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ABRASIVE WEAR OF MATERIALS IN A BLAST FURNACE UNDER ACTUAL WORKING CONDITIONS

by

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ABSTRACT The purpose of this study was to det. the wear of pairs from various steel (in mutual contact as they are present in blast-furnace charging machinery) in an atm. of blast-furnace gas and dust. The tests were carried out in an industrial blast furnace, whereby the gap between the pair of materials and the angle of the gas entrance were varied. The gas and dust compns. are given in the text. The following pairs of steels were tested (1st figures for the bell, 2nd figures for the cup): 10, 10; 35,35; 45, 45; 50G2, 50G2; 6KhV2S, 60KhV2S; 30KhGSA, 30KhGSA; R18, R18; 3Kh2V8, 3Kh2V8; 2Kh13, 2Kh13; T590, T590; T620, T620; G13, G13; U15Kh17N2, U15Kh17N2; Kh20N10G6, Kh20N10G6; 1Kh18N9T, 1Kh18N9T; U20Kh17T, U20Kh17T; 30KhGSA, T590; T590, 3Kh2V8; 1Kh18N9T, 45; and 1Kh18N9T, T590. Cast, welded-on, and forged materials, as well as materials forged, quenched, and tempered at 400 degrees, were tested for 3 consecutive days. The best erosion resistance was shown by materials which retained hardness at high temp., such as T590 and T620. Austenitic steels showed more wear than hard materials, but the former showed higher plasticity, and for this reason they can be recommended for welding onto the surfaces working under erosion wear.

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Reference [1] offers data on the wear of contacting surfaces, which were obtained in laboratories from samples whose shape and dimensions not even remotely simulated real parts.

The purpose of our work is to study the wear of contacting pairs, made from various materials, in a flow of gas under conditions quite similar to the operating conditions of the charging machinery in a blast furnace.

Tests were made on one of the blast furnaces at the F. E. Dzerzhinskiy Plant. The size of the gap between the samples, the approach angle of the gas to the gap, and the cup-bell coupling profile were varied with the aid of a device whose operating principle is easily understood from Fig. 1.

To calculate the effect of gas temperature on sample wear chromel-copel thermocouples [2], joined by compensation wires with an EPP-09M electronic potentiometer, were mounted on this device. The daily mean temperature of the samples varied from 350 to 450°C. At the same time the potentiometer recorded the temperature of the blast-furnace gas in the gas vents.

The gas consisted of, %:

CO_2	CO	N_2	CH_4	H_2
14,0	28,2	55,0	0,4	2,0

Percentage of dust in the gas was, %:

SiO_2	Al_2O_3	CaO	MgO	Fe	FeO	Fe_2O_3	Zn	C
7,60	3,36	7,40	1,38	31,20	16,21	35,03	0,20	4,00

The material studied was heat-treated, forged steel having various chemical compositions and alloys based on St. 6 steel (see table). The contacting surfaces could be made from the same or different material.

Tests were made on each pair of samples for twelve days. After each 24-h period the samples were taken from the device, photographed, and weighed, after which the test continued.

It was found that the character of the wear on samples representing the cup and the bell is approximately the same. If the gas jet enters at a 60° angle, maximum wear is localized near the inlet. With the passage of time wear extends along the entire surface and into the sample.

The dependence of sample wear on the length of the test is a linear dependence. Low-carbon, soft steels wore more rapidly, and also alloys, such as T590 and T620, had decreased in weight by a factor of 15 after twelve days. However, in combination with softer steels they wore more rapidly than when paired with the same brand. For example, a bell of sormite 1 combined with a cup of 35 steel wears 1.5 times faster than when both parts are made from sormite 1.

On the basis of the data obtained, we have plotted the amount of wear versus the hardness of the samples (Fig. 2).

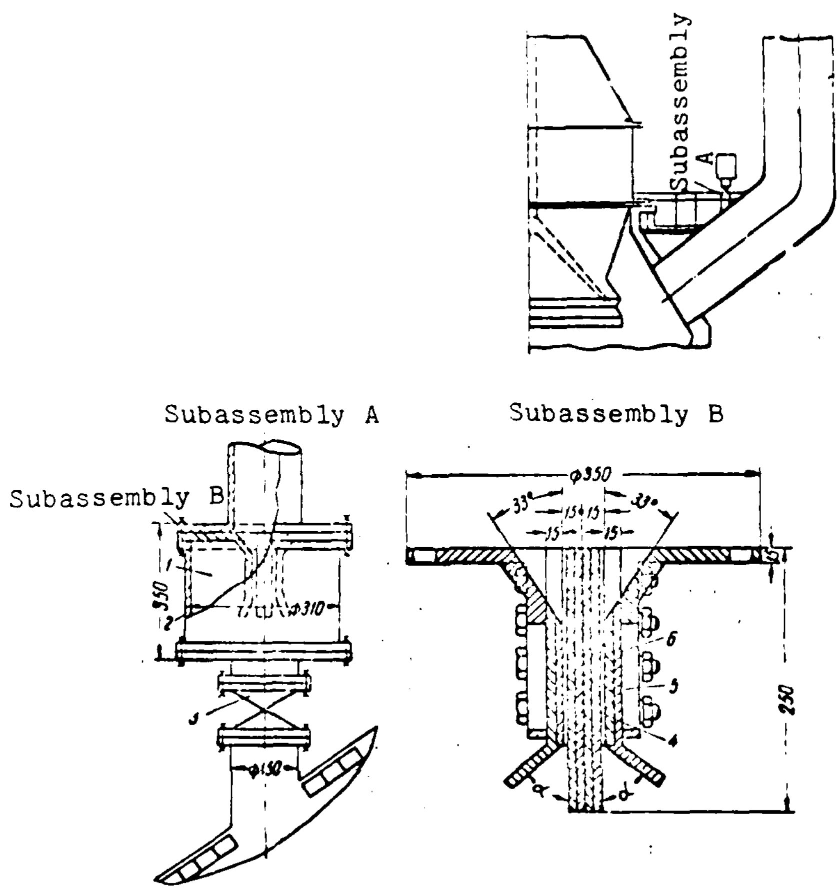

Fig. 1. Device for the wear-testing of parts in a flow of blast-furnace gas: subassembly A – mounting of device on the furnace; subassembly B – cassette assembled; 1 – cassette; 2 – working chamber; 3 – valve; 4 – 3 mm gap; 5 – generating line of the bell; 6 – generating line of the cup.

For parts with a ferrite + carbide phase state and hard alloys, the variation in wear is expressed as a hyperbolic function (Fig. 2, Curve 1). For austenitic steels with hardness from 200 to 500 HB, wear remains virtually constant. This peculiarity in the abrasion resistance of austenitic steels can be explained by the surface cold-hardening of their abrasive particles. As is known, austenitic steels harden more than other steels mainly because part of the austenite becomes martensite.

Thus, of all the studied alloys, those possessing high hardness at elevated temperatures (T590, T620) have the best resistance to erosive wear (Fig. 3). The resistance of alloys T590 and T620 is 1.8 times higher than the resistance of sormite 1 which is widely used for welding.

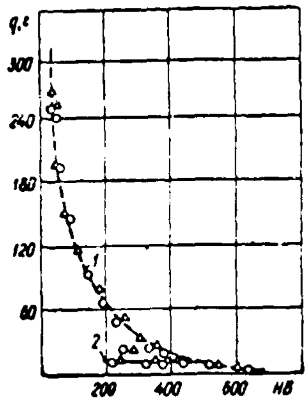

Fig. 2. Losses in sample weight (q) as a function of their hardness: 1 – martensitic steels; 2 – austenitic steels; o – cup hardness; Δ – bell hardness.

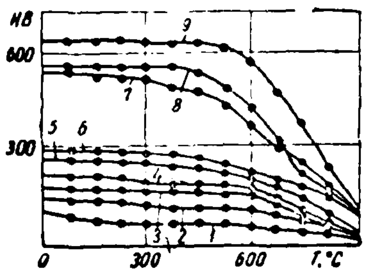

Fig. 3. Variation in sample hardness as a function of test temperature: 1-4 – steel 10, 15, 35, 65, respectively; 5 – 1Kh18N9T; 6 – 30KhGSA; 7 – sormite 1; 8 – 3Kh2V8; 9 – T590.

Austenitic steels wear more than hard alloys; however, they have high plasticity. Because of this, highly alloyed austenitic steels can be recommended for facing surfaces operating in abrasive conditions.

Table. Wear in samples representing the coupling of a bell with a cup in an active blast furnace.

Material		Treatment		HB		Losses in sample weight, g									
						к					ч				
						Periods					Periods				
к	ч	к	ч	к	ч	I	II	III	IV	Total	I	II	III	IV	Total
10	10	П	П	94	94	39,34	46,84	48,36	48,54	182,92	37,02	47,22	49,34	45,41	179,20
35	35	П	П	152	152	26,10	38,52	28,00	29,30	121,90	27,19	30,15	29,75	29,41	116,53
45	45	П	П	174	174	26,64	32,16	26,11	27,16	111,10	23,00	26,79	23,14	25,35	98,28
50G2	50G2	П	П	197	192	24,15	30,65	23,25	26,30	104,35	20,35	24,89	19,49	23,59	88,23
50G2	50G2	П(з)	П(з)	551	551	10,35	17,40	10,70	11,25	50,70	9,15	15,21	10,01	10,45	41,52
6KhV2S	6KhV2S	П	П	208	222	19,81	22,15	15,45	19,02	76,43	17,35	22,30	12,17	16,35	68,17
6KhV2S	6KhV2S	П(з)	П(з)	587	606	8,20	11,40	9,25	10,30	39,15	9,85	11,72	10,28	8,16	40,01
30KhGSA	30KhGSA	Н	Н	261	261	20,30	28,10	16,17	18,12	82,69	19,52	23,70	18,45	17,35	79,02
R18	R18	П	П	551	551	2,01	3,10	3,12	3,42		2,71	2,99	3,06	3,35	
3Kh2V8	3Kh2V8	Н	Н	551	551	4,27	5,35	3,75	3,98	17,35	3,75	4,99	3,95	3,54	16,23
2Kh13	2Kh13	Н	Н	361	344	8,45	11,15	10,57	12,16	42,33	9,44	12,06	11,60	14,01	47,12
Sormite 1	Sormite 1	Н	Н	587	587	3,59	4,42	2,41	2,82	13,24	3,08	3,86	3,53	2,80	13,27
Sormite 2	Sormite 2	Н	Н	401	380	8,44	9,61	10,12	10,36	38,56	10,70	11,12	10,42	12,55	41,79
T590	T590	Н	Н	605	605	1,45	2,60	2,21	1,75	8,01	1,36	1,69	3,51	1,99	8,54
T620	T620	Н	Н	587	587	2,64	3,20	3,25	3,90	12,39	2,41	2,20	3,04	2,91	10,53
G13	G13	Л	Л	222	240	5,95	4,40	4,23	3,85	18,43	5,15	4,95	4,45	3,22	17,77
U15Kh17N2	U15Kh17N2	Н	Н	401	423	4,30	6,25	6,75	4,17	21,47	4,55	5,81	3,99	5,28	19,63
Kh20N10G6	Kh20N10G6	Н	Н	347	330	5,35	4,70	4,15	3,30		4,16	3,98	3,54	3,50	
1Kh18N9T	1Kh18N9T	П	П	249	249	7,20	9,15	7,60	7,75	31,70	8,49	9,91	6,85	7,68	31,37
U20Kh17T	U20Kh17T	Н	Н	468	468	4,21	5,17	4,01	3,47	16,80	4,20	4,98	3,84	2,67	15,69
10	Sormite 1	П	Н	94	587	53,35	54,[illegible]	65,10	57,30	229,70	3,31	5,00	4,41	5,50	18,20
35		П	Н	152	587	32,13	28,43	29,36	27,40	117,32	5,85	4,60	5,25	4,75	20,54
30KhGSA	T590	Н	Н	269	606	30,40	34,24	22,70	37,32	124,66	9,45	10,08	12,20	10,16	41,99
T590	3Kh2V8	Н	Н	605	551	2,69	3,22	3,35	4,97	14,23	6,79	7,55	4,41	6,56	25,34
1Kh18N9T	45	П	П	131	250	15,85	21,72	18,41	14,39	68,76	24,31	28,38	30,11	26,75	109,55
1Kh18N9T	T590	П	Н	131	606	18,17	24,34	20,40	22,20	81,91	8,12	6,98	7,43	8,65	31,45

Note: 1. к – bell; ч – cup; П – forged piece; Н – welded piece; П(з) – forged piece, hardened and tempered at 400°C. 2. Each period lasted three days.

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1. Leynachuk, Ye. I. Trudy NTO ChM. Metallurgizdat, 1960, Vol. 21.

2. Tylkin, M. A., et al. Stal' (Steel), 1964, No. 5, p. 408.

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