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ABRASIVE WEAR OF HARDFACING DEPOSITS

ABRAZIVNÍ OPOTŘEBENÍ TVRDÝCH NÁVAROVÝCH VRSTEV

Abstract

Martensitic welds are often used with one layer, two layers, sometimes with three layers. They are more abrasive wear resistant at sufficient plasticity. Abrasive wear of martensitic weld deposits depends primarily on the structure and then on the hardness. This paper is intended for the structural properties study of martensitic layers weld deposits.

Abstrakt

Martenzitické návarové vrstvy se používají jako jednovrstvé, dvouvrstvé, někdy i jako třívrstvé. Tyto vrstvy mají vyšší odolnost proti abrazívnímu opotřebení a současně dostatečnou plasticitu. Abrazívní opotřebení martenzitických vrstev je závislé na struktuře a výsledné tvrdosti. Článek je zaměřen na studium vlastností martenzitických návarových vrstev.

1 INTRODUCTION

Hardfacing is a commonly employed method to improve surface properties of agricultural tools, components for mining operation, soil preparation equipments and others. An alloy is homogenously deposited onto the surface of a soft material (usually low or medium carbon steels) by welding, with 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. Deposits with a microstructure composed by disperse carbides in austenite matrix are extensively used for abrasion applications and are typically classified according to the expected hardness. Nevertheless the abrasion resistance of a hardfacing alloy depends on many other factors such as the type, shape and distribution of hard phases, as well as the toughness and strain hardening behavior of the matrix. Chromium rich electrodes are widely used due to low cost and availability; however, more expensive tungsten or vanadium rich alloys offer better performance due to a good combination of hardness and toughness. Complex carbides electrodes are also used, especially when abrasive wear is accompanied by other wear mechanisms.

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 most important differences among these techniques lie in the welding efficiency, the weld plate dilution and the manufacturing cost of welding consumables. The present investigation aims to study commercial electrodes in terms of their chemical composition, microstructure, hardness and abrasive wear resistance.

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2 EXPERIMENTAL PROCEDURES

Material characterization

The substrate material was steel CSN EN S235JR with dimensions of 80 x 80 x 25 mm. The commercial hardfacing and buffer consumables, in the form of solid wire coated electrodes, were used as per direction of the electrode manufacturer.

Welding conditions

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 Tab. 1.

Tab. 1 Welding conditions

Diameter electrode	1.6 mm
Arc voltage	27 V
Welding current	250 A
Electrode polarity	positive
Traveling speed	13 cm/min
Preheating	no
Deposit rate	14.3 kg/h

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 (Fig. 1) consists of the uniform rotating disk whereon the abrasive cloth is fixed. 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.

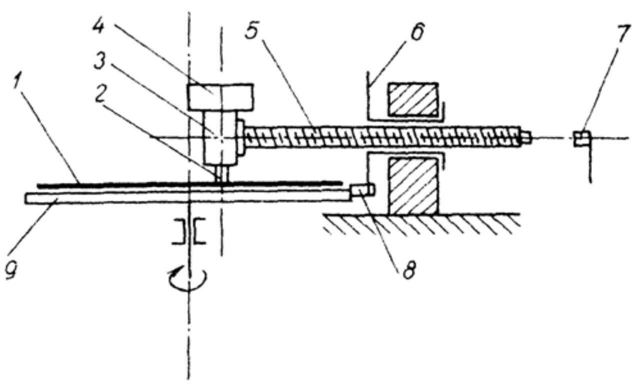

Fig. 1 Diagrammatic representation of the pin-on-disk testing machine: 1 – abrasive cloth, 2 – specimen, 3 – holder, 4 – weight, 5 – screw, 6 – nut with cogs, 7 – limit switch, 8 – pin, 9 – horizontal plate.

The 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 second layer of the overlay material.

Chemical composition, metallography and hardness test

The chemical composition (Tab. 2) was determined on the overlay surface of the specimen using GDOES. The hardfacing deposited plates were sectioned using the high speed SiC cutter with cooling for specimens for chemical analysis, metallography (25 x 25 x 25 mm), and for wear test specimens (25 x 25 x 25 mm).

Metallography test specimens were then ground successively using the belt grinder and emery papers and finally polished with Al_2O_3 powder, cleaned with acetone and dried. The polished specimens were etched with Nital or Vilella-Bain`s reagent and microstructure was observed using an optical microscope.

Tab. 2 Chemical composition (w_t %)

	C	Si	Mn	Cr	Mo	V	Nb	W	Fe
Substratum	0.047	-	0.24	0.076	-	-	-	-	rest.
electrode 1	0.5	2.3	0.4	9	-	-	-	-	rest.
electrode 2	0.5	0.8	1.3	7	1.3	-	0.5	-	rest.
electrode 3	0.9	0.8	0.5	4.5	-	1.2	-	2.0	rest.

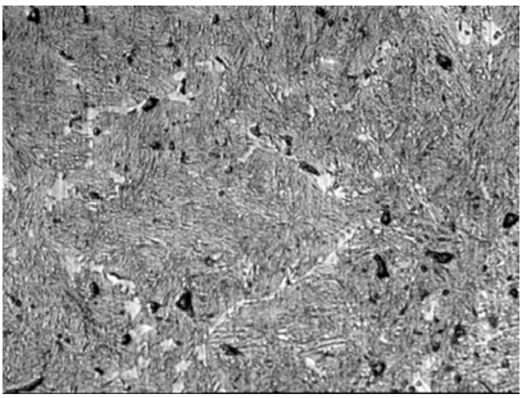

Fig. 2 Electrode 1 – martensite and fine austenite grains, nital 500×

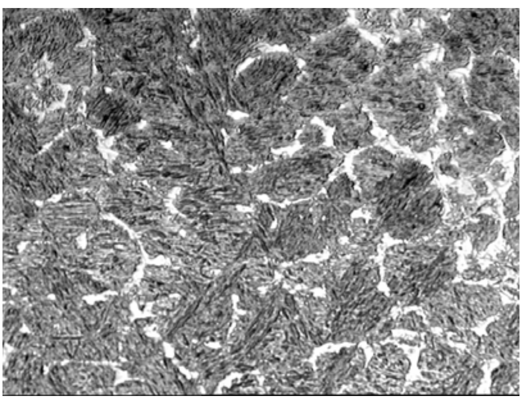

Fig. 3 Electrode 2 – martensite and fine retained austenite on the boundaries of grains, Villela-Bain 500×

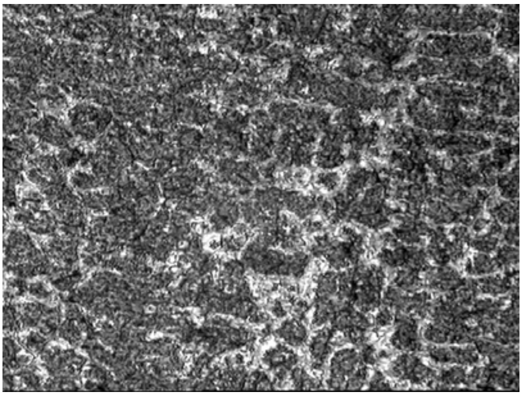

Fig. 4 Electrode 3 – martensite and fine austenite on the boundaries of grains, Villela-Bain 500×

Fig. 5 shows the relation between the microhardness and the distance measured from the surface to the basic material. The determined hardness values were interlined by a straight line $y = k.x + c$. Equations of these straight lines and the determination index are presented in Tab. 3

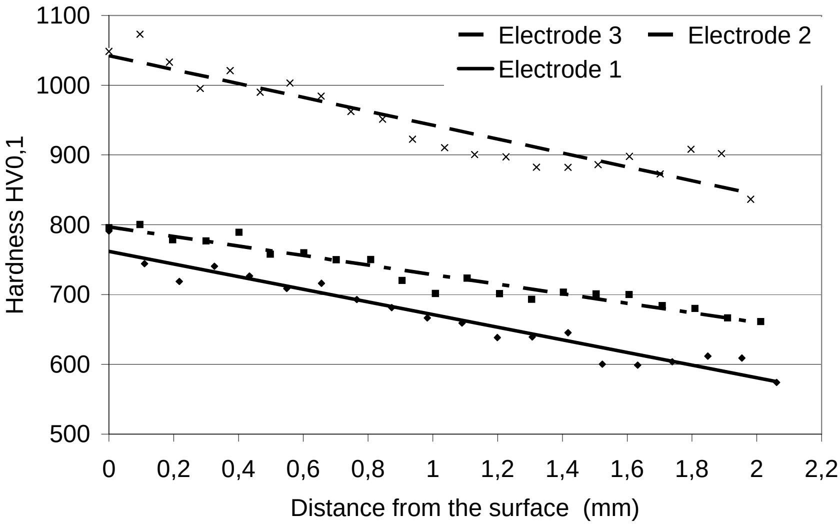

Fig. 5 Overlay hardness (microhardness $HV_{0.1}$) related to the distance from the overlay surface

Tab. 3 Equation of linear regression hardness of martensitic overlay

	Equation of linear regression	Determination index
Electrode 1	-90,648x + 762,01	0,9435
Electrode 2	-68,365x + 796,86	0,9422
Electrode 3	-99,569x + 1042,3	0,8721

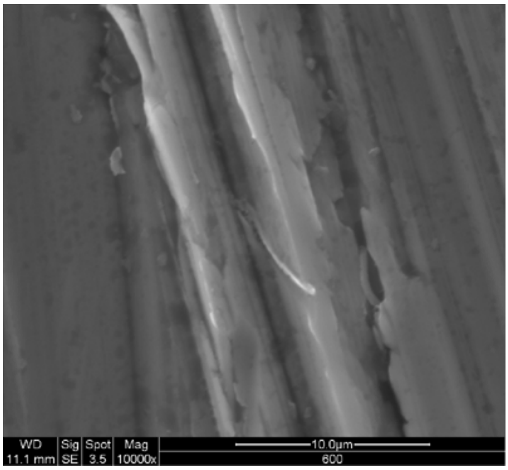

Fig. 6 Scanning electron micrographs of the worn surfaces electrode 1 after pin-on-disc test.

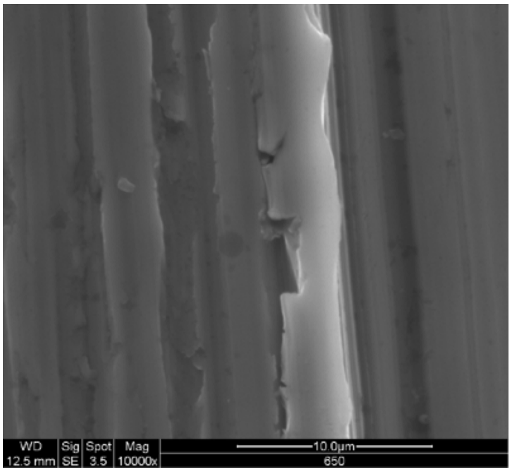

Fig. 7 Scanning electron micrographs of the worn surfaces electrode 2 after pin-on-disc test.

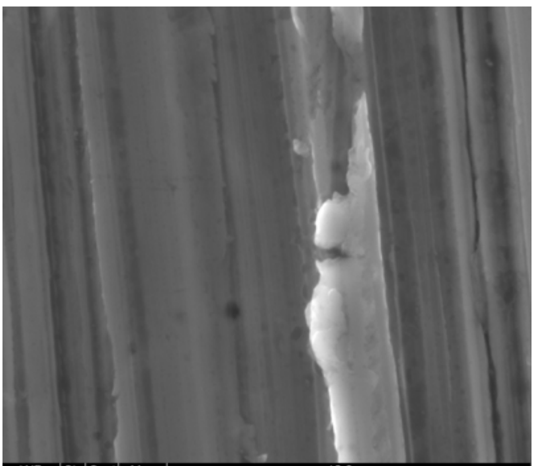

Fig. 8 Scanning electron micrographs of the worn surfaces electrode 3 after pin-on-disc test.

Fig. 6-8 shows wear mechanism of weld deposit materials.

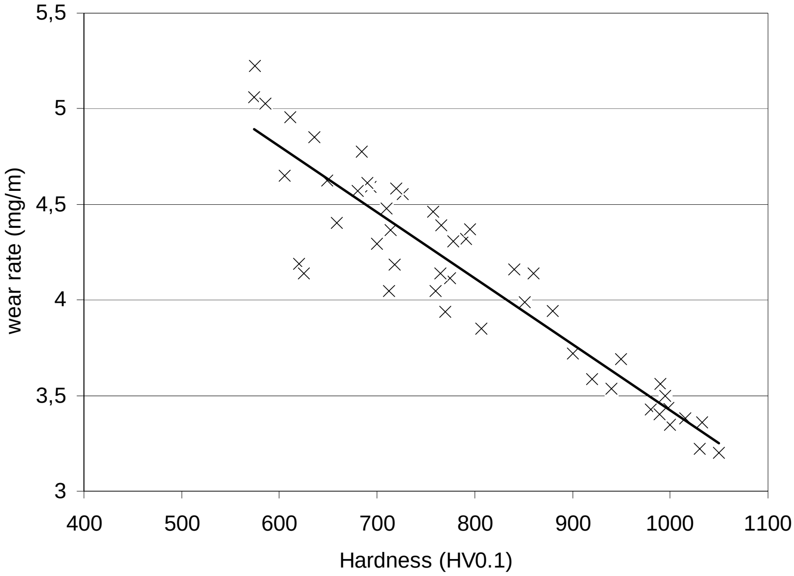

Fig. 9 Effect of hardness value on wear rate of martensitic overlay materials

3 CONCLUSIONS

The resultant hardness of the tested martensitic overlays single zones was decreasing. This decrease is possible to express by a linear equation. In single zones of the overlay the contents of martensite and austenite were determined. On the basis of this measuring the decreased part of retained austenite in the direction to the basic material was determined. The decreasing character of the overlay hardness can be explained by the different rate of cooling of single layer zones and also by the different chemical composition.

The wear resistance of tested martensitic overlays depends on the overlay hardness. Wear mechanism martensitic overlays was microploughing.

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