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The Effect of Type of Welding Sequence During Hardfacing Chromium Cast Iron for Erosion Resistance

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Abstract

The paper presents the capabilities of welding techniques to creating properties of wear resistant high chromium cast iron alloy. The use of the right kind of welding sequence allows you to change the structure and properties of the obtained welds. Tests were conducted for one type of additive material in the form of self shielded core wire. In order to determine the effect of the type of welding sequence on the properties of welds performed welding using string bead and weave bead. The resulting weld was tested on hardness and research structure in an optical microscope. In the following studies have been made erosive tests wear of made hardfacing. String beads gave structure rich in carbides and harder about 270 HV of the weld with weave bead. Also, wear resistance was nearly twice as better for welds made with string beads. In the experiment a decisive role in the resistance to wear plays a high hardness of the deposit and the presence of carbides in its structure. Changes in the basic parameters of the deposition process allows for the formation of structure and properties of hardfacing welds in a wide range.

Keywords: Wear resistant alloys, Hardfacing, erosion, Welding sequence, Hardness

1. Introduction

The use of materials with structure of cast chromium iron on to protect against wear is common practice dictated by practical considerations as well as economic reasons. Chrome cast iron is characterized by good wear resistance and relatively low manufacturing cost compared to other hard wearing materials, it is also possible the formation of their respective properties by modifying the chemical composition and heat treatment [1-3]. There are also many other opportunities to improve the properties of the surface layer, eg. by the use of welding techniques as melting surface or surfacing with various of materials and different heat input [4-13]. By using self shielded cored wires it became possible to also receive materials about the structure of chromium cast iron welding methods by welding [14-18]. In the case of deposition layer thicknesses obtained and their properties they depend not only on the chemical composition but also on the same parameters of the deposition process. Conducted in this direction research indicates a high possibility of forming properties of welds by changing the conditions of current-voltage process or generally linear change in heat input. An important factor that may affect the properties of welds is also a bead shape, which is used to create wear resistant plates. The use of a string beads and weave bead can affect the crystallization conditions resulting welds and their inherent heat treatment which they are subjected during welding the next bead. The main objective of the study was to investigate the effect of string beads and weave bead on the properties of the obtained wear resistant plates.

2. Experimental procedure

Non-alloy structural steel of designation S235 for general purpose was selected as parent material for hardfacing layers. The thickens of deposited steel plate was 6 mm. Self shielded cored wire with a diameter of 1.2 mm and the chemical composition specified by the manufacturer in Table 1 was selected for hardfacing. The deposition process was carried out on using an Cloos Quinto Profi welding source.

Table 1.
Chemical composition of self shielded cored wire wt%

C	Cr	V	W	Fe
3,8	22	0,8	0,8	balance

The process of deposition was carried out in two embodiments using a string beads and the weave bead. The hardfacing process parameters are shown in Table 2. The specimen buildup string beads designated as A, specimen made with weave bead as B.

Table 2.
Hardfacing process parameters

Specimen	Voltage [V]	Current [A]	Width of bead [mm]	Wire speed feed [m/min]
A	22-23	170-180	5	4,3
B	22-24	130-150	35	4,3

In the case of string beads surfacing was made by 6 beads per length of 200 mm. Weave bead was made as a single bead of the same length. In both cases the final width of hardfacing was 40 mm and the height of the hardfacing was up to 4 mm. Made in this way, the deposit has been subsequently tested with metallographic optical microscope Olympus GX51,scanning electron microscope (SEM) with energy dispersive spectrometry facilities (EDS) and hardness tests with Vickers method. The study of structure were performed using metallographic reagent MI19Fe. Erosive wear tests were carried out on a modified position of the jet milling. Ejector nozzle diameter was 6 mm, and its distance from the sample was fixed at 6 mm. Tests were carried out with use of a fixed pressure jet erosion at 5 atmospheres. As a material erosion used corundum. Specimen before the test were cleaned and weighed and then assembled into the device and erosion tests were carried out at 90° and 10 min. The time of erosion test was determined on the basis of earlier trials, which made it possible to determine how much time is reached the level of consumption set. After 10 minutes the samples were removed from the machine, cleaned stream of air and reweighed to the nearest 0.001g .

3. Results and discussion

The results of metallographic investigation of the obtained welds show large differences in the structure of completed welds. This is also confirmed by EDS microanalysis results (Table 3) Hardfacing made with string beads (Fig.1-2) had numerous chromium carbide type precipitates of $(Fe,Cr)_7C_3$ that is characteristic for the materials deposited on the structure of chromium cast irons [19-21]. Precipitations of the carbide had varied shape and placement of the cross-section of the deposit. In the first weld bead marked A carbides precipitation are rare, and the nature of the dendritic structure has a high degree of dispersion. In Figure 2, in the left part is visible transition between adjacent string beads and a number of carbide precipitation in the interior beads.

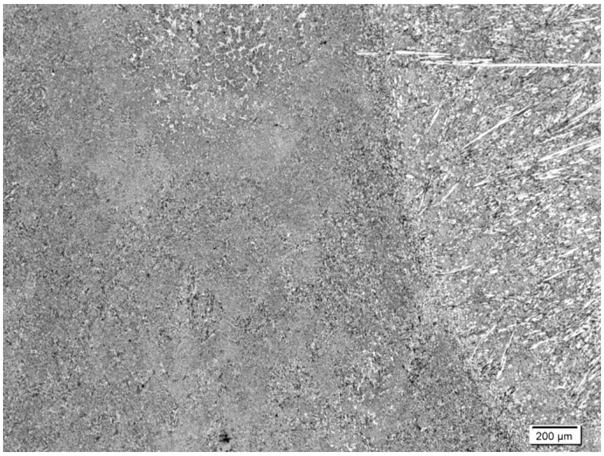

Fig. 1. The structure of specimen A, magnification x 50

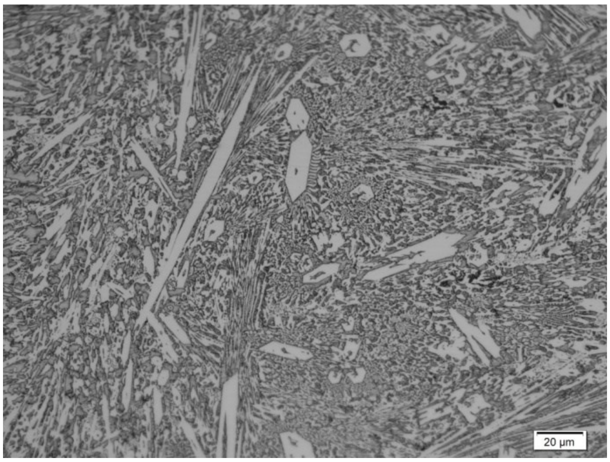

Fig. 2. The structure of specimen A, magnification x 500

The hardfacing made by weave bead is characterized by a different structure of the deposit (Fig. 3-4). In this case, the structure of the entire cross section of the weld is of a dendritic with individual carbide precipitations of shape similar to a sphere. Crystallization in non-equilibrium conditions causes flow of carbides existing in the core wire in most to a solution and enriching eutectic interdendritic areas. Hardness testing confirmed the differences in the structure obtained welds. In Figure 5 are shown the results of hardness test performed on the cross-sectional welds. Studies were carried out in each case in the middle of the sample, and the results show the differences of up to nearly 270 HV10. Hardness above 900 HV10 for the deposit weld by string beads are higher by nearly 40% of the sample weld by weave bead. It is noted that for sample A hardness in excess of 1000 HV10 was observed in the central area of the weld rich in carbides. In the external beads hardness was lower and fluctuated in the range of 850-900 HV10. The structure of the sample B was made more uniform.

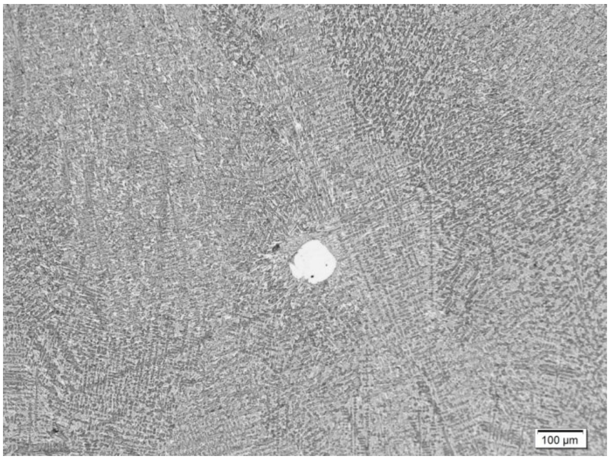

Fig. 3. The structure of specimen B, magnification x 100

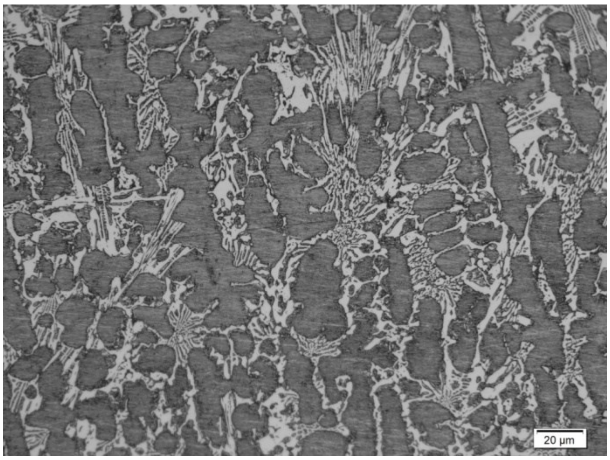

Fig. 4. The structure of specimen B, magnification x 500

Table 3.
Typical chemical composition obtained for structure present by EDS analysis, ignoring carbon content (wt.%).

Specimen	Cr	Fe	V	Nb	Mn	Si
A - carbides	37,38	48,67	1.07	0,71		
A - matrix	17,54	70,95	0,62	0,85	0,90	0,80
B - dendrite	8,87	77,58			0,81	0,65
B – interdendritic	21,76	53,48	0,88	0,85	0,56	

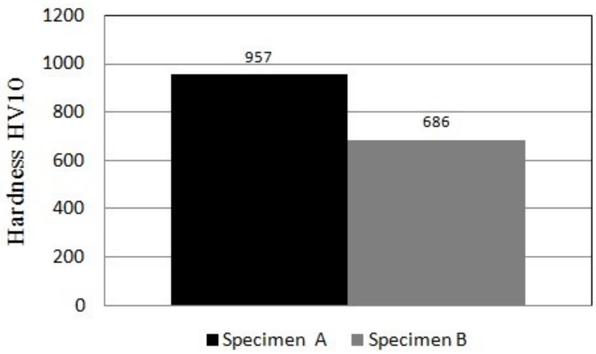

Fig. 5. The average hardness of the hardfacing

The research on the erosive wear resistance showed that the highest wear resistance has specimen A made by using string beads. Figure 6 shows the results of studies on the erosive wear

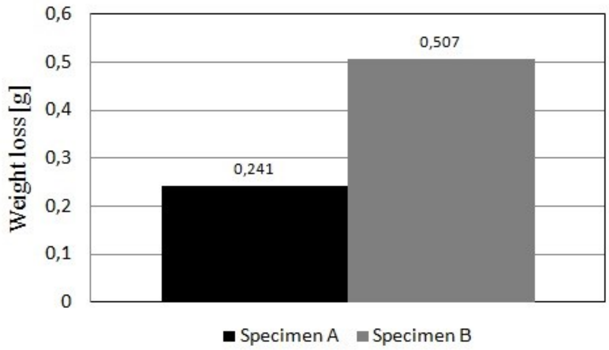

Fig. 6. Results of erosion test

The study showed that in the proposed conditions of the erosive wear specimen B was characterized by greater mass loss about 110% than to the specimen A.
The analyzed hardfacing welds have shown significant differences in the tested properties. This is due to the nature of the deposition process of the string bead and weave bead. When laying subsequent string beads occurs spontaneous heat treatment previous beads what contributed to the formation of carbides in the central part of the deposit. Single carbide precipitation were also observed in the structure of welds made with weave bead (Figure 3). Carbides are likely to come from additional core materials for welding, and not created in the process of crystallization of the deposit and possible transformation. There was observed that in the case of the weld made by weave bead in the entire cross-section of the sample were primary dendritic structure and the eutectic interdendritic areas. Lack of the carbides in the structure is responsible for the lower hardness about 270 HV of the weld compared to the weld made by string beads. Similarly, inferior wear resistance of the sample B under the conditions of the experiment can be explained by the lower hardness and lack of carbides in the matrix. In this case, the main factors responsible for the higher wear resistance is high hardness and the presence of large carbides in the structure of the deposit. Note, however, that the tests were carried out at an angle of

incidence of stream erosion of 90°. The use of a different angle of incidence abrasive or its use in place of corundum, could change the situation. The authors plan to conduct this type of research in the future. The use of an appropriate welding program is therefore of utmost importance to the properties of welds made.

4. Conclusions

The research and analysis allowed to draw the following conclusions.

- In the experiment a decisive role in the resistance to wear plays a high hardness of the deposit and the presence of carbides in its structure.
- It is possible to shape the structure of welds through the use of various types of beads in the performance of welds.
- It is preferable to perform welds using string beads. Obtained in this way the deposit of greater hardness and resistance to erosive wear.
- The use of a one kind of filler material for hardfacing and change the basic parameters of the deposition process allows for the formation of structure and properties of hardfacing welds in a wide range.

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