INFLUENCE OF STRUCTURE AND MECHANICAL PROPERTIES ON HYDROABRASIVE WEAR RESISTANCE OF CAST IRON

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ABSTRACT

Results of study of hydro abrasive wear resistance of unalloyed and micro alloyed Sn and Sb cast irons with different forms of graphite and metal base structure are presented. It is shown that high-strength ductile cast iron with spherical graphite and pearlitic-ferritic base (P70) with high ductility and high impact toughness has the greatest resistance to hydro abrasive wear.

KEYWORDS: *Cast Iron, Lamellar Graphite, Vermicular Graphite, Spherical Graphite, Metallic Base, Hydro-Abrasive Wear Resistance, Pumps Flow Parts.*

INTRODUCTION

Increasing the service life of irrigation system nozzles is an urgent task. Pump flow parts operate under severe conditions and are subject to hydro-abrasion, cavitation-erosion wear and corrosion.

Currently, pump flow parts are mainly made of gray cast iron with lamellar graphite, which has low hydroabrasive wear resistance. At the same time there is every reason to believe that highstrength cast irons with spherical and vermicular graphite, which have a higher complex of mechanical properties, can be a promising material for such parts.

Analysis of Publications

As shown in [1 - 3], hydroabrasion wear significantly depends on mechanical properties. According to the author of [1], the durability of materials under hydroabrasive wear can be estimated by the product KS-HB, where KS is the impact toughness and HB is the hardness. At the same time, it was stated that such dependence is the same for all materials, which is not confirmed by experiments.

In work [4] it was proposed to estimate wear resistance of materials at abrasive wear on the basis of complex parameter HB-δ^n, where HB is hardness value of material, δ is plasticity index, *n* is degree index determined experimentally. In this case we are referring, firstly, to steels, and, secondly, to abrasion, not hydroabrasion. The presence of graphite in cast irons, as well as a different character of wear makes it impossible to use the method proposed in to assess the wear resistance of pump flow parts [5]. There is insufficient data on the influence of graphite shape and metal base structure on abrasion resistance in castings [6].

Purpose and Mission Statement

The purpose of this work was to investigate mechanical properties and hydroabrasion resistance of unalloyed and microalloyed with tin and antimony gray and high-strength cast irons.

It was necessary to establish connection between graphite shape and metal base structure, mechanical properties parameters and hydroabrasive wear resistance of cast irons.

Determination of Hydro Abrasive Wear Resistance

As the material for the study the following was selected: gray cast iron A48-30B, currently used for parts of irrigation pumps; gray cast iron micro alloyed with tin; unalloyed high-strength cast iron and high-strength cast iron micro alloyed with tin and antimony.

Steel 45 was used as a reference. The chemical composition of the studied materials is given in Table 1.

All high-strength cast irons have practically identical contents of the main components, which is very close (except for silicon) to the composition of grey irons used for cast parts of pump flow parts.

The results of metallographic analysis of pig iron are given in Table 2.

The Cr20 (0) nodular cast iron has a fused graphite and pearlitic-ferritic matrix. Microalloying with 0.02% Sn had no effect on the graphite phase, but it can lead to the metal base has been completely perliticized. Micro alloying of such cast iron with 0.02% Sn practically does not influence the shape and size of graphite inclusions, but makes the matrix predominantly pearlite (P94).

TABLE 1 CHEMICAL COMPOSITION OF THE STUDIED MATERIALS

№ material	Type of cast iron	Element content, %							
		C	Si	Mn	S	P	Mg	Sn	Sb
0	PMG(PM 20)	3,38	2,24	0,73	0,0066	0,056	-	-	-
1	PSC micro alloyed Sn	3,38	2,24	0,75	0,0066	0,056	-	0,02	-
2	CSHH unalloyed Sn	3,43	2,95	0,83	0,0055	0,054	0,048	-	-
3	CSHH micro alloyed Sn	3,43	2,97	0,85	0,0055	0,055	0,045	0,02	-
4	PVG micro alloyed Sb	3,42	2,95	0,83	0,0056	0,062	0,050	-	0,0 32
5	Steel 45 (hot	0,46	0,25	0,80	0,04	0,017	-	-	-

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The micro alloying of ductile cast iron with0.032% Sb leads to the formation of twisted (GF5) and thickened (GF6) vermicular graphite and to a significant increase in perlite content (P96).

Mechanical tests of the studied materials performed the results of which are given in Table 2. High-strength cast irons have significantly higher values of strength and, especially, ductility and toughness as compared to gray irons. The high-strength cast iron 2 with perlitic-ferritic structure of the metal matrix has the highest mechanical properties. Although this cast iron is inferior to ferriticperlitic microalloyed cast iron 3 in hardness, it is superior to it in strength, ductility, and toughness. The presence of vermicular graphite in cast iron 4, micro alloyed with0.032%Sb, at leads to a significant reduction in all mechanical properties compared to cast iron 2, which has spherical graphite and a significant amount of ferrite in the metal base structure.

TABLE 2. MICROSTRUCTURE AND MECHANICAL PROPERTIES OF INVESTIGATED CAST IRONS

№	Microstructure		Mechanical properties			
	Graphite	Metal base	σ_b, Pa	σ, %	CC, J/sm^2	HB, Pa
0	Gf2, Gf4, Graz90 – Graz 180	P70(F30)	200	-	6,0	1700
1	Gf2, Gf4, Graz90 – Graz 180	P100(F0)	210	-	5,0	2070
2	Gf12, Gf13, Graz25 – Graz 45	P70(F30)	750	5,5	39,0	2550
3	Gf13, Gf12, Graz25 – Graz 45	P94(F6)	670	1,7	11,7	2930
4	Gf5, Gf6, Gf12 Graz25 – Graz 45	P96(F4)	370	1,0	11,0	2690
5	-	P50(F50)	620	16	50	2070

Hydro abrasion resistance of materials was determined on a specially designed setup with horizontal shaft positioning. The used setup allows changing conditions of materials testing for hydro abrasive wear in a wide range, significantly increasing the number of simultaneously tested specimens and directly using the specimens after tests for further structural research. The results of hydro abrasive wear tests at 1% abrasive concentration are shown in Table 3.

TABLE 3 HYDRO ABRASIVE RESISTANCE OF MATERIALS AT 1% ABRASIVE CONCENTRATION

Melt down number	Amount of wear, mg*	Wear rate, mg/sm^2·h	The power of the system is not bone, %
0	58,1	2,32	62
1	55,0	2,22	65
2	47,9	1,79	80
3	47,6	1,90	76
4	52,2	2,09	69
5	36,1	1,44	100

*Test time is 5 hours

As follows from the above data all ductile irons (2, 3, 4) have higher abrasion resistance compared to gray irons (0.1). This is inevitably related to the spherical and vermicular shape of graphite, which weakens the metal matrix to a lesser extent than the lamellar graphite. At the same time, it is noteworthy that cast iron 2, which has the same graphite form as cast iron 3 and differs from it by the presence of ferrite in the structure (30%) and correspondingly higher values of ductility and ductility, is more resistant to hydroabrasion. This proves that the abrasion resistance of cast irons significantly depends not only on the strength properties, but also on the ductility and toughness characteristics.

CONCLUSION

Micro alloying of grey and ductile cast iron within (0.02%) has practically no effect on the structure of the graphite phase and contributes to almost complete fertilization of the metallic backbone and considerable increase in hardness.

High-strength cast iron micro alloyed with tin has 3 times lower ductility and impact toughness values than unalloyed cast iron.

Antimony microalloying of high-strength cast iron (0.032%) results in the formation of vermicular graphite, pearlitization of the metal base and a significant decrease in both strength (2 times), ductility (5.5 times) and impact toughness (3.5 times).

The highest wear resistance among high-strength cast irons under hydro abrasion conditions is for cast iron with spherical graphite and perliticferritic (P70) metal base. Cast iron with vermicular graphite and pearlitic metallic base has the lowest wear resistance.

Hydro abrasive wear resistance is determined not only by strength properties, but also to a large extent by plasticity and viscosity properties.

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