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The Properties of High Chromium Hardfacings Made with Using Pulsed Arc

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Abstract

The paper discusses the possibility of using pulsed arc hardfacing for depositing high chromium and carbon surfaces. In these studies self-shielded cored wire was used as a material for hardfacing. Pulsed arc is used in welding technologies to better control of transport molten metal in the welding arc and heat input. The correct heat input results in limited dilution surfaces that is very important in wear prevention technologies. The paper presents the results of research on the geometric parameters and hardness of deposited surfaces. The investigation was carried out with various welding parameters that were designed in heat source. The survey was conducted on the specimens that were subjected to metallographic examination hardness test.

Keywords: Hardfacing, Heat input, Self-shielded cored wire, Dilution

1. Introduction

The development of new materials and technologies directed towards improving mechanical properties especially with advantageous tribological properties is one the interesting task for researchers. These materials and technologies give various possibilities of application and we can consider in this group for example composites, steels, casting irons [1-6] and a wide range of welding techniques used for improving surface [7-15].

One of the most useful and economical welding technologies to improve surface properties is hardfacing. An alloy is deposited onto the surface of a soft material (usually low or medium carbon steels) by welding, with the purpose of increasing hardness and wear resistance without significant loss in ductility and toughness of the substrate. A wide variety of hardfacing alloys is commercially available for protection against wear. Chromium cored wires belong to the welding materials that find a wide use in mining industry, processing of minerals, energetics etc., first of all on the elements that is necessary high abrasive resistance. Several welding techniques such as oxyacetylene gas welding (OAW), gas metal arc welding (GMAW), shielded metal arc welding (SMAW) and submerged arc welding (SAW) can be used for hardfacing. The differences among these techniques resolve mainly to the welding efficiency, heat input, size of heat affected zone (HAZ), the weld plate dilution and the economic aspects. One of the most important factor is heat input that determines properties of the remelted or hardfacing surfaces. The studies on heat input and heat flow give chance to predict material reaction and properties of surface [16-19]. The type of welding arc has a significant impact on the quality and efficiency of welding technologies [20]. Pulsed arc is very often used to achieve good quality of welding, low heat input and the arc stabilization. There are very desirable factors in hardfacing which can ensure a good quality of deposited materials in first layer through low dilution.

In the last year a new filler material called self-shielded cored wires became more widely used. This kind of welding wire is filled with powder of metals, carbides and substances that eliminate the necessity of using shielding gases. There is little information in literature about hardfacing by pulsed arc and self-shielded core wire.

2. Research methodology

The primary aim of this study is to investigate whether there is a possibility to use pulsed arc for cladding with cored filler material.

In order to achieve this aim, 6 hardfacing welds were made in a side position using a semi-automatic welder Lorch Saprom S 3 Mobile. This power source is designated to the MIG-MAG pulsing welding. For the tests, S235JR steel specimens of dimensions of 200x40 mm and a thickness of 8 mm were used. Cored wire of the trade named Most F-64 with the diameter 1.2mm was used as a filler. This kind of wire is self shielded cored wire and there is no need to use shielding gases. The chemical composition of the filler material is shown in table 1.

Table 1.
Chemical composition of cored wire wt%

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

It was assumed that parameter changes were limited to the remote mode of welding in the used power source. Table 2 shows data used for determining the heat input of the welding process. Specimens hardfacing with the impedance 0 were denoted 1,2,3, while those welded with the impedance 20 have the denotation 1.1, 2.2, 3.3. The other parameters, such as hardfacing speed (30 cm/min), wire diameter, the angle of wire inclination to the surface and the polarity, remained the same in each case. The exposed length for the cored wire in all samples was assumed to be 20 mm.

Table 2.
Hardfacing process parameters

Programs	Puls		Twin Puls		Speed	
Sample designation	1	1.1	2	2.2	3	3.3
Set current [A]	265	265	265	265	224	224
Measured current	187	236	183	210	151	177
Set voltage [V]	28,7	28,7	28,7	28,7	27,9	27,9
Measured voltage	36,3	40,4	36,7	40,9	33,8	38,1
Heat input [kJ/mm]	1,52	1,52	1,52	1,52	1,25	1,25
Heat input according to measured values	1,36	1,91	1,34	1,72	1,02	1,35
Impedance	0	20	0	20	0	20

Each of the prepared specimens was subjected to macroscopic examination. The examinations were conducted using an image analysis program by Olympus. The next step was carrying out the hardness tests. One of the most important parameters of the deposited hardfaced layers is dilution of welded metal. These parameters were investigated in macroscopic examination and with use of the following equation:

$$\gamma = \frac{F_w}{F_n + F_w} \cdot 100\% \qquad (1)$$

where: F_w – area of fusion deposited metal,
F_n – area of weld reinforcement.

3. Research results and their analysis

The figure below shows the appearance of the obtained hardfacing welds, which were the subject for further investigation. Macroscopic investigation revealed porosity on the obtained hardfacings. This is caused probably by circumstances of arc burning. Self shielded cored wire in time of hardfacing produces a big amount of shielded gases and that factor may have a significant impact on the stability of arc burning and the mode of transport of molten metal in the arc. The programs that were available on the welding machine were designated mainly for cored wire which require external shielding gases.

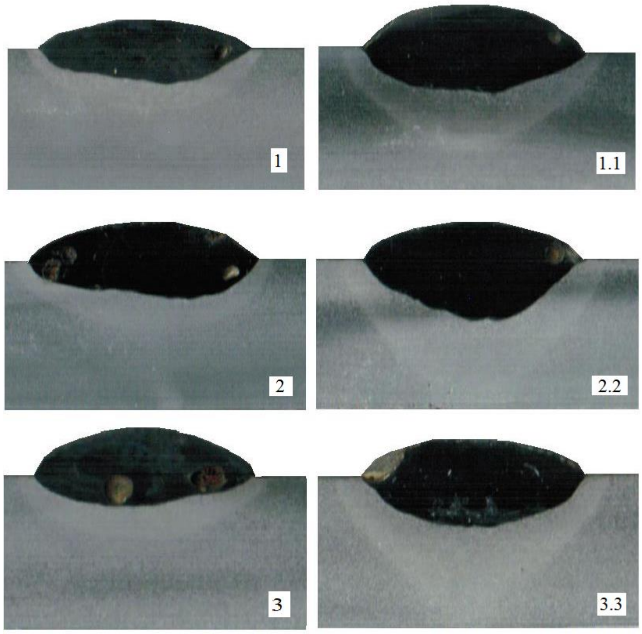

Fig. 1. The view of hardfacing welds

A meaningful difference can be observed in the size and the shape of heat affected zones. In each case the HAZ was bigger for the samples made with impedance value 20. For the samples denoted 2.2 and 3.3 the HAZ reaches the bottom side of plate. This has a direct impact on the dilution rate what can be observed on figure 2.

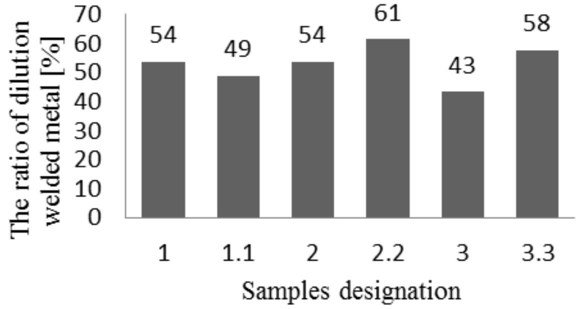

Fig. 2. The ratio of dilution of welded metal

The obtained ratio of dilution of hardfacing overly are very high. It was expected that this parameter would be in low level that could gives a chance to achieve better properties in first layer. In this case probably the transport of molten metal in the short arc mode would determine the significant lower dilution of welded materials. Unfortunately in chosen programs of welding machine the dip transfer arc was very unstable and resulted in big amount of spatters. Spray transfer arc was much more steady with observed low amount of spatter. The mode of transfer metal in arc and measured parameters of hardfacing process resulted in geometrical properties of hardfacing overlays. Figure 3 presents the obtained width and height for deposited layers.

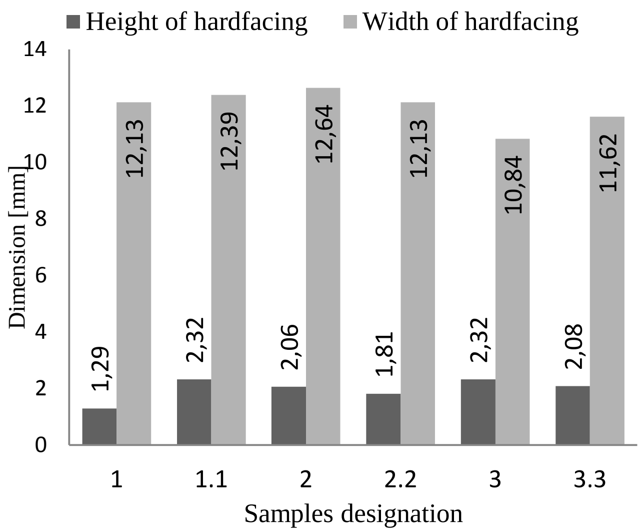

Fig. 3. Geometrical parameters of hardfacing overlays

The results represented in Figure 3 show that only for the specimens denoted 1 and 1.1 increasing impedance gives result in greater reinforcement of hardfacing overlays. In the rest of specimens with greater value of impedance it is observed that reinforcement of weld are decreasing. Measured current and voltage confirm greater values of welding parameters that give the higher level of heat input and heat affected zones.

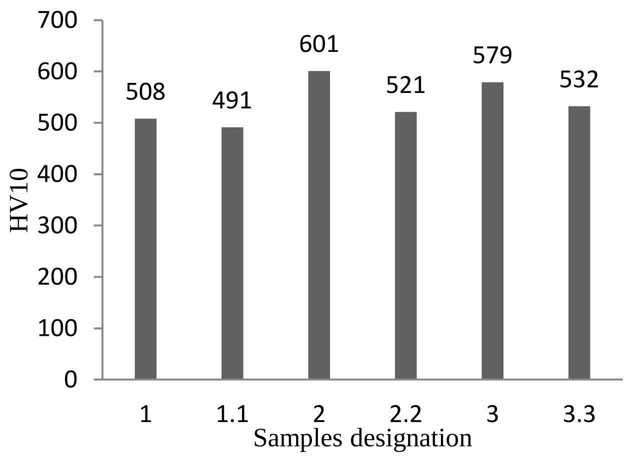

Fig. 4. The average hardness of the investigated samples

The figure above presents the results of the hardness test. High chromium wire that was used in this research according to catalogue data should reach hardness level up to 800HV10. This kind of material can be applied to single layer hardfacing with no notable loss of hardness. In the case of investigated samples the average higher hardness is 601HV10. It is much more lower than the expectation but it must be noticed that very rare assumed properties are obtained in the first layer. In practice it is necessary to deposit 2 or 3 layers to achieve desirable properties of the surface. Next layers would impact decreasing of the dilution rate too. The differences of the hardness result from the dilution rate and the small distinction in size of carbides in the structures. Exemplary of the structure is shown on fig 5. Dendritic structures with different size of carbides can be found in each obtained hardfacing. For the samples made with impedance 0, the differences in structure and hardness were much more lower in cross section than for these made with impedance value 20.

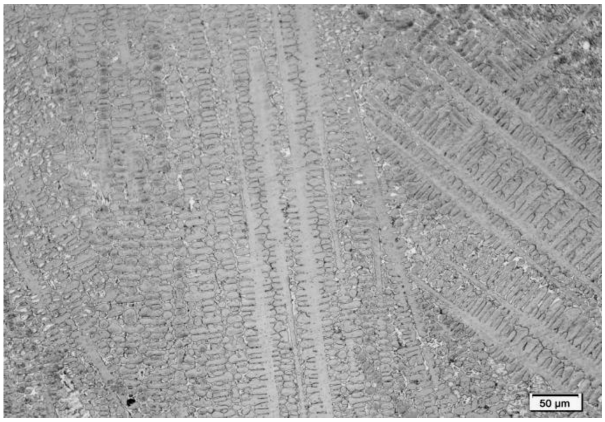

Fig. 5. Microstructure of samples 2.2, etched with Mi19Fe

4. Conclusions

The research results reported in the paper enable the following conclusions to be drawn:

1. Change of the impedance from 0 to 20 results in increase of heat input and size HAZ in investigated samples.
2. The dilution about 50-60% in single layer of obtained hardfacing is too high. The second layer should gives lower dilution and higher hardness.
3. The hardness of investigated samples depends on heat input and particulary impedance. The best results was obtained for program Twin Puls and impedance 0.
4. Pulsed arc hardfacing was characterised unstable arc burning and resulted in spatter and porosity in the deposited material. Programs dedicated in this power source were designed for solid and cored wire with shielded gases. Probably the fumes and gases produced from substances included in self shielded core wire have an impact on arc burning characteristic.

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