Computer Simulation and Analysis of High-precision Automated Assembly Line in Telecommunication Industry

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Session: Tools, techniques, and best practices of engineering education for the digital age

Abstract

In this project, a mechanism for inserting assembly technology is described. The process is separated into two portions: pick-up and assembly. In the pick-up portion, process planning for industry assembly is a very complex task, which is mostly dependent upon the combination of experience along with up-to-date assembly technology. Attempts to simulate the automated assembly process have been largely unsuccessful and it remains a difficult task especially for current college student majoring in manufacturing, in the field of mechanical engineering. Besides pursuing automating assembly process planning, this research also investigates the effectiveness of assembly simulation as a project for groups of graduate students by using computer-aided design. Student can view assembly simulations through Pro/E software. The research was accomplished by reviewing process plans from different groups of graduate students and presents the best result to establish a baseline of process plan complexity, which shows huge gaps between college study and current leading manufacturing industry.

1. Introduction

In classroom lectures, we not only learn how to do design in the pro/Engineering simulation system, but also launch some simple warm up projects with which to start. All students are divided into several groups at their own request, group discussion helps in team building and the ability to handle the project as a group. Different groups and different warm up projects help reduce copying from each other. All these basic projects contribute to and regulate their path to industry design.
There are thousands of different ways to design an assembly line but there are only several left after optimization. So, discussions between groups are the best way to share ideas and knowledge with everybody. Professor Li evaluates and gives more info about current industry standards.

Several different groups are divided into designing different steps, including: feeding process, loading process, assembling process, and offloading process. Different methods are introduced by group members and the most important and optimized process is: insert assembly technology presented in this article.

In our simulation, the workpiece is only 50mm. In current technology, large size assembly is common, but small size assembly is less common and cost is high. For the small workpiece, it is difficult to assemble accurately. Compact cylinders, and compact grippers are used in this project. At same time, cost still needs to be considered. Designing high speed automatic machines requires different principles compared with traditional low-speed assembly machines. High-speed considerations include unpredictable forces and moments when a machine is working at high accelerations, decelerations, when many new materials need to be applied and when there is more frication than in traditional low-speed machines. Intermittent motion systems, unlike continuous-motion systems, must stop the process periodically to perform particular actions. Because of the stops, intermittent motion systems cannot achieve the high number of cycles that continuous motion can. Intermittent motion tops out at around 250 per minute, whereas continuous motion systems can achieve speeds many times that.
In this project, there are two parts, male and female, that are assembled together (as Fig.1.1 shows). The male part faces up; the female part goes above of the male part and faces down.

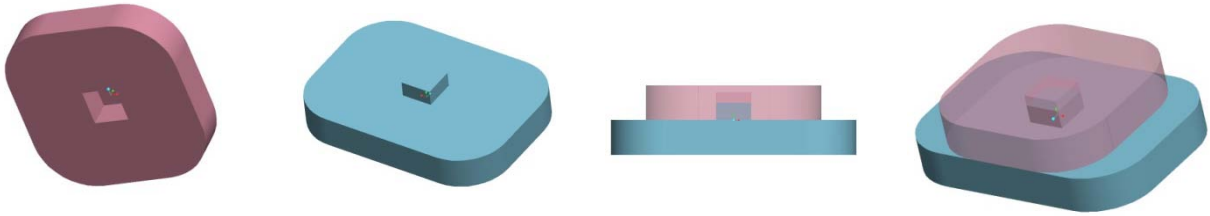


Fig.1.1 Female part, male part, assembly parts

2. Description of Process

2.1 Pick-up System

2.1.1 air cylinders and grippers

a. MY1H10, Mechanical Joint Rodless Cylinder, High Precision Guide

- High precision guide type
- Bore size: 10mm
- Strokes up to 1000mm
- Stroke adjusting unit: 2 types available
- Auto switch capable

b. MY2H, Mechanical Joint Rod less Cylinder, High Precision Guide

- Mechanically joint rodless cylinder
- High precision guide type
- Bore sizes (mm): 16, 25, 40
- Thread types: M, Rc, NPT, G
- Maximum standard stroke: 600mm
- Auto switch capable

c. C (D) Q2W, Compact Cylinder, Double Acting, Double Rod

- Rods at both ends of cylinder
- Bore sizes in mm: 12, 16, 20, 25, 32, 40, 50, 63, 80, 100
- Strokes from 5mm to 100mm depending upon bore size
- Mounts: through hole, both ends tapped, foot, flange
- Screw in piping or one-touch fittings
- Variety of switches and a variety of lead wire lengths

d. Three stages hydraulic cylinder

- Available in two, three, four, and five stage force multiplying models.
- Output forces up to 19,000 at 100 PSI.
- Rated for 125 PSI pneumatic or hydraulic operation.
- MSE series provides multiplied force in the stroke extend, MSR series provides multiplied force in the stroke retract.
- Many options available to allow for incredible design flexibility.
- Eight bore sizes available from 1-1/2" up to 8”.
- Permanent lubrication design provides outstanding service life.

e. Rack and pinion rotary actuator

- Compact unit
- Body can be mounted as flange
- Equipped with an angle adjusting mechanism
- No backlash
- Auto switch mounting possible

f. MHZ2, Air Gripper, Parallel Type, Standard

- Standard parallel type air gripper
- Bore sizes from 10mm to 40mm
- Double acting and Single acting available
- Auto switch capable
- Improved rigidity of guide rail

g. MHZL2, Air Gripper, Parallel Type, Long Stroke

- Long stroke type parallel gripper
- Bore sizes from 10mm to 25mm available
- Double acting and single acting available
- Four finger options available
- Auto switch capable

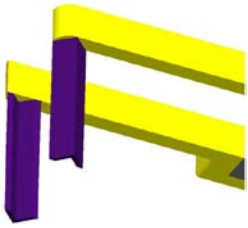
h. MRHQ, Rotary Gripper, Parallel Type, 2 Fingers

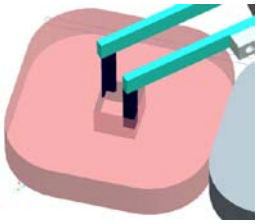
The MRHQ series is a rotary gripper suitable for holding and reversing work pieces on transfer lines. The compact integration of gripping and rotating functions eliminates the peripheral piping and wiring of the previous product (rotary table + adapter + air gripper). The length of the MRHQ series has been reduced by approximately 20% compared with previous products.

2.1.2 gripper finger design

In Fig.2.1, two right-angle fingers are designed in this project （purple model）in order to grip parts in a diagonal way. The finger's right-angles suit in the diagonal angle of parts. Thus, four sides of parts have force to be gripped. This method is steady and sure. For the female parts, gripper picks up the parts internally (as Fig.2.2 shows).

For the male parts, gripper picks up externally (as Fig.2.3 shows).





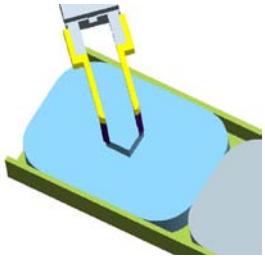
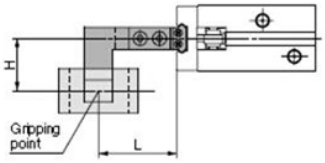


Fig.2.1 Gripper design Fig.2.2 Grip female part Fig.2.3 Grip male part

According to the grippers catalog, the finger length is stipulated by



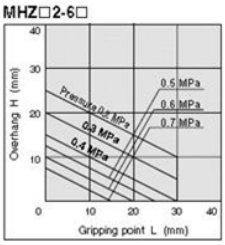
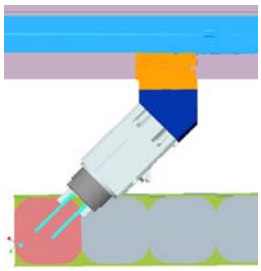


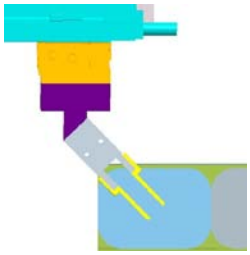
Fig.2.4 Gripper size parameter

2.1.3 45° angle pick-up system

Due to the grippers pick up the workpiece diagonally, therefore the whole pick-up system has to be designed at 45 degrees. (As Fig.2.5 shows)



Female parts pick up



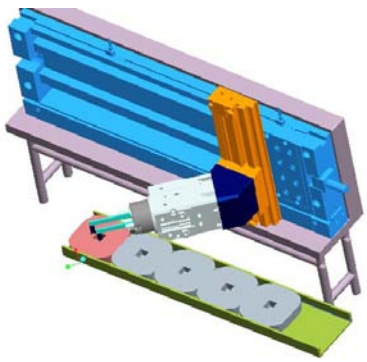
male parts pick up

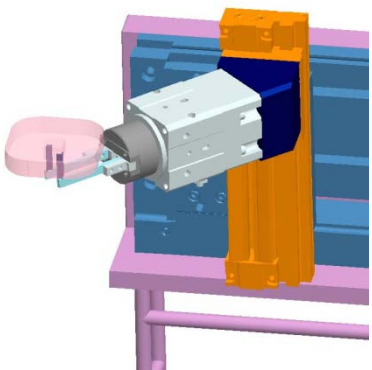
Fig.2.5 45°angle pick-up system

The pink piece is the female part and the blue one is the male part. Two types gripper are used in this portion, small air gripper is used for male parts. The rotary gripper is used in the female parts pick up system. This will be illustrated in the follow paper.

2.1.4 Female parts pick-up system

For the female parts pick up, there are some special designs is generally separated into two portion: rotation and preparation. When the gripper completes the pick-up, the female part has to be rotated. Because the pocket of female part is not a through hole, female parts have to be picked up when they are facing up. But, as mentioned, the assembly section is that female parts face down and male parts under the female parts face up. So there must be a provision to turn the female parts over from face up to face down. This is why the rotary gripper is would be used. After the female part has been picked up, the head of rotary gripper (white model in the Fig.2.6)





will turn over in order to make the female part to face down.

Fig. 2.6 Turn over process of female part pick-up

In Fig.2.6, the light blue model is horizontal air cylinder. The orange color model is a vertical air cylinder. The navy blue model is a 45 degree junction between rotary gripper and vertical air cylinder. The second portion is called preparation: get the female parts ready to be assembled. After rotation, two gripper fingers are still in the pocket. The pocket is not available to be assembled. So, the female part has to be placed on another set of gripper fingers (for support) and the pusher holds the parts to avoid movement caused by mechanical vibration.

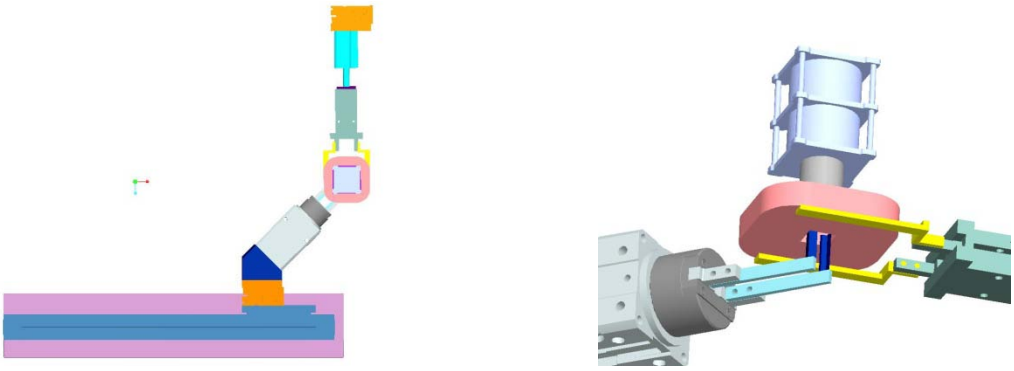


Fig.2.7 Preparation process of female part pick-up

In Fig.2.7, green piece is a gripper provides support for the female parts. It has two yellow fingers. The top white piece is a three stage cylinder. In this step, only first stage is used. When the pick-up gripper puts the female parts on the fingers of the support gripper, at same time, the three stage cylinder drivers the pusher (violet piece) to hold the female parts in order to avoid movement caused by mechanical vibration.

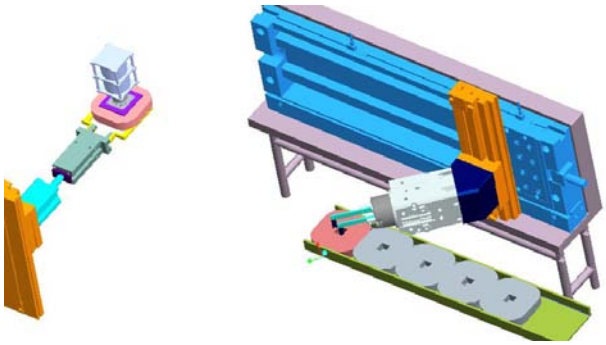


Fig. 2.8 Whole female parts pick-up system

2.1.5 Male parts pick-up system

For the male parts, the pick-up system is quite simple. When the gripper completes the pickup, the horizontal air cylinder drives the gripper and part to the work table, and the vertical air cylinder moves down to put the male part on the table. When the male part stands on the table, there are two “L” shape clamps driven by rotary actuators that close to hold the male part to avoid movement by mechanical vibration.(as Fig.2.6 shows)

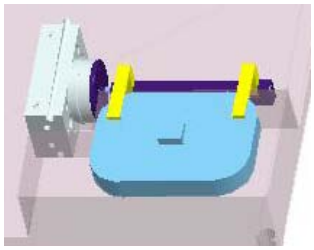


Fig.2.6 “L” shape clamp

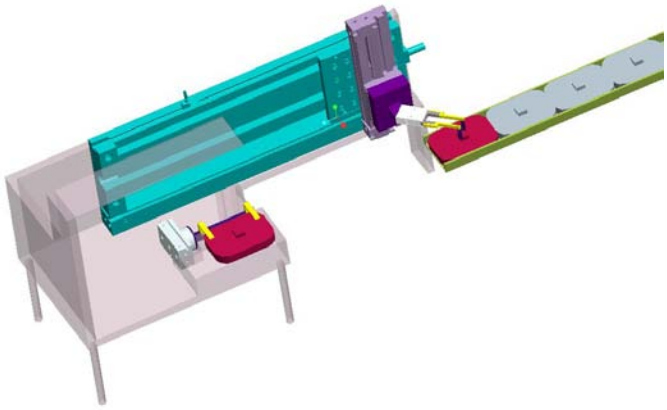


Fig.2.7 Whole male parts pick-up system

2.2 Assembly System

When the female parts have been prepared, the male part is ready for assembly. A three-stage cylinder will pushes the female part down. when the stud is inserted into the pocket 1 mm. and three-stage cylinder finishes the second stage and stops, the support gripper fingers open and retreat at this moment(as Fig. 2.8 shows). After that, the three-stage cylinder proceeds the third stage to push female part till completely assembled.

In the Fig.2.9, after the assembly process completed, support gripper and pusher cylinder released.

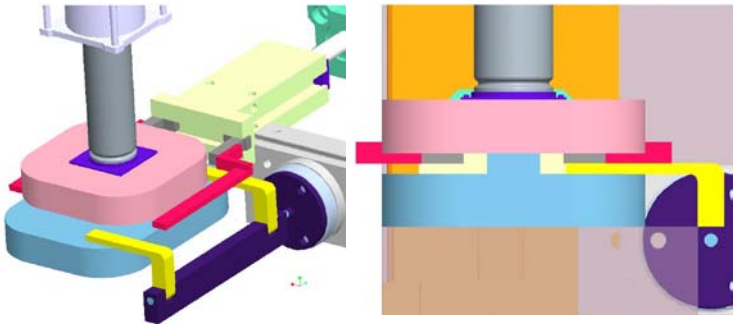


Fig.2.8 Fingers of support gripper retreat

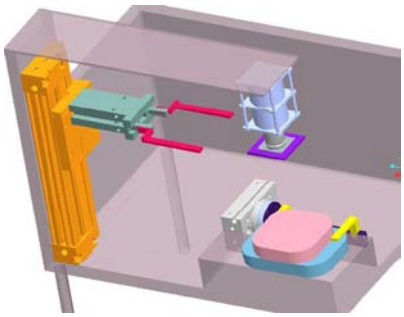


Fig.2.9 Gripper and pusher released

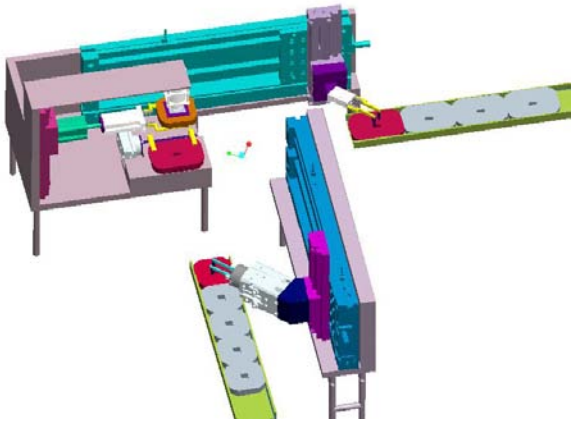


Fig.2.10 Entire assembly section

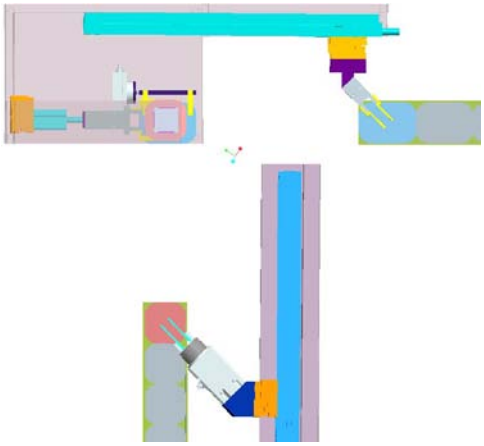


Fig.2.11 Entire assembly section lay-out

3. Conclusion

Simultaneous engineering usually covers the integration of design and planning during product development. Yet there is still a gap between the planning and the subsequent implementation of assembly systems. This article describes an approach to the consistent integration of assembly systems planning into the assembly control system of a real assembly facility within the same environment. The assembly mechanism developed can be used to simulate assembly process for validation purposes as well as to communicate with real assembly fixtures and equipment. As it is a research-related activity, methods to meet current industry manufacturing needs and lower the costs are critical for manufacturers to stay competitive. To conclude, the most important challenge for the whole project is not the computer-aided design technology by putting everything together and simulate the whole assembly process but the key factors from currently industries such as loading process (feeding, positioning), insert assembly (griper design, grasping and holding mechanism) and off-loading process.

BOM

Table 1: BOM

Bom Report : ASSEMBLY_STATION		
Assembly ASSEMBLY_STATION contains:		
Quantity	Type	Name
1	Sub-Assembly	FEMALEPARTS_SYSTEM
1	Sub-Assembly	MALEPARTS_SYSTEM
Sub-Assembly FEMALEPARTS_SYSTEM contains:		
Quantity	Type	Name
1	Sub-Assembly	FEMALEPARTS_PICKUP
1	Sub-Assembly	FEMALEPARTS_PREPARE
1	Part	LOADING
5	Part	FEMALEPART
1	Part	FEMALEPART_TABLE
Sub-Assembly FEMALEPARTS_PICKUP contains:		
Quantity	Type	Name

1	Part	MY1H10
1	Part	MY2H
1	Part	FEMALEPART_JUNCTION1
1	Part	MRHO
2	Part	FEMALEPART_PICKUPFINGER
Summary of parts for assembly FEMALEPARTS_PREPARE:		
Quantity	Type	Name
1	Part	MY1H10
1	Part	FEMALEPART_JUNCTION2
1	Part	MHZL2
2	Part	FEMALEPART_ASMFINGER
1	Part	MSE-MSR-6×4×3S-MPR
1	Part	C (D) O2W
1	Part	PUSHER
1	Part	PUSHER_JUNCTION
Summary of parts for assembly MALEPARTS_SYSTEM:		
Quantity	Type	Name
1	Part	MALEPARTSPICKUP_TABLE
1	Sub-Assembly	MALEPARTS_PICKUP
1	Sub-Assembly	MALEPARTS_FIX
1	Part	LOADING
5	Part	MALEPART
Summary of parts for assembly MALEPARTS_PICKUP:		
1	Part	MY1H10
1	Part	MY2H
1	Part	C (D) O2W
1	Part	MALEPARTSPICKUP_JUNCTION
2	Part	FEMALEPART_PICKUPFINGER
Summary of parts for assembly MALEPARTS_FIX:		
2	Part	LSHAPECLAMP
1	Part	MSOB1A
1	Part	LSHAPECLAMP_BAR
1	Part	LSHAPECLAMP_ROD

4. Reference List

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[4] http://www.smcusa.com/

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