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Research of welding of martensitic and martensitic-ferritic steels

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ABSTRACT: This article provides a study of the features of welding technology for martensitic and martensitic-ferritic steels

KEY WORDS: welding, steel, technology, martensite, ferrite

I. INTRODUCTION

Martensitic steels are hardened to martensite with high hardness and low deformability under conditions of the welding thermal cycle in the heat-affected areas (as well as in the weld metal, if its composition is similar to the metal being welded). As a result of the deformations accompanying welding, as well as the long-term action of high residual and structural stresses present in welded joints in the initial state after welding, cold cracks may form in such metal.
They are formed at the last stage of continuous cooling (at temperatures of 100°C and lower) or when the metal is kept at room temperatures. Hydrogen, which is present in welded joints and diffuses even at low temperatures, contributes to the embrittlement of the metal and the formation of such cold cracks.

II. LITERATURE SURVEY

Coarse-grained weld metal, as well as metal in the heat-affected zone, is more prone to cracking than fine-grained metal. Therefore, modification of the weld metal (for example, with titanium) and the use of more severe modes (with lower heat input) reduce the likelihood of crack formation [1,2].
An increase in the rigidity of the welded products increases the likelihood of cold cracks forming, and to a greater extent, the less deformable the hardened metal has. Welding in CO2 without preheating products of small rigidity does not cause cracks: for steel grade 20X13 with a thickness of no more than 8-10 mm; for products made of steel 12X12 with a thickness of up to 10–12 mm, and for products made of steel 08X13 with a thickness of up to 18 mm [3,4].

Preheating and heating during welding usually prevents the formation of cracks. For chromium steels of martensitic and martensitic-ferritic classes, as a rule, general (sometimes local, using, in particular, flexible inductors powered from welding transformers) heating to 200-450 ° C is recommended. The heating temperature is assigned higher with increasing susceptibility to hardening (mainly with an increase in carbon concentration in steel) and product rigidity.

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However, it is preferable not to heat the metal to temperatures that cause an increase in brittleness (for example, due to blue brittleness), limiting the temperature of the heating accompanying welding. So, for example, for steel 08X13 this temperature turns out to be 100–120°C. The upper range of long-term accompanying heating should be limited by the temperature at which temper brittleness or blue brittleness of steels appears (200-250° C). With any accompanying heating, cooling by wind (or drafts) is dangerous, since this increases the likelihood of cracks appearing [5].
Heating products during welding to low or high temperatures does not protect the weld metal in the heat-affected zone from decomposition according to the martensitic mechanism when cooled to room temperatures. Therefore, in the post-weld state with rapid cooling characteristic of these conditions, welded joints have high hardness and fairly low toughness [6].

III. METODOLOGY

To improve the structure and properties, it is necessary to carry out high tempering. The structure after tempering is characterized by tempering sorbitol, with a varying amount of free ferrite. The best properties are achieved with the complete or almost complete absence of free ferrite in the structure.
However, heat treatment cannot be carried out outside of temporary connection with the welding operation. If immediately after welding the product is cooled to room temperature, then a martensite structure will be obtained in the metal of the welds and heat-affected zones. Subsequent high tempering during heat treatment leads to the formation of a sorbitol structure.
However, during the cooling period at temperatures below ~100°C and during the period of aging the product before the start of heat treatment, cracks can form in welded joints, both extending to the surface and internal tears with a size (length) of 1–4 mm, which can then develop.
If, after welding carried out with heating above the upper martensitic point, the product being welded is placed in a furnace without reducing its temperature below 350°C, then martensitic transformation in the seams and in heat-affected zones will not occur, cracks will not form in the joints, but the final structure will be coarse-grained ferritic. carbide A metal with such a structure has low strength and low toughness.
The best properties can be obtained when, after welding from the accompanying heating temperatures, they are cooled down to approximately 100°C, held at this temperature for 2 hours (to complete the decomposition of austenite-martensite, without the formation of cracks) and placed in a furnace for heat treatment of the entire product. As studies have shown, the same results are obtained if the metal of the product or in the area of the welded joints is given a "rest" at 100-120°C for 10 hours. After such a rest, the product can be cooled to room temperature and kept for a long time before heat treatment. No cracks are observed after such a "rest", and the structure and properties after heat treatment of the tempering are optimal.
The properties of welded joints to ensure equal strength with the base metal depend not only on the heat treatment mode of the product after welding, but also on the heat treatment mode before welding. If tempering after hardening before welding was carried out at temperatures lower than those used during heat treatment after welding, then in welded joints the weakest zone is found at a short distance (up to 4-5 mm) from the fusion boundary, in which the temperature was reached during welding the most softening vacation.
Heat treatment of the product after welding in such cases does not restore the properties of the metal in this zone to the properties of the base metal. To ensure equal strength, tempering after welding is recommended to be carried out at a temperature approximately 20°C below the tempering temperature of the workpieces before welding.
Heat treatment of welded joints after welding affects not only the mechanical properties, but also corrosion resistance, heat resistance and other properties.
For example, contact of hardened weld metal and heat-affected zone metal with an unhardened (tempered) base metal leads welded joints of 14X17H2 steel to a state of lack of corrosion resistance, and when exposed to an aggressive environment, selective corrosion of the hardened zone appears. At the same time, corrosion resistance also depends on the ratio of the surfaces of the weld and the base metal interacting with the aggressive environment.

Chromium steels have some tendency to intergranular corrosion (ICC); this is typical not only for ferritic, but also for martensitic-ferritic steels. They acquire a particularly high tendency to MCC after rapid cooling from high temperatures. To restore resistance against MCC, high tempering can be used, and its temperature and duration vary for different steels.
Types of welding (mainly manual arc with coated electrodes) that ensure the production of deposited metal with an austenitic or austenitic-ferritic structure, used to produce joints of chromium steels of the martensitic and martensitic-ferritic class, as a rule, do not ensure equal strength of welded joints and can be recommended only for operating conditions under static load with low stress.

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IV.CONCLUSION

The results of the research performed provided the necessary basis for the development and implementation of welding technology for martensitic and martensitic-ferritic steels.

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