STUDY OF THE WELD DEPOSIT PROPERTIES CONTAINED TUNGSTEN CARBIDES IN THE IRON MATRIX

HLAVATÝ Ivo[1], KOZÁK Jindřich[1], KREJČÍ Lucie[1]

[1]*VSB - Technical University of Ostrava, Czech Republic, EU*

Abstract

The components used in the mining and construction industry, agriculture, etc., during its lifetime are exposed to the various types of wear, which include abrasion, erosion, impacts, and others. Currently, there are several variants of protective surface layers which are wear resistance. This group includes special weld deposits combining the metal matrix alloyed with boron and tungsten carbide particle. The parts, hard-faced already in production, can be classified as a group of composite materials that can gradually replace conventional parts made of quality steel. Using these protective layers helps to minimize the cost of repair or replacement of worn parts. The aim of the experiment is to study the properties of the weld deposit with a matrix based on iron with increased content of boron in combination with particles of tungsten carbides of size 1-2 mm using structural steel S235JR as a parent material. The influence of welding parameters, type of matrix and the size of unmelted particles of tungsten carbide was evaluated in terms of the macrostructure assessment, the HV0.1 measurement and the microstructure assessment of selected areas in the view of the possible rate of wear and service life of the weld deposit.

Keywords: Tungsten, carbide, hard-facing, wear, weld deposit

1. INTRODUCTION

Machine parts (teeth of excavators, screw conveyors, etc.) in the construction and mining industries, agriculture, etc., are exposed during its lifetime period to extreme loads, which include impact, corrosion, abrasion, erosion, and others. Modifications of these components can be done several ways. These include laser cladding, thermal spraying or surfacing. One possibility of increasing the service life of parts is hard-facing using various combinations of the additional materials to achieve the desired properties of the weld deposit. In this particular example was performed hard-facing on structural steel S235JR (see **Table 1**) used additional material with a martensitic matrix (Megafil A864M, see **Table 2**) in order to achieve higher resistance against wear, especially abrasion [1, 2, 3, 4].

The martensitic matrix is additionally combined with the tungsten carbide particles with 1-2 mm size. This leads to reinforcement of the matrix and increase of the resistance of the material surface against wear. Tungsten carbide particle diverts abrasive from the component surface and thus protects the matrix from exposure to abrasive [3].

As a filler material for hard-facing flux cored Megafilm A864M (Method 138) in a protective gas atmosphere M21 (18% CO2 and 82% argon) was used. For the transportation of particles of tungsten carbide into the weld pool vibratory feeder Lincoln Electric was used, which enables regulation of the amount of added particles into the molten bath by frequency regulation [2].

Tungsten carbide particles are located mainly at the bottom of the welded deposit. The reason is a higher density of the carbide material with respect to the density of matrix. During the hard-facing these particles are going down through the molten pool towards the basic material. Analysis of the microstructure of the weld deposit exhibits dendritic formations formed during the crystallization and solidification of the molten bath. Simultaneously, in **Figure 2** areas of the melted tungsten carbide particle are showed, which depends on the value of the welding current used during hard-facing [4]. The matrix hardness of the sample 1 (**Figure 1**) reaches values between 631 and 828 HV0.1. Sample 2 achieves lower hardness between 412 and 704 HV0.1.

Sample 3 shows a hardness of the weld deposit slightly higher because slightly alloyed by tungsten from melted tungsten carbide particles. The hardness of the matrix is in the range of 810 and 1050 HV0.1. Particles placed in the sample 3 reaches hardness up to 2680 HV0.1. The matrix of the sample 4 exhibits lower hardness between 652 and 943 HV0.1. The particles achieve hardness up to 2520 HV0.1. Chemical analysis of the cross sections of individual samples gives us the image about the amount of individual chemical elements in direction from the weld deposit to the base material, see in **Figure 3**.

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 1	Sample 2	Sample 3	Sample 4
Welding current	210 A	250 A	210 A	250 A
Welding voltage	25 V	30-32 V	28 V	29 V
Welding speed	4-5 mm.s^{-1}	4-5 mm.s^{-1}	5-6 mm.s^{-1}	5-6 mm.s^{-1}
Gas flow	18 l.min^{-1}	18 l.min^{-1}	18 l.min^{-1}	18 l.min^{-1}
WC particles (size)	No	No	Yes (≈1-2mm)	Yes (≈1-2mm)

3. RESULTS

3.1. Microhardness

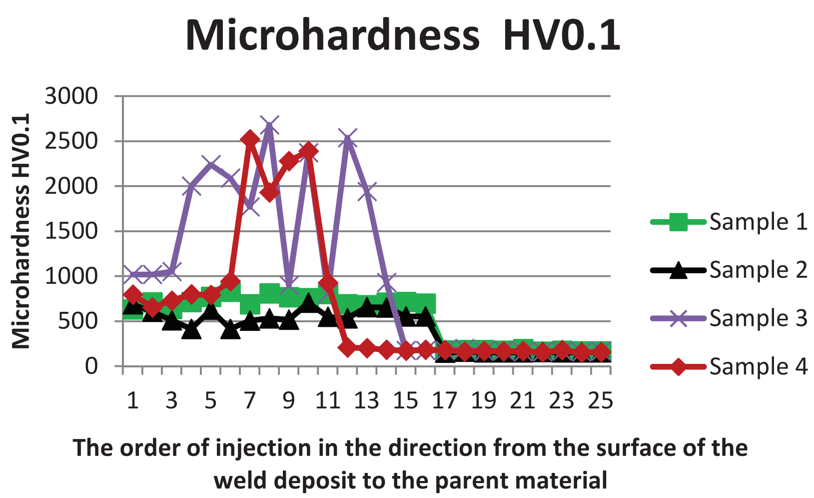


Figure 1 Microhardness HV 0.1 in direction from the surface to the parent material

3.2. Microstructure

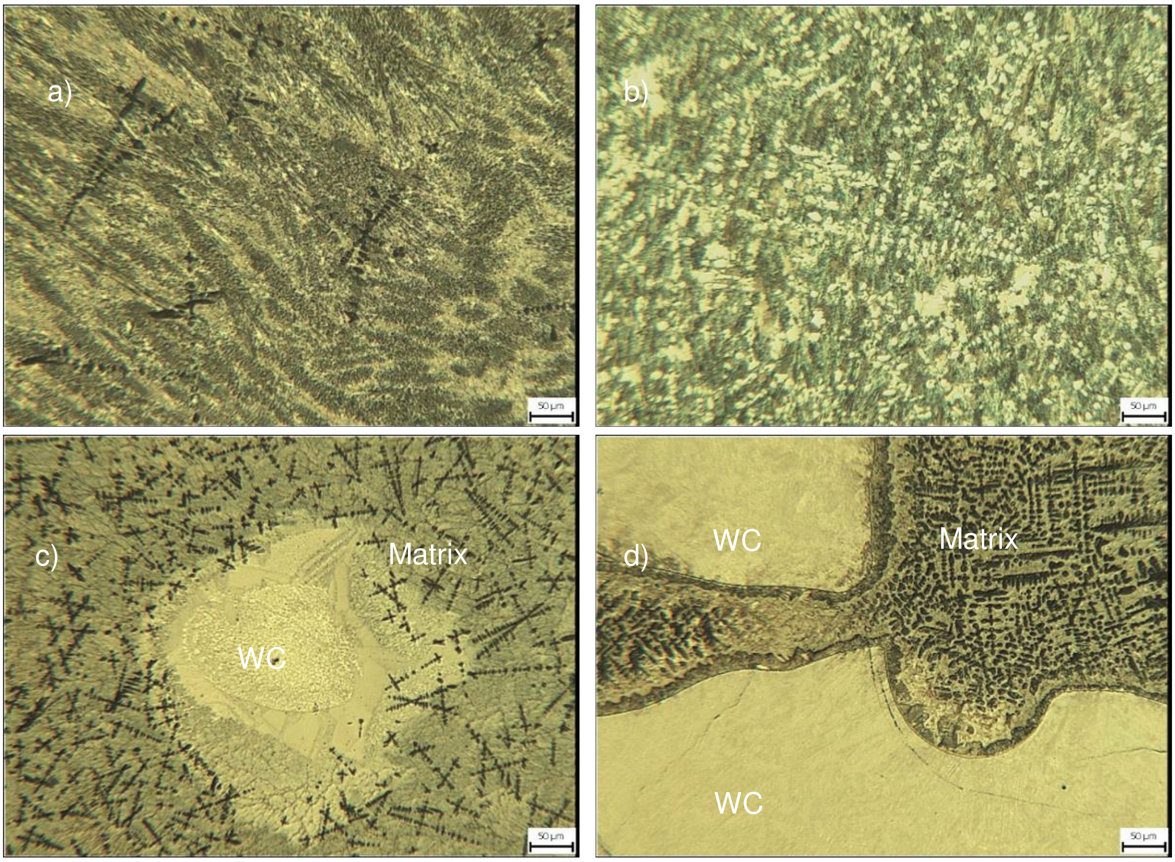
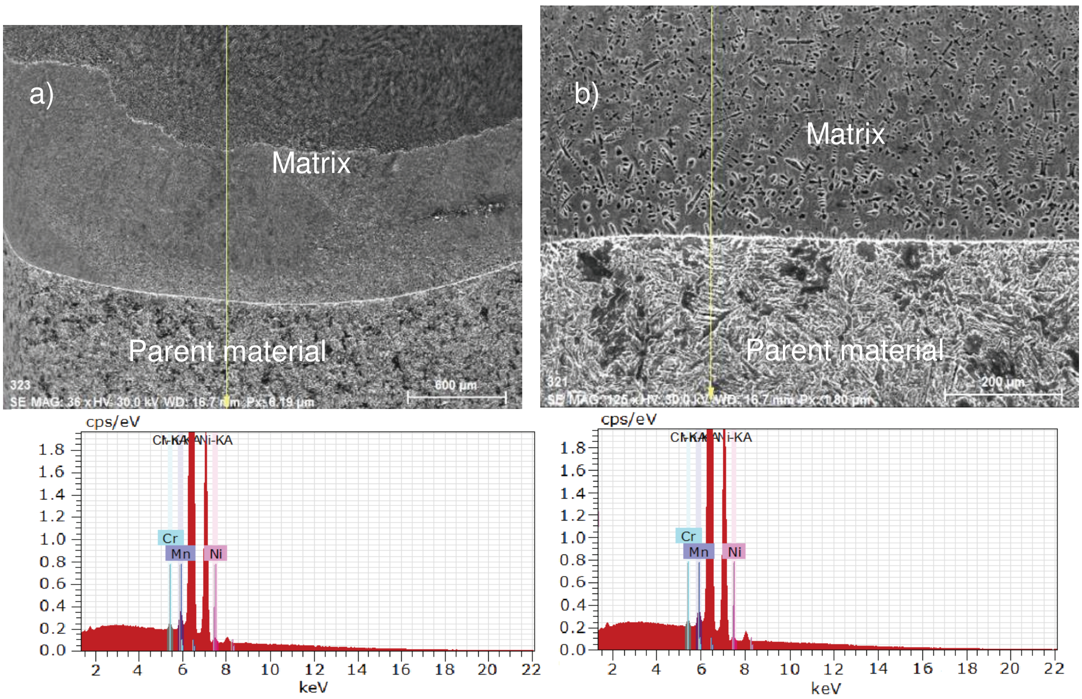


Figure 2 a) Weld deposit microstructure of sample 1; b) Weld deposit microstructure of sample 2; c) Weld deposit microstructure of sample 3; d) Weld deposit microstructure of sample 4

3.3. Chemical analysis



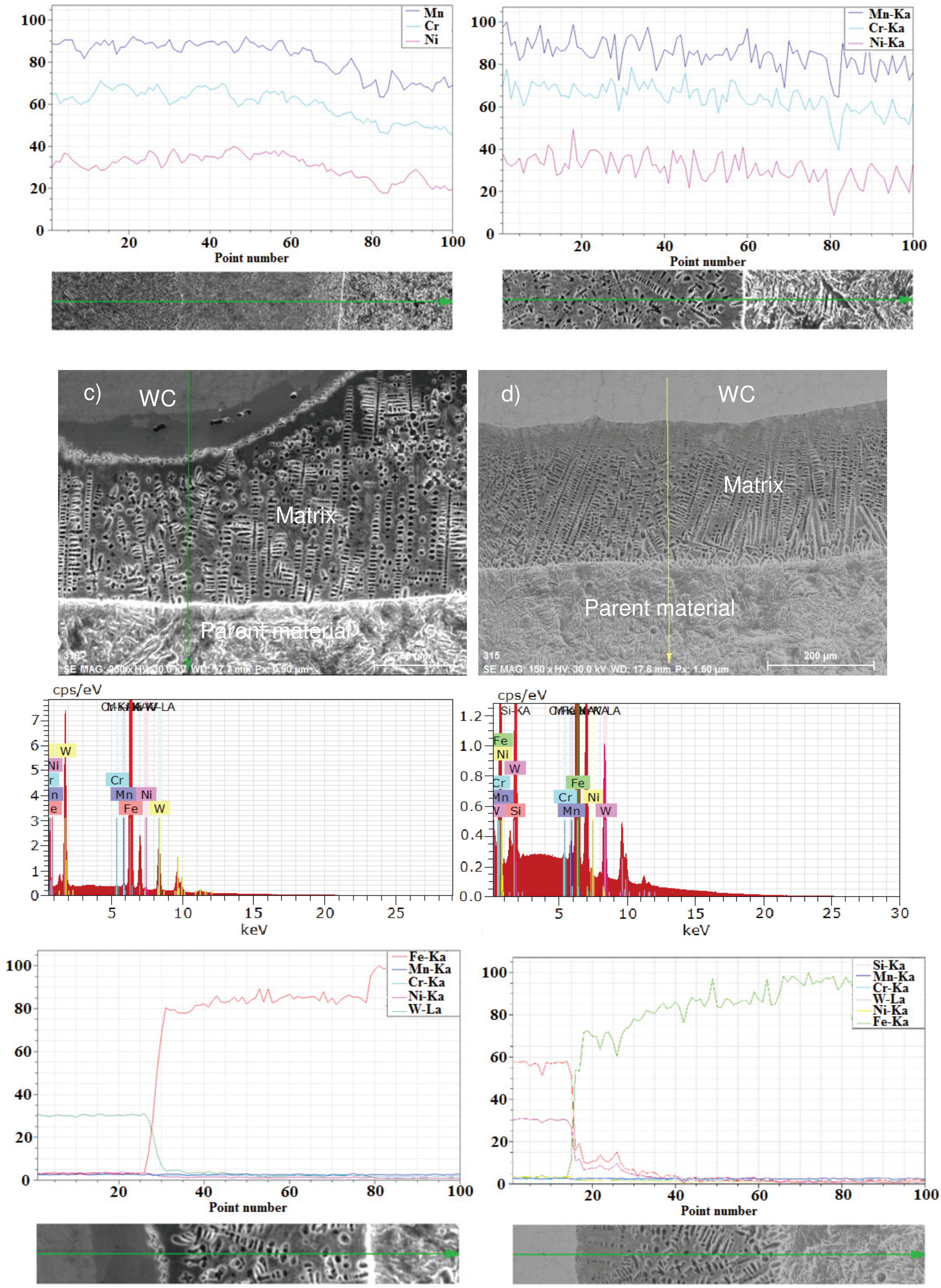


Figure 3 Linear analysis of chemical composition in the weld deposit, heat affected zone and parent material.

a) Sample 1, b) Sample 2, c) Sample 3, d) Sample 4

4. CONCLUSION

The hardness can be increased by application of boron material. Another important element is the amount of tungsten carbide in weld. Welding parameters lead to a partial or complete meltdown of tungsten carbide grains (see the welding current in **Table 3**). It can be noted that we can create a weld deposit with very different results by changing of welding parameters and amount of added carbide grains. The partially melted tungsten carbides have an effect in its surrounding matrix, not only by changing of the chemical composition, but also by mechanical properties (e.g., hardness increasing of matrix), which may results in a higher failure of welded joints and reduces its lifetime. It is concluded that the properties of weld deposit can show large differences in properties and lifetime of welded layers. Therefore, it is necessary to optimize the welding parameters in order to achieve the desired results such as wear resistance of surfaces.

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