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RESISTANCE OF WELDCLADS MADE BY FLUX-CORED ARC WELDING TECHNOLOGY AGAINST EROSIVE WEAR

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The paper deals with the tribological properties of investigated types of hardfacing materials at erosive wear process. Influence of impact angle of abrasive grains on wear resistance and microhardness changes of hardfacing layer were investigated too. From quantitative aspect weldclads wear resistance were evaluated on the base of weight loss. Results achieved showed that impact angle is one of determining factors of material's wear measure.

Key words: renovation, wear resistance, impact angle

INTRODUCTION

Today, in times of economic crisis it is becoming more and more relevant and interesting for manufacturers to lengthen the lifespan of the functional surfaces of machine parts exposed to hard tribological conditions [1]. Continually rising costs of raw materials and producing new quickly worn parts forces producers into seeking economical solutions using repairing technology [2]. One convenient economical solution is renovation of functional surfaces using hard surfacing technology [3,4]. Arc surfacing methods enable in a relatively short time to restore the shape and dimensions of the components of the friction nodes, or to form functional surfaces resistant against abrasive, adhesive and erosive wear [5,6]. Newly formed layers deposited on repaired surfaces often have better properties than original base material. One interesting and now more and more used option is to apply layers of highly resistant materials or coatings onto parts of the lower steel grades in the production of new components [7,8]. Optimal utilization of the weld layers properties, however requires knowledge of their behaviour in various wear conditions [9-12]. This paper deals with evaluation of the resistance of weldclads deposited on slip surface of ore hopper made by FCAW technology against erosive wear considering impact angle of particles. Resistance against erosive wear was assessed by weight loss at specified time intervals. There was also evaluated the influence of the impact angle on resistance of weldclad. Microstructure of weld deposits was documented on metallographic cuts using light microscopy and course of microhardness was assessed using Vickers hardness test.

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MATERIAL AND METHODS

As a base material for hard surfacing and following experiments steel sheets S235JRG1 EN 10025-94 of dimensions 300 mm x 600 mm and thickness 10 mm were used. This is a structural carbon steel with good weldability. Chemical composition and mechanical properties of the material declared by manufacturer are: 0,17 % C, 0,005 % N, 0,03 % S, 0,03 % P, Fe balance. Mechanical properties are listed in Table 1. The specimens were taken from the test sheet with weld deposit using water-jet cutting.

Table 1 **Mechanical properties of the base material S235JRG1 EN 10025-94**

Hardness / HV	Impact strength / kJ/m^2	Ultimate elongation / %	Tensile strength / MPa
140	≥ 27	≥ 26	340 - 470

Renovation was realized by welding method 114 in accordance with EN ISO 4063 - FCAW (Flux cored arc welding) using a pulsed power source Kempact 3000 (Kemppi). For hard surfacing welding wire Lincore 420 (MF6-GF-55-CGR, DIN8555-83) diameter of 1,6 mm product of Lincoln Electric was used. Hardfacing was performed as a double layer, due to the elimination of the mixing of cladding with base material. The chemical composition of the welding wire are: 0,2 % C, 1,7 % Mn, 0,9 % Si, 11 % Cr and balance of Fe.

Parameters used for hard surfacing are listed in Table 2. Considering the type and thickness of the base material it was not necessary to apply preheating or afterheating after finishing the hard surfacing.

Wear resistance of weld clads was tested using laboratory abrasive grit blasting equipment.

Test conditions:

- abrasive - steel grit GB 8 – ISO 11124-3,
- grain size: 0,71 mm

Table 2 **Welding parameters**

Layer	1 (interlayer)	2 (cover layer)
Welding method EN ISO 4063	114	114
Welding wire	Lincore 420	Lincore 420
Diameter of the wire / mm	1,6	1,6
Welding position ISO 6947	PA	PA
Current / A	180	200
Voltage / V	23-33	23-33
Polarity	DC +	DC +
Stick-out /mm	15-20	15-20
Welding speed /m/min	4,2	4,2

- abrasive hardness: 600 - 700 HV0,1
- test portion of abrasive: 2 kg
- blasting wheel speed: 7000 rpm
- abrasive speed: 70,98 mps
- impact angles of abrasive: 0°,45°,75°,90°
- weight losses detected after 25, 50, 100, 300, 500, 1 000 blasting cycles

Abrasives were exchanged during the experiment in order to ensure its operational life, and also because of the change of geometric characteristic of particular grains. The wear intensity was determined quantitatively by weight loss of samples in various stages of testing. The weight loss of the samples was measured using analytical weight METTLER TOLEDO, precision of measurement 10^{-4} g.

To determine the effect of the abrasive impact angle on surface layers hardening of the material tested caused by abrasive impact, as well as to determine the thickness of affected layer, the microhardness was measured in according to ISO 4516 using hardness tester PMT 3 with the following parameters:

- indentor – Vickers,
- test load 100 g (980,7 mN),
- full load duration 15 s.

Metallographic analysis and photo documentation were performed using light microscope Neophot 32.

RESULTS

The results of metallographic analysis are documented in Figure 1, 2 and 3. Microstructure of thermally unaffected base material is fine-grained ferrite - pearlite structure (Figure 1). From macroscopic point of view, there can be clearly observed mixing of base material with the first cladding layer on metallographic cuts. Mixing area extends from base material into 25 % of weld thickness. In heat-affected zone (HAZ) consists of bainite structure (Figure 2) there was observed a significant increase in the grain size.

Next cladding layer (cover layer, Figure 3) consists of a mixed martensite-ferrite structure with dispersed inclusions.

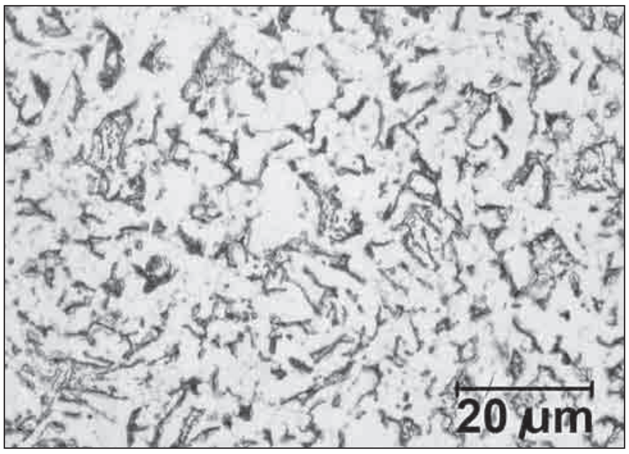

Figure 1 Microstructure of base material

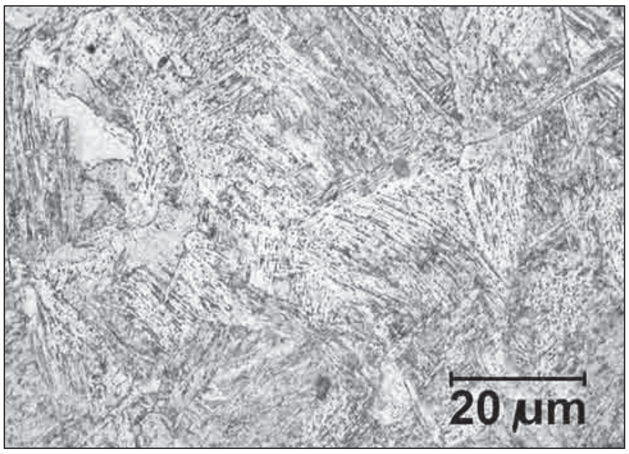

Figure 2 Microstructure of HAZ

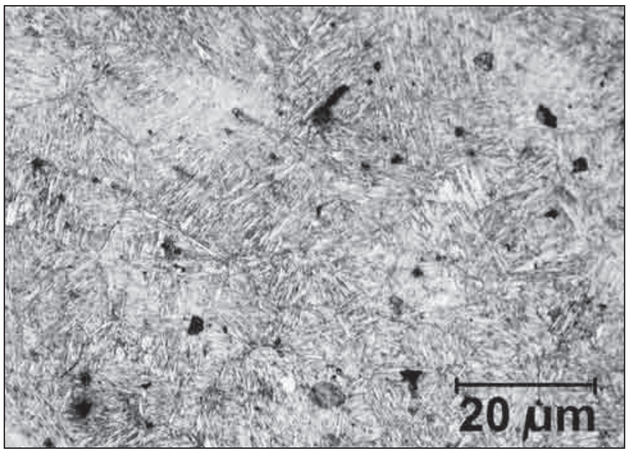

Figure 3 Microstructure of cover layer

Whereas chemical analysis of inclusions was not realised, it is reasonable to conclude, based on various references, that it is sulphide and a fine-grained carbidic inclusions. There can be observed visible transitions between particular layers in both weld clads.

Results of wear test studied hardfacing layers are showed in Figure 4. The figure presents the dependence of average mass loss Wh on impact angle of abrasive.

Based on analysis of the influence the impact angle on wear intensity of the investigated hardfacing layer using sharp-edged grains it was shown that the greatest wear was obtained at impact angle 45 ° (average mass

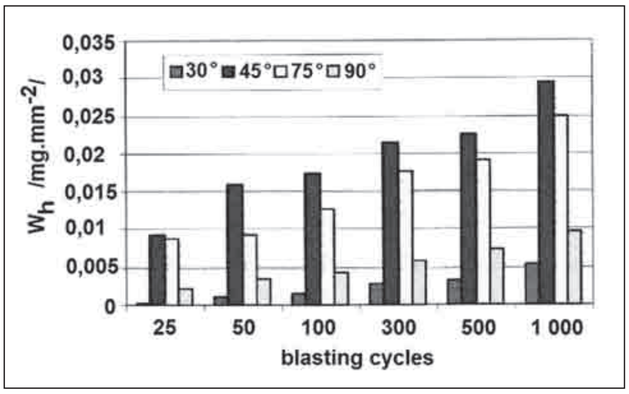

Figure 4 Average mass loss of hardfacing layer

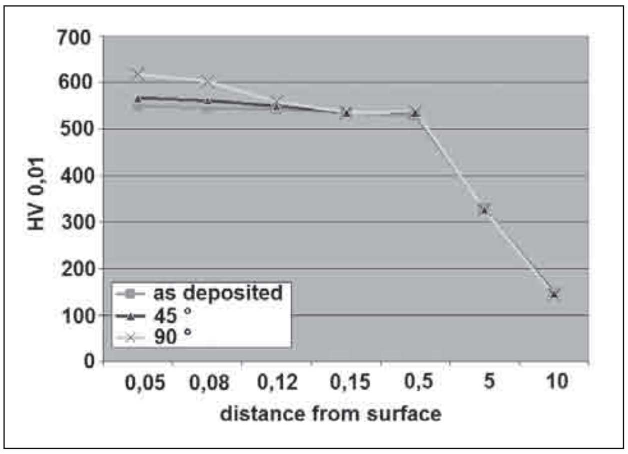

Figure 5 Microhardness of weldclad before and after wear

loss 0,0293 g). The slightly lower average value (0,025 g) was measured on samples worn by abrasive with impact angle 75 °. When particle impinge surface under angle of 90 °, forging effect of abrasive grains prevails.

Part of the experiment was also evaluation the influence of the impact angle of blasting abrasive on change the microhardness of weldclad. The average measured values found on test samples after 1 000 blasting cycles are documented in Figure 5. Reference sample for microhardness measurement is weldclad without wear.

From Figure 5 can be seen, that the impact angle of the particles has a significant influence on microhardness of the material surface layers.

The most significant strengthening was observed in a distance of 0,05 mm below the surface at impact angle 90 °. Used blasting parameters influenced the strengthening of the surface layer to a depth of 0,1 mm. Microhardness values decreased with decreasing of impact angle.

Microhardness values correspond to hardness of structural components that have been documented using microscopic analysis.

CONCLUSIONS

Experiment presented in the article demonstrates possibilities of increasing the lifespan of slip chutes exposed to erosive wear. Increasing the lifespan of components with regard to the economic aspect of this effort is increasingly aim of research. Replacement of high alloy heat treated parts in structural units is expensive. However, there are several ways how to apply on several times cheaper material some layers with parameters that come up to tribological characteristics of the original component or exceed them. One way how to realize that is presented in this article.

FCAW is now increasingly applied in renovation of surfaces by hard surfacing method. High alloy tubular wires enable creation of weld clads with hardness of 65 HRC (840 HV), e. g. using welding wires with high carbide content as MF4-GF-60-S DIN 8555-83 or welding materials, which weld metal hardens when exposed to deformation, for example MF6-GF-45KP DIN 8555-83. For surfacing mild steel, as S235JRG1 EN 10025-94 is required applying the underlayer, so called interlayer using welding wire E 18 8 Mn R 53 EN 1600. By applying these welding wires using FCAW hard surfacing method it is possible to renovate also extremely exposed surfaces such as excavator teeth, excavator buckets, share blades, mine mills, and parts of crushers hoppers etc. Plate with deposited hardfacing layer is to be applied as part of the crusher ore hopper construction.

Evaluated weldclad realized using welding wire MF6-GF-55-CGR, DIN8555-83 can be used in conditions of erosive wear.

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