Design of Lead-acid Battery Assembly Flexible Production Line Based on Industrial Robot

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Abstract

With the advent of industrial 4.0, intelligent manufacturing has developed rapidly. As the application of new technology in the field of industrial automation, industrial robotics technology has attracted much attention and has been applied in more and more automatic flexible production lines. The flexible production line of lead-acid battery assembly designed in this paper is centered on motoman-ES165D industrial robot. The robot hand grasp is installed. It is responsible for the grasp, 180 degree rotation and assembly of battery tank. The production line is also equipped with battery tank conveyor belt and battery cover tooling cycle line. The flexible production line for lead-acid battery transfer has reasonable layout, good structure design and stable operation, which greatly improves the assembly efficiency of the battery box and has a high level of flexibility and automation.

Keywords

Lead-acid Battery ; Flexible Production Line; Industrial Robot.

1. Introduction

Lead-acid battery industry has a high market share at the present stage due to its mature technology and low cost. With the continuous renewal of technology, it will still occupy a monopoly position in the battery market in the future. However, the lead-acid battery industry is still mainly manual, with high labor intensity, low production efficiency and harsh production environment. It is urgent to upgrade the automation technology [1-3]. With the continuous development of industrial robotics technology, industrial robots have been applied in all walks of life. Industrial robots are integrated into the application of automation industry, which can realize the functions of product grasping, handling, palletizing, welding, polishing and forging [4-6].

The flexible production line of industrial robot automation has become the mainstream of automation equipment and the future development direction. As a new technology, flexible manufacturing line has been more and more applied in production practice and achieved good results. Intelligent manufacturing line based on industrial robots can effectively help all walks of life to improve the production environment and increase production [7-9].

With the development of robot intelligence and automation, the advantages of avoiding industrial accidents, reducing the impact of environment on health and improving efficiency are discussed[10]. The flexible production line of lead-acid battery box assembly designed in this paper is based on industrial robots instead of manual work. It is not only highly automated, but also adaptable to lead-acid battery assembly and has strong flexibility. In order to design a reasonable and better industrial robot production line, taking lead-acid battery box as carrier, battery cover and battery cell as shown in Figure 1, the working principle, structure design and main components design of the production line are carried out for the assembly process of lead-acid battery.

2. Working Principle of Flexible Production Line

2.1 Assembly Process Settings of Lead-acid Batteries

The main specifications of lead-acid batteries are 12NDC100 and 12NDC150. The main sizes are as shown in Table 1. For larger batteries, the cover size of 12NDC150 is 310*126*28, and it weighs 150 KG. In the assembly process, the main process includes manual glue filling of battery tank cover, manual turnover of battery tank box 180 degrees, and finally complete the assembly of battery tank and battery cover. The whole process includes glue filling, turnover, fit and other actions, which require a lot of labor and work intensively.

Table 1 Type and specification of lead-acid batteries

Type	Cover size	Slot size	Quality
12NDC100	287×108×28	287×108×360	30 KG
12NDC150	310×126×28	310×126×513	50 KG

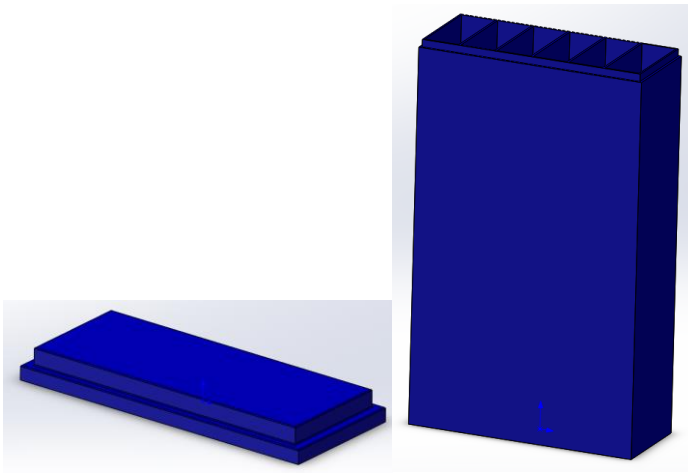


Fig. 1 battery cover and battery cell

2.2 Workflow Design of Flexible Production Line

Because the load ratio of the box is as large as 30 kg and 50 kg, the volume of the box is relatively large. Taking industrial robot as the main body, the whole grabbing and assembling action of the battery box is completed. The assembled battery is placed on the front conveyor belt of the oven. At this time, the workstation completes the action requirements. The order of the grabbing rhythm of the manipulator is shown in Table 2.The working process of flexible production line is designed as follows:

(1) Battery trough conveyor belt completes the transportation and positioning of battery trough.

(2) In the cycle line of fixture and fixture for battery cover, after the battery cover is placed into the fixture manually, the charging and gluing of the battery cover are completed. At the same time, the circulation line completes the transportation and positioning of the battery cover, and realizes the circulation transportation of the fixture and fixture for the battery cover.

(3) The robot can grasp, change direction and move the battery tank.

(4) The robot completes the assembly of battery cell and battery cover.

Table 2 The order of the grabbing rhythm of the manipulator

Serial number	Working procedure
1	Robots move from waiting position to grabbing station and grabbing battery tank
2	Lift, flip, move to the top of the assembly station

3	Install battery cell into battery cover
4	Grab the battery cover
5	Lift and move to the top of the oven preparation section
6	Battery placement
7	Robot Back to Waiting Position

3. Structural Design of Flexible Production Line

3.1 Overall Layout of Flexible Production Line

Battery assembly flexible line is based on industrial robots, with customized grips, battery cover tooling cycle line, battery tank conveyor belt and so on, to complete the charging, positioning, turnover and assembly of battery cell and battery cover. The flexible line is suitable for 12NDC100 and 12NDC150 battery production lines. The three-dimensional schematic diagram of the battery assembly sequence workstation is shown in Figure 1as follows:

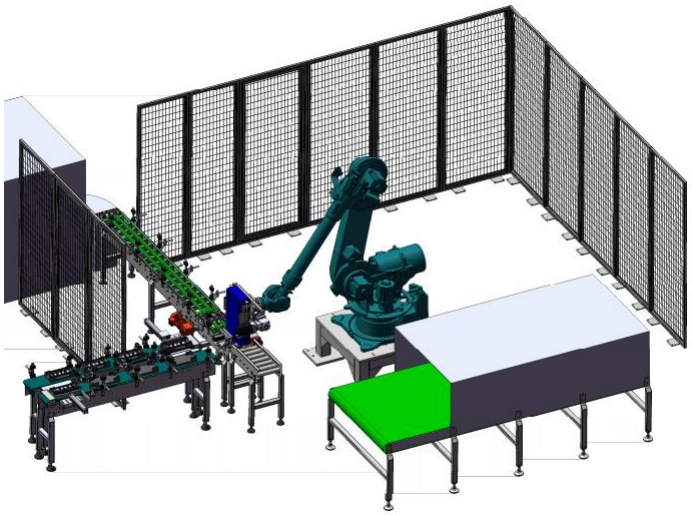


Fig. 2 the battery assembly sequence workstation

Because of the technological requirements of the assembly objects of the battery assembly workstation, the specific work of the industrial robot mainly completes the following actions:

(1) The robot completes the grasping, reversing and moving of the battery cell.

(2) The robot completes the assembly of battery cell and battery cover.

(3) The robot completes the whole grasping and turning of the battery, and places the assembled battery on the front conveyor belt of the oven.

According to the requirement of output, rhythm and load, and considering about 30KG and 30KG of 12NDC100 and 12NDC150 batteries respectively, the motoman-ES165D industrial robot is selected in this project considering the layout and cost.

3.2 Design of Main Components of Flexible Production Line

3.2.1 Design of Battery Tank Positioning Conveyor Belt

Battery tank is transferred to the conveyor belt by the front conveyor belt of the workstation. As shown in Figure 3, two different specifications of battery tank can be conveyed by adjusting the guardrail width. Through the cooperation of two groups of cylinders on the conveyor belt, one battery cell can be positioned, while the rest of the battery cells are waiting in line.

When the workstation is unable to work normally due to maintenance, maintenance or malfunction, the battery tank can be manually assembled and sequenced by means of powerless drum conveyor belt.

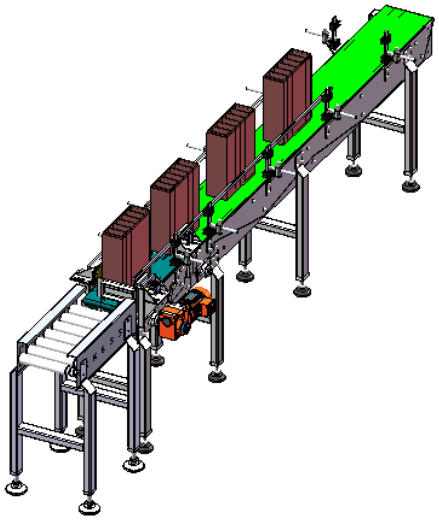


Fig. 3 Battery Tank Positioning Conveyor Belt

3.2.2 Design of Circulating Line of Battery Cover Fixture

The circulating line of fixture for battery cover is composed of two adjacent conveyor belts with opposite conveying direction, as shown in Fig. 4. Cycling and positioning of fixture can be realized by cooperating with cylinder and positioning mechanism.

The battery cover is fixed in the customized fixture manually on the auxiliary conveyor belt, and after filling, the battery cover is conveyed to the assembly station of the main conveyor belt by the circulating line and positioned by a group of cylinder positioning components. After the robot completes the capture of the battery tank and the battery cover, the tooling fixture is pushed to the auxiliary conveyor belt by the push block cylinder, and the cycle of tooling fixture is completed.

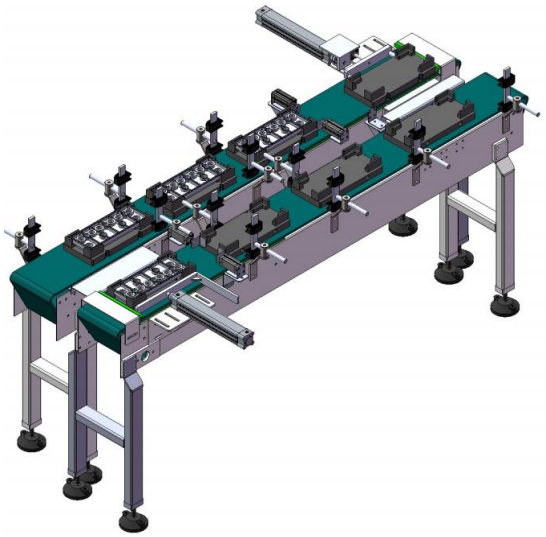


Fig.4 Battery Cover Fixture Cycle Line

In the design of fixture for battery cover, V-grooves and positioning guide holes are arranged on both sides to realize the positioning of fixture. Tool fixture is equipped with two sides convex platform, As shown in Figure 5,12NDC150 battery cover is fixed by lower convex platform and 12NDC100 battery cover is fixed by upper convex platform.

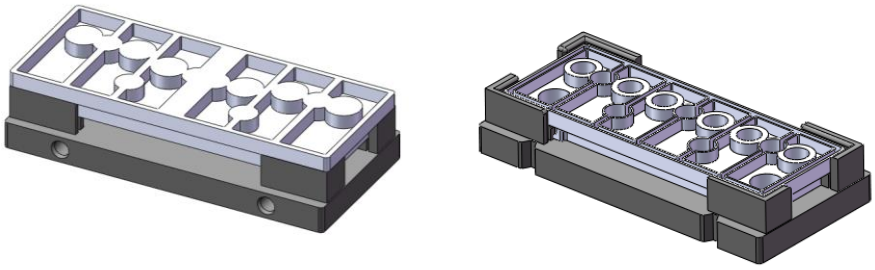


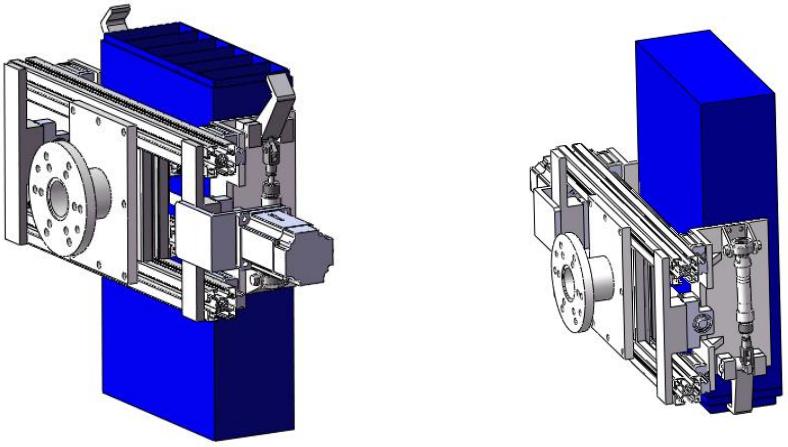
Fig. 5 Fixture for Battery Cover Tool

4. Design of Robot Grab for Flexible Production Line

4.1 Design of Robot Battery Grapper

The customized gripper for 12NDC batteries uses servo motor, reverse lead screw and cylinder components to achieve precise positioning of two different specifications of battery cell and battery cover. As shown in Fig. 6, after the robot gripper moves to the gripping station, the clamping plates on both sides are driven by the servo motor to clamp the battery cell, which is then moved to the upper part of the battery assembly station to complete 180 degree rotation of the battery cell.

After the assembly action is realized at the battery assembly station, two cylinders on both sides of the gripper drive the gripper to rotate, and then insert the gap between the gripper and the fixture to achieve the clamping of the battery cover.



(a) Clamping Battery Tank (b) Clamping Battery Tank and Cover

Fig. 6 12NDC Battery Robot Grab

4.2 Debugging and Operation of Manipulator Grab

The industrial robot hand grasp of flexible production line for lead-acid battery assembly is shown in Fig. 7, taking 12NDC100 and 12NDC150 lead-acid battery cells as grasping objects. When working, the lead-acid battery cell is placed in the worktable, and the industrial robot can quickly grasp the battery cell and battery cover by servo hand for assembly. The whole process mainly completes the battery cover fixture cycle line glue filling, positioning and transporting of the battery tank, the assembly of manipulators, the whole flexible production line works quickly, runs steadily, and meets the production requirements.

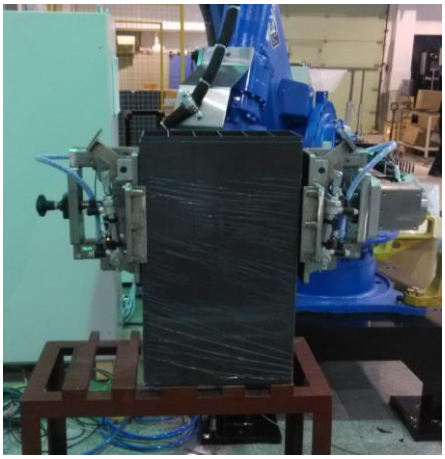


Fig. 7 Debugging and Running of Industrial Robot Grab

5. Conclusion

The flexible production line of lead-acid battery assembly designed in this paper adopts automation technology, centering on motoman-ES165D industrial robot, and designs the main parts of the robot grip, the positioning conveyor belt of battery tank and the fixture cycle line of battery cover. The flexible production line finally completes the functions of capturing, reversing and assembling the battery box. The flexible production line of the industrial robot has reasonable layout, strong applicability, greatly saves human costs and improves work efficiency. The practical application proves that the whole flexible production line runs well, the working speed is stable, and it has high flexibility. It has high popularization and application value.

Acknowledgements

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