Zagazig University

Fuclty of Engineering

Mechanical design and production Departement

Graduation project book

Design and manufacturing of desktop Pick and place Machine

Under supervision of

Dr. Ahmed Ibrahim

2021/2022

Project Team

1. **ENG. Ahmed Mohamed Abdellatif**
2. **ENG. Mohamed Adel Hamza**
3. **ENG. Mostafa Nabil Negeda**
4. **ENG. Osama Khaled Fathy**

Abstract

Table of Contents

1. Chapter 1 Introduction

1-1 Introduction

Pick and place systems, pick and place machines or pick and place robots as they can be known are part of the success of surface mount technology.

Pick and place machines are a key element of any PCB assembly line enabling components to be automatically placed on a printed circuit board quickly and accurately.

In this way manual placement which is slow and relatively inaccurate is avoided, thereby hugely increasing the throughput and quality.

With some electronic circuit boards using over 1000 surface mount technology, SMT components, many of which are very small, and most of the components requiring very accurate placement, it is not feasible to place them manually. Accordingly pick and place machines are used that can place all the components accurately and in a repeatable fashion.

Pick and place machines are used for PCB assembly where they take components in reels or tubes or on flat packs and place them on the board as defined by software generated from the PCB files.

1-2 what is a pick and place machine?

Pick and place machines are relatively sophisticated machines use for PCB assembly. As the name indicates the pick components up and place them onto the printed circuit board.

In most PCB assembly areas, boards will be soldered using infra-red reflow, and this means that prior to the pick and place process, the boards come having had solder paste applied in the relevant areas of the board.

The pick and place machine is also loaded up with components. There are many feeds either side of the machine. These can take component reels, tubes and in some instances they may even be in a form of flat packaging known as a waffle pack.

The pick and place machine has a head on an arm which can reach all the reels, tubes, etc and it picks them up and then places them onto the board. Typically the head uses a small vacuum to pick the components up and then release them onto the board.

The head is very accurately controlled by the software, and uses both the accurate positioning of the board as well as optical location on some machines to ensure that everything is placed in exactly the right position.

Accurate positioning is of great importance because some components are very small, and also track widths are very narrow.

The pick and place machines are pre-programmed with the information about component positions so that they know where to place the components. This program is normally developed directly from the printed circuit board design information.

1-3 Benefits of Using a Pick-and-Place Machine:

Pick-and-place machines have become an essential part of the modern manufacturing environment, offering customizable ways to solve problems and ultimately bolster companies' bottom lines.

1. **Speed:** used in assembly or packaging products. The technology is improving as pick-and-place machines have become multitaskers over the last two decades. Designers have also adopted multiple heads and several gantry features. Pick-and-place machines can handle a wide variety part and can theoretically handle 136,000 components per hour (cph). The fastest machines can perform 200,000 cph.

2. **Precision:** Pick-and-place machines work at a level of accuracy human assembly can never match. A pick-and-place machine device can set a binder part within 1/10,000th of an inch of the proper placement. This precision ensures better performance for the final product while reducing the number of defective products coming off the line.

3. **Flexibility:** Pick-and-place machines are extremely flexible. They are easily programmed to handle whatever dimensions, movements or specifications operators have in mind. Therefore, they accommodate a wide range of components and operations. A pick-and-place machine can also handle different shapes and types of products thanks to its design.

4. **Cost savings:** Pick-and-place machines earn their keep by bringing automation to the factory floor. Automation can be a great source of greater precision and speed, which both translate into money saved.

5. **Safety:** Safety is an essential part of the workplace. Pick-and-place machines make factory floors safer by shouldering a sizeable portion of the physically demanding labor. This means workers no longer need to perform labor-intensive tasks time and again.

   Furthermore, pick-and-place machines can handle heavy products that humans may struggle to move and manipulate by hand. And the stresses of the modern workflow do

not affect their performance. Plus, they do not have to take breaks or vacations to recoup their energy.

6. **Consistency:** There are two ways to think about error: precision and accuracy. Precision involves performing a task within a small margin of error. Accuracy is a measurement of how far that task is from its desired outcome.

7. **Ease of use:** There are three different types of pick-and-place machines: manual, automatic and semi-automatic. Each option improves overall workflow, in part because the devices are easy to use. Although the technology they display is complicated, mastering the automation is not.

8. **Low maintenance:** Pick-and-place machines might use cutting-edge technology, but they only require minimal attention to maintain. When operators are cleaning or tuning up pick-and-place equipment, proper technique is essential. For instance, improper nozzle maintenance or low-quality products can lead to problems with a part or process.

9. **Efficiency:** Efficiency is essential for businesses trying to get the most out of their employees, payroll, raw materials, tools and investments. Pick-and-place machines raise the overall level of efficiency, which makes them a cost-effective solution.

   Furthermore, pick-and-place machines save space on the assembly line. For starters, the devices only work and stay within a relatively small and confined area, which creates more room for employees. Operators can program them to work within a predetermined space to improve the overall use of the assembly floor.

1-4 what is Soldering: technology & basics?

Soldering is a key process in many industries including electronics where it enables both electrical conductivity and some mechanical strength.

Soldering is one of the key processes in the manufacture of electronic equipment. Soldering allows electronic components to be electrically joined and also held in place.

Accordingly soldering is at the heart of electronics construction and manufacture for the hobbyist and enthusiast or student as well as for commercial organisations producing electronic equipment on a huge scale.

Whilst soldering is used in a variety of different industries including the plumbing trade where it is used to join pipes and seal them to prevent water leaking out, and it is used in the jewellery trade amongst others, it is key to the electronics industry.

What is solder?

It is the material that melts around a joint and solidifies to provide mechanical rigidity and electrical conductivity.

There are many different types of solder. Essentially solder can be defined as a fusible (i.e. it can melt and become solid again) metal alloy used to create a permanent bond between two or more metal items.

The solder is a metal alloy that has a much lower melting point than the main constituents, and in this way it can be made to melt at temperatures that can be attained relatively easily and without very specialized equipment.

Solder can be used in many areas, but the type of interest for making electrical connections must have a high degree of electrical conductivity. It also helps if it is resistant to corrosion, as this would mean the joints and their conductivity would degrade over time.

Soldering techniques:

There are different techniques used for small scale and large scale soldering. Labour intensive schemes cannot be used for large scale manufacture, where high degrees of automation are needed to provide the throughput required, whereas small scale production for commercial enterprises as well as prototyping and home building and construction for hobbyists as well as students, etc require soldering techniques that do not require the large scale investment and set up needed for mass production.

Two of the major approaches to soldering include:

- ***Mass production soldering:*** Mass scale production uses soldering techniques including wave soldering and now more commonly techniques like infrared reflow where the components are mounted on a board and all the components are soldered at the same time.

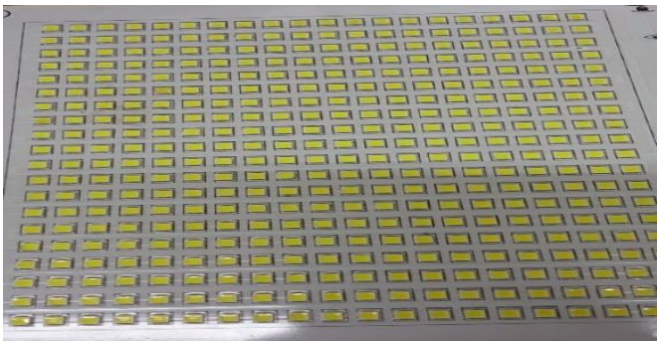
- ***Small scale production:*** For small scale production and home construction manual soldering techniques with the use of a soldering iron and solder wire are the most widely used method. Some skill is required to make neat and effective joints, but this can be learned quite easily. This type of soldering technique can be used for making small projects, soldering PCBs, making leads and a host of other applications.

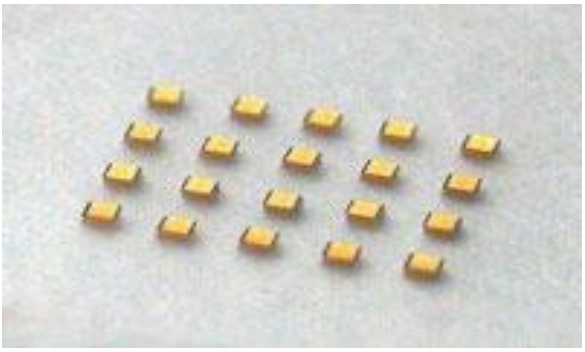
1-5 Industries for pick and place machine?

The pick and place machine is a high-tech, fully automatic, and multi-functional placement production type machine. The use of pick and place machines can speed up production and improve efficiency. For companies with large product demand, the pick and place machine is undoubtedly a good assistant, which can promote the vigorous development of the company. So industries can the pick and place machine provide automatic placement and production services is:

The pick and place machine is used in the electronics industry:

The common mounting products of the pick and place machine include electronic products such as diode chips, so it can provide great help for the mounting tasks in the electronics industry. In the process of mounting production tasks, we can set up the pick and place machine according to the size of the components to be mounted. Adding work to the database can help us quickly mount and produce the circuit boards of electronic products. In this way, for high-tech electronic products such as computers and mobile phones, the pick and place machine can provide faster





The pick and place machine is used for LED products:

We walk on the street at night, and we can see the lights shining everywhere. These colored lights, street lights, display screens, etc. that flicker at night are usually made of LED products. LED products are products in high demand. An enterprise needs to process tens of thousands of LEDs every day. At this time, it needs to customize LED Pick and place machine according to its own needs. For an enterprise, owning a pick & place machine means having faster and stronger placement capabilities, and it can also solve the problem of high demand and customers running orders.

The pick and place machine is used in the automotive and home appliance industries:

Cars and electrical appliances are products that are often used in our modern lives. We can see cars everywhere on the road. Back home, all kinds of electrical appliances at home also make the family warmer. These products can be produced by pick and place machines, such automotive PCB and circuit boards on TVs.

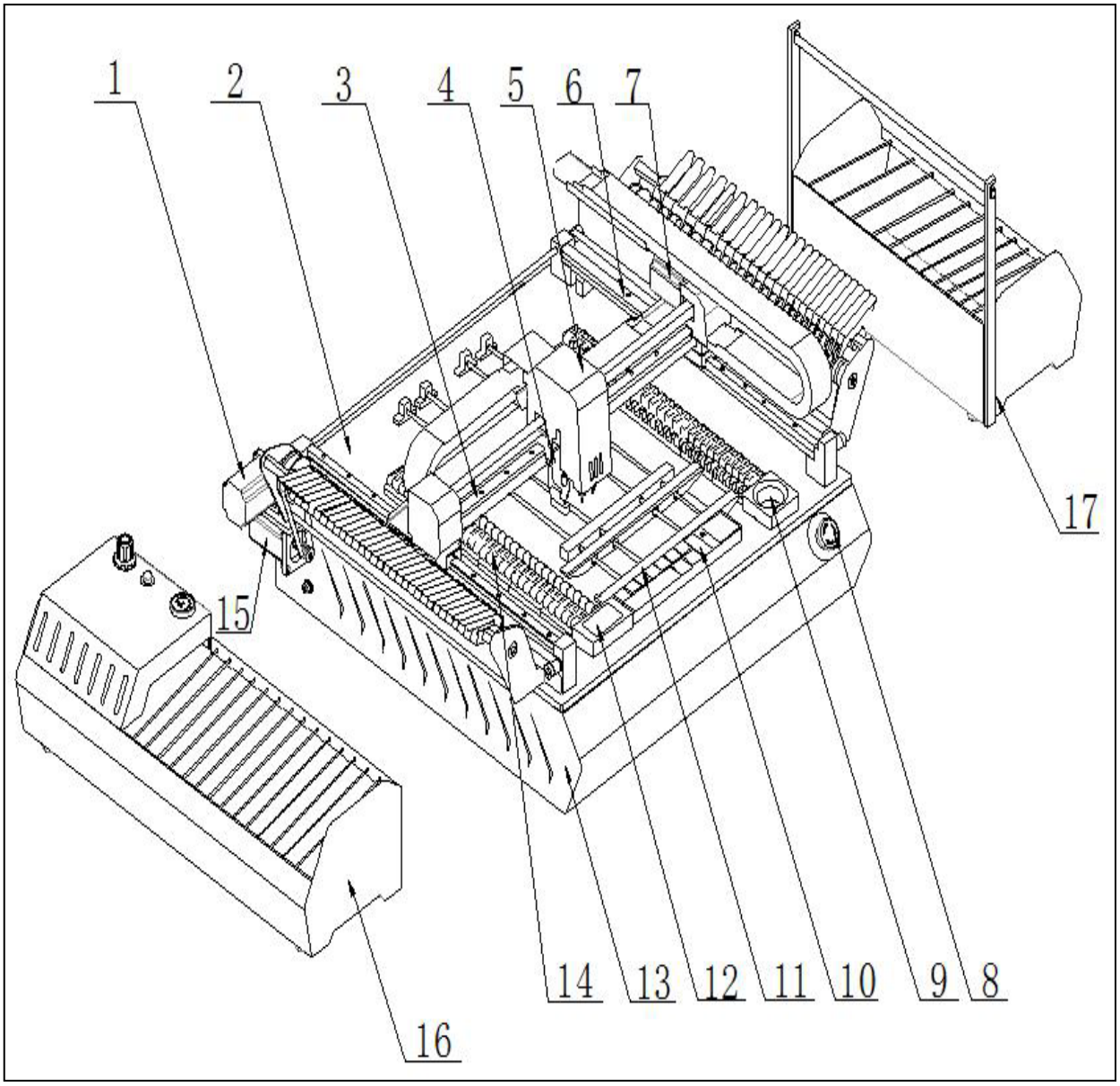
1-6 Components of pick and place machine:

Electrical components:

1. Power supply (150 W 24 V 6,5 A).
2. Voltage Relay (40 Amp, 12 Volt DC).
3. Two mini Pumps (DSL 370 DC 3V-6V).
4. CWT/channel well technology Adapter (12V 5A, 4-Pin Din, IEC C14).
5. DC Stepper Motor Driver (L298N).
6. Hyprid step servo (Nema348.5，Nm 6A 1200Oz-in DC (40-110V)/AC(60-80V)).
7. Mini CPU (Intel i5 4200U to 16 GB, SSD).
8. Wires
9. Small Pump
10. Black Adaptor (AC, 12 V)
11. 3 stepper Motor(Nema23, 12 V)

型号 Type	额定电压 Rated voltage	工作电流 Working current	介质 Medium	水流量 Max water flow	最大水压 Max water Pressure	噪音 Noise	寿命 Life test
WPS27D-3	DC3V	≤1200mA	水 water	≥1000mL/min	≥14.5PSI	≤65dB	400H
WPS27D-6	DC6V	≤800mA	水 water	≥1000mL/min	≥14.5PSI	≤65dB	400H
WPS27D-12	DC12V	≤500mA	水 water	≥1000mL/min	≥14.5PSI	≤65dB	400H
WPS27D-24	DC24V	≤300mA	水 water	≥1000mL/min	≥14.5PSI	≤65dB	400H

Chapter2 Equipment Summary



2-1 Equipment Constitute

Figure 2.1

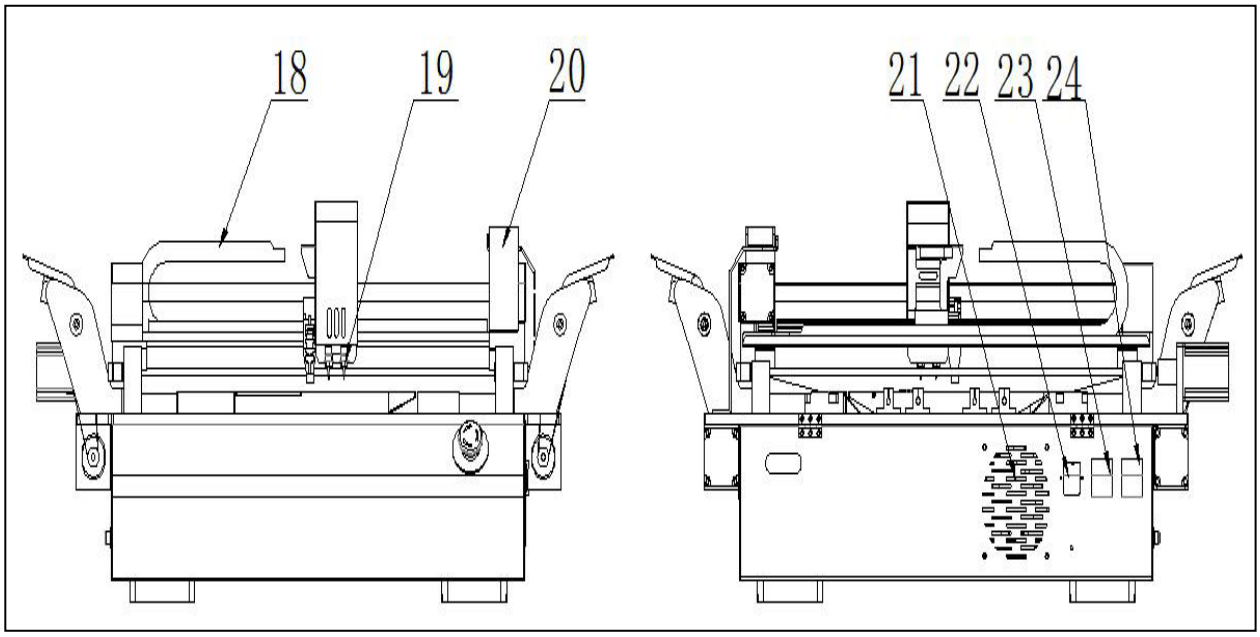


Figure 2.2

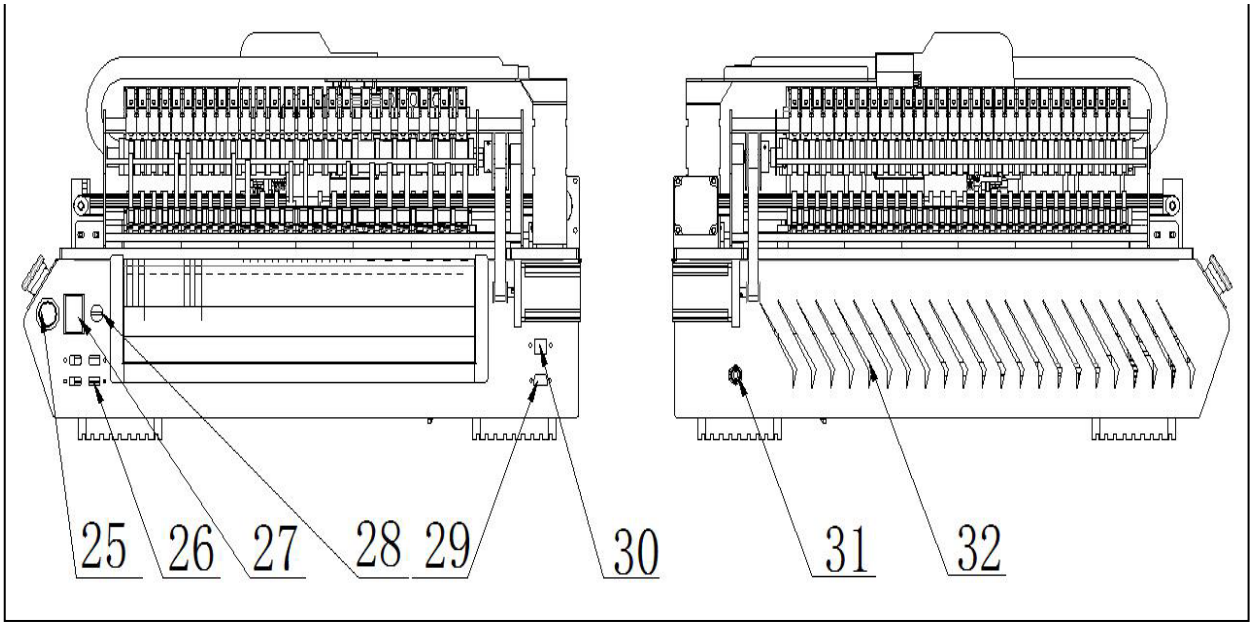


Figure 2.3

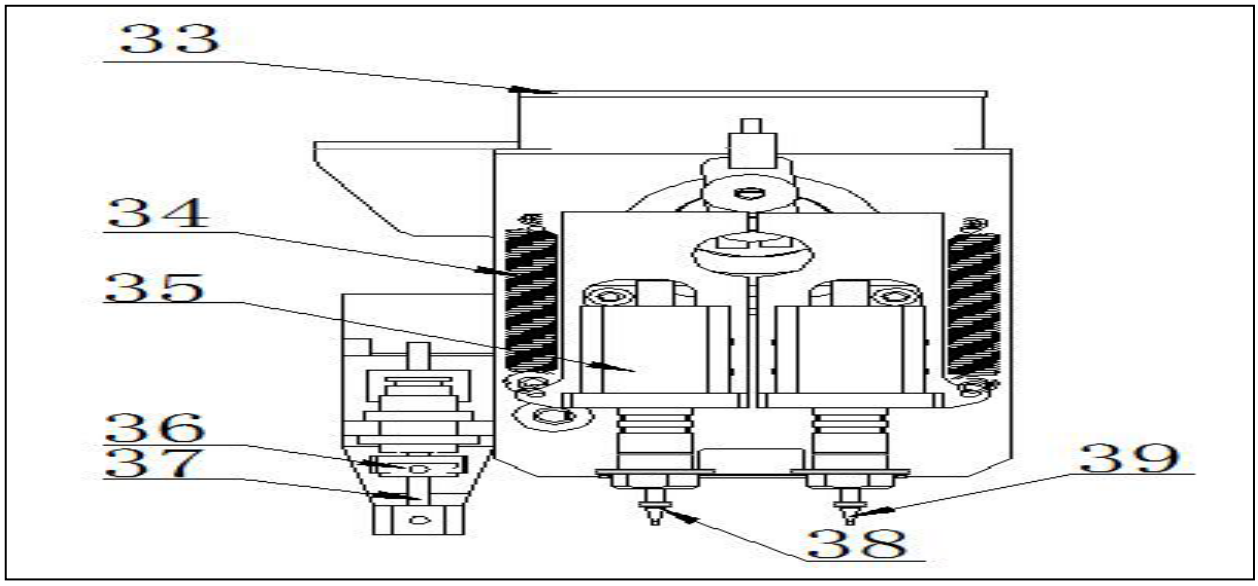


Figure 2.4

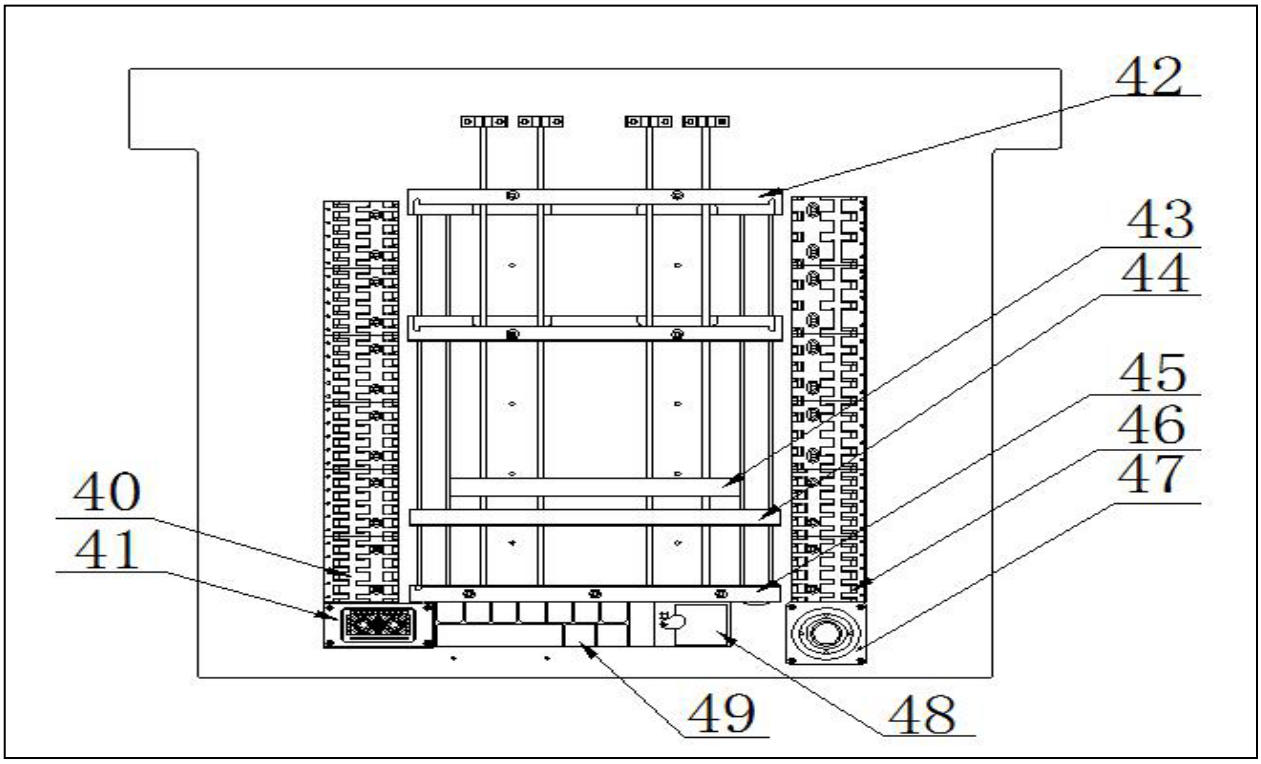


Figure 2.5

1	**Y-axis stepping servo motor**
2	Operation platform
3	X-axis linear slide rail
4	Pin
5	Mounting head
6	Y-axis guide rail
7	X-axis stepping servo motor
8	Button for emergency stop
9	HD Camera
10	Loose IC material stack, Material throwing chute
11	PCB holding device
12	RC Camera
13	Machine casing
14	Band shape groove
15	Thin-film recycling step motor
16	Feeder
17	Feeder
18	X-axis drag chain
19	Nozzle
20	X-axis drag chain
21	Cooling fan
22	Power plug

23	Socket
24	Socket
25	Fast start
26	USB port
27	Power switch
28	220V power plug of stick feeder
29	VGA port
30	Internet Socket
31	Gas entrance
32	3D cooling window
33	Vacuum checkerboard
34	Z-axis extension spring
35	Electric rotating machinery
36	Pull needle test part
37	Pin
38	2# nozzle
39	1# nozzle
40	Material groove
41	RC Camera
42	IC tray holder
43	PCB board adjustable support
44	PCB board movable mount
45	PCB board fixed mount

46	Material groove
47	HD Camera
48	Material throwing groove
49	Pre IC material position

2-2 X, Y, Z and R axis Description

The machine has the following 4 axis (X, Y, Z, R) for numerical control.

(1) X, Y axis: The left and right direction of the device is X, and the front and back direction is Y, with 0.01mm as the unit, which is shown as X=000.00mm, Y=000.00mm.

(2) Z axis: Height, with 0.01mm as the unit, shown as Z=00.0mm.

(3) R axis: Display the rotation angle of the mounting head, with 0.1 degrees as the unit, shown as A=00.0. Counter clockwise rotation

is positive.

X, Y axis moving range 430×530 mm.

Z axis moving range 19 mm.

Z axis rotation angle 0～360°.

2-3 Equipment Parameters

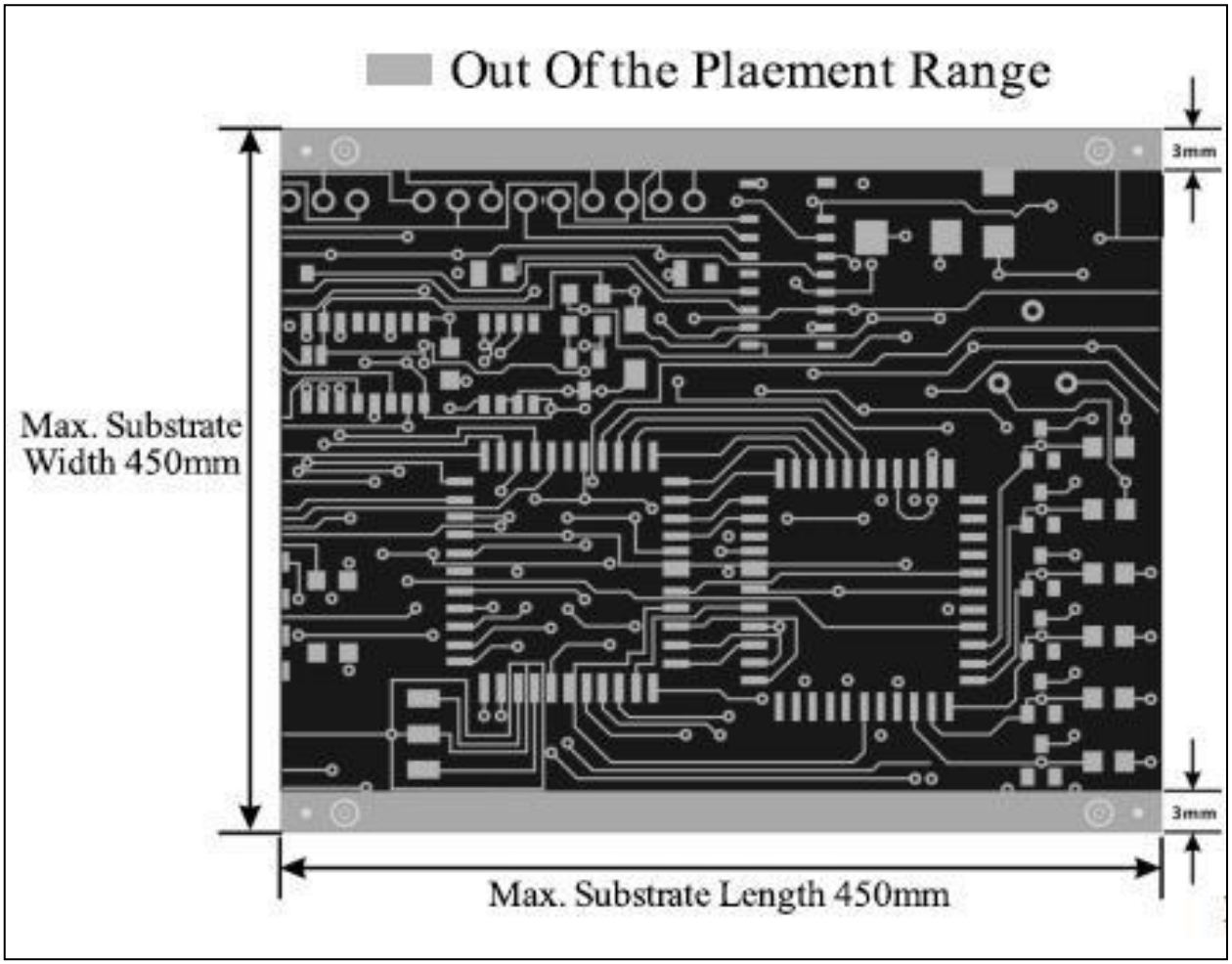
System	Items	Content
	Mounting head number	2 pieces
	Mounting accuracy	0.05mm
	Mounting angle	0～360°
	Theoretical Velocity	7000pcs/hour
	Normal mounting	5000pcs/hour
	Visual Mounting	3500pcs/hour
	Nozzle type	Juki nozzle
Mounting System	Element for mounting	RC (0402, 0603, 0805, 1206, etc) LED lamp (0603, 0805, 3014, 5050, etc) Chip (SOT, SOP, QFN, BGA, etc)
Substrate	Substrate minimum size	10×10 mm
	Substrate maximum size	320×220-450 mm
	Substrate thickness	≤2mm
	Substrate warp allowed value	<1mm
Feeders	8mm	20 bit
	12mm	4 bit
	16mm	2 bit
	24mm	1 bit
	Pre IC material level	10 bit
	IC pallet	1 bit

Visual System	Visual camera	CCD HD Camera
	Visual quantity	4pieces
	Identification ability	MAX.20*20mm
	PC system	Microsoft WIN7
Control system	Operational software	independent research and development
	Compatible file format	CSV, TXT. format file
	Programming mode	Support online and offline
	Pressure	0.4 Mpa (Internal pump)
	Vacuum value	-92kpa
	Power	230 W
Basic parameter	Power supply	AC220V±10％ 50Hz
	Host size	L 990 × W 730 × H 385 mm
	Feeder size	L 235 × W 700 × H 245 mm
	weight	85kg

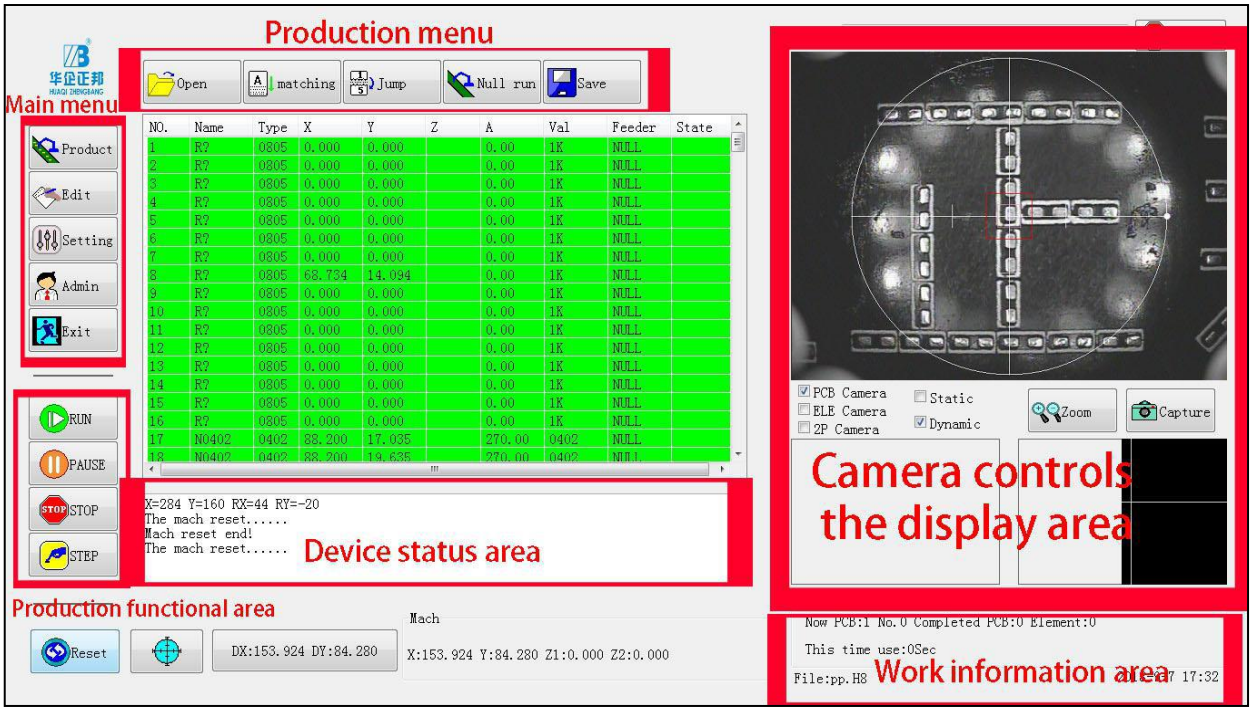
2-4 Nozzle specification

NO	External diameter	Inner diameter	Appearance	Applicable component
502	Φ0.7mm	Φ0.4mm		0402
503	Φ1.0mm	Φ0.6mm		0603
504	Φ1.5mm	Φ1.0mm		0805、1206、1210、SOT23
505	Φ3.5mm	Φ1.7mm		SOP8、SOP14、1812、2220
506	Φ5.0mm	Φ3.2mm		QFN、TQFP、BGA

2-5 Substrate Limiting Condition

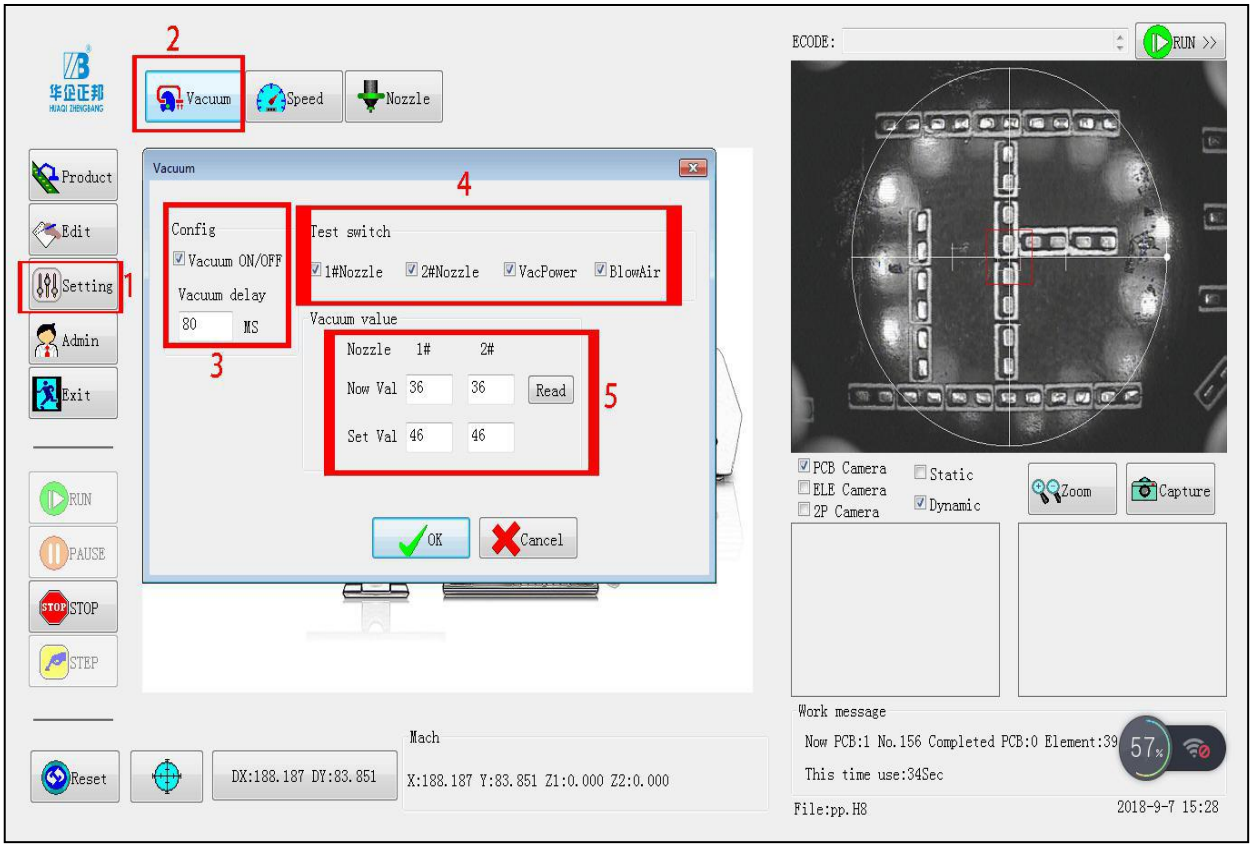


2-6 Menu Constitute



Chapter 3 System Settings

3-1 Vacuum setting



1. Open vacuum detection switch

Tick “working detection” with “√”to start vacuum detection, System judges “sucking up” successful or not automatically,

Decide next action according to result. Erase “√” to close vacuum detection switch.

2.Vacuum level setting

Turn on debug switch for all nozzles, click “read” to read current vacuum value, The system sets the vacuum value automatically.

！Attention:

If visual adjustment is opened for all feeders, vacuum detection can be closed.

Vacuum stabilization time is factory default value and it is not suggested to change it.

3-2 Speed Setting

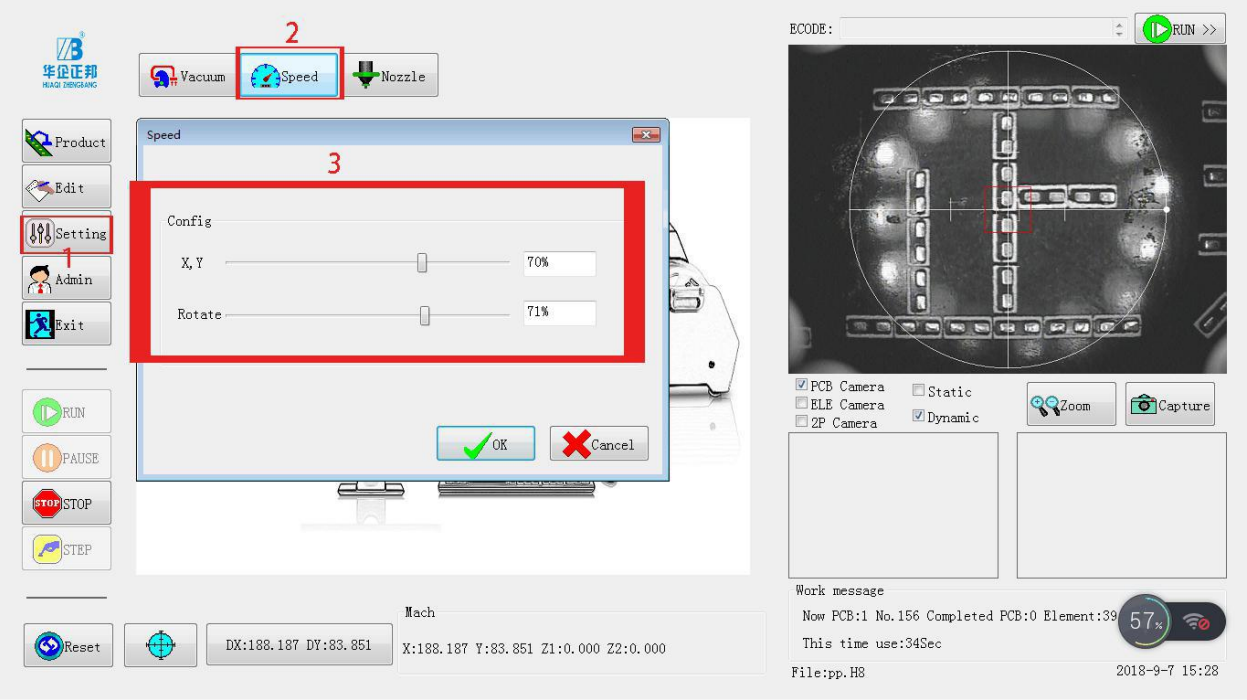


Fig.3-2 Speed Setting

The speed setting is realized by moving the speed sliding block to adjust X/Y axis operation speed and the rotation speed of the nozzle,

which is quite simple. The higher the value is the speed is higher.

Note: Z axis movement speed is set in feeder edit!

3-3 Nozzle adjustment

The adjustment function mainly works on coordinate offset of top camera, bottom camera and nozzle and keep nozzles in same center

to ensure pasting precision. Adjustment is finished during exiting factory test and no need to adjust in common replacing. Offset resulted from

abrasion of machine and nozzle problem can all be corrected by nozzle adjustment.

1.Open ceramic substrate

Open ceramic substrate cover on right side of IC tray with spanner which is provided together with machine, then put ceramic

substrate in the middle.

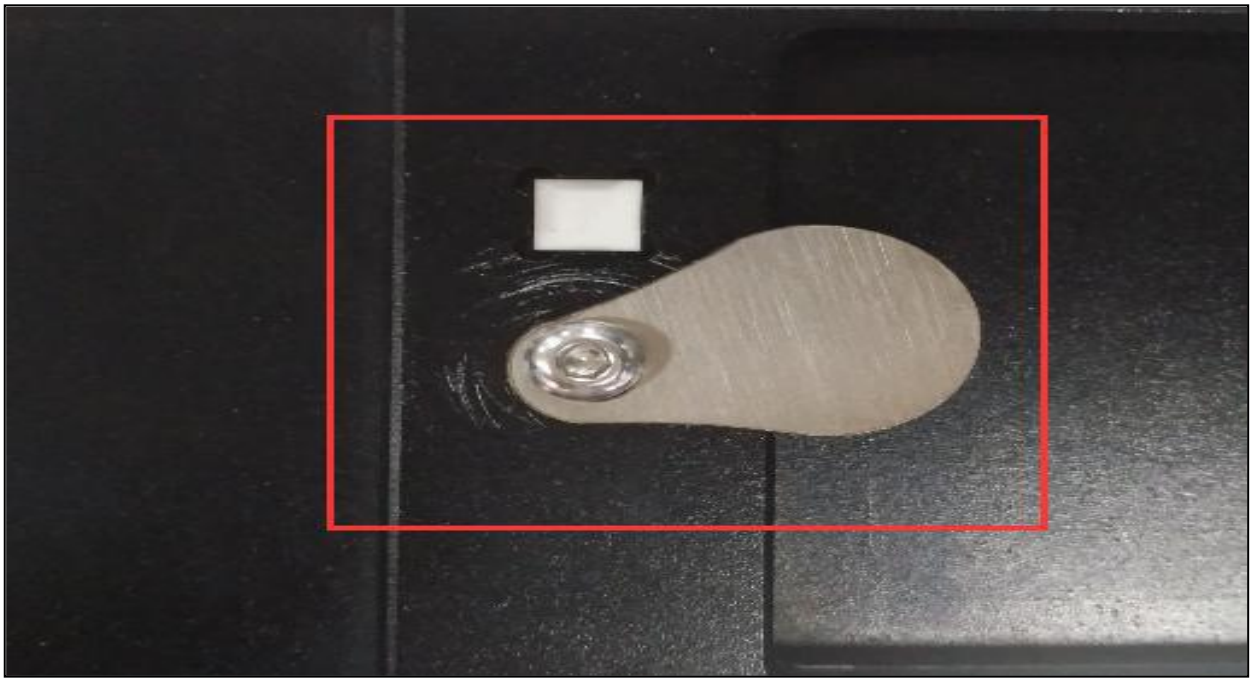


Fig.3-3 Ceramic substrate

2. Open nozzle switch to adjust nozzle

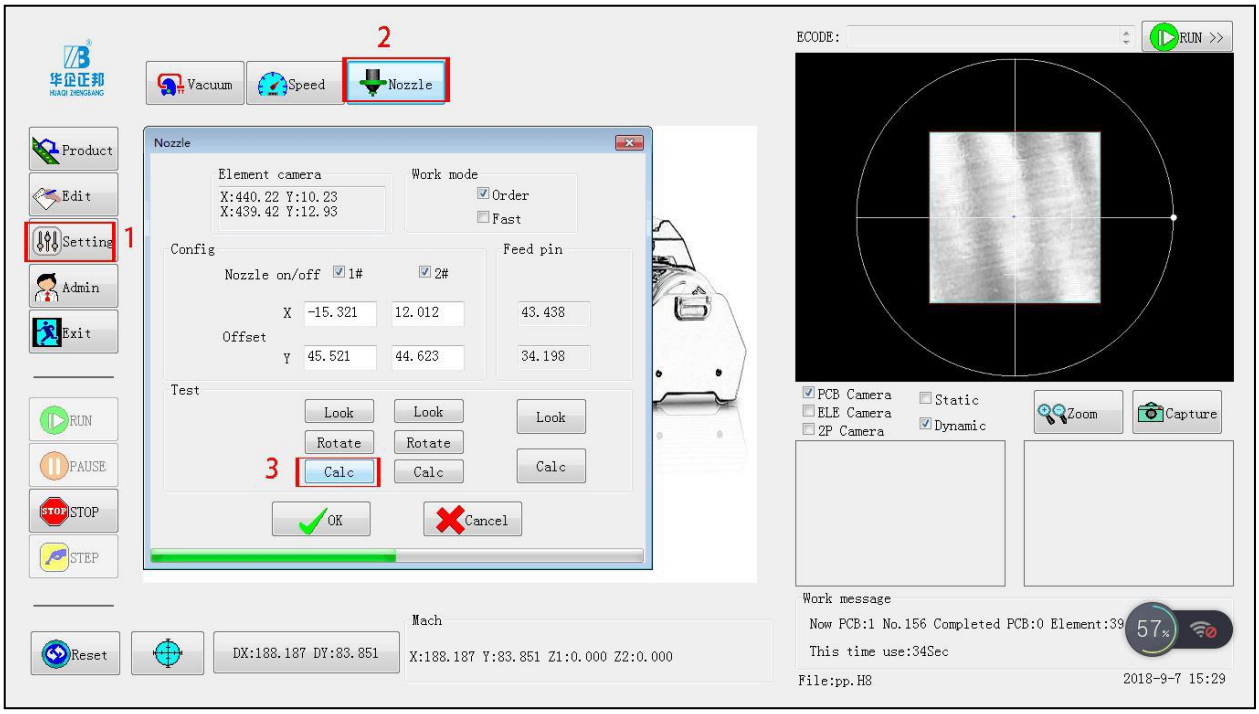
System shift to nozzle setting interface, tick all nozzle switches, click relevant “adjust” button,

System starts to adjust coordinate of top camera automatically and pick up ceramic substrate,

Adjust nozzle coordinate by bottom camera,

Put ceramic substrate back automatically after adjustment finished,

Click 2# nozzle to adjust it the same way.



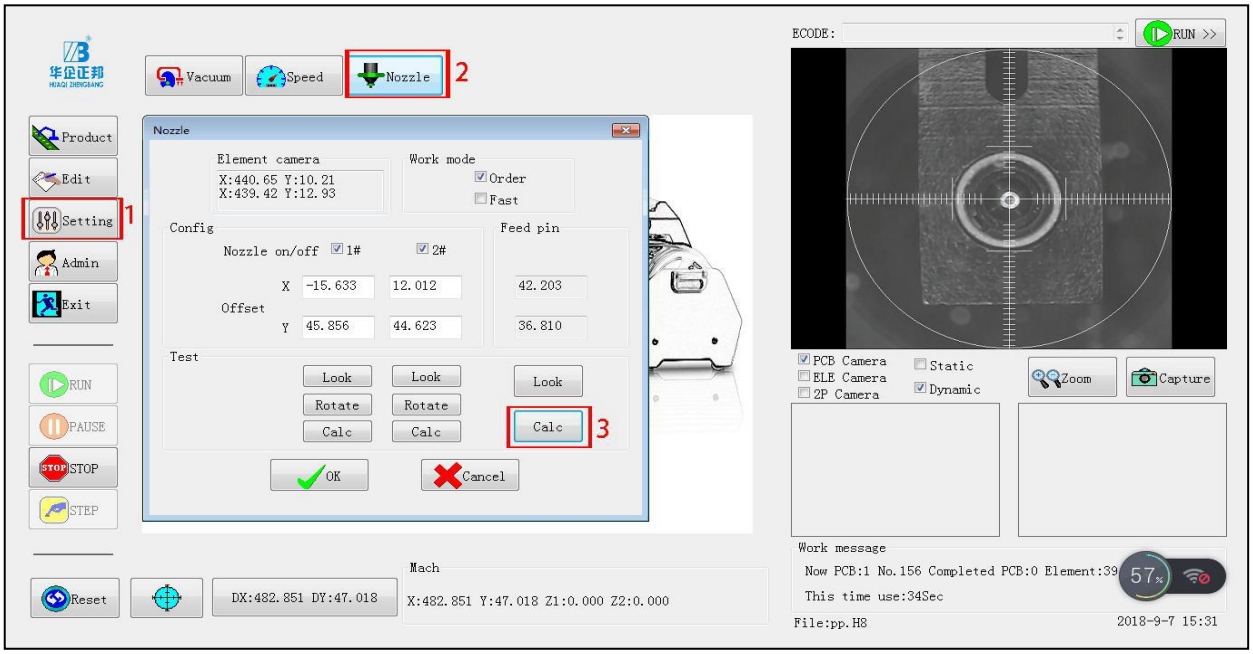
！Attention:

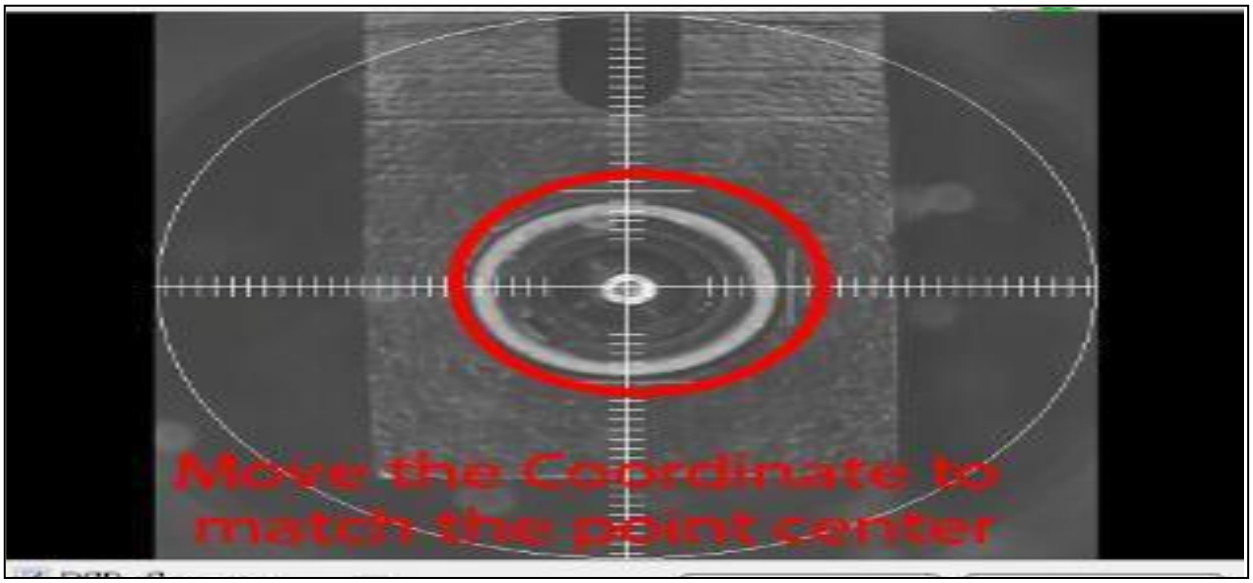
Since the ceramic substrate for calibration of nozzle has small size and is difficult to keep, it is recommended to put it back to

The original place and fasten the ceramic substrate cover after use to prevent from being lost.

3-4 Pin calibrate

Click "set --nozzle -- calibration" to move the coordinates to the position of the center of the pull needle, confirm and save.





Chapter4 operating instructions

Operation process:

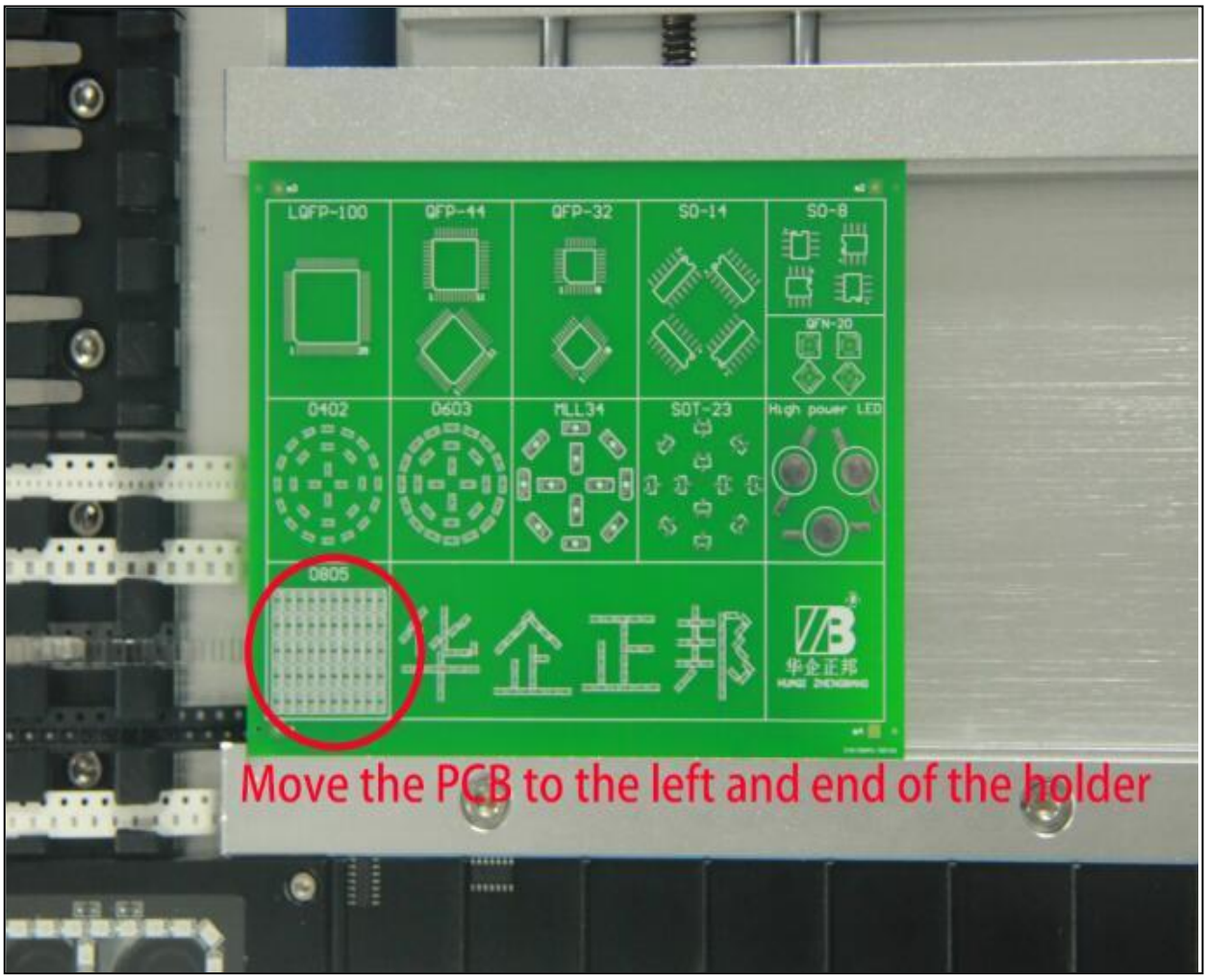
Step 1:	Load materials	Step 2:	Edit the program	Step 3:	Production
NO.1-1	Load PCB	NO.2-1	Output CSV Coordinate File	NO.3-1	Input Procedure
NO.1-2	Load Feeders	NO.2-2	Edit PCB Original Point	NO.3-2	Match Feeder Parameters
NO.1-3	Load Nozzle	NO.2-3	Edit Mark Point	NO.3-3	Production
		NO.2-4	Edit Coordinate File		
		NO.2-5	Edit Feeders		

Step 1：Load materials:

NO.1-1 How to load PCB

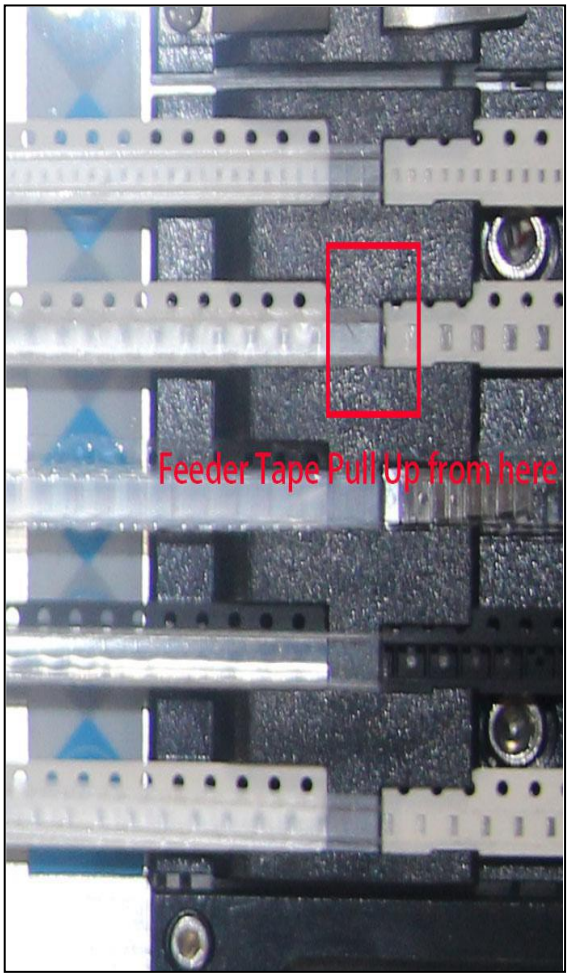
Adjust the bar to let the width less than the PCB's, then let the PCB against the fixed bar and pull back the active to fix the PCB and

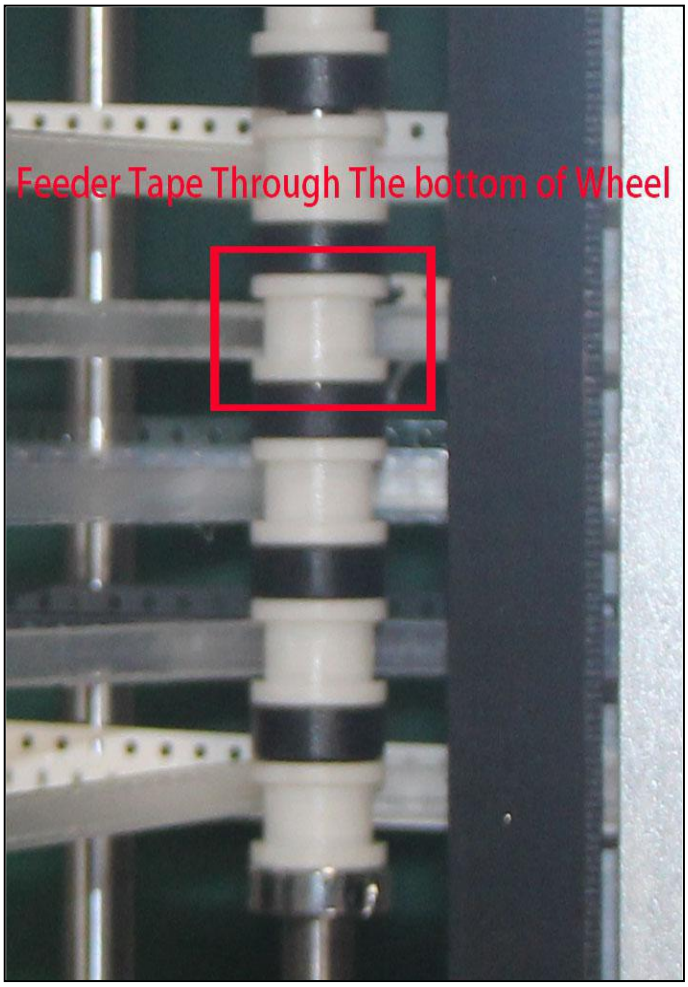
make sure that the PCB is at the left and end of the holder.


LQFP-100
QFP-44
QFP-32
SO-14
SO-8
QFN-20
0402
0603
MLL34
SOT-23
High power LED
0805
华企正邦
Move the PCB to the left and end of the holder

NO.1-2 How to Load feeders

Put the prepared feeder plate on the feeder location, pass the material belt through the polished rod and gets stuck in the material tank, and then peel off about 200mm of feeder tape and press it under the press wheel.





NO.1-3 Load Nozzle

Pick the nozzle and install it to the nozzle base

Step 2：Edit the program:

NO.2-1 Output CSV Coordinate File

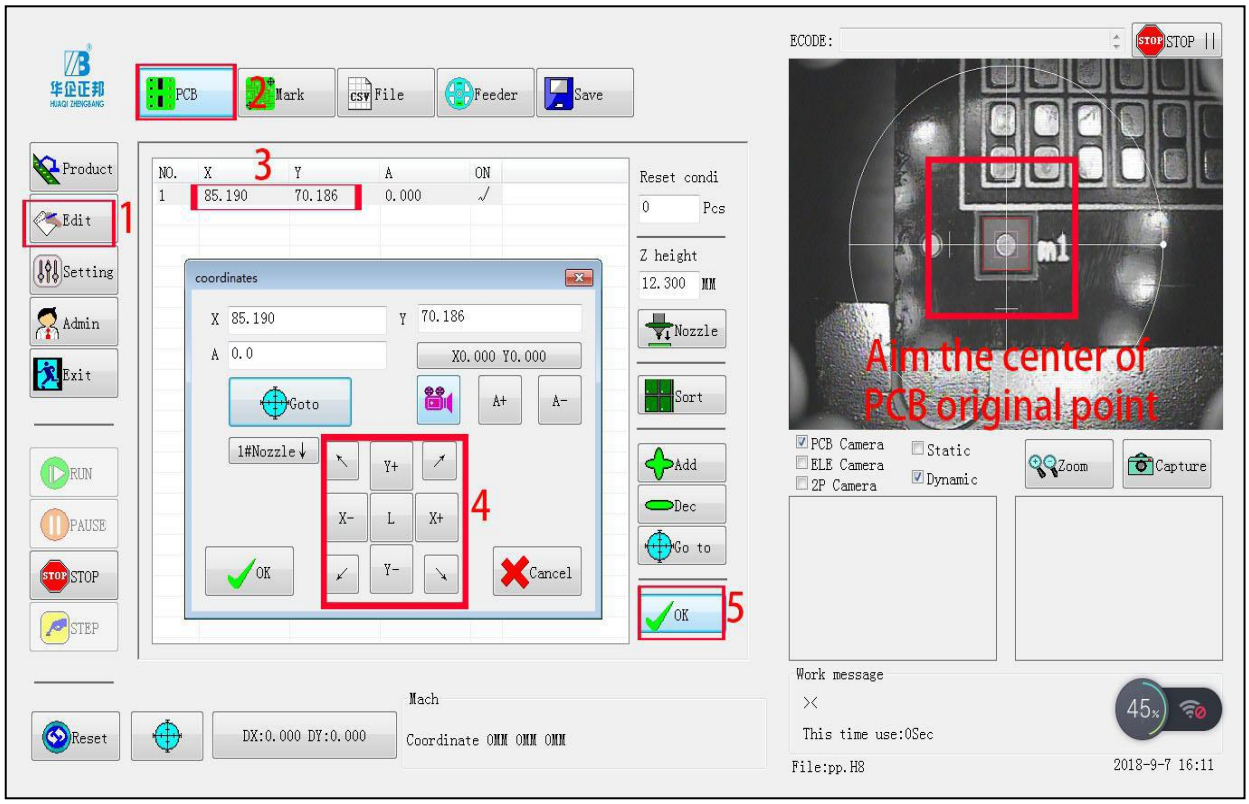
Open the DXP or other PCB design software, open the PCB original file, click “Edit-original Point”, then click “File-assembly Output-Generates Pick And Place Files” (format: CSV Unit: metric system),output CSV coordinate file.

NO.2-2 PCB Original Point Edit

Open the pick and place machine software, click “Edit-PCB”, double click “X/Y” Coordinate bar to find the coordinate edit frame.

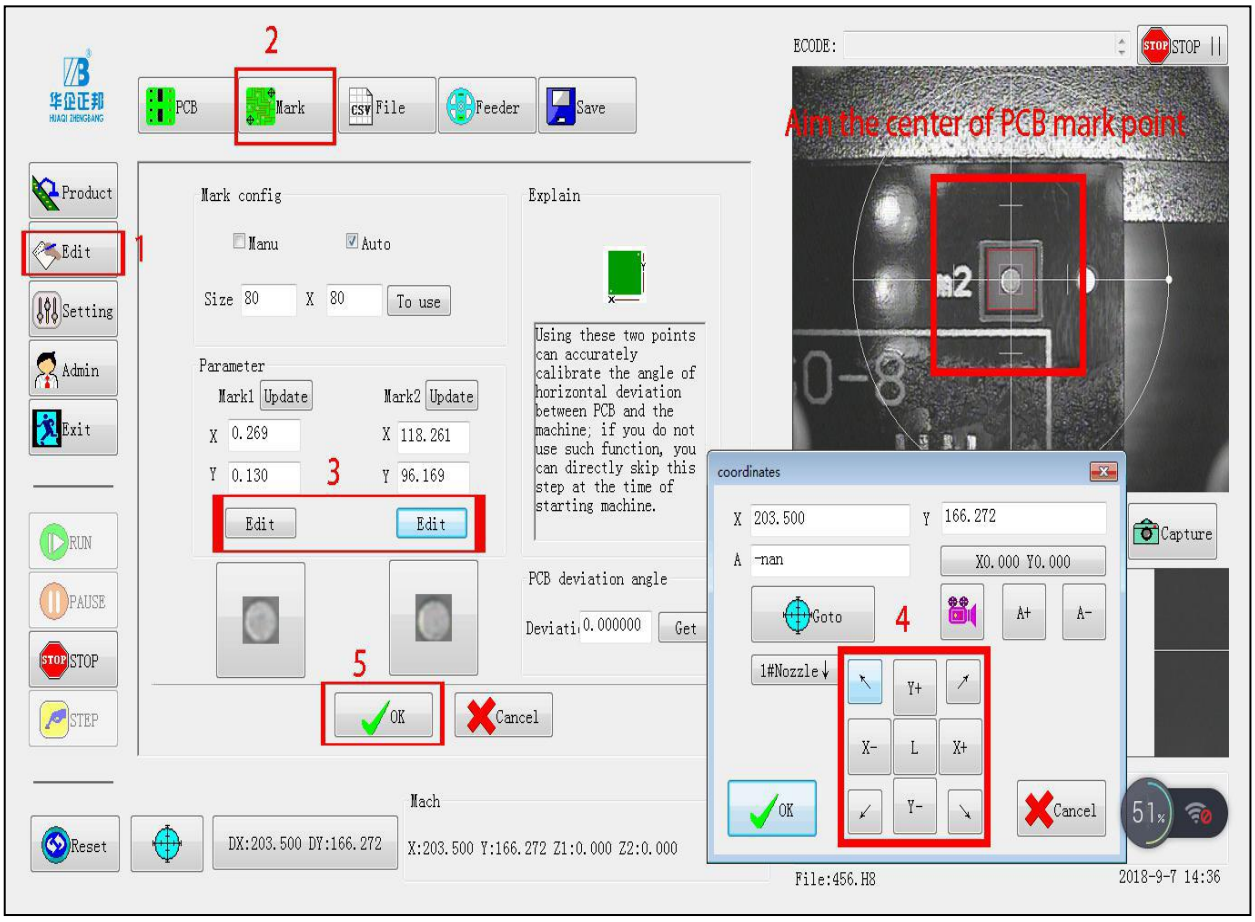
! Attention:

The original point coordinate must be the same as the step NO.2-1 in CSV file.

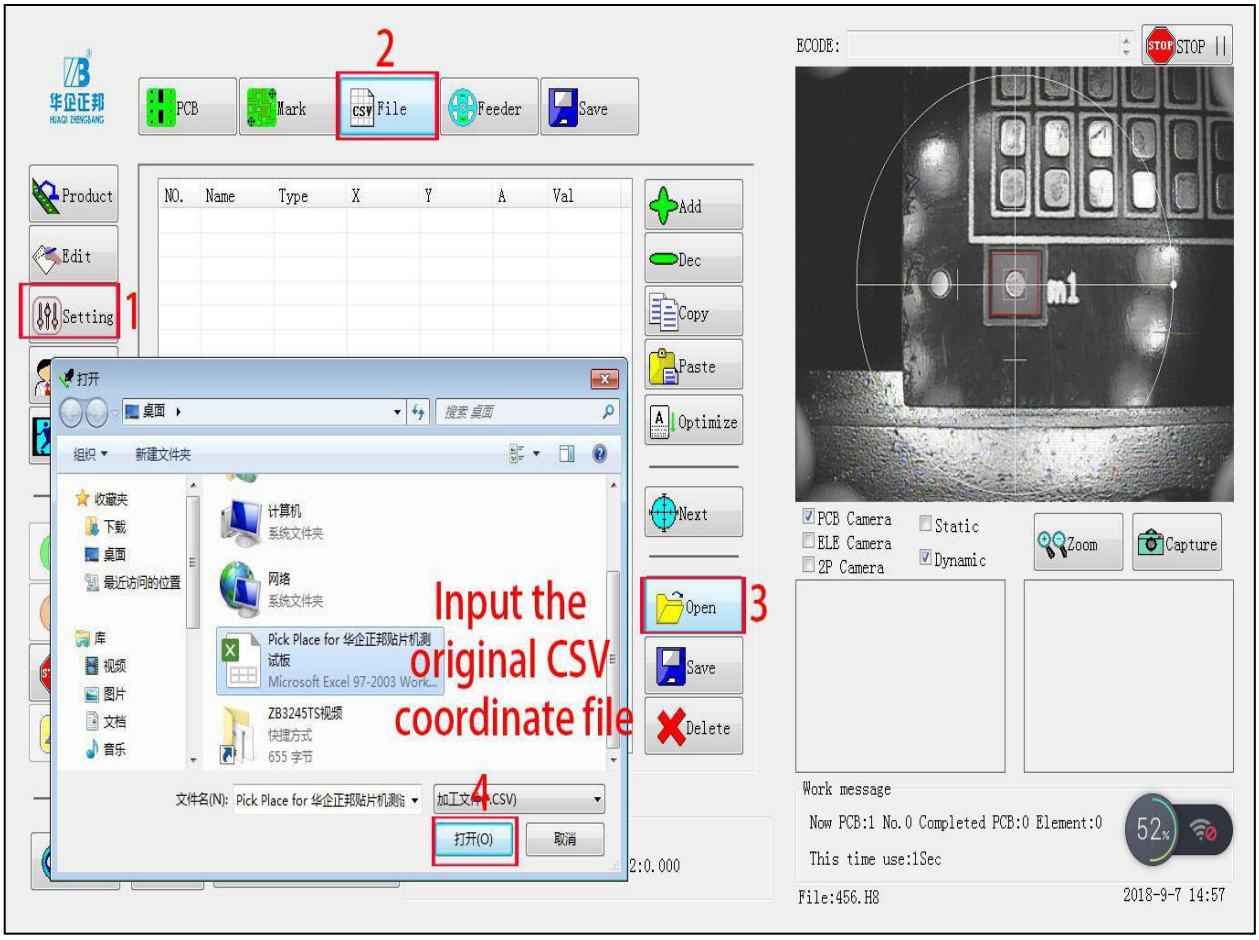


NO. 2-3 MARK Point Edit

Click “Edit-Mark” then click “Mark1/edit” move the coordinate to the PCB mark1 position. Do the same step to edit the mark2 coordinate.



NO.2-4 Coordinate File Edit



Click “Edit-CSV file”, then click “open” to input the NO.2-1 CSV file

Fig.4-7 CSV File

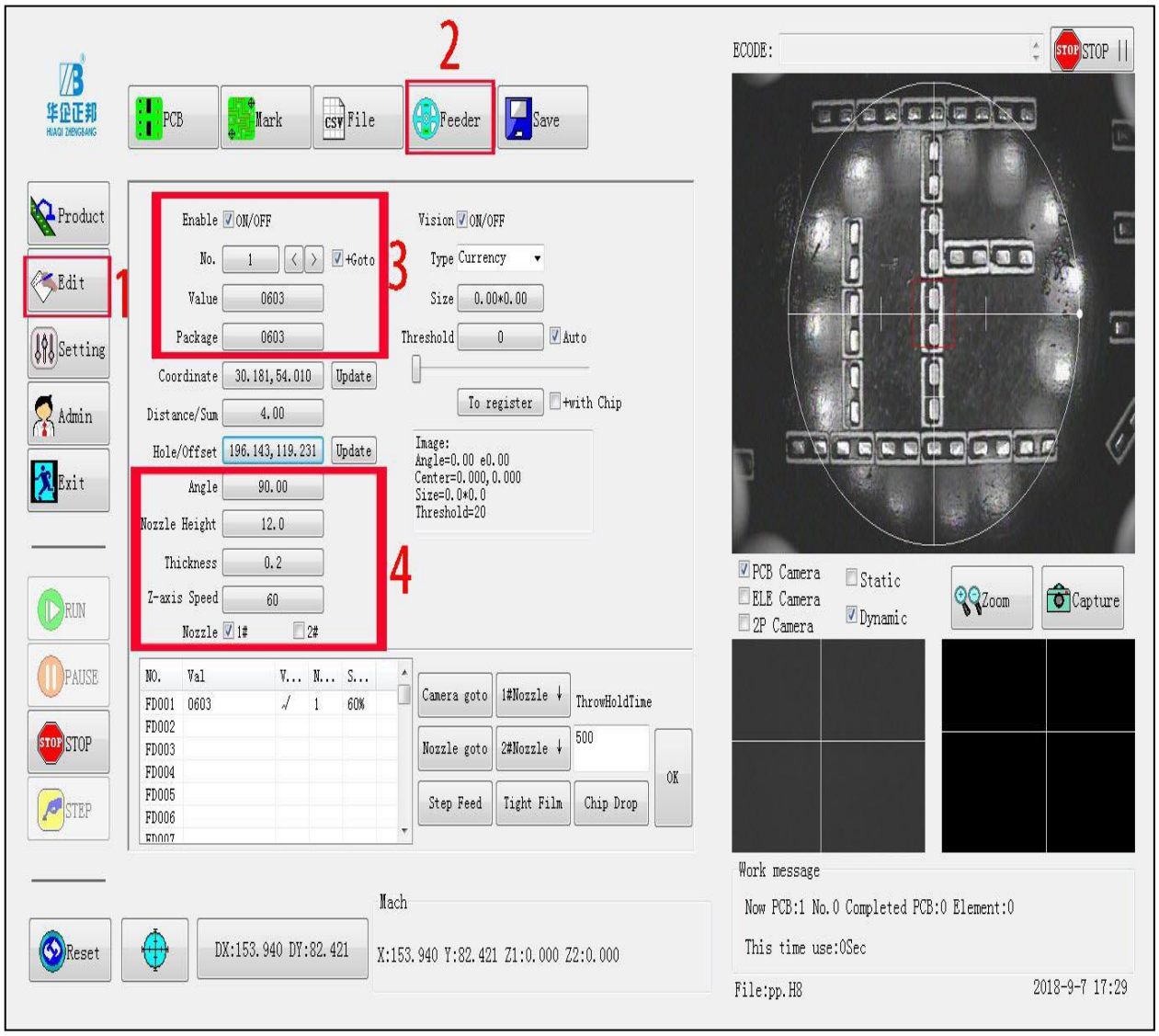
NO.2-5 Feeder Edit

Click “edit-feeder” to log in the feeder edit mode.

Input the feeder no., open the switch Input the component value and type.

! Attention:

The component value and type must be the same as the CSV file (included the capital and small



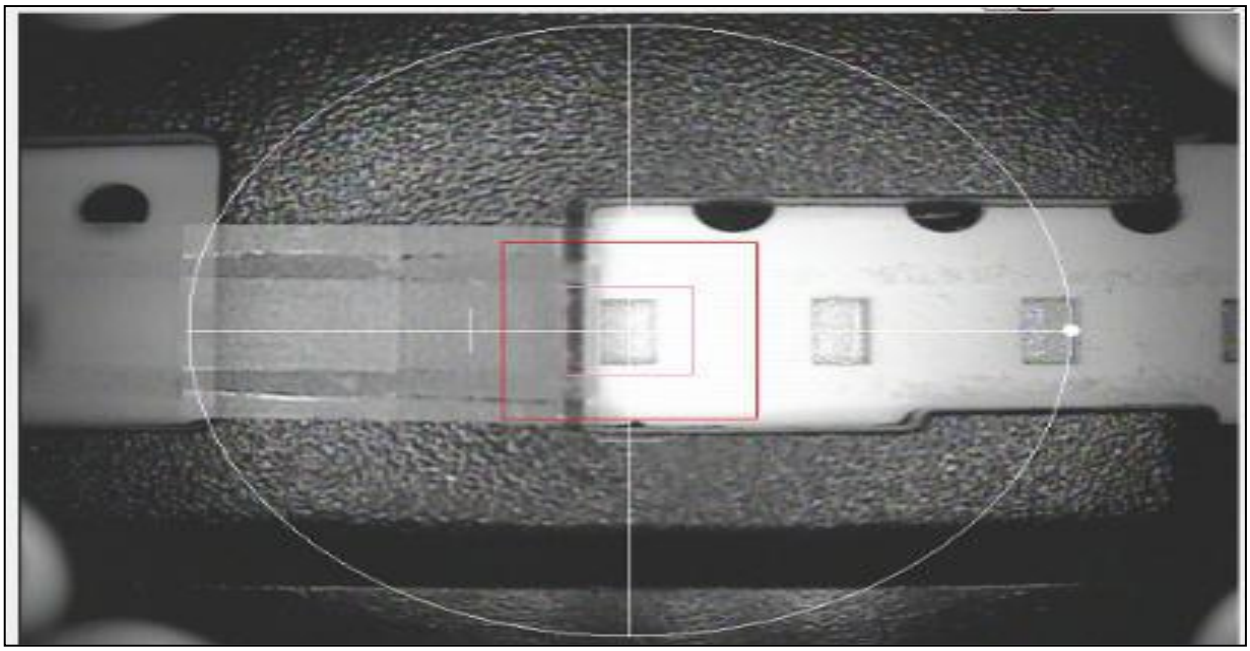
letter).

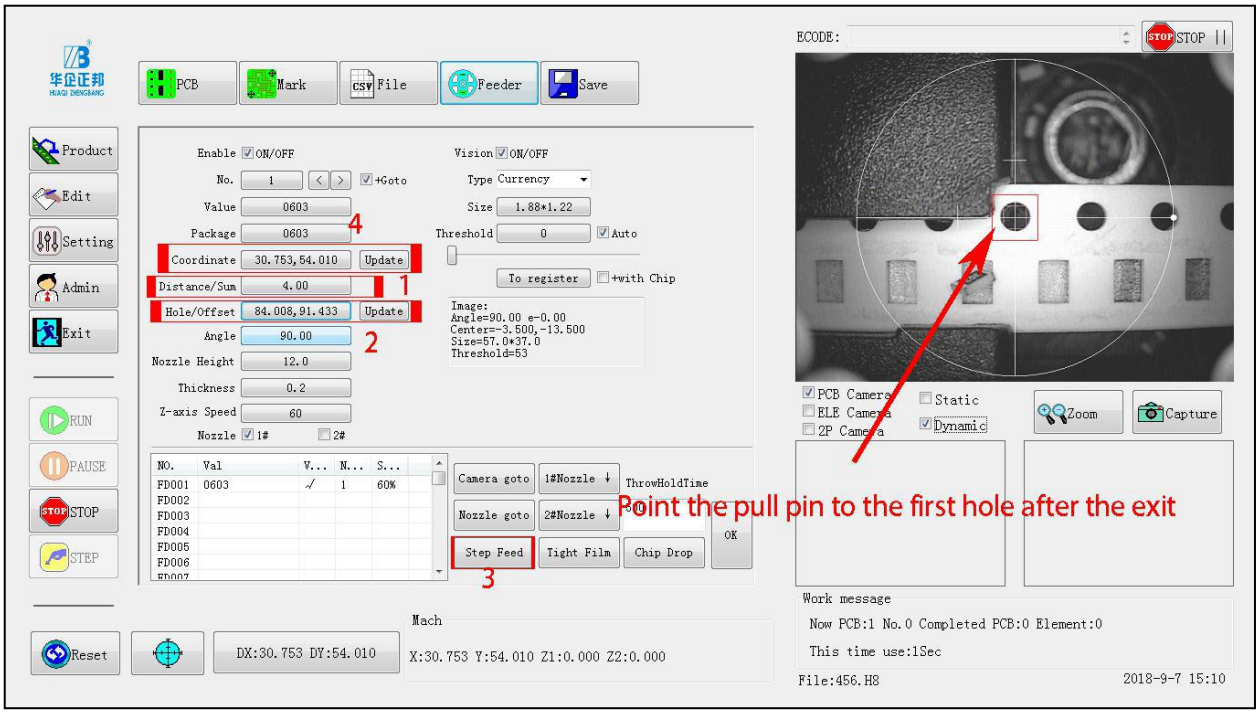
1. Edit the feeder angel, height, components thickness, Z axis speed choose the nozzle.

Fig.4-8 Edit the Feeder Basic Parameters

2. Input the feeder range, click “Step Feeder”

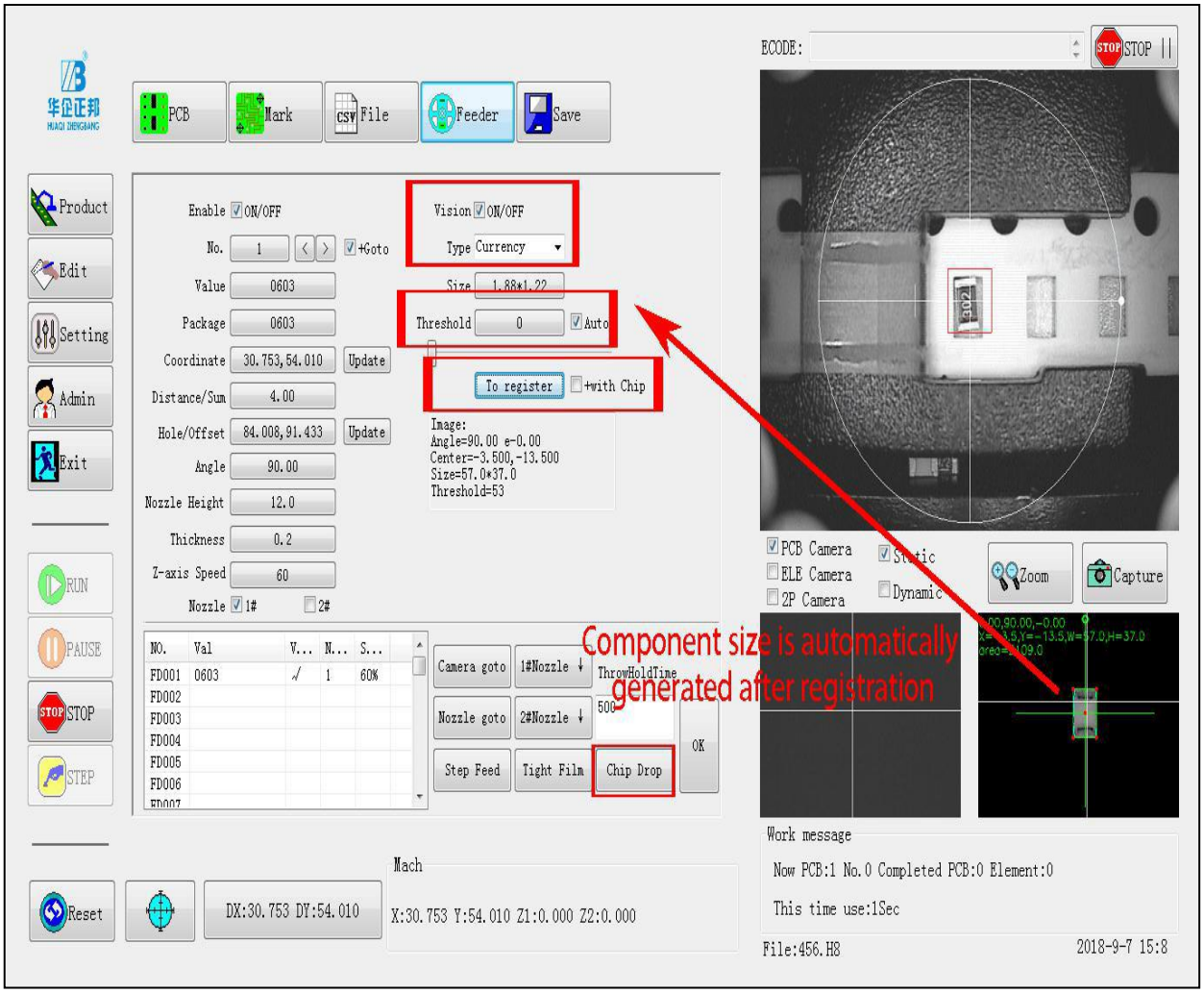
3. Then click “XY Coordinate” to move the coordinate to match the hole of the fist component center as shown in the picture. Calibrate the component pick up coordinate.





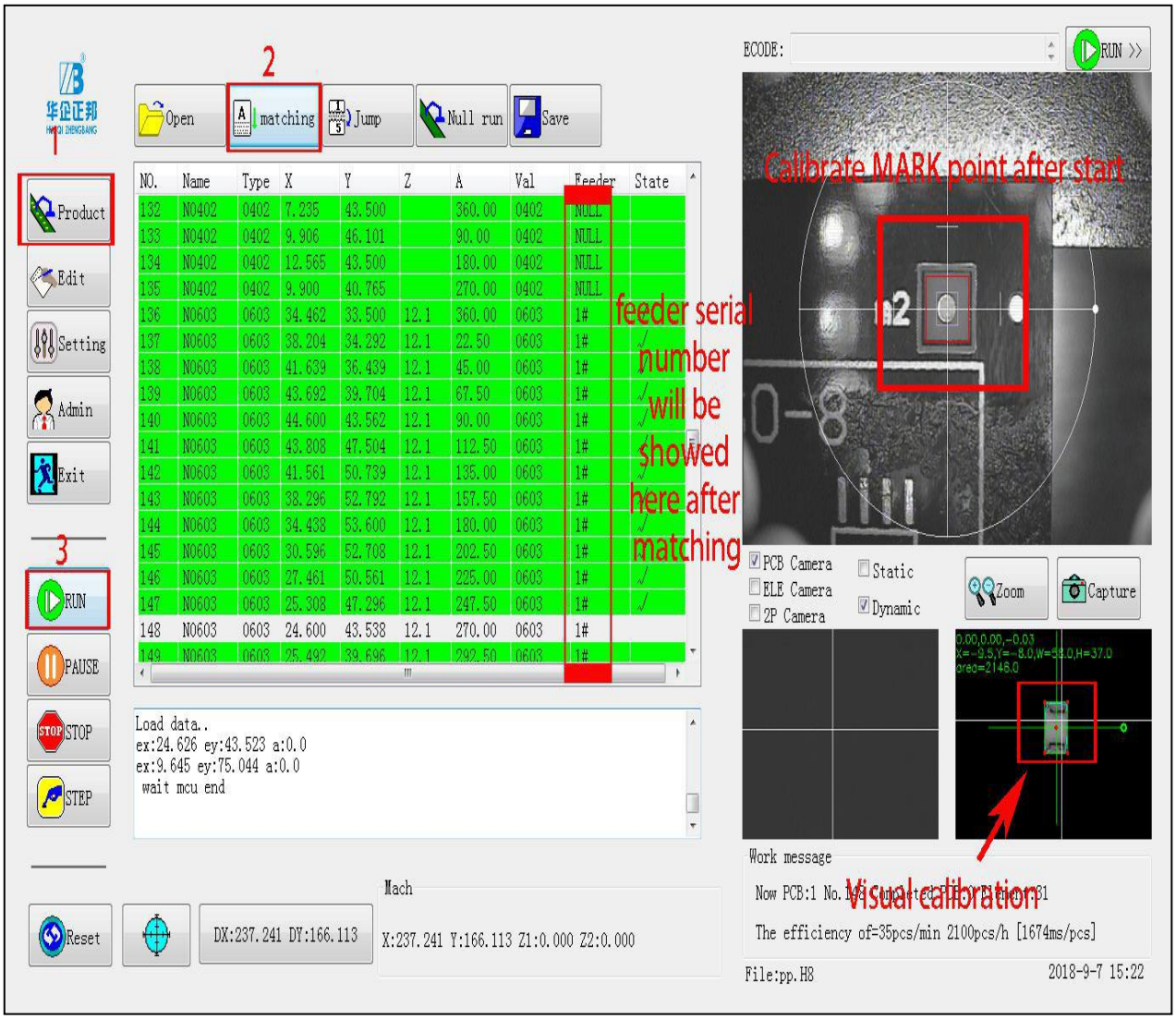
4.Open the visual calibrate switch, choose the component identification Type, √ the right side box of visual threshold to create the threshold automatically, √ the right side box of “register” then click “register” to register the component size, after that please click “throw” to throw the component.

5. Refer to the above steps to edit all feeders, and click "Confirm" to save the data.



Step 3：Production

Click “Product-Open” to input the PCB file, then click “Matching” to find the feeders, then click “Start” to start the production.



Chapter 5 Design of pick and place machine

5-1 pneumatic system components

Main components:

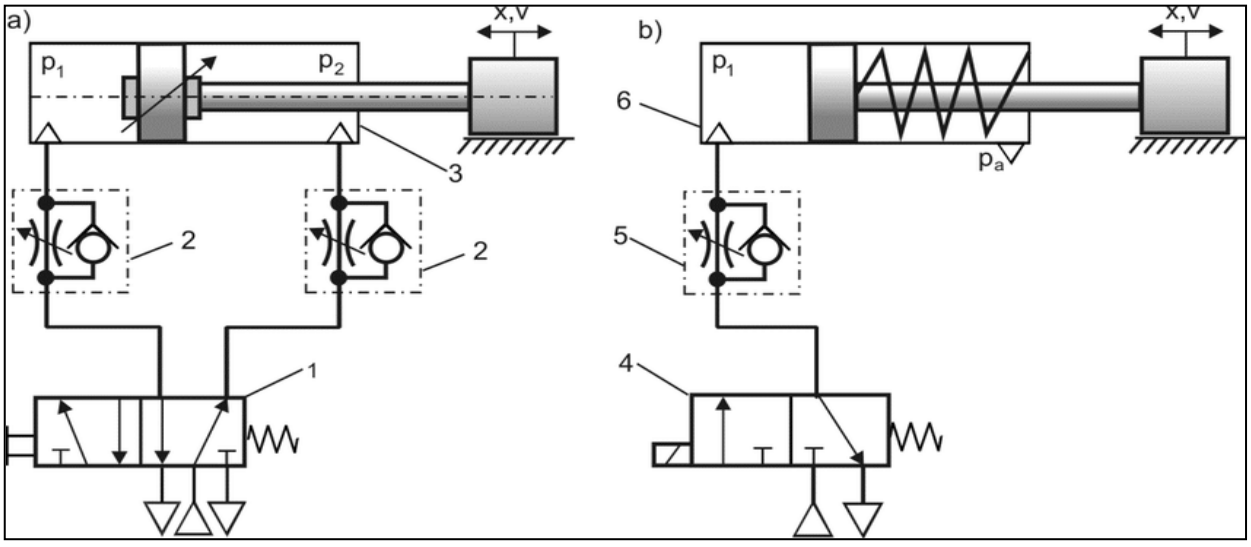
1. Compressors
2. Pistons [linear or rotational]
3. Pneumatic Motors
4. Valves
5. Tanks

Piston Types:

1. Single acting piston
   Load only in one direction
   Used to minimize control unit of Electric Circuit
2. Double acting piston
   Load in both directions (Open and Close).

Piston selection depend on:

1. Inner diameter of cylinder
2. Stroke length
   Example: Festo DNC-50-320



Fitting specification:

Types of Fitting:

1. With Valve (Flow control valve)
2. Without valve

Specification

1. Thread diameter
2. Air Hose diameter

Control Elements:

1. Pressure control valve
2. Flow rate valve
3. Directional control valve

Advantages of Pneumatic systems than Hydraulic:

1. Compressible
2. Easy Maintenance
3. More safe and clean than hydraulic
4. Low cost

Compressor specifications:

1. Max Pressure (6 to 8 bar)
2. Capacity (2 to 5.30 HP)
3. Tank Volume (ex: 500 liter)
4. Dimensions (L*W*H)
5. VolT/HZ (220V/50HZ)
6. Air displacement (60 liter/min)
7. No. of pistons

Compressor calculations:

$P = F / A$

Pressure = 8 Bar = 8 * 10^5 N

Diameter of cylinder = 100 mm

Area = 3.14/4 * D^2

Force = 3310 N = 331 Kg.F

Standard Compressor Force = 3400 N

VOLT/HZ= 220-240 volt/ 50 hz

Air displacement = 23 liter/Min

Motor = 0.2 HP

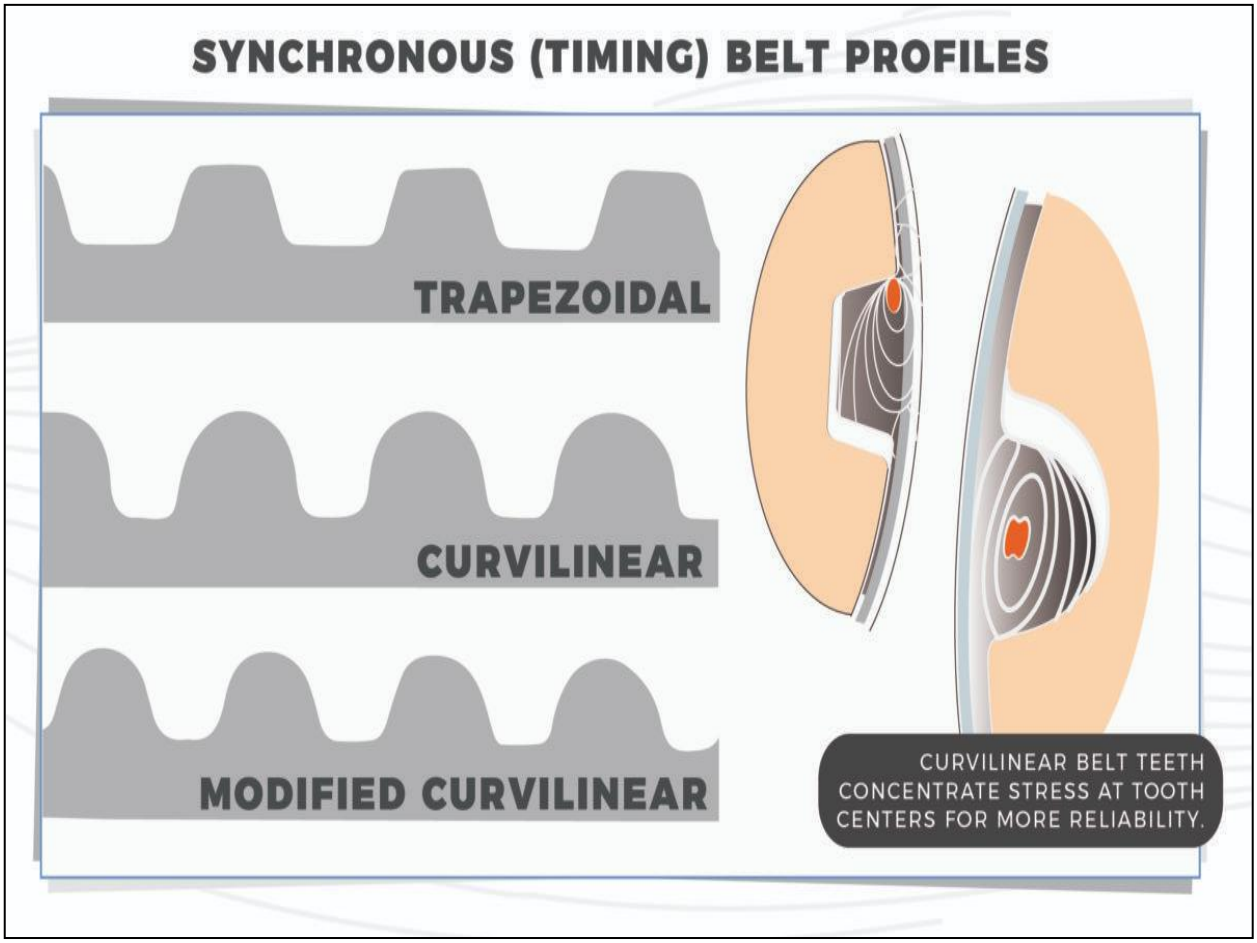
N = 1450 RPM

Model; TC-20 series

5-2 Timming Belt

Tooth profiles:

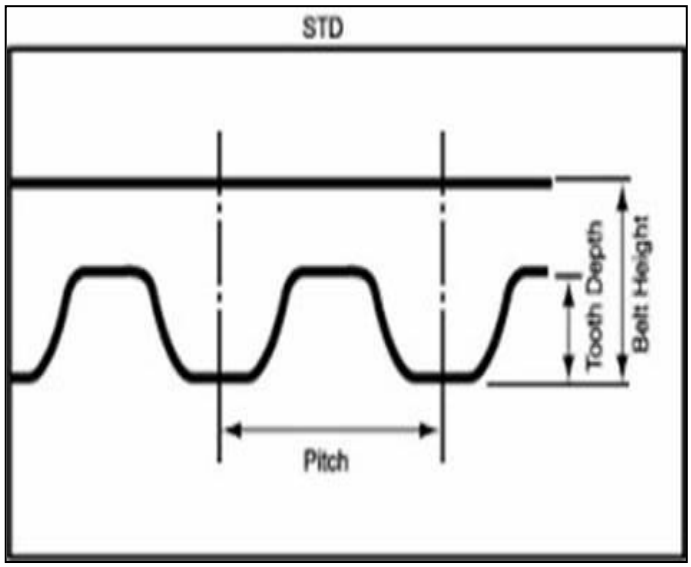
1. Trapezoidal
   - The most widely used in timing belts, especially for linear positioning and conveying applications.
   - Good force transmitting capabilities and low backlash.
   - Lead to High wear rate due to stress concentrations at the belt-pulley interface when the transmitted torque or speed is high.
2. Curvilinear
   - Less stress concentration than Trapezoidal.
   - Higher backlash than trapezoidal profiles.
3. Modified curvilinear



Advantages of Timing Belt:

1. High Accuracy of Transmission.

2. High loads of transmission.
3. Combination of advantages of gears and belts.
4. Flexibility compared with gears.
5. Transmit High Capacities.
6. Reduce loads as weight of belts less than Gears.



Specification According to:

1. Material of Tensile member
2. Pitch
3. Belt width
4. Thickness
5. Profile of tooth
6. No of Grooves

Types of Timing belts:

1. GT

High Accuracy, light loads Machines

Used in 3d printers & pick and place machines.

2. FHT (high Torque Processes)

Reduce Noise

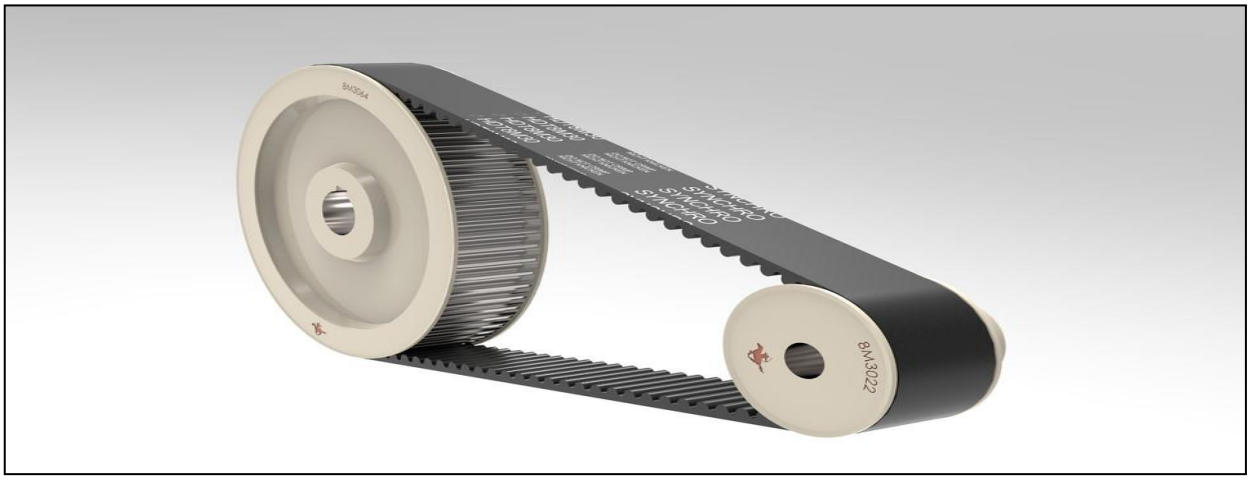
Reduce Vibration

Low backlash

3. HTD – MXL – XL – T

High Torque

NO Accuracy required



5-3 Guideways selection

Types of guideways:

1. **Sideways (with sliding friction)**

Hydrodynamic slideways

Hydrostatic slideways

2. **Anti-friction ways(with rolling friction**)

Roller type (using cylindrical rollers)

Ball type (using spherical balls)

Design considerations of slideways:

1. Material with high wear resistance.
2. Minimum friction and wear by using suitable lubricant.
3. Retaining the lubricant continuously at the interface between the sliding parts.

Materials for slide ways:

1. Cast iron (gray, spheroidal): Coated or Hardened.
2. Low carbon steel (C-20): carburized and quenched.
3. Structural steel (C-40): Induction hardened.
4. Non-ferrous (Bronze and Zn alloys).
5. Plastics.

Types of slide ways:

1. Flat slideway:
   - Easy to manufacture,
   - Require special devices for adjusting clearance.
2. V slideways:
   Difficult to manufacture,
   - Automatic adjustment of clearances,
   - Better accuracy in machining and travel.

3. Dovetail slideways:
   - More difficult than previous types
   - Simple for clearance adjustment
   - Used in vertical columns, carriages and saddles.

4. Cylindrical slideways:
   - Simple to manufacture,
   - Not used usually because of its low rigidity,
   - Used in columns of radial drilling machines

5-3 Selection of Bearing

Selection of Bearing depend on:

1. Inner and outer diameter
2. Bearing width
3. Type of Bearing
4. Loading direction
5. Resulting Torques
6. Forces applied
7. Temperature
8. lubrication

Bearing Types:

1. Radial
   - Deep Grove Ball Bearing
   - Angular contact
2. Axial (Thrust bearing)
3. combined (radial + axial)

Rolling Element Bearings:

Rolling element bearings contain rolling elements in the shape of balls or cylinders. We know that it is easier to roll a wheel than slide it on the ground as the magnitude of rolling friction is lower than sliding friction. The same principle is in work here. Rolling element bearings are used to facilitate the free movement of parts in rotational motion.

Rolling elements carry the load without much friction as the sliding friction is replaced with rolling friction. Rolling element bearings can be subdivided into two major types: ball bearings and roller bearings.

Ball Bearings:

Ball bearings are one of the most common types of bearing classes used. It consists of a row of balls as rolling elements. They are trapped between two annulus shaped metal pieces. These metal pieces are known as races. The inner race is free to rotate while the outer race is stationary.

Ball bearings provide very low friction during rolling but have limited load-carrying capacity. This is because of the small area of contact between the balls and the races. They can support axial loads in two directions besides radial loads.

Ball bearings are used for controlling oscillatory and rotational motion. For example, in electrical motors where the shaft is free to rotate but the motor housing is not, ball bearings are used to connect the shaft to the motor housing.

Advantages of ball bearings:

- Good wear resistance
- Do not need much lubrication
- Provide low friction, thus little energy loss
- Long service life
- Easy to replace
- Small general dimensions
- Comparatively cheap
- Can handle thrust loads

Disadvantages of ball bearings:

- May break due to shocks
- Can be quite loud
- Cannot handle large weights

Deep Groove Ball Bearings:

This is the most widely used ball bearing type. Trapped between the two races is a ring of balls that transmit the load and allows rotational motion between the two races. The balls are held in place by a retainer.

They have very low rolling friction and are optimized for low noise and low vibration. This makes them ideal for high-speed applications.

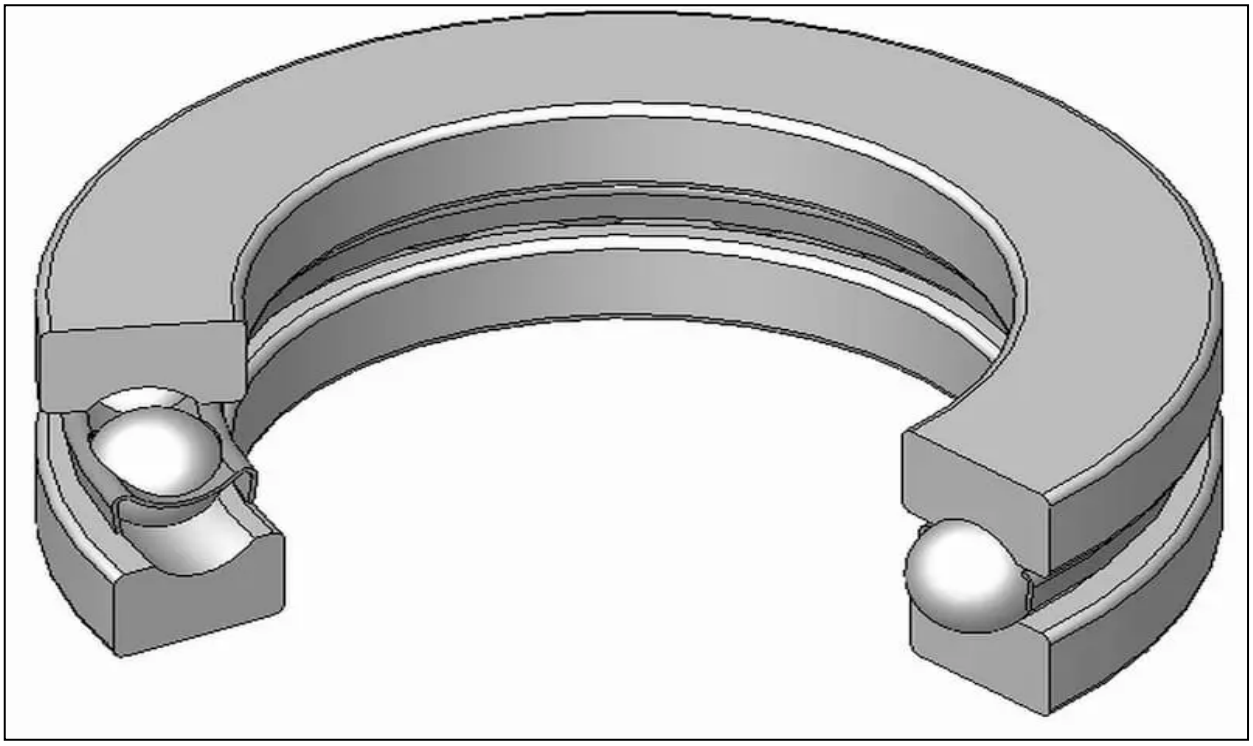
They are comparatively easy to install and require minimal maintenance. Care must be taken during installation to prevent denting of the races as they have to be push fit onto shafts.

Thrust Ball Bearings:

Thrust ball bearings are a special type of ball bearings designed specifically for axial loads. They cannot sustain radial loads at all.

Thrust ball bearings exhibit low noise, smooth operation and are capable of high-speed applications.

They are available as single direction or double direction bearings and the selection relies on whether the load is unidirectional or bidirectional.



Roller Bearings:

Roller bearings contain cylindrical rolling elements instead of balls as load carrying elements between the races. An element is considered a roller if its length is longer than its diameter (even if only slightly). Since they are in line contact with the inner and outer races (instead of point contact as in the case of ball bearings), they can support greater loading.

Advantages of roller bearings:

- Easy maintenance
- Low friction
- Can take high radial loads
- Tapered roller bearings can withstand high axial loads
- Great accuracy
- Used to adjust axial displacement
- Low vibrations

Disadvantages of roller bearings:

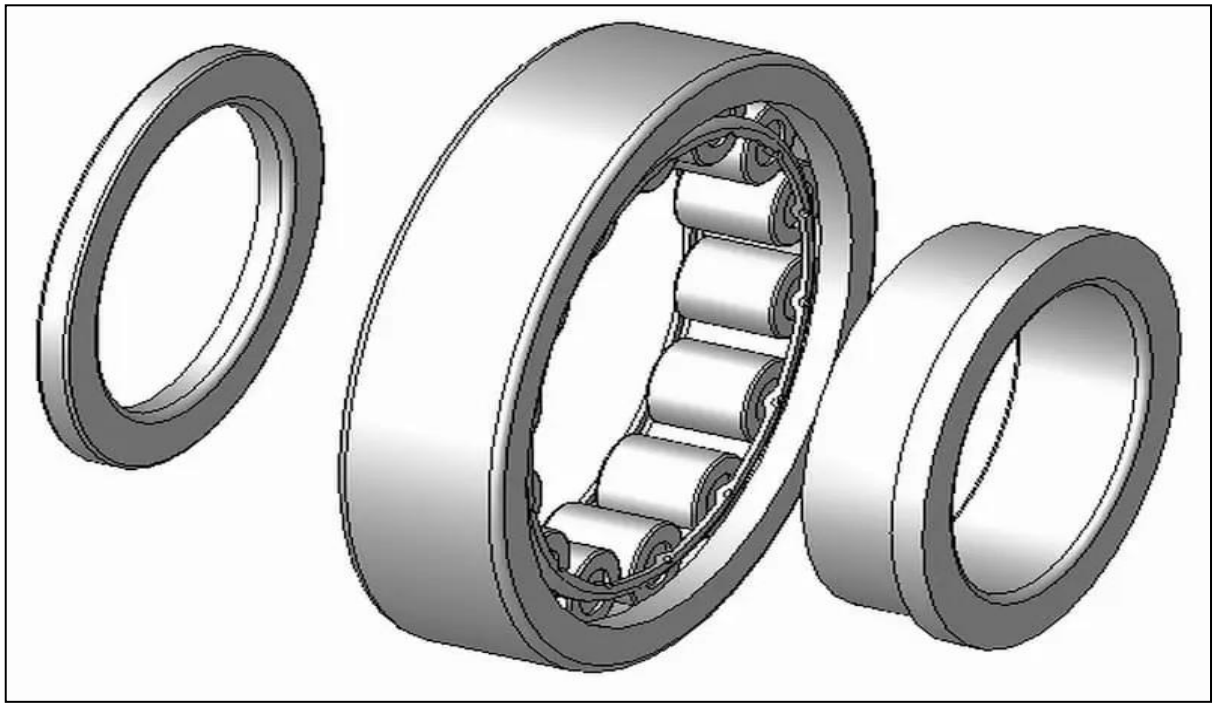
- Noisy
- Quite expensive

Cylindrical Roller Bearings:

These are the simplest of the roller bearings family. These bearings can face the challenges of heavy radial loading and high speed. They also offer excellent stiffness, axial load transmission, low friction, and a long service duration.

The load capacity can be increased further by obviating the use of cages or retainers that are usually in place to hold the cylindrical rollers. This permits the fitting of more rollers to carry the load.

They are available as single row, double row and four-row types. They also come in split and sealed variants.



When to Use Roller Bearings?

Roller bearings are the most common alternative to ball bearings. So, let's determine what kind of working conditions are best suited for this type of bearing.

1. Heavy loads. Roller bearings provide a considerably larger area of contact, distributing the load more evenly. Thus, they are less prone to failure and can withstand high forces.

2. Lower speeds. This, again, comes down to the contact area. There is more friction which can result in higher temperature generation and quicker wear.

5-4 Picker Heads and Vacuum Control:

For picking we use Timming belt drives for vertical movements of two nozzles.

For rotating the components, we decided that the easiest option would be to use a hollow shaft NEMA 9 motor with the nozzle fitted on one end and a Delrin cap fitted over the top end with the vacuum hose attached. This would allow free rotation of the nozzle without leaking air into the vacuum hose.

We decided to use commercial nozzles as making several different sizes to exactly the same length and tolerance. A coupling system was designed using a pair of brass pins held onto the motor shaft with a rubber O-ring. This allows us to quickly pull out a nozzle and replace it with a different size. It also adds a small amount of spring into the nozzle assembly so if it pushes down too far with a component it will not damage the component or lose track of the picker height.

5-5 Component tape feeders and actuators:

We initially went with a simple block of metal with grooves cut into it so the paper could be pulled forwards and the components lifted out with a vacuum pickup. This worked ok but you had to pull the cover off of the tape by hand which had a nasty habit of causing the paper to spring upwards throwing components everywhere. Next we tried making a way of automatically feeding the paper reels but we couldn't come up with a design that would feed them exactly the right distance every time while pulling the plastic tape off by just the right amount.

So, we used 16 commercial feeders for 8mm reels which is the size we use most.

We designed a gantry system for the component feeder which consisted of a pair of stepper motors and a vertical slide. One of the steppers would move the slide across to be above the required component feeder and the second would use a lead screw to push the slide down onto the component feeder activating it and feeding a component forward. As this system worked well on the manual machine, we decided to copy it for the new machine.

We ended up going through three different designs for the feeder mechanism on the automatic machine. The first version was a slimmed down design based on the feeder from our old machine. We use a pair of round rails with slide bearings housed in a block with the vertical motor and slide fitted on the front. This looked like it would work well enough but when we tried driving the stepper motor quickly, we found that the bearings had too much play and would jam causing the stepper motor to lose steps and throwing everything out of alignment

The second version used linear bearings similar to the ones we used on main slides. This had far less play than the cheap Chinese bearings we previously used allowing us to drive the motor

faster and more accurately. This version of the feeder system worked well for the first few hours of use but then we found that the motor on the vertical slide would start to jam and skip steps. It turned out to be a combination of the stepper motor not having enough torque to drive the lead screw properly and the nut on the lead screw wasn't up to the task of taking the load we were putting onto it.

For the third version of the component feeder, we decided to scrap the stepper motor on the vertical slide and replace it with a pneumatic ram which is activated by a solenoid on the head assembly. We had to buy a silent compressor as the cheaper workshop compressors are very noisy and would have annoyed others but this new design appears to be working well and can pick components far quicker than any of our previous designs.

5-6 Tube fed chip feeder system:

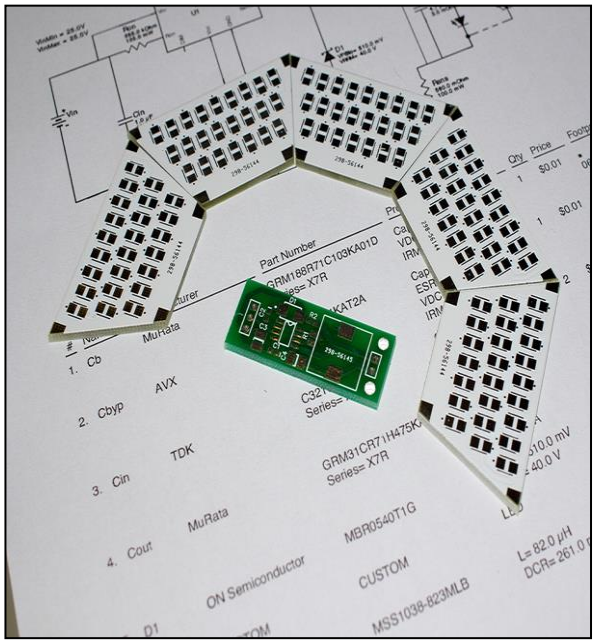
The feeder system for tube supplied chips is a vibration feeder which shakes the chips down the tubes and into a picker location at the base.

The base of the assembly was machined from a section of 30mm sheet and the separate inserts for each chip size from 4mm aluminum sheet. Over this a clamping plate was fitted and this holds a vibration motor. At the rear of the feeder is a threaded bar which uses nuts to clamp each side of the component tubes.

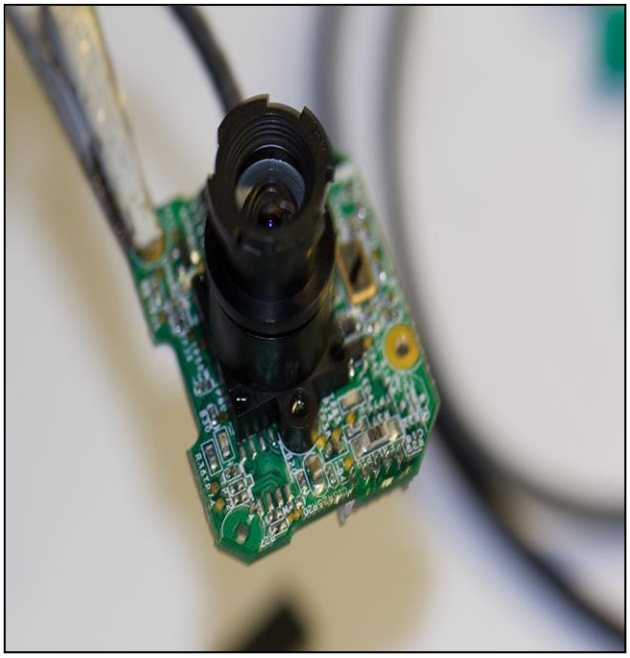
The motor is controlled via the PC software and runs for approx. 750ms each time to feed a new chip into the base ready to be picked and placed.

5-7 Vision system

The vision system compromises of two USB cameras, a base camera with a large LED array which will use OpenCV to detect the component held above and determine if the position and rotation are correct and apply any changes necessary and the head camera will be used to find the location of the PCB and set the offsets. It will also be used for manual placement.



The base LED array has 140 red leds controlled via a custom driver and dimmer board.



Control boards and interfaces:

For controlling the pick and place machine we decided to use a combination of commercial drivers combined with parts which we designed ourselves.

Power is provided through a 15 amp 24V DC Power supply. The NEMA 17 and NEMA 21 motors are driven with commercial stepper drivers which run at 24V while the NEMA 8 motors on the picker head are driven using Pololu A4988 drivers running at 12V. All of the logic circuits run at 5V so we designed a power supply and relay control board which used a pair of PTN78060 DC-DC converters.

For controlling all of the motors and relays we went with a Smooth stepper Ethernet controller. To interface the Smooth stepper with the rest of the machine we designed a breakout board that connected directly on top of the Smooth stepper.

A small PCB was designed for all of the optical stop switches needed on the machine. We designed the PCB so it could be used with slotted or reflective optical switches depending on where they were being used.

5-8 Motor selection

How do motors work?

Electric motors work by converting electrical energy to mechanical energy in order to create motion. Force is generated within the motor through the interaction between **a** magnetic field and winding alternating (AC) or direct (DC) current.

As the strength of a current increases so does the strength of the magnetic field. Keep Ohm's law (V = I*R) in mind; voltage must increase in order to maintain the same current as resistance increases.

Types of motors:

There are many types of **DC motors**, but the most common are brushed or brushless. There are also vibrating motors, stepper motors, and servo motors.

DC brush motors are one of the most simple and are found in many appliances, toys, and automobiles. They use contact brushes that connect with a commutator to alter current direction. They are inexpensive to produce and simple to control and have excellent torque at low speeds (measured in revolutions per minute or RPM). A few downsides are that they require constant maintenance to replace worn out brushes, have limited in speed due to brush heating, and can generate electromagnetic noise from brush arcing.

Brushless DC motors use permanent magnets in their rotor assembly. They are popular in the hobby market for aircraft and ground vehicle applications. They are more efficient, require less maintenance, generate less noise, and have higher power density than brushed DC motors. They can also be mass-produced and resemble an AC motor with a constant RPM, except powered by DC current. There are a few disadvantages however, which include that they are difficult to control without a specialized regulator and they require low starting loads and specialized gearboxes in drive applications causing them to have a higher capital cost, complexity, and environmental limitations.

Stepper motors for precise positioning. They're found in printers, machine tools, and process control systems and are built for high-holding torque that gives the user the ability to move from one step to the next. They have a controller system that designates the position through signal pulses sent to a driver, which interprets them and sends proportional voltage to the motor. They are relatively simple to make and control, but they draw maximum current constantly. Small step distance limits top speed and steps can be skipped at high loads.

Calculations of Motor:

Power = Torque * w = Torque * 2 π N /60

Assume the efficiency in timing belt is .95

Power W.R.T catalog = 230 watt

Power of motor required = 230$watt$ / .95 = 250 power

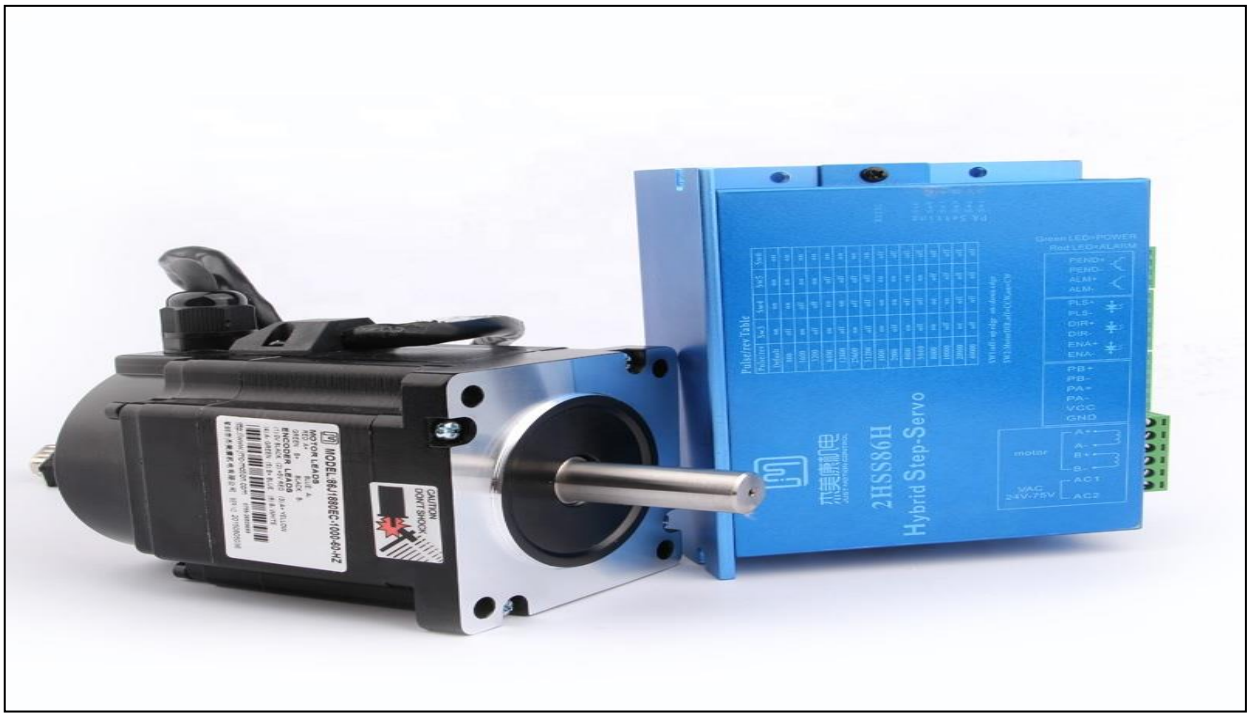
Torque = POWER / W

Torque = 250 / 141.78 = 1.763 N.M

For taking F.O.S = 2

T = 3.526 N.M

The required For providing this torque we need HYCNC 8 nm 12N China factory OEM available 1.8 degree NEMA 34 stepper motor stepping motor controller driver kit with CE.



Chapter 6 Control

24-volt DC power supply

Twenty-four-volt DC power supplies require something more complex than a transformer. There are electrical circuits called "rectifiers" that consist of several parts that can transform AC to DC and adjust the voltage level at the same time. These circuits are built into devices like computers and televisions that need 24 volts of DC but have access to the 120 AC that comes from the wall.

Relay

Relay is an electronic switching device that switches on or off when an external voltage (AC or DC) is applied across its control terminals. It serves the same function as an electromechanical relay, but has no moving parts and therefore results in a longer operational lifetime.

Specification

MY2N MY2P HH52P MY2NJ 220V AC coil 12V 24V high quality general purpose DPDT micro mini relay with socket power relay.

relay

Motors drivers

Motor drivers acts as an interface between the motors and the control circuits. Motor requires high amount of current whereas the controller circuit works on low current signals, So the

function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor.

We use four motors drivers. each driver to a single motor.

Stepper motor driver

Stepper motor driver is an actuator which can transform pulse signal into angular displacement signal, Stepper drivers drive stepper motors to rotate at an angle called step angle in the set direction when receiving a pulse signal. The motor speed is up to the pulse frequency given from the controller, and the displacement is decided on the pulse quantity given from the controller. Stepper system consists of a stepper motor and a stepper driver. Performance of a stepper system is not only up to the motor, but also depends on the stepper driver.

Types of Stepper Motor Driver

1. Digital Stepper Driver

Digital stepper driver is developed with advanced DSP control algorithm based on the latest motion control technology. It is an ideal choice for stepper motor solutions. Its high quality, high-level performance and long service life impress many customers.

2. Integrated Stepper driver

Integrated stepper drivers are drivers can be mounted on stepper motors. The most advantage for integrated stepper motor is space and greater reliability. Currently, STEPPERONLINE offer three type of integrated stepper motor with:

a. Stepper Motor + Stepper Driver
b. Stepper Motor + Stepper Driver + Controller
c. Stepper Motor + Stepper Driver + Encoder

Integrated stepper drivers

3. Closed Loop Stepper Driver

Closed loop stepper drivers work with closed loop stepper motors with an encoder to receive the signal of position. It offers higher peak torque ranges at high speed and greater machine throughput, as well as

quieter operation and less power consumption.

Chapter 7 Sensors

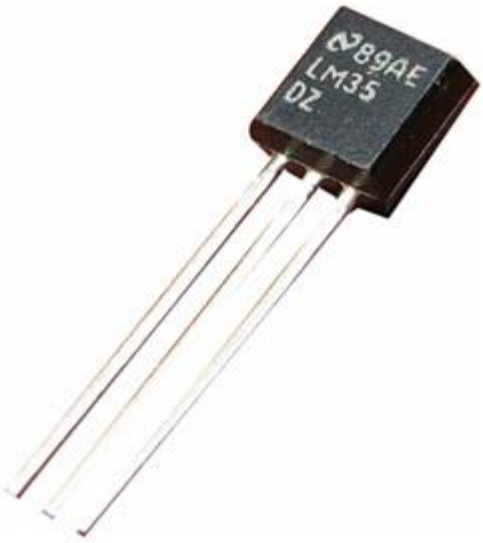
Different types of sensors:

1. Temperature Sensor

2. Proximity Sensor
3. Accelerometer
4. IR Sensor (Infrared Sensor)
5. Pressure Sensor
6. Light Sensor
7. Ultrasonic Sensor
8. Smoke, Gas and Alcohol Sensor
9. Touch Sensor
10. Color Sensor
11. Humidity Sensor
12. Position Sensor
13. Magnetic Sensor (Hall Effect Sensor)
14. Microphone (Sound Sensor)
15. Tilt Sensor
16. Flow and Level Sensor
17. PIR Sensor
18. Touch Sensor
19. Strain and Weight Sensor

Temperature Sensor

One of the most common and most popular sensors is the Temperature Sensor. A Temperature Sensor, as the name suggests, senses the temperature i.e., it measures the changes in the temperature.



LM35 - Temperature Sensor IC

10KΩ NTC Thermistor

There are different types of Temperature Sensors like Temperature Sensor ICs (like LM35, DS18B20), Thermistors, Thermocouples, RTD (Resistive Temperature Devices), etc.

Temperature Sensors can be analog or digital. In an Analog Temperature Sensor, the changes in the Temperature correspond to change in its physical property like resistance or voltage. LM35 is a classic Analog Temperature Sensor.

Coming to the Digital Temperature Sensor, the output is a discrete digital value (usually, some numerical data after converting analog value to digital value). DS18B20 is a simple Digital Temperature Sensor.

Temperature Sensors are used everywhere like computers, mobile phones, automobiles, air conditioning systems, industries etc.

Proximity Sensors

A Proximity Sensor is a non-contact type sensor that detects the presence of an object. Proximity Sensors can be implemented using different techniques like Optical (like Infrared or Laser), Sound (Ultrasonic), Magnetic (Hall Effect), Capacitive, etc.

This can be done using the electromagnetic field or electromagnetic radiation beam in which the

field or return signal changes in the event of the presence of any object in its surrounding. This object sensed by the proximity sensor is termed as a target.

Proximity Sensors are available in models using high-frequency oscillation to detect ferrous and non-ferrous metal objects and in capacitive models to detect non-metal objects. This models are

available with environment resistance, heat resistance, resistance to chemicals, and resistance to water.

Features of the Proximity Sensor

Contactless Sensing

Proximity Sensors detect an object without touching it and therefore, they do not cause abrasion or damage to the object. The devices such as limit switches detect an object by contacting it, but Proximity Sensors are able to detect the presence of the object electrically, without any touch.

Unaffected by Surface Condition

Proximity Sensors detect the physical changes of an object, so they are almost completely unaffected by the object's surface colour.

Suitability for a Wide Range of Applications

Proximity sensors are suitable for damp conditions and wide temperature range usage, unlike your traditional optical detection. They can be used in temperatures ranging from −40 to 200°C.

Longer Service Life

Since a proximity sensor uses semiconductor outputs so there are no moving parts dependent on the operating cycle. Thus, it's service life tends to be longer as compared to traditional sensors!

High-Speed Response

Compared to switches where contact is required for sensing, proximity sensors offer a higher-speed response rate.

Applications:

Used in automation engineering to define operating states in process engineering plants, production systems and automating plants.

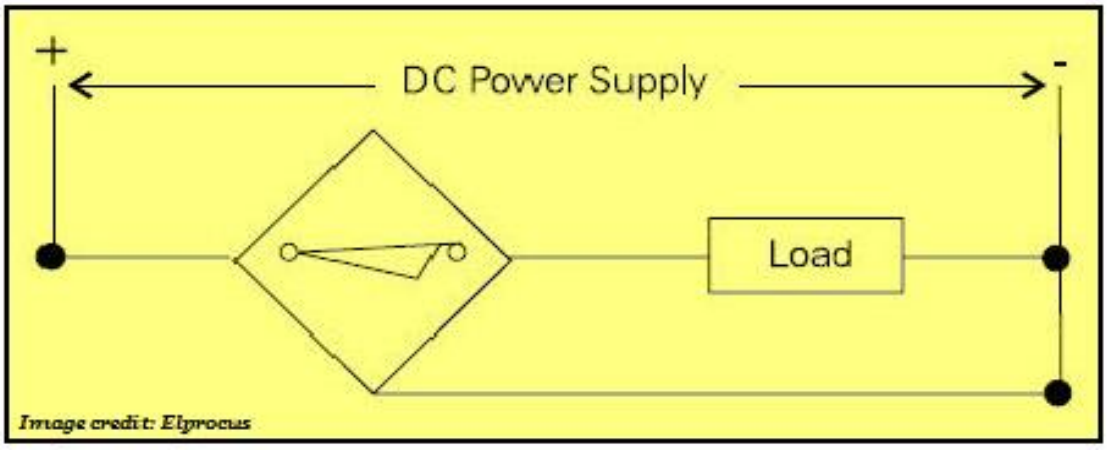
Used in Windows and the alarm is activated when the window open

Used in machine vibration monitoring to calculate the difference in distance between a shaft and its support bearing

How does Proximity Sensor Works?

The proximity sensor circuit wiring is shown in the below figure. Depending on the transistor condition based on the absence of a target, proximity sensor outputs are considered as NC (normally closed) or NO (normally open).

If PNP output is low or off when the target is absent, then we can consider the device as normally opened. Similarly, if the PNP output is high or on when the target is absent, then we



can consider the device as normally closed.

Chapter 8 Maintaining

8-1 Routine Maintenance

1.Check whether the nozzle tip is worn or damaged, and whether the nozzle is blocked or pasted by solder paste, replace or clean it

when necessary.

2.Check if there's any dust or debris on lens of PCB camera and clean with soft cloth if necessary.

3.Check if there's any left components or other things on feeder and clean if necessary.

4.Check if there's any dirt on lens of component camera and clean with soft cloth if necessary.

5.Check if there’s any extra components or other things on table surface and clean with hairbrush if necessary.

5-2 Weekly Scheduled Maintenance

1.Check if there’s any PM or other things on synchronous belt of X-axis and clean if necessary.

2.Check if lubricating grease on slide rail of X-axis is hardened and if there’s any debris on it.

3.Check if there’s any PM or other things on synchronous belt of Y-axis and clean if necessary.

4.Check if lubricating grease on slide rail of Y-axis is hardened and if there’s any debris on it.

5.Check if there’s any debris or leftovers on Z-axis and clean if necessary.

6.Check if there’s any air leakage on pneumatic connector and replace is necessary.

7.Check if there’s any aging or twist on air pipe and replace is necessary.

5-3 Monthly Scheduled Maintenance

1.Check whether the brightness of each LED lamp is enough; if not, the entire LED part should be changed.

2.Check O-ring of each nozzle shaft and replace it immediately after the nozzle shaft aging is found.

3.Check if there’s any looseness on synchronous belt of X-axis and tension it if necessary.

4.Clean dust and leftovers on slide rail of X-axis and coat with new lubricating oil.

5.Check if there’s any looseness on synchronous belt of Y-axis and tension it if necessary.

6.Clean dust and leftovers on pole of X-axis and coat with new lubricating oil.

7.Clean dust and leftovers on slide rail of Z-axis and coat with new lubricating oil.

8.Clean dust and leftovers on PCB clamping guide axis and coat with anti-rust oil.

9.Clean dust and leftovers on air cylinder of pulling needle and coat with new lubricating oil.

10.Check if there’s any looseness on outer silicone ring of nozzle base and replace if necessary.