Simulation Design of Spot Welding of Body Structure and Transfer Robot Workstation

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Abstract. Application of virtual simulation technology to manufacturing industry today can shorten the development cycle, reduce costs and improve the design accuracy. This paper takes the spot welding workstation of auto body structure as the research object. Firstly, the production demand of spot welding of auto body structure is analyzed, the structure and production characteristics of spot welding robot workstation are analyzed, and the appropriate equipment is selected for the layout of spot welding robot workstation. Secondly, the work path of the robot is planned reasonably, and the planning of the robot trajectory can facilitate the writing of program instructions later. In the design process, three-dimensional modelling software is used to model some components in the workstation. Finally, through the use of simulation software, the welding path optimization and off-line programming of the whole spot welding robot workstation are simulated. The results show that the designed robot workstation can meet the use requirements.

1. Introduction

Spot welding is a commonly used processing method in automobile parts processing. Using robots for spot welding can not only improve the work efficiency, but also ensure the stability of welding quality. The dual-robot workstation for spot welding and transfer of automobile parts designed in this paper adopts spot welding industrial robot for welding processing. Spot welding torch is mounted to the flange of spot welding robot, which is used for spot welding of automobile parts. At the same time, in order to realize efficient and automatic operation, the transfer robot is used to transport the workpiece.[1-3]

This design adopts robot simulation and offline programming software. The workstation requires two working stations. While spot welding is carried out in one station, the workpiece in the other station can be mounted or removed by a transfer robot. Through the design of double stations, the work efficiency is improved. The workstation requires fully closed-off management, and the workers operate outside the protective fence. The workstation can be controlled by the electrical control cabinet outside the protective fence, and the programming and debugging of the robot are carried out by the robot controller outside the protective fence, which secures the safety of operators.[4-6]

2. Overall layout design of the workstation

The workstation is equipped with two welding stations, and the outer axis is used for the walking of the robot, so as to realize the movement of the welding robot between the two stations in the workstation. A sliding track is used in the external axis, a welding robot is mounted on the track, and a
spot welding torch is mounted to the flange end of the spot welding robot. In addition, a transfer robot is set up, and used to transport the welding workpiece between two stations.

In the spot welding, the transfer robot places auto body structure that needs spot welding on two stations. Then, the spot welding robot on the track moves to the first station for spot welding. After spot welding of the auto body structure at the first station is finished, the spot welding robot moves to the second station through the track for spot welding. At this time, the transfer robot transports the processed auto body structure at the first station to the finished product area, and then moves the auto body structure to be processed from the material area to the first station. In this way, only one spot welding robot and one transfer robot are needed, and the spot welding processing and production of auto body structure can be carried out more accurately and efficiently.

3. **Three-dimensional modelling of the robot workstation**

3.1. **Three-dimensional model**

The main components of the workstation are robot controller, transfer robot, spot welding robot, spot welding torch, spot welding tip dresser, electrical control cabinet, conveyor belt, workbench, workpiece, robot track and so on. The three-dimensional modelling of most of the models related to robots based on the model library can be conducted by the robot simulation software. Models of robot tracks and workpieces and others need to be drawn by three-dimensional modelling software and then imported into the workstation.

The three views of the three-dimensional model of the robot workstation established by software are shown in Figure 1. The three-dimensional model of the main equipment in the robot workstation is shown in Figure 2.

![Figure 1-a. Front view of robot workstation](image1.png)

![Figure 1-b. Side view of robot workstation](image2.png)
3.2. Setting of robot’s external axis model

In this design of spot welding robot workstation for auto body structure, two work stations are designed, and the welding robot selected is a six-degree-of-freedom vertical structure robot which cannot move freely between the two stations. After the comparison of various design schemes, the design scheme is determined that the work station is fixed and the spot welding robot moves to the station to work.

Firstly, the track model of the external axis of the robot is set up. A three-dimensional model of the chassis (tai) is mounted to a three-dimensional model of its track (conv). Then, a three-dimensional model of the spot welding robot body (DX200-R01) is placed on the cuboid chassis (tai) of the external axis track. In this way, when the workstation is in operation, the track periodically reciprocates from left to right, which can ensure the spot welding robot to work in order between the two stations. The assembly drawing of robot moving track is shown in Figure 3:
Figure 3. Assembly drawing of moving track

After creating the three-dimensional model of welding robot and three-dimensional model of external axis track, it is necessary to set relevant parameters of external axis. First, the external axis coordinate in the Y direction (DX200-R01_y) is created in the robot. Then, in the three-dimensional model tree diagram of the workstation, the chassis (tai) is set as a sub-model of the external axis coordinate (DX200-R01_y). In this way, the three-dimensional model of the chassis (tai) can move along the external axis. The three-dimensional model tree diagram of the robot’s external axis track is shown in Figure 4.

Figure 4. Three-dimensional model tree diagram of robot’s external axis track

4. Work flow analysis

4.1. Overall work flow of the workstation

The work flow of the robot workstation is as follows:

- The spot welding robot moves to the workbench 1.
- Spot welding torch is used for spot welding processing of workpiece 1.
- Spot welding robot moves from workbench 1 to workbench 2.
- The transfer robot starts to transport workpiece 1.
- Spot welding torch is used for spot welding processing of workpiece 2.
- Spot welding robot moves from workbench 2 to the origin and the transfer robot starts to transport workpiece 2.

4.2. Welding process analysis

First, the robot maintains its initial position and posture. The initial state of the robot is taken as the first entry point, whose program instruction is MOVJ. Then, the robot, together with the electrode
holder at its end, moves to the vicinity of the first spot welding target point P1. Here, it is designated as the second entry point, whose program instruction is MOVJ. After reaching the vicinity of the first target point P1, the electrode holder is translated accurately to the position of the first spot welding target point P1. This is the third entry point, whose program instruction is MOVL. After the electrode holder reaches the point of weld P1 accurately, the holder performs the relevant spot welding procedures. When the spot welding is completed at the first target point P1, the electrode holder is moved to the vicinity of the second spot welding target point P2 according to the robot’s movement instruction. After that, referring to the spot welding instruction of the above-mentioned target point P1, we can complete the programming of other spot welding positions.

4.3. Program instruction of the transfer robot
The initial position of the transfer robot is set as the first entry point, and also the end of the program loop.

When the welding robot processes on the first workbench, the transfer robot waits, so a delay of more than 10 seconds should be set before it takes the initial action. After the welding robot completes the welding of the first workpiece, the transfer robot moves to the workpiece, transports the workpiece to the rear conveyor belt through the electrode handler amounted to its flange, and then returns to the initial position.

Later, after the spot welding of the workpiece on the second workbench is completed, the similar procedures for transporting mentioned above are executed.

5. Conclusions
In this paper, three-dimensional simulation design is put forward for spot welding robot workstation of auto body structure. The stability, rationality and effectiveness of the robot simulation welding workstation are studied. The overall work flow of the robot welding workstation is planned. The simulation workstation of spot welding robot is established, which verifies the effectiveness of the designed spot welding robot workstation of auto body structure. By means of simulation design, the manpower, material resources and site resources are saved, and a feasible workstation for auto body structure production is designed, which improves the work efficiency.

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