Design of Parts Flexible Palletizing System

Yuan Yang[1], Ligang Qiang[2], Yong Zhang[2], Xudong Yang[1]

[1]School of mechanical engineering, Guizhou University, Guiyang 550000, China
[2]Aerospace Jiangnan Group Co., Ltd, Guiyang 550000, China

Abstract. Part palletizing packaging is an important part of the logistics industry. Traditional manual palletizing can no longer meet today 's order volume. In order to improve the production efficiency of the palletizing process, a part flexible palletizing system was designed. The S7-1200 PLC was used as the controller, and the high-precision altimeter and length measurement photoelectric sensors were used to check the parts in real time, and the manipulator and the end actuator were used for grasping and stacking. The end actuator with multi-axis synchronous control technology is adopted to realize simultaneous grasping of multiple boxes of different specifications, which greatly improves the production efficiency and automation level of part palletizing. This flexible palletizing system and robotic gripping technology greatly improves the efficiency of gripping small objects and also allows for extended applications in the field of FAST disassembly and handling robots.

Key Words: flexible palletizing; PLC; manipulator end actuator; manipulator.

1. Introduction

Material sorting and palletizing is a common process in manufacturing, logistics and transportation industries. In the past, the sorting and palletizing of materials were completed manually, which not only had high labor intensity, but also had a high error rate of sorting and palletizing, which made the process inefficient12. In order to improve efficiency, the targeted technical transformation was needed to conform to the development trend of automation. The different specifications of the same material also increase, which brings great challenges to the palletizing of small materials34. Based on this background, the part palletizing system is designed. PLC is used as the controller, combined with the length and height sensor to realize the detection and palletizing of parts, and the multi-axis palletizing mechanism is controlled to realize the simultaneous grabbing of multiple specifications, which accelerates the palletizing efficiency. PLC through Ethernet connection touch screen, PC and manipulator controller, to achieve human-computer interaction, equipment monitoring and manipulator movement, thus improving the automation level of palletizing process.

2. Part Flexible Palletizing System

2.1 Structure of Part Flexible Palletizing System

The flexible palletizing system mainly consists of grab belt, manipulator, manipulator end actuator, pallet and control cabinet, as shown in figure 1.The grabbing belt is mainly powered by a servo motor, and the belt is equipped with a corresponding in-place photoelectric sensor and a length-measuring photoelectric sensor to realize the positioning and review of the part 5. The system uses an EPSON LS20-B804S robot with the advantages of high speed and high performance ratio. The end actuator is the key to realizing the flexible palletizing system, using 9 stepper motors to control 9 shafts, to achieve the suction cup in the X and Z direction of movement. Pallets are the necessary structure from palletizing to packaging. The control cabinet is the control center of the whole system, which contains PLC, touch screen and other electrical components, completing the system control, communication and human-computer interaction.

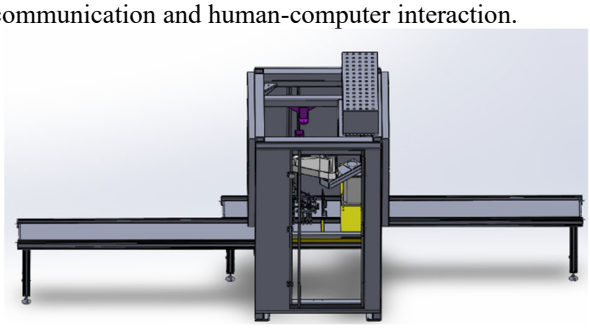

Fig. 1 Part Flexible Palletizing System

2.2 Part Flexible Palletizing System Process

The sorted parts are transported to the top of the grasping belt through the cache belt, and the parts are reviewed by the photoelectric sensor and the length measuring

photoelectric sensor. After the review is completed, the grasping signal is sent. After the manipulator waiting above the grabbing point receives the grabbing signal, the

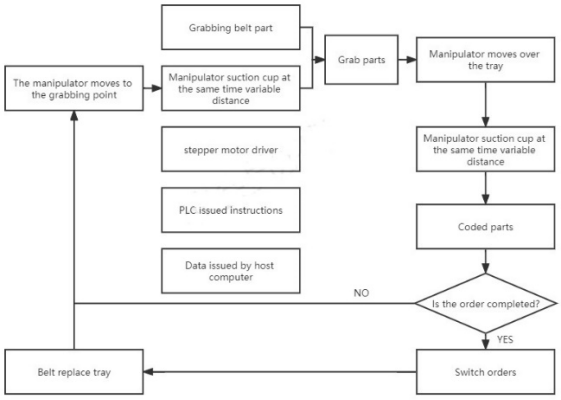

Fig. 2 Process Flow

suction cup grabs the part with variable distance. When the tray reaches below the code point, it sends an allowable dispensing signal to the manipulator. After receiving the part release signal, the manipulator moves to the parts release point for parts release. After the part is released, the manipulator returns to the above of the grasping point and waits for the instruction. This process is repeated in the order after the completion of the part palletizing signal, the tray is delivered to the packaging station by belt, as shown in Figure 2.

3. Control Hardware Design.

The hardware of the part flexible palletizing system was designed according to the process flow. The system mainly includes palletizing mechanism and electric control cabinet. Palletizing mechanism mainly uses the EPSON LS20-B804S type manipulator, its structure also includes the manipulator end actuator, tray, grab belt and tray belt. Among them, 7 groups of position photoelectric sensors and a group of length measuring photoelectric sensors are used. One group of position photoelectric sensors is used to judge the position of the tray, the other 5 groups are used to judge the position of the part, and the last group is the limit position of the belt. The end actuator of the manipulator is the key technology of this paper. It is equipped with 9 stepping motors, which provides X and Z axis power for the sucker. Because the end actuator is based on the third set of suckers, four origin slot photoelectric sensors are also set up to determine the X-axis origin of the 1,2,4 and 5 sets of suckers. At the same time, five altimeter photoelectric sensors were set up to review the part specifications. The end actuator of the manipulator is shown in Figure 3. The vacuum pump, solenoid valve, three-color signal lamp and buzzer are also set outside. The cooperation of the vacuum pump and the solenoid valve realizes the suction and blowing of the suction cup, and ensures the grasping and discharge of the part.

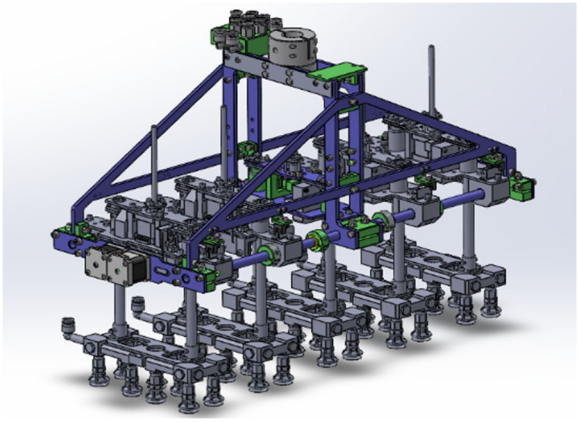

Fig. 3 Manipulator End Actuator

The electric control cabinet is the hardware core of the part of system, which can be divided into the terminal plug, insurance switch, fuse, transformer, servo motor controller, stepper motor driver, relay, power supply, control terminal, switch, touch screen and manipulator controller, as shown below. The terminal socket is used to transfer the power line and signal line inside and outside the cabinet, and the insurance switch controls the on-off power of the electrical components outside the cabinet. The fuse is the insurance part of the control cabinet to ensure that the circuit can be protected in the case of short circuit. The transformer converts 380V voltage to 24V. Servo motor controller is to control the grab belt and tray belt start and stop and anyway, stepper motor drive by changing the pulse and direction control suction movement. The control end includes three SIMATIC S7-1200 PLCs, one of which is the main control PLC, which is responsible for the control and calculation of the whole system. The other two are XPLC and ZPLC, which control the X-axis motion and Z-axis motion of the sucker in the end actuator of the manipulator respectively. The purpose is to share the calculation amount of the main control PLC and improve the operation speed. The touch screen is the main interface of human-computer interaction. It can not only observe the control information, but also control the operation of the end actuator of the manipulator. Manipulator controller is the brain of the manipulator, which controls the movement of the manipulator. The controller of EPSON RC90 is used to achieve the effect of fast communication through the connection with PLC Ethernet. The layout is shown in Figure 4.

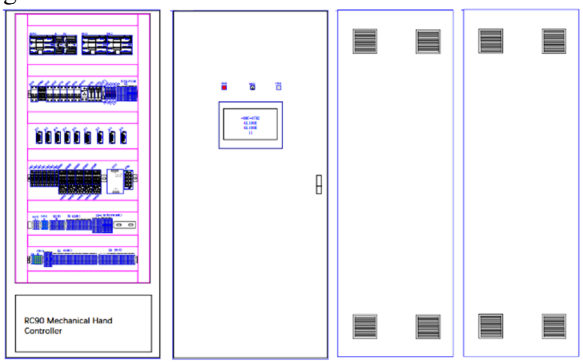

Fig. 4 Control Cabinet

The combination of the palletizing mechanism and the control cabinet realizes the whole process of the system from grasping the part to palletizing. The coordinated motion of the end actuator of the manipulator is realized by multi-axis synchronous control technology, which ensures the synchronization of the end actuator. The hardware structure of the whole system is shown in Fig.5.

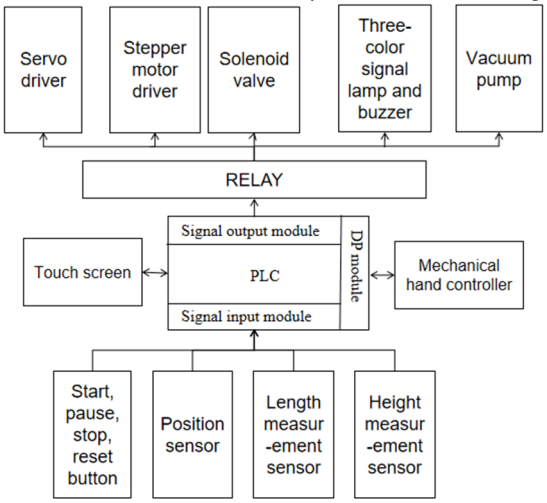

Fig. 5 Hardware Structure Chart

4. Control Software Design

The hardware system is the carrier of the control system, and the software system is the key to measure the stability and reliability of the whole system. The part flexible palletizing system software is not only required to realize the control of the movement of each mechanism, but also to monitor the operation of the equipment in real time. It has the functions of alarming and protecting the safety of workers, and can provide a convenient human-computer interaction system.

4.1 PLC Program

The main control PLC receives the palletizing data sent by the host computer, and then after the system is started, the three PLCs enable the manipulator to reset the X and Z axes, and detect the zero return of each axis through the slot photoelectric sensor; after the reset is completed, wait for the write of each axis moving data; the manipulator receives the standby point signal and moves to the standby point while the flexible sucker changes the distance. The height and length of the part are then checked by the height sensor and the length sensor; after the review is correct, the part signal is issued to the manipulator to grab the part; at the same time, the PLC performs the drop detection. If it is correct, the signal above the dispensing point is sent to the manipulator and moved to the top of the dispensing point. At the same time, the PLC allows the palletizing signal to be returned. When the manipulator receives the allowable palletizing signal, the solenoid valve is started, and the flexible sucker is changed to break the vacuum dispensing. After the part is released, the manipulator again receives the standby point signal and returns to the standby point to cycle this process. Fig.6 is the control flow chart.

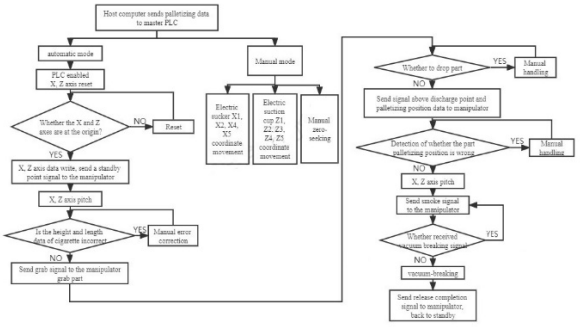

Fig. 6 The Control Flow Chart

4.2 Touch Screen Design

Touch screen mainly realizes the equipment running state monitoring, palletizing data manual application, manual click device, fault display, clear data, start the suspension system and other functions. The touch screen has six interfaces, namely Palletizing Main Interface, Sensor Parameters, Data Interaction, Palletizing Data, Sucker Motor and Manipulator. The bit state switching switch in the interface is directly connected to the relevant contacts in the electrical control program through the connection port Net, select the corresponding address type and then enter the corresponding contact address for communication. Achieve the control of each button on the system. When the flexible sucker reaches the zero point, the electricity will automatically stop. This method is to obtain the signal of the pause shaft by connecting a zero-point switch in series with a positive and negative normally open contact.

The main interface of palletizing mainly includes five parts, Virtual Palletizing, Alarm Message, Normal Operation, Palletizing Information and interface switching button. The virtual palletizing simulates the palletizing process, and can observe the signals of 6 sets of in-place photoelectric sensors and 1 set of length measuring photoelectric sensors. It also simulates the position of the end actuator and the order number of the tray. This part can also perform the belt 's point movement, buzzer and safety door status. Alarm Message is used to display the alarm information of the system, so that the operator can more accurately find the location of the failure, in order to solve faster. The Normal Operation section is set up START, STEP, RESET, Vacuum-Breaking, Manual Grab, Manual Palletizing, Manual Vacuum Pump and Total Clear Data. Each button controls the corresponding functions, among which Manual Grab and Manual Palletizing control one layer and one single manual palletizing respectively. Palletizing Information displays Odd Number, Coded, Overall Amount and Height. The interface switching button controls the switching of various interfaces, including Sensor Parameters, Data Interaction, Palletizing Data, Sucker Motor and Manipulator.

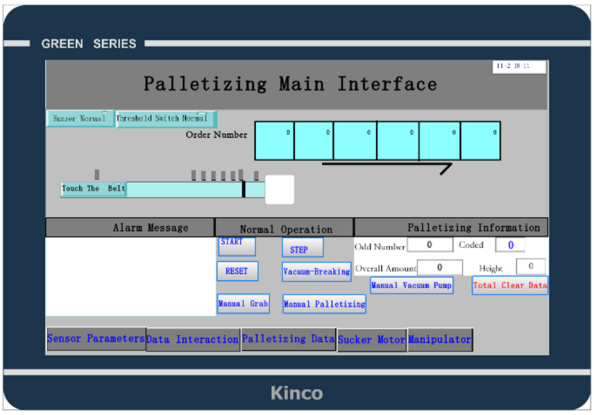

Fig. 7 Palletizing Main Interface

5. Conclusion

In order to improve the palletizing efficiency of the part logistics center, this paper designs a set of flexible part palletizing system, which breaks the limitation that the manipulator can only grab a single material, and realizes the simultaneous grabbing of multiple parts. The system takes SIEMENS S7-1200 PLC as the control core, and reduces the amount of computation of a single PLC by using a master-slave PLC. The multi-axis synchronous control technology is used to control the motor motion of the end actuator, and the synchronization of each sucker is realized. The touch screen is designed again, which can display the motion of the sucker, alarm information and palletizing data, and realize the human-computer interaction function. This system improves the automation level of the part palletizing system and improves the efficiency of palletizing. The flexible palletizing system and robotic gripping technology significantly improves the efficiency of small object gripping, and the technology provides a good theoretical and applied research basis for the group's next research on the Five-hundred-meter Aperture Spherical radio Telescope (FAST) feeder receiver disassembly and handling robot system, which further enables maintenance operation robots to efficiently handle the parts of the FAST feeder receiver that require maintenance.

Acknowledgements

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