Design of Robots’ Automatic Packaging and Palletizing

Gou Weijie1*, Wang Lihong2

1Automotive Engineering Institute, Beijing Polytechnic, Beijing, 100176, China
2Foreign Language Teaching Department, Beijing Polytechnic, Beijing, 100176, China

*Corresponding author’s e-mail: gvjie@126.com

Abstract. All articles must contain an abstract. The abstract text should be formatted using 10 point Times or Times New Roman and indented 25 mm from the left margin. Leave 10 mm space after the abstract before you begin the main text of your article, starting on the same page as the abstract. The abstract should give readers concise information about the content of the article and indicate the main results obtained and conclusions drawn. The abstract is not part of the text and should be complete in itself; no table numbers, figure numbers, references or displayed mathematical expressions should be included. It should be suitable for direct inclusion in abstracting services and should not normally exceed 200 words in a single paragraph. Since contemporary information-retrieval systems rely heavily on the content of titles and abstracts to identify relevant articles in literature searches, great care should be taken in constructing both.

1. Introduction
The development of fieldbus technology has improved the automation of production and logistics. The development of robot technology has made robotic palletizing technology widely used in automatic production and logistics system. In the automatic assembly line, quickly and accurately transferring, sorting and sorting the workpieces to be packaged in real time is the key to improve production efficiency. The use of robots for packaging and palletizing has become a necessity for the automation of production lines.

The automatic packaging and palletizing system uses robots based on Modbus fieldbus technology as the main body of carrying and palletizing workpieces in the production line. At the same time, the Siemens S7-1200 PLC is used to control the conveying of workpieces on the material conveying line, and select the position of the packaging and palletizing line. The visual intelligence system performs photographs to identify the shape and position parameters of workpieces during the conveyance of workpieces. Modbus fieldbus realizes the information interaction between robots. Material conveying line, visual intelligent detection, packaging- palletizing line and upper computer running together at the same time in the process of system operation. In order to complete the workpiece transportation, classification, packing and palletizing, and improve the efficiency of the logistics system and the applicability of the production line in the current automatic production.

2. Working principle of automatic packaging and palletizing system based on industrial robots
The main function of the automatic packaging and palletizing system is to recognize shape and position of the workpieces to be packaged from the material conveying line through the intelligent vision system, and then send them to the to-be-handled area. Robots extract, carry, package and
palletize the workpieces according to the visual identification information. The system requires precise control, fast grabbing, stable handling, normative palletizing, convenient and quick use, so that production efficiency can be further improved.

The robot packaging and palletizing system is mainly composed of a 6-joint robot, a material conveying line, an intelligent visual inspection, a packaging and palletizing line, and a main control system (PLC control unit). The workflow is shown in Figure 1.

![Figure 1. Workflow of the robotic packaging and palletizing system](image)

At the beginning, each mechanism is in the initial state, the material conveying line detects that there is a tray for transporting the workpiece. The tray is transported to the visual inspection photographing position and the blocking cylinder is extended. The tray stops, waiting for visual photo recognition, and then the cylinder is retracted, and the tray continues to advance till the to-be-transported area. The robot receives the processing result of visual inspection information from the main control PLC, extracts the workpieces, and transports them to the position where workpieces are to be palletized. The packaging and palletizing line moves to the corresponding position according to the visually recognized workpiece information and the palletizing requirements, and the robot starts to perform palletizing. So far, packaging and palletizing of a workpiece is completed.

The tray for conveying the workpiece can carry many workpieces at a time, and then the robot will move again to the tray-handling position according to the number of workpieces, and workpieces are extracted, packaged, and palletized. After workpieces on the tray are extracted, the robot moves to the tray-handling position again and move the tray to the tray storage. A process of transporting, packaging and palletizing is completed. This process can be cycled.

3. Design for industrial robots’ automatic packaging and palletizing system

With the development of computer, control, communication, network and other technologies, industrial control has moved from stand-alone control to centralized monitoring and centralized-distributed control. The development of fieldbus technology enables a perfect combination between robotics and field automation equipment.
3.1 Modbus bus
Modbus is an Ethernet communication system that supports distributed automation. It can be used in real-time control with minimal hardware cost, with fast update cycle and high stability. Modbus can interoperate with information between all the centralized devices on the network, and the centralized control device can communicate with other devices via the network. The use of Modbus fieldbus enables the control devices produced by different manufacturers to be connected into an industrial control network for distributed layout and centralized monitoring. The use of Modbus fieldbus can greatly save resource configuration and debugging costs on production site.

3.2 selecting the type of Palletizing robot
According to the shape and position of the workpieces to be packaged on the automation line, the robot system of the palletizing system uses a 6-axis robot. The robot system supports the Modbus TCP/IP communication protocol to communicate with the host computer PLC system. The robot's I/O information can be extended to fully satisfy the communication connection between the robot and its peripherals.

3.3 Design of control system for the tools of palletizing robot
According to the characteristics of the workpieces, the robot uses the suction cup tool to carry the workpiece, which ensures the changeability and diversity of the shape of the workpiece on the production line, so as to achieve the simultaneous use of various shapes of the production line.

- **Design of pneumatic control circuit for suction cup tool.**

![Diagram of suction tool pneumatic control circuit](image)

The suction tool of the robot should extract both workpiece and workpiece tray. The suction cup tool is designed into a single suction cup at one end for easily grasping workpieces, and a double suction cup at the other end for grasping the tray for placing workpieces. The angle between the two is 80°. Through the 6th rotation axis of the robot, switching between the two is achieved. As shown in Figure 2, the pneumatic control system uses a dual electronically controlled two-position five-way reversing valve to control the vacuum opening and closing of the suction cup.

- **Design for electronic control system of suction cup tool.**

In order to complete a specific task, the robot system needs to interact information with other devices on the production line. The robot requires vacuum opening and closing of the suction cup tool to complete the handling work. The robot's IO system consists of a digital input and an output. In order to communicate with the robot-controlled peripherals, the digital input and output can be used to
control the vacuum opening and closing of the suction cup and detection information. The robot's suction cup tool uses the address wiring as shown in Table 1 below.

Table 1. I/O address allocation table of the robot system

| Serial number | Detection position | I/O address | Signal type | Description |
|---------------|--------------------|-------------|-------------|-------------|
| 1             | Grab the workpiece | Dout24      | Output      | The reversing valve solenoid YV1 is energized, the single suction cup is vacuum-opened; the reversing valve solenoid YV1 is de-energized, and the single suction cup is vacuum-closed. |
| 2             | Grab the workpiece in place | Din24 | Input | Check that the single suction cup has grabbed the workpiece |
| 3             | Grab tray | Dout25 | Output | The reversing valve solenoid YV2 is energized, the double suction cup is vacuum-opened; the reversing valve solenoid YV2 is de-energized, and the double suction cup is vacuum-closed. |
| 4             | Grab the tray in place | Din25 | Input | Detect that the double suction cups have grabbed the tray |

3.4 Design for Visual Intelligence Detection System

The visual intelligence system is installed in the material conveying line. When the goods in the tray move to the visual inspection station, the intelligent vision system visually recognizes the workpieces in the tray, and gives the identified position, shape, number and other characteristic data to the main control--PLC. The data is processed by the main control PLC and then is transmitted to the robot through the network. The robot performs the corresponding action according to the received information.

The visual recognition system consists of hardware such as a smart camera, a light source controller, a light source, and a lens. The light source is backlit and the light source is under the workpiece to identify related information of a variety of different types of workpieces. When the tray reaches the station and meets the photographing conditions, a trigger signal is given to the input end of the light source controller, and the camera takes a picture. After the photographing is completed, the light source controller gives an output signal, and the system performs the next action. The visual recognition system supports the Modbus bus communication protocol. It transmits the camera photographing result through the Modbus bus and the main control system.

4. Control design of PLC main control system

Siemens S7-1200 PLC has a variety of different communication interfaces, connects industrial Ethernet bus systems through a variety of communication processors, and supports a variety of fieldbus types, Modbus bus technology is fully applied on this system. Style and spacing

4.1 Type selection of PLC main control system

This automatic packaging and palletizing system selects Siemens S7-1200 PLC as the main control system, supports Modbus communication protocol, and the operation is simple and accurate, which is convenient for connection with slave systems such as robots.

PLC communicates with the material conveying line and the packaging-palletizing line through internal I/O to complete the transportation of the workpiece to be palletized and the determination of the palletizing position. At the same time, PLC acts as the main control system, communicates with the robot, visual intelligent detection system and host computer through the fieldbus Modbus, and completes the information processing and interaction with the robot, visual intelligent detection.
system and the upper computer to realize remote operation and control of the system, and provide a prerequisite for the distributed layout of the entire production line.

4.2 Sequential control of PLC main control system
The main control system adopts the sequential control of PLC, which can realize the automatic control of the whole process. The sequential control is to generate corresponding control results in turn when the corresponding conditions are met. From Figure 1, we can see a complete process of packing and palletizing, and if starting condition is satisfied after a process is completed, and the system has no stopping condition, continuous packaging and palletizing can be realized.

5. Conclusion
The widespread use of robots is a fast and efficient way to achieve industrial automation and increase production efficiency. The use of robots for handling, packaging, and palletizing has become the mainstream and future direction of automated production lines. With the development of fieldbus technology, robots and PLC technology are integrated to further increase the automation of the production line. On the automated production line, the packaging and palletizing system adopts PLC as the main control system and the robot carries on the palletizing, which meets the actual requirements of production line the possibility of rapid change of various products in one production line, and is also the best choice of saving production cost.

Acknowledgments
Supported by Program for Research Team in Beijing Polytechnic.

References
[1] Hu Jian. Siemens S7-300/400 PLC Engineering Application [M]. Beijing University of Aeronautics and Astronautics Press, 2008.9.
[2] Chen Aizhen. Development status of robots at home and abroad [J]. Mechanical Engineer, 2011.
[3] Wang Baojun, Teng Shaofeng. Foundation of Industrial Robots [M]. Huazhong University Press, 2015.10
[4] Yu Zhigen. Sensor and Detection Technology [M]. Beijing: Science Press, 2007.
[5] Qi Guili. Configuration Software Control Technology [M]. Beijing: Beijing Institute of Technology Press, 2007.
[6] Du Enming, Zhang Renchao. Research on Automatic Sorting and Grading System Based on Machine Vision [J]. Packaging Engineering, 2018, 39(15): 194-198.
[7] Guo Xiaobao, Zhao Zhen, Huang Wei, Jia Zhiwen. Design principle of palletizing robot in beverage production line [J]. Equipment Machinery, 2018 (02): 1-4+9.
[8] Bai Yurong. Design of Cartesian Control System for Cartesian Coordinates [J]. Machinery Manufacturing & Automation, 2018, 47(03):181-183.
[9] YU Lei, XU Lida. Research on Palletizing Robot Based on PID Iterative Learning Control [J]. Machine Tool & Hydraulics, 2018, 46(11): 70-74.
[10] Wang Bo, Xue Wenkui. Design and application of palletizing robot intelligent workstation under PLC technology [J]. Science and Technology, 2018(15):64-65.
[11] Chen Xuefeng. Research on trajectory planning algorithm of palletizing robot [J]. Control Engineering, 2018, 25(05):925-929.
[12] Li Weidong. The Enlightenment of “Industry 4.0” to Promote “Made in China 2025” [D]. Diplomatic Academy, 2017.
[13] Wei Anbang. Analysis on the Definition and Training Path of Talents Training in Higher Vocational Education [J]. Technology and Education, 2015, 29(02): 1-6.
[14] Wang Dahai. Research on Palletizing Robot Control of Production Logistics System Based on PLC [J]. Logistics Technology, 2014(14):24-29.