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Improving the Quality of Welding Seam of Automatic Welding of Buckets Based on TCP

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Abstract: Since February 2014, the welding defects of the automatic welding line of buckets have been frequently appeared. The average repair time of each bucket is 26min, which seriously affects the production efficiency and welding quality. We conducted troubleshooting, and found the main reasons for the welding defects of the buckets were the deviations of the center points of the robot tools and the poor quality of the locating welding. We corrected the gripper, welding torch, and accuracy of repeat positioning of robots to control the quality of positioning welding. The welding defect rate of buckets was reduced greatly, ensuring the production efficiency and welding quality.

1. Introduction

The Tool Center Point (TCP) of robots is the relative position between the center of the six-axis flange plate of the robots and the end of welding torch. The robots record the position information of each axis of the robots through a Resolver Digital Converter (RDC). Because of the welding deformation of the small assembly or the dimension error of the single plate, The deviation of workpiece is unavoidable in the process of assembly and these deviated robots conduct automatic compensation by the locating and arc tracing, while TCP is the precondition of locating compensation error. When the TCP is deviated, the corrected arc-start point and the arc-end point will also be deviated, which leads to the deviated welding of the arc-start point and the arc-end point. For welding seam that is suitable for arc tracing, even if there is a small deviation in the arc-start point, the welding seam can automatically make alignment through arc tracing. But when welding is not suitable for the welding seam with arc tracing (such as the butt welding seam, the welding seam with too large swing, the welding seam with too small welding angle, etc.), if the arc-start point or the arc-end point is deviated, the whole welding seam will have deviated welding; the structures of buckets are complex; there are many types of the butt welding seam or lap welding seam; the plates are thin, which is not conducive to locating of robots. When TCP is deviated, welding seam defects are continuously appeared. When welding arc, the robots automatically establish a theoretical arc through the arc-start point, the arc-auxiliary point, and the arc-end point recorded by RDC, and the theoretical arc establishes the

actual arc through the TCP relationship. When TCP is deviated, the established actual arc will be deviated, which will lead to deviated welding and collided welding torch.

2. Summary Questions

Since February 2014, the welding defects of the welding line of buckets have been frequently appeared. The time of repair welding was long with high labor intensity. At the same time, 2-3 technicians in each shift were required to carry on-site tracking service for the robot groups, seriously affecting the production efficiency. Table 1 The quality feedback of automatic welding of 5T bucket on March 2, 2014.

Table 1. The quality feedback of automatic welding of 5T bucket

Buckets No.	Welding defect positions and defect types	Defect length	Repair time
11402465	1. Deviated weldings in 6 reinforcing bar plates. 2. Bended reinforcing bar plates-deviated weldings in wall plate of buckets. 3. Plates of large blade-incompletely filled welding in the bottom protection plates of bucket.	1160mm	24 min
11402468	1. Deviated weldings of U-type cover plates. 2. Deviated weldings in 6 reinforcing bar plates. 3. Wall plate of bucket-deviated weldings in the side plate of bucket. 4. Plates of large blade-Air hole and deviated weldings in wall plate of bucket. 5. Incompletely filled welding in the bottom protection plates of bucket of plates of large blade.	1370mm	30 min
11402480	1. Wall plate of bucket-deviated weldings in the side plate of bucket. 2. Incompletely filled welding in the filled plug welding seam of T-type bar plates. 3. Plates of large blade-Deviated weldings in wall plate of bucket.	1160mm	26 min
11402201	1. Deviated weldings in 6 reinforcing bar plates. 2. Wall plate of bucket-deviated weldings in the side plate of bucket. 3. Bended reinforcing bar plates-deviated weldings in wall plate of buckets.	1000mm	18 min
11402483	1. Deviated weldings in 6 reinforcing bar plates. 2. Bended reinforcing bar plates-deviated weldings in wall plate of buckets.	700mm	14 min
11402507	1. Deviated weldings in 6 reinforcing bar plates. 2. Wall plate of bucket-deviated weldings in the side plate of bucket. 3. Bended reinforcing bar plates-deviated weldings in wall plate of buckets. 4. Incompletely filled	1800mm	38 min

	welding in the filled plug welding seam of T-type bar plates.		
11402505	1. Deviated weldings in 6 reinforcing bar plates. 2. Plates of large blade-incompletely filled welding in the bottom protection plates of bucket. 3. Bended reinforcing bar plates-deviated weldings in wall plate of buckets.	950mm	16 min
11402503	1. Deviated weldings in 6 reinforcing bar plates. 2. Wall plate of bucket-deviated weldings in the side plate of bucket. 3. Plates of large blade-incompletely filled welding in the bottom protection plates of bucket. 4. Bended reinforcing bar plates-deviated weldings in wall plate of buckets.	1750mm	34 min

From table 1, it can be seen that the deviated weldings of buckets, air holes, undercutting, incompletely filled welding, and other defects are serious. The average repair time is 26.4min, becoming the bottleneck of loader production.

Problem Analysis and SolutionWe arranged and analyzed the welding defects, and found that the root reasons for the welding defects of the buckets were the TCP deviations and the poor quality of the locating welding table 2.

Table 2. Causes and solutions for the welding defects of the buckets

Defect Types	Defect Reasons	Solutions
Deviated weldings in 6 reinforcing bar plates.	1. The reinforcing bar plates in positioning welding were not straight (tooling deformation of reinforcing bar plates; operation of positioning welding was not standard). 2. TCP deviation.	1. Adjust tooling of reinforcing bar plates. 2. Control the quality of positioning welding. 3. Correct TCP.
Deviated weldings in U-type plates	1. TCP deviation. 2. The greater error of the assembly (operation of positioning welding was not standard; some operators directly conducted assembly without make lines).	1. Correct the TCP. 2. Control the quality of the assembly, and strengthen the inspection of incoming materials before complete welding.
Plates of large blade-Air hole and deviated weldings in wall plate of bucket.	1. TCP deviation. 2. The incoming materials of knife plates were unqualified.	1. Correct TCP. 2. Control the pass rate of incoming materials; prohibit assembly of unqualified single board pieces.

3.Quality Improvement of Positioning Welding

When the buckets were under assembly, there were many single board pieces; the types of welding seam were complex; the cumulative deformation was relatively large; some operators did not have

strong sense of responsibility, and lacked of work experience. All these resulted into poor quality of assembly point of the buckets. Combined with the structure forms of the loader products, the welding programming office of the technical department now develops the general norms for positioning welding as follows.

We strictly control the pass rate of incoming materials, prohibit the use of expired the single board pieces not meeting the requirements of the process, and timely respond to the leaders in related process section. 2) We require the assembly to be conducted in strict accordance with drawings. For the welding seam required to leave a gap by process, we strictly control the gap of assembly within the tolerance range. 3) We try our best to use the tooling or the underlined template to make the assembly, in order to ensure the consistency of assembly of workpiece. 4) We forbid personal increase or decrease of spare parts. If the structure is changed, this must be notified to the programming office in advance. 5) If the inner opening welding seam requires the robots to conduct welding, the process tie bar must be underlined for assembly. The length of the tie bar should be equal to or slightly larger than the opening size, and the height of the tie bar should be controlled15mm below as far as possible. 6) If the gap of assembly caused by accumulated error of the assembly is greater than 1.2mm, the small welding parameters must be used to fill the gap. The height of filled welding seam is advisable to the height of filling the gap of assembly. It is strictly prohibited to appear soybean welding and residual welding wire. 7) It is strictly prohibited to conduct assembly in the single board pieces with label paper. We must fix the label paper position in the structure of the finished spot welding, and the label paper position shall be away from the welding seam and shall not fall off easily. 8) Within the 30mm range from the arc-start point, it is prohibited to conduct spot welding in the arc-start point and the arc-end point, so as to prevent that the welding points affect the robots' data acquisition on arc tracking and debugging of welding posture. 9) For the T-joints whose height of vertical plate are 5mm higher than those of the theoretical welding, the spot welding requirements are shown in the requirements 8. 10) For the T-joints whose height of vertical plate are 5mm lower than those of the theoretical welding (such as the pasting board and the joints requiring the end of the full welding to connect the T-joints), within the 60mm range from the arc-start point or the arc-end point, it is prohibited to conduct spot welding, but we require the spot welding with multiple welding points, small and high welding (the welding height of spot welding is not 0.5 times greater than that of the theoretical welding height), so as not to affect the robot locating and welding. 11) For the butt welding seam in the end of single groove, we should avoid the spot welding within the groove. If the spot welding within the groove is unavoidable, the welding height of spot welding should not be 0.5 times greater than that of the theoretical welding height. 12) For the welding seam with ladder-like transition, we should conduct spot welding at the ladder, so that the welding of robots can be smoothly transited during the transition (such as the welding seam composed by bucket hinge plate-wall plate of bucket-bended reinforcing bar plates). 13) Within the 30mm range from the straight line segment, the tangent point of straight line and the arc, and the midpoint of the arc, it is prohibited to conduct welding, so as not to affect the robot locating and welding posture debugging. 14) In the positions of 0°, 90°, 180°, and 270° of the circle, it is prohibited to conduct spot welding, so as not to affect the robot locating. The length direction of the workpiece is X-axis) 15.When conducting spot welding on the first new product, the technicians of the programming office must confirm it, and also determine the unfinished spot welding requirements on-site.

Through training the operators on site, we control the quality of spot welding of buckets, paving the

ground for subsequent automatic welding of robot.

4. Improvement of TCP Precision

The reasons of the robot's TCP deviation mainly include four aspects: welding torch deformation, gripper deformation, anti-collision deformation, and motor reducer failure. The failure of the motor reducer directly affects the repeated positioning accuracy of the robots. We used the inside micrometer to detect the repeated positioning accuracy of the various axes of 24 robots, got the results, and we found that the repeated positioning accuracy of the 24 robots were all within the error range, thus eliminating the influence of the fault of the motor reducer on the TCP deviation.

As a safety protection device for the robot system, anti-collision Figure 1 is installed in the center of 6-axis flange of robots and is connected with the upper part of the gripper of welding torch. Anti-collision is a constant closed loop under work. When the welding torches are collided, the anti-collision built-in spring Figure 2 occurs elastic deformation, and the constant closed loop disconnects. The anti-collision effects, and the robot control system is outage shutdown. After the long-term use of anti-collision, the built-in spring occurs plastic deformation, and TCP is deviated. We conducted troubleshooting on the collision prevention of the 24 bucket robots, and found that the anti-collision springs of No. 2 machine in 5T bucket line and No. 12 machine in 3T bucket line were deviated, and we replaced the anti-collision springs in time.

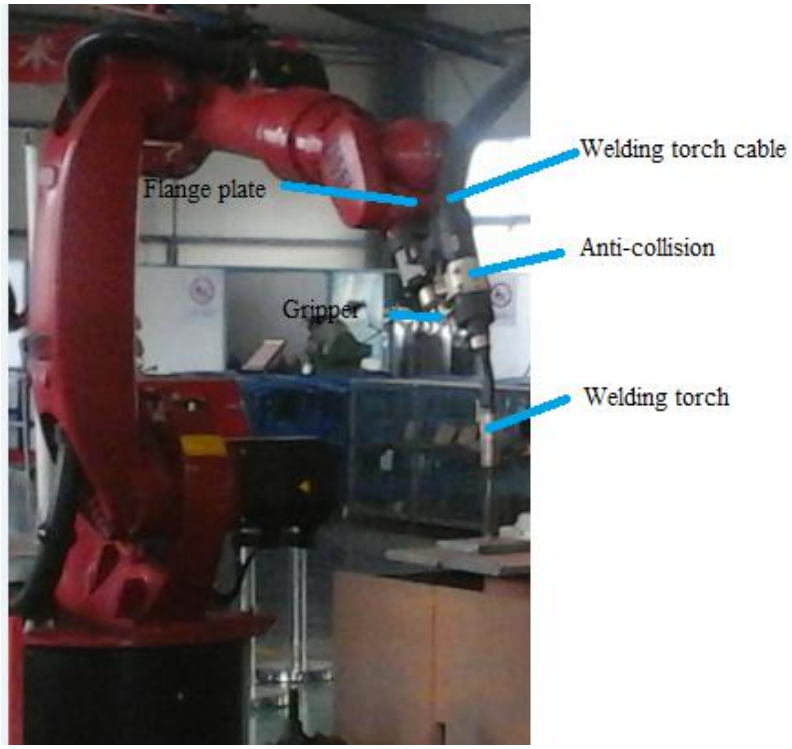

Figure1. Assembly diagram of accessory parts of robots

Figure 2 .Anti-collision structure diagram

5. Conclusion

The product quality is related to the survival and development of enterprises. With the aging of equipment and product transformation and upgrading, the market has put forward higher requirements on product quality, and the bucket welding production line also have a long way to go. However, no matter how the market changes, as long as we adhere to the quality concept, we adopt scientific analysis means coupled with effective coordination among departments, and we believe that we can solve any encountered difficulties in the future.

6.Reference

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