The Quality Control of Oil Leakage in Weld Seam of Small Head Rod of a Common Piston Rod

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Abstract. We study mainly the reasons of shallow insertion depth of positioning sleeve of piston rod, welding sequence, welding parameters and small foot size. Then, we take the following measures, such as improving the welding sequence and position, strictly controlling welding process parameters, improving the quality awareness of welding operators and controlling the depth of positioning sleeve. Finally, we have perfectly controlled the quality problem of plugging and welding oil leakage of the small end rod.

1 Introduction
The 21st century is a century of quality. With the deepening of China's globalization process, various products have participated in international market competition, and product quality has become the main problem for domestic products to further expand the market and enter high-end [1]. The hydraulic cylinder is an actuator commonly used in hydraulic system [2]. It is a device that converts liquid pressure into mechanical energy. The pressure relief caused by oil leakage of hydraulic cylinder is one of the main reasons that make the hydraulic cylinder lose its function. The products described in this paper are used for crane telescopic boom [3]. Because the telescopic boom of crane produced now has no self-locking function, once oil leak occurs, it will lead to rapid retraction of telescopic boom, and the result is machine destruction. Most of the oil leakage of hydraulic cylinders is caused by the welded joints, so it is urgent to solve the problem of oil leakage caused by welds [4].

2 Structure of QY12.16II Piston Rod
This paper takes the QY12.16II piston rod of a large crane manufactured by a factory in Xuzhou City, China as an example. The piston rod is mainly composed of 45 # steel rod body and core pipe (as shown in Figure1). The core pipe is welded by 45 # steel rod plug, 20 # steel tubing and 45 # steel earrings.

Figure 1. The appearance structure of QY12.16II piston rod
The welding equipment used on the small end rod plug is Panasonic KR500 gas shielded welding machine with 10-meter derrick rubber pulley. The welding wire used is ER50-6, and the welding position is the weld path composed of rod body, rod plug and positioning sleeve. The leakage location is shown in Figure 2.

![Figure 2. Oil Leakage Location](image)

3 Analysis of the Main Causes of the Problem

The length of QY12.16II piston rod is 7 meters. Although three supporting plates are added to the core tube (as shown in Figure 3), it is unavoidable that the welding seam with one end of the positioning sleeve will be cracked due to the restraint of rod diameter and the influence of gravity [5]. At the same time, due to the unreasonable welding sequence of operators and the factors such as operation without drawing process and welding defects, the oil leakage in the weakest part of the product. the oil leakage in the welding zone, was detected at the pressure test station.

![Figure 3. Distribution of the supporting plate position](image)

After in-depth analysis, the specific causes of oil leakage in welds are as follows:

3.1 Improper insertion depth of positioning sleeve

The operator has great randomness in the process of assembling the positioning sleeve for the drawing does not specify the depth of the positioning sleeve, the QY12.16II piston rod does not need to determine the coaxiality between the rod plug and the rod body and the piston is directly mounted on the rod body. As shown in Figure 4, many operators just put the positioning sleeve in 3-5 mm to catch up with the production schedule and began to weld[6].

![Figure 4. Depth of placement of positioning sleeve](image)
Because the depth of the positioning sleeve is too shallow, which makes the actual size of the cross-section weld very small, and thus reduces the strength of the weld, so under the action of stress, cracks easily occur, and there will be oil leakage in the pressure test station [7]. Because the shallow depth of the positioning sleeve will not only cause the weld strength to be insufficient, but also bring inconvenience to the welders, so the welders must always pay attention to the change of the pool, otherwise, there will be welding deviation and excessive weld height[8]. In the case of welding deviation and excessive weld residual height, there will be welding defects such as non-fusion, which will eventually lead to oil leakage in the weld. Because the excess height of the weld is too high, the operator will not have the opportunity to repair the weld twice. The final solution is only to go to the lathe and re-weld the weld to solve the problem of oil leakage, which is time-consuming and labor-consuming.

3.2 Inappropriate welding parameters and foot size
For the workers who have been engaged in welding for a long time, most of them are skilled and familiar with the workpiece. Usually, they use 280-300A current and 30-32V voltage to weld, which makes the welding heat input too large and easy to occur such problems as undercut, depression and overheating of heat affected zone. Even in the process of welding, because the welding moving speed is faster than the metal melting speed, the phenomenon that the weld is not fused and penetrated appears. As a result, a large number of welding defects and welding stress concentration will occur, so that the strength of the weld is not enough, and cracks will occur in the weld under the action of stress, resulting in oil leakage.

3.3 Inappropriate welding sequence
After controlling the depth and process parameters of the positioning sleeve, the most important thing is to find a correct welding sequence to effectively guarantee the welding quality. As shown in Fig. 5, the operators usually start the arc at 6 o'clock and complete the welding of the workpiece by three-layer and three-pass welding. Because of the large width of the end weld, there is still a large gap after twice welding at 6 o'clock, but this gap can’t be welded twice, so the operator usually only welds once again to complete the welding. As the gap of the last pass is much smaller than that of the first two, it is easy to form a pit when the molten pool metal flows down from the weld in the last pass. At the same time, it is unavoidable that the joint will appear again.

![Figure 5. Inappropriate welding sequence](image)

In addition, QY12.16II piston rod should be tested after welding, which belongs to pressure vessel welding. It is taboo to frequently occur joints. Some operators also use four-pass four-layer four-pass welding sequence, but the appearance of the weld after four-pass welding is very poor. Finally, all operators adopt three-layer three-pass welding method. Although this method has a good shape, compared with four-layer four-pass welding, three-layer three-pass welding is difficult to effectively control oil leakage of piston rod small head rod. Moreover, arc welding at 6 o'clock requires the operator to be steady and observe the molten pool carefully. A slight tremor in the
welding process will be welded to the piston rod, which will lead to the scrap of the piston rod due to de-chromium, so improper welding sequence will lead to oil leakage.

4 Solutions to the Problem

4.1 Strictly control the insertion depth of positioning sleeve
According to the label on the drawing, when the positioning sleeve is placed at a depth of 8 mm, the positioning sleeve does not need spot welding positioning. Because the matching of positioning sleeve and rod body and rod plug is over-matching, the welding process will not be loose or deformed, so before welding, the depth of positioning sleeve should be strictly checked to ensure that each product positioning sleeve is positioned, and ensure that the positioning sleeve is positioned and not deviated. In this way, the weld seam after welding is also very flat, ensuring that the size and strength of the weld seam specified in the drawings are obtained, preventing cracks and reducing oil leakage.

4.2 Selection of Reasonable Welding Process Parameters
In production, we revised the reasonable welding parameters according to the welding operation instructions and a large number of test instructions, as shown in Table 1.

| Table 1. Reasonable welding process parameters |
|-----------------------------------------------|
| Welding Current [A] | Voltage [V] | Gas flow rate [L/min] | Number of welding layers | Welding speed [mm/s] |
|---------------------|------------|-----------------------|--------------------------|---------------------|
| First layer         | 200-220    | 22-24                 | 2                        | 5-6                 |
| Second layer        | 180-200    | 20-22                 | 15-20                    | 2                   |

With the above welding parameters, we can ensure penetration, weld size and appearance, avoid undercut and heat affected zone overheating, reduce welding stress and weld crack probability, and improve weld strength and quality.

4.3 Selection of Reasonable Welding Sequence
Since the oil leakage quality accident was discovered, we have carried out theoretical analysis and many welding experiments, and found a good welding method (as shown in Figure 6). This welding method can effectively reduce the occurrence of oil leakage. Firstly, we change the number of welding layers from three-layer three-pass welding to two-layer four-pass welding. The second layer of welding is beneficial to improve the first layer of weld structure and make up for the welding defects of the first layer. Secondly, we changed the position of the torch to weld 1 weld at 11 o'clock, then 2 weld at 6 o'clock, 3 weld at 11 o'clock and 4 weld at 6 o'clock. The 1 and 3 welds made arc blocking to the rod and increased the fusion of rod plugging and positioning sleeve. The 2 and 4 welds made arc blown to the rod body to promote the rod body and rod body. The fusion of positioning sets. Such a pressure together can ensure compactness and penetration.
Figure 6. Welding sequence and position after changing

4.4 Preheating before welding and heat preservation after welding
In order to reduce the cracks of 45# steel during welding, workers are urged to take pre-heating and post-welding insulation measures strictly according to the process requirements. The specific approach is to use oxygen acetylene flame to preheat 100–150 °C, then welding. Local heater is used for 0.5-1 hour after welding, and the holding temperature is 250-280 °C. The cooling rate is delayed, the hardening degree of weld and heat-affected zone is reduced, the crack generation is reduced, and the oil leakage caused by crack is greatly reduced.

5 Effect of measures taken
After taking the above measures, the quality inspectors randomly sampled 60 pieces of small head rod plug of QY12.16II piston rod. The test results are shown in Table 2. From Table 2, we can see that the oil leakage rate of QY12.16II type decreased from 20% to 5% after taking measures, which effectively controlled the oil leakage of plugging weld of piston rod small head rod. It shows that the above measures are feasible.

| Table 2 Sampling results before and after taking measures |
|---------------------------------------------------------|
| Total production | Number of oil spill products | Oil leakage ratio |
|------------------|-----------------------------|------------------|
| Before improvement | 60                          | 12               | 20%              |
| After improvement | 60                          | 3                | 5%               |

6. Conclusion
In this paper, we mainly study the quality control measures of plugging weld of small end rod. After analyzing the reasons that affect the weld quality, such as shallow insertion depth of piston rod positioning sleeve, welding sequence, welding process parameters and small foot size, we take measures to change the welding sequence and position, strictly control welding process parameters, improve the quality consciousness of welding operators, and control the depth of positioning sleeve. Through the above measures, the quality of our welds has been greatly improved, and the problem of oil leakage has also been solved.

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