The Control of Welding Deformation of the Three-Section Arm of Placing Boom of HB48B Pump Truck

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Abstract: The concrete pump truck is the construction equipment of conveying concrete with self contained base plate and distributing boom. It integrates the pump transport mechanism of the concrete pump, and the hydraulic roll-folding type distributing boom used to distribute materials, and the supporting mechanism into the automobile chassis, and it is the concrete conveying equipment with high efficient and the functions of driving, pumping, and distributing materials. The placing boom of the concrete pump truck is the main force member in the pump parts with bearing great pressure, and its stress condition is complex. Taking the HB48B placing boom as an example, this paper analyzes and studies the deformation produced by placing boom of pump truck, and then obtains some main factors affecting the welding deformation. Through the riveter “joint” size, we controlled the process parameters, post-welding processing, and other aspects. These measures had some practical significance to prevent, control, and reduce the deformation of welding.

1. Use Background of Concrete Pump Truck

The concrete pump truck is a special vehicle which integrates the pump transport mechanism used for pumping concrete and the boom used for distributing materials into the automobile chassis. When under working, it uses the power of the diesel engine in the automobile chassis; passes the power to the hydraulic pump through the transfer case; and then drives the concrete pumping mechanism and the boom system; the pumping mechanism adds pressure on the concretes in the hopper and pumps them into the pipe; the pipe is attached to the boom; the boom can be moved; the concrete pumped out by the pumping mechanism will be directly sent to the pouring point. Compared with other pumps, the pump truck has the following advantages. 1. The pipe is attached to the boom. When the pump truck is driven to the workplace, it can soon open the boom and work. The preparation time is short, and usually the the pump truck is ready for work within half an hour. 2. The pump truck is equipped with hydraulic roll-folding type boom, which can flexibly rotate within the scope of work. The distributing material is convenient with fast pumping speed generally within 903-1503 m/h, and the work efficiency is high. 3. The degree of automation is high. Only one person can operate the entire pump from the pumping to the distributing material. The pump truck is generally equipped with wireless remote control system, easy to operate. 4. The maneuverability is good. After the completion of one project, the pump truck can quickly come to another project for continuous operation, and the pump truck can simultaneously pump concrete to several projects, so the equipment utilization rate is high. The pump truck was first used in 1979 in China. Then, the pump trucks were introduced from Japan, and then they were constructed in Shanghai Baosteel. In 1982, the Hubei Construction
Machinery Factory introduced the boom production technology from Japan IHI Corporation and began to produce pump truck, so the Hubei Construction Machinery Factory became the first concrete pump truck production plant. With the development of the construction industry, the pump manufacturers are gradually increased, but the booms were mostly imported in the beginning. Now, the production supporting mode of the booms is mainly homemade with auxiliary import. In 1999, the SANY Heavy Industry Co., Ltd began to develop its own 37-meter-long concrete pump truck, becoming the earliest enterprise to self-develop the long boom concrete pump truck.

2. The Main Description of the Three-Section Arm

The main structures of the three-section arm are composed of base plates, side plates, cover plates, bar plates, reinforced plates, and axle sleeves. The axle sleeves in the front and rear end of the three-section arm have the role to connect the second and the fourth arm. In the welding process, the front and rear end of the three-section arm are deviated in the horizontal direction. In the welding process, the welding parts of the undertaking axle sleeves produce the angular deformation and distortion deformation, mainly resulting into this problem. The welding deformation caused by the welding seam in the front and rear ends of the side plates makes the dimension deviation appeared in the front and rear ends exceed the technical requirement of 2mm. This does not conform to the production process requirement, and the product quality is not guaranteed, resulting in unnecessary rework and repair as well as reducing the production efficiency.

3. The Deformation Cause of HB48B Three-Section Arm

3.1 Dimensional Deviations Caused in Splicing

The axle sleeves in the two ends of the three-section arm and the side plates formed an annular welding seam; the side plates and the cover plate lap of base plate formed the main welding pass; the welding seam had the V-shaped groove. The material of the plate parts was the WELDOX700 low-alloy high-strength steel; the groove angle was 40°; the thickness of plate was 12mm. The joint type was the butt joint; the butt welding seam was formed after welding; the flat welding was used in the welding position, as shown in Figure 1 and 2. Because some steel plates were bended in the material-discharging, this led to overall not too flat the cover plate of the base plate. Moreover, in the splicing process of riveters, the process was not strictly controlled with assembly error, resulting in the uneven gap of welding seam of red arrow. The gap exceeded the 0-1mm stipulated by the process. The welding pass size of the annular welding seam in the axle sleeves was uneven, and a gap was appeared among the base plate, the cover plate, and the side plate. This caused the too big partial hot input, so the heat was too concentrated, thus producing the welding deformation after welding by welder.

3.2 Wrong Welding Order

The welding order has a great influence on the welding residual stress and deformation, and the distribution law of residual stress can be changed when different welding sequence is adopted, which has a great effect on controlling the welding deformation. Especially in the welding lap plate, the
welding seam distribution is more concentrated and the function is more obvious. In order to prevent leakage welding, the welder often first conducted bottom welding on the two welding seams in the side plate and the base plate, and then turned over the welding parts. The welder then welded the main welding pass in the side plate and the cover plate. It is shown in Figure 3 below.

![Figure 3 Wrong welding order](image)

If we first finished welding the four main welding seams, and then if we welded the inner welding seams and the annular welding seams in the axle sleeve, this welding method could not make the cover plate, the axle sleeve and the side plate effectively rigid fixed, resulting in the welding deformation. Furthermore, in the actual welding process of the main welding pass, the welders did not use decentralized symmetrical welding, but they often directly used continuous straight-through welding, so that the heat of the whole welding seam was more concentrated and uneven distribution, which made the components produce greater internal stress and increased the amount of deformation.

### 3.3 Unreasonable Selection of Welding Parameters

Because the HB48B three-section arm uses the 12mm WELDOX700 high-strength steel plate, the process guidance book requires that we adopt the 3-layer 3-way welding, and it also requires that we preheat the welding seam 100-150 °C before welding. Meanwhile, it also requires that we control the temperature among layers within 150-170 °C in the welding process. In actual production, due to the heavy production task, in order to complete the daily production task as soon as possible, the workers often adopted incorrect welding parameters, as shown in table 1. The workers increased the current and voltage without preheating, and also increased the thickness of the bottom welding. Meanwhile, they did not pay attention to control the temperature among the layers, resulting in increased welding heat input, heat concentration, and increased deformation.

**Table 1 The actually used welding parameters**

| Welding layers | Welding method | Welding position | Method of moving welding rod | Welding materials | Welding current (A) | Arc voltage (V) | Welding speed (cm/min) | Gasflow (L/min) | Welding torch angle (°) |
|----------------|----------------|------------------|----------------------------|-----------------|-------------------|----------------|------------------------|-----------------|------------------------|
| The first layer | CO₂ gas-shielded welding | Flat welding | Flat welding | SLD-70 diameter 1.2 | 260~280 | 26~28 | 36~40 |
| The second layer | | | | | 260~280 | 26~28 | 32~36 | 15~25 | 40~55 |
| The third layer | | | | | 280~300 | 28~32 | 30~32 |

### 3.4 Unreasonable Display of Welding Parts

Because the three-section arm was a Z-type structure. When welding both ends, it required that backing plates were used to make completely flat two ends and parallel both ends of the arm. But in
the actual welding, in order to improve production efficiency, the welders would often ignored the parallel, resulting in unnecessary welding deformation as shown in Figure 4.

Figure 4 Wrong placement when welding

4. Measures for Controlling Deformation of HB48B

4.1 Guaranteeing the Quality When the Arm is in Splicing

In the bended plate connected by the base plate, the cover plate, and the side plate, for the positions with gaps, we used hammer to hit them and made the gaps reduced to the technical requirements of the 0-1mm, and we ensured that the surrounding gap of the annular welding seam connected by the side plate and axle sleeve was even. After completing the splicing, we reasonably reinforced the entire arm, and we welded 40mm every 30cm, guaranteeing the rigidity strength of steel plate connection, in order to control the welding distortion.

4.2 Reasonable Selection of Welding Order

According to the degree of contraction, we first welded the welding seam with small shrinkage, and then we welded the long welding seam with large shrinkage. After this, we conducted bottom welding on the axle sleeve and the base plate of the side plate near the axle sleeve. Finally, we welded the inner welding seam. After all welding seams were completed, we welded the cover plate. The welding order could effectively connect the axle sleeve, the side plate with the base plate. For the welding seam of the side plate near the welding axle sleeve, the welding order could prevent the welding deformation, could effectively fix welding, and could reduce the welding deformation.

4.3 Reasonable Selection of Welding Parameters

The welding parameter requirements for the three-section arm in the HB48B Welding Operation Guide are shown in table 2.

| Welding layers | Welding method | Welding position | Method of moving welding rod | Welding materials | Welding current (A) | Arc voltage (V) | Welding speed (cm/min) | Gas flow (L/min) | Welding torch angle (°) |
|----------------|----------------|------------------|-----------------------------|------------------|-------------------|----------------|------------------------|----------------|------------------------|
| The first layer | MAG welding    | Flat welding     | SLD-70 diameter 1.2 circle reciprocating |                  | 240-250          | 23-26          | 32-36                  |                |                        |
| The second layer|                |                  |                             |                  | 250-260          | 24-26          | 30-32                  | 15-25          | 40-55                  |
| The third layer |                |                  |                             |                  | 240-250          | 26-28          | 28-30                  |                |                        |

And it requires the welding pieces to be preheated to 100-150 ℃ before welding. The welding torch is perpendicular to the base material, and the angle between the welding torch and welding seam is 40-55°. The welding wire grade is SLD-70 wire. We require that we use the welding parameters in strict accordance with the requirements of the welding operation guidance book in the welding process, and we require that we can conduct welding after we preheat the welding seam within 100-150 ℃.
During the welding process, we pay attention to control the temperature among the layers within 150-75 °C. Using this welding method can not only improve the weld quality, but also make the welding seam heat even. It also reduces the concentration of heat, and effectively reduces the welding deformation.

4.4 Reasonable Placement of Welding Parts

According to the drawings as well as the actual size of the three-section arm, we developed backing plate with suitable height, which could guarantee the parallelism of the three-section arm in the production. The appropriate use of backing plate avoided workpiece hit the ground in the turning and reduced unnecessary deformation. It is shown in Figure 5 below. In the figure 5, h=570mm.

![Figure 5, the three-section arm](image)

4.5 Flame Correction

After the welding of the three-section arm was finished, we measured the three-section arm. If the measured results were different to those in the process sizes of the drawings, we conducted flame correction on the arm. The flame correction used linear heating method, using 700-800 °C. We used infrared thermometer for real-time measurement to ensure the accuracy of the temperature. After the correction was completed, the welding parts were measured again.

4.6 Control Results

After we applied the series of measures mentioned above to measure the deformed parts, the deformation errors were all within 2mm, which conformed to the requirements of the process technology completely. The problem of assembly interference caused by welding deformation was avoided. The comparison before and after controlling deformation is shown in table 3.

| Numbers of welding groups | The deformation before improvement (mm) | The deformation after improvement (mm) |
|---------------------------|----------------------------------------|----------------------------------------|
| The first group           | 1.5                                    | 0.8                                    |
| The second group          | 1.8                                    | 0.9                                    |
| The third group           | 3                                      | 1.2                                    |
| The fourth group          | 2.2                                    | 1.1                                    |
| The fifth group           | 5                                      | 1                                      |
| The sixth group           | 4.5                                    | 0.9                                    |
| Mean                      | 3                                      | 0.98                                   |

Conclusion:

In the manufacturing process of the arm supports, we ensured the quality of the arm in splicing, reasonably selected the welding orders and the welding parameters, and we reasonably placed the welding parts and corrected flame. After we applied the series of measures mentioned above to measure the deformed parts, the deformation errors were all within 2mm, which conformed to the requirements of the process technology completely.

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