Effect of C Element Change on Microstructure and Properties of Fe-Cr-C Surfacing Alloy

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Abstract. Iron-based surfacing alloys have a wide range of applications. They are lighter in structure, simpler in technology, and better in toughness and wear resistance. They can meet different performance requirements. It is cheaper and more diverse in variety, so they are most widely used. In this paper, a Fe-Cr-C surfacing layer sample was prepared on Q235 low carbon steel substrate by submerged arc welding. The effect of changes in the content of C on the microstructure and hardness of Fe-Cr-C surfacing alloys was studied. The microstructure of the solder layer was analyzed using optical microscope. The results show that the change of carbon content directly affects the morphology of carbides and the number of carbides. When the carbon content increases by a certain value, the hardness increases but the crack resistance deteriorates. With the increase of carbon content, the hardness increases, but the crack resistance decreases.

1. Introduction

The surfacing welding process is an important branch in the field of welding. It is applied to the repair of parts in mines, power plants, vehicles, metallurgy, and agricultural machinery industries. It also has a wide range of applications in design and manufacturing[1-4]. In this paper, the Fe-Cr-C surfacing sample was prepared on a Q235 steel substrate by surfacing. The effect of carbon content on the microstructure and properties of Fe-Cr-C surfacing alloys was studied. Aiming at Fe-Cr-C wear-resistant alloys with different carbon contents, the mechanical properties after welding were studied, and the microstructure of the welding layer was analyzed using an optical metallographic microscope. The mechanism and influence of carbon content on the surfacing layer were discussed.

2. Experiments and Materials

2.1. Materials

The test materials are shown in Table 1. Submerged arc welding machine and ordinary H08A welding wire were used to deposit the prepared alloy powder on the Q235 substrate for surfacing to obtain the surfacing layer, surface layer, and chemical composition required for the experiment. (mass fraction).
2.2. Methods for Testing
Optimize the welding process parameters so that the welding process performance is good. The powder feeding speed is 760-800g/h, the welding voltage is 25V, and the welding current is 180-200A.

| Number | High carbon ferrochrome % | MnFe % | SiFe % | powder Fe % | powder C % |
|--------|---------------------------|--------|--------|-------------|------------|
| NO.1   | 80                        | 3.5    | 1.5    | 15          | 0          |
| NO.2   | 80                        | 3.5    | 1.5    | 10          | 5          |
| NO.3   | 80                        | 3.5    | 1.5    | 0           | 15         |

The test plate is clamped on the welding tool table to ensure clamping when we weld. This is to prevent the deformation of the test plate. The test plate thickness should be 8mm. On the test plate, the size of the overlay shall be 100mm × 25mm × 6mm, and the welding performance test shall be conducted. In the welding process, each weld must first be cleaned and welded to the surface in order to avoid slag inclusion. Surfacing a layer, mainly to consider the actual operation, the temperature for a long time, the heating process, requirements, is to reduce the base metal on the surfacing layer, the dilution rate of the impact.

Samples were cut using the QG1 model metallographic sample cutter and the samples were grouped after the build-up layer was made. When cutting, avoid both ends of arcing and arcing, and remove 2~5cm on both sides. We select the middle to use as a sample. After removing the test specimens, the surfacing surface is roughly ground using a grinder, but the amount of grinding is approximately equal. This is to facilitate the observation and comparison of the performance of each experiment under the same conditions. Then according to the specific operation of each experiment, it is required to make different samples for the analysis of organization and performance.

3. Results and Analysis

3.1. Hardness test
The H-100 Rockwell hardness tester is the equipment used in this test. The load of the test is 1470N. The hardness is measured from the three welding layers of the sample. The obtained five sets of data are added and averaged. The Rockwell hardness values of Samples 1, 2 and 3 are shown in Table 2, Table 3 and Table 4, respectively.

| frequency | 1 | 2 | 3 | 4 | 5 | average |
|-----------|---|---|---|---|---|---------|
| the hardness /HRC | 47.5 | 51 | 48.6 | 55.1 | 51.5 | 50.74 |

| frequency | 1 | 2 | 3 | 4 | 5 | average |
|-----------|---|---|---|---|---|---------|
| the hardness /HRC | 57.5 | 59.5 | 56.5 | 53.4 | 54.1 | 56.2 |

3.2. Observe and analyze the microstructure
Metallographic analysis is one of the main methods to study the internal structure and defects of metals and alloys. Its application is very important in the field of metal materials research. We use metallographic microscope to enlarge a certain multiplier on the prepared sample to study the mechanical properties of metal and the microstructure of the alloy called metallographic microanalysis. It is the most basic experimental method to study the microstructure of metal materials. Microanalysis can also be used to study the relationship between the microstructure and chemical composition of metals and alloys; it can be used to determine the microstructure of alloy materials after different work and heat treatment, and the quality of metal materials can be determined, such as the distribution of various metallic inclusions, oxides and vulcanization, and gold. The size of the grain is the size of the genus. In modern metallographic microscopic analysis, we usually use two main categories of optical instruments, optical microscope and electron microscope. We use the optical metallographic microscope commonly used here.

| frequency | 1   | 2   | 3   | 4   | 5   | average |
|-----------|-----|-----|-----|-----|-----|---------|
| the hardness /HRC | 59.1 | 61.1 | 61.1 | 59.4 | 58.3 | 59.8    |

In this paper, an optical metallographic microscope was used, after heat treatment, the samples were lapping and polishing, then corroded with 4% ethanol. After etching, the magnification is 200 times and 500 times respectively under optical microscope.

Fig. 1. The Fe-Cr-C surfacing layer of No.1 sample

Fig. 2. The Fe-Cr-C surfacing layer of No.2 sample
From Table 2 to Table 4, it can be seen that the carbon content increases and the hardness increases. As the carbon content increases, the hardness increases, but the crack resistance decreases dramatically. Figures 1 to 3 show the microstructure of the Fe-Cr-C alloy surfacing layer containing 0%, 5% to 15% carbon, respectively. Since carbon is a strong oxidant, the welding speed decreases as the C content increases. Slow and there may be serious breakage. The carbon content directly affects the morphology of carbides and the number of carbides. Because of the characteristics of the welding process, atomic diffusion of the welding layer increases the transition zone from the base metal to the welding layer, and dendritic crystals appear near the cross-section of the welding layer. Hypoeutectic structure morphology.

4. Conclusions
Through the study of the microstructure and hardness of the Fe-Cr-C hardfacing alloy welding layer, the conclusions are as follows: First, the carbon content changes directly and the carbide morphology and the number of carbides, and the carbon content increases by a certain amount. At that time, the hardness decreased but the crack resistance deteriorated. Second, as the C content increases, the welding speed slows down, and severe cracking may occur. Finally, due to the characteristics possessed by the welding metallurgy process, the atomic diffusion of the weld layer increases the transition zone from the base metal to the weld layer and a dendritic hypoeutectic structure forms near the cross-section of the weld layer.

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