Welding Process Optimization of WELDOX960 High Strength Steel

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Abstract: This paper studies WELDOX960 high strength steel, analysis of the welding ability of WELDOX960 high strength steel. Analyze the weld ability of WELDOX960 high-strength steel materials, and study the influence of process parameters such as welding current, welding voltage, and welding speed on penetration depth and weld width in the automated welding process. Through this test, the welding process is optimized to ensure the weld quality. The results show that WELDOX960 high-strength steel adopts multi-layer and multi-pass welding to form better welds.

INTRODUCTION

With the continuous development of large-tonnage crane products, the use of high-strength steel plate is large, and the strength of the jib is also improved. The welding process is the main process for manufacturing the metal structure of the hoisting machinery. The welding quality and assembly process are directly related to the quality of the hoisting machinery. As the main force part of heavy equipment, boom is mainly made of imported high strength steel, and the welding technology of boom is the key and difficult point in manufacturing process. According to market research, this kind of low alloy high strength steel produced by Sweden is usually made of large boom. This kind of low alloy high strength steel is usually achieved by welding process. Although some mature welding techniques are adopted in the process of production, the same kind of welding process is not exactly the same in different environment, and the welding workers with different construction environment of the same kind of material are welded. Art is also different. Compared with the traditional alloy structural steel, the yield strength of WELDOX960 high strength steel is greater than that of 960MPa. It has high strength and good plasticity, and has good advantages in welding and mechanical properties. However, experts and scholars have proved through practice that under the steel alloying principle, the strength of low-alloyed steels is increased, and the carbon content and alloying elements in the chemical composition are also increased. In the welding robot welding process, brittleness of the welded joints is likely to occur. Welding defects, such as welding cracks, destroy the structure and performance of welded structural parts. Therefore, it is particularly important to study WELDOX960 high-strength steel weld properties, improve the weld ability of low-alloy high-strength steel, and reduce the welding defects.

1 WELDOX960 HIGH STRENGTH STEEL WELD ABILITY

Low alloy quenched and tempered has good weld ability and is close to low carbon steel. With the increase of alloy elements in the steel, the strength grade is increased, the hardenability is great and the

weld ability of steel is becoming worse and worse. The problems mainly include two aspects, one is the crack sensitivity, and the carbon content of the secondary high strength steel is lower, generally below. The high strength and good mechanized performance are improved by adding a variety of improvement on the low carbon base. Hardenability alloying elements and quenched and tempered heat treatment obtained low carbon lath martensite and some lower bainitic structure with high strength and toughness. Low strength low-alloy high-strength steel, such as grade I, is the mechanical property of welding heat affected area due to the low content of alloy element in steel. How to ensure the welding quality of welded components and obtain the proper strength and good toughness is the key of low alloy high strength steel welding. Therefore, in the process of welding low-alloy high-strength steel, it is necessary to improve the strength and impact toughness of weld metal and welding heat affected zone while ensuring the quality of weld. Due to the excellent weld ability and mechanical properties of high strength steel, the steel plate thickness between mm and mm can be applied to all conventional welding methods[1]. Such as gas solid wire, flux-cored wire welding, manual arc welding, self-protection flux cored wire, submerged arc welding, can be used in practice, the selection of welding methods are often based on the structure, construction conditions, welding quality, efficiency and the level of cost accounting and other comprehensive consideration, often use the selection principles for under the lower economic cost accounting, labor condition security friendly, can efficiently complete the high quality of weld. In these welding methods, gas shielded welding is the first choice. Reasonable selection of welding material can guarantee the weld composition and comprehensive performance, but it is more important to choose the proper welding process specification. This paper adopts KUKA welding robot to weld WELDOX960 high strength steel plate butt weld, optimize welding process and ensure qualified weld joint[2].

2 WELDING MATERIAL

In this test, the thickness of the WELDOX960 low alloy high strength steel is three specifications: 12mm, 16mm and 20mm. Table1.1 the mechanical performance of weldox960 and Table1.2 the chemical compositions of weldox960(wt%)

Table1.1 the mechanical performance of weldox960

Material、thickness	σ_b	σ_s	δ	AKV(J)10			RT\180°
	(MPa)	(MPa)	(%)	0°	-20°	-40°	R=3t
Weldox960 t=20mm	980/1150	960	12	35	30	27	Perfect

Table1.2 the chemical compositions of weldox960(wt%)

Material、thickness	C	S_i	M_n	P	S	N_b	V	N_i
	0.20	0.50	1.6	0.02	0.01	0.04	0.06	2.00
Weldox960 t=20mm	C_u	C_r	M_0	T_i	Al	B	N	
	0.30	0.70	0.70	0.04	0.018	0.005	0.015	

The KUKA CO2 gas shielded welding robot was welded with gas content of 20%CO2+80%Ar and gas pressure of 15~20Mpa. The choice of welding material is the solid core wire produced by the Swedish company of diameter 1.2mm, the type is E-FK1000 welding wire. The chemical composition and mechanical properties are shown in table 1.3

Table1.3 Chemical composition of wire

Welding wire	C	S_i	M_n	P	S	C_r	M_0	N_i
E-FK1000 ϕ1.2	0.13	0.81	1.73	0.012	0.024	0.024	0.59	2.27

3 WELDING TECHNOLOGY

In view of the characteristics of the welded material, the actual structure or the form of the joint, the welding process should be used to weld bottom welding, fill welding, cover welding and angle welding when welding with different welding methods. In this paper, the process measures include preheating before welding, cooling after welding and multi-layer

multi-channel welding. Proper selection of process parameters is the key to ensure welding quality of joints. In the design of welding process, the arc voltage, welding current and welding speed three welding process parameters is the key factor affecting the quality of welding process parameters, the reasonable selection directly affects the size of the welding line energy, in order to meet the design requirements of welding joint, should be within a certain range, adjust the arc voltage, welding current and welding speed. Whether the welding current size is suitable or not will directly affect the final quality of welding. In the design of welding process, the arc voltage, welding current and welding speed three welding process parameters is the key factor affecting the quality of welding process parameters, the reasonable selection directly affects the size of the welding line energy, in order to meet the design requirements of welding joint, should be within a certain range, adjust the arc voltage, welding current and welding speed[3]. Whether the welding current size is suitable or not will directly affect the final quality of welding. If the welding current is too large, though it can increase the penetration depth, it is easy to have the defects such as nibble welding tumor, and it is difficult to control the welding pool in the welding operation of vertical welding. With the increase of arc length, produce the bite edge welding current will decrease greatly, while the penetration depth decreases, and very easy to appear incomplete fusion, slag inclusion, fusion defects such as bad, low-alloy and high strength steel with thick plate welding, the recommended injection in order to achieve the transition to an appropriate welding current.

In the welding process, reasonable control of the arc length is a key factor to ensure the stability of the welding quality. If the arc is too long, the protection of the molten metal will deteriorate, and harmful gases such as oxygen and nitrogen in the air will invade easily, making the weld seam easy to produce. Air holes, while reducing the mechanical properties of the weld metal. However, the arc length should not be too short, otherwise it will cause sticking. At the same time, the surface pressure of the welding arc on the molten pool is too large, which affects the gas and slag floating velocity in the molten pool of the molten pool, which can cause slag inclusions, pores, and other defects. Therefore, before welding, the arc voltage matching the welding current should be adjusted to obtain higher welding quality. In the test, the welding current is 80~100A, the welding voltage is 20~22V, the welding speed is 220~260mm/min, the welding current is 240~260A, the welding voltage is 28~30V, the welding speed is 400~450mm/min, and the cover welding The welding current is 280~300A, the welding voltage is 28~30V, the welding speed is 400~450mm/min; the dry length of the welding wire is 12~18mm. In the welding process, in order to minimize the residual stress and deformation of the welded structure, it is necessary to pay attention to the welding from the most rigid position to the free end of the unconstrained welding; avoid the beginning and end of the weld in the high stress area Under the premise of satisfying the performance requirements of the weld, try to use low-strength welding material with good toughness; perform symmetrical welding; minimize the cross-section of the weld and the cross-section to ensure minimum; consider the geometry of the joint; reduce the joint Deformation and residual stress measures.

4 WELDING PROCESSING

WELDOX960 low-alloy high-strength steel has excellent weld ability, and generally does not require post-heating and post-weld heat treatment. However, for thick slabs with a tendency to cold cracks, where the stress is concentrated on the weld, if the post weld heat treatment cannot be performed immediately after the welding work is stopped, postheating should be performed. After the welding work is stopped, the weldment is heated to a certain temperature immediately. 200°C ~ 400°C, heat for a certain period of time, an hour, so that the weldment slowly cool down to accelerate the escape of hydrogen in a welding heat treatment process. For high-strength steel parts

with high degree of restraint or deposition, in order to avoid welding cracks, asbestos can be used for heat preservation immediately after welding. The holding time is not less than 0.5 hour for each 25mm of the composite sheet thickness, and the total holding time must not be less than 1 Hours to determine, reach the holding time should be slowly cooled to room temperature. Under the guidance of the technical staff, it is also possible to add a post-heating process for hydrogen elimination treatment, and use a flame heater or the like for heating. The heating temperature is controlled at 200°C to 250°C. After the welding work is completed, the weldment is heated to a temperature below the phase change temperature of the material, AC1, for a certain period of time to allow the weldment to slowly cool down to improve the microstructure and properties of the weld joint or to eliminate residual stresses. Welding heat treatment process. High-strength steel should be post-weld heat treatment only if there are special requirements in the design rules.

5 SUMMARY

WELDOX960 low-alloy high-strength steel welding joint quality of the main problem is to ensure that the impact of the prevention of embrittlement and softening, high overall performance of the weld, to ensure that the fusion zone and heat-affected zone does not occur cold and hot cracks, and a certain plastic, toughness. Through the above tests, it is proved that the multi-pass multi-pass automatic welding process parameters are set reasonably, the weld seam is well formed, and it can meet the production needs of enterprises.

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