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STUDYING PROPERTIES AND STRUCTURE OF ANTIFRICTION CAST IRON ADDITIONALLY ALLOYED WITH TITANIUM

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Preliminary Note – Prethodno priopćenje

This article presents data on the study of the properties and structure of antifriction cast iron additionally alloyed with titanium. On the basis of experimental data favorable effect of titanium microalloying in an amount of 0,25 % on the performance properties of antifriction gray cast iron AChS-2 is shown: sliding factor increases almost 1,5 times, shape, and size of craters after shock-cycling impact are improved. This improvement in properties suggests an increase in structural strength and service life of parts made of the experimental alloy. The alloy was smelted in an industrial furnace.

Keywords: cast iron, titanium, graphite inclusions, structure, hardness.

INTRODUCTION

Many parts of mining and metallurgical equipment are made of antifriction cast iron of AChS-2 grade. Cast iron of this grade has good enough antifriction properties, strength, and low price. The latter circumstance has led to its wide distribution for the manufacture of cast parts operating under conditions of dry wear. A significant disadvantage of this alloy is a wide range of properties, both in strength and antifriction properties. For example, parts that work under the same conditions show completely different service life: from 2 months to a year.

Earlier studies [1] have shown that the above properties of cast iron are strongly influenced by the parameters of the graphite phase. It was proved that in terms of sliding coefficient and, consequently, the effectiveness of the alloy AChS-2 as an antifriction material, it is necessary to obtain sufficiently fine graphite inclusions.

In the basic alloy AChS-2, the size of graphite inclusions varies in a wide range from 18 to 202 microns, and the size of inclusions corresponds to GOST 1585, which regulates the graphite phase for these cast irons.

Based on the results obtained in [1], it is obvious that to grind graphite inclusions and, consequently, to increase antifriction properties, it is necessary: to reduce both the average size of graphite inclusions and the size range, i.e., graphite inclusions should be more homogeneous in size.

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EXPERIMENTAL PART

The information analysis [2-8] suggested that titanium microalloying would allow the graphite phase to be ground and made more homogeneous in size. Based on the theory put forward in [5], the presence of titanium should contribute to the comminution of graphite and thus indirectly influence the mechanical properties of cast iron, in particular the sliding coefficient.

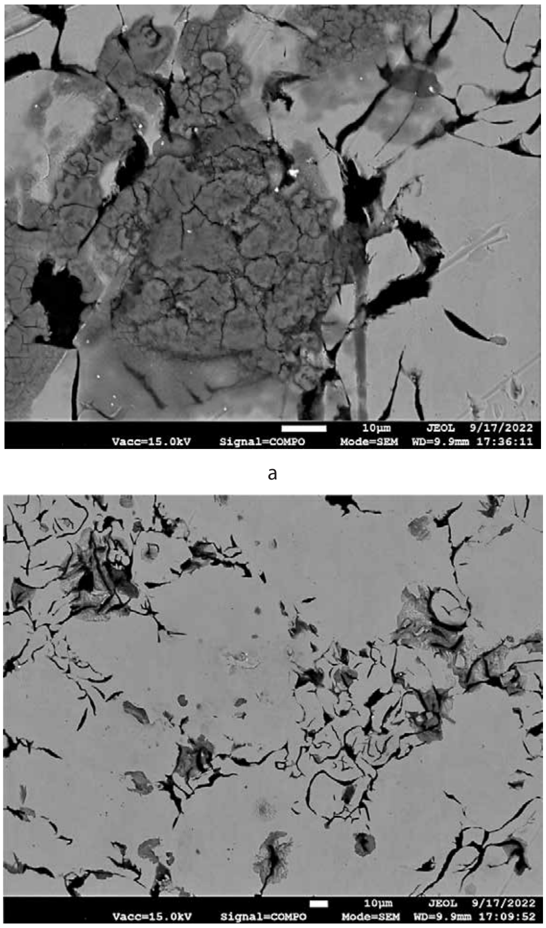
For this purpose, the following experiment was conducted. The experimental alloy (Table 1) was melted in an industrial arc furnace at the production site of KMZ named after Parkhomenko, casting was carried out in a sand-clay mold. Compared to the composition of the classical cast iron AChS-2, the titanium content in the experimental alloy was increased to 0,25 %, i.e., more than twofold. The required titanium content was provided by the introduction of FeT70 ferrotitanium.

Casting conditions did not change during the experiment. After complete cooling, samples of the castings were prepared for microstructure and mechanical properties testing.

Slides were prepared on a Strue metallographic complex, Thixomet Pro software was used for metallographic analysis, and hardness was determined on a Vilson hardness tester. The sliding coefficient was determined on a COF-P01(M) device with the following characteristics dry friction (unlubricated), angle of inclination - 150; angular velocity - 100/s. Tribological tests were performed using a tribometer (CSM Instruments). Test conditions: counter-body - WC ball with diameter of 6 mm; “ball-disc” scheme; load 5N; sliding speed 10 cm/s; running length 500 m.

Table 1 **Chemical composition of the experimental alloy**

Sample number	Sample	Content of elements / %						
		C	Si	Cr	Mn	Ni	Cu	Ti
1	basic (according to GOST 1585)	2,9-3,2	1,0-2,4	0,2-0,6	0,8-1,0	0,3-0,4	0,3-0,5	0,05-0,1
2	experimental	3,1	2,0	0,5	0,8	0,35	0,45	0,25



b

Figure 1 SEM microstructure of the studied alloys:
a - basic: b - experimental

The basic alloy AChS-2 was used as a comparison sample.

Figure 1 shows of Scanning Electron Microscopy (SEM) microstructures of the base and prototype alloys.

Even a visual analysis of Figure 1 shows that inclusions in the experimental alloy are smaller, and the area occupied by graphite is smaller. Quantitative structure analysis was performed using Thixomet Pro software, an example of the interface is shown in Figure 2.

Analysis of the structures of experimental and basic samples carried out in 100 fields of view showed that the average length of graphite inclusions decreased by more than 3 times, and the area of graphite inclusions decreased by about 30 % (Table 2).

Obviously, such a radical change in the parameters of the graphite phase should lead to a change in the properties of the alloy itself. For this purpose, the antifriction and tribological properties of the base and experimental alloys were studied.

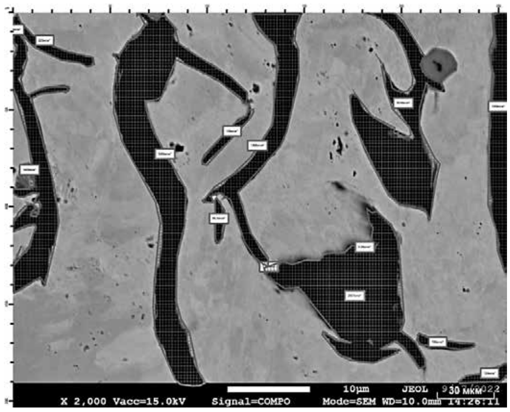


Figure 2 Example of graphite inclusions analysis
with Thixomet Pro software

Figure 3 shows examples of shock-cyclic impact with the formation of craters on the surface. In the first case, the shape of the crater and its size indicate the heterogeneity of the material. In the second case, the crater shape is flatter and more regular, and the size of the crater is smaller. Such characteristics of craters after shock-cyclic impact indicate a higher hardness of the alloy on the one hand, on the other hand - indicating a

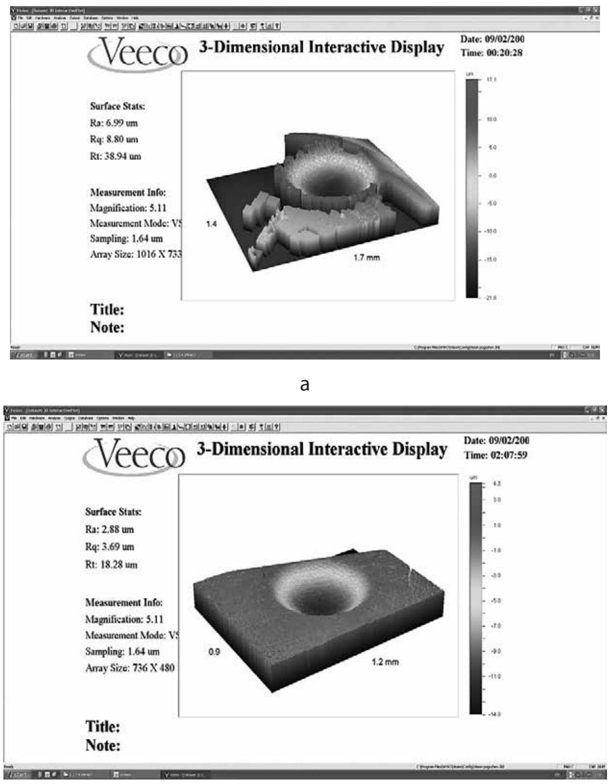


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Figure 3 Surface craters after shock-cyclic impact:
a - base sample; b - experimental sample

Table 2 **The results of experimental studies**

Sample	Length of graphite inclusions / μm	Area occupied by graphite / %	Slip Coefficient	Hardness / HV	Crater parameters / mm
Base alloy AChS-2	186	12,5	0,28	175	1,4 / 1,7
Experimental alloy	57	9,4	0,44	196	0,9 / 1,2

higher degree of homogeneity of the medium and less anisotropy.

Table 2 shows the averaged results of structure, hardness, sliding coefficient and shock-cyclic effects.

As can be seen from Table 2 sliding ratio in the experimental alloy has increased by more than 1.5 times, while the hardness has increased slightly (about 12 %). Some increase in hardness can probably be explained by the formation of titanium carbides as a result of alloying. In this case, titanium carbides also act as a limiting factor for the growth of graphite inclusions [4, 8], as well as other refractory phases of introduction.

Some of the difference between the laboratory [1] data and the results obtained at the production site can be explained by the technological features of casting, the rate of heat dissipation of the mold during crystallization and the purity of the initial charge.

CONCLUSION

The experimental studies of the properties and structure of the experimental alloy melted under production conditions have confirmed the beneficial effect of titanium microalloying in an amount of 0,25 % on the operational properties of antifriction gray cast iron AChS-2: the sliding ratio increases almost 1,5 times, the shape and size of craters after shock-cycling effects are improved. This improvement in properties suggests an increase in structural strength (in this case, a combination of strength and antifriction properties) and, consequently, an increase in the service life of the experimental alloy part.

Acknowledgments

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Note: Responsible for the English language is Natalya Drak, Karaganda, Kazakhstan