Universe Scientific Publishing

10.18686/ahe.v6i19.6230

Vibrating Plate Screw Automatic Assembly Line

Khan Fazal, Mon Der, Ronghao Zhong, Hongxia Xi corresponding author

Beibu Gulf University, Guangxi Province, Qinzhou City 535011

Abstract: With the contentious development in automated industries automated assembly line become more and more important. In this paper we will be focusing on a automated components assembly line that can easily assemble many components at the same time and reduce stress of manual labor .The assembly line is built off of customized materials yet it has a high efficiency count it is designed in an easy and intuitive way so that it is very convenient to operate .This paper discusses a automated assembly line which is primarily geared towards the fastener industries who do not have a lot of money to spend and are short in terms of space and time. The main purpose of the automation is to cut down on more people needing to give extra efforts do get more fast production in minimum time period Automated assembly line is essential for every production plant/factory it is very versatile in that sense because it has sensors and control system provide its services effortlessly.

Keywords: Assembly line layout; Assembly process; Vibratory plate bowl &Linear feeders

Assembly line layout

According to assembly line layout all components fill up in vibrating plate bowl feeder at every station. The all 4 stations are correspondingly: Brass nut station, washer Station, Brass insert station- 1-2, clamping and transfer station-3-4, are shaped in an 'O' shape(figure 1): More precision production can be achieved using robotic arms. The assembly speed is can be adjusted according to process cycle time.Station-1, the EPDM(ethylene polypropylene dine monomer) washer, is used to be assemble. EPDM is soft material so need customized gripper for handling . here we customized gripper for EPDM washer. Gripper offers a fantastic grip so washer didn't slip.washers fill up in feeder hopper, then linear feeder take washer to picking point sensor detect the washer's position and robot arm pickup and place on table where a customized jig already installed on rotatory table After completing first process, 2nd process starts and robot arm repeat the action and place a brass nut on sub-assembly at the same station- 1.

(Figure:1 assembly stations)

(Table:1 assembly process time at each station)

Work station	Task	Task time(s)	Work Station time(s)
1	1 3	18 14	32
2	2 7	18 3	21
3	4 5 6	10 13 13	36
4	7 8 9	10 12 3	25

After completing first station's action program relocate the sub-assembly position at station-2, station-2 is brass insert station, Brass is related to steel,its hard material but still need force to tight grip rubber gripper use for this process .at the same time at station-2 assembling stainless steel nipple, stainless steel nipple are small in size so we customized gripper for minimum force. Robot arm repeat the action and place stainless steel nipple on sub-assembly.After completing action Program relocate the rotary table position to station-3, where nylon braided tube need to assemble with sub-assembly. nylon braided tube is

flexible so we customized rubber gripper for this process. Stainless sleeve also need to assemble at this station robot arm repeat action and assemble stainless steel sleeve with sub-assembly ,here we need external force to press stainless sleeve with sub-assembly so robot arm place sub-assembly under hydraulic press ,hydraulic press press the sub-assembly under a limit. After action robot arm repeat the action and place sub-assembly on rotary table again. station-4 is pick and place station where process complete and 6-axis robot arm pick the assembly and place into a preposition place for further process.

Process Cycle

This is the actual time duration spent during the processing of component assembly time from input to output. Measured from first task to last task. Its also can be extended workstation time in assembly line.

Formula: T= (1)

T = product assembly time required to meet requirement

T_a= net time available to work

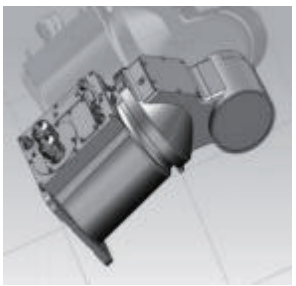
D = customer demand

Basic Elements of Automated assembly line

Assembly process Control

Automated screw,washer assembly line features a stationary frame, stepper motors, sensors and control system for working and dealing. According to bowl feeder's and robot arm base structure a Stainless steel based designed to hold line structure.Stepper motors used for vibratory bowl feeders, and driving of rotary dial- plate.Based on process different stepper motors been used for different process.Automated assembly line is basically tend to involve intelligence control system and sensors. Proximity senors detects the presence of components at pick up point and robot arm pick up the assembly component and place at assembly station. This process repeats continuously on every station.

(Figure:2 Dial-plate mechanism)



(Figure:3 robot arms mechanism)

Speed changer intelligence

Speed control system allow to easily set speed. Optional speed control system is designed to set line speed, its an close loop control system when operator set line speed its automatically changes every station process speed. When line speed set controller adjusts the phase and amplitude of current pulse to control the torque of motor and get precise positioning as well.

Vibratory plate bowl feeder

Vibrating plate bowl feeder utilize vibration to align and feed different sizes of parts to assembly line. Bowl feeders are important part of assembly line. Bowl feeders are responsible for sorting the components. Operator fill up bowl feeders with components, vibrating plate orient the components on linear feeder. Linear feeder in bowl feeder moves the components to pick up point. Bowl feeders are made of customized steel as it provides rigidity and robust longevity

Robot arms

Robot arms are one of the main part of assembly line it is a mechanical arm that can be controlled by programme to perform a variety of process related to assembly process. The robot arm is equipped with an sensor mechanism on the wrist in order to perform the accurate work.robot arms picks the assembly components and place to new assembly station ,for different components clamping jaw are customized according to components size and required force to clamp accurately.

Sensors

Proximity sensors are used for detecting the presence of components and bin picking. Sensors are installed on linear feeder and can detect the components presence at minimal accuracy.

Vibratory plate bowl &Linear feeder

vibratory bowl feeder is part of feeding system which transfer components at each station. Bowl feeder helps to sorting and align bulk components. Bowl feeders are comprised of a vibrating plate that align the components and linear feeder that lead the component to pick up point. a detecting sensor also installed on every linear feeder to detect the component presence.

(Figure 4: vibratory plate bowl& Linear feeder)

Method

Layout planning and sorting

Basic aim of layout planning is how to mate out assembly process task to the various assembly stations of an assembly line ,while optimum different intellect-ion such as to determine the numbers of assembly stations, process time cycle , or the cost of per cycle . as base on results of process tasks need to be perform, here with the help of Line balancing its easy to divide and combine the different various process task to make sure that work on each assembly station having minimum process time. Process cycle time is exactly equal to taken time,then line is perfectly balanced, and the assembly line each station is in use. As well the idle time will also reduced to minimum . As well assembly line efficiency will increase . in assembly line design and assembly process, line balancing is very essential factor. The net cost of process cycle and working hour both decrease.

Line balancing is strategy in layout planning to analyse all the task being performed in assembly process. the purpose of layout planning is to improve the process time and line efficiency. After process planning minimum labor and less space required to get the same numbers assembly components.

For the sorting components at each station we use flexible automation option ,flexible automation use an intelligent control system for controlling assembly line equipment such as a robot arms ,rotatory table stepper motor, and tools with minimal intervention of labour. Here we have two types of automation systems one is fixed that we called (hard) automation system. And flexible that we called (soft) automation system. Fixed (hard) automation are high technology custom-made tools for a specific process task. besides flexible automation mean a robot or a mechanical system cable to assemble different parts or capable to perform different process tasks. Flexible automation in assembly line allows the process to rapid configuration ability of the assembly line process cycle in order to assemble number of components at the same time. (hard) automation is composed of 6-axis and gantry robot arms to perform process task actions, proximity sensors to inspect and detect the presence of components. because assembly components are different so the robot arms equips different grippers for different process.The design can also be modified to meet the individual criteria of people those who want to use it for assembly of different components.The individual needs of a customer can be met just by tweaking some key aspects of the design yet still keeping the basic design constant.

Assembly line analysis

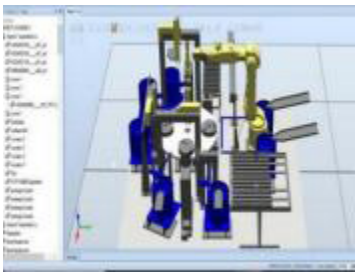
Because of automated assembly process, the automated assembly line is now flexible to different types of screw and

washer assembly with process time reduced to 43sec ,that means component assembly amount increased to 150 components per hour. Automation in assembly process is one of the most important factor in manufacturing sector. When someone imagines a fastener factory, they are likely to picture work in progress to decrease working hour and traveling down cost. through an automated assembly line its nearly possible now to save cost. automation become mainly associated with fastener industry because of its incredible efficiency,versatility and long-standing. Besides the working space covered by assembly line will be decreased 32 square meters to 16 square meters and the numbers of operator decrease. automated robots will take the place of labor ,according to needs different robot arms distributed in different assembly stations.

Assembling different components at the same time, next station required sub-assembled components from previous station. According to components requirement at different assembly station, we formed the numbers of bowl feeders. Vibrating bowl feeder used to feeding different parts at every station. Rotary table rotate and relocate the assembly position to next station.

Because we already installed detecting sensors at each assembly station for detecting components, proximity sensors detect presence of components and as result of bin picking components will be picked up. at every bowl feeder when its vibrate and rotate the vibratory disk the component which is in sequence will come up to linear feeder and move to pick up point. in case of changing in the assembly process, like changing speed of assembly at each station .according to the process time each station cycle time will be change automatically. It can balance the assembly line cycle time and capable to use various stations complete process tasks at the same time as well as capable to transfer the sub-assemblies to the next assembly station.

(Figure 5 : layout in 2D)

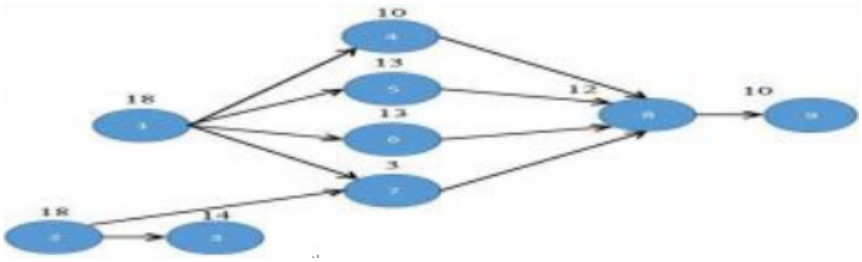


(Figure 6 : layout in 3D)

Advanced assembly Planning

Assembly components in hopper are fill up irregularly. Linear feeder lead the component to in predefined- positions on linear feeder where robot arm will pick up the component. The components are different in size and shape , assembly components are in different orientation, and the component pick up positions were predefined in program. so the robot arm know the exact position to pick the component. Because assembly components has regular shapes so we don't need to use advance system to detect shape, without high cost system in it, it is simple and impacted so its cheaper. And for bin picking is referred as random pose component picking with the help of sensors robot arm detect the random pose of components and pick and place to new location.with the help of Bin picking we can grip components with various position, sizes and shapes. Bin picking also reduces the process cycle time and improve productivity. Here we use various types of grippers mostly mechanical or magnetic gripper which can use for bin picking.Mock up also included.

In assembly planning that determine the layout of work process.There are 4-stations in total and and 9 stages to complete a assembly. The distances between different stations are very close assembly process flow station after station. we did the simulation of assembly line and measured the timing from Start to end and timing to fill up feeder hopper as well. If the assembly process continuous performing tasks for half an hour that's 75 units output. As we have the different components and for every component times is different. we calculate the real time and the real quantity that feeders could last. Because the operator to have fill up feeder hopper so the number we estimate is result of simulation for all components.



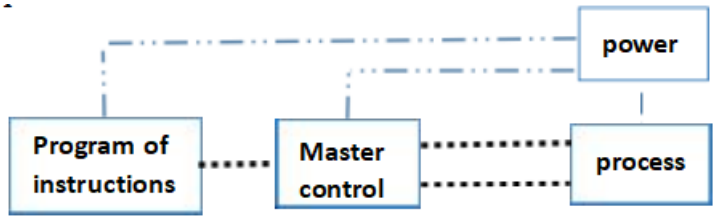
(Figure 7: Line balancing)

We repeat the process number of times, after calculating the mean value we determine it's more close to the sum number. So run process several time the determine that feeders need to fill up at every 10 minutes round.

As considering the process procedure,Task 4,5,and 6 must be performed in station-3, task 7,8and 9 should be complete in station-4 and so on Based on this outcome, we calculated the line efficiency and some other data.

Power to accomplish the automation

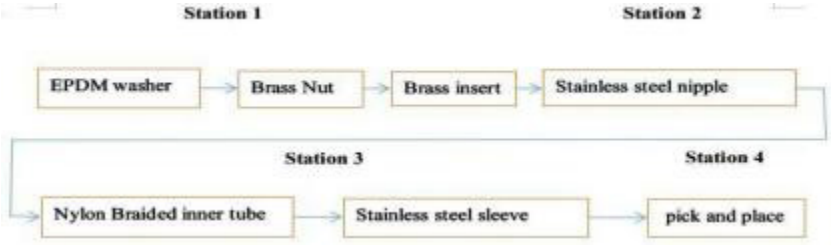
An customized automated system is used for operating assembly line and control the process and power required to operate and process. Main source of power in automation is electricity, electric power use in automated and non-automated processes.



(Figure 8: power flow & control)

The procedure of controlling the power system of assembly line is closed-loop cycle from program instructions to process feedback ,using power system devices and instrumentation automated assembly process cycle become more efficient and assembly line hardware and control devices with less human intercession increase productivity. In assembly line power system 4-main electric parameter being measured and monitored constantly, the real active power being used in process namely, P, Q, V and δ,(watts, kW, MW), and the reactive power that is (ampere-voltage-reactive, KVAR,VAR, MVAR), the voltage (M, V, kV) and the power angle (degrees), respectively. Process required number of relays and sensors feedback to master control for this purpose devices are installed in power grid for energy statements and data collection from grid equipment. because of smart control power system size is minimal. Automated assembly line use processor base hardware such as DNP3, IEC 61850 such system help in process with huge reliability.

Robot actions and automation options



(Figure 9: assembly process flow)

Conclusion

Through basic concepts and analysis we proved our layout which consist different assembly station for different components. The efficiency and productivity of assembly line will increase to120- 150pieces/hour that is much higher as comparing to current manual assembly line. With different options and comparing different bowl feeders vibratory plate bowl feeder has been chosen for our assembly line.

References:

[1] Malin Löfving, Boel Wadman (2018) Evaluation of flexible automation for small batch production, Procedia Manufacturing 25 177–184, doi: 10.1016/j.promfg.2018.06.072.

[2]Daria Leiber, Veit Hammerstingl, Felix Weiß, (2019) Automated design of multi- station assembly lines, Procedia CIRP 79 137–142, doi: 10.1016/j.procir.2019.02.029.

[3] Zheng YF, Pei R, Chen C. Strategies for automatic assembly of deformable objects. In: Proceedings of the1991 International Conference on Robotics and Automation. Los Alamitos: IEEE Computer Society Press;1991. p. 2598–2603.

[4] Saadat M, Nan P Industrial applications of automatic manipulation offlexible materials Industrial Robot:An International Journal, 29 (2002), pp. 434-442.

[5] Milberg J, Diess H, Warnecke HJ. The Automated Assembly of Dimensionally Instable Parts. In: CIRP Annals. Amsterdam: Elsevier Ltd; 1986.