ABRASION RESISTANCE EVALUATION OF THE FEBNICR WELD DEPOSITS WITH TUNGSTEN CARBIDE PARTICLES

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Abstract

The service life of components used in the construction, mining or agricultural industry depends on several factors. Primarily lifespan is influenced by the type of wear to which the parts would be subjected (for example abrasion) and environment in which components perform their function. The choice of material and technology depends on these factors. The part exposed to abrasion can be made entirely from a durable material, which is often quite expensive. Another possible approach is the production of the part from conventional structural steels, such as steel S235JR. Consequently, worn surface can be equipped with a layer of highly wear-resistant material (e.g. by weld deposit) which prolongs the service life of entire component and reduces its repair or replacement costs for producers and customers.

This study deals with the evaluation of wear resistance test of selected weld deposits combining FeBNiCr matrix with an increased content of the boron and tungsten carbide particles spread in monolayer weld deposit and all at once with comparing microhardness in selected areas of the welded layer. This weld deposit was made from S235JR structural steel using hard-facing with cored wire in protective atmosphere of argon and carbon dioxide mixture. This contribution also deals with evaluation of mechanisms abrasion which appeared on the surface of the weld deposits in selected areas.

Keywords: Tungsten; carbide; hard-facing; wear; weld deposit, structural steel

1. INTRODUCTION

Abrasion is a type of wear that produces scratches on the surface of the worn material, or even material punching. This is due to the movement of the abrasive on the surface. Abrasive particles typically have sharp edges that cause material to be removed and results in abrasive wear. Depending on the size of the cutting angle, it is possible to distinguish between ploughing and cutting. The rate of abrasion is determined by the amount of material loss or by the changes in the dimensions of the part. Abrasion can be either two-body or three-body. In the case of two-body abrasion, movement moves loosely across the surface of the component, while in the case of three-body abrasion, abrasive particles are trapped between two surfaces of the material and are reflected between them [1, 2, 3].

Abrasion occurs mainly in the construction or mining industry but also in other industries processing material such as steel, wood and other raw materials. It can be fought either with high resistant materials such as Hardox or with the use of advanced surface treatment technologies. These technologies include thermal spraying or hard-facing of materials combining a tough matrix with hard particles (e.g. ceramic) on a classical structural steel [3, 4].

This paper deals with the S235JR steel hardfaced by 138 technology using the Megafil A864M cored wire and protection gas argon (82 %) mixed with CO_2 (18 %). The weld deposit combines martensite FeBNiCr matrix (Megafil A864M) with increased content of boron and tungsten carbide particles (1-2 mm), which can be classified as non-oxide ceramic. This composite material is capable of resist abrasive wear and, as a result, reduce the manufacturer’s costs for the renovation of components used in the industrial sectors. Samples were made from the weld deposits and the water jet was used to cut them. The reason was the avoidance of the thermal influence of the weld deposits and the heat-affected zone, which could occur with the use of another method of cutting (e.g. plasma, laser) [5, 6].

2. EXPERIMENTAL

Table 1 Chemical composition of parent material (substrate) S235JR

C	Mn	Si	S	P	Cr	Ni	Cu
0.14	0.67	0.20	0.019	0.01	0.02	0.01	0.01
Ti	Al	As	N	Mo	V	Nb	Fe
0.003	0.046	0.002	0.006	0.001	0.003	0.002	rest

Table 2 Chemical composition of filler metal Megafil A864M

C	Si	Mn	P	S
0.426	0.27	1.05	0.025	0.025
Cr	Ni	B	Fe	
0.27	1.57	4.62	rest	

Table 3 Welding parameters

	Sample 3	Sample 4
Welding current	210 A	250 A
Welding voltage	28 V	29 V
Welding speed	5-6 mm·s^{-1}	5-6 mm·s^{-1}
Gas flow	18 l·min^{-1}	18 l·min^{-1}
WC particles (size)	Yes (≈1-2mm)	Yes (≈1-2mm)

3. RESULTS

3.1. Microhardness

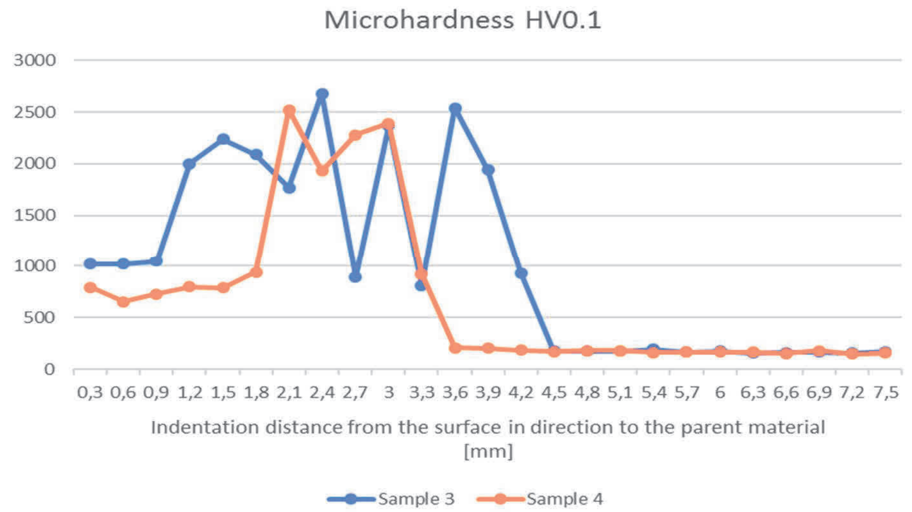

Figure 1 Microhardness HV 0.1 in direction from the surface to the parent material

3.2. Abrasion resistance

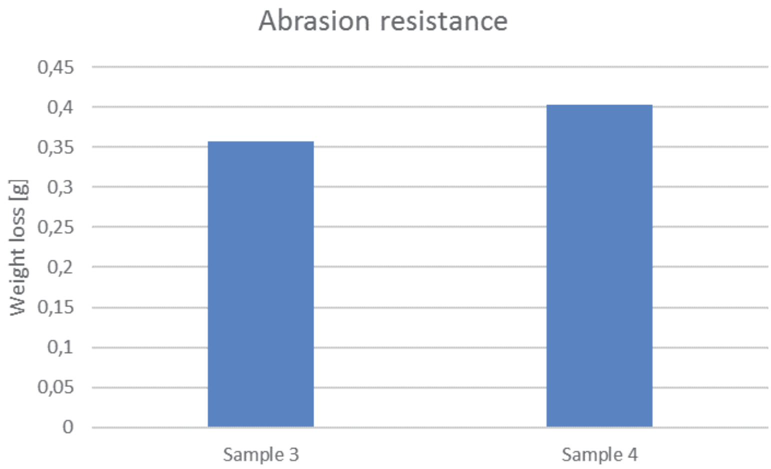

Figure 2 Weight loss of the samples after abrasion test according to ASTM G65 standard

3.3. Surface analysis

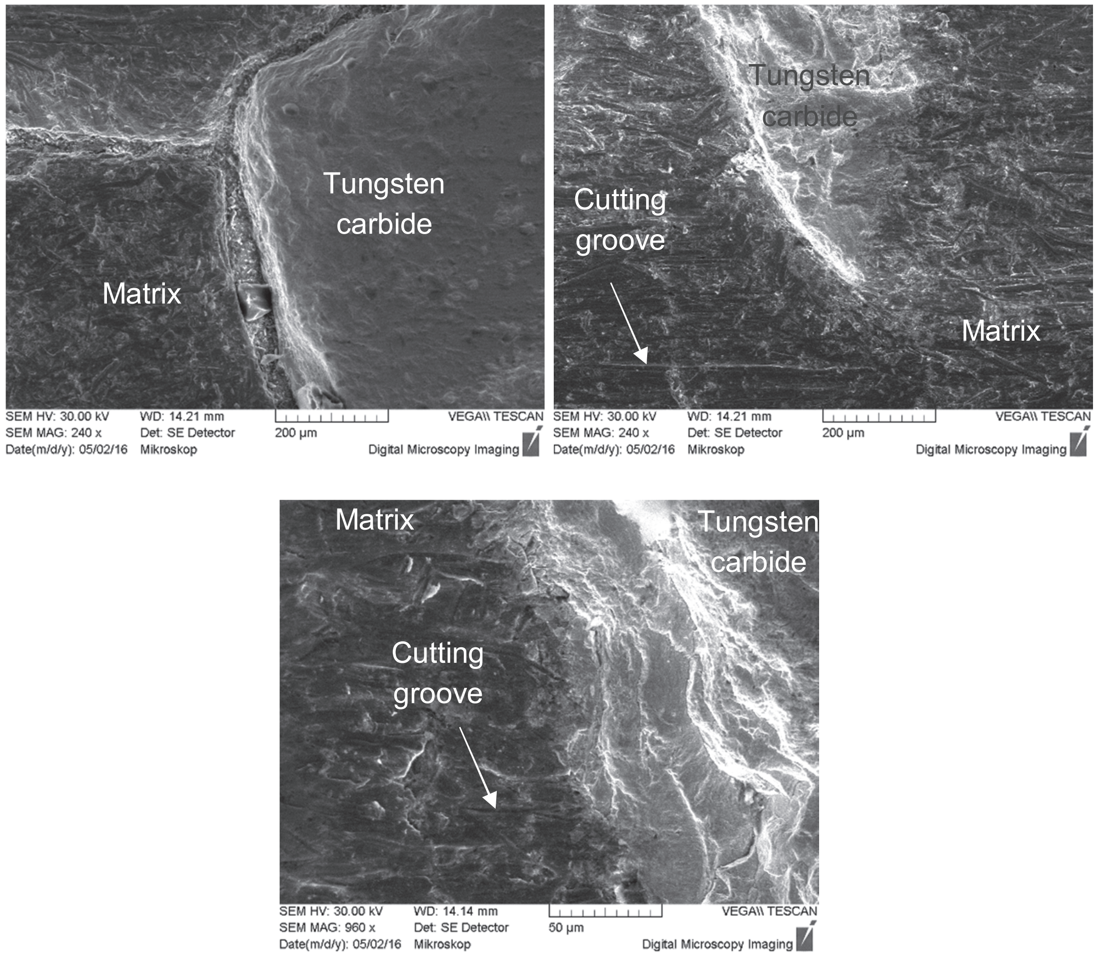

Figure 3 Surface of the sample 3 after abrasion test

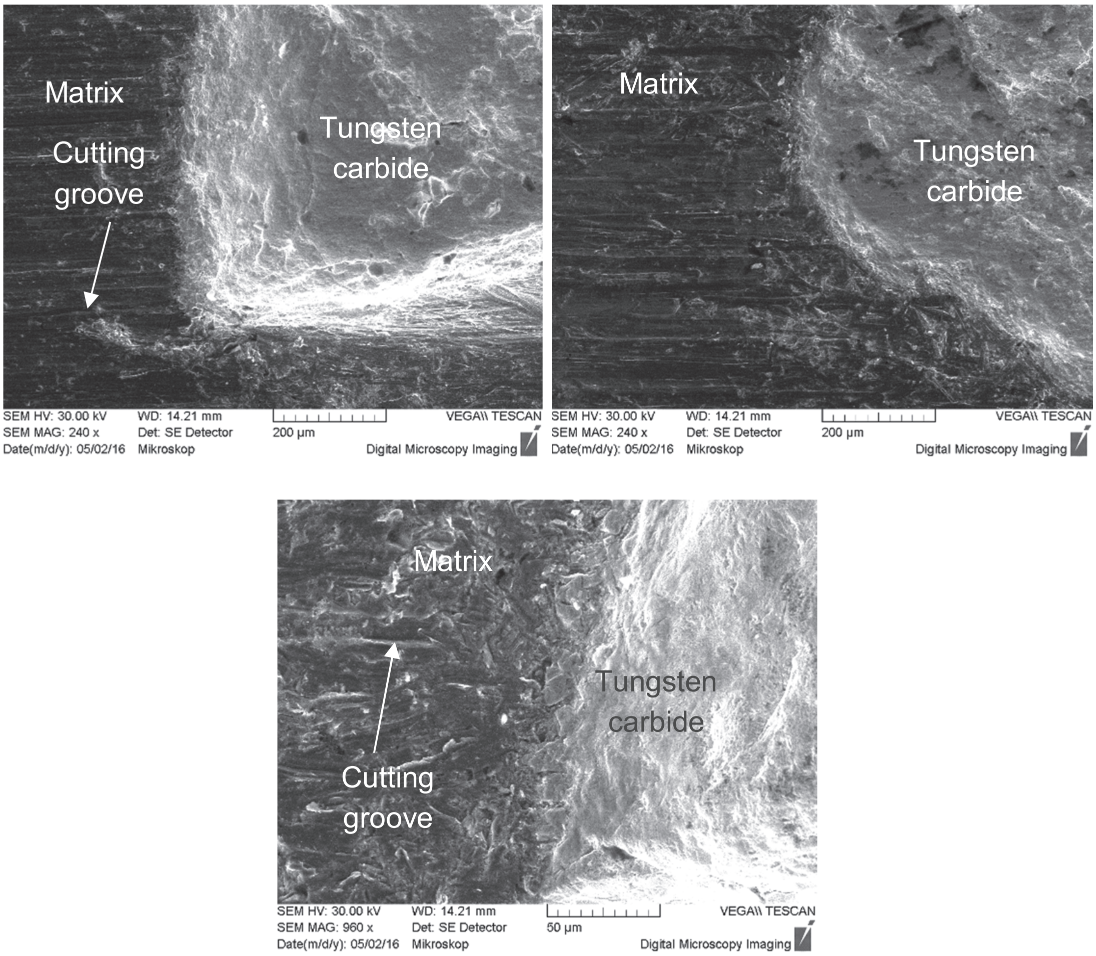

Figure 4 Surface of the sample 4 after abrasion test

4. CONCLUSION

The weight loss of sample 3 is 0.357 g versus 0.403 g for sample 4. This is due to the slightly higher microhardness of the sample 3 matrix (see **Figure 1**, average microhardness approximately 954 HV0.1 versus 804 HV0.1), due to the use of lower welding parameters, so faster cooling of the molten pool followed. However, sample 3 showed a significantly higher appearance of cracks, and in some areas there was a peeling and degradation of the weld deposit, which also sometimes occurs with other types of the weld deposits, e.g. Hadfield's steel [7]. Measured weight loss values are significantly lower than on samples not containing any tungsten carbide particles that were used for comparison. For these samples, the weight loss was between 0.728-0.899 g.

For both samples, the material was removed by abrasive particles cutting. In some areas, the material was ploughed. Traces of abrasive particles can be observed but they end at the interface of the tungsten carbide particle and matrix, which acts as a kind of barrier that reflects them and prevents them from moving further along the surface of the sample. Tungsten carbide particles also show traces of material damage, but because of the high hardness of these particles, the loss of material is not so noticeable. Tungsten carbide particles thus act as matrix reinforcement and reduce surface wear. The results are applied in practice for machine parts used in the mining industry.

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REFERENCES

[1] LUDEMA, K.C. Introduction to Wear, Friction, Lubrication, and Wear Technology, *ASM Handbook*, Vol 18, ASM International, 1992, p. 175-175.

[2] LEECH, P.W., LI, X.S., ALAM, N. Comparison of abrasive wear of a complex high alloy hardfacing deposit and WC-Ni based metal matrix composite. *Wear*, vol. 294-295, 2012, s. 380-386

[3] HERMAN, P. Materiály pro navařování a žárové nástřiky s obsahem wolframkarbidů. [online]. [cit. 2017-5-24]. < http://www.svarak.cz/c/cz/materialy-pro-navarovani-a-zarove-nastriky-sobsahem-wolframkarbidu.htm >

[4] CHEN, H., HUTCHINGS, I.M. Abrasive wear resistence of plasma-sprayed tungsten carbide-cobalt coatings. *Surface & Coatings Technology*, vol. 107, 1998, s. 106-114

[5] BADISCH, E., KIRCHGAßNER, M. Influence of welding parameters on microstructure and wear behaviour of a typical NiCrBSi hardfacing alloy reinforced with tungsten carbide. *Surface & Coatings Technology*, vol. 202, 2008, s. 6016-6022

[6] KREJCI, L., HLAVATY, I., SEVCIKOVA, X. Transition zones study of the heterogenous welded joints. *In METAL 2013*: *22nd International Conference on Metallurgy and Materials*. Brno: TANGER, 2013, pp. 785-789.

[7] SCHMIDOVA, E., HLAVATY, I., HANUS, P. The Weldability of the Steel with High Manganese. *Tehnicki vjesnik-Technical gazette*, Vol. 2016, 23, No. 3, pp. 749-752, ISSN 1330-3651.