IMPROVING THE STRUCTURE AND PROPERTIES OF HEAT AND ABRASION RESISTANT CAST IRONS BY TREATING THEM WITH CALCIUM STRONTIUM CARBONATE

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ABSTRACT

The article considers the influence of calcium strontium carbonate additives on the structure and properties of complex alloyed white cast irons and establishes the optimum amount of the carbonate determining the maximum properties for white cast irons of various alloying systems.

Keywords: calcium strontium carbonate, white cast iron, modification, microstructure, microhardness, abrasion resistance, heat resistance.

INTRODUCTION

The creation of new multifunctional high-quality materials with a combination of high mechanical, technological and operational properties is among the main tasks of modern materials science. The majority of all presently known high-quality alloys are multi-component, therefore it is possible to choose their new chemical compositions on the basis of careful theoretical and experimental investigation of the way components interact in complex alloyed systems [1 - 8].

Especially important are the issues of additional alloying and modification, the variation of cooling conditions in the solidification of alloys, including steels and cast irons, which are to provide the most favorable structural phase state and combination of required properties.

It seems promising to use white complex alloyed cast irons as a material for manufacturing cast parts operating under conditions of abrasive wear at normal and elevated temperatures [2 - 11].

The durability of parts is significantly influenced by the processes of their interaction with the operating environment. They are under the influence of processes of cast iron internal and external oxidation, the volume of the casting grows irreversibly. As a result of growth, parts may warp and crack. The resulting tensile stresses accelerate the process of high-temperature oxidation.

Long exposure to high temperatures and external loads can lead to a lower abrasion resistance due to irreversible structural and phase transformations. Therefore, the castings operating under these conditions must possess a number of properties - high abrasion resistance and scaling resistance, as well as resistance to growth.

Increasing requirements for the quality, mechanical and operational properties of parts in metallurgy and machine building require the development of new effective ways of controlling the structure formation processes in the manufacture of the parts.

Modification is among the main and most effective methods of improving the mechanical and technological properties of alloys. The method has been known for a long time and is widely used in the production of iron and steel castings [12].

The purpose of this paper is to study the influence of calcium strontium carbonate as the modifier and of the metal cooling temperature modes in the mold on the structure, mechanical properties, heat resistance and abrasion resistance of complex alloyed white cast irons.
EXPERIMENTAL

The research was performed on the samples of complex alloyed white cast irons of the following alloying systems: Cr-Mn-Ni-Ti (cast irons No 1), Cr-Ni-Ti-Nb-B (cast irons No 2), Cr-Ni (cast irons No 3). Additives of calcium strontium carbonate in experimental meltings were 1, 3, 5, 6, 7 and 9 kg/t. Alloys were smelted in the IST-006 basic-lined induction furnace and cast into various types of molds: dry and wet green sand molds and a chill mold. In the dry green sand mold, the cooling rate in the crystallization interval was 3 - 10 deg/min, in the wet green sand mold it was 8 - 12 deg/min, in the cast iron chill - up to 30 deg/min.

The quantitative metallographic analysis and the automated processing of microhardness measurement results were performed using the Thixomet PRO image analyzer. Heat resistance was evaluated on the basis of GOST 6130-71 and 7769-82 according to two indicators: scaling resistance and resistance to growth.

Tests on the abrasive resistance of alloys and cast irons during friction against loosely fixed (semi-fixed) abrasive particles were performed according to the procedure specified in GOST 23.208-79.

RESULTS AND DISCUSSION

If cast irons are treated with carbonate, it leads to an increase of properties factors. The effect of the additive is crucial. The maximum properties factors for cast irons No 1 and cast irons No 2 observed with the addition of carbonate to 5 kg/t, and for cast irons No 3 - up to 6 kg/t (Fig. 1).

The structure of cast irons before and after treatment with carbonate consists of excess dendrites of austenite, carbides and austenite-chromium-carbide eutectic of the rosette structure. The amount of a particular component depends on the mold type and the carbonate proportion.

Fig. 1. The influence of (Ca,Sr)CO$_3$ on the properties of cast irons: 1 - cast irons No 1; 2 - cast irons No 3; 3 - cast irons No 2 cast in the wet green sand mold.
Thus, as the mold’s heat-storage capacity increases, the amount and size of the primary austenite dendrites decrease, the microhardness of the metal substrate grows from 540 to 800 HV and eutectic grows from 610 to 900 HV, together with the increase of the dispersity and the volume fraction of austenite carbide eutectic.

The microstructure of the cast irons № 1 cast iron before and after treatment with carbonate in the amount of 5 kg/t is shown in Fig. 2.

When introduced into the liquid iron melt, calcium strontium carbonate dissociates to form refractory inclusions of SrO and CaO, they become crystallization seeds, which leads to a considerable supercooling of the melt. Due to the supercooling, the crystallization proceeds more rapidly from many seeds, which results in the formation of a dispersed structure. Thus, carbonate additives reduce the size of carbide inclusions and increase their amount.

Prior to treatment with carbonate, the complex carbides of the (Ti, Cr, Fe, Mn) C type in the microstructure of cast irons No 1 are of different shapes: prolate-irregularly shaped; regular- quadrangular, close to compact. Carbides are unevenly distributed, in separate groups. The area of carbides varies from 1 to 55 μm², depending on the type of the mold (1 μm² - chill, 55 μm² - dry green sand mold, average-wet green sand mold, respectively). With the introduction of an optimum amount of carbonate of 5 kg/t, carbides become dispersed, globular, evenly distributed along the plane of the specimen (Fig. 3). The

Fig. 2. The microstructure of cast irons No 1 unmodified (a) and with (Ca, Sr)CO₃ additives in the amount of 5 kg/t (b).

Fig. 3. The morphology of titanium carbides of cast irons No 1 cast in dry green sand mold: a - without treatment with carbonate; b - treated with carbonate.
area of carbides varies from 0.2 to 22 μm². If cast iron is treated with carbonate, it increases their abrasion resistance. The maximum abrasion resistance is observed when up to 5 kg/t carbonate is added.

Further increase in the amount of carbonate up to 9 kg/t leads to the coarsening of carbides and their growth, i.e. makes the structure rough, which reduces the abrasion resistance of cast irons. Hence the decrease of the modifying effect called “overmodification” or “aging” of the modifying effect.

With the addition of 1 kg/t (Ca, Sr)CO₃, the microhardness of chromium carbides increases from 1040 to 1300 HV. When 5 kg/t is added, the microhardness of chromium carbides increases to 1360 HV. An increase in the proportion of the additive up to 9 kg/t leads to a drop in the microhardness to 1195 HV. When the quantity of (Ca, Sr)CO₃ introduced per ton of melt increases from 1 kg to 9 kg, the microhardness of the metal substrate and that of eutectic continuously increase from 540.97 to 736.5 HV and from 609.25 to 780.9 HV, respectively. At the same time, the quantity and dispersity of eutectic are continuously increasing, while the quantity and size of austenite dendrites are decreasing. Despite the increase in the amount of eutectic, abrasion resistance decreases with the introduction of over 5 kg/t of carbonate, which is connected with the above-mentioned changes in the characteristics of the carbide phase.

CONCLUSIONS

As a result of the conducted research it was established that the treatment of cast irons with calcium strontium carbonate leads to an increase in their properties. The maximum properties factors for cast irons No 1 and cast irons No 2 observed at the addition of up to 5 kg/t carbonate, and for cast irons No 3 - up to 6 kg/t. The properties are improved due to the change in the parameters of the cast iron microstructure - quantity, morphology and dispersity of structural components.

REFERENCES

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