PROPERTIES OF MARTENSITIC OVERLAY MATERIAL

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Abstract. The abrasive wear resistance of martensitic overlays is the function of many variables. The hardness is one of the variables. This fact is raised by the possibility of carbidic phases separating from the austenite in the course the overlay layer cooling and by the possibility of the further martensite disintegration and carbidic phases precipitation. The paper is engaged in the hardness and abrasive wear resistance problems of one-layer and two-layer martensitic overlays material.

Keywords: welding, overlay material, abrasive wear

1. Introduction

For repairing using surfacing or for preventive surfacing such procedures are sought so that the best wear resistance would be gained. The wear resistance depends on the overlay hardness and on the structure. The overlay hardness is affected by many factors. The chemical composition of the weld deposit belongs to these factors and it affects the temperatures of the austenite transformation starts [5]. The alloyed elements content influences the hardenability and the trough-hardenability. Using the martensitic overlays we have to secure the martensite start conditions in the whole overlay volume [5, 6].

The conditions of the martensite start can be modified by the quenching rate of the weld deposit, too. The next factor which affects the resultant weld deposit hardness is the mixing of the basic molted down material and the overlay material [2]. The rate of the melting down and then the rate of the overlay material thinning can be affected by the surfacing conditions (the voltage and current rate). In the top of it the surfacing conditions affect the by heat influenced zone, which properties are different from the properties of the basic material and of the weld deposit [2, 8]. Using multilayer deposits the next factor accedes, namely the tempering resistance of the surfaced overlay material. At low tempering resistance the expressive variation in hardness and in wear resistance of single overlay zones occurs. The limitless tempering resistance of the overlay material is the ideal state [1, 4].

The properties of martensitic overlays depend on the tempering temperature. The tempering processes affect expressive the hardness. It is caused by the martensite tempering and by the transformation of the retained austenite in the deposit. At the same time carbides can arise, which owing to their size will take part in the abrasive wear mechanism [3, 7, 9].

The by heat affected depth of the first layer is determined by its thermal conductivity. For the basic material the first layer acts as the heat barrier and it is possible to presuppose that the next heat effect will be minor.

2. Experiment details

2.1. Materials

The substrate material was steel CSN EN S325J0 with dimensions of 80×80×25 mm. The commercial hardfacing and buffer consumables, in the form of solid wire coated electrodes, were used as per the direction of the electrode manufacturer.

2.2. Welding conditions for hardfacing deposits

Hardfacing electrodes were deposited on the plate without preheat in the flat position using manual metal arc welding method. Before welding, the electrodes were dried at 100 °C for 2 h. On completion of weld deposits, each test piece was allowed to cool in air. The welding parameters of the electrodes are given in table 1.

2.3. Chemical composition, metallography and hardness test

The chemical composition (table 2) was determined on the overlay surface of the specimen using GDOES [10]. The Hardfacing deposited plates were sectioned using the high speed SiC

cutter with cooling for deposit chemistry, metallography sample (20×20×25 mm) and also for wear test sample (25×25×25 mm).

Metallography test samples were then ground successively using belt grinder and emery papers and finally polished with Al_2O_3 powder, cleaned with acetone and dried. The polished samples were etched with Nital (electrode A) and Vilella-Bain´s (electrode B) reagent and the microstructures were observed using both an optical microscope.

Bulk hardness values of different Hardfacing deposits were taken in a Vicker´s micro hardness testing machine using a 0.1 kg load and 136° diamond pyramid indenter. Using these specimens the microhardness was measured from the surface to the basic material (figure 1).

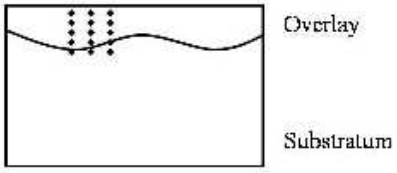

Figure 1. Scheme of hardness measurement cross overlay

2.4. Abrasive wear test

Before the abrasive wear test, all specimens were cleaned with acetone and then weighed on a mechanical balance with an accuracy of ± 0.05 mg. The laboratory tests of the relative wear resistance were carried out using the pin-on-disk machine with the abrasive cloth according to ČSN 5084. The pin-on-disk machines are used most often. The simplicity and the reliability are their advantages. The results variance is relatively small. The variable quality of the abrasive cloth must be continuously compensated by use of etalons. The pin-on-disk testing machine (figure 2) consists of the uniform rotating disk whereon the abrasive cloth is fixed.

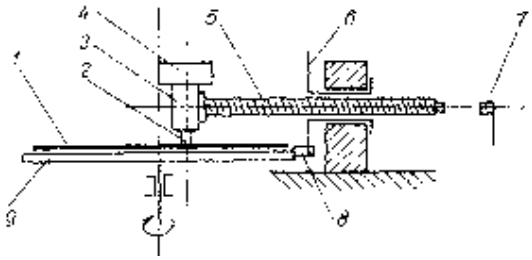

Figure 2. Diagrammatic representation of the pin-on-disk testing machine
1 – abrasive cloth, 2 – specimen, 3 – holder, 4 – weight, 5 – screw, 6 – nut with cogs, 7 – limit switch, 8 – pin, 9 – horizontal plate

The tested specimen is fixed in the holder and pressed against the abrasive cloth by the weight of 2.35 kg. The screw makes possible the radial feed of the specimen. The limit switch stops the test. During the test the specimen moves from the outer edge to the centre of the abrasive cloth and a part of the specimen comes in contact with the unused abrasive cloth.

The wear resistance was tested in various overly zones as far as the limit stage was reached. The limit stage was at the time when the tested surface contained less than 90 % of the overlay material.

$$wear\ ratio = \frac{weight\ lost\ of\ deposit}{trace\ of\ specimen\ on\ disc\ (41.5\,m)}$$

Table 1. Welding parameters

Electrode	Curent (A)	Voltage (V)	Sample number	Number of layers
A	120	16	A1	1
		16	A2	2
B	110	17	B1	1
		17	B2	2

Table 2. Chemical composition of electrodes and of base metal (weight percentage), Fe - Rest

	C	Si	Mn	Cr	W
Substratum	0.05	-	0.24	0.08	-
Electrode A	0.6	2.3	0.4	9	-
Electrode B	0.9	0.8	0.5	4.5	2.0

Table 3. Chemical composition layer of overlay (weight percentage), Fe - Rest

	C	Si	Mn	Cr	W
A 1	0.49	1.55	0.31	6.88	-
B 1	0.85	0.65	0.37	3.15	1.05
A 2	0.60	1.95	0.36	8.65	-
B 2	0.87	0.78	0.39	4.32	1.7

3. Results

The chemical composition layer of overlay as given in table 3 shows considerable variation among the deposits.

The structures of tested overlay materials are shown in figures 3 to 6.

Figures 7 and 8 shows the relation between the microhardness and the distance measured from the surface to the basic material.

Figures 9 and 10 presents the relation between the wear rate and the distance from the overlay surface measured from the surface to the basic material.

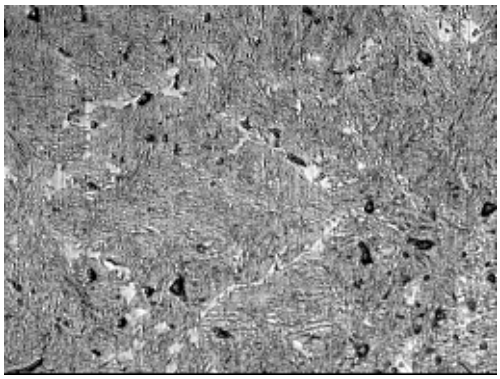

Figure 3. Sample number A 1 – martensite and fine austenite grains, nital 500×

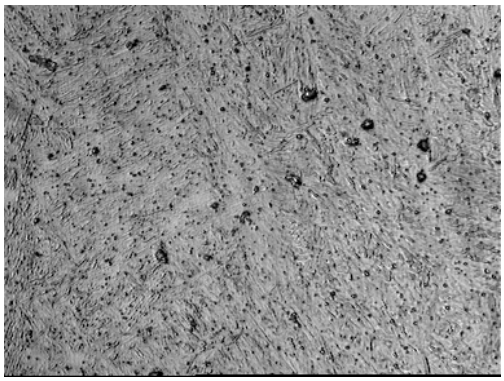

Figure 4. Sample number A 2 – martensite without fine austenite, nital 500×

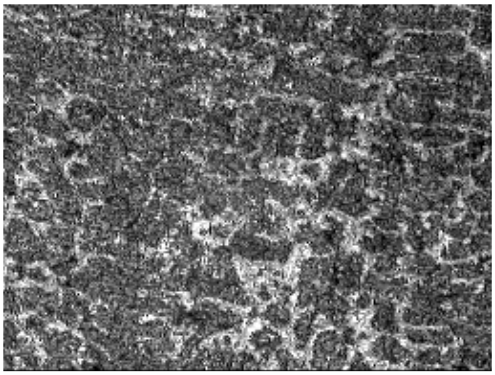

Figure 5. Sample number B 1 – martensite and fine austenite on the boundaries of grains, Villela-Bain 500×

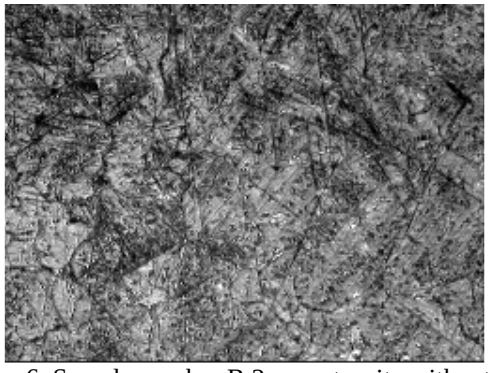

Figure 6. Sample number B 2 – martensite without fine austenite, Villela-Bain 500×

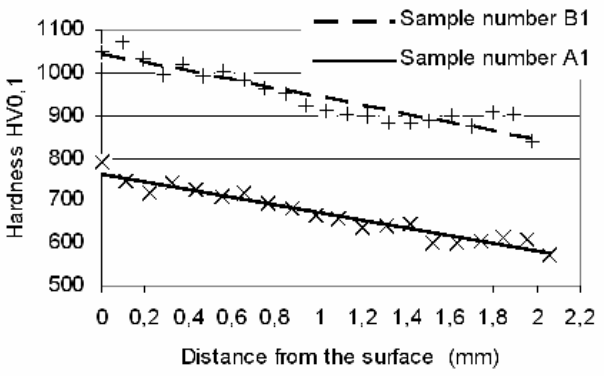

Figure 7. Relation between the microhardness and the distance for samples A 1 and B 1

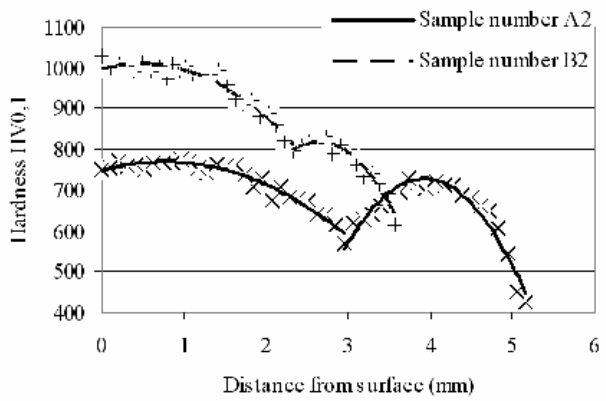

Figure 8. Relation between the microhardness and the distance for samples A 2 and B 2

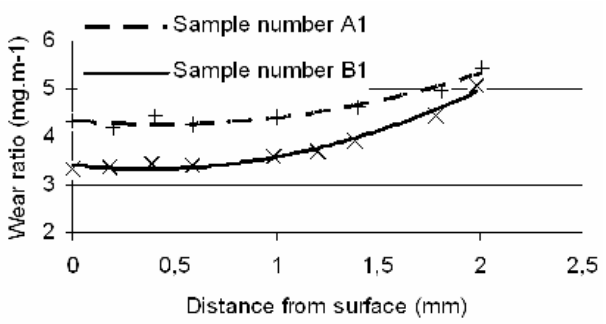

Figure 9. Relation between the wear rate and the distance from the overlay surface for samples A 1 and B 1

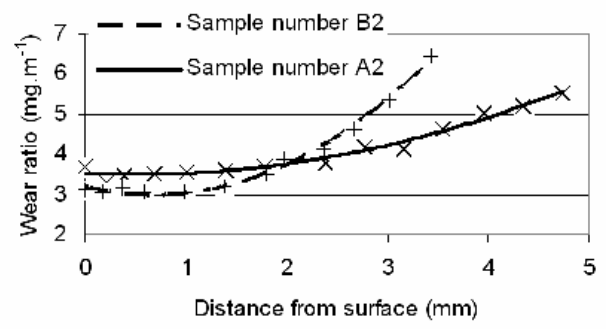

Figure 10. Relation between the wear rate and the distance from the overlay surface for samples A 2 and B 2

Table 4. Equations of the wear rate related to the distance from the surface

Sample number	Equation	Determination index
A1	$0{,}359x^2 - 0{,}2562x + 4{,}3741$	0,8735
A2	$0.1155x^2 – 0.1121x + 3.5273$	0.9739
B1	$0{,}4307x^2 - 0{,}188x + 3{,}3738$	0,9762
B2	$0.4475x^2 – 0.6254x + 3.2204$	0.9921

For the comparison of the one-layer overlays we must know the total covered distance when the whole overlay runs out. The total covered distance we can calculate using the equation

$$s = \frac{1}{h} \cdot m \cdot \int_0^x \Psi_m(x)^{-1} \cdot dx \,, \qquad (2)$$

where m – overlay weight, h – depth of overlay layer, $\Psi_m(x)$ – equation of the wear rate related to the distance from the surface (table 4), x – zone distance from the surface.

Overlay weight

$$m = S \cdot x \cdot \rho \,, \qquad (3)$$

where S – functional surface of the specimen, and ρ – density of overlay material.

The total covered distances of tested martensitic overlays are:

A 1 = 2 129 m
B 1 = 2 622 m
A 2 = 5 685 m
B 2 = 4 500 m

4. Conclusion

The resultant hardness of tested overlays single layers was variable. Its character cannot be described by one equation.

In single overlay zones the martensite and austenite content was determined. On the basis of this study the decreasing content of retained austenite in the direction to the first layer was determined. In the first layer no retained austenite occurred.

The decreasing character of the overlay hardness can be explained by the different rate of cooling in single zones and by the different chemical composition, too. The strengthening occurs, what corresponds to the given chemical composition and structure.

Owing to the mixing of the overlay first and second layer and to the by heat affected zone the decrease in hardness occurs. In the minor affected zones of the first layer the hardness increase occurs up to the points where the first layer and the basic material interact.

The measured values of the overlay layer wear rate can by described by the conic. But this description neglects the single zones of the overlay layer.

5. Acknowledgment

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