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PRODUCING A LAYER OF IRON FE-CR-C-NB UNDER CONDITIONS OF INTENSE HEAT RECEPTION

R. Bęczkowski[*], J. Cebulski[**], D. Pasek[***], M. Gucwa[****]

Abstract: *The paper analyzes the influence of the quality of the new flux cored wire intended for cladding process by one set cladding parameters such as welding speed, thermal conductivity coefficient of aluminum, power source setting, the length of projecting portion of the electrode, wire speed and speed of oscillation on the hardness distribution and structure in bead. The results of hardness distribution analysis allows to illustrate the nature of the impact of the examined input variables on parameters of generated surface. The most important parameters here are the hardness distribution and structure of bead. The cladding process was conducted by Flux Cored Arc Welding (FCAW). As additional material for cladding Fe-Cr-C-Nb was used. To describe the properties of the layers Vickers hardness, optical microscope (OM) and scanning electron microscope (SEM) were used.*

Keywords: Cladding, FCAW, Hardness, Structure, SEM.

1. Introduction

Special materials are available for production of hard plates with high abrasive resistance. Cored wires belong to welding materials that are often used to deposit cladding with high resisting. The problem to solve in industrial practice is the correct setting of the flux-cored self-shielding arc welding parameters and their impact on the final desired surface parameters such as hardness, structure and lifespan (Bęczkowski, 2017 and Kejžar, 2003).

The use of core wire in the production of clad with different chemical composition and good quality has a great potential. The problem is to determine which of the surfacing parameters have a significant impact on the final characteristics of clad (Pernis et al., 2013 and Mendez et al., 2014).

Hardness distribution and structure are one of the most important parameters of abrasion plates. The producer allows possibility to choose plate in the configuration for example 10+5. The first number gives the information about the thickness of the parent material. Mostly S235 material grade is used. And the second number describes the thickness of hard layer. This number gives the information about the length of the lifespan. Hardness distribution and structure are responsible for durability and adhesive (Bęczkowski et al., 2015 and Bęczkowski et al., 2016 and Dwivedi, 2004).

The development of new materials as cored wire and technologies as flux cored arc welding in the process leads to improvement of tribological properties of deposited coatings designed for protection against wear. Special cored wires belong to cladding materials that are often used to deposit surface with high wear resistance.Special hardfacing alloys of high-chromium white irons with carbides in the deposited structure using cladding are well known for their wear resistance (Adamiak et al., 2010 and Dwivedi, 2004 and Kejžar, 2003).

[*] Robert Bęczkowski, PhD.: Institute of Mechanical Technology, Częstochowa University of Technology, Armii Krajowej Street 21; 42-201, Częstochowa;PL,rbeczkowski@spaw.pcz.pl

[**] Janusz Cebulski, PhD.: Faculty of materials engineering and metallurgy, Silesian University of Technology; Krasińskiego Street 8, 40-019; Katowice; PL, Janusz.Cebulski@polsl.pl

[***] Dorota Pasek, M.Sc., Eng.,: Faculty of materials engineering and metallurgy, Silesian University of Technology; Krasińskiego Street 8, 40-019; Katowice; PL, Dorota.Pasek@polsl. pl

[****] Marek Gucwa, PhD.: Institute of Mechanical Technology, Częstochowa University of Technology, Armii Krajowej Street 21; 42-201, Częstochowa; PL, mgucwa@spaw.pcz.pl

High-chromium white irons with carbides in the structure are commonly used for the hardfacing plate in the different sector in industry. Hardfacing alloys consist of Cr_7C_3, $Cr_{23}C_6$, Cr_3C, NbC, Nb_2C primary and eutectic carbides and eutectic austenite or martensite. To make hardfacing layers many cladding technologies were used. Using the cored wire gives additional possibility to change the properties of clads.In the wire core different kind of carbides like chromium, niobium with hardness over 1000 HV can be found. Using the flux cored arc welding against wear is one of the most common technology to develop the hard layer (Bęczkowski et al., 2015 and Mendez et al., 2014 and Niagaj, 2011 and Orłowicz, 2009 and Winczek, 2016).

2. Methods

Workplace with a water-cooled table was used in the sample welding and additionally the pad receiving heat from the space surfacing made of aluminum was laid. As the parent material S235JR steel with a thickness of 10 mm and dimensions of 200 x 400 mm was used, wire (C = 5.4 %, Cr = 29 %, Si = 1.2 %, Nb = 3.0 %, Mn = 0.4 %, B < 1 %) was used for the cladding. For the test the input factors were defined by: cladding speed, (160 mm/min), coefficient of thermal conductivity of aluminum, (2.15 W/mK), power source setting, (11480 W), the length the projecting portion of the electrode, (30 mm), the frequency of oscillation (2.4 m/min), wire feed speed (5.8 m/min), diameter of cored wire (2.8 mm) and width of amplitude of bead (35 mm).

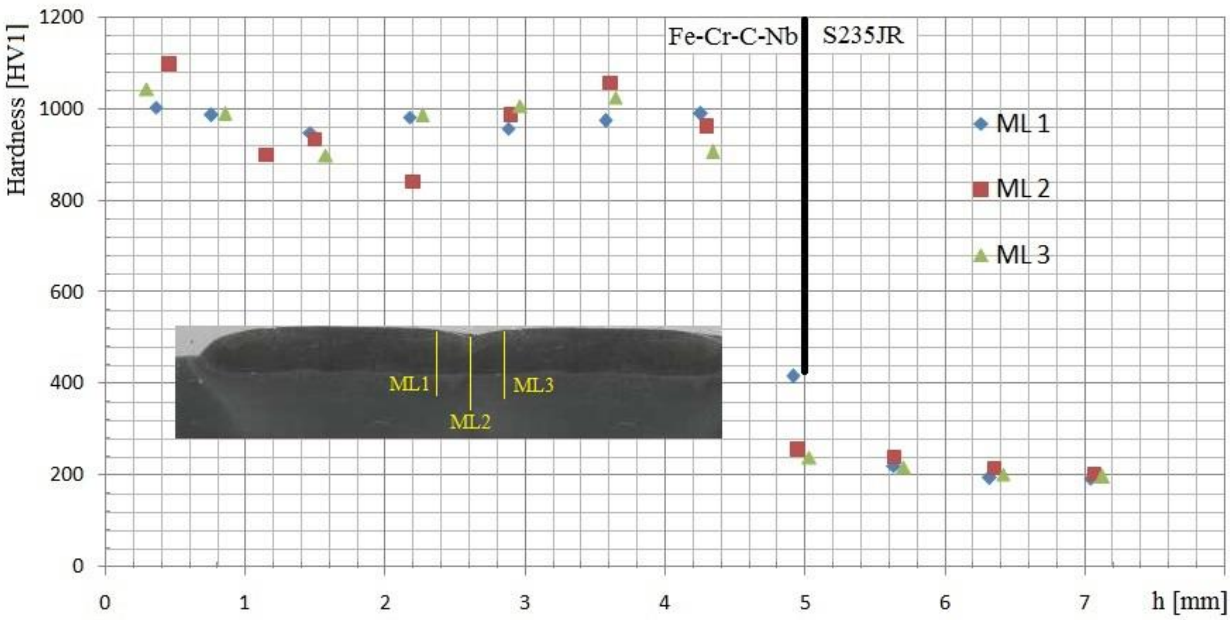

Fig. 1: Hardness distribution of the distance from the top surface of the bead.

Hardness measurement was conducted on cross-section material. Hardness was measured with Vickers method according to a norm PN-EN ISO 6507-1 with a load 9.81 N (HV1) the device type ZWICK. Fig. 1 shows the results of measure hardness distribution HV1 of the distance [mm] from the top surface of the bead. Hardness was done in three lines of measurement (ML), which were denoted by ML1, ML2 and ML3.

Fig. 2 shows cross-section of all the layers: parent material (a), line fusion: under (b) and over (c), bead (d-f).

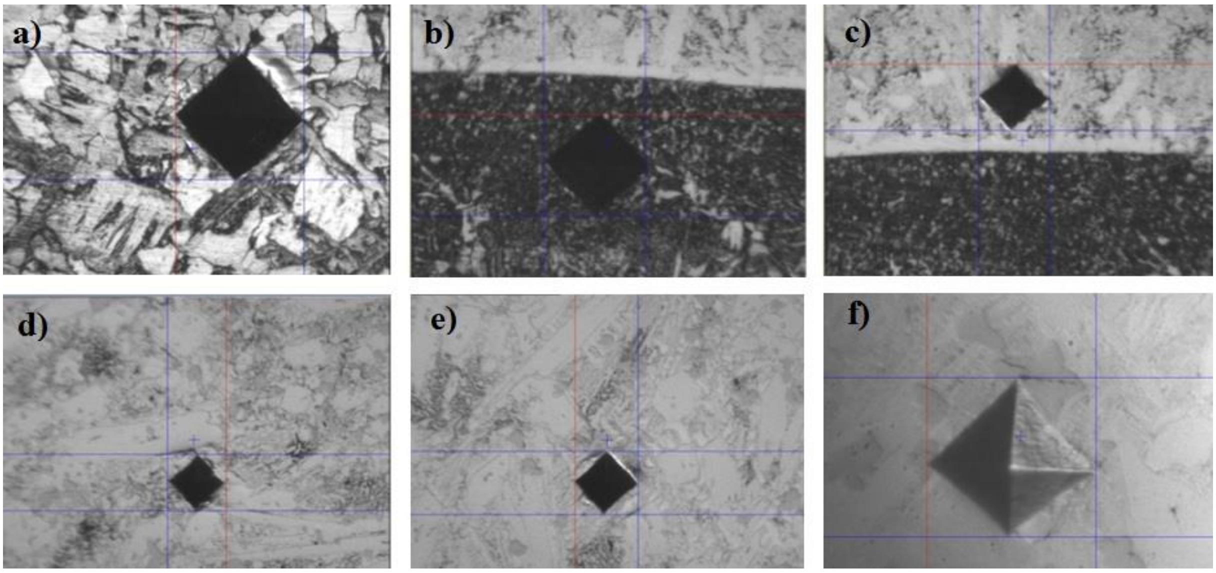

Fig. 2: View of hardness distribution from the parent material to the top of the bead.

Metallographic tests were conducted on polished micro-sections etched in 3% alcohol solution of nitric acid (nital). Microstructure observations were conducted with the use of metallographic microscope Olympus GX51.

Fig. 3 shows the distribution of carbides in the clad. Fig. 3a shows general view of structure. The distribution of carbides with low (Fig. 3b) and high (Fig. 3c) participation of niob carbides is showed.

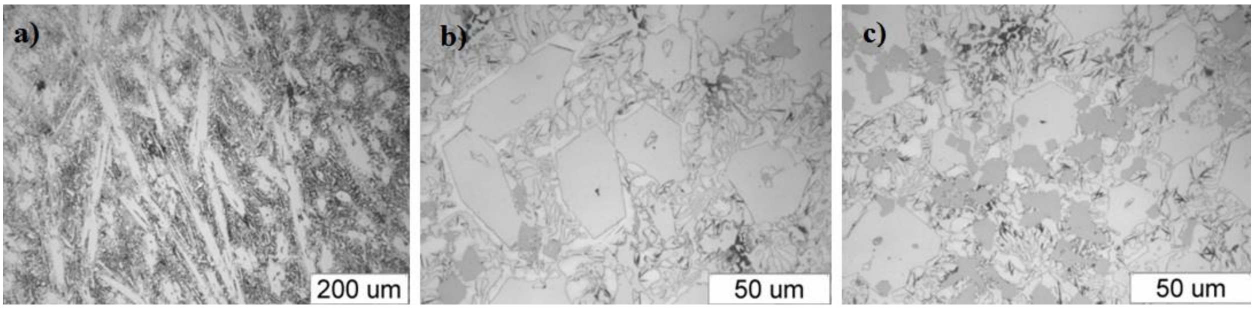

Fig. 3: Structure of bead with distribution of the carbides.

The chemical composition was determined by X-ray microanalysis EDS using a scanning electron microscope equipped with a Hitachi S4200 ray EDS detector. Fig. 4 shows the SEM surface analysis of hardfacing layers, with the presence of Fe, Cr, Nb and C. Given the chemical affinity it should be assumed that in the material are niobium and chromium carbides. Due to the methodology research, share of coal should be considered approximately.

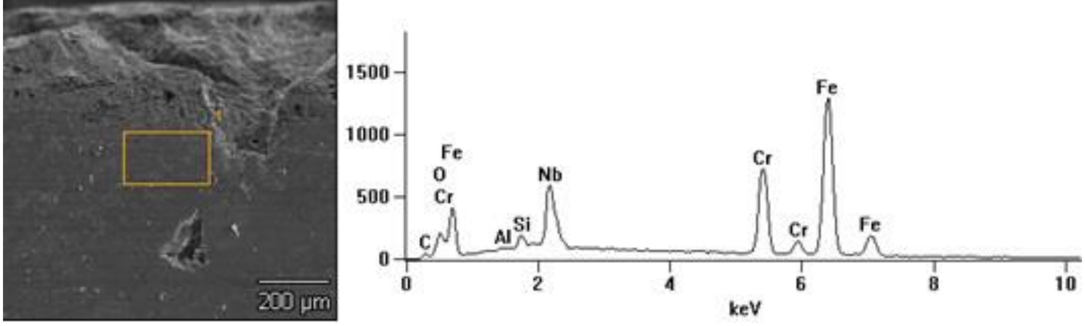

Fig. 4: SEM analysis of the microscope together with an indication of the chemical composition.

Tab. 1: Number of Weight %.

C	***O***	***Al***	***Si***	***Cr***	***Fe***	***Nb***
1.5	4.3	0.3	1.0	19.6	61.7	11.7

Tab. 2: Number of Atom %.

C	***O***	***Al***	***Si***	***Cr***	***Fe***	***Nb***
6.1	13.1	0.5	1.8	18.4	54.1	6.1

3. Conclusions

Hardness distribution was checked in several lines and the results of this test show that on the top of specimen the hardness is the highest, in the middle section hardness goes down and by the parent material value of hardness goes up. Surprisingly, in the middle section of clad, hardness is lower than in the top and bottom section. Normally, the bottom section made by mixed clad with parent material has the lowest hardness. In this case using additional aluminum plate gives the quickest heat dissipation.

Observations under the optical microscope (Fig. 3) show the principal axes of the distribution of carbides in the direction of heat dissipation. The location of niobium carbides is not uniform. There are places with small areas of niobium carbides (Fig. 3b) and areas with a high proportion (Fig. 3c) of niobium carbides. Their presence depends on the area of the bead. The increase of the share of niobium carbides was observed over the line of fusion, which proved by hardness measurements.

Tests performed using a scanning electron microscope (SEM) with X-ray and chemical composition allow to conclude that the multiphase layer is deposited, and it is composed of chromium and niobium carbides. This information is confirmed in studies of surface distribution of elements included in the weld hardfacing layers and forming areas with different phase composition.

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