Research on the Structure and Performance of Bimetal Composite Hammer

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Abstract. In order to improve the service life of the hammer head of the crusher, the high chromium cast iron-medium carbon low alloy steel double liquid composite hammer head is used to replace the single material high manganese steel hammer head; the production process uses lost foam casting instead of sand casting. This article mainly studies the production technology of composite hammers from the aspects of hammer material selection, model making, pouring system design, pouring process and heat treatment process, and uses a metallurgical microscope to observe the bonding interface, and uses a scanning electron microscope to observe both sides of the interface. For element diffusion, the universal testing machine tests the interface combination. The results show that the composite hammer has a firm bonding surface and good bonding quality.

1. Introduction

As a crushing equipment, hammer crushers are widely used in electric power, coal, metallurgy and other industries. Among them, the hammer head is in direct contact with the material, which is the key and easy to wear parts [1~3]. When the crusher is working, the working conditions are harsh, the hammer head runs at high speed, and the material is hit and crushed through inertia, and the force is complicated; Although the wear resistance has been improved, it is far from meeting the high efficiency and low consumption requirements of modern production [4,5]. Because in many low impact stress conditions, the work hardening degree of the high manganese steel hammer is not enough and the wear resistance is poor. The use of high-chromium cast iron-carbon steel composite hammer head, the hammer handle maintains the original toughness while improving the wear resistance of the hammer head part, extending the life cycle of the hammer head; the lost foam casting process has simple operation technology and casting production cost Low characteristics [6], so the lost foam casting process is used to produce the liquid-liquid composite hammer, and the research on its production technology is launched.

2. Test materials and methods

The smelting of the bimetal liquid is carried out in 100Kg and 250Kg medium frequency induction furnaces. The foam model is made by hand-cutting polystyrene (EPS) with resistance wire; self-made water glass paint is painted; the model is dried in the far-infrared baking room Proceed; use a five-sided...
wall pumping special sand box, after the completion of the box, use a one-dimensional vibrating table to vibrate the molding sand; SK-20 water ring vacuum pump system vacuum, the heat treatment of the hammer head is in the RT2-220-12 trolley heat treatment It is carried out in the furnace; the microstructure is observed and characterized by means of metallurgical microscope, scanning electron microscope and other means, and the tensile test is carried out on the universal testing machine.

3. Results and discussion

3.1. Hammer structure division and corresponding material system design
By analyzing the failure behavior of the wear-resistant hammer head of the crusher, the use structure of the wear-resistant hammer head is defined. According to the use situation, the wear-resistant hammer head is divided into two areas, the easy-wear area and the installation fixed area. The specific structure ratio is shown in Figure 1. Part 1-Hammer shank part, which belongs to the fixing area of the hammer head. It requires a good match of hardness and toughness. The material is selected as medium carbon. Low alloy steel, the mass fraction of its chemical composition is: C: 0.40%~0.45%, Si: 0.60%~0.90%, Mn: 0.80%~1.50%, Cr: 1.80%~2.00%, Mo: 0.15%~0.25%, P≤0.04%, S≤0.04%. Part 2-the end of the hammer head, the material is required to have high hardness and good wear resistance. The material is selected as high chromium cast iron [3,4], and the mass fraction of the specific components is: C: 2.30%~3.00%, Si: 0.50%~0.80%, Mn: 0.50%~1.00%, Cr: 14.0%~16.0%, S≤0.06%, P≤0.10%.

![Figure 1 Three-dimensional model and structure diagram of a wear-resistant hammer](image-url)

3.2. The influence of the gating system structure on the joint surface
The ideal gating system can smoothly, continuously and steadily introduce the molten metal into the mold cavity, while ensuring that the molten metal is not involved in gas in the gating system, and can make the residue generated by the gasification and cracking of the foam model escape. For this reason, three different gating systems were designed during the research process of the project, namely the "—"-shaped, cylindrical and "Tian"-shaped structure designs. The specific design results are shown in Figure 2.
The test results show that the high chromium cast iron liquid flow distribution of the composite hammerhead castings using the "one" gating system is uneven, and the high chromium cast iron part does not reach a reasonable size and height; the castings using the cylindrical gating system are due to the sharing of two metal liquids For an inner runner, the metal poured first adheres to about 1/3 of the cross-sectional space of the inner runner, which reduces the filling capacity of the molten steel after the pouring, and the casting appears to be underfilled; the casting using the "Tian" gating system, The size of the high chromium cast iron part reaches a reasonable height, and the boundary of the bimetallic bonding interface is relatively smooth from a macroscopic point of view. The internal quality of the hammer head is good, and there is no defects such as sand inclusion and hot cracking, which is ideal.

3.3. Metallographic observation
After the heat treatment, the cut sample is polished, polished, and corroded with 4% nitric acid alcohol. The microstructure of the sample is observed and analyzed through a Zeiss microscope, as shown in Figure 3.

It can be seen from Figure 3 that different parts of the composite hammerhead after the same heat treatment process show different organizational morphologies. Observe and analyze the microstructure of the wear-resistant part of the high chromium cast iron in Figure 3(a), where the matrix is martensite, with skeleton-like carbides distributed, and the discontinuously distributed strip-like carbides are very hard high. Figure 3 (b) observes and analyzes the structure of the transition zone of the bimetallic bonding interface. It can be seen that the bimetallic bonding interface is wavy. The liquid-liquid bimetal melts and interpenetrates during the formation process, and the structure is dense. The atoms diffuse each other to form a band-shaped bonding area with a certain width, and there are no defects such as micro cracks, pores and inclusions, and metallurgical bonding is achieved. In Figure 3(c), by observing the structure morphology and hardness test, this part of the structure is mainly lath martensite and acicular martensite.
3.4. Microhardness analysis

| Table 1 | Microhardness value (Hv) |
|---------|--------------------------|
| The distance of microhardness (Hv1) from high chromium cast iron to medium carbon low-alloy steel (µm) |
| 0.5 | 0.4 | 0.3 | 0.2 | 0.1 | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 |
| Hardness value | -- | -- | 766 | 803 | 835 | 711 | 684 | 671 | 663 | -- | -- |

Taking the bimetal bonding interface as the center, hit 3 to 5 points on each side of the interface at 0.1 µm intervals to obtain the microhardness data from the high-chromium cast iron to the medium-carbon low-alloy steel side as shown in Table 1. The corresponding microhardness photo is shown in Figure 4.

The microhardness changes on both sides of the interface and the transition layer when the bimetal is well bonded are: the hardness on both sides of the interface is very different, while the hardness value of the transition zone is a gentle transition, and the hardness value of the composite material bonding interface changes linearly, and there is a stable transition zone in organization and performance. As shown in Figure 5.

3.5. Scanning electron microscope to observe the diffusion and distribution of main elements

The diffusion of elements on both sides of the interface is related to the change of the microhardness of the transition zone. The higher the carbon content and the chromium content, the easier it is to form network carbides and the higher the microhardness of the corresponding area. On the high-chromium cast iron side, the bonding interface, and the carbon steel side, by testing the composition of each point, the diffusion distribution of each element is judged as shown in Figure 6.
Figure 6 Scanning the diffusion distribution of each element

Figure 7 (a) and (b) are the distribution of elements Cr and C in different parts of the sample. By observing Figure 7, it can be found that there is a large concentration gradient in the element distribution between the hammerhead installation part and the working part, but at the bonding interface, the element content presents a smooth transition zone, which causes the hardness change in these areas.

3.6. Hammer tensile performance test
In order to test the bonding strength of the bimetal composite interface, a hammer head was sampled to make a tensile test specimen, and a tensile test was carried out using a universal testing machine. The test results showed that the specimen always fractured on the side of the high chromium cast iron, indicating that the interface Achieve the effect of metallurgical bonding. Figure 9 shows the fracture morphology of the hammer tensile specimen. It can be seen from Figure 8 that the fracture of the sample is brittle fracture, and the fracture mechanism is dissociation fracture. The macroscopic morphology of the corresponding sample is river-like, and the test results are consistent with the toughness difference of high chromium cast iron.
4. Conclusion

(1) For castings using the "Tian" gating system, the size of the high chromium cast iron part reaches a reasonable height, and the boundary of the bimetallic bonding interface is relatively smooth from a macro point of view. The internal quality of the hammer head is good, and there are no defects such as sand inclusions and hot cracks. The result is very good.

(2) The bimetal bonding interface is wavy and the structure is dense, indicating that the atoms of the two metals have mutually diffused to form a band-shaped bonding area with a certain width, and there are no defects such as micro cracks, pores and inclusions, and metallurgical bonding has been achieved.

(3) The sample always fractures on the side of the high chromium cast iron, indicating that the interface has achieved the effect of metallurgical bonding.

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