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Off-line simulation of robot welding of radar pedestal *

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Abstract: A study of the interference simulation based on robot welding of the radar pedestal was carried out by using the KUKA Sim Pro simulation software and off-line program technology. Compared with the actual robot welding process, it was found that the trajectory of the simulated robot welding process in line with that recorded in the actual welding process, and the actual limit and interference appeared at the same place as the simulation process. There was no interference phenomenon on the outside weld-seam; on the internal weld-seam, especially on the weld-joint of support plate connected to the cylinder, a phenomenon of interference appeared. It was helpful to use the simulation method to guide the actual robot welding so as to protect robot from impacting and reduce the weld defects.

Keywords: robot; welding; off-line program; interference; simulation

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1 Introduction

As a kind of traditional manufacturing technology, welding industry was known as high fatalness, heavy dust, much more radiation and bad work environment. Nowadays, with the rapid development of modern manufacturing industry, automation, robotization, and intellectualization of welding process have become important development trends of welding technology [1-2]. And welding automation has been widely used, such as in the automobile industry [3] and the equipment manufacturing industry [4-5]. Robot welding is the most classic automatic welding system, off-line simulation technology is an important technology of this system. Robot off-line programming technology with the advantage of high efficiency, anti-collision and no damage, can use computer graphics technique, to establish the geometric model of robot and its working environment, and it can use some planning algorithms based on the graphic control and operation, to realize the trajectory planning in the case of off-line [6-10].

Radar large components is one of the important weapon equipments at home and abroad, robot welding technology is an important processing technology of this structure. The radar pedestal is an important part of the whole radar antenna system [11], due to the particular weld position of this part, the accurate

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operation of the robot arm is to be limited and intervened [12-15]. The KUKA Sim Pro welding simulation software was used to research interference phenomenons during robot welding process of the radar pedestal, and a proper robot welding off-line program was resaved. Then the actual robot welding of the radar pedestal was carried out to verify the correctness of progam.

2 Moldeling

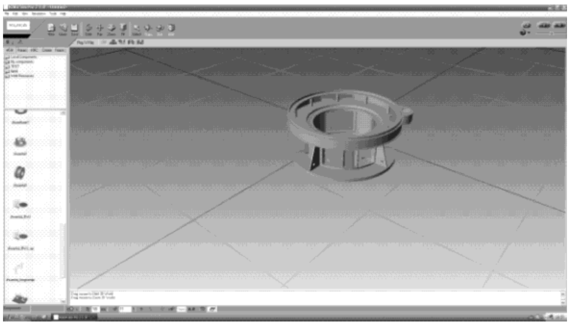
2.1 Modeling of the radar pedestal

The model of radar pedestal was established by Pro/E 3D modeling software according to the assembly drawing, and was imported to KUKA Sim Pro database. Meanwhile, the radar pedestal was disassembled, which was more convenient for simulation software to simulate the actual welding process. And the upper and lower part of the model was colored with the color command respectively, therefore, the process of simulation would be more real and vivid. Fig. 1 shows the imported model.

2.2 Modeling of the welding robot system

The model of the welding robot was imported from KUKA Sim Pro simulation software databases, including two displacement machines and a girder bracket. The welding robot system was built based on the actual size, and the LINKs were set up according to the robot kinematic relations, including the rotation and reversal of displacement machine, horizontal and longitudinal movement of girder, and the 6-axis linkage of welding robot arm. The upper and lower part of the imported model was placed on the right and left of robot welding positioner respectively. The robot system and the radar pedestal were connected by LINK orders. Fig. 2 shows the whole model. In this model system, linkage between each axis can be realized through the movement of the robot arm, and the movement of the base followed the movement of dislocation machine as the actual process, so the simulation of the whole welding system can be realized.

a



b

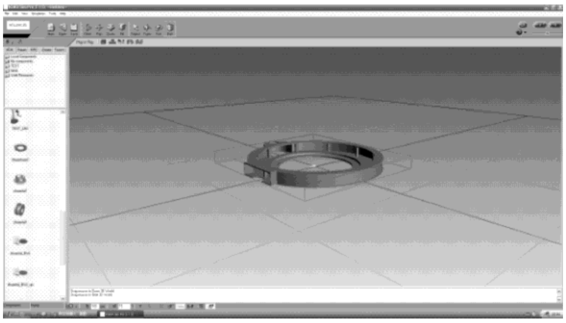


Fig. 1 Imported radar pedestal model of a) the upper part and b) the lower part

3 Interference simulation and analysis

The radar pedestal was a typical cavity parts, which was consisted of complex cylinder and support plates. In the teaching process of welding robot, the interference was easily to take place. It was helpful by simulating to determine the optimal trajectory and direction of the robot arm, which could prevent interference between robot arm and radar pedestal occurring at any time, and so as to guide the actual welding process. Fig. 3 shows the simulated welding situation of the radar pedestal.

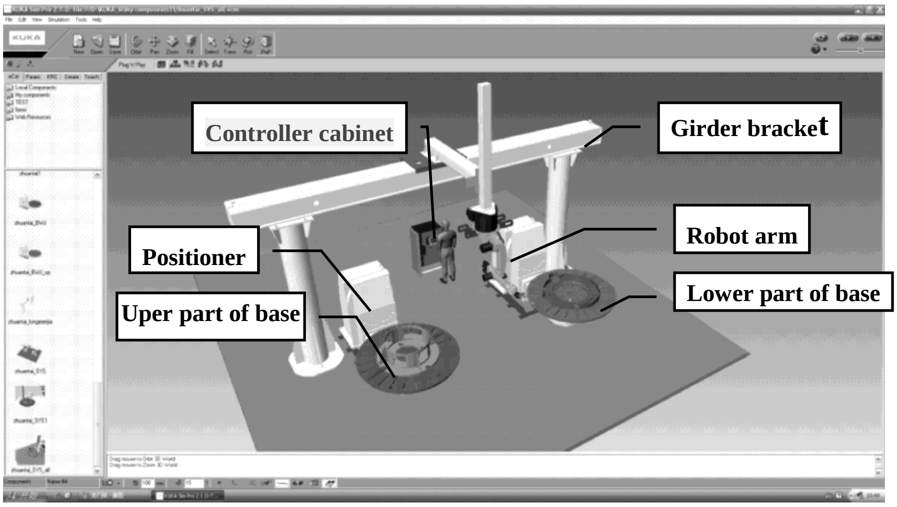


Fig. 2 The integrated model of welding robot system

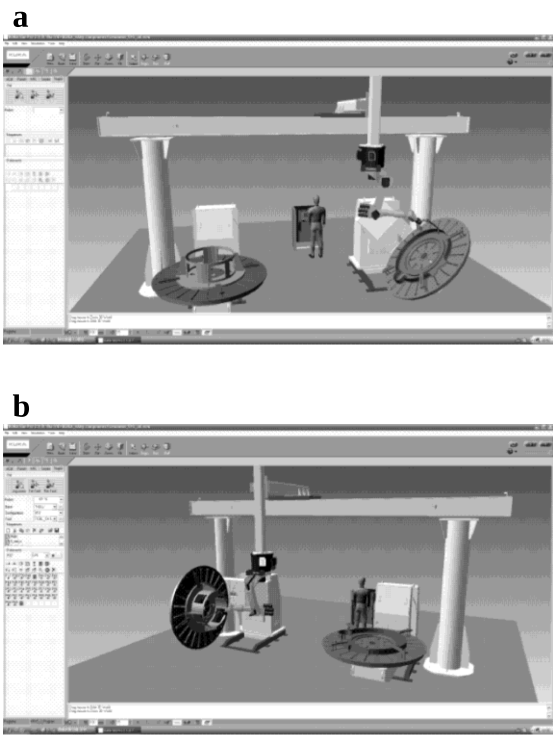


Fig. 3 Welding simulation of radar pedestal of a) the lower part and b) the upper part

The simulation was carried out by KUKA Sim Pro simulation software based on off-line program and the actual welding process. In the simulate program, the null point of robot was set as: (*X*: 13.57 mm, *Y*: −1 690.96 mm, *Z*: 33.60 mm); (*A*: −110.07°, *B*: 39.43°, *C*: −29.92°). In any direction, the distance of robot motion had a maximum value, which was defined as a limit. Normally, the movement of robot was unlimited when the distance did not exceed the limit except that there were some interferences. Once robot's track reached a limit or closed to some interferences, the robotic arm would stop automatically or bump against the barrier, and a warning dialog would emerge (Fig. 4). And the positions of limit and interference could be estimated according to relevant data. Table 1 lists several robot positions of limit and interference as examples.

According to the comprehensive analysis, no interference phenomenon was found on the outside seam of radar pedestal. On the internal weld, especially on the joint of support plate and cylinder, phenomenon of interferences were easy to found, and the robot arm could not reach it normally. A path of robot could be planed by off-line programming according to the simulation, which would insure that when robot approached the limits or barriers, the activated command would be blocked, and a new order would be executed to keep away from these points.

Table 1 Typical points of limit and interference

Interference/limit point No.	Robot position	
	Space coordinate/mm	Spatial orientation/°
1	*X*: –5.23	*A*: –119.00
	Y: –5 479.42	*B*: 86.19
	Z: –2 085.34	*C*: 35.37
2	*X*: 613.02	*A*: –119.02
	Y: –5 490.03	*B*: 86.18
	Z: –2 099.69	*C*: –35.38
3	*X*: 1 815.97	*A*: 51.11
	Y: –2 728.85	*B*: 53.32
	Z: –907.32	*C*: –77.74
4 (a limit)	*X*: 2 316.31	*A*: 48.67
	Y: –3 517.23	*B*: 79.52
	Z: –6 723.51	*C*: –127.89

4 Comparison and analysis

The off-line program received in simulation was imported to the teach pendant, and the actual soldering was carried out by KUKA (KR16) robot. The null point of robot must be the same with the simulated one. Fig. 5 shows an actual welding situation. Comparing the results of simulation process, it was found that the actual welding procedure was consistent with the path of the simulated process, and the interference and limit appeared at the same position as that happened in the simulation procedure.

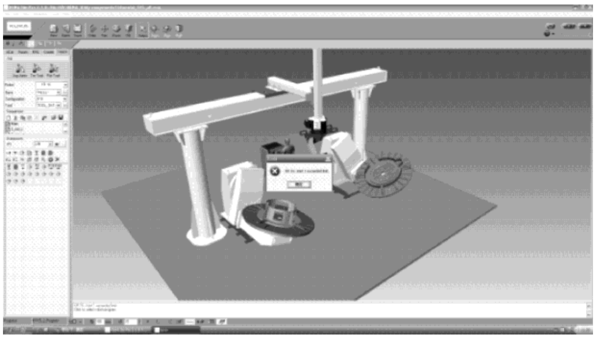
5 Conclusions

The interference simulation of radar pedestal robot welding was carried out. Comparing with the actual welding process, the following ideas can be summarized:

In the robot welding process of radar pedestal, there was no interference phenomenon on the outside weld. On the internal weld, especially on the joint of support plate connected to the cylinder, a phenomenon of interference appeared, and the robot arm could not touch it normally. The simulated trajectory of robot welding process was roughly consistent with that of the actual welding, and the interference situation was basically identical. The validity of the simulation method was verified, and it was helpful to use this simulation method and typical interference situations to guide the welding production of the similar products.

The off-line program technology was useful to increase productivity and protect the robot from impacting.

a



b

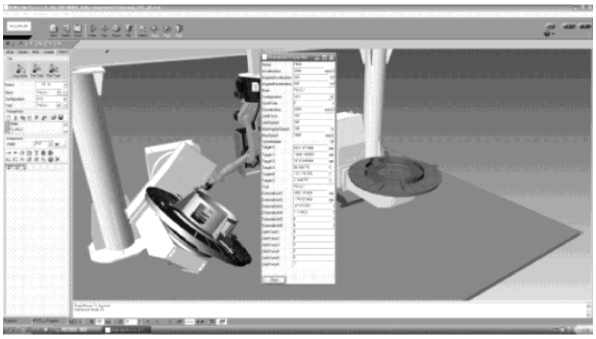


Fig. 4 a) Welding robot alarm window and b) interference alarm data graph

Fig. 5 Actual welding scene of welding robot

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