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Abrasion Resistance of Nickel- and Iron-base Hardfacings

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ABSTRACT

The present study is directed to the problem of hardfacing and restoration of worn industrial equipment. Wear tests were carried out using especially built rig which reproduces working conditions of machinery applied in cement plants. The results of tribological tests on 20 Fe- and Ni-base hardfacings are presented. The effect of hardfacing hardness and chemical composition was evaluated. It was found in SEM examinations that matrix was removed from the zone adjacent to carbides which made them liable to cracking and digging out. The mechanism of matrix removal depended on its hardness and include microcutting and low cycle fatigue. Ni-based hardfacings outperformed Fe-based coatings. The abrasion resistance of the best Ni-base coating, the Stelcar 6 was 38.7 times higher than that of S235JR steel. Eutectics in Ni-base coatings disturb motion of abrasive grains and force them to rotate instead of sliding over hardfacing surface. Ni-based coatings can be considered in hardfacing or reclamation of numerous industrial components applied in cement plants.

Keywords: abrasive wear, soft abrasive, cement plant, Ni-base hardfacings, Fe-base hardfacings

INTRODUCTION

Preventative maintenance and repair can reduce production downtime and increase service life of industrial components. Demand of high production rates at lowest possible costs forces reduction of maintenance periods. In cement plant, raw material contains limestone and clay. The raw material is pulverized using mills and crushers. Raw material is heated in a rotary clinker kiln to a sintering temperature of about 1450°C to produce the clinker. In cement industry, abrasive-erosive wear is experienced by fans, transport piping, cyclones, clinker cooler grates. Abrasive wear occurs in impact ball mills, crushers, feeders and chain exchangers [1-3].

Hardfacing applied in the restoration process should maintain the original profile of the component as to ensure optimum production conditions. Hardfacing of a particular industrial component can be repeated several times and performed on site or in a workshop. It follows from industrial experience that numerous equipment, including excavator shovel, wheel loaders, conveyor systems, raw material mills, cyclones and fans, clinker mills, bag packing units can be reclaimed by welding [4]. Hammer crushers have been highly used to reduce the size of rocks which are raw material in cement plant. Hammers are frequently made from high chromium cast iron or from alloy steels used also for turbine rotor shafts. Weld overlay Fe-based coating containing chromium carbide applied onto hammer extended hammer's life by 5 times while increasing hammer cost by 2 times only [5, 6]. In cement manufacture, large-sized fans consume nearly 30% of the total electric energy consumed by the whole cement plant. Service life of fans can be extended by re-design of fan rotors and casing to make the flow of gases more laminar, another solution is application of wear resistant pads made from chromium cast irons [6]. Fortini et. al. [7] demonstrated that the Fe-Cr-C hardfacing can face erosive wear. Large toothed gears experience plastic deformation and abrasive wear of teeth, fatigue cracking at tooth fillets [8,9]. Domazet et. al. [8] showed the successful reclamation of fatigue cracks by welding.

The processes of abrasion are commonly divided into high- and low-stress abrasion. High stress abrasion takes place when abrasive particles are compressed between two rigid surfaces. It occurs, for instance, in grinding mills. On the worn surface, indentations and scratches are visible and the abrasive particles undergo fragmentation. Low stress abrasion produces lower wear rates. Microscopic examinations reveal ploughing and cutting on a microscopic scale [10]

Dry sand rubber rimmed wheel abrasion test (DSRW) simulates low stress abrasion and it was developed to cope with wear problems in mining and transportation industry. The disadvantages of the test are that coarse silica sand is applied as the abrasive and the contact area between the specimen and the wheel is continuously increasing with test time. Pin-on-drum (POD) or pin-on disk tests were developed to reproduce high stress two body abrasion. The virtue of the test is a constant area of contact between specimen and abrasive. In order to simulate wear conditions of impact hammers and blow bars used in crushing and grinding of minerals, the impeller-in-drum test was developed [11]. Gouging wear is reproduced in laboratory jaw crusher (JC). Abrasion wear in comminution equipment was considered by Jensen et al. [12], who used a modified polishing machine previously applied in a metallographic laboratory. The characteristic feature of overlay coatings, also termed hardfacings, is the metallurgical bond between the coating and the parent metal. Hardfacing can be easily performed not only in workshops but also on site. In hardfacing, most welding processes are used. The oxy-acetylene welding process belongs to the oldest hardfacing processes. Filler material is in the form of a rod or powder. The most widely used filler materials are Ni- and Co-based alloys. The disadvantage of this process is low deposition rate but the process offers low dilution of the deposited material. In shielded metal arc welding (SMAW), filler material is in the form of a rod covered with the flux. At arc temperature, flux creates gas shield and liquid slag, both protect molten pool from oxidizing. The rate of deposition is low, quality of weld overlays is poor, dilution is high but the advantage is vast range of available electrodes and mobility of used equipment. Hardfacing materials can be classified into: Ni-, Co- and Fe-based alloys and composite materials.

Some inherent problems are associated with deposition of Fe based alloys, mainly, a risk of cracking. The attempts to increase the performance of Fe-based hardfacings through a modification of hardfacing chemistry should be noted. Bembenek et. al. [13] investigated properties of hardfacings deposited using flux cored arc welding process and self-made cored electrodes. The electrodes were produced using pure metals. Ti promoted formation of TiC particles thus causing a refinement of grain whereas Mn addition results in a formation of work hardenable austenite. Both additives put up the wear resistance. Fan et. al. [14] made the coatings by PTA fusing of WC containing powders pre-placed on the steel substrate. Although hardfacing revealed high wear resistance, the deposit was inhomogeneous because of uneven distribution of WC particles these preferably located at the substrate surface. The distribution of carbides is however dependent on arc current in PTA pad welding [15].

Cobalt base hardfacing alloys have reached high status. The first developed alloys were Stellites, which combine high adhesion and abrasion resistance with corrosion resistance. Microstructure of Stellites comprises hard carbides in a Co solid solution. In Triballoys, Laves' phases provide strengthening effect. However, despite of high performance of Co-based alloys, their high cost and worse welding properties, compared with Ni-based alloys, impose limit on their application. Ni-based alloys are resistant to gaseous corrosion except for atmospheres rich in sulphur compounds. Chromium produces abrasion and corrosion resistance. Boron forms hard borides and along with silicon provides self-fluxing feature and also reduces melting point of the alloy, which can be significantly lower than that of Fe-based alloys. It was proved that NiCrSiFeB alloys can be easily deposited on carbon tool steel [16].

The motivation to conduct this study was the fact that there are scarce information concerning abrasive wear caused by soft, fine and fragile particles. Welding materials have been developed basing on industrial observations and tests these mostly reproduce working conditions of earth moving equipment. NiCrSiFeB hardfacings contain in their microstructures various eutectics, which potentially have capability to hinder sliding of abrasive over hardfacing surface. To verify this hypothesis, abrasion tests were carried out on Fe- and Ni-base hardfacings having comparable hardness values.

Experimental

Overlay coatings were pad welded from Ni- and Fe-alloys. Test specimens were cut off from pad welded plates. Metallographic examinations were performed by using the Nikon Eclipse MA 100 optical microscope equipped with the digital camera. Vickers microhardness was measured using the Future-Tech FM800 tester under 0.49 N load. The Phenom ProX scanning electron microscope was applied to investigate wear mechanism of deposits. The especially developed abrasion test rig used in the present study is shown in Figure 1.The counter specimen is in a form of the 250 mm dia. disk [2] covered with rubber. The weighed portion of Portland cement is placed on the surface and replaced at regular intervals. The disk performs 106 revolusions per minute. Three specimens [5] having the form of a cube with 10 mm edge are placed in fixtures [4] located on the 205 mm diameter. Specimens are loaded with deadweights [6], the imposed force is 15N. Abrasive is directed to the friction zone by the vanes [7] attached to the cover [3]. The cover is attached with screws to the rig housing [1]. In the test, the dependence of mass loss of specimen on path of friction was investigated. The slope of straight line fitted to the data points is called the wear intensity. The wear resistance is the reciprocal of the wear intensity. The relative wear resistance is defined as a ratio of wear resistance of tested material to wear resistance of the standard material (normalized S235JR steel). Sieve analysis of Portland clinker revealed that 23.4% of grains were smaller than 2.5 µm, 26.2% of them were 2.5÷10 µm in size and the size of remaining 30.6% was 10÷25 µm.

The major microstructural constituent of cement clinker is alite (57÷69 mass%). Alite (Ca_3SiO_5) crystallizes in three different crystal lattices. Cement clinker is not chemically pure and alite present in cement clinker contains substituent metal oxides. Belite content is a few times lower (12÷21%). Belite (Ca_2SiO_4) has five polymorphs and forms solutions containing metal silicates The remaining part constitute calcium aluminate, calcium aluminoferrite and periclase [17,18]. Hardness of alite, due to its porosity and chemical composition, is 5 in Mohs' scale. It corresponds to the microhardness value in the range of 402÷554 HV [19-21]. Portland cement is made of milled clinker and contains some admixture of soft gypsum and anhydrite to retard setting of cement. Therefore, Portland cement can be used to assess abrasion caused by cement clinker.

RESULTS AND DISCUSSION

Ni-base hardfacings

Although NiCrSiFeB coatings are widely used in industry, only few papers deal with the relationship between their microstructure and

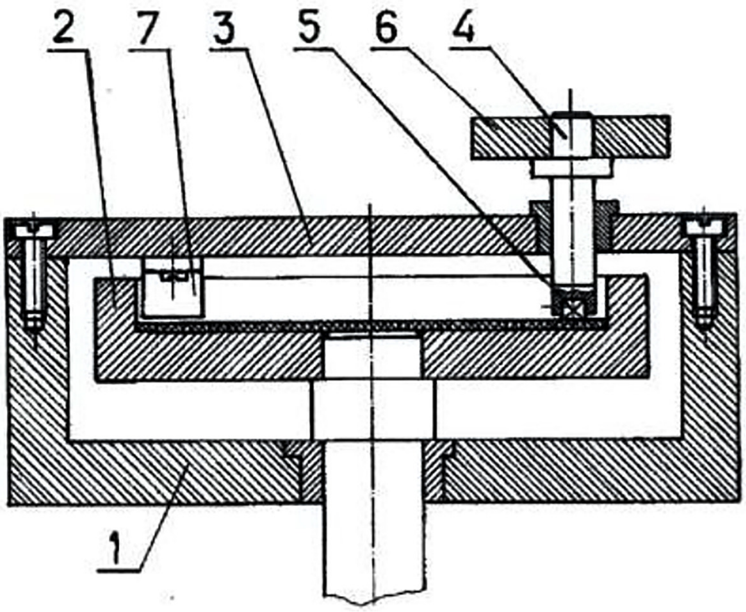

Figure 1. Abrasion test rig

abrasion performance [22-24]. Chemical compositions of Ni-based filler materials used in the present paper are in Table 1. Powder materials constitute the majority of filler materials, the exception is the no. 8 coated electrode. Coatings nos. 3-6 and 9-11 were deposited using the oxy-acetylene SPT100 torch. Coatings nos. 1,2 were plasma deposited using the PTA process and the NP 1-250 plasma unit. Coating no. 7 was deposited using the Uni-Spray-Jet oxy-acetylene torch. Coating no. 8 was deposited using SMAW method. The standard material used in abrasion test was the S235JR steel in a normalized condition. Coatings were deposited on substrates made from S235JR steel having 60×120×6 mm dimensions. Specimens for microstructural and wear examinations were cut off from the pad welded plates.

Free surface of NiCrSiFeB coatings is usually covered with borosilicates [16] produced in a selfluxing process, which takes place during welding, and prior to the wear test, this layer was removed by grinding. During solidification of hardfacing, Ni solid solution crystallizes first, followed by various eutectics, among them the most important is Ni-Ni_3B. Hardness of NiCrSiFeB alloys, depending on their chemistry, is in the range 15-60 HRC. The hardness of Ni solid solution is 300-400 HV, the hardness of Ni-Ni_3B eutectics 412-450 HV and that of carbide-boride eutectics 584-644 HV.

Abrasive wear intensity of tested materials is shown in Figure 2. Surprisingly, coating no. 8 revealed the highest wear intensity. The deposit has austenitic microstructure and undergoes work hardening only in severe abrasion conditions. Material is recommended for applications, in which high temperature corrosion resistance is required (for instance clinker cooling grate). Coatings nos. 2 and 5 contain in the microstructure Ni-rich γ(Ni,Fe) solid solution, carbides of M_7C_3, $M_{23}C_6$ and Cr_3C_2 types and carbide eutectics. In spite of similar microstructures coating nos. 2 and 5 differ markedly in wear intensity, which means that effect of hardness prevails. Coating 6 contains large

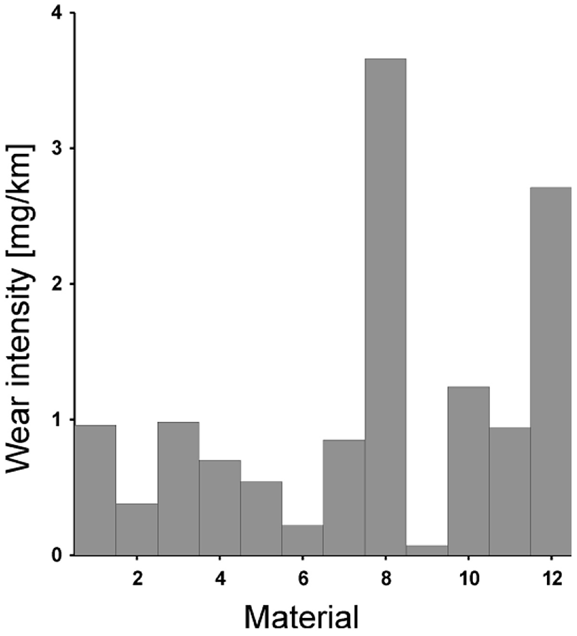

Figure 2. Wear intensities of Ni-base hardfacings

Table 1. Chemical compositions of filler materials

No.	Material	Content, mass %							Hardness HV30
		C	Si	B	Fe	Cr	Others	Ni	
1	PMNi30	0.1	3.0	1.4	1.5			Bal.	223
2	PMNiCr55P	0.4	4.0	2.6	2.5	12		Bal.	618
3	Deloro Alloy 35	0.17	3.1	1.5	1.6	4.7		Bal.	332
4	Deloro Alloy 40	0.25	3.5	1.6	2.5	7.5		Bal.	612
5	Deloro Alloy 50	0.45	3.9	2.3	2.9	11		Bal.	728
6	Deloro Alloy 60	0.9	4.3	3.3	4.2	16.3		Bal.	789
7	AMI1060	0.97	4.25	3.58	3.59	14.9	Co = 0.2%	Bal.	841
8	OK 92.35	0.06	0.7	-	3	15.5	Mn = 0.7%, W = 3.8%, Mo = 16.5%	57	250
9	Stelcar 6	0.65	4.2	3.1	4.2	15	35% WC	Bal.	958
10	Colmonoy 237		2.8	1.3		4	Others 5.1%	Bal.	381
11	Colmonoy 43	0.4	2.3	2.1	3	10		Bal.	352
12	S235JR(St3S)	0.22_{max}	0.15-0.35	-	Bal.	-	-	-	140

M_7C_3 precipitates which act as obstacles to the sliding abrasive grains. Coating 9 contains large angular WC particles in the matrix microstructurally similar to hardfacing 6. The relative wear resistance of this hardfacing is 38.7, which is the highest value among tested deposits.

Effect of coating hardness on wear resistance is illustrated in Figure 3. Hardness of coatings should exceed 600 HV, which corresponds to clinker hardness. The scatter of experimental points is noteworthy ,which clearly points to the effect of coating microstructure. A similar conclusions was arrived at by Szala et. al. [25]. who ascertained in cavitation erosion study of NiCrSiB hardfacings that hardness cannot be used as a sole hardfacing feature used in prediction of coating performance. Effect of total boron and carbon content on wear resistance is shown in Figure 4. Borides and carbides contained in eutectics have fine size. Effect of carbide forming elements is depicted in Figure 5 .These elements can either form carbides or be diluted in a Ni-solid solution.

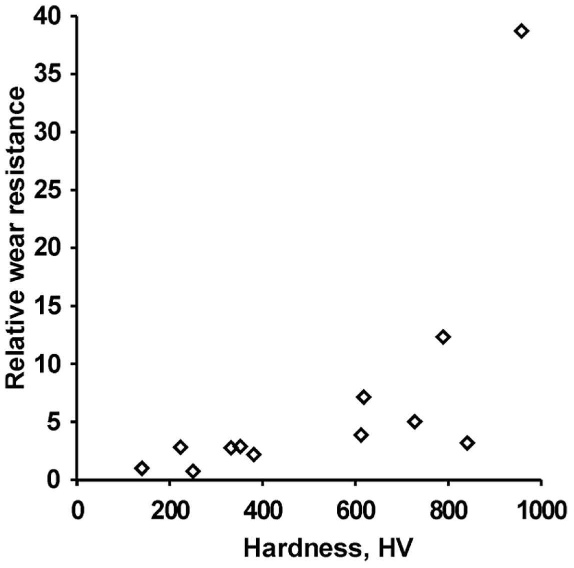

Figure 3. Effect of hardness on wear resistance of Ni-base hardfacings

In the abrasion test carried out using fine milled silica on a range of PTA,TIG and flame deposited hardfacings, abrasion resistance correlated with the total content of B and C. Hardness of coatings had strong effect on wear resistance. In this test the intense wear of the matrix made carbides protruding from the surface and vulnerable to cracking, pulling and digging-out. Hardness of silica is about 900 HV, grains have angular shape and were below 100 µm in size. The divergence between results obtained in the cited and the present study can be attributed to different properties of abrasives [26].

The dependence of mass loss on wear path length is shown in Figures 6 and 7. Average values are represented by open symbols. The plots for particular specimens are mutually almost parallel which points to high homogeneity of the coating. Microhardness of coating 1 matrix is 330-359 HV and that of eutectics 498-850 HV. Microhardness of coating 6 is in the range of 970-2386 HV. Microstructure of coating 1 is shown in Figure 8.

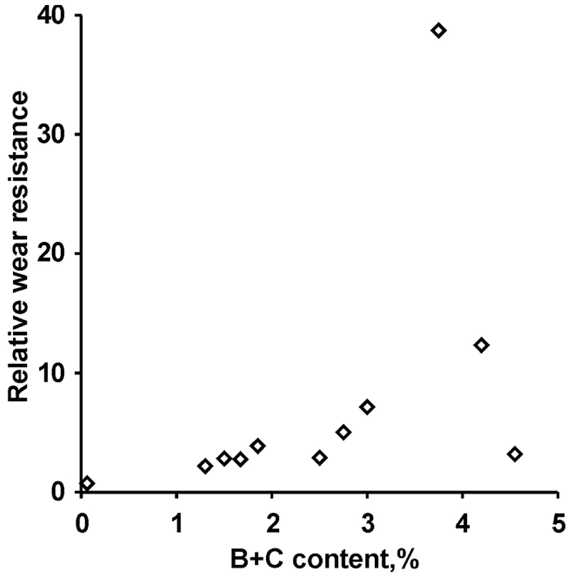

Figure 4. Effect of boron and carbon content on wear resistance

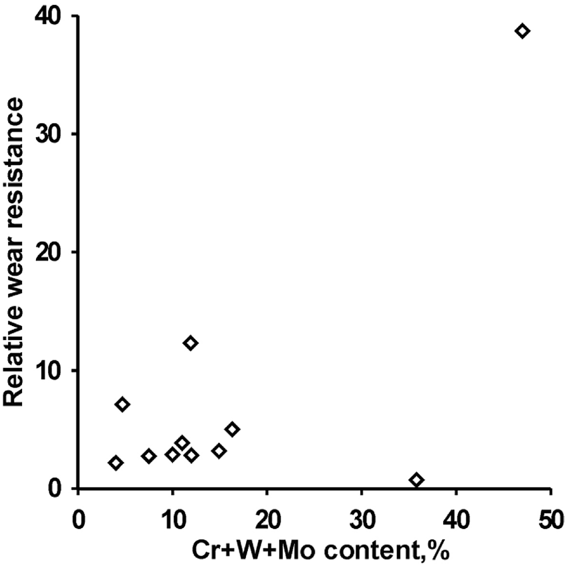

Figure 5. Effect of carbide forming elements on wear resistance

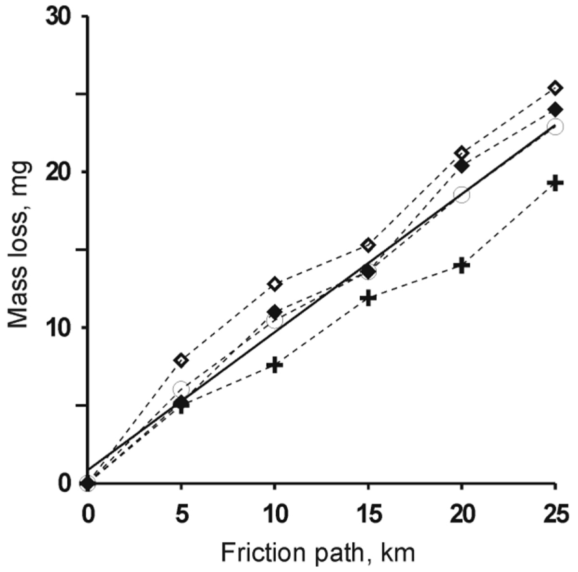

Figure 6. Dependence of mass loss on friction path, Ni-base hardfacing 1

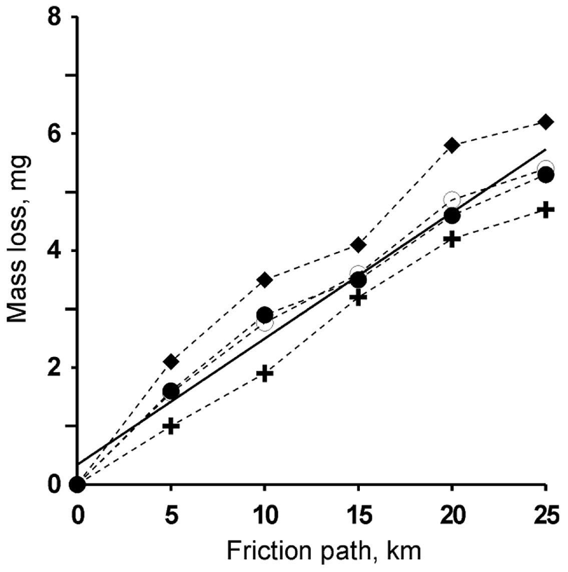

Figure 7. Dependence of mass loss on friction path, Ni-based hardfacing 6

Dilution line is straight, continuous zone of Ni-solid solution adjoins the substrate, Ni-solid solution dendrites and interdendritically located fine carbides are seen at further distance from the substrate. Coarse carbides embedded in NiCrSiFeB matrix are seen in Figure 9. Worn surface of coating 2 is shown in Figure 10. The pattern of long, parallel scratches is seen. Abrasive grains terminated at carbides producing scratches on hardfacing surface. Wear is enhanced at borders of carbides, especially at their straight segments. At these straight segments motion of abrasive particles is directed along the boundary which obviously raised wear in this area. Pits are seen in places, from which hard particles were removed. Abrasive wear was intensified there. Ploughing of the matrix is negligible, massive carbides are intact. Worn surface of coating 9 is shown in Figure 11. Few narrow, shallow and intermittent scratches are seen, these were effectively blocked by WC carbides. Matrix is removed from the zone adjacent to carbides. NiCrSiFeB alloys have a considerable potential. These coatings can be pad welded or thermally sprayed and subsequently fused.

The second process is used in case of large elements. It follows from our own experience that the advantageous fusing effect is achieved using an induction coil. TIG and flame remelting produced incompletely melted coatings. González et al. [27] recommends laser fusing.

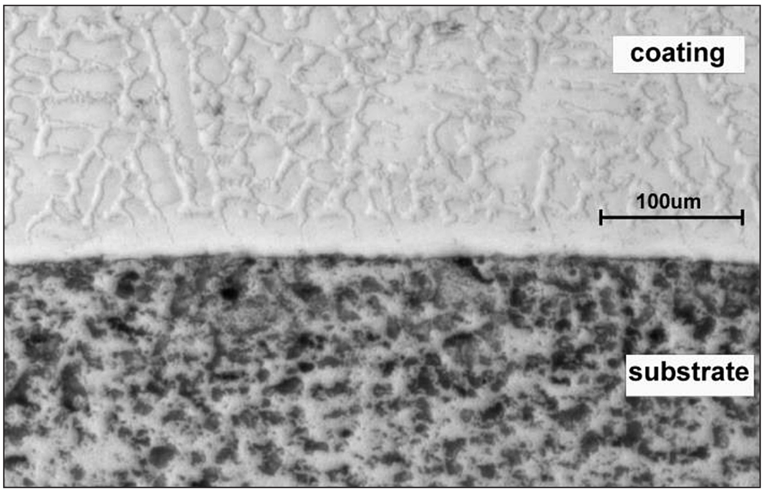

Figure 8. Microstructure of hardfacing 1,HCl-HNO$_3$ etched

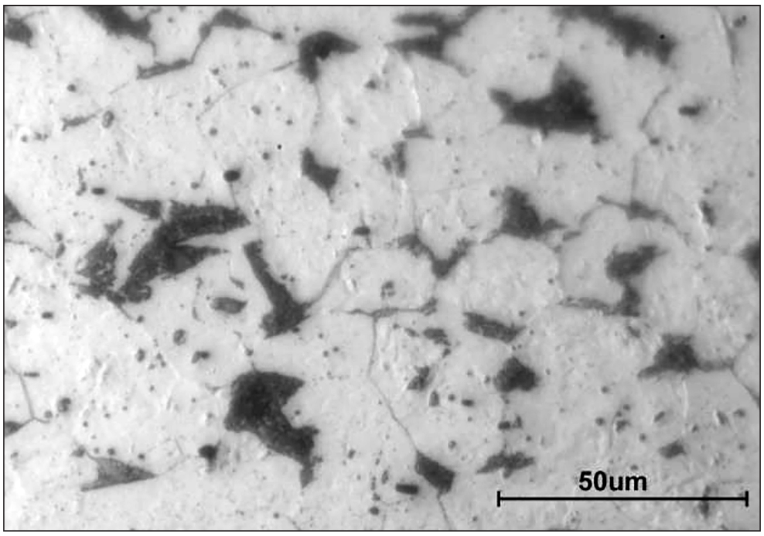

Figure 9. Microstructure of hardfacing 9, HCl-HNO_3 etched

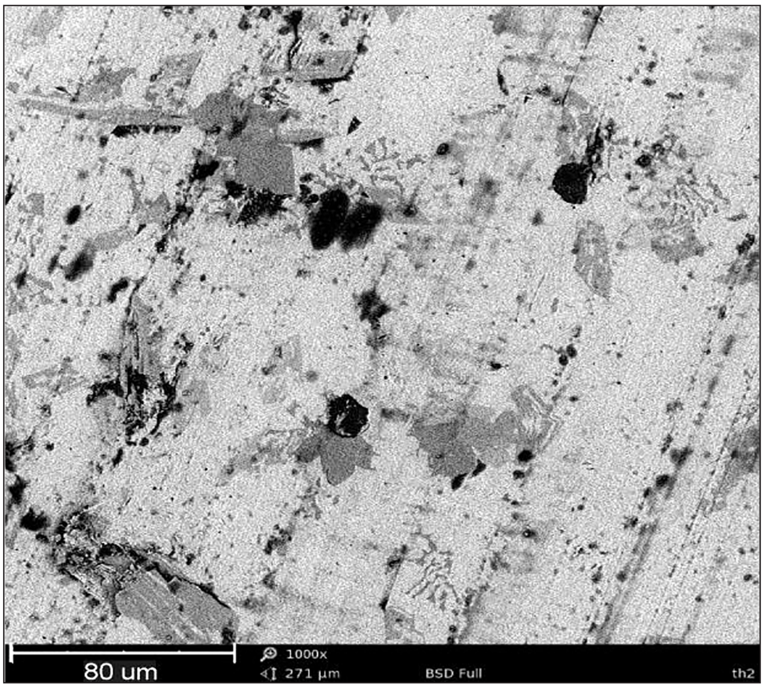

Figure 10. Abraded surface of coating 2, SEM BSD

Modification of NiCrSiFeB coating chemical composition is not difficult. Harsha et al. [28] found that the admixture of 10-20% of CrC particles to NiCrSiB alloy provides three to eightfold increase in resistance to three body abrasion. Hejwowski [54] found that hardfacings can be deposited via the PTA process using simultaneously two powder feeders delivering NiCrSiB and Stellite powders to the plasma torch to perform coating of mixed chemical composition. Cobalt content in hardfacing alloy can be reduced thus lowering its cost.

Fe-base hardfacings

Three layered pad welds were performed on the S235JR steel substrate using SMAW method. Chemical composition of nine electrodes are in Table 2, white cast iron and Hadfield cast steel are added for comparison. The type of carbides in the deposit depends on both chromium and carbon contents. Hardfacings nos. 1,3,4,8 contained $M_{23}C_6$ carbides, coatings nos. 2,3,4,5 contained M_7C_3 carbides. Microhardness of M_7C_3 carbides is the range 1080-1650 HV, $M_{23}C_6$ 1049-1567

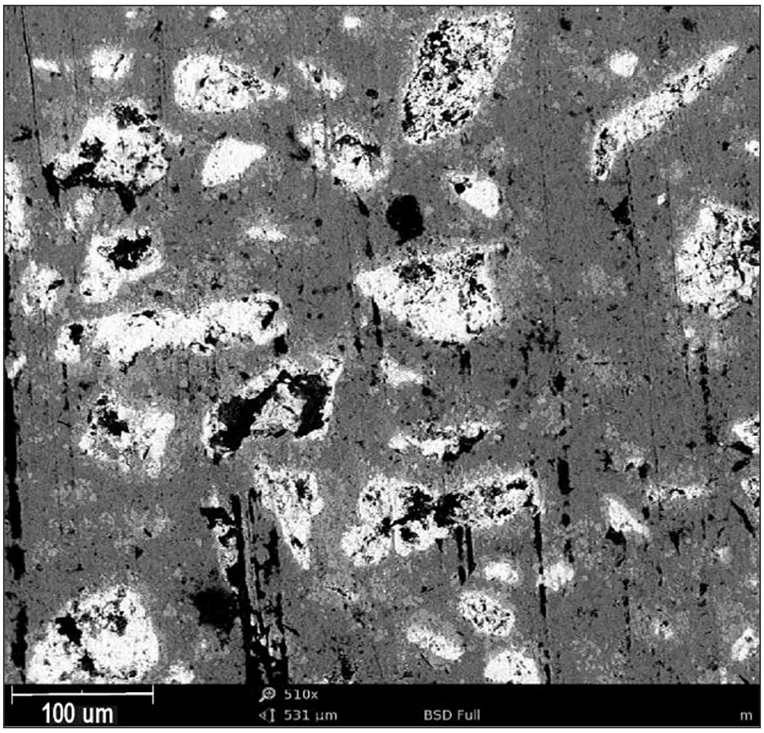

Figure 11. Abraded surface of coating 9, SEM BSE

Table 2. Nominal chemical composition of hardfacings

No.	Material	Content, mass %						Hardness HV30
		C	Si	Mn	Cr	Mo	Others	
1	OK 84.52	0.25	0.5	0.5	13			565
2	OK 83.50	0.4	0.4	0.5	6	0.6		733,8
3	OK 84.78	4.5	0.8	1.6	33			780
4	OK 84.58	0.7	0.6	0.7	10			622,3
5	EN 600B	0.6	1.2	1.4	5.6			731,8
6	EN400 MnB	0.9	0.4	12				249,8
7	EN 450B	0.3	0.9	2.0	0.9			402
8	OK 84.42	0.12	0.5	0.5	13			453
9	EN 350B	0.2	0.6	2.0	0.6			240
10	S235JR	0.22	0.15-0.35				$P_{max}=S_{max}=0.05\%$	140
11	White cast iron	2.2	0.75	1.25	6	-	V=5.75%	528
12	Cast steel	1.2	-	14	-	-		630

HV, MC 1610-3220 HV, M_6C 1900 HV [29,30]. Majority of tested electrodes is recommended for reclamation of transport and earth moving equipment and they provide hypoeutectoid deposit having the supersaturated α-solid solution (nos. 1-5,7) or ferritic-pearlitic structure (no. 9). The exception is hypereutectoid electrode no.3 which produces austenitic deposit with large M_7C_3 carbides which act as effective obstacles to abrasive grains moving over the hardfaced surface. The measured microhardness was in the range of 694-1102 HV, which was well above that of cement. Hadfield cast steel revealed exceptionally high wear resistance which was probably caused by work hardening during surface grinding prior to the test. In contrast, hardfacing no. 6 having similar chemical composition revealed significantly higher wear intensity. Alloy no. 11 has bainitic-martensitic structure and contains spherical V_6C_5 and elongated M_7C_3 carbides. Positive effect of MC carbides and large M_7C_3 precipitations was proved in tests carried out on relatively hard abrasives [31-35]. Results of tribological experiment are depicted in Figures 12 and 13 demonstrates that microstructure is more significant material property than its hardness.

Figure 14 illustrates a poor effect of carbon content on the relative abrasion resistance. Effect of the total content of carbide forming element is considerably weaker (Fig. 15). Similar conclusions were drawn by Kotecki and Ogborn [32] who tested two hundred Fe-based hardfacings using rubber wheel test rig. Lines plotted in Figure 16 for particular specimens cut off the same test plate considerably differ in the inclinations which testifies to the inhomogeneity of this hardfacing.

Figure 18 shows surface of hardfacing no.1 after abrasion test. Scratches are seen, the appearance of the surface is also the evidences of ploughing. Sliding of abrasive grains was almost undisturbed. The plastically deformed material was pulled up at both sides of scratches. Material loss occurred on exceeding the critical strain value or through low cycle mechanism when the same portion of material was deformed many times. Coating flakes formed by low cycle fatigue

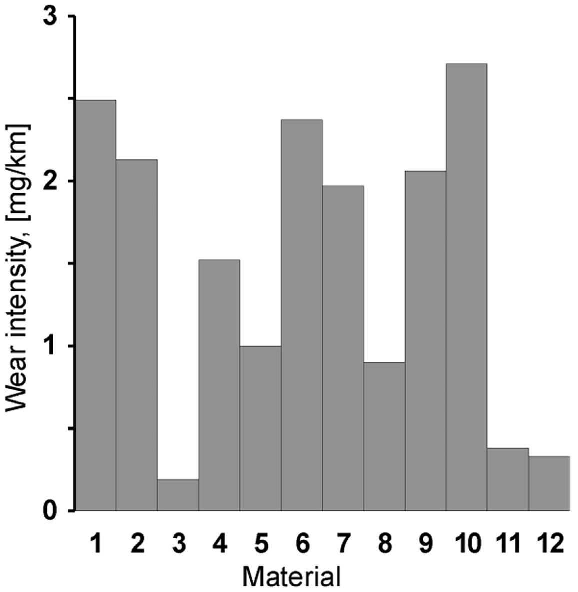

Figure 12. Wear intensity of Fe-base hardfacings

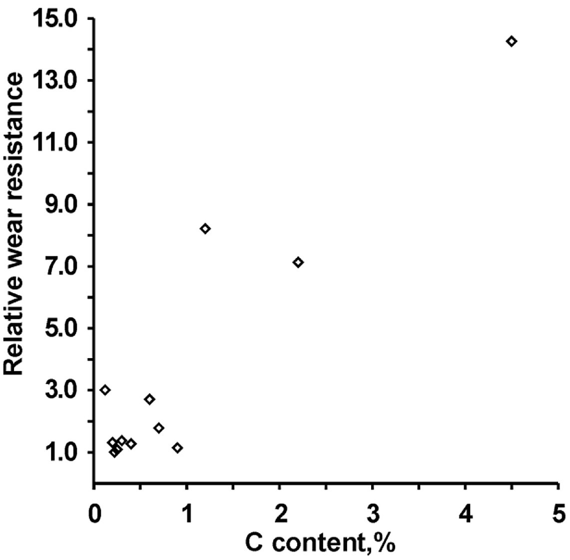

Figure 14. Dependence of wear resistance on carbon content

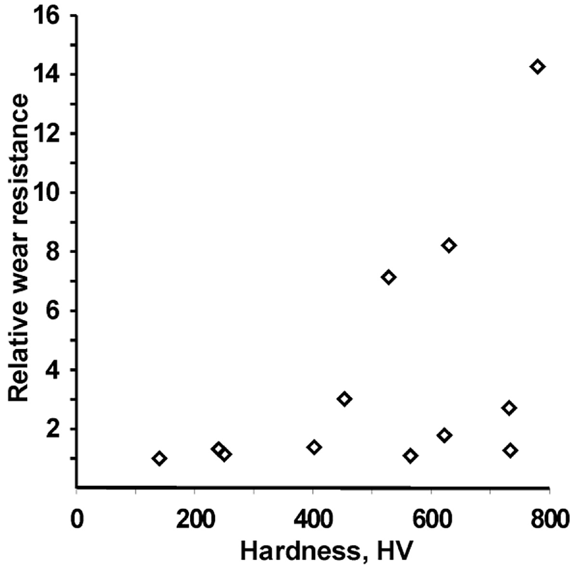

Figure 13. Dependence of wear resistance on hardness

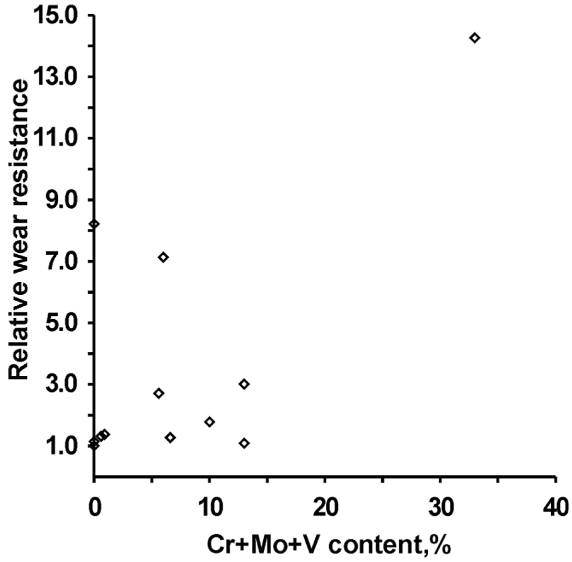

Figure 15. Dependence of wear resistance on content of carbide forming elements

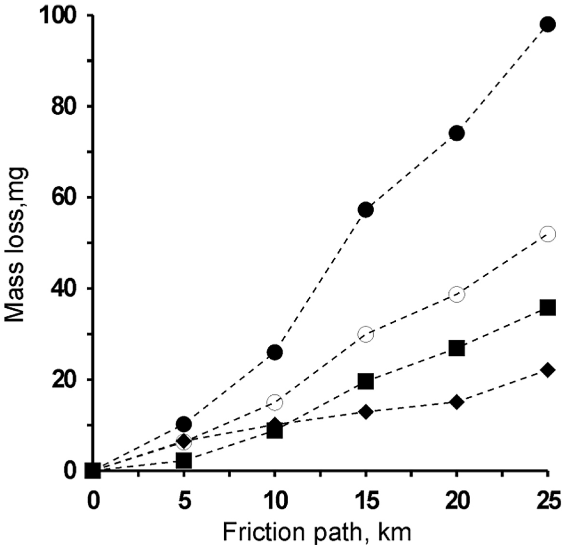

Figure 16. Dependence of mass loss on friction path, hardfacing no. 2

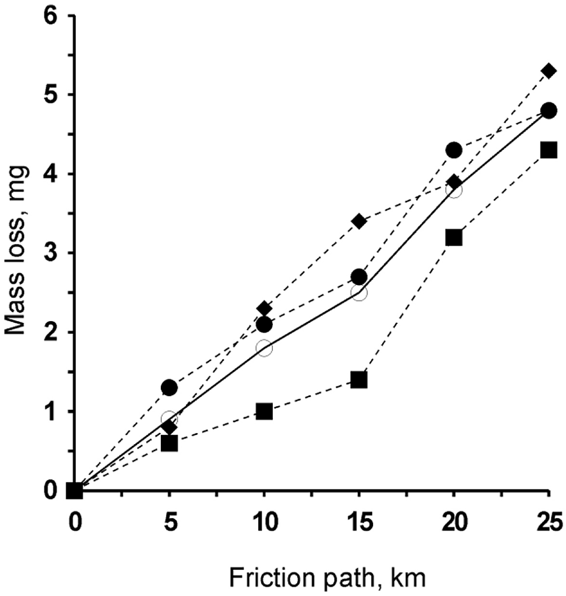

Figure 17. Dependence of mass loss on friction path, hardfacing no. 3

on wear surface are seen. Similar pattern of wear caused damage was found by Szala et. al. [36] in the study of abrasive wear mechanisms of a set of steels. Surface of hardfacing no.3 after abrasion test is depicted in Figure 19. Few short scratches are seen. Removal of matrix is intensified in the zones adjacent to hard precipitations. Wear process is also enhanced at welding imperfections, that is at pores and inclusions. Specimen holders were free to rotate in their seats during the abrasion test, therefore the whole perimeter of carbide was exposed to the action of abrasive. Wear was enhanced at carbide borders, especially at their straight fragments. In large carbides, recesses left by removed carbide fragments are seen. It presumably occurred at carbide imperfections. In the matrix, short, deep scratches are seen. Carbides were almost intact, no scratches are seen on the surface of sound carbides.

Hardfacing no. 3 provided the highest wear resistance (which amounts to 14.3), the group of remaining electrodes has comparable wear resistances with better welding properties than coating no. 3. Therefore, the choice of electrode for the hardfacing job should be rather based on weldability than on wear resistance. In case of abrasion caused by minerals and ores, only hard constituents are usually taken into account and serve as abrasive in wear test. The effect of less aboundant constituents is neglected [37,38]. It simplifies test procedure at the expense of accuracy. The test used in the present study is more realistic, it reproduces low stress abrasion faced by, for instance, chutes, silos, conveyors. Information concerning abrasion by soft particles are scarce. Cement clinker can have some hard inclusions these have capability to cause microcutting and microploughing. Other possible mechanism are fatigue and adhesion. It was found that if abrasive particles possess low cutting capacity they cause plastic deformation confined to the subsurface zone. The deformed zone undergoes spalling due to low cycle fatigue or fracture on exceeding its limit to fracture [39]. The second mechanism which can be invoked is adhesion between abrasive particle and abraded material [40,41].

Ni-based coatings outperformed Fe-based hardfacings. The average hardness is almost the same in both groups, in spite of this, the average relative wear resistance of Ni-based harfacings is over 2.5 times higher than that of Fe-based coatings. Due to low melting point, dilution in Ni-based overlays is lower compared with Fe-based alloys and the required chemical composition is attained for low coating thickness in contrast to Fe based overlays. Other advantages of these coatings are superior homogeneity and microstructure almost free of welding defects. High wear resistance of Ni base hardfacings can be rationalized in terms of the leading micromechanism of wear which was removal of matrix. It decreased mechanical support for carbides thus exposing them to fracture and pulling out. Similar micromechanism of wear was revealed by De Mello and Polycarpou [42] in tests carried out on

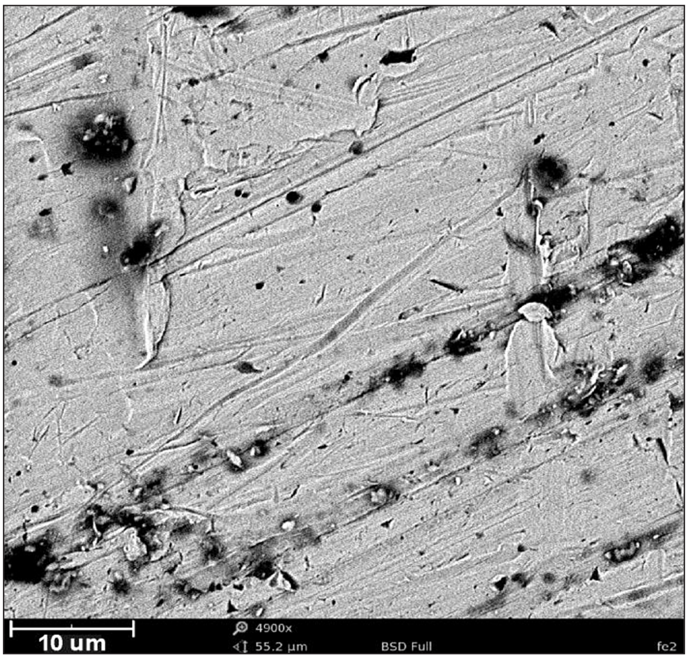

Figure 18. Abraded surface of hardfacing no. 1

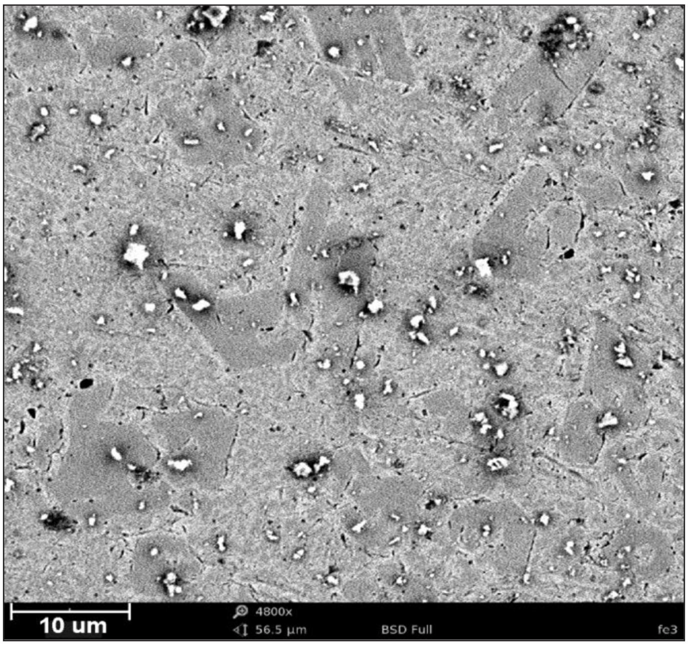

Figure 19. Abraded surface of hardfacing no. 3

ferrous alloys with various V and Mo contents using fine silica. It was found that eutectic carbides considerably reduced wear intensity (up to 5 times) compared with matrix alloy and their effect was almost independent of eutectic carbide fraction. In the present study, eutectics in Ni-base alloys played a prominent role in protection of hardfacings from abrasion. Eutectics disturb motion of abrasive particles and force particles to rotate instead of sliding over the surface. It explains higher abrasion resistance of tested Ni-based coatings compared with Fe-based hardfacings. This conclusion is supported by Kishore et al. [43] who found high wear resistance of Fe- based hardfacing containing various carbides of different chemical compositions and sizes.

Overlays with white cast iron structure usually contain surface cracks which cause failure when applied under impact abrasion conditions. Application of overlays on high alloy steels and pad welding with high carbon alloys forces application of preventive measures to avoid a risk of cracking in heat affected zone or in hardfacing.

CONCLUSIONS

In the paper, results of tribological tests and microstructural examinations are presented. The tests were carried out on Ni- and Fe-base hardfacings. Among Ni-based deposits two were performed using PTA method, the remaining nine coatings were applied using oxy-acetylene powder torch. Fe-base coatings were deposited using SMAW method. Fe-base coatings were inferior to Ni-base hardfacings. The average wear resistance of Ni-base overlays was over 2.5 times as high as that of Fe-base hardfacings despite of comparable hardness values. The abrasion resistance of the best Ni-base coating, the Stelcar 6 was 38.7 times higher than that of S235JR steel. The leading micro mechanism of wear was the removal of matrix which was intensified in zones adjacent to hard precipitates. The mechanism of matrix removal depended on its hardness and include microcutting and low cycle fatigue. The important feature of Ni-based hardfacings is the presence of various eutectics which disturb motion of abrasive particles and force particles to rotate instead of sliding over the surface. It explains higher abrasion resistance of Ni-based coatings compared with Fe-based hardfacings. The studied Ni-based coatings, offer a feasibility of deposition of thin coatings with low dilution and even face. Therefore, Ni-based coatings can be considered in hardfacing or reclamation of numerous industrial components applied in cement plants such as screw conveyors and collection trays in conveyors systems, preheater fans and cyclones, elements of electrostatic precipitators, transport piping, cement silos and packing units.

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