

The First World Vocational College
Skills Competition
Mechatronics Project

Test Project

Module II

Notice for competitors:

1. The Test Project (“TP”) consists of 46 pages in total. If there is any problem such as missing pages or illegible handwriting in the TP, please promptly indicate them to the judges and have them replaced.
2. There are two programming computers for the competition task, and the reference materials (including the components related to the competition platform, such as mechanical diagrams, electrical diagrams and manuals) are placed under the “D:\References” folder.
3. Teams should complete the content specified in the TP within **three hours**; the program files created by competitors during the Competition must be stored under the “D:\Skill Competition\Competition Number” folder. No points will be given to the operation records or program files that are not stored under the designated folder.
4. Competitors should not write their names or information related to their capacities on the submitted competition paper, or their results will be invalid.
5. Damage to PLC, touch screen, frequency converter, industrial robot controller and I/O components, and servo amplifiers due to incorrect wiring and improper operation will be handled in accordance with the competition rules.
6. In the process of completing the task, please save the program and data in time.

The First World Vocational College Skills Competition

I. Project Name: Mechatronics Project

II. Task Scenario: Assemble, program, and debug a small automated production line

There is a small automatic production line, which needs to be assembled, programmed and debugged according to customer requirements. It includes designing, installing and debugging mechanical components and electrical systems, and could complete equipment control system and human-machine interface programming, and conduct maintenance, repair, system integration and technical improvement of automated production lines.

III. Project Tasks and Timeline: The mechatronics project mainly aims to assess competitors' performance on assembling, programming, and debugging a small automated production line which consists of six units: Particle feeding unit, capping and screw capping unit, detection and sorting unit, industrial robot handling unit, and intelligent storage unit. The Competition lasts for two days, in which, competitors should complete six tasks, and realize the automation of the production process. The cumulative completion time is six hours, and it should be completed by two students and one teacher in a team.

The tasks, content and time allocation of the Mechatronics Project of the World Vocational College Skills Competition are as follows:

Day	Module name	Module content	Completion time	Task type
Day 1	Task A	Mechanical installation and debugging of units	3 hours	Mechanical assembly and debugging
	Task B	Electrical wiring and debugging of units		Electrical wiring
	Task C	Troubleshooting of units		Equipment maintenance
Day 2	Task D	Programming and debugging of units	3 hours	Programming and debugging
	Task E	Programming, debugging and optimization of mechatronics equipment system		Program optimization
Day 1-2	Task F	Professional quality	Whole Process	

Competition equipment description

The competition platform is mainly composed of particle feeding unit, capping and screw capping unit, detection and sorting unit, industrial robot handling unit, and intelligent storage unit. It can realize the whole automatic production process, including empty bottle feeding, particle material feeding, material sorting, particle filling, capping, screw capping, material detecting, bottle cap detecting, finished product sorting, robots handling qualified products into boxes, box cover packaging, labeling and warehousing.

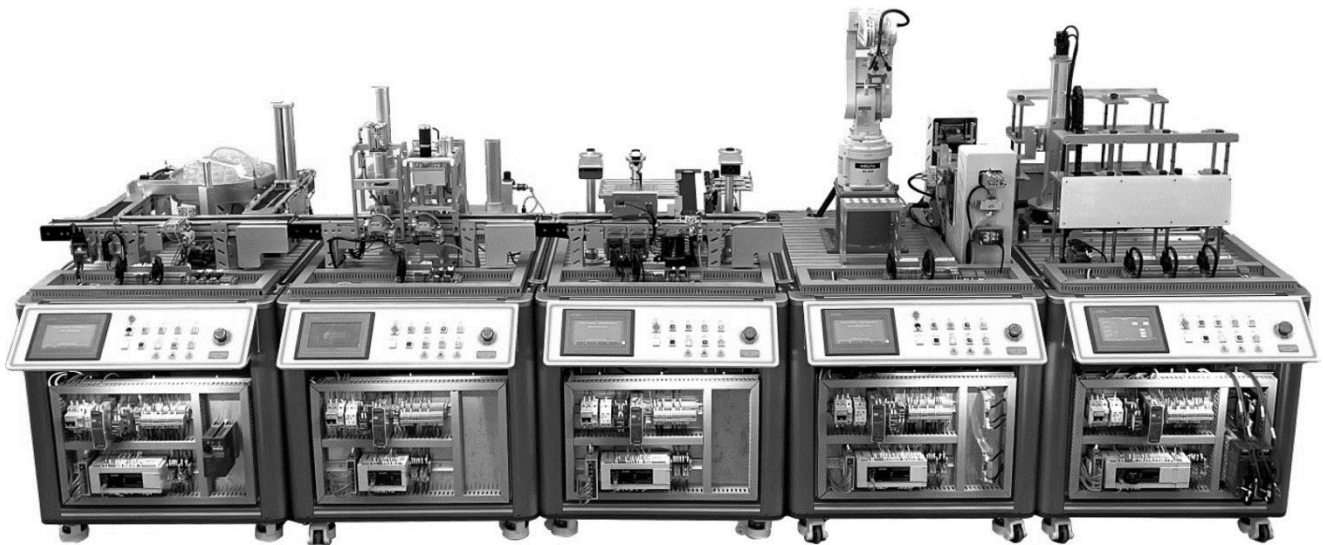


Figure 0-1 Schematic Diagram of Automated Production Line

The working process of this system is outlined as follows:

- i. The disc conveying mechanism of the particle feeding unit conveys the empty bottles to the feeding conveying line. The disc empty bottle limit detection sensor detects the bottles, and the disc conveying mechanism stops. The feeding conveyor belt conveys the empty bottles to the main conveyor belt. When the empty bottles reach the filling position, the filling and positioning mechanism fixes the empty bottles and the main conveyor belt stops; at the same time, the feeding mechanism pushes out the corresponding color materials according to the task requirements; the filling mechanism sucks the particle material in place and puts it into the empty material bottles; after the filling material in the material bottle reaches the set quantity of particles, the filling and positioning cylinder is released; the main conveyor belt starts, and the material bottle is conveyed to the next workstation.

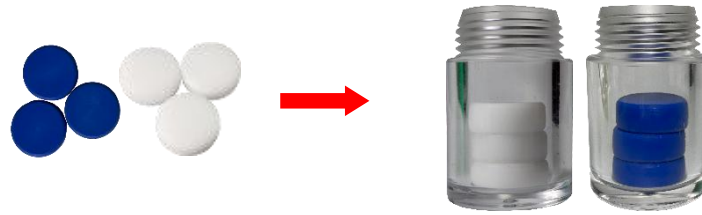


Figure 0-2 Material Bottling

ii. The material bottles are conveyed to the capping mechanism of the capping and screw capping unit, the capping and positioning mechanism fixes the material bottle, and the capping mechanism starts the capping process to add the cap (white or blue) onto the material bottle; the material bottle with the cap continues to be conveyed to the screw capping mechanism; below the screw capping mechanism, the screw capping and positioning mechanism fixes the material bottle, and the screw capping mechanism is activated to tighten the bottle cap.

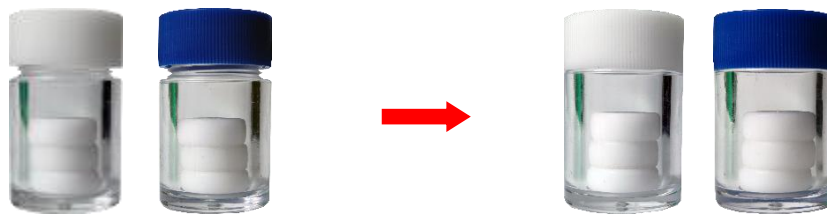


Figure 0-3 Capping and Screw Capping

iii. The bottles whose caps are screwed come to this unit for detection: The feeding detection sensor detects whether the material bottles whose caps are screwed are in place, and the retro-reflection sensor detects whether the bottle caps are tightened; the detection mechanism detects whether the particles inside the bottles meet the requirements; the cap color is judged and distinguished for the bottles with qualified screw capping and particles; the bottles with unqualified screw capping and particles will be pushed by the sorting mechanism to the waste belt for sorting; the bottles with qualified screw capping and particles will be conveyed to the end of the belt, waiting for the robots to handle them.



Qualified Products



Unqualified Products

Figure 0-4 Schematic Diagram of Qualified and Unqualified Products

iv. Industrial robot handling unit: Two lifting platforms A and B store packaging boxes and box covers; Lifting Platform A pushes the packaging boxes to the material table; six-axis robots grab the bottles and puts them into the packaging boxes on the material table; after packing the full bottles of four workstations, the six-axis robots pick up the box covers from Lifting Platform B and cover them on the boxes; the six-axis robots label the boxes at the label position on the box cover according to the color of the bottle caps and wait for the finished product to enter the storehouse after sticking four labels.

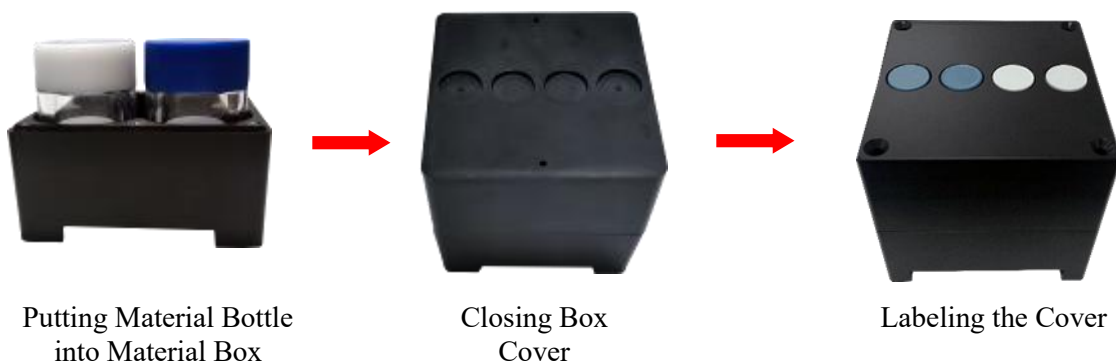


Figure 0-5 Packaging Process

v. Intelligent storage unit: The stacking mechanism takes out the packaging boxes on the material table of the industrial robot handling unit, and then puts them into the corresponding storehouse in sequence according to the requirements. Two 3×3 storehouses are equipped with a detection sensor in each position. The horizontal axis of the stacking mechanism is a precision rotating mechanism, and the vertical mechanism is a turbine screw lifting mechanism, all of which are controlled with high precision by precision servo motors. The travel shaft is driven by a synchronous belt and controlled by a stepper motor.

Task D Programming and debugging of units

Task scenario:

After competitors complete the mechanical assembly and debugging, electrical wiring and troubleshooting of Module 1, teams are now required to complete the PLC programming and robot program writing of particle feeding unit, capping and screw capping unit, detection and sorting unit, industrial robot handling unit, and intelligent storage unit, from empty bottle feeding, particle material feeding, material sorting, particle filling, capping, screw capping, material detecting, bottle cap detecting, finished product sorting, robot handling qualified products into boxes, box cover packaging, labeling to warehousing, so as to ensure correct operation and the system conforms to professional technical specifications. Teams should complete the programming and debugging of the whole production line within the specified time, so that the production process can be automated in the later stage of the production line.

Poin ts	Competition duration	Informatio n
30/1 00	Task D/E (3 hours)	See D drive for details

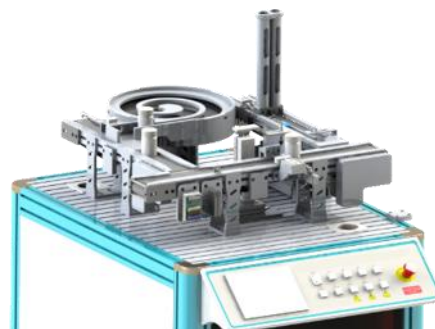
Task I. Programming and debugging of particle feeding unit

1. Task overview

Teams are now required to complete the control program design and debugging of the particle feeding unit, so that the production process can be automated in the later stage of the production line.

Equipment status:

The electrical installation of the hanging panel, the installation and wiring of the countertop module of the working unit have been completed, and the programming and debugging of the unit have not yet been carried out.



Particle feeding unit

2. Task description

Complete the control program and touch screen engineering design of the particle feeding unit and conduct standalone debugging to ensure correct operation, so that the production process can be automated in the later stage of the production line.

When the task is completed, you need to check the following contents:

(1) The mechanical installation, electrical wiring and pneumatic connection of the unit have been completed, and the equipment operates correctly.

(2) Set the parameters of the frequency converter to realize the operation functions of the unit, but the high speed cannot be higher than (50 Hz), and the low speed cannot be lower than (10 Hz).

(3) The operation functions of the unit are in accordance with the requirements.

(4) Design the touch screen according to the monitoring table of monitoring screen data provided in the TP, and use the touch screen of this unit to conduct single-station debugging, including starting, stopping, resetting and single cycle. The configuration screen is shown in Figure C-1, and the indicator light is green when the input information is 1, and remains gray when the input information is 0. When 1 is forced to be output by pressing the button, the indicator light is red, and when 0 is forced to be output by pressing the button, it is gray. A manual/automatic button must be set on the touch screen. Only when the button is pressed and the unit is in the “Standalone” status, the manual forced output control button is valid.

Monitoring Table of Monitoring Screen Data of Particle Feeding Unit

No.	Name	Type	Description of function
1	Suction cup filling limit	Limit indicator light	Filling limit indicator light of suction cup
2	Front limit of Pushing Cylinder A	Limit indicator light	Front limit indicator light of Pushing Cylinder A
3	Front limit of Pushing Cylinder B	Limit indicator light	Front limit indicator light of Pushing Cylinder B
4	Start	Limit indicator light	Start status indicator light
5	Stop	Limit indicator light	Stop status indicator light
6	Reset	Limit indicator light	Reset status indicator light
7	Standalone/online	Limit indicator light	Standalone/online status indicator light
8	Material bottle feeding detection	Limit indicator light	Material bottle feeding detection indicator light
9	Particle filling limit	Limit indicator light	Particle filling limit detection

No.	Name	Type	Description of function
	detection		indicator light
10	Color confirmation A detection	Limit indicator light	Color confirmation A detection indicator light
11	Color confirmation B detection	Limit indicator light	Color confirmation B detection indicator light
12	Barrel A material detection	Limit indicator light	Barrel A material detection indicator light
13	Barrel B material detection	Limit indicator light	Barrel B material detection indicator light
14	Particle limit detection	Limit indicator light	Particle limit detection indicator light
15	Rear limit of filling and positioning cylinder	Limit indicator light	Rear limit indicator light of filling and positioning cylinder
16	Upper limit of filling and lifting cylinder	Limit indicator light	Upper limit indicator light of filling and lifting cylinder
17	Lower limit of filling and lifting cylinder	Limit indicator light	Lower limit indicator light of filling and lifting cylinder
18	Start and stop of feeding tape conveying motor	Standard button	Start and stop manual output of feeding tape conveying motor
19	Start and stop of main tape conveying motor	Standard button	Start and stop manual output of main tape conveying motor
20	Rotating cylinder	Standard button	Solenoid valve manual output of rotating cylinder
21	Lifting cylinder	Standard button	Solenoid valve manual output of lifting cylinder
22	Reclaiming suction cup	Standard button	Solenoid valve manual output of reclaiming suction cup
23	Positioning cylinder	Standard button	Solenoid valve manual output of positioning cylinder
24	Pushing Cylinder A	Standard button	Solenoid valve manual output of Pushing Cylinder A
25	Pushing Cylinder B	Standard button	Solenoid valve manual output of Pushing Cylinder B
26	Inverter motor forward rotating	Standard button	Forward rotating manual output of inverter motor
27	Inverter motor reverse rotating	Standard button	Reverse rotating manual output of inverter motor
28	Inverter motor high speed	Standard button	High speed manual output of inverter motor
29	Inverter motor medium speed	Standard button	Medium speed manual output of inverter motor
30	Inverter motor low	Standard button	Low speed manual output of

No.	Name	Type	Description of function
	speed		inverter motor
31	Manual/automatic	Standard button	When the button is pressed, the unit is in the manual test status, and the manual forced output control button is valid.
32	Single cycle	Standard button	When the button is pressed, the unit performs a single-cycle operation demonstration

Intelligent training platform: Particle feeding unit		GZ-2021 wo
Layout area of input indicator light	Layout area of manual output control	

Figure C-11 Configuration Screen of Particle Feeding Unit

(5) Complete the control program design according to the I/O Allocation Table provided in the TP.

No.	Name	Description of function	Notes
1	X0	The feeding sensor senses the material, and X0 is closed	
2	X1	The particle filling position senses the material, and X1 is closed	
3	X4	It is detected that there is material in Barrel A, and X4 is closed	
4	X5	It is detected that there is material in Barrel B, and X5 is closed	
5	X6	It is detected that there is material at the reclaiming position on the conveyor belt, and X6 is closed	
6	X7	The rear limit of filling and positioning cylinder senses the material, and X7 is closed	
7	X10	Press the start button, and X10 is closed	
8	X11	Press the stop button, and X11 is closed	
9	X12	Press the reset button, and X12 is closed	

No.	Name	Description of function	Notes
10	X13	Press the online button, and X13 is closed	
11	X14	The upper limit of filling and lifting cylinder senses the material, and X14 is closed	
12	X15	The lower limit of filling and lifting cylinder senses the material, and X15 is closed	
13	X20	The filling limit of suction cup senses the material, and X20 is closed	
14	X21	The rear limit of Pushing Cylinder A senses the material, and X21 is closed	
15	X22	The rear limit of Pushing Cylinder B senses the material, and X22 is closed	
16	X23	The left limit of filling rotating cylinder senses the material, and X23 is closed	
17	X24	The right limit of filling rotating cylinder senses the material, and X24 is closed	
18	X25	Disc empty bottle limit detects the material, and X25 is closed	
19	Y0	Y0 is closed and the feeding conveyor belt operates	
20	Y1	Y1 is closed and the main conveyor belt operates	
21	Y2	Y2 is closed and the filling rotating cylinder rotates	
22	Y3	Y3 is closed and the filling and lifting cylinder descends	
23	Y4	Y4 is closed and the suction cup picks up	
24	Y5	Y5 is closed and the positioning cylinder extends out	
25	Y6	Y6 is closed and the Pushing Cylinder A pushes the material	
26	Y7	Y7 is closed and the Pushing Cylinder B pushes the material	
27	Y10	Y10 is closed, and the start indicator light is on	
28	Y11	Y11 is closed, and the stop indicator light is on	
29	Y12	Y12 is closed, and the reset indicator light is on	
30	Y23	Y23 is closed and the inverter motor forward rotates	
31	Y24	Y24 is closed and the inverter motor reversely rotates	
32	Y25	Y25 is closed and the inverter motor operates in high speed	
33	Y26	Y26 is closed and the inverter motor operates in medium speed	
34	Y27	Y27 is closed and the inverter motor operates in low	

No.	Name	Description of function	Notes
		speed	
35	Y30	Y30 is closed, and the disc operates	

Requirements for the process of unit operation function:

(1) Power is on, and the system is in the “stop” status. The “Stop” indicator light is on, and the “Start” and “Reset” indicator lights are off.

(2) In the “Stop” status, press the “Reset” button and the unit resets. During the reset process, the “Reset” indicator light flashes (2 Hz), and all mechanisms return to their original positions. After the reset is completed, the “Reset” indicator light is always on, and the “Start” and “Stop” indicator lights are off. In the “Operate” or “Reset” status, pressing the “Start” button is invalid.

(3) In the “Reset” ready status, press the “Start” button, and the unit starts. The “Start” indicator light is on, and the “Stop” and “Reset” indicator lights are off.

(4) Pushing Cylinder A pushes out three white materials.

(5) The particle feeding mechanism starts high-speed operation, and the frequency converter outputs at a frequency of 50 Hz.

(6) When the white material reaches the reclaiming position, the particle limit detection sensor operates, and the particle feeding mechanism stops.

(7) The filling mechanism descends.

(8) The suction cup turns on to suck the material.

(9) The filling mechanism rises.

(10) The filling mechanism turns to the filling position.

(11) With the start of Step (4), the disc conveying mechanism begins to rotate, and the feeding conveyor belt and the main conveyor belt start simultaneously. When the disc empty bottle limit detection sensor detects the empty bottles, the disc conveying mechanism stops, and the feeding conveyor belt conveys the empty bottles to the main conveyor belt. When the feeding detection sensor senses the empty bottles, the feeding conveyor belt stops.

(12) When the particle filling position detection sensor detects the empty bottles and waits for the empty bottles to reach the filling position, the filling and positioning cylinder extends out to fix the empty bottles.

(13) When Steps (10) and (12) are completed, the filling mechanism descends.

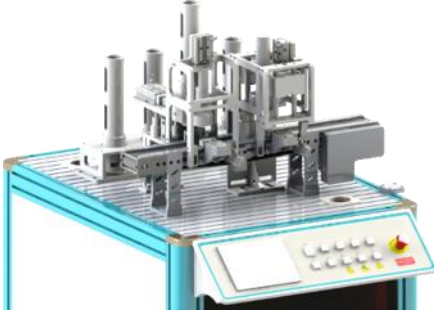
(14) After the filling mechanism descends to the position where the filling limit switch of the suction cup can sense it, the suction cup is closed, and the material is put into the bottle smoothly without any collision.

- (15) The filling mechanism rises.
- (16) The filling mechanism turns to the reclaiming position.
- (17) When the bottle is filled with three pieces of white material.
- (18) The filling and positioning cylinder retracts.
- (19) The bottle is conveyed to the next workstation.
- (20) The cycle goes to Step (6) to fill the next bottle.

(21) In any start and operation status, press the “Stop” button; if the current filling mechanism sucks material, it should stop after completing Step (15), otherwise stop immediately, all mechanisms do not work, “Stop” indicator light is on, and the “Start” and “Reset” indicator lights are off.

Task II. Programming and debugging of capping and screw capping unit

1. Task overview

<p>Teams are now required to complete the control program design and debugging of the capping and screw capping unit, so that the production process can be automated in the later stage of the production line.</p> <p>Equipment status:</p> <p>The electrical installation of the hanging panel, the installation and wiring of the countertop module of the working unit have been completed, and the programming and debugging of the unit have not yet been carried out.</p>	 <p>Capping and screw capping unit</p>
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2. Task description

Complete the control program and touch screen engineering design of the capping and screw capping unit and conduct Standalone debugging to ensure correct operation, so that the production process can be automated in the later stage of the production line.

When the task is completed, you need to check the following contents:

- (1) The mechanical installation, electrical wiring and pneumatic connection of the unit have been completed, and the equipment operates correctly.

(2) The operation functions of the unit are in accordance with the requirements.

(3) Design the touch screen according to the monitoring table of monitoring screen data provided in the TP, and use the touch screen of this unit to conduct single-station debugging operation, including starting, stopping, resetting and single cycle. The configuration screen is shown in Figure C-2. Requirements for the screen color assignment and “manual/automatic button” of the touch screen are the same as those for configuration screen of the particle feeding unit.

Monitoring Table of Monitoring Screen Data of Capping and Screw Capping Unit

No.	Name	Type	Description of function
1	Start	Limit indicator light	Start status indicator light
2	Stop	Limit indicator light	Stop status indicator light
3	Reset	Limit indicator light	Reset status indicator light
4	Standalone/online	Limit indicator light	Standalone/online status indicator light
5	Bottle cap barrel detection	Limit indicator light	Bottle cap barrel detection indicator light
6	Capping limit detection	Limit indicator light	Capping limit detection indicator light
7	Screw capping limit detection	Limit indicator light	Screw capping limit detection indicator light
8	Front limit of capping telescopic cylinder	Limit indicator light	Front limit indicator light of capping telescopic cylinder
9	Rear limit of capping telescopic cylinder	Limit indicator light	Rear limit indicator light of capping telescopic cylinder
10	Upper limit of capping and lifting cylinder	Limit indicator light	Upper limit indicator light of capping and lifting cylinder
11	Lower limit of capping and lifting cylinder	Limit indicator light	Lower limit indicator light of capping and lifting cylinder
12	Rear limit of capping and positioning cylinder	Limit indicator light	Rear limit indicator light of capping and positioning cylinder
13	Upper limit of screw capping and lifting cylinder	Limit indicator light	Upper limit indicator light of screw capping and lifting cylinder
14	Rear limit of screw capping and lifting cylinder	Limit indicator light	Rear limit indicator light of screw capping and lifting cylinder
15	Upper limit of	Limit indicator	Upper limit indicator light of capping and

No.	Name	Type	Description of function
	lifting base	light	lifting base cylinder
16	Tape conveying motor start and stop	Standard button	Start and stop control output of tape conveying motor
17	Screw capping motor start and stop	Standard button	Start and stop control output of screw capping motor
18	Capping telescopic cylinder	Standard button	Solenoid valve output of capping telescopic cylinder
19	Capping and lifting cylinder	Standard button	Solenoid valve output of capping and lifting cylinder
20	Capping and positioning cylinder	Standard button	Solenoid valve output of capping and positioning cylinder
21	Screw capping and lifting cylinder	Standard button	Solenoid valve output of screw capping and lifting cylinder
22	Screw capping and positioning cylinder	Standard button	Solenoid valve output of screw capping and positioning cylinder
23	Lifting base cylinder	Standard button	Solenoid valve output of capping and lifting base cylinder
24	Lifting suction cup	Standard button	Solenoid valve output of capping and lifting suction cup
25	Manual/automatic	Standard button	When the button is pressed, the unit is in the manual test status, and the manual forced output control button is valid.
26	Single cycle	Standard button	When the button is pressed, the unit performs a single-cycle operation demonstration

Intelligent training platform: Capping and screw capping unit		GZ-2021 wo
Layout area of input indicator light	Layout area of manual output control	

Figure C-2 Configuration Screen of Capping and Screw Capping Unit

(4) Complete the control program design according to the I/O Allocation Table provided in the TP.

No.	Name	Description of function	Notes
1	X0	The bottle cap barrel senses the bottle cap, and X0 is closed	
2	X1	The capping limit sensor senses the material, and X1 is closed	
3	X2	The screw capping limit sensor senses the material, and X2 is closed	
4	X3	The front limit of the capping telescopic cylinder extends out, and X3 is closed	
5	X4	The rear limit of the capping telescopic cylinder retracts, and X4 is closed	
6	X5	The upper limit of capping and lifting cylinder senses the material, and X5 is closed	
7	X6	The lower limit of capping and lifting cylinder senses the material, and X6 is closed	
8	X7	The rear limit of capping and positioning cylinder senses the material, and X7 is closed	
9	X10	Press the start button, and X10 is closed	
10	X11	Press the stop button, and X11 is closed	
11	X12	Press the reset button, and X12 is closed	
12	X13	Press the online button, and X13 is closed	
13	X14	The upper limit of screw capping and lifting cylinder senses the material, and X14 is closed	
14	X15	The rear limit of screw capping and lifting cylinder senses the material, and X15 is closed	
15	X16	The upper limit of capping and lifting base senses the material, and X16 is closed	
16	Y0	Y0 is closed, and the main conveyor belt operates	
17	Y1	Y1 is closed, and the screw capping motor operates	
18	Y2	Y2 is closed, and the capping telescopic cylinder extends out	
19	Y3	Y3 is closed, and the capping and lifting cylinder descends	

No.	Name	Description of function	Notes
20	Y4	Y4 is closed, and the capping and positioning cylinder extends out	
21	Y5	Y5 is closed, and the screw capping and lifting cylinder descends	
22	Y6	Y6 is closed, and the screw capping and positioning cylinder extends out	
23	Y7	Y7 is closed, and the lifting base cylinder descends	
24	Y10	Y10 is closed, and the start indicator light is on	
25	Y11	Y11 is closed, and the stop indicator light is on	
26	Y12	Y12 is closed, and the reset indicator light is on	
27	Y13	Y13 is closed, and the lifting suction cup sucks	

Requirements for the process of unit operation function:

- (1) Power is on, and if any part of the equipment is not in the initial position, the system will reset automatically;
- (2) or when the system is in the stop status, press the “Reset” button and the system will automatically reset. Pressing this button in other operating statuses is invalid;
- (3) “Reset” light (yellow light, the same below) flashes;
- (4) “Stop” light (red light, the same below) is off;
- (5) “Start” light (green light, the same below) is off;
- (6) All parts return to their original positions;
- (7) The “Reset” light is always on, and the system enters the ready status.

Unit start control:

- (8) Press the start button when the system in the ready status; the unit enters the operate status, but pressing this button in the stop status is invalid;
- (9) “Start” indicator light is on;
- (10) “Reset” indicator light is off;
- (11) The main conveyor belt starts operating;
- (12) Manually place the material bottle without a cap at the beginning of the unit;

(13) When the capping limit detection sensor detects there is a material bottle and waits for the material bottle to be conveyed below the capping workstation, the conveyor belt stops;

(14) The capping and positioning cylinder extends out to accurately fix the material bottle;

(15) If there is no bottle cap in the capping mechanism, that is, the bottle cap barrel detection sensor does not operate, the capping mechanism does not operate;

① After the cap is manually put in, the bottle cap barrel detection sensor senses the bottle cap;

② The bottle cap barrel detection sensor operates;

③ The capping mechanism starts to operate, and continues with Step (9);

(16) If there is a bottle cap in the capping mechanism, the bottle cap barrel detection sensor operates, and the lifting base descends; the capping telescopic cylinder extends out, and the bottle cap is pushed to the blanking port;

(17) The capping and lifting cylinder extends out and the bottle cap is pressed down;

(18) The bottle cap falls on the material bottle accurately without deviation;

(19) Capping telescopic cylinder retracts;

(20) The lifting base rises;

(21) Capping and lifting cylinder retracts;

(22) Capping and positioning cylinder retracts;

(23) The main conveyor belt starts;

(24) When the capping limit detection sensor detects a material bottle and waits for the material bottle to operate below the capping workstation, the conveyor belt stops;

(25) The screw capping and positioning cylinder extends out to accurately fix the material bottle;

(26) The screw capping motor starts to rotate;

(27) Screw capping and lifting cylinder descends;

(28) The cap is fully tightened;

(29) The screw capping motor stops operating;

(30) Screw capping and lifting cylinder retracts;

(31) The screw capping and positioning cylinder retracts;

(32) The main conveyor belt starts;

(33) When the material bottle is conveyed to the end of the main conveyor belt, the material bottle is manually removed. Repeat Steps (5) to (25) until four material bottles and four bottle caps are used up. In each cycle, if any step is wrong, the step will not be scored.

Unit stop control:

(1) When the system is in the operation status and the “Stop” button is pressed, the unit will stop immediately, and all mechanisms will not work;

(2) The “Stop” indicator light is on; the “Operate” indicator light is off.

Task III. Programming and debugging of detection and sorting unit

1. Task overview

Teams are now required to complete the control program design and debugging of the detection and sorting unit, so that the production process can be automated in the later stage of the production line.

Equipment status:

The electrical installation of the hanging panel, the installation and wiring of the countertop module of the working unit have been completed, and the programming and debugging of the unit have not yet been carried out.



Detection and sorting unit

2. Task description

Complete the control program and touch screen engineering design of the detection and sorting unit and conduct Standalone debugging to ensure the correct operation, so that the production process can be automated in the later stage of the production line.

When the task is completed, you need to check the following contents:

(1) The mechanical installation, electrical wiring and pneumatic connection of the unit have been completed, and the equipment operates correctly.

(2) The operation functions of the unit are in accordance with the requirements.

(3) Design the touch screen according to the monitoring table of monitoring screen data provided in the TP, and use the touch screen of this unit to conduct single-station debugging operation, including starting, stopping, resetting and single cycle. The configuration screen is shown in Figure C - 3. Requirements for the screen color assignment and “manual/automatic button” of the touch screen are the same as those for configuration screen of the particle feeding unit.

Monitoring Table of Monitoring Screen Data of Detection and Sorting Unit

No.	Name	Type	Description of function
1	Start	Limit indicator light	Start status indicator light
2	Stop	Limit indicator light	Stop status indicator light
3	Reset	Limit indicator light	Reset status indicator light
4	Standalone/online	Limit indicator light	Standalone/online status indicator light
5	Feeding detection sensor	Limit indicator light	Indicator light of feeding detection sensor
6	Tightening detection sensor	Limit indicator light	Indicator light of tightening detection sensor
7	Bottle cap blue detection sensor	Limit indicator light	Indicator light of bottle cap blue detection sensor
8	Bottle cap white detection sensor	Limit indicator light	Indicator light of bottle cap white detection sensor
9	Unqualified limit detection sensor	Limit indicator light	Indicator light of unqualified limit detection sensor
10	Discharge detection sensor	Limit indicator light	Indicator light of discharge detection sensor
11	Sorting cylinder retract limit	Limit indicator light	Sorting cylinder retract limit indicator light
12	Three material limit detection	Limit indicator light	Three material limit detection indicator light
13	Four material limit detection	Limit indicator light	Four material limit detection indicator light
14	Start and stop of main tape conveying motor	Standard button	Start and stop manual output of main tape conveying motor
15	Auxiliary tape conveying	Standard button	Start and stop manual output of auxiliary tape conveying motor

No.	Name	Type	Description of function
	motor start and stop		
16	Indicator light with bright green	Standard button	Manual output of indicator light with bright green
17	Indicator light with bright red	Standard button	Manual output of indicator light with bright red
18	Indicator light with bright blue	Standard button	Manual output of indicator light with bright blue
19	Solenoid valve of sorting cylinder	Standard button	Solenoid valve manual output of sorting cylinder
20	Manual/automatic	Standard button	When the button is pressed, the unit is in the manual test status, and the manual forced output control button is valid.
21	Single cycle	Standard button	When the button is pressed, the unit performs a single-cycle operation demonstration

Intelligent training platform: Detection and sorting unit		GZ-2021 wo
Layout area of input indicator light	Layout area of manual output control	

Figure C-3 Configuration Screen of Detection and Sorting Unit

(4) Complete the control program design according to the I/O Allocation Table provided in the TP.

No.	Name	Description of function	Notes
1	X00	The feeding detection sensor senses the material, and X00 is closed	
2	X01	The tightening detection sensor senses the bottle cap, and X01 is closed	
3	X03	Bottle cap color sensor senses blue, and X03 is closed	

No.	Name	Description of function	Notes
4	X04	Bottle cap color sensor senses white, and X04 is closed	
5	X05	Unqualified limit detection sensor senses the material, and X05 is closed	
6	X06	The discharge detection sensor senses the material, and X06 is closed	
7	X07	The retract limit of sorting cylinder senses the material, and X07 is closed	
8	X10	Press the start button, and X10 is closed	
9	X11	Press the stop button, and X11 is closed	
10	X12	Press the reset button, and X12 is closed	
11	X13	Press the online button, and X13 is closed	
12	X14	Three material limit detection	
13	X15	Four material limit detection	
14	X20	Unqualified bottle cap sorting detection sensor senses the material, and X20 is closed	
15	X21	The retract limit of unqualified bottle cap sorting cylinder senses the material, and X21 is closed	
16	X22	Unqualified material sorting detection sensor senses the material, and X22 is closed	
17	X23	The retract limit of unqualified material sorting cylinder senses the material, and X23 is closed	
18	X24	Unqualified bottle cap and material sorting detection sensor senses the material, and X24 is closed.	
19	X25	The retract limit of unqualified bottle cap and material sorting cylinder senses the material, and X25 is closed	
20	Y00	Y00 is closed, and the main conveyor belt operates	
21	Y01	Y01 is closed, and the auxiliary conveyor belt operates	
22	Y02	Y02 is closed, and the indicator light of the detection mechanism is always on in green	
23	Y03	Y03 is closed, and the indicator light of the detection mechanism is always on in red	
24	Y04	Y04 is closed, and the indicator light of the detection mechanism is always on in blue	
25	Y05	Y05 is closed, and the sorting cylinder extends out	

No.	Name	Description of function	Notes
26	Y06	Y06 is closed, and the indicator light of the detection mechanism is always on in yellow	
27	Y10	Y10 is closed, and the start indicator light is on	
28	Y11	Y11 is closed, and the stop indicator light is on	
29	Y12	Y12 is closed, and the reset indicator light is on	
30	Y20	Y20 is closed, and the unqualified bottle cap sorting cylinder extends out	
31	Y21	Y21 is closed, and the unqualified material sorting cylinder extends out	
32	Y22	Y22 is closed, and the unqualified bottle cap and material sorting cylinder extends out	

Requirements for the process of unit operation function:

(1) Power is on, and the system is in the “Stop” status. The “Stop” indicator light is on, and the “Start” and “Reset” indicator lights are off;

(2) In the “Stop” status, press the “Reset” button and the unit resets. During the reset process, the “Reset” indicator light flashes, and all mechanisms return to their original positions. After the reset is completed, the “Reset” indicator light is always on, and the “Start” and “Stop” indicator lights are off. In the “Operate” or “Reset” status, pressing the “Start” button is invalid.

(3) In the “Reset” ready status, press the “Start” button, and the unit starts. The “Start” indicator light is on, and the “Stop” and “Reset” indicator lights are off.

(4) The main conveyor belt starts operation, and the indicator light of the detection mechanism is always on in blue;

(5) Manually place the material bottle with three materials and a tightened white cap to the beginning of the unit;

(6) When the feeding detection sensor detects there is a material bottle and the tightening detection sensor does not operate, the indicator light of the detection mechanism is always on in green when the bottle passes through the detection mechanism, and the material bottle is conveyed to the end of the main conveyor belt; the discharge detection sensor operates, the main conveyor belt stops, and the material bottle is manually removed; the conveyor belt continues to start operation, the green indicator light of the detection mechanism is off, and the blue light is always on.

(7) Manually place the material bottle with three materials and a tightened blue cap to the beginning of the unit;

(8) When the feeding detection sensor detects that there is a material bottle and the tightening detection sensor does not operate, the indicator light of the detection mechanism flashes in green ($f=2$ Hz) when the bottle passes through the detection device, and the material bottle is conveyed to the end of the main conveyor belt; the discharge detection sensor operates, the main conveyor belt stops, and the material bottle is manually removed; the conveyor belt continues to start operation, the green indicator light of the detection mechanism is off, and the blue is always on;

(9) Manually place the material bottle with two materials and a tightened cap to the beginning of the unit;

(10) When the feeding detection sensor detects there is a material bottle and the tightening detection sensor does not operate, the indicator light of the detection mechanism is always on in yellow and the blue one is off when the bottle passes through the detection device; when the material bottle passes the unqualified limit detection sensor, the sensor operates and the solenoid valve of sorting cylinder is triggered and energized; when the bottle reaches the position of the sorting cylinder, it is pushed to the auxiliary conveyor belt; when the material bottle passes through the unqualified material sorting detection sensor on the auxiliary conveyor belt, the sensor operates, and the solenoid valve of the unqualified material sorting cylinder is energized, so that the material bottle is pushed into the unqualified material sorting tank;

(11) Manually place the material bottle with three materials whose bottle cap is not tightened to the beginning of the unit;

(12) When the feeding detection sensor detects there is a material bottle and the tightening detection sensor operates, the indicator light of the detection mechanism is always on in red when the bottle passes through the detection device; when the material bottle passes the unqualified limit detection sensor, the sensor operates and the solenoid valve of the sorting cylinder is triggered and energized; when the material bottle reaches the position of the sorting cylinder, it is pushed to the auxiliary conveyor belt; when the material bottle passes the unqualified bottle cap sorting detection sensor on the auxiliary conveyor belt, the sensor operates, and the solenoid valve of the unqualified bottle cap sorting cylinder is energized, so that the material bottle is pushed into the unqualified bottle cap sorting tank;

(13) In any start and operate status, press the “Stop” button, and the unit stops working; the “Stop” indicator light is on, and the “Start” and “Reset” indicator lights are off.

Task IV. Programming and debugging of industrial robot handling unit

1. Task overview

Teams are now required to complete the control program design and debugging of the industrial robot handling unit, so that the production process can be automated in the later stage of the production line.

Equipment status:

The electrical installation of the hanging panel, the installation and wiring of the countertop module of the working unit have been completed, and the programming and debugging of the unit have not yet been carried out.



Industrial Robot Handling Unit

2. Task description

Complete the control program and the touch screen engineering design of the industrial robot handling unit, as well as the program design of the robot and robot I/O configuration, and conduct Standalone debugging to ensure the correct operation, so that the production process can be automated in the later stage of the production line.

When the task is completed, you need to check the following contents:

- (1) The mechanical installation, electrical wiring and pneumatic connection of the unit have been completed, and the equipment operates correctly.
- (2) The operation functions of the unit are in accordance with the requirements.
- (3) Configure Robot I/O according to your own programming requirements.
- (4) Design the touch screen according to the monitoring table of monitoring screen data provided in the TP, and use the touch screen of this unit to conduct single-station debugging operation, including starting, stopping, resetting and single cycle. The configuration screen is shown in Figure C - 4. Requirements for the screen color assignment and “manual/automatic button” of the touch screen are the same as those for configuration screen of the particle feeding unit.

Intelligent training platform: Robot handling unit		GZ-2021 wo
Layout area of input indicator light	Layout area of manual output control	

Figure C-4 Configuration Screen of Industrial Robot Handling Unit

Monitoring Table of Monitoring Screen Data of Industrial Robot Handling Unit

No.	Name	Type	Details
1	Start	Limit indicator light	Start status indicator light
2	Stop	Limit indicator light	Stop status indicator light
3	Reset	Limit indicator light	Reset status indicator light
4	Standalone/online	Limit indicator light	Standalone/online status indicator light
5	Lifting Platform A origin	Limit indicator light	Indicator light of Lifting Platform A origin
6	Upper limit of Lifting Platform A	Limit indicator light	Upper limit indicator light of Lifting Platform A
7	Lower limit of Lifting Platform A	Limit indicator light	Lower limit indicator light of Lifting Platform A
8	Lifting Platform B origin	Limit indicator light	Indicator light of Lifting Platform B origin
9	Upper limit of Lifting Platform B	Limit indicator light	Upper limit indicator light of Lifting Platform B
10	Lower limit of Lifting Platform B	Limit indicator light	Lower limit indicator light of Lifting Platform B
11	Front limit of pushing cylinder	Limit indicator light	Front limit indicator light of Pushing Cylinder A
12	Rear limit of pushing cylinder	Limit indicator light	Rear limit indicator light of Pushing Cylinder A

No.	Name	Type	Details
13	Box cover discharging	Standard button	When the button is pressed, the material box rises by the height of a box cover.
14	Box discharging	Standard button	When the button is pressed, a material box is discharged.
15	Manual/automatic	Standard button	When the button is pressed, the unit is in the manual test status, and the manual forced output control button is valid.
16	Single cycle	Standard button	When the button is pressed, the unit performs a single-cycle operation demonstration

(5) Complete the control program design according to the I/O Allocation Table provided in the TP.

No.	Name	Description of function	Notes
1	X00	Lifting Platform A moves to the origin, and X0 is disconnected	
2	X01	Lifting Platform A hits the upper limit, and X1 is disconnected	
3	X02	Lifting Platform A hits the lower limit, and X2 is disconnected	
4	X03	Lifting Platform B moves to the origin, and X3 is disconnected	
5	X04	Lifting Platform B hits the upper limit, and X4 is disconnected	
6	X05	Lifting Platform B hits the lower limit, and X5 is disconnected	
7	X06	Pushing Cylinder A extends out, and X6 is closed	
8	X07	Pushing Cylinder A retracts, and X7 is closed	
9	X10	Press the start button, and X10 is closed	
10	X11	Press the stop button, and X11 is closed	
11	X12	Press the reset button, and X12 is closed	
12	X13	Press the online button, and X13 is closed	
13	X14	Pushing Cylinder B extends out, and X14 is closed	
14	X15	Pushing Cylinder B retracts, and X15 is closed	
15	X16	Stopper cylinder extends out, and X16 is closed	
16	X17	Stopper cylinder retracts, and X17 is closed	

No.	Name	Description of function	Notes
17	X20	Undefined	The output point of the robot is connected to the input point of the PLC
18	X21		
19	X22		
20	X23		
21	X24		
22	X25		
23	X26		
24	X27		
25	X30		
26	X31		
27	X32		
28	X33	Capping and positioning cylinder extends out, and X33 is closed	
29	X34	Suction cup A is valid, and X34 is closed	
30	X35	Suction cup B is valid, and X35 is closed	
31	X36	There is material on the material table, and X36 is closed	
32	X37	Capping and positioning cylinder retracts, and X37 is closed	
33	Y0	Y0 is closed to pump pulse to the Lifting Platform A	
34	Y1	Y1 is closed to pump pulse to the Lifting Platform B	
35	Y2	Y2 is closed to change the direction of the Lifting Platform A	
36	Y3	Y3 is closed to change the direction of the Lifting Platform B	
37	Y4	Y4 is closed and the Cylinder A of the lifting platform extends out	
38	Y5	Y5 is closed and the Cylinder B of the lifting platform extends out	
39	Y6	Y6 is closed and the capping and positioning cylinder extends out	
40	Y10	Y10 is closed, and the start indicator light is on	
41	Y11	Y11 is closed, and the stop indicator light is on	
42	Y12	Y12 is closed, and the reset indicator light is on	

No.	Name	Description of function	Notes
43	Y20	Undefined	The output point of the PLC is connected to the input point of the robot
44	Y21		
45	Y22		
46	Y23		
47	Y24		
48	Y25		
49	Y26		
50	Y27		
51	Y30		
52	Y31		
53	Y32		
54	Y33		
55	Y34		

Requirements for the process of unit operation function:

- (1) The unit is in the Standalone status, and the robot switches to the automatic operating status; press the “Reset” button, the unit resets, and the robot returns to the safe origin pHome.
- (2) “Reset” light (yellow light, the same below) flashes;
- (3) “Stop” light (red light, the same below) is off;
- (4) “Start” light (green light, the same below) is off;
- (5) All parts return to their original positions;
- (6) The “Reset” light is always on, and the system enters the ready status.
- (7) Press the “Start” button for the first time, and the cover lifting mechanism of the industrial robot handling unit lifts the material cover of the material box.
- (8) The stopper cylinder extends out, and the pushing cylinder of the material box lifting mechanism pushes the material box out to the assembly table. When the box is in place, the pushing cylinder retracts, and the positioning cylinder retracts at the same time.
- (9) The material table detection sensor operates.
- (10) The robot on this unit starts to carry out the function of handling bottles: The robot conveys the material bottle to the packaging box from the discharge position of the detection and sorting unit. **The path planning is reasonable, and it must not collide with any mechanism during the handling process.** The sequence of handling material bottle is shown in Figure C-5 on the left.

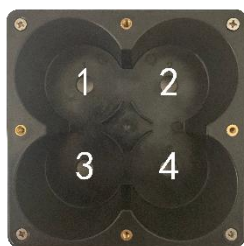
① After the robot has conveyed a material bottle, if it is detected that there is no material bottle at the discharge position of the detection and sorting unit, the robot will return to the original position and wait until there is a material bottle at the discharge position, and then grab the bottle.

② After the robot has conveyed a material bottle, if it is detected that there is a material bottle waiting to be grabbed at the discharge position of the detection and sorting unit, the robot does not need to return to the original position, and can directly grab it to improve efficiency.

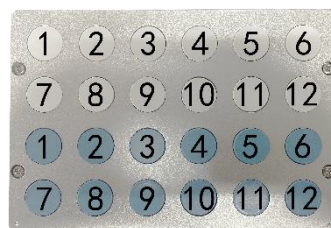
(11) After the packaging box is filled with four material bottles, the robot returns to the original position. Even if it detects that there is a material bottle at the discharge position of the detection and sorting unit, the robot will no longer grab it.

(12) Press the “Start” button for the second time, and the robot starts to automatically perform the function of handling a box cover: From the point to the box cover position, the robot uses suction cups to suck the box cover and cover it on the box. The path planning is reasonable, and it must not collide with any mechanism during the handling process. It returns to its original position after the box is covered.

(13) Press the “Start” button for the third time, and the robot starts to automatically perform the function of handling labels: From the point to the label table position, the robot uses suction cups to suck two blue and two white labels in turn and stick them on the cover of the packaging box. The path planning is reasonable, and it must not collide with any mechanism during the labeling process; the label placement and suction sequence are shown in Figure C-5 on the right.



Sucking Order of White Labels



Sucking Order of Blue Labels

Figure C – 5 Schematic Diagram of Material Bottle Workstation and Label Placement

(14) The robot does not need to return to the origin position after sticking a label, and returns to the origin position after sticking four labels. The labeling sequence of the robot is shown in Figure C-6;



Figure C - 6 Schematic Diagram of Labeling Workstation

(15) After the robot sticks the labels, the positioning cylinder extends out, and the stopper cylinder retracts, waiting for storage;

(16) When the system is operating, press the “Stop” button, and the unit enters the stop status, that is, the robot stops moving; however, the robot fixture should keep the current status to avoid the material falling, and pressing this button in the ready status is invalid.

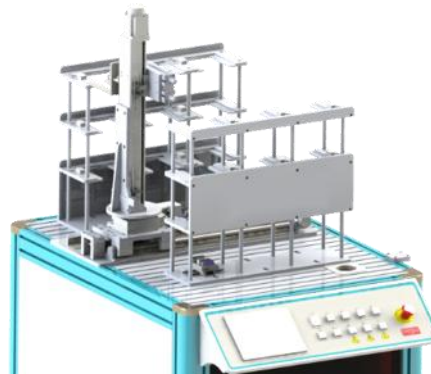
Task V. Programming and debugging of intelligent storage unit

1. Task overview

Teams are now required to complete the control program design and debugging of the intelligent storage unit, so that the production process can be automated in the later stage of the production line.

Equipment status:

The electrical installation of the hanging panel, the installation and wiring of the countertop module of the working unit have been completed, and the programming and debugging of the unit have not yet been carried out.



Intelligent storage unit

2. Task description

and conduct Standalone debugging to ensure correct operation, so that the production process can be automated in the later stage of the production line.

When the task is completed, you need to check the following contents:

(1) The mechanical installation, electrical wiring and pneumatic connection of the unit have

been completed, and the equipment operates correctly.

(2) The operation functions of the unit are in accordance with the requirements.

(3) Complete the control program design according to the I/O Allocation Table provided in the TP.

No.	Name	Description of function	Notes
1	X00	The lifting direction origin sensor is sensed in place, and X00 is disconnected	
2	X01	The rotation direction origin sensor is sensed in place, and X01 is disconnected	
3	X02	Position A1 detection sensor senses the material, and X02 is closed	
4	X03	Position A2 detection sensor senses the material, and X03 is closed	
5	X04	Position A3 detection sensor senses the material, and X04 is closed	
6	X05	Position A4 detection sensor senses the material, and X05 is closed	
7	X06	Position A5 detection sensor senses the material, and X06 is closed	
8	X07	Position A6 detection sensor senses the material, and X07 is closed	
9	X10	Press the start button, and X10 is closed	
10	X11	Press the stop button, and X11 is closed	
11	X12	Press the reset button, and X12 is closed	
12	X13	Press the online button, and X13 is closed	
13	X14	The front limit of the pickup cylinder is sensed in place, and X14 is closed	
14	X15	The rear limit of the pickup cylinder is sensed in place, and X15 is closed	
15	X17	The travel axis origin sensor is sensed in place, and X17 is disconnected	
16	X20	The right limit of the rotation direction is sensed in place, and X20 is closed	
17	X21	The left limit of the rotation direction is sensed in place, and X21 is closed	
18	X22	The upper limit of the lifting direction is sensed in place, and X22 is closed	
19	X23	The lower limit of the lifting direction is sensed in place, and X23 is closed	
20	X25	Detection sensor X25 of the Position A7 is	

No.	Name	Description of function	Notes
		closed	
21	X26	Detection sensor X26 of the Position A8 is closed	
22	X27	Detection sensor X27 of the Position A9 is closed	
23	X30	Detection sensor X30 of the Position B1 is closed	
24	X31	Detection sensor X31 of the Position B2 is closed	
25	X32	Detection sensor X32 of the Position B3 is closed	
26	X33	Detection sensor X33 of the Position B4 is closed	
27	X34	Detection sensor X34 of the Position B5 is closed	
28	X35	Detection sensor X35 of the Position B6 is closed	
29	X36	Detection sensor X36 of the Position B7 is closed	
30	X37	Detection sensor X37 of the Position B8 is closed	
31	X40	Detection sensor X40 of the Position B9 is closed	
32	X42	The right limit of the travel axis is sensed in place and X42 is closed	
33	X43	The left limit of the travel axis is sensed in place and X43 is closed	
34	X44	Encoder A	
35	X45	Encoder B	
36	Y00	Y00 is closed, and the motor of lifting direction rotates	
37	Y01	Y01 is closed, and the motor of rotation direction rotates	
38	Y03	Y03 is closed, and the motor of lifting direction reverses	
39	Y04	Y04 is closed, and the motor of rotation direction reverses	
40	Y05	Reserved	
41	Y06	Y06 is closed, and the solenoid valve of the stacker pickup cylinder starts	

No.	Name	Description of function	Notes
42	Y10	Y10 is closed, and the start indicator light is on	
43	Y11	Y11 is closed, and the stop indicator light is on	
44	Y12	Y12 is closed, and the reset indicator light is on	
45	Y13	Y13 is closed, and the travel axis motor reverses	

Requirements for the process of unit operation function:

(1) When power is on and the system is in the “Reset” status, the “Start” and “Stop” indicator lights are off, and the unit resets; during the reset process, the “Reset” indicator light flashes, and all mechanisms return to their original positions; after the reset is completed, “Reset” indicator light is always on. (In the “Operate” status, pressing the “Reset” button is invalid.

(2) In the “Reset” ready status, press the “Start” button, and the unit starts. The “Start” indicator light is on, and the “Stop” and “Reset” indicator lights are off. (In the status of “Stop” or “Reset not completed”, pressing the “Start” button is invalid).

(3) Press the “Start” button for the first time, the stacker starts to operate and operates to the position of the packaging workbench to wait.

(4) Press the “Start” button for a second time, and the stacker pickup cylinder extends into place.

(5) After the stacker lifts up to a suitable height, the pickup cylinder retracts.

(6) The stacking mechanism rotates to the storage position B1. During the rotation of the stacking mechanism, the packing box is not allowed to have any friction or collision with the packing workbench or the intelligent storehouse.

(7) If there is a box in the current position, the stacking mechanism rotates to the storage position B4, and so on in the order of B1, B4, B7, B2, B5, B8, B3, B6, B9.

(8) If the current position is empty, the stacker pick up cylinder extends out. After the cylinder extends into place, the stacker lowers down to a suitable height, and then the pickup cylinder retracts. The packing box is not allowed to collide with or deviate from the intelligent storehouse.

(9) The stacking mechanism returns to the packaging workbench.

(10) Put another packaging box on the packaging workbench of the industrial robot handling

unit; the unit will repeat Steps (4) to (9), and the packaging boxes will be conveyed to the vacant positions of the corresponding storehouse in sequence.

(11) In any start and operate status, press the “Stop” button, and the unit stops immediately and all the mechanisms do not work; the “Stop” indicator light is on, and the “Start” and “Reset” indicator lights are off.

Task E Optimization and debugging of mechatronics system program

Task scenario:

After the Standalone debugging of all units is completed, the online communication signal of the master station unit has not been programmed yet. Teams are now required to improve the program functions of the particle feeding unit, the detection and sorting unit, the industrial robot handling unit, and the intelligent storage unit, increase the system online program, and complete online debugging. Meanwhile, teams are also required to complete and deliver a production line consisting of a particle feeding station, a capping and screw capping station, a detection and sorting station, an industrial robot handling station and an intelligent storage station within the specified time to realize automated production.

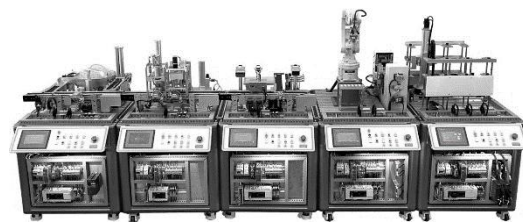
Points	Competition duration	Information
20/100	Task D/E (3 hours)	See D drive for details

1. Task overview

After the Standalone operation and debugging of all the units have been completed, competitors need to carry out the online communication of each unit, optimize the PLC control program, write the touch screen configuration program, and finally realize the online operation function of the production line.

Equipment status:

Each unit can realize Standalone operation, but lack configuration program and online communication program, so it can not meet the requirements for online operation of the full line.



Automated Production Line

2. Task description

The task of the teams is to set up an Ethernet or 485 network, complete the writing of the PLC communication program of each unit, optimize the PLC's full-line operation control function program,

and design the touch screen configuration.

When the task is completed, you need to check the following contents:

- (1) Set up a PLC communication network with the intelligent storage unit as the main station, and establish communication with the touch screen;
- (2) The touch screen configuration program should include the following interfaces: Master control screen of the touch screen and the monitoring screen of intelligent storage unit.
- (3) Improve the particle feeding unit and increase the quantity of particles to be filled on the touch screen: The total number of particles to be filled can be entered as three or four on the touch screen. When particles are filled in the particle feeding unit, they should be filled according to the input requirements, and at the same time, the filling quantity should be displayed in real time on the touch screen.
- (4) Optimize the air consumption of automated production lines to reduce energy consumption in the production process.
- (5) Write equipment operation instructions for customers, describe the use and operation steps of equipment clearly, including production preparation, preparations before production line station, touch screen operation, alarm information processing and precautions.

You need to check whether the following operation flow is normal:

- (1) Press the online button of each unit, and select the “online” mode on the master control screen of the touch screen system, and the system enters the online operation status.
- (2) Press the “Online Stop” button on the touch screen, and the system stops immediately; the “System Stop” indicator light on the touch screen is on, and the “System Start” and “System Reset” indicator lights are off.
- (3) In the “System Stop” status, press the “Online Reset” button, and the system starts to reset; the “System Reset” indicator flashes during the reset process. After the reset is completed, each unit enters the ready status, and the “System Reset” indicator light on the touch screen is always on, and the “System Start” and “System Stop” indicator lights are off. In other statuses, pressing the “Online Reset” button is invalid.
- (4) When the “System Reset” is ready, press the “Online Start” button on the touch screen and the system starts; the “System Start” indicator light on the touch screen is on, and the “System Reset” and “System Stop” indicator lights are off. In other statuses, pressing the “Online Start” button is invalid.

- (5) The particle feeding unit starts operating, and the main conveyor belt starts.
- (6) The operating indicator light is on.
- (7) Enter three or four for the total number of particles to be filled on the touch screen, and one to four for the number of white particles.
- (8) After the set quantity of filling is reached in the particle feeding unit, the filling and positioning mechanism is released. During the filling process, the total number of particles and the number of white particles in the current filling bottle, as well as the total number of accumulated filling particles in the production line, should be displayed in real time on the system master control screen.
- (9) The bottle is conveyed to the capping and screw capping unit; the conveyor belt of the capping and screw capping unit starts, and the bottle is conveyed to the capping workstation and the screw capping workstation for capping and screw capping, respectively; the main conveyor belt of the particle feeding unit does not start in the screw capping status, and can restart after screw capping is completed; if there have been no new bottle in the capping and screw capping unit for 5 s, the conveyor belt of the unit stops operating.
- (10) After the capping and screw capping are completed, the bottle is conveyed to the detection and sorting unit.
- (11) The main conveyor belt of the detection and sorting unit starts, and detects the tightness of the bottle cap, the color of the bottle cap and the number of material particles, so as to sort out qualified and unqualified products; the total number of qualified and unqualified products in the production line is displayed in real time on the system master control screen.

① If the bottle cap of the material bottle is tightened and the number of material particles is three, it is regarded as a qualified product. If the current bottle cap is white, the indicator light of the detection mechanism is always on in green; if it is blue, the light flashes in green ($f=2$ Hz); the material bottle is conveyed to the end of the main conveyor belt, the discharge detection sensor operates, and the main conveyor belt stops, waiting for the robot to grab;

② If the bottle cap of the material bottle is not tightened tightly, no matter how many material particles are, it will be regarded as an unqualified product. The indicator light of the detection mechanism is always on in red; the sorting cylinder pushes it to the auxiliary conveyor belt; the unqualified bottle cap sorting cylinder on the auxiliary conveyor belt pushes it into the unqualified bottle cap sorting tank;

③ If the bottle cap of the material bottle is tightened but the number of material particles is not three, it is regarded as an unqualified product, and the indicator light of the detection mechanism is always on in yellow; **the text scrolling alarm message “Material particle filling is wrong. Please correct it in time!” appears on the touch screen of the master control system;** the sorting cylinder pushes it to the auxiliary conveyor belt; the unqualified bottle cap sorting cylinder on the auxiliary conveyor belt pushes it into the unqualified bottle cap sorting tank.

(12) If the waiting time for the robot to grab the qualified products of the detection and sorting unit at the end of the conveyor belt exceeds 3 s, the main and auxiliary conveyor belts of the particle feeding unit and the conveyor belt of the capping and screw capping unit will not start, and then the working unit will enter a pause status, waiting for qualified products to continue to operate after being grabbed.

(13) The industrial robot handling unit completes the bottling and labeling operations according to the set control program and the robot teaching path. The color of the label on the labeling workstation number described in Task 3 should correspond to the color of the cap on the material bottle workstation number.

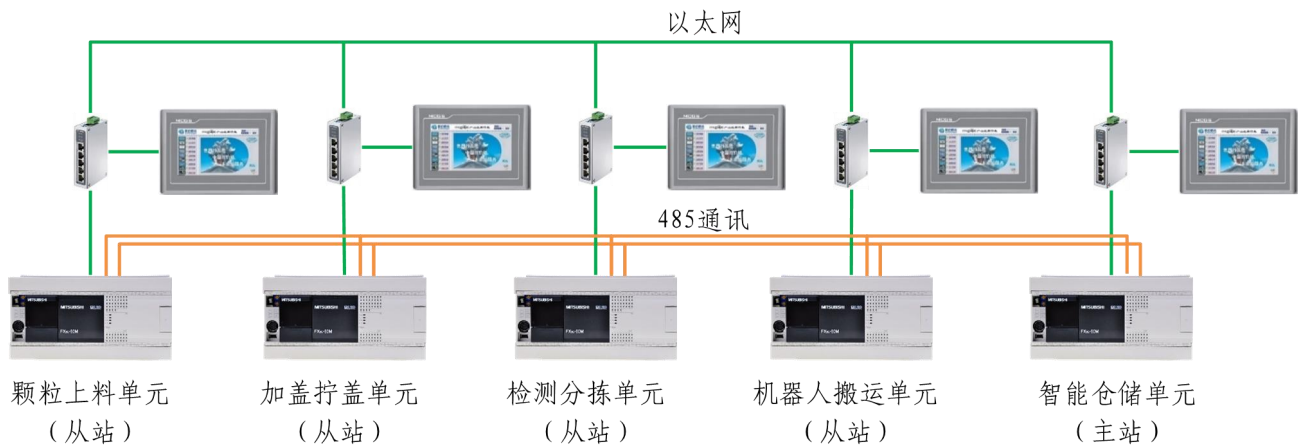
(14) The completed boxes in the industrial robot handling unit are conveyed to the position of the intelligent storage unit designated by the touch screen. If there is a box in the designated position, the stacker will automatically convey the box to the next free position in the order of B1, B4, B7, B2, B5, B8, B3, B6, and B9, and **when the stacker starts operating, the text scrolling alarm message “The current designated position is full, and the system has automatically adjusted!” appears on the master control touch screen until the stacker returns to the initial position and disappears.**

(15) Competitors need to set a timing display box on the master control screen. When the online start button in Step (4) is pressed, the timing display box starts timing, and stops until a process is completed (four material bottles for particle filling + capping and screw capping + detection and sorting + putting into the box + warehousing).

(16) The industrial robot handling unit and the intelligent storage unit complete the corresponding process according to the original set program (no points for this operation).

3. System network structure

— 以太网
— 485



以太网	Ethernet
485通讯	485 communications
颗粒上料单元 (从站)	Particle feeding unit (Slave station)
加盖拧盖单元 (从站)	Capping and screw capping unit (Slave station)
检测分拣单元 (从站)	Detection and sorting unit (Slave station)
机器人搬运单元 (从站)	Robot handling unit (Slave station)
智能仓储单元 (主站)	Intelligent storage unit (Master station)

Figure E- 2Structure Diagram of System Network

System communication address assignment





Name of Station	Master station (read) ← Slave station (write)	Master station (write) → Slave station (read)	
		M	Function
All stations		M1000	Online start
		M1001	Online stop
		M1002	Online reset
		M1003	Online manual

4. Configuration screen requirements

(1) System control screen

Figure E-2 shows the required area division and color assignment for the touch screen configuration (Standalone/online-blue, online start-green, online stop-red, online reset-yellow). When the input information is 1, the indicator light displays the corresponding color. When the input

information is 0, the light is gray.

机电一体化项目		GZ-2021 工位	
<input type="checkbox"/> 单机/联机		<input type="checkbox"/> 单机/联机	总填装数量：设定 <input type="text"/> 实时 <input type="text"/>
<input type="checkbox"/> 联机启动		<input type="checkbox"/> 单机/联机	物料颗粒总数 <input type="text"/>
<input type="checkbox"/> 联机停止		<input type="checkbox"/> 单机/联机	物料瓶合格总数量 <input type="text"/>
<input type="checkbox"/> 联机复位		<input type="checkbox"/> 单机/联机	物料瓶不合格总数量 <input type="text"/>
总控界面	当前时间		智能仓储单元

机电一体化项目	Mechatronics Project
GZ-2021 工位	GZ-2021 workstation
单机/联机	Standalone/online
联机启动	Online start
联机停止	Online stop
联机复位	Online reset
总控界面	Master control screen
当前时间	Current time
智能仓储单元	Intelligent storage unit
总填装数量：	Total filling quantity:
设定	Set
实时	In real time
物料颗粒总数	Total number of material particles
物料瓶合格总数量	Total number of qualified material bottles
物料瓶不合格总数量	Total number of unqualified material bottles

Figure E-33 System Master Control Configuration Screen

Monitoring Table of Screen Data of System Master Control

No.	Name	Type	Details
1	Standalone/online	Standard button	Switching of system Standalone and online mode
2	Online start	Standard button	System online starts
3	Online stop	Standard button	System online stops
4	Online reset	Standard button	System online resets
5	Standalone/online	Limit indicator light	The blue light is on in the Online status
6	Start instructions	Limit indicator light	The green light is on in the start status
7	Stop instruction	Limit indicator light	The red light is on in the stop status
8	Reset indication	Limit indicator light	The yellow light is on in the reset status
9	Set the total filling quantity	Analog input box	Determine the total number of particles filled in a single bottle
10	Set the filling quantity of white particle	Analog input box	Determine the filling quantity of white particles in a single bottle
11	Total filling quantity in real time	Analog display box	Display the total number of particles currently filled in the bottle
12	Real-time filling quantity of white particles	Analog display box	Display the current number of white particles filled in the bottle
13	Total number of material particles	Analog display box	Display the total number of material particles currently completed
14	Total number of qualified material bottles	Analog display box	Display the total number of bottles that have been inspected by the inspection sorting unit
15	Total number of unqualified material bottles	Analog display box	Display the total number of bottles detected by the detection and sorting unit
20	Intelligent storage unit	Screen switch button	Jump to the intelligent storage unit screen

(2) Monitoring screen of the intelligent storage unit

The unit configuration screen is shown in Figure E-3. Requirements for the screen color assignment and “manual/automatic button” of the touch screen are the same as those for the configuration screen of the particle feeding unit.

Mechatronics intelligent training platform: Intelligent storage unit		GZ-2021 wo
Layout area of input indicator light		Layout area of manual output control
Master control screen	Current time	Intelligent storage unit

Figure E-4 4Configuration Screen of Intelligent Storage Unit

Monitoring Table of Monitoring Screen Data of Intelligent Storage Unit

No.	Name	Type	Details
1	Start	Limit indicator light	Start status indicator light
2	Stop	Limit indicator light	Stop status indicator light
3	Reset	Limit indicator light	Reset status indicator light
4	Standalone/online	Limit indicator light	Standalone/online status indicator light
5	Position B1	Limit indicator light	Indicator light of Position B1
6	Position B2	Limit indicator light	Indicator light of Position B2
7	Position B3	Limit indicator light	Indicator light of Position B3
8	Position B4	Limit indicator light	Indicator light of Position B4
9	Position B5	Limit indicator light	Indicator light of Position B5
10	Position B6	Limit indicator light	Indicator light of Position B6
11	Position B7	Limit indicator light	Indicator light of Position B7

No.	Name	Type	Details
12	Position B8	Limit indicator light	B8 position indicator light
13	Position B9	Limit indicator light	Indicator light of Position B9
14	Lifting origin	Limit indicator light	Indicator light of lifting origin
15	Lifting upper limit	Limit indicator light	Indicator light of lifting upper limit
16	Lifting lower limit	Limit indicator light	Indicator light of lifting lower limit
17	Rotation origin	Limit indicator light	Indicator light of rotation origin
18	Rotation left limit	Limit indicator light	Indicator light of rotation left limit
19	Rotation right limit	Limit indicator light	Indicator light of rotation right limit
20	Front limit of pickup cylinder	Limit indicator light	Front limit indicator light of pickup cylinder
21	Rear limit of pickup cylinder	Limit indicator light	Rear limit indicator light of pickup cylinder
22	Solenoid valve of stacker pickup cylinder	Standard button	Solenoid valve manual output of stacker pickup cylinder
23	Rotation pulse number of packing box suction position at the electrical angle	Input field	Pulse number register address D200
24	Rotation pulse number of the placement position of Storehouse A for packing boxes at the electrical angle	Input field	Pulse number register address D204
25	Rotation pulse number of the placement position of Storehouse B for packing boxes at the electrical angle	Input field	Pulse number register address D206
26	Vertical rotation pulse number of	Input field	Pulse number register address D208

No.	Name	Type	Details
	the motor at the packing box suction position		
27	Pulse number of the travel axis of the motor at the packaging box suction position	Input field	Pulse number register address D210
28	Pulse number in the third row of the position	Input field	Pulse number register address D212
29	Pulse number in the second row of the position	Input field	Pulse number register address D214
30	Pulse number in the first row of the position	Input field	Pulse number register address D216
31	Pulse number in the first column of the position	Input field	Pulse number register address D218
32	Pulse number in the second column of the position	Input field	Pulse number register address D220
33	Pulse number in the third column of the position	Input field	Pulse number register address D222
34	Manual/automatic	Standard button	When the button is pressed, the unit is in the manual test status, and the manual forced output control button is valid.
35	Single cycle	Standard button	When the button is pressed, the unit performs a single-cycle operation demonstration

Task F Professional quality

Task scenario:

Exam the safety regulations of competitors during the operation; the use of facilities and equipment, tools and instruments; their hygiene and cleaning habits, proper wearing, work discipline and civilization and politeness. The on-site judges will record the process, mark on-site competition, and check competitors.

Points	Competition duration	Information
6/100	The whole process of the Competition	None