GMAW welding process training for high neck flange of thin-walled tube of transmission tower

Hanyang, Liyang, Qubao

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

Abstract: In order to meet the increasing demand for transmission and improve the transmission and economic performance, the development of UHV power grid is the commanding heights of the global transmission technology competition in the future.[1] with the development of welding manufacturing technology, a steel tower with steel tube and flange as main component has been invested in the transmission line. The welding process performance has become an important part of quality assurance for transmission line. In the manufacturing process, thin walled pipe and neck flange welding, because of reducing the pipe diameter and wall thickness, accordingly put forward some new difficulties for its welding process. According to the welding technology characteristics of thin-walled pipe and neck flange, the corresponding welding training process is worked out, and training for relevant employees is carried out, so as to achieve the purpose of controlling the welding process and improve the qualification rate of products at a time.

1 Introduction

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. [2]The transmission tower is an important part of UHV transmission lines, in accordance with its components, they can be divided into the form of angle steel tower and steel tower, due to the continuous improvement of modern transmission line voltage level and transmission capacity, large cross-section conductor, double loop and multi loop lines have appeared, tower load and tower size are also increasing, The conventional angle steel tower has been unable to meet the design requirements, Steel tube tower due to good mechanical performance won the rapid development and application. Steel tube tower is a lattice tower consisting of steel pipes or steel sections. The main components are connected by high neck flange welded by welding. The welding quality directly affects the construction progress and the bearing capacity of the whole transmission line. In the actual production process, Steel tube towers are mostly completed by automatic welding equipment. when the diameter is less than 273mm, the wall thickness is less than 6.0mm, there are lots of problems, resulting in poor welding, so it is difficult to guarantee the quality. In order to ensure good weld formation and quality, manual welding should be used. Semi-automatic CO_2 gas shielded welding for melting pole can effectively control the welding quality. Now, let us talk about the training process.

2 Specific process

2.1 A specimen and material preparation

Selection of the material and specifications of the specimen: The component in the actual production of thin-walled tube, Most of them are middle diameter tubes of high strength steel, and in order to be closed to the actual welding environment, we choose the specifications for phi 159 * 6, Q345 type common low alloy steel as the training specimen, as shown in Figure 1 Schematic diagram of the specimen specifications.

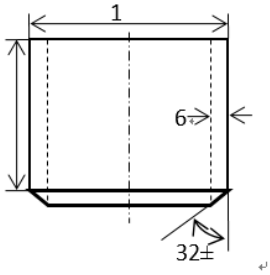


Figure 1 Schematic diagram of specimen specifications

Corresponding author:Email:hy19870604@163.com

Welding material selection: When low alloy high strength steel is welding, besides satisfying chemical composition and mechanical property of welded joint, we should fully guarantee the plasticity and toughness of welded joint. Therefore, we should select high quality welding materials such as S and P with low impurity content. Because the test piece is Q345 type ordinary low alloy steel, so the welding material has selected the Atlantic ER50-6 - 1.2 solid core wire. [3]

Protective gas: Welding of Q345 steel with protective gas for gas purity (volume fraction) of bottled gas CO_2 greater than 99.5%, in order to ensure its purity, should be used before the cylinder inverted 1-2h drainage, drainage after the cylinder is placed upright 2h, 2-3min gas before use; when pressure drops to 1Mpa, we should stop using gas.[4]

2.2 Pre welding preparation

Welding equipment: because the typical training project of the selected steel tube tower is "V groove pipe butt horizontal rotation" welding. In order to effectively control the shape of the molten pool and get good weld shape, we choose the thyristor to control the CO_2/MAG welding equipment. The control of CO_2/MAG welding equipment by thyristor can effectively control the residual height of the weld root and the forming of the weld.

Specimen cleaning: clean specimens available, angle grinder and file the specimen surface and pipe wall, oil groove on both sides of the range of 20mm corrosion to clean up, until clean metallic luster is appropriate.

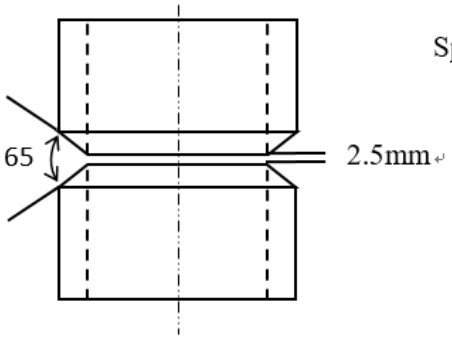
Welding roller frame: because the selected typical training project is horizontal rotary pipe, so before welding, the inspection and rotation of the welding roller rack should be carried out to ensure the normal operation of the welding process.

2.3 Assembly and positioning welding of specimen

In order to ensure the quality of the weld, the same process should be used in the welding of the positioning welding and the formal welding.

The selection of test pieces: when selecting specimens, we should pick out the specimens with ellipse deviation within the range of ±1.5mm, and the ellipse will pass through the assembly, resulting in the excessive deformation and the wrong side of the weldments, resulting in welding defects such as incomplete fusion and incomplete penetration.

The assembly of the specimen: the concentricity of the specimen must be guaranteed when the specimen is assembled, and the clearance of the weld should be retained. The fitting clearance of the specimen after the test is suitable for 2-3mm, and the assembly drawing of figure 2-a is shown in detail.



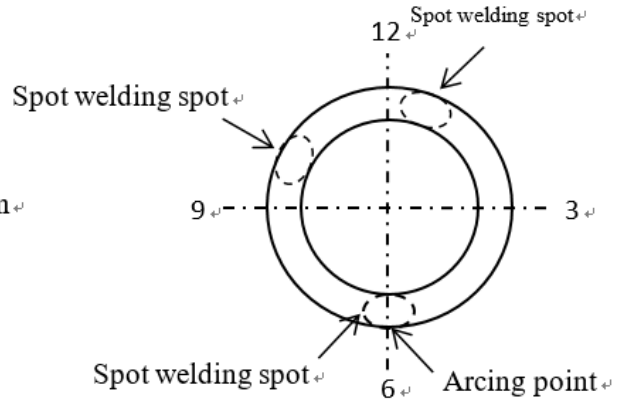


Figure 2-a Assembly drawings **Figure 2-b** positioning welding point diagram

Positioning: positioning the welding solder joint was 3 points, each point of length 10-20mm, located in the solder joint specimens the groove position of the clock 6 points, 10 points and 1 points, as shown in Figure 2-b schematic diagram of solder joint; Positioning welding should be welded with the same welding material as the formal welding, welding position must be strong, excessive distortion to prevent cracking or welding.

Blunt side: the blunt side of the test part is not only to ensure the full fusion of the weld root and the base material, but also to prevent the burning though. The appropriate thickness of the blunt edge is particularly important. Excessive blunt edge can cause weld defects, such as unweldment, unfusion, etc,if it is too small,it will be easy to be burned though and cause many welding defects, so 0-1mm should be reserved for a blunt edge.

2.4 Welding specifications and parameters

The number of weld layer: They are showed in Figure 3.

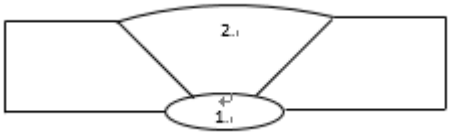


Figure 3 Schematic diagram of bead arrangement

Table 1 welding specification parameter list

Parameters / Project	welding Method	Power Supply Polar	Wire Diameter (mm)	welding Electric current (A)	welding Voltage(V)	Gas flow protection (L/min)	Wire feeding Speed (mm/min)	Trunk Length (mm)
Alignment welding	GMAW	DC back connection	Φ1.2	90-100	18-19	12-15	29—30	10—15
Root layer soldering	GMAW	DC back connection	Φ1.2	90-100	18-19	12-15	29—30	10—15
Cover layer welding	GMAW	DC back connection	Φ1.2	100-110	19-20	12-15	29—30	10—15

The welding parameters of all layers of weld seam: see the welding standard parameter table 1.

The main points of operation:

Bottom welding :as the backing welding specimen thickness is thin, the molten pool under the action of gravity, it is difficult to control the shape of melt hole welding process, resulting in the back weld height exceed the standard; but also easy to make the weld groove and groove angle produced, resulting in slag and non fusion between layers and other serious defects. Therefore, it is particularly important to choose the appropriate operation specification.

Firstly, the torch to the 1 point positioning welding fittings, ensure proper wire length after pressing the switch arcing, then do fast swing to end sawtooth positioning welding joint, and observe the joint metal fully fused turn specimen, specimen rotation direction tangent should maintain the right angle between welding torch in the process, the welding arc swing mode in the crescent shape of uniform swing, and the swing welding torch inclination Fig. 4-A layer welding direction and angle diagram, 4-b hit bottom arc swing mode diagram.

During the welding process, the welding torch always has a forward 80 degree angle with the tangent of the pipe rotation direction. The inclination angle of the welding gun which is too large or too small will affect the formation of the root weld. If angle is too large ,the root reinforcement will increase,if the root is too small,it is difficultly to be welded completely.

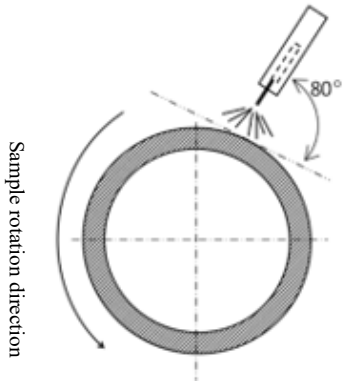


Figure 4-A welding direction and dip angle of bottom layer

Figure 4-b schematic diagram of bottom arc wobble

In the arc swing process, the time of staying in the arc groove on both sides should be slightly larger than in the middle, so as to ensure that the weld and base material will be fully melted and also can prevent weld burn though.

The welding operation starts from 1 points and ends at the 6 point. To hold out the welding switch in order to turn off the welding power source. Then the welding gun should not leave the weld quickly, and it can be removed after cooling sufficiently, so as to prevent the occurrence of weld shrinkage cavity and air hole.

After the bottom layer is welded, the oxide and splash in the weld will be cleaned up to ensure that there is no deeper angle between the weld and the base metal, so that the cover can be welded. The smooth surface of the weld can effectively avoid the defects such as slag inclusion and non fusion between layers.

Cover face welding: the weld of the cover surface is full and uniform. Therefore, the welding direction and the zigzag swing way should be adopted for the welding of the cover surface.

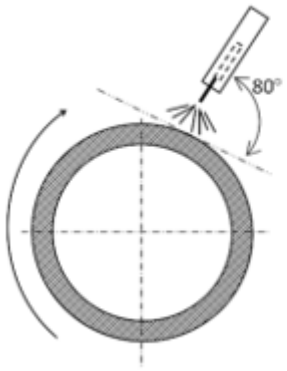


Figure 5-a the welding direction and dip angle of the cover layer **Figure 5-b** arc oscillating mode of cover surface

The torch starts from the 1 point fitting position of the clock, to ensure the proper inclination and stem elongation before turning on the arc welding torch switch, when it is smoothly burning and formation of molten pool is comed out, start the test piece and swing welding torch to swing along the sides of the weld., Details of the angle and swing of the welding gun are shown in figure 5-a, arc swing mode of cover layerfigure is shown in 5-b.

During welding, in order to prevent the defect of undercut and groove from being fused, whenever the arc swings to the sides of the groove, it can be swung to the opposite side until the hot metal fills the groove.

The welding operation is arced at the 1 point position of the clock, it is end with the arc from 9 points back to 1 points, loosen the gun switch to close the welding power supply, the cover layer arc operation is the same to the underlayer operation.

After the specimen is welded, the weld pool must be uniform, narrow and close, and the remaining height is uniform. The spatter and oxide of the weld surface and the root of the specimen should be cleaned up.

2.5 Post weld inspection

According to the requirements of the national Power Grid Corp welder qualification training and assessment program, the appearance and internal inspection of the specimens shall be in conformity with the relevant provisions of the "DL/T 679-2012 welder technical assessment procedure".[5]

The weld appearance size and the weld surface quality shall be in accordance with the provisions in Table 2, table 3 respectively.

Table 2 Weld shape allowed size range unit: mm

Weld form	Weld residual height		Difference of weld seam height		Weld width	
Butt weld	Flat	Other positions	Flat	Other positions	An increase in width than the original slope	Widening of each side
	0-2	0-3	≤1.5	≤2	2-3	1-2

Table 3 Weld shape allowed size range

Defect name	Defect allowable range
Cracks, non fusion, surface blowholes and slag inclusion	Not allow
Undercut	The depth is not more than 0.5mm, and the total length of edge bite on both sides of the weld does not exceed 10% of the full length of the weld.
Non weld penetration	The depth is not more than 15% of the thickness of the specimen, and it is not more than 2.5mm. The total length is not more than 15% of the full length of the weld.
Heel protruding	A pipe piece or a pipe with a diameter greater than or equal to 108mm. The height is not more than 3mm. The pipe diameter is less than 108mm in diameter 85% ball shall prevail.
Sunken	1.When T = 6mm, depth of not more than 10% of the thickness; when T>6mm, depth of not more than 15% of the 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 more than 15% of the thickness, and it is not more than 2.5mm. The total length of the weld is not more than 10% of the full length of

	the weld, and the position of the weld is not specified.

The bending deformation of the weldment should not be greater than the length of the 1.5% test, 3mm; wrong port value should not exceed 0.6mm (≤0.10 δ and not more than 2.0mm).

The edge of the weld shall be smooth and smoothly transit to the parent material; the weld surface shall not have cracks, slag, porosity, non fusion welding and fatal defects.

X-ray inspection is adopted in the internal inspection of the weld, and the ray inspection shall not be less than the B II requirements specified by GB/T3323.

Cold bending experiment:the test specimen after the inspection of the ray should also be subjected to the cold bending test. One of the specimens of the bending and back bending should be taken each. The test method should be in accordance with the provisions of GB/T 2653.

Standard: there shall be no cracks or other defects with length greater than 3mm in any direction of the tensile surface of the specimen, And the total length of the crack and other defects of the single specimen shall not be more than 7mm. Except for the cracks on the corners of the specimen, the cracking due to the welding defects should be taken into account.

3 Conclusion

The establishment of a typical welding training project for the manufacture of steel tube towers is a favorable guarantee for the manufacturing process of the steel structure in the whole power grid. Selecting proper welding methods and correct welding specifications is an effective measure to improve the welding efficiency of thin-walled tube and forging neck flange and improve the pass rate of welding once, and it is a technical means to maintain all aspects of power grid steel manufacturing. Manual semi-automatic MAG welding provides support for the welding quality of thin-walled tube for its convenience, high quality and high efficiency.

With the continuous progress of the times, the welding method and technology have also been developed in a variety of ways. Only scientific formulation and strict implementation of welding process measures are the eternal main purpose of ensuring the quality of welding joints.

References

1. Liu Zhenya. China electric power and energy [M]. Beijing: China Electric Power Press, 2012. 161-161
2. Liu Zhenya. Global energy Internet [M]. Beijing: China Electric Power Press, 2015. 200-200.
3. Zou Cheng. Welding manual (welding of materials) [M]. Beijing: Machinery Industry Press, 2008.247-252.
4. Zhang Yanmin. International welder training [M]. Harbin: Heilongjiang people's press, 2002. 53-53
5.]DLT 679-2012, specification for welder technology assessment [S].