

Welding technology of ultra high voltage transmission steel pipe tower butt welded joint by MIG welding

Hanyang^{1,a}, Liyang², Tangyanling³

¹ State Grid of China Technology, Ji'nan, Shandong 250000, China

² State Grid of China Technology, Ji'nan, Shandong 250000, China

³ State Grid of China Technology, Ji'nan, Shandong 250000, China

^a Hanyang: hy19870604@163.com

Abstract. In twenty-first Century, China vigorously promoted the research and construction of AC and DC transmission technology in order to ensure the optimal allocation of energy resources in a large scale^[1]. The transmission line is the core of the power grid, which plays the role of transmission, transformation and distribution of electric energy, and each tower is the core component of the transmission line. At present, because the force of the steel tube tower is more reasonable, it has been widely used in the construction of UHV, and the link of the key position of the steel tube tower is welded, so the quality of the welding is of great significance to the construction of the whole network frame. For the welding of the steel tube tower, the manual semi automatic CO₂ gas shielded welding is mostly used. Because of the characteristics of the protective gas medium, it is easy to produce a large number of splashes and not easy to clean up during the welding process. It is easy to make the weld penetration rate and forming decline. It is effective to use the melting pole mixture gas protection welding, If we can make a scientific welding standard, it is possible to reduce the occurrence of welding spatter, achieve the purpose of improving welding efficiency and controlling manufacturing cost.

1. Preparation of specimens and welding materials

1.1 Material and specifications

The material of the steel tube tower is mostly ordinary low alloy high strength steel, and the welding joint is usually the form of “plate- plate” butt, “tube-tube” butt. In order to be closer to the actual welding environment, we choose the Q345.δ=12 steel plate with good welding performance as the parent material for the training test parts, and the specification of the specimen is shown in Figure 1.

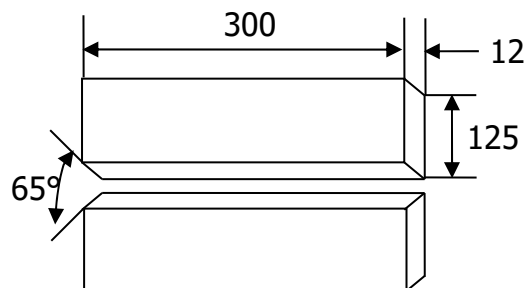


Figure 1. Schematic diagram of specimen specifications.

1.2 Selection of welding materials

According to the principle of strong matching of the welding material and the base material, because the specimen material adopts the ordinary low alloy steel with Q345 material, and the gas is weak oxidizing rich argon mixture gas, the core wire with less Mn and Si content is selected as the training welding material(ER50-3 Φ 1.2).

1.3 Selection of protective gas

The purity of CO₂ for low alloy high strength steel welding should be more than 99.8%. The purity of Ar gas for low alloy steel shielded should be over 99.99%-99.999%. In order to ensure the purity and proportion of gas, we chose mixed gas as the protective gas. The proportion of the mixture of protective gases is "80% CO₂,20%Ar".

2.Pre welding preparation

2.1 Welding equipment

In order to effectively control the stability of the arc in the welding process and the weld formation, we choose a fully digital control IGBT inverter CO₂/MAG welding power as the welding equipment[2].

2.2 Test piece cleaning

The cleaning of the specimens of the specimen is particularly important to ensure the quality of the weld, so the oil, rust, moisture and other dirt in the 15-20mm range at the near slope should be cleaned up before welding until the metal luster is leaking. Cleaning can be done by means of file, angle grinder and sandpaper. In order to prevent the weld from burning, the 0.5-1mm edge can be reserved at the edge of the groove.

3.Assembly and positioning welding of specimen

3.1 Specimen assembly

In order to prevent welding shrinkage deformation, the assembly gap of final welding end should be slightly smaller than that of the initial welding end, and the assembly gap 2-3mm is appropriate. The assembly parameters are shown in Figure 2-A.

3.2 Positioning welding

The welding process and specification should be the same as that of the formal welding. The number of solder joints is two, the length of each spot should be less than 20mm, and the end of welding is slightly thicker than the beginning of welding, thus avoiding the decrease of the gap due to the weld shrinkage. The welds near the end of each location are grinded with an angle grinder or file to facilitate the operation of the weld joint. The position of the welding spot is shown in Figure 2-B.

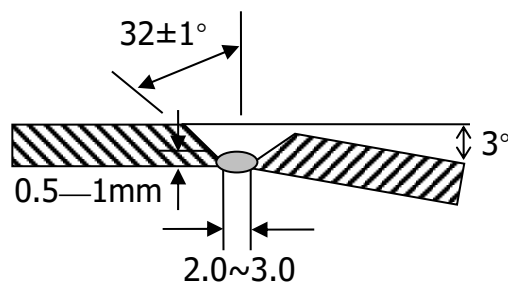


Figure 2-A. Assembly drawings.

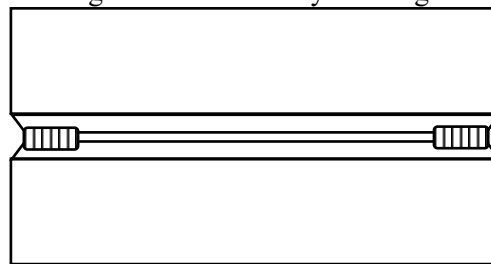


Figure 2-B. Positioning welding intent

4. Welding process parameters

4.1 Welding layer

The reasonable thickness and arrangement of weld seam can effectively avoid the formation of weld slags and non-fusion between layers. For the "V" butt joint ($\delta=12$), we adopt four layers and four channels of welding seam arrangement to ensure the quality of weld joint, and 3 of the welds arrangement show opinion diagram.

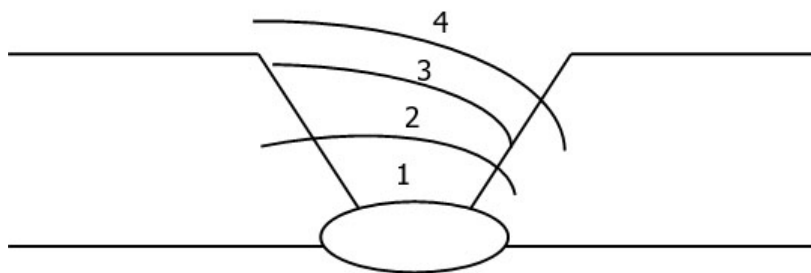


Figure3. Diagram of track arrangement



Figure4. Schematic diagram of arc wobble trajectory

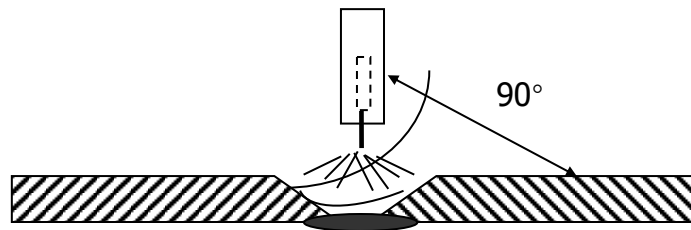


Figure 5-A. welding gun's circumferential angle

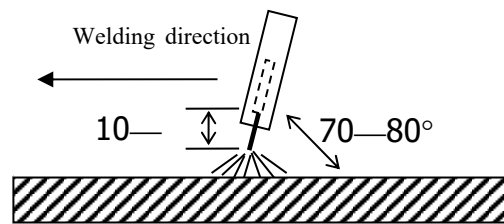


Figure 5-B. A sketch map of the axial inclination of the welding gun

4.2 Specification parameters of welding seam welding

Specifications for welding seam welding are shown in Table 1.

5.Operation specification

5.1 Welding layer

In order to ensure the forming of the back of the weld, the transition form of droplet in the bottom layer is short circuiting transition. In order to get stable arc combustion, the welding wire should be as short as possible. First, the welding can be carried out after the arc is stabilized. In the process of welding, the oscillating mode of the arc is swinging at the speed of the sawtooth. In the process of arc swinging, it should be observed that the size of the dissolving hole on both sides of the slope is consistent, and it is appropriate to melt off the edge of each side of the slope 0.5mm. The residence time of the arc on both sides of the groove is slightly larger than that of the middle, thus ensuring that the weld seam and the base metal are fully fused to prevent weld burn through. The welding gun switch is discontinued first, but the welding gun does not leave the weld quickly, and the gas delay protection can be removed after the time delay protection is closed. The purpose of this operation is to prevent the weld crack and the gas hole. The arc swing trajectory and welding torch inclination are shown in figure 4 and figure 5.

Table 1. Specification of welding parameters.

	welding Method	welding Electric current (A)	welding Voltage (V)	Flow of protective gas (L/min)
Positioning welding	MAG	100-110	20-21	15-20
Bottom welding	MAG	100-110	20-21	15-20

Filler layer welding	MAG	220-250	25-27	20
Cover layer welding	MAG	200-240	24-26	20

5.2 Filler layer welding

The filling layer is divided into two layers and two welding lines. The arc starting, arc closing operation and welding torch inclination are consistent with the backing layer welding. In order to ensure the full fusion of the weld seam, the swing trajectory of the welding arc in the filling layer is swinging in the shape of the tooth in the previous month, and when the arc swings to the groove, a little stay should be done. This operation is beneficial to the welding of the next seam. The weld section of the filler layer should be "U", and the arc swing track and weld section of the filling layer are shown in figures 6 and 7.



Figure 6. A schematic diagram of the arc wobble trajectory of a filling layer

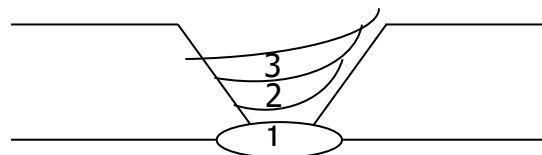


Figure 7. Sketch map of filling layer weld

5.3 Cover layer welding

The cover surface should be not only single layer but also single channel weld, and the weld thickness is 2-4mm. The arc welding method of the cover surface welding and the inclination angle of the welding gun are welded with the filling layer. In order to ensure the fullness of the weld seam of the cover layer, the arc swing trajectory of the welding seam should be zigzag, and the arc swing trajectory of the cover surface is shown in Figure 8. In the process of welding, in order to prevent the defects such as edge and non fusion, when the arc swings to the two ends of the slope, it is necessary to wait for the iron water to fill the edge of the groove before swinging to the bevel on the opposite side. When the arc is stopped, the welding end must be welded to the end of the weld, and then arc quenching operation is used to fill the arc hole and reassemble the 5-10mm arc. The appearance of the cover should be uniform and beautiful with no appearance of weld defects.



Figure 8. A chematic diagram of the arc wobble track of the cover layer

6. Inspection of weld

The appearance of the weld and the internal inspection standard should be according to the relevant regulations of the welder of the DL/T 679-2012 [3].

The appearance of the weld should be neat, and the edges should be smooth.

The size of weld and the allowable range of weld surface defects shall be in accordance with the requirements of tables 2 and 3 respectively.

Table 2. Weld shape allowed size range. Unit:mm

Table 2: Weld shape allowed size range.					Unit:mm	
Weld form	Weld residual height		Weld height difference		Weld width	
Butt Weld line	Flat welding	Other positions	Flat welding	Other positions	Slope widening	Widenin g of each side
	0-3	0-4	≤2	≤3	≤6	≤3

Table 3. Allowable range for weld surface defects

Defect name	Defect allowable range
Crack etc	Not allow
Bite the edge	The depth is not greater than 0.5mm, the total length of the sides of the weld is not more than 10% of the weld length.
Non weld penetration	The depth is not greater than 15% of the thickness of the specimen, and not more than 2mm. The total length is not more than 15% of the full length of the weld.
Heel protruding	The height of the plate or pipe with diameter greater than or equal to 108mm is not greater than 3mm.

Sunken	1. when T is less than 6mm, the depth is not greater than 10% of thickness; when $T > 6\text{mm}$, the depth is not greater than 15% of thickness, and not more than 2mm. The total length is not more than 10% of the full length of the weld. 2. The depth is not greater than 15% of the thickness, and not more than 2.5mm. The total length is not more than 10% of the weld length, and the welding position is not specified.
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The deviation value of the angle distortion of the weldment should be less than 3 degrees; the wrong value should not be greater than 10% of the base material wall thickness, and not more than 3mm. The internal inspection of welds shall be done by radiographic inspection, and the radiographic inspection shall not be lower than the requirements of grade II specified in NB/T 47013-2015.

Cold bending experiment: After the radiographic examination is qualified, the cold bending test shall also be carried out, and each specimen of the face bending and back bending shall be taken one by one, and the test method shall conform to the requirements of GB/T 2653. **Standard:** after bending, the test piece shall not have a defect with length more than 3mm on the side and side, except the cracks on the four corners of the specimen, but due to the crack caused by the welding defects, it should be evaluated according to the fracture of the weld and the macroscopic inspection requirements of the metallographic phase.

7. Summary

Driven by the growth of energy and electricity demand, the world power grid has experienced the leap from traditional power grid to modern power grid, from isolated urban power grid to trans regional and transnational large power grid[4]. The situation of the reverse distribution of energy resources and load center in China determines that UHV transmission technology has a wide application space in China[5]. For the welding of butt welded joint of steel tube tower, the fusion gas protection welding is adopted, and the typical and scientific welding specifications are formulated according to the actual work, which can effectively reduce the production of welding spatter, so as to improve the welding efficiency and control the manufacture.

References

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