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STUDYING PROPERTIES OF CHROME CAST IRONS MODIFIED WITH TITANIUM CARBIDE

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Preliminary Note – Prethodno priopćenje

The paper presents the results of studying hardness and wear resistance of chrome cast irons. In the study there were considered samples of cast iron of the ChN2H, ChN4H2 grades and ChN2H after treatment with titanium carbide. Titanium carbide in the amount of 1 % by weight with dispersity of 500 microns was introduced during casting into ChN2H cast iron. As a result of this treatment, the cast iron hardness and wear resistance become comparable to those of Nihard grade cast iron. Studies have shown the promise of using refractory compounds as modifiers for cast irons.

Keywords: nihard cast irons, titanium carbide, heat treatment, hardness, wear resistance.

INTRODUCTION

A number of parts for mining and metallurgical equipment are made of Nihard cast irons (grates, fittings, plates, pump parts, etc.). The information analysis of works [1-3] shows that abrasive wear is a frequent cause of failure of many parts of mining and metallurgical equipment, as a result of low hardness and wear resistance of the surface. On average, replacement of such parts as blades of mixing systems, liners and other elements of dredge pumps and others is carried out every 3-5 months [4-5], which leads to equipment downtime and reduced productivity.

Own proactive studies [6-8] have shown that in addition to abrasive wear in such working conditions there are also significant impact, vibration and alternating loads. As a result, parts of mining and metallurgical equipment operating in such conditions must also have a sufficiently high margin of viscosity. Such a combination of properties can be achieved by adjusting the phase composition by means of introducing additional alloying elements and changing some stages of the technology including controlled crystallization, improvement of the heat treatment and modification modes.

For parts operating under abrasive wear conditions, such as fittings for grinding equipment, dust and slurry pipelines, nozzles, screens, parts of dredge pumps, etc., low-alloy cast iron of the ChN_2H grade and high-alloy cast iron of the ChN_4H_2 grade of the Nihard group are used. The chemical composition and some mechanical properties of these grades are shown in Table 1 (reference data).

Table 1 **Chemical composition of the ChN grades cast irons**

Grade		ChN_2H	ChN_4H_2
Elements / %	C	3-3,6	2,8-3,6
	Ni	1,5-2	3,5-5
	Cr	0,4-0,6	0,8-2,5
	Si	1,5-2	0,1-1,0
	S	to 0,12	to 0,15
	P	to 0,25	to 0,3
Hardness / HB		215-280/230	400-650/420
Ultimate strength / MPa		290	200
Yield bending strength / MPa		490	400

The ChN_4H_2 alloy belongs to the group of Nihard alloys, in which, as it is known, carbon is both free and bound in the form of Cr_3C and Cr_7 C_3, which ensures high hardness and wear resistance of this group of alloys. The ChN_2H alloy does not belong to the Nihard group, it has lower hardness and wear resistance but its cost is about 30-40 % lower.

Introducing refractory substances as a modifier significantly changes the structure of the alloy, in particular, the shape, grain size and carbide phase [9-12]. It is obvious that introducing such a refractory substance as titanium carbide into the composition of cast iron can also change its structure and therefore, its properties.

Titanium carbide is a refractory compound (melting point 3 140 °C), it does not practically melt in liquid iron and retains its phase individuality, retaining its inherent property, high hardness. In cast irons, titanium carbide (TiC) is introduced as a complex master alloy, which provides an additional hardening phase of penetration in the structure. The presence of titanium carbide in the structure should increase this structure hardness and its wear resistance.

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EXPERIMENTAL PART

To check this assumption, titanium carbide was introduced into cast iron of the ChN$_2$H grade in the amount of 1 % by weight with dispersibilty 500 µm. After cooling, the samples were subjected to normalization at 1 100 °C within 1 hour to homogenize the structure.

For comparison, 2 samples were used: ChN$_2$H without TiC treatment and ChN$_4$H$_2$. The reference samples were subjected to the same heat treatment. After heat treatment, hardness (WH1150 hardness tester) and wear resistance (TABER ABRASER 352G, S-35 abrasive disc, tungsten carbide material) were measured on all the samples. Wear resistance (L) was determined by the relative change in the mass of the sample before and after testing by the formula:

$$L= M1/M2*100 \%$$

where M_1 is the mass of the sample after testing; M_2 is initial mass of the sample.

DISCUSSION OF THE RESULTS

Table 2 shows the samples characteristics and the results of measuring hardness and wear resistance.

It is seen from the data in Table 2 that introducing titanium carbide, as expected, has a beneficial effect on hardness and wear resistance of ChN2H cast iron. After treatment of cast iron with titanium carbide, hardness and wear resistance of ChN2H become comparable to those of ChN4H2. The dispersion of titanium carbide above 500 µm was not used in this study, because standard deliveries of carbide powder present the 500 microns fraction at least 80 % according to the TS.

The comparison diagram constructed according to the data in Table 2 (Figure 1) shows that with introducing titanium carbide, hardness and wear resistance of ChN2H become comparable to the properties of ChN4H2.

Table 2 **Results of testing experimental samples for hardness and wear resistance**

Sample No	Sample characteristics	Hardness / HB	Wear resistance / %
1	ChN2H cast iron (without TiC)	230	84,07
2	ChN4H2	420	97,73
3	ChN2H	410	97,7

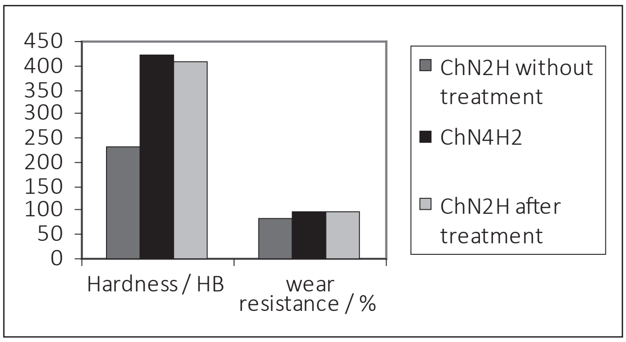


Figure 1 Comparative diagram of hardness and wear resistance of cast irons

It is obvious that hardness and wear resistance are unambiguously related to the nature of the sample microstructure. Figures 2-3 show the microstructures of the metal matrix of samples No. 2 and No. 3. In these figures, the fractions of structural components and dispersion of the structure were estimated. The analysis was performed using the Thixomet Pro software, which automatically performs many types of quantitative metallographic analysis.

The amount of components was calculated as follows: one component phase (blue) was 24 687,5 µm^2, the total area of the field of view was 45 171 µm^2. Consequently, the share of the area occupied by the second component was 54,65 %.

The structure dispersion was estimated by the distance between the plates: the indicator was calculated at 10 points in at least 10 fields of view. The metal matrix of sample No. 3 was evaluated in a similar way.

Table 3 presents the summary results of the metallographic analysis and the data of hardness and wear resistance given above.

The data in Table 3 show that in sample No. 2 the proportion of the solid component is higher than in sample No. 3, the dispersion is also higher. At the same time, an interesting fact is observed: the size of graphite inclusions is more than 10 times lower, and the density of their distribution is almost 1.5 times higher. It can be

a)

b)

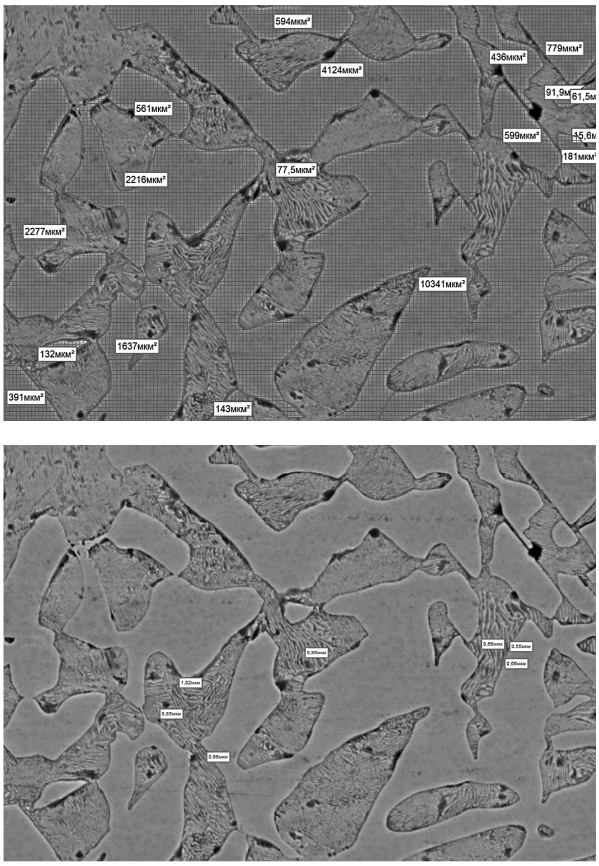
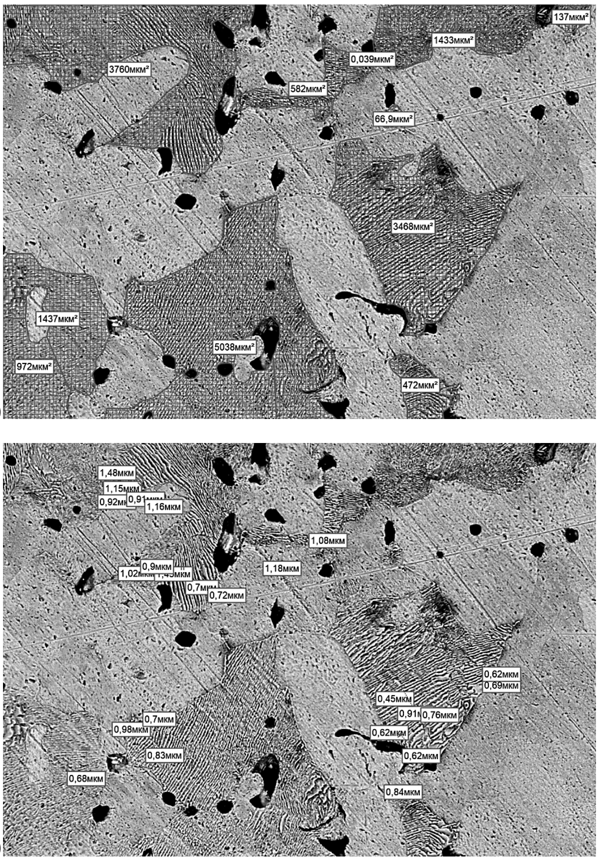


Figure 2 Quantitative estimation of the sample No. 2 metal matrix: a) – the amount of component; b) - dispersity



a) b)

Figure 3 Quantitative estimation of the sample No. 3 metal matrix: a) – the amount of component; b) - dispersity

concluded that introducing TiC leads to the refinement of graphite inclusions, simplification of their shape (the perimeter of the inclusions decreases), and increasing the distribution density of inclusions per mm^2.

This fact can be explained by only one circumstance: titanium carbide acts as a passive modifier; it does not contribute to the complete changing of the graphite shape (for example, to spherical), but it contributes to its refinement and more uniform distribution of graphite inclusions.

Such changing the nature of graphite inclusions leads to increasing hardness and wear resistance, which was observed in experimental sample No. 3.

It should be noted that rounded inclusions were observed in the structure of sample No. 3 at high magnifications (x1 500). Using (MRSA), they were diagnosed as titanium carbide (Figure 4).

It should be noted that inclusions of titanium carbide have a fairly isometrically developed shape. It is seen from the given example (Figure 3b) that the average shape factor is 0.65, i.e. the shape of the inclusions is close to spherical. The average diameter of the inclusions is 7,5 µm.

When titanium carbide was introduced, its dispersion, according to the data of photo sedimentation analysis, was -500 µm at least 80 %. Consequently, in the process of casting and crystallization, the size of inclusions of titanium carbide sharply decreased, this phenomenon can only be explained by its partial dissolution. This assumption is supported by the relatively round shape of the titanium carbide particles. This fact indirectly confirms the assumption that relatively large particles of titanium carbide are used for modification.

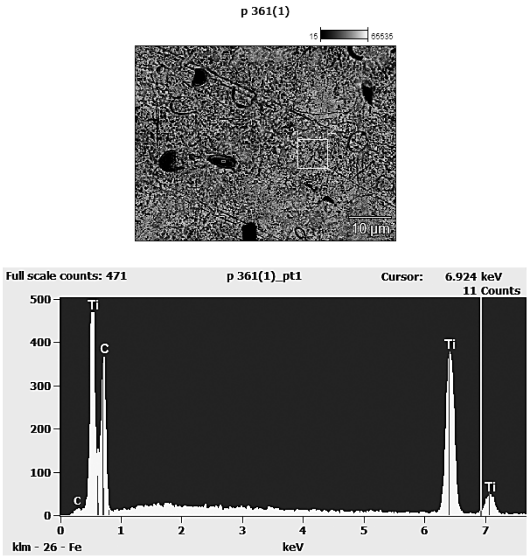


Figure 4 – Titanium carbide inclusions: (X-ray microanalysis)

Table 3 **Results of the metallographic analysis and the data of hardness and wear resistance**

Sample No.	No. 2 (ChN$_4$H$_2$ cast iron)	No. 3 (ChN$_2$H after treatment with TiC)
Share of the components area / %	54,65	38,43
Dispersion / µm	0,75	0,92
Average area of inclusions / µm^2	561,8	87,1
Distribution density / pcs/mm^2	29 652	43 479
Hardness / HB	420	415
Wear resistance / %	97,73	97,5

CONCLUSION

The results of the studies show that introducing titanium carbide as a modifier in the treatment of chrome cast irons contributes to changing the nature of the microstructure and, as a consequence, to increasing hardness and wear resistance of the alloy.

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Note: The responsible for England language is Natalya Drak, Karaganda Kazakhstan