish item (e.g. a fork) from the second buffer station 77 for placing onto the pile of cutlery items 31. The third vision robot 79 further checks all piles of incoming cutlery items 31, and transfers a replenish item (e.g. a toothpick sachet) from the third buffer station 79 to the cutlery conveyor belt 70. Unpicked 30 toothpick sachets 33 will be transported to the end 52 of the conveyor belt 48 and dropped into the recycling bin whereby the operator 115 will manually reload it into the hopper at the starting of the toothpick conveyor 48.

[0047] A second process flow 104 relates to the cutlery conveyor belt 70. At the left end 72 of the cutlery conveyor belt 70, washed and dried cutlery items 31 (e.g. spoon) 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 dispenses the cutlery in a small quantity at a time onto the cutlery conveyor belt 70 whereby the cutlery items 31 are mechanically agitated to spread out for minimizing cutlery stacking onto each other. The cutlery items 31 are then transported to the top vision inspector 56. Cutlery items 31 that failed the top surface inspection (e.g. having water stain or food debris) will be transported to the end 74 of the conveyor belt 70 and dropped into the cutlery reject bin 68. Those cutlery items 31 (cutlery items) that passed the top vision inspector 56 will be flipped over by the flip over machine 58 (e.g. a vision-enabled robotic arm) and be transported through the bottom vision inspector 60 for checking opposite surfaces (bottom surfaces) of the cutlery items 31 to ensure it meets the acceptance criteria. The vision inspection machine 40, the toothpick vision robot 41, the top vision inspector 56, the flip over machine 58 and three vision robots 62, 64, 66 are connected a central computer such that sets of quality compliant cutlery items 31 (including toothpick sachets) are placed onto the serviettes 37 for wrapping by the cutlery packaging machine 42. The Wrapped cutlery sets are checked by the cutlery inspection machine 44 such that quality-compliant sets are neatly stacked into the collator 46, whilst quality-failed sets (e.g. wrapping film torn) are moved by the toothpick conveyor 48 into the cutlery reject bin 68.

[0048] As the cutlery items 31 move with the cutlery conveyor belt 70, the top vision inspector 56 examines 128 top surfaces of all incoming knives, forks, soup spoons and tablespoons, etc. The top vision inspector 56 provides hygiene quality examination 128 to top surfaces of the cutlery items 31. The top surfaces are blown with pressurized and filtered air to remove dust before the examination 128 for reducing error in vision inspection. Unclean cutlery items 31 are transported 132 to the end 74 of the conveyor belt 70 and casted 132 into the cutlery reject bin 68 for rewash. The top vision inspector 56 also projects 134 ultraviolet light onto the cutlery items 31 for further sanitizing.

[0049] Each of the cutlery items 31 are flipped over 136 at the flip over machine 58 when passing through the next station. The flip over machine 58 extends 138 its

robotic arms (now shown), picks 140 each of these cutlery items 31 up and rotates (flip over) 142 these cutlery items 31 for exposing their bottom surfaces toward top/ceiling/sky.

5 [0050] The flipped cutlery items 31 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 bottom vision inspector 60 checks 146 the bottom surfaces of the  
10 cutlery items 31 for hygiene quality control. Identified unclean cutlery items 31 (with water stain) are rejected such that a robotic arm of the bottom vision inspector 60 grasps 148 the unclean cutlery items 31 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  
15 31.

[0051] Vision cameras of the two vision inspectors 56, 60 take pictures of cutlery and/or toothpick on the cutlery conveyor belt 70 continuously, and the two vision inspectors 56, 60 communicate with the a quality control (QC) computer to decide  
20 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.

25 [0052] The vision inspectors 56, 60 also inspect surface integrity and profile of the cutlery items 31. Only quality-compliant (good) cutlery items 31 are allowed to proceed along the cutlery conveyor belt 70, whilst chipped/broken or contaminated cutlery items 31 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  
30 optimize cutlery packaging quantity and speed with crash-proof prevention mechanism.

[0053] As mentioned above, the four vision robots 41, 62, 64, 66 connect the toothpick line 32 and the cutlery assembly line 34. Each of these four vision robots 41,

62, 64, 66 has a vision-picking module (not shown) for detecting shapes and locations of the cutlery items 31, the folded tissue papers and the sachets of toothpicks 33. 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  
5 noticing 152 the incoming cutlery items 31 and the folded tissue paper by its sensors/camera. The incoming folded tissue paper already has a sachet of toothpick on top. The second vision robot 64 grabs 156 a tablespoon and a soup spoon from the cutlery conveyor belt 70 and puts 158 them onto the folded tissue paper, together with knife and the fork in forming a dinning utensil set.

10 [0054] 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 dinning utensil sets. In other words, the third vision robot 66 brings 160 a fork onto a folded tissue paper if the third vision robot 66 cannot find  
15 (detect) 162 a fork on the folded tissue paper. In fact, the third vision robot 66 will bring 160 any type(s) of the cutlery items 31 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 fork from the third buffer station 79 to a pile of dinning utensil if it finds no fork on the folded tissue paper (serviette).

20 [0055] Alternatively, according to a predetermined program or control logic, the third vision robot 66 will transfer a pile of a folded tissue paper, a sachet of toothpick, a fork, a knife and a tablespoon away because a soup spoon is missing from the pile. The third vision robot 66 can further take a redundant cutlery item (e.g. fork) away from a  
25 folded tissue paper if the third vision robot 66 finds two forks on the folded tissue paper.

[0056] Piles of cutlery items 31, a folded tissue paper and a sachet of toothpick are transported 164 to the cutlery-packaging machine 42. A set of cutlery items 31, folded  
30 tissue paper and a sachet of toothpicks are collectively known as a dinning utensil set. The cutlery-packaging machine 42 is flow-wrap type of packaging device that seals 166 each pile of the cutlery items 31, 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.

[0057] At a downstream of the cutlery-packaging machine 42, the cutlery inspection machine 42 checks 170 the cutlery packages and ejects 172 rejected (quality non-compliant) 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.

[0058] Functionally, the auto tissue dispenser 36 allows the serviettes 37 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 76 to 92 centimeters (cm). The auto tissue dispenser 36 also allows tissue refilling without stopping the auto tissue dispenser 36, which is safe to operators. The auto tissue dispenser 36 can dispense one serviette 37 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 to refill tissue papers. The auto tissue dispenser 36 will stop automatically and sound another signal if the auto tissue dispenser 36 detects serviette jam. Once jammed serviettes 37 are removed, the auto tissue dispenser 36 will resume its normal operation.

[0059] The auto toothpick dispenser 38 is configured to allow sachets of toothpicks 33 placed directly into a magazine-like holder/hopper. The holder/hopper is positioned at a table height (e.g. 70 to 92 cm) such that operators can refill the sachets of toothpicks 33 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 or conveyor belts 48, 70. The auto toothpick dispenser 38 has a near-empty-toothpick alarm to alert the operators for refilling the toothpick sachets 33. The auto toothpick dispenser 38 can stop automatically when auto toothpick dispenser 38 detects toothpick jam and sends an alarm to the operators. Jammed toothpicks are removed such that the auto toothpick dispenser 38 can continue to work safely. Rejected toothpick sachets 33 (e.g. sachet with no toothpick inside, or toothpick with damaged wrapping) are ejected and replaced by good toothpick sachets 33.

[0060] The cutlery sorter 54 allows assorted cutlery items 31 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. about 76.2 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 31 in small batches at regular interval onto cutlery conveyor belt 70. When dispensing the cutlery items 31, the cutlery sorter 54 prevents dispensed cutlery items 31 from being stacked onto each other. The cutlery sorter 54 can sound an alarm if the cutlery sorter 54 finds its stored cutlery items 31 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 31 is jammed inside the cutlery sorter 54 and the jammed cutlery item can be safely removed by the operator.

[0061] 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 31 by projecting ultraviolet light onto the top surfaces of the cutlery items 31. In contrast, the bottom vision inspector 60 shines ultraviolet light onto bottom surfaces of the cutlery items 31 for further sterilization. Both the top and bottom vision inspectors 56, 60 can eject dirty or chipped cutlery items 31 into a bin for rewashing.

[0062] The four vision robots 41, 62, 64, 66 are fully enclosed during operation. Each of these vision robots 41, 62, 64, 66 is equipped with safety interlock when opening. In other words, the four vision robots 41, 62, 64, 66 will stop immediately if their covers are open. Each of the four vision robots 41, 62, 64, 66 is installed with a HEPA type air purifier with anti-static ionic air for minimizing dust interference. Each of four vision robots 41, 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 41, 62, 64, 66 are designed for food industry. For example, lubricating grease(s) used for the vision robots 41, 62, 64, 66 is/are food grade. An operating system of the vision robots 41, 62, 64, 66 allows the vision robots 41, 62, 64, 66 to be configured to suit wide ranges of cutlery items 31 and can work in wide spectrums of environments. Any of the vision robots 41, 62, 64, 66 can automatically find its home position upon and return to its original or default position when encountering power shut down or

failure. The vision robots 41, 62, 64, 66 are able to be calibrated for their orientation, position and speed adjustments with precision. The vision robots 41, 62, 64, 66 further have good repeatability and stability such that they 41, 62, 64, 66 can operate reliably and continuously without human intervention for an extended period (e.g. 3 months).

[0063] The vision inspection machine 40 can blow air to cutlery items 31 prior to its vision inspection. The vision inspection machine 40 can further eliminate dirty cutlery items 31, which include a water-stained knife, a cracked tablespoon, an exposed toothpick or a contaminated/darkened tissue paper. After packaging, the cutlery inspection machine 44 can perform a final quality inspection of packaged cutlery items 31. Non-compliant packages are discarded to a reject bin, which an operator will clear.

[0064] The cutlery buffer stations 75, 77, 79 are platforms for temporarily holding substantially quantities and various types of cutlery items 31. The cutlery buffer stations 75, 77, 79 are used as backups when certain cutlery items 31 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 31 or serviettes 37 are found on the cutlery conveyor belt 70.

[0065] 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 dinning utensil set (cutlery set), which includes a serviette 37, a knife 31, a spoon 31, a fork 31, a teaspoon 31 (magnetic or non-magnetic), pre-packed tooth picks and condiments. The cutlery package machine 42 can complete 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 (bi-axially oriented polypropylene film). The cutlery package machine 42 can alternatively use laminated & heat-able plastic films. Programmable Logic Controller (PLC) of the cutlery package 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 31, 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 monitored, 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.

[0066] 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 31. The cutlery package 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 (not shown) of the cutlery package machine 42 is integrated with the collator 46. The cutlery package machine 42 has a 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.

[0067] The collator 46 can load packaged dining utensils automatically into the bin with a predetermined orientation. The bin for receiving the packaged cutlery items 31 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 operation of the 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 first flexible assembly line 30 or violating any safety guideline.

[0068] 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 terminals of enterprise application software packages (e.g. SAP™) for direct on-line presentation. The CMS is further connected to a remote monitoring system in Technical Duty Control Room.

[0069] Faulty vision robot(s) 41, 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 31 for production at a lower speed.

[0070] The flexible assembly line 30 can be modified or configured 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 31 whose top surfaces have already been checked by the top vision inspector 56.

[0071] Fig. 4 illustrates a second flexible assembly line 200 for cutlery packaging. The second flexible assembly line 200 has parts or operation steps that are similar to those of the first flexible assembly line 30. The similar parts or method steps are labeled with identical or similar reference numerals. Descriptions of the similar parts or steps are hereby incorporated by reference where appropriate.

[0072] 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 those of the first flexible assembly line 30. However, the cutlery assembly line 34 of the second flexible assembly line 200 has three vision robots 62, 64, 66 that operate across three lines 34, 202, 204, namely the cutlery assembly line 34, the tissue assembly line 202 and the toothpick line 204.

[0073] The toothpick line 204 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 capability for guiding and inspecting toothpick allocations on the toothpick conveyor belt 208.

5

[0074] The tissue assembly line 202 is located between the toothpick line 204 and the cutlery assembly line 34. The tissue assembly line 204 includes a tissue dispenser 214, a tissue conveyor belt 216, a cutlery package machine 42, a cutlery vision inspection machine 44, a collator 46 and a cutlery reject bin 68, which are sequentially connected. The tissue conveyor belt 216 is substantially parallel to both the toothpick conveyor belt 208 and the cutlery conveyor belt 70 in their longitudinal directions respectively.

10

[0075] 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.

15

20

[0076] 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 tissue assembly line 202 (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 onto a folded tissue paper (serviette) 37 on the tissue conveyor belt 216. Here, the folded tissue paper is kept in a magazine for dispensing onto the tissue conveyor belt 216. The first vision robot 62 further draws a butter knife and a 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 conveyor 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.

25

30

[0077] As the tissues conveyor 216 progresses, the second vision robot 64 brings a spoon and a fork from the cutlery conveyor belt 70 and places them onto the folded tissue paper. The second vision robot 64 will take a spoon or a fork from a second  
5 buffer station 77 instead if the second vision robot 64 finds a missing spoon or fork from the tissue conveyor belt 216.

[0078] The second flexible assembly line 200 packages cutlery items 31, folded tissue papers 37, sachets of toothpicks 33 and other items (e.g. butter, jam, salt, etc.) similar  
10 to that of the first flexible assembly line 30. Both flexible assembly lines 30, 200 can be reprogrammed or loaded with different sets of applications/parameters to package different types, shape and quantity of food utensils.

[0079] In an alternative, the toothpick dispenser 206 can dispense the sachets of  
15 toothpicks 37 with regular intervals onto the toothpick conveyor belt 208. The toothpick dispenser 206 can further disperse the sachets of toothpicks 37 by employing a vibrator bowl for preventing the sachets of toothpicks 37 from stacking or clogging onto each other. The vision robots 62, 64, 66 can thus easily pick and place the sachets of toothpicks 37 for packaging easily. Stacked sachets of toothpicks 37,  
20 which the vision robots 62, 64, 66 do not pick up, will be dropped into a bin at the end 52 for reuse.

[0080] Fig. 5 illustrates a third flexible assembly line 220 for cutlery packaging, which provides another embodiment of the invention. The third flexible assembly line 220  
25 has parts or operation steps that are similar to those of the first flexible assembly line 30 or the second flexible assembly line 200. The similar parts or method steps are labeled with identical or similar reference numerals. Descriptions of the similar parts or steps are hereby incorporated by reference where appropriate.

[0081] In the third flexible assembly line 220, 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 (one spoon, one knife, one teaspoon and one fork) into the respective pockets of the flow wrap machine in its designated orientation. The cutlery set further includes  
30

tissue and toothpick items, collectively known as a dinning utensil set. 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 speeds of the cutlery belt and flow wrap conveyors by sending signals to the machine main control PLC. The third flexible assembly line 220 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.

[0082] In the third flexible assembly line 220, each of the vision robots 62, 64, 66 is equipped with a blower 222, a vision camera 224 and a reject bin 226, in addition to the buffer stations 75, 77, 79. The cutlery assembly line 34 of the third flexible assembly line 220 further has a dry blower 228 and a top vision inspector 56. The dry blower 228 releases pressurized clear/dry air over the cutlery items 31 on the cutlery conveyor belt 70 before their vision inspection. The top vision inspector 56 scrutinizes the blown cutlery items 31 over their top surfaces for quality compliance. Non-complaint cutlery items 31 are picked up by the first vision robot 62 and thrown into its neighboring reject bin 226. The vision robots 62, 64, 66 inspect bottom surfaces of the cutlery items 31 passing on the cutlery conveyor belt 70 and bring quality non-compliant cutlery items 31 into their respective reject bins 226. The blower 222 discharge compressed air over the cutlery items 31 before the vision inspection by the vision cameras 224.

[0083] Fig. 6 illustrates a fourth flexible assembly line 230 for cutlery packaging, which provides another embodiment of the invention. The fourth flexible assembly line 230 has parts or operation steps that are similar to those of the first flexible assembly line 30, the second flexible assembly line 200 and the third flexible assembly line 220. The similar parts or method steps are labeled with identical or similar reference numerals. Descriptions of the similar parts or steps are hereby incorporated by reference where appropriate.

[0084] In the fourth flexible assembly line 230, 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 (a spoon, a knife, a teaspoon and a 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 230 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.

[0085] All of the flexible assembly lines 30, 200, 220, 230 of Figs. 1-6 have incorporated modular design features. For example, in the first flexible assembly line 30 of Figs. 1-3, all machine stations can be individually installed onto removed from the flexible assembly line 30 independently, without affecting remaining stations of the flexible assembly line 30. The machine 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.

[0086] Each of the flexible assembly lines, as shown in Figs. 1-6, has machine vision capability that can perform surface quality inspection on cutlery items 31. The flexible assembly lines 30, 200, 220, 230 further make decisions for accepting or rejecting washed cutlery items 31 based on results of the vision inspection. Following the inspection, the flexible assembly lines 30, 200, 220, 230 can assemble the cutlery

items 31 by picking each type of cutlery items 31 according to preloaded packaging instruction at the CMS. Here, a cutlery package includes toothpicks, tissues/serviettes 37 and sugar packs. The flexible assembly lines 30, 200, 220, 230 can also pack the loose cutlery items 31 into plastic bags. In short, each of the flexible assemble  
5 assembly lines 30, 200, 220, 230 according to Figs. 1-6 has 4-in-1 functions, which are auto-sorting, machine inspection, auto assembly and auto packaging.

[0087] Any of the flexible assembly lines (Figs. 1-6) can include an Automatically Guided Vehicle 231 (i.e. AGV: automated guided vehicle or automatic guided vehicle).

10 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 another empty bin is placed at the collator for collecting cutlery packages.

15 [0088] Fig. 7 illustrates a side view of an inspection station 240 for checking quality compliance of the cutlery items 31. The inspection station can replace the top vision inspector 56, the flip over machine 58 and the bottom vision inspector 60.

[0089] The inspection station 240 comprises a robotic arm 242, a top vision camera 20 244 and a bottom vision camera 246, which are connected together. In particular, the cutlery conveyor belt 70 comprises two segments 70a, 70b sequentially and linearly aligned following the process flow direction 127. The inspection station 240 further comprises a reject bin 248 that is placed between an upstream conveyor belt 70a and a downstream conveyor belt 70b of the cutlery conveyor belt 70. The robotic arm 242  
25 and the reject bin 248 face each other vertically, whilst the robotic arm 242 is on top and the reject bin 248 is at bottom. The robotic arm 242 has a suction cup 243 as its end effector for picking cutlery items (31) (e.g. spoon). The top vision 244 camera 244 faces a top surface of the upstream conveyor belt 70a, and the bottom vision camera 246 faces a bottom side of the robotic arm 242.

30

[0090] The inspection station 240 is 2D and 3D machine vision enabled, similar to the toothpick vision robot 41, the cutlery inspection machine 44, the top vision inspector 56, the bottom vision inspector 60, the first vision robot 62, the second vision robot 64 and the third vision robot 66. The machine vision (MV) provides imaging-based

automatic inspection and analysis for checking washing quality of the cutlery items 31 (no water stain or dirt) and profile integrity of the cutlery items 31 (e.g. no chip off). The inspection station 240 can acquire images of the cutlery items 31 via the cameras 244, 246 under suitable lighting. The inspection station is installed with software packages then employ various digital image processing techniques to extract the required information, and make decisions (e.g. pass/fail) based on the extracted information. For example, the inspection station 240 employs a pattern recognition technique that causes finding, matching, and/or counting specific patterns based on preloaded templates of dinning/eating utensils 31 (e.g. fork). Locations, angles and orientations of an image-captured object (e.g. knife) may be rotated, partially hidden by another object, or varying in size. Additionally, the inspection station 240 has an edge detection ability which checks dimensions and profile integrity of scanned/captured cutlery items. Broken, chipped or bent cutlery items 31 can thus be detected before packaging for avoiding wastage in operation.

[0091] More particularly, the inspection station 240 can provide automated optical inspection (AOI) to eating/dinning utensils 31. The AOI can visually scan surfaces of the incoming cutlery items 31 on the upstream conveyor belt 70a when the incoming cutlery items 31 are lit by several light sources and observed by the top vision camera 244. This enables the monitoring of all external areas of the cutlery items 31, even those hidden in one direction by other components. Common defects of the washed cutlery items 31 include scratches, cut, water stain, food debris or dirt attachment and discolouring.

[0092] All machine vision enabled stations 44, 56, 60, 62, 64, 66, 240 are connected together such that they can perform neural net processing, enabling them to conduct weighted and self-training multi-variable decision makings.

[0093] Fig. 8 illustrates a top view of the inspection station 240 according to Fig. 7. Fig. 8 further shows the toothpick conveyor 48, which is parallel to both the upstream conveyor belt 70a and the downstream conveyor belt 70b.

[0094] When in use, the washed cutlery items 31 move along the upstream conveyor belt 70a. The top vision camera 244 takes pictures of the randomly scattered cutlery

items 31 continuously such that the inspection station 240 examines captured images with preloaded templates of quality-compliant cutlery items. Criteria of the quality-compliant cutlery items include surface cleanness (e.g. free from water stain), profile integrity (no broken corner and bending) and free from discoloring.

5

[0095] If a cutlery item 31 (e.g. a fork) fails the vision inspection, the failed cutlery item 31 will be transported directly into the reject bin 248 at an end of the upstream conveyor belt 70a. If a cutlery item 31 (e.g. a spoon) satisfies all criteria of vision inspection, the quality-compliant cutlery item 31 is picked up by the robotic arm 242 and moved over a gap between the upstream conveyor belt 70a and the downstream conveyor belt 70b. In the process of moving over, also known as "fly-over", a bottom surface of the top surface quality-compliant cutlery item 31 is further vision-inspected by the bottom vision camera 246 for checking its quality compliance. If the bottom surface also satisfies the inspection criteria, the cutlery item 31 is brought over to the downstream conveyor belt 70b. If the bottom surface does not satisfy the inspection criteria, the cutlery item 31 is dropped into the reject bin 248 below by the robotic arm 242. The cutlery item 31, which satisfies the quality criteria for both its top and bottom surfaces, is transported for providing eating utensil set. The arrangement of inspection station 240 provides swift vision inspection of cutlery items 31 and avoids disruption to the packaging process flow.

10  
15  
20

[0096] 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.

25

[0097] 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.

30

[0098] 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  
5 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.

10 [0099] In the embodiments or claims, orders of some of the method steps may be altered or reversed without affecting the relevant invention.

[0100] 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  
15 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.

## Reference Numerals

|    |    |                              |
|----|----|------------------------------|
|    | 30 | first flexible assembly line |
|    | 31 | cutlery items                |
| 5  | 32 | toothpick assembly line      |
|    | 33 | sachet of toothpicks         |
|    | 34 | cutlery assembly line        |
|    | 36 | auto tissue dispenser        |
|    | 37 | serviette                    |
| 10 | 38 | auto toothpick dispenser     |
|    | 40 | vision inspection machine    |
|    | 41 | toothpick vision robot       |
|    | 42 | cutlery package machine      |
|    | 44 | cutlery inspection machine   |
| 15 | 46 | collator                     |
|    | 48 | toothpick conveyor           |
|    | 50 | left end                     |
|    | 52 | right end                    |
|    | 54 | cutlery sorter               |
| 20 | 56 | top vision inspector         |
|    | 58 | flip over machine            |
|    | 60 | bottom vision inspector      |
|    | 62 | first vision robot           |
|    | 64 | second vision robot          |
| 25 | 66 | third vision robot           |
|    | 68 | cutlery reject bin           |
|    | 69 | bin                          |
|    | 70 | cutlery conveyer belt        |
|    | 72 | left end                     |
| 30 | 74 | right end                    |
|    | 75 | first buffer station         |
|    | 76 | arms                         |
|    | 77 | second buffer station        |
|    | 78 | arms                         |

79 third buffer station  
80 arms  
100 method  
102 first process flow  
5 104 second process flow  
106 dispense  
108 check  
110 reposition  
112 add  
10 114 trigger  
115 operator  
116 sort  
118 allot  
120 check  
15 122 pour  
124 sort  
126 spread apart  
127 process flow direction  
128 examine  
20 130 pick up  
132 cast  
134 project  
136 flip over  
138 extend  
25 140 pick up  
142 rotate  
144 discharge  
146 check  
148 grasp  
30 150 shine  
152 take  
154 notice  
156 grab  
158 put

- 159 regulate  
160 bring  
162 detect  
163 take  
5 164 transport  
166 seal  
168 illuminate  
170 check  
172 eject  
10 174 place  
176 provide  
200 second flexible assembly line  
202 tissue assembly line  
204 toothpick line  
15 206 toothpick dispenser  
208 toothpick conveyor belt  
210 toothpick recycle bin  
212 toothpick dispenser  
214 tissue dispenser  
20 216 tissue conveyor belt  
220 third flexible assembly line  
222 blower  
224 vision camera  
226 reject bin  
25 228 dry blower  
230 fourth flexible assembly line  
231 Automatically Guided Vehicle  
240 inspection station  
242 robotic arm  
30 243 suction cup  
244 top vision camera  
246 bottom vision camera  
248 reject bin

## Claims

1. Flexible assembly line (30, 200, 220, 230) for cutlery packaging comprising:  
a cutlery assembly line (34) for receiving and dispensing cutlery items (31),  
5 wherein the cutlery assembly line (34) further comprises an automatic organizer (36, 38, 40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240) for picking the cutlery items (31) in forming at least one set of eating utensils (31).
2. Flexible assembly line (30, 200, 220, 230) of Claim 1 further comprising  
10 a toothpick and tissue assembly line (32, 202, 204) for providing serviettes (37) and/or sachets of toothpicks (33) in forming the at least one set of eating utensils (31).
3. Flexible assembly line (30, 200, 220, 230) of Claim 1 or 2 further comprising  
15 a cutlery packaging machine (42) coupled to both the cutlery assembly line (34) and the toothpick and tissue assembly line (32, 202, 204) for wrapping selected cutlery items (31), a serviette (37) and a sachet of toothpick (33) together in forming the at least one set of eating utensils (31).
- 20 4. Flexible assembly line (30, 200, 220, 230) of Claim 1, wherein the automatic organizer (36, 38, 40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240) comprises an industrial robot (40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240) that is configured to recognize and choose different types of cutlery items (31) in forming the at least one set of eating utensils (31).
- 25 5. Flexible assembly line (30, 200, 220, 230) of Claim 1 or 4, wherein the industrial robot (40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240) has machine vision capability in order to pick or check the cutlery items (31), the serviette (37) or the sachet of toothpick (33) for providing quality compliant eating  
30 utensils (31).
6. Flexible assembly line (30, 200, 220, 230) of Claim 5, wherein

the industrial robot (40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240) is configured to scan profiles of the cutlery items (31) for recognizing different patterns of the cutlery items (31).

- 5     7.     Flexible assembly line (30, 200, 220, 230) of Claim 5 or 6, wherein  
the industrial robot (40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240) is figured to  
scan surface texture of the cutlery items (31) for quality inspection.
- 10     8.     Flexible assembly line (30, 200, 220, 230) of any of the preceding Claims,  
wherein  
the cutlery assembly line (34) further comprises a spreader (54) for scattering  
the cutlery items (31).
- 15     9.     Flexible assembly line (30, 200, 220, 230) of any of the preceding Claims,  
wherein  
the toothpick and tissue assembly line (32) further comprises a sorter (36, 38,  
41, 206, 214) for disseminating sachets of toothpicks (33), serviettes (37) or  
both.
- 20     10.    Flexible assembly line (30, 200, 220, 230) of any of the preceding Claims  
further comprising  
a transporting line (32, 34) connected to the spreader (54), the sorter (36, 38,  
41, 206, 214) or both to the cutlery packaging machine (42).
- 25     11.    Flexible assembly line (30, 200, 220, 230) of Claim 1, wherein  
the automatic organizer (36, 38, 40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240)  
comprises a vision inspector (40, 56, 60, 62, 64, 66, 240) for recognizing  
patterns, surface texture or quantity of the cutlery items (31), the serviettes and  
the toothpicks before their packaging.
- 30     12.    Flexible assembly line (30, 200, 220, 230) of Claim 1 or 11, wherein  
the automatic organizer (36, 38, 40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240)  
further comprises a blower (222) next to the vision inspector (40, 56, 60, 62, 64,  
66, 240) for discharging air onto the cutlery items (31).

13. Flexible assembly line (30, 200, 220, 230) of any of the Claims 4 to 7, wherein the industrial robot (40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240) comprises a buffer station (75, 77, 79) for storing cutlery items (31).

14. Flexible assembly line (30, 200, 220, 230) of any of the Claims 4 to 7 and 13, wherein  
an end effector (243) of the industrial robot (40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240) comprises a suction cup (243) for grabbing a cutlery item (31).

15. Flexible assembly line (30, 200, 220, 230) of any of the preceding Claims, wherein  
the automatic organizer (36, 38, 40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240) comprises an auto tissue dispenser (36) for laying folded tissue paper (37) onto a toothpick conveyor (48, 70, 208, 216) in an orderly manner.

16. Flexible assembly line (30, 200, 220, 230) of any of the preceding Claims, wherein  
the cutlery assembly line (34) comprises an upstream conveyor belt (70a), an inspection station (240) and a downstream conveyor belt (70b) that are sequentially laid out following a process flow direction (127) (in a longitudinal direction), the inspection station (240) further comprising a top vision camera (244) at the upstream conveyor belt (70a) and a bottom vision camera (246) at the downstream conveyor belt (70b) for checking opposite surfaces of a cutlery item (31).

17. Flexible assembly line (30, 200, 220, 230) of any of the Claim 16, wherein  
the cutlery assembly line (34) further comprises a reject bin (248) between the upstream conveyor belt (70a) and the downstream conveyor belt (70b) for collecting quality non-complaint cutlery items (31).

18. Flexible assembly line (30, 200, 220, 230) of any of the preceding claims, wherein

machine stations (36, 38, 40, 41, 42, 44, 46, 54, 56, 58, 60, 62, 64, 66, 69, 224, 240) of the automatic organizer (36, 38, 40, 41, 54, 56, 58, 60, 62, 64, 66, 224, 240) and the vision inspection station (36, 40, 44, 54, 56, 224, 240) are connected in forming an artificial neural network for adaptive control.

5

19. Flexible assembly line (30, 200, 220, 230) of any of the preceding claims further comprising  
a flip over machine (58) for turning over an cutlery item (31) before or after vision inspection.

10

20. Flexible assembly line (30, 200, 220, 230) of any of the preceding Claims further comprises  
an Automatically Guided Vehicle (231) for transporting packaged cutlery items (31) to or from the flexible assembly line (30, 200, 220, 230).

15

21. Method for packaging cutlery items comprising:
- dispensing (126) cutlery items (31) onto a cutlery conveyor belt (70),
  - picking up (130) the cutlery items (31) in forming at least one eating utensil set (31).

20

22. Method of Claim 21 further comprising  
inspecting (128, 146) the cutlery items (31) by machine vision for picking quality complaint cutlery items (31).

25

23. Method of Claim 21 or 22 further comprising  
automatically packaging (166) quality compliant cutlery items (31) in forming sets of eating utensils (31).

30

24. Method for making or installing a flexible assembly line (30, 200, 220, 230) comprising  
providing a cutlery assembly line (34),  
presenting a toothpick and tissue assembly line (32, 202, 204), and  
connecting the cutlery assembly line (34) and the toothpick and tissue assembly line (32, 202, 204) together for packaging sets of eating utensils (31).

25. Method of Claim 24 further comprising  
installing at least one industrial robot (36, 38, 40, 41, 54, 56, 58, 60, 62, 64, 66,  
224, 240) at the flexible assembly line (30, 200, 220, 230) for picking or moving  
various types or shapes of cutlery items (31) adaptably.

5