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Comparison of chromium cast iron deposits of wear plates

A. Klimpel, J. Górka*, A. Czupryński
Welding Department, Silesian University of Technology,
ul. Konarskiego 18a, 44-100 Gliwice, Poland
* Corresponding author: E-mail address: jacek.gorka@polsl.pl

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ABSTRACT

Purpose: of these researches was to compare of chromium cast iron wear plates deposits properties.
Design/methodology/approach: : the quality of wear plates was assessed by low-stress abrasion resistance to metal-ceramic scratching by means dry quartz sand as the abrasion material tests according to G65 standard, erosion resistance tests according to G76 standard, metallographic examinations and hardness tests.
Findings: due to the fact that the wear plates were produced by overlap weave beads surfacing method, the analysis of properties of the plates was performed in the middle area of deposits as well as overlap beads area.
Research limitations/implications: for complete information about tested wear plates it is needed to compare theirs properties with others presented plates
Practical implications: results of this paper is to increase quality of wear plates and comparison of properties of wear plates produced by different producers.
Originality/value: the researches (hardness tests, abrasion and erosion resistance tests) were provided in the middle area of deposits and also in overlap area, the results were compared.
Keywords: Welding; Chromium cast iron; Wear plates; Wear and erosion resistance

1. Introduction

Wear plates are one of modern solutions of the production and regeneration of high wear and erosion resistance industrial installations. The significant economical advantage of wear plates applications are ensured by covering large heavy working wear surfaces of the machinery in cement works, mines and guarries. Wear plates are produced by automatic SSA surfacing of 5-10 mm thick mild steel base plates 0,8÷1,2x1,2÷2,7 m which next are cut and shaped to the demanded dimensions. The typical thickness of the high abrasive and erosion resistance SSA deposit is 3 to 18 mm. Very high thickness of surfaced layer, 50÷80% of the base plate thickness, requires to use technically advanced mechanisation of the surfacing process. Additionally the fabrication process of the wear plates has to ensure uniform mechanical properties on cross section of the surfaced wear resistant layer. The stress distribution in the surfaced layer of the wear plate resulting from changes in volume of the cooling down metal and differences in the thermal expansion between the deposit and the base material induces a network of cracks, nevertheless the properties of deposit are not decreased. Abrasive wear resistance of wear plates is approximately 8 to10 times higher than wear resistant alloy steel. This fact enables to overcome economical problems and increase regeneration process efficiency of different industrial installations. It directly results from the lower expenditures for maintenance and frequency requirement of the replacement of used parts in industrial devices. Wear plates have been especially developed to satisfy the increasingly stringent demands of profitability and productivity in heavy industry [1-10].

2. Researches

The aim of this work was to compare the properties of 4666DP0604 and XMC wear plates. Due to the fact that the wear

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plates were produced by SSA surfacing of overlapped weave beads method, analysis of the properties of the deposits of wear plates was performed in the middle area of weave beads and as in weave beads overlap area. Chemical composition of 4666DP0604 wear plate: Fe + 5,2%C, 22%Cr, 7%Nb, 1,8%B and XMC wear plate: Fe + 4,8%C, 26%Cr. Both tested wear plates contain in chromium cast iron matrix have over 50% primary solidified chromium M_7C_3, and additionally niobium NbC carbides and chromium borides Cr_2B in the structure of 4666DP0604 wear plate.

2.1. Metallographic examinations

The metallographic examinations were investigate in the middle and overlap areas of weave beads deposits of both wear plates, Figs. 1 to 3.

4666DP0604 wear plate XMC wear plate

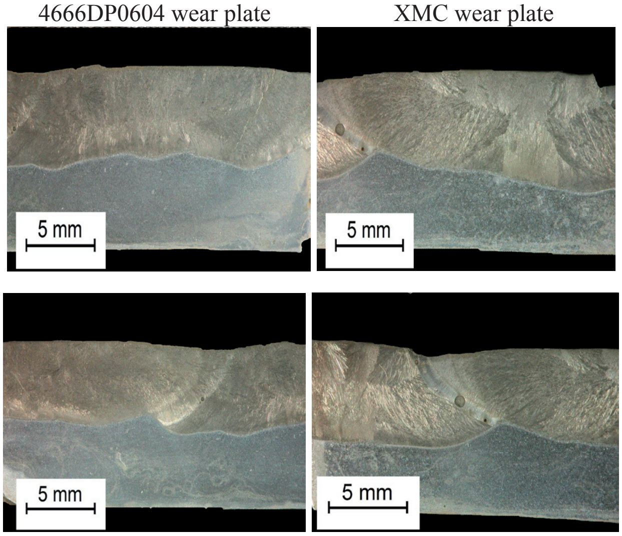
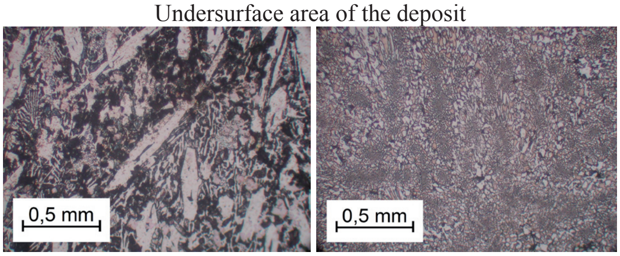


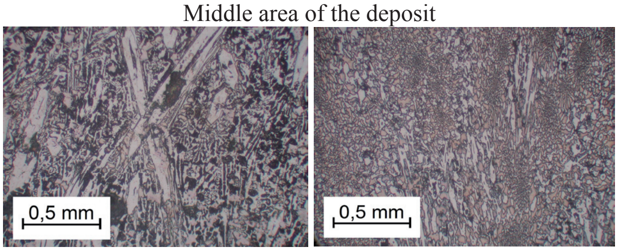
Fig. 1. Macrographs of 4666DP0604 and XMC wear plate in middle area and overlap area of the deposit. No internal defects observed and uniform fusion of the deposit to the base metal

4666DP0604 wear plate XMC wear plate

Undersurface area of the deposit



Middle area of the deposit



Fusion zone area of the deposit

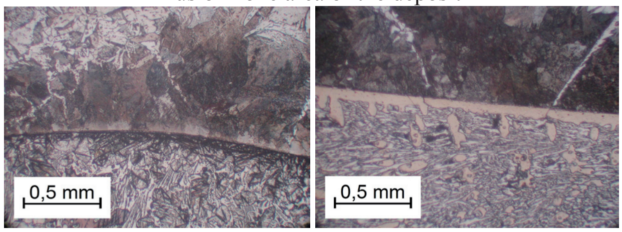
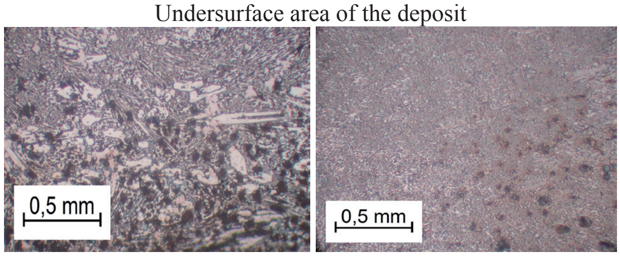


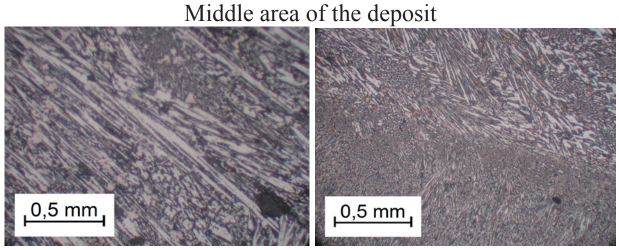
Fig. 2. Micrographs of 4666DP0604 and XMC wear plate in middle area of the deposit

4666DP0604 wear plate XMC wear plate

Undersurface area of the deposit



Middle area of the deposit



Fusion zone area of the deposit

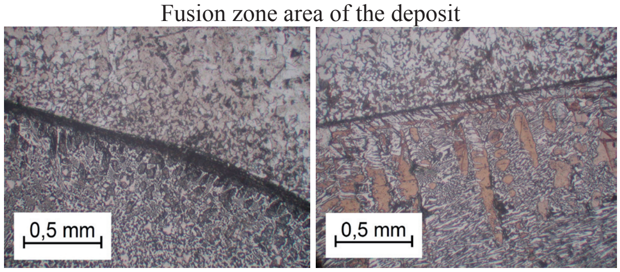


Fig. 3. Micrographs of 4666DP0604 and XMC wear plate in the area of overlap of the weave beads of the deposit

2.2. Hardness tests

To analyze the hardness of deposits of both wear plates HV30 hardness test was chosen to provide very high accuracy of hardness measurements and information of the wear plates deposits hardness. Four hardness measurements were taken:

- on the 0,5 [mm] deep ground surface of deposit in the middle area of the deposit,
- on the 0,5 [mm] deep ground surface of deposit in the area of weave beads overlap of the deposit,
- on the cross-section of the deposit in the area of weave beads overlap, Fig. 4 and Table 1.

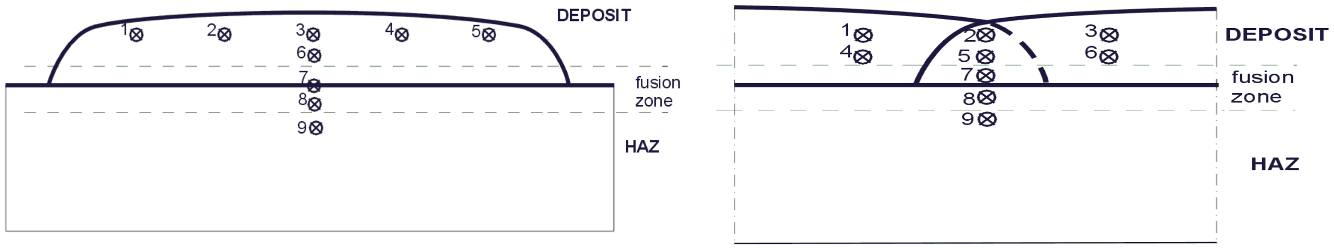


Fig. 4. Distribution of hardness points measurements on the cross section of the wear plates in the middle area and weave beads overlap of the deposit

Table 1. Results of hardness HV30 tests on the cross section on the surface, wear plate in the middle area and of the weave beads overlap area of the deposit of 4666DP0604 and XMC wear plate

Specimen designation	HV 30 hardness measurement points								
	Deposit						Fusion zone	HAZ	
	1	2	3	4	5	6	7	8	9
On the surface									
4666DP0604	720	829	810	769	745	816			
XMC	730	757	780	769	767	775			
Middle area of the deposit									
4666DP0604	748	760	790	720	736	768	498	332	179
XMC	644	644	741	700	705	626	308	212	177
Overlap area of the deposit									
4666DP0604	736	741	730	757	746	675	695	695	179
XMC	780	746	849	763	780	810	666	657	177

2.3. Abrasive wear resistance tests

To determine quantitatively the abrasive wear resistance of XMC wear plate in comparison to 4666DP0604 wear plate and reference HARDOX 400 steel plate, the tests of abrasive wear type metal-ceramic were conducted in accordance to standard ASTM G 65 - Standard Test Method for Measuring Abrasion Using the Dry Sand/Rubber Wheel Apparatus. Procedure A of the ASTM G65 standard was chosen. Quartz Ottawa sand was used for the tests. Sand had tightly limited particle size in U.S. sieve size -50 to +70 (-300 to +212 microns) and moisture content under 0,5% weight. The rate of sand flow through the special nozzle, in the shape of thin layer between the test piece and a hard rubber wheel 229 mm dia., was adjusted at the rate 300-400 [g/min]. The 25 [mm] wide and 75 [mm] in length abrasive wear resistance test specimens were cut from wear plates middle area of the deposit and the area of the weave beads overlap, and all test specimens were weighed to the nearest 0,0001 [g] as required by ASTM G65. Next, the abrasive wear resistance tests were conducted. The force applied was pressing the test coupon against the wheel was TL = 130[N] (test load - TL) and 6000 revolutions of the rubber wheel at 200 [rpm]. After the abrasive wear resistance test, the test specimen was weighed at weight sensitivity 0,0001 [g]. Mass loss was reported directly and relatively in comparison to the mass loss of the reference HARDOX 400 steel plate, which were chosen as the reference material for tested specimens of XMC and 4666DP0604 wear plates. Abrasive tests results were reported as volume loss in cubic millimeters, Table 2, by converting mass loss to volume loss as follows:

Volume loss, [mm^3] = mass loss [g] : density g/cm^3] x 1000 (1)

2.4. Erosion resistance tests

To determine quantitatively the erosion resistance of XMC wear plate in comparison to 4666DP0604 wear plate, the tests of erosion were conducted in accordance to standard ASTM G 76-95 - Standard Test Method for Conducting Erosion Tests by Solid Particle Impingement. Nozzle tube is manufactured from WC and is 50 [mm] long and 1,5 [mm] inner diameter. Abrasive particles of angular Al_2O_3 of nominal dimension – 50 [μm] are feed with the rate 2,0±0,5 [g/min] during the tests. The abrasive particles velocity was kept in the range 70±2 [m/s] and stream of dry air was supplied with flow rate 8,0 [l/min]. Samples 70x25x10 [mm] cut from wear plates middle area and overlap area of the deposit were prepared by grinding to provide surface roughness smaller then 1,0[μm] followed by careful alcohol cleaning. The erosion resistance test of wear plates samples was done during 10 [min], at impact angle 90^o, and results are collected in Table 3.

3. Conclusions

On the bases of results of study of properties of deposits of 4666DP0604 and XMC wear plates, the following could be concluded:

- both of wear plates tested have shown the characteristic regular fusion line and contain no internal defects. The structure of the 4666DP0604 wear plate has larger sizes of chromium carbides precipitations then XMC wear plate deposit and evenly distributed tiny niobium NbC carbides, chromium borides Cr_2B in the middle area of deposit and overlap, Figs. 2-3,

Table 2
Results of low-stress abrasive wear resistance of HARDOX 400 steel, 4666DP0604 and XMC wear plates

Specimen designation	Number of specimen	Weight before test [g]	Weight after test [g]	Mass loss [g]	Average mass loss [g]	Average volume loss [mm^3]	Relative* abrasive wear resistance
HARDOX 400	H – 1	62,2260	60,7526	1,4734	1,4617	185,730	1,00
	H - 2	63,1222	61,6721	1,4501			
4666DP0604 middle area	CDP-M1	128,6154	128,4378	0,1776	0,1697	23,3882	7,941
	CDP-M2	128,9438	128,7821	0,1617			
4666DP0604 overlap area	CDP-O1	131,2604	131,0951	0,1653	0,16385	22,5819	8,224
	CDP-O2	127,4774	127,3150	0,1624			
XMC middle area	XMC-M1	122,8486	122,5842	0,2643	0,2451	34,3018	5,414 (0,714)**
	XMC-M2	114,7941	114,5682	0,2259			
XMC overlap area	XMC-O1	108,4141	108,1042	0,3099	0,3149	44,0703	4,214 (0,557)**
	XMC-O2	97,8589	97,5390	0,3199			

* - relative abrasive wear resistance to HARDOX 400 steel plate. ** - relative abrasive wear resistance to 4666DP0604 plate

Table 3
Results of erosion resistance tests of XMC wear plate and 4666DP0604 wear plate

Specimen designation	Number of specimen	Erosion weight loss [mg]	Erosion rate [mg/min]	Erosion value [mm^3/g]	Average erosion value [mm^3/g]	Relative abrasion resistance*
4666DP0604 middle area	CDP-M1	6,5	0,65	45,3277	31,3807	–
	CDP-M2	3,6	0,36	25,1046		
4666DP0604 w overlap area	CDP-O1	6,4	0,64	44,6304	46,2575	–
	CDP-O2	7,5	0,75	52,3012		
XMC middle area	XMC-M1	5,3	0,53	37,1148	54,8552	0,57
	XMC-M2	8,7	0,87	60,9243		
XMC overlap area	XMC-O1	10,7	1,07	74,9299	59,2346	0,78
	XMC-O2	5,7	0,57	39,7489		

* - relative to 4666DP0604 wear plate. Angle of solid particle impingement - 90^o.

- higher hardness was measured on the surface and cross section in middle area of the deposit of 4666DP0604 wear plate then in the deposit of XMC wear plate but this wear plate shows slightly higher hardness in the weave beads overlap area of the deposit then 4666DP0604 wear plate. The hardness at the surface of 4666DP0604 wear plate is 750 HV and in the area of overlap is 730 HV. In the case of XMC wear plate the hardness at the surface is 650 HV and in the area of overlap is 780 HV,
- abrasive wear resistance tests have shown that due to presence of larger chromium carbides and tiny NbC carbides and chromium borides Cr_2B in chromium cast iron matrix of 4666DP0604 wear plate deposit its abrasive resistance is 30-40% higher then XCM wear plate deposit, Table 2.
- erosive wear resistance tests were conducted in accordance to standard ASTM G76-95 at an angle of solid particle impingement 90 degrees have showed that 4666DP0604 wear plate deposit has 20-40% higher erosive resistance then the XMC wear plate deposit, Table 3.

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