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SECTION 5

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MECHANICAL ENGINEERING TECHNOLOGIES

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TRANSCOM 2013
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TRANSCOM 2013, the 10th international conference of young European researchers, scientists and educators, aims to establish and expand international contacts and co-operation. The 10th international conference TRANSCOM is jubilee. It will be held in the year when the University of Žilina celebrates 60 years since her constitution (1953 – 2013).The main purpose of the conference is to provide young researchers and scientists with an encouraging and stimulating environment in which they present results of their research to the scientific community. TRANSCOM has been organised regularly every other year since 1995. Between 160 and 400 young researchers and scientists participate regularly in the event. The conference is organised for postgraduate students and young researchers and scientists up to the age of 35 and their tutors. Young workers are expected to present the results they had achieved.

The conference is organised by the University of Žilina. It is the university with about 13 000 graduate and postgraduate students. The university offers Bachelor, Master and PhD programmes in the fields of transport, telecommunications, forensic engineering, management operations, information systems, in mechanical, civil, electrical, special engineering and in social sciences.

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Selection of the Optimal Reparation Technology for Working Parts Subjected to Abrasive Wear

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Abstract. The aim of this paper is to perceive possibilities for extension of the working life of parts exposed to abrasive wear. For this problem to be successfully solved it is necessary to understand the mechanism of abrasive wear which leads to damage of the working parts. The optimal technology of hard-facing is determined based on voluminous model investigations, where the microhardness and wear resistance of the hard-faced layer were examined. The selected technology was then tested on the real hard-faced parts.

Keywords: hard-facing, abrasive wear, reparation, hardness, microstructure

1. Introduction

Considering that wear is the inevitable phenomenon in industrial systems, the tendency should be to decrease it to the lowest possible extent. Abrasive wear is the most dominant type of wear. In order to extend the working life of parts subjected to abrasive wear, they are, the most frequently, hard-faced with some of the welding technologies. Thus hard-faced parts usually exhibit longer working life than the newly manufactured non hard-faced parts, what is also accompanied by the significant positive techno-economical effects.

The numerous experimental investigations on models have led to establishing of the relationship between the input and output parameters of the hard-facing process. The input parameters are the base metal properties and the required properties of the hard-faced layer, while the output parameters are properties of the hard-faced layer metal, its microstructure, microhardness, wear resistance, corrosion resistance, toughness, etc.

2. Basic Causes of the Working Parts Damages

Main causes of working surfaces damages of various parts of machines and devices are the tribological processes, while the costs caused by them are exceptionally high. For decreasing those costs, it is necessary to possess modern knowledge from the area of tribology that are related both to design and exploitation of parts, bearing in mind all the requirements for more economically efficient material consumption, rational consumption of energy resources, as well as for efficient maintenance and increase of the working life and reliability of products [1].

2.1 Abrasive Wear

Abrasive wear is defined as the process of the surface material destruction caused by sliding of harder material (abrasive) over the softer material, what causes the plastic deformation and leads to micro destructions, the most often plowing of the softer material surface. Abrasive wear includes more than a half of all the types of wear. The parts that are the most exposed to abrasive wear are parts of agricultural machines, elements of transportation devices, working parts in metallurgical plants, parts of railway equipment, hydraulic turbine wheels, drills for oil and water wells, sand-blasting equipment parts, civil engineering mechanization parts and others. The abrasive wear mechanism consists of appearance of hard particles, their adhesion and sticking to the surface of the softer material, what leads to destruction of its surface layers. In the process of the two solid bodies interaction, the separated particles can additionally strain harden and in the further process act as abrasives. Investigations have shown that resistance to abrasive wear of metals depends on some of their mechanical properties. This is primarily related to hardness, considering that the depth of the foreign particles penetration into the metal is directly proportional to hardness of the surface layers. Numerous investigations led to conclusion that the wear resistance depends on the type and conditions of the working parts material. Thus, the least resistant are thermally not treated materials, somewhat more resistant are thermally treated and alloyed steels, while the most resistant to wear are strain hardened pure metals and steels, which can achieve required wear resistance that remains unchanged and does not depend on further increase of hardness.

It should also be emphasized that resistance to abrasive wear for alloys of the same hardness could be different, what depends on the alloy's chemical composition and structure, i.e. resistance does not depend on hardness only, but on shape, size and distribution of structural phases, as well. The unique opinion was not yet formed about the optimal type of the steel structure. Some authors consider that to be the austenite-carbide structure [1], while the others give preference to martensite carbide structure [2]. Abrasive wear is primarily caused by possibility of the abrasive insertion into the surface layer of steel, and as the second by strength of structural phases' bonds at grain boundaries. This means that the self-hardened steel would be more resistant than the steel with ferrite-pearlite structure. Thus the hardness can not be the sole criterion, since it was shown that the purely martensite structure is more resistant than the martensite-carbide structure, even at lower hardness. It was established that the austenite-carbide structure is more favorable than the martensite-carbide one, though from the aspect of hardness it would not be easy to come up with such a conclusion. The reason for that is a stronger bond between the austenite-carbide grains' boundaries due to lesser difference in their crystal lattices' parameters than in the martensite-carbide combination.

3. Selection of Procedure, Filler Metal and Hard-facing Parameters

The reparatory hard-facing optimal technology selection for the rotational terrain leveling device's knives is presented in [3]. The models represent in the proper way the real operating conditions, based on which the selection of the optimal technology would be performed. The knives were manufactured from the low alloyed steel for tempering Č4830 (JUS) – 50 CrV4 (DIN), with hardness of 488 HB; the microstructure was estimated as interphase tempering one. Since this structure is not highly resistant to abrasive wear, the relatively fast wear of parts occurred, especially in conditions of aggressive abrasive wear.

Filler metal for hard-facing is usually selected based on required properties of the hard-faced part and available equipment. Here are presented results of experimentally tested and applied electrodes: E DUR 600 (E 6-UM-60, DIN 8555/33), E Mn14 (E7-UM-200-KP, DIN 8555/33), E Mn17Cr13 [3]. According to manufacturer's recommendations, those electrodes produce hard-faced layers that possess high wear resistance and high toughness and can withstand high impact loads as well. The hard-faced layers can be processed by grinding only. Those electrodes are especially recommended for hard-facing of parts where the hard-faced surfaces would be subjected to friction and wear with minerals. The hard-faced parameters, presented in Table 1, were selected according to manufacturers' recommendations and the chosen procedure was the REL welding.

4. Experimental Investigations

4.1. Model Investigations

After considering the tribological working conditions and the base metal analysis, the experimental hard-facing was done, first on the selected models and then on the real parts. Hard-facing samples were selected based on geometrical similarity with the hard-faced part; they can be made of good weldable steel or of material with the similar or the same chemical composition as the part that is to be regenerated. Numerous tests on models were conducted as single or multi pass layers in conditions with and without preheating (Figure 1 a, b, c). From thus hard-faced model-samples were prepared ground blocks (Figure 1d), which served for measuring hardness and estimates of microstructure of the hard-faced layers characteristic zones. The maximal measured hard-faced layer hardnesses were dependent on the type of the applied material and on the treatment: E DUR 600 (600 HV1), E Mn14 (240 HV1 without forging and 520 HK-after cold forging) and E Mn17Cr13 (290 HV1 without forging and 560 HK after cold forging) [3, 4, 5].

Electrode mark		Core diameter, d_e, *mm*	Welding current, I, *A*	Voltage, U, *V*	Hard-facing speed, v_z, *cm/s*	Driving energy, q_l, *J/cm*
Fiprom Jesenice	DIN 8555/33					
E DUR 600	E 6–UM-60	3.25	120	25	≈ 0.119	20168
E Mn14	E7-UM-200-KP	3.25	120	25	≈ 0.148	16218
E Mn17Cr13	-	3.25	130	25	≈ 0.152	17105

Tab. 1. Welding parameters for the REL procedure [3]

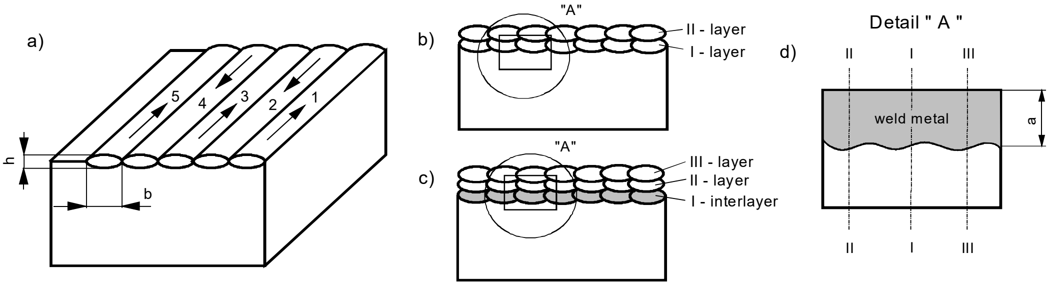

Fig. 1. Sequence of hard-facing layers deposition: a) 1 layer; b) 2-layers; c) 3 layers; d) metallographic ground block.

Microstructures of the hard-faced layers characteristic zones, depending on the filler metal, were estimated as: martenite-carbide with residual austenite (E DUR 600), dendritic austenite with excreted carbide at the grain boubdaries (E Mn14) and sorbite with prominent grain boundaries of the austenitic grains and carbides of even distribution (E Mn17Cr13). The characteristic example of hardness distribution and appearance of micro structure of certain zones of the two-layer hard-faced sample with deposited inter-layer are presented in Figure 2. Martensitic structure of the hard-faced layer ensures the high hardness while the inter-layer has somewhat lower hardness, but more favourable toughness, which ensures higher impact strength.

The aditional tribological investigations in laboratory conditions were performed as well. The objective was to determine the wear resistance of the coupling base metal (MB) – hard-faced layer. The linear contact "block on disc" was realized in tests. The obtained results for the friction coefficient (μ) varied slightly. The wear scar width was also measured, what showed that wear is the most prominent in BM (lowcarbon soft steel) with hard-facing realized with the E Mn14 and E Mn17Cr13 electrodes, while it was the least prominent for hard-facing done with the E DUR 600 electrode in conditions without preheating [3-5].

4.2. Hard-facing of Real Parts

After hard-facing on test samples, the established optimal technology was applied on the real parts as well. The hard-facing was done in two passes, on cutting edges of knives longitudinally. The width of the hard-faced layer was 25 mm. Afterwards, the hard-faced knives were sharpened by grinding and thus definitely prepared for operation. It was established that durability of knives hard-faced according to adopted technology surpasses several times (at least two to three times) durability of the non hard-faced knives, what is primarily attributed to microstructure of the hard-faced layer, which is more favorable for these working conditions [3].

5. Conclusion

Theoretical and experimental investigations presented in this paper ought to point to multiple advantages of applications of the damaged parts reparatory technology related to extension of the working life of parts, as well as shortening the time needed for capacitating the working parts and lowering the costs, etc.

Quality of the hard-faced layers was established by measuring the microhardness, testing of microstructure and checking the wear resistance. Model investigations enable selection of the best filler metal, establishing of the optimal reparatory technology and establishing the relationship between the input and output parameters of the hrad-facing procedure. Checking of the some parts damages degree was performed both on the new and the hard-faced knives for terrain leveling. It was shown that the working life of the hard-faced knives is significantly longer than that of the new ones what decreases the costs of parts replacement and shortens the time of the working machines down time.

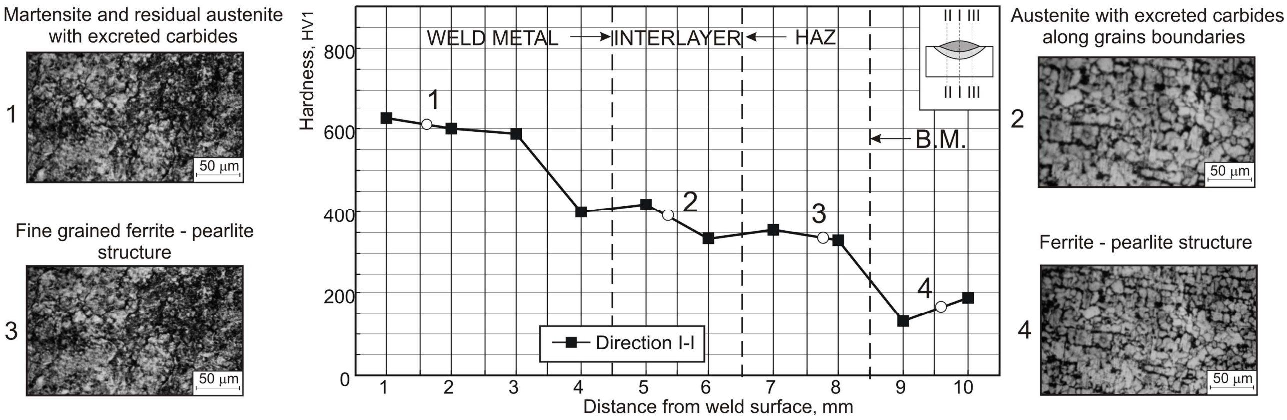

Fig. 2. Hardness distribution and microstructure of the hard-faced layer characteristic zones – inter-layer (INOX B 18/8/6) and the two layers (E DUR 600) [3]

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