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RESEARCH

Model Investigations of the Filler Materials for Regeneration of the Damaged Parts of the Construction Mechanization

The aim of this work is to establish the optimum hard facing technology, based on complex and costly model investigations, as well as to determine the most convenient filler metal, depending on the operating conditions of the particular part of the construction machines. In this way it is possible to establish the relationship between the input hard facing parameters and the output parameters of the realized hard faced layers. The quality of the hard faced layer was determined by the measurement of the microhardness, testing of the microstructure and checking the wear resistance.

Keywords: Regeneration, Hard facing, Filler material, Tribology

1. INTRODUCTION

Choosing of all procedure, filler material, and hard facing technology beside on working conditions in great deal depends on properties of base material. For the base material, say steel, is important to determine chemical composition which has very important influence to weldability of repaired part.

In this paper special attention is devoted to choice of filler materials dependable on both kind and type of wear. Quality of hard faced surface has been determined by measuring of micro-hardness, by examination of microstructure and by control of wear resistance. Numerous experimental testing on models have led to establishing dependence between input and output parameters of hard facing process. Input parameters of hard facing process are properties of base material and required properties of surfaced layer, whereas output parameters are properties of surfaced material determined through all microstructure, micro-hardness, wear and corrosion resistance, toughness, etc. To obtain required quality of surfacing, often it is not enough to choose suitable hard facing process, but is necessary to recommend choice of hard facing parameters and suitable technique for placement of filler material. Quality control may be performed according to different criteria, and choice of optimal hard facing technology is the most often based on model testing [1-5].

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2. THE BASIC CAUSERS OF DAMAGE ON PARTS OF THE CONSTRUCTION MECHANIZATION

Examination of causes of damages on parts of machinery and equipments leads to conclusion that in more than 50% belongs to tribological prcesses. Consequently to propose technology of regeneration of deteriorated parts it is necessary to examine mechanisms of wear of contact parts. Thereby it should be in minds that, besides the hard facing of deteriorated parts caused during normal service, damaged parts as well as new parts made with defect may be hard faced. Great significance has hard facing of new parts in order to achieve greater hardness of outer surfaces by proper choice of filler materials instead of usage of traditional methods of thermal treatments. Above mentioned implies that hard facing has important role in advanced technologies [1-5, 10-12].

2.1 Damages due to tribological influences

Term wear means losing material of contact surfaces developed mainly as exert of mechanical loads. Wear is consequence of friction or concurrent action of friction, thermal, chemical, electrochemical, and other factors on parts of tribo-mechanical system, that is consequence of friction on its contact surfaces. Losing of material produces change of shape and properties of parts of mechanical system, and therefore change of their service performances [6-9].

In study of hard facing the aim is to estimate dominant influences in given working conditions such as base material and working surfaces properties, quality and properties of contact surfaces, properties of media between contact surfaces, relative displacements between working surfaces, load level, quantity and properties of particles arose during wear etc. Thus, wear affects properties and has influence on change of system parts shape independently which kind of mechanical wear is dominant whether it is abrasive, adhesive, erosive, cavitational, fatigue, vibrational, or combined wear [6-9].

All kind of wears are usually chemically influenced. In the cases in which parts are exposed to combined influences it is usually indicated in title of process as, for example erosive-cavitational wear in active chemical environment. It is hard to predict effects of combined wears. Chemical processes, which are developed during exploitation, may be main reason of either wear or general loss of material [6-9].

3. BASIC PRINCIPLES FOR CHOICE OF FILLER MATERIAL

Filler material for surfacing in most cases may be chosen with respect to either required properties or available equipments. On the basis of wear mechanism and by analyzing of wear process of any particular part it may be concluded that wear is the most often developed by friction, although sometimes influence may have corrosion, thermal and thermo-mechanical fatigue etc. In case of big corrosion influence filler materials must be chosen on the base of chemical composition which has chemical resistance, but in case of parts exposed to friction forces choice of filler material is more complex. However hardness and chemical composition could not be only criteria for estimation of hard facing material serviceability. In references [4, 5] are given lists of most often applied filler materials specially those which are resistant to wear, electrochemical corrosion, and oxidation.

Filler materials for wear resistant hard facing may be classified in six classes which are: steel, cast iron (white), wolfram carbide, cobalt alloy, nickel alloy, and cooper alloy. In the most cases industrial components stop service because of wear (53% abrasive, 24% adhesive, 10% impact) and 13% because of corrosion, and therefore filler materials may be classified on the basis of that criteria [4, 5, 6, 8, 9].

Table 1. *Mechanical properties and application of tested electrodes [13]*

Electrode code SŽ Fiprom-Jesenice	Hardness	Application
1. E DUR 600	57-62 HRC	For hard facing which require high wear resistance, good toughness, and resistance to impact and shear in both cold and hot environments.
2. E Mn14	220 HB – after surfacing 48 HRC - after cold hammering	For hard facing manganese steel up to 10 mm thick for applications on railway tracks and for parts of crushing machines.
3. E Mn17Cr13	220 HB - after surfacing 48 HRC - after cold hammering	For hard facing of mallet of hydraulic presses, parts of loading bucket of construction mechanization, parts of crushing machines, railway tracks and crossbeams.
4. CrWC 600	57-62 HRC (60 HRC at 20ºC)	For very hard surfacing with high content of Cr and W carbides with high wear resistance in tooling stones, but with low level of impact and shear resistance.
5. ABRADUR 58	57-62 HRC	Hard facing of tools exposed to intensive abrasive wear with minerals.
6. FILTUB DUR 16	57-62 HRC	Filled wire for hard facing of parts exposed to intensive friction and variable impact load.
7. INOX B 18/8/6*	-	For welding of Cr and Cr-Ni steel, and various steel, for hard facing resistant to corrosion and for deposition of plastic interlayer.
8.FILTUB 12 B*	-	Filled base wire for welding of general structure steel. In hard facing of hardening steel it is used for placement of inter-layers.

*) Rarely used for hard facing, but the most often for placement of inter-layers and welding.

Typical representatives of filler materials may be chosen according producer recommendation, as shown in Table 1, but for reliable structures it is necessary to check properties such as microstructure, hardness and wear resistance [1-5, 13].

4. EKSPERIMENTAL EXAMINATION OF MODELS

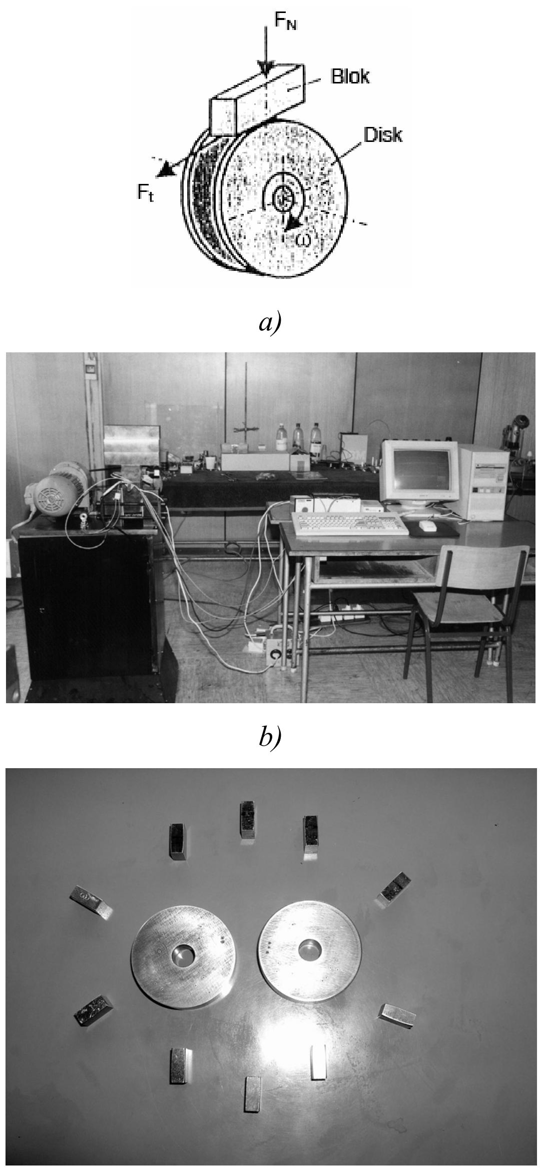
4.1 Models testing

Above described tribological consideration and listing the most important filler materials for hard facing is used as a base for experimental hard facing of models leading to decision which technique should be used on real parts, which are in service. Experimental hard facing of models is used to decide which hard facing technology is optimal. Models are hard faced with one or more pass (layers) with or without preheating (Figure 1a,b,c). Hard faced models are used to cut from them the metallographic samples – blocks, as shown in Figure 1d. On surfaces of blocks has been measured hardness in different directions necessary to estimate microstructure of characteristic surfaced zones. Samples are chosen to be geometrically similar to hard faced item and they are made either of good weldable steel, here it was steel Č0361, or of material, with either similar or same chemical composition as surfaced item, for example ČL3134.

Metallographic microstructures of characteristic hard faced zones and surfaces, depending on filler material, are estimated as: martensite - carbide with residual austenite (E DUR 600), small lath martensitic with hardness of 636-717 HV1 (FILTUB DUR 16), dendrite-austenite with excreted carbides on the grains boundaries (E Mn14) and sorbite with perceived boundaries of austenite grains and uniformly distributed carbides (E Mn17Cr13), ledeburite (CrWC 600), martensite-ledeburite with residual austenite and excreted carbides (ABRADUR 58), and mainly austenite (INOX B 18/8/6, FILTUB 12B), [1, 2, 5, 9, 10]. Typical example of hardness distribution and microstructure of respective zones two-layered hard facings (E DUR 600) with deposition interlayers (INOX B 18/8/6) is given in Figure 2 [1, 5].

4.2 Tribological examinations

Tribological examinations are performed in contact of block specimen, with tribometer TPD-93 (Figure 3a,b) designed and installed in Laboratory for tribology at Faculty of Mechanical Engineering in the Kragujevac Univesity. The aims of these examinations were to determine wear resistance of joint base material-hard facing metal. Samples for tribological examinations, as prismatic blocks 6.5×15×10 *mm,* are taken from both surfaced and base material (Fig. 3c). During testing line contacts "block on disk" have been realized. External variables were contact force, sliding speed and lubricant. Motor oil GLX 2 SAE 15-W-40 has been used as lubricant.



a)

b)

c)

Figure 3. *Tribometer TPD-93 (a), measurement equipments (b) and shape of blocks and discs (c)*

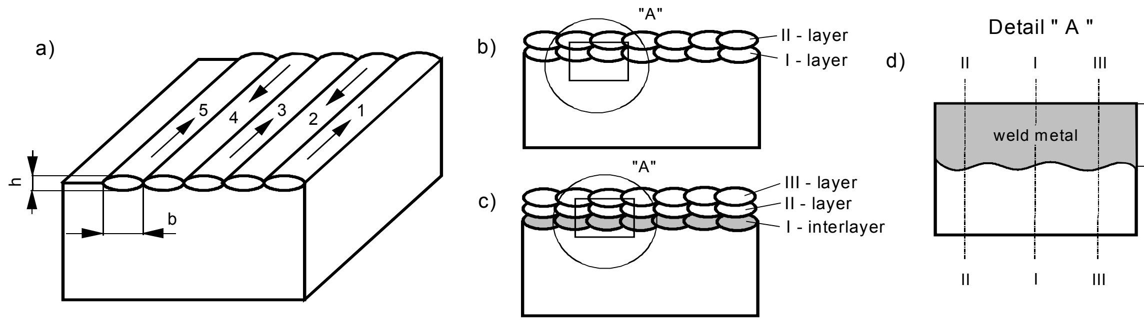


***Figure 1**. Order of hard faced layers placement: a - 1st layer, b - 2nd layer, c - 3rd layer, d-metallographic block*

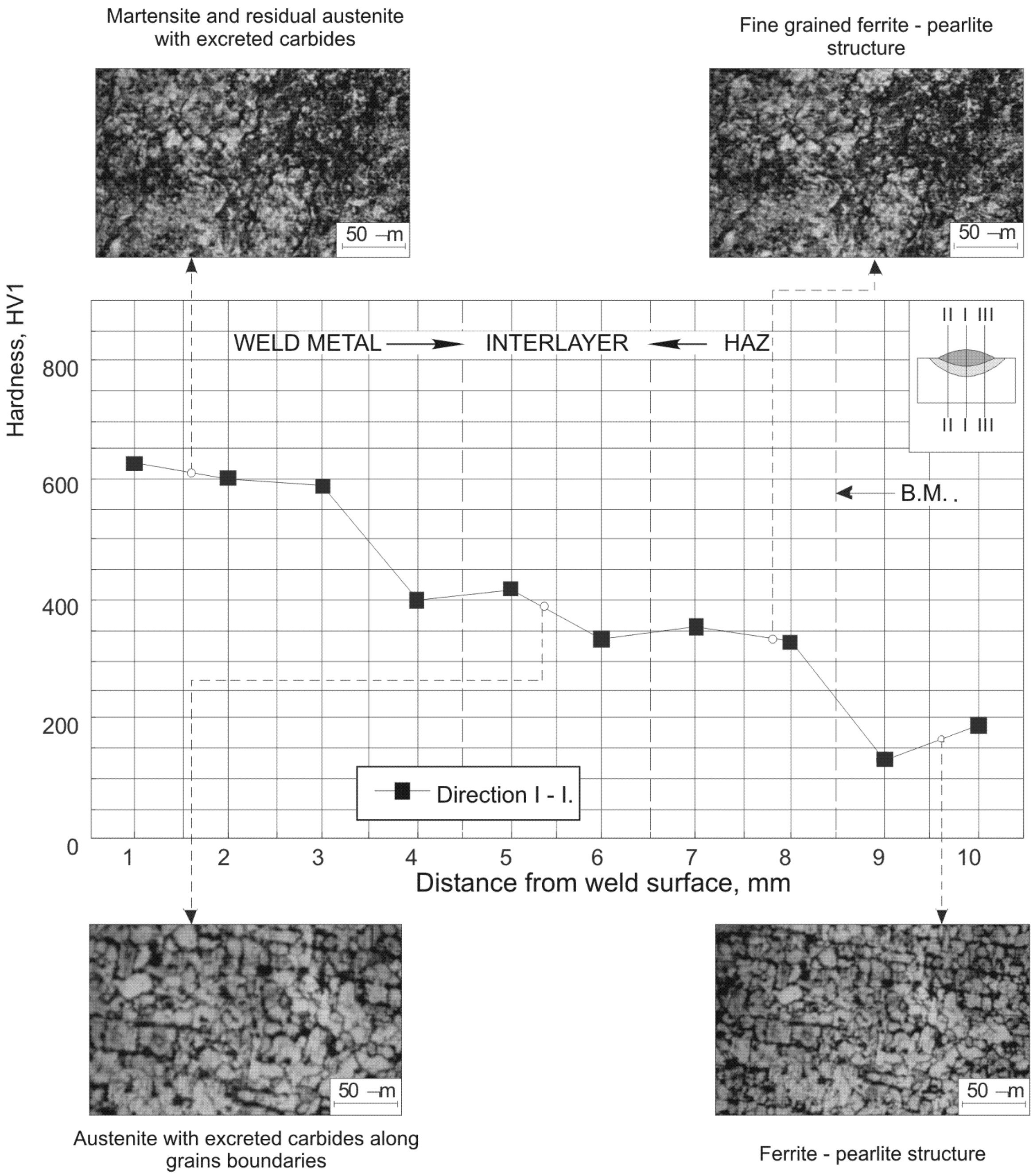


***Figure 2.** Hardness distribution and microstructure of typical hard faced zones (filler metal-E DUR 600)*

Prior to testing topography of discs and blocks, on digital measurement system Talysarf 6, has been measured. Contact has been achieved with normal force F_N = 300 N and sliding speed v_{ss} = 1 m/s. During contact of about 60 min change of coefficient of friction (Figure 4 to 11), and after contact breaking surface topography of discs and blocks, that is wear scare width, have been recorded. In this way tribological characteristics of blocks, made of above mentioned materials, have been determined. Wear scare width has recorded with microscope UIM-21, which had 50 time magnification, illustrated in Figure 12 [1, 2, 4, 5, 11].

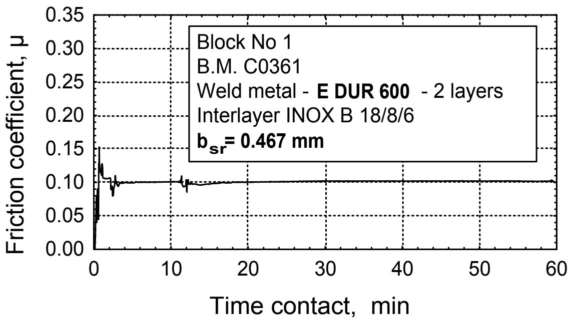


Figure 4. *Change of friction coefficient during the contact period of 60 min (weld metal - E DUR 600)*

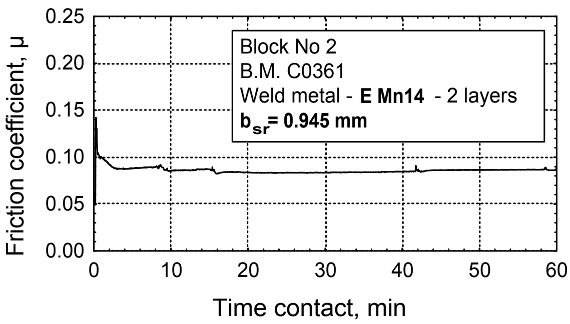


Figure 5. *Change of friction coefficient during the contact period of 60 min (weld metal - E Mn14)*

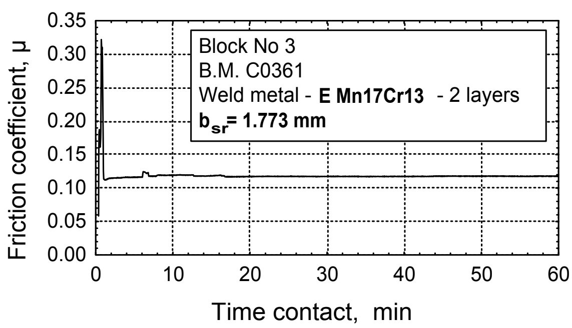


Figure 6. *Change of friction coefficient during the contact period of 60 min (weld metal - E Mn17Cr13)*

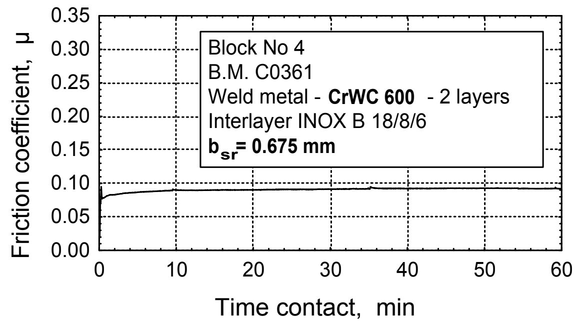


Figure 7. *Change of friction coefficient during the contact period of 60 min (weld metal - CrWC 600)*

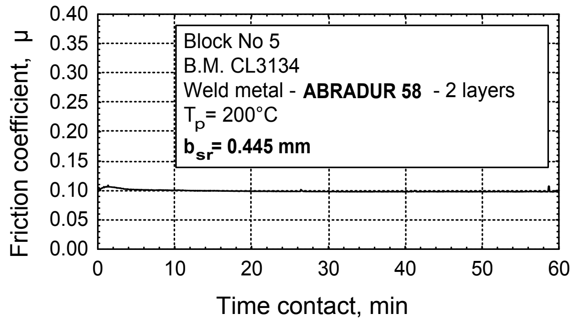


Figure 8. *Change of friction coefficient during the contact period of 60 min (weld metal - ABRADUR 58)*

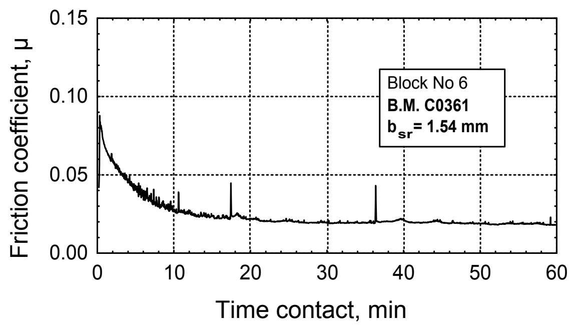


Figure 9. *Change of friction coefficient during the contact period of 60 min (B.M.- Č0361)*

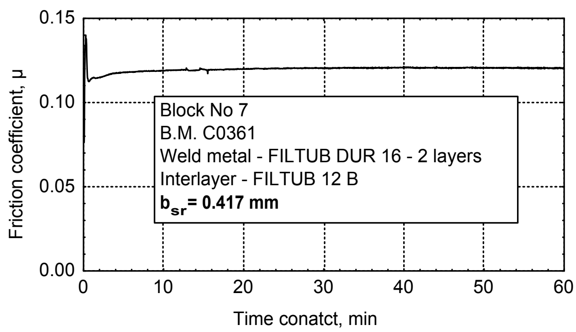


Figure 10. *Change of friction coefficient during the contact period of 60 min (weld metal-FILTUB DUR 16)*

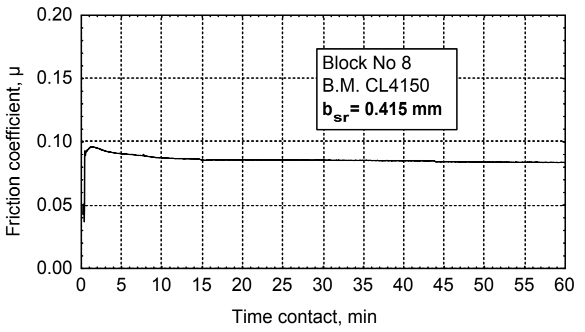


Figure 11. *Change of friction coefficient during the contact period of 60 min (B.M.-ČL4150)*

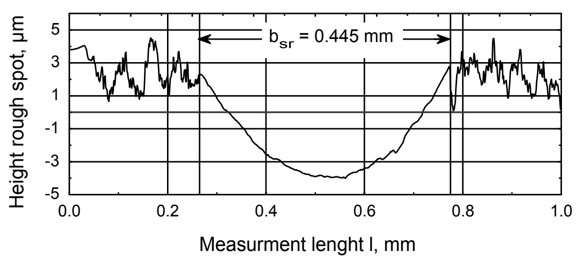
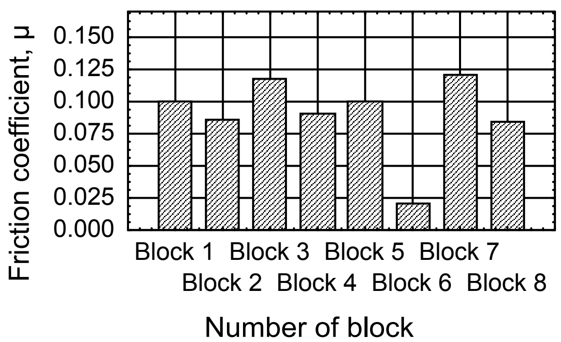
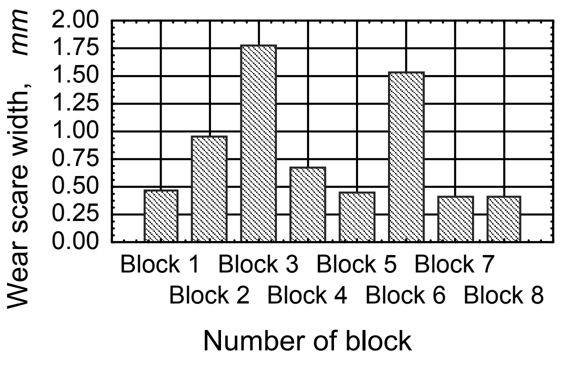


Figure 12. *Layout the wear scare - Block No 5 (after the contact period of 60 min)*

Mean values of examined blocks friction coefficients are shown in Figure13a, and mean values of wear scare width are given in Figure 13b.



a)



b)

Block 1-E DUR 600, Block 2-E Mn14, Block 3-E Mn17Cr13, Block 4-CrWC 600, Block 5-ABRADUR 58, Block 6-Č0361, Block 7-FILTUB DUR 16, 8-ČL4150

Figure 13. *Histograms of mean values of friction coefficients (a), and wear scare width (b) after the 60 minutes contact [1-3, 5]*

On the basis of performed tests, by measuring wear scare width, it may be concluded that hard faced layers made with FILTUB DUR 16, E DUR 600, ABRADUR 58 and CrWC 600 have much better wear resistance in comparison to layers made with E Mn14 and E Mn17Cr13. According to this test base material - steel ČL4150 has good wear resistance, whereas base metal - steel Č0361 has the purest wear resistance. However, by measuring widths of wear scares only, it may not be concluded that is better to perform hard facing with electrodes FILTUB DUR 16, ABRADUR 58, E DUR 600 and CrWC 600 than with E Mn14 i E Mn17Cr13.

Effective wear resistance to different kinds of wear may be determined reliably after testing in real working conditions. Analysis of such results may lead to ranking of both filling materials and hard facing technologies for actual case of either production or reparative works. Contradictious results of tribological tests during hard facing with E Mn14 and E Mn17Cr13, may be explained with fact that contact between block and disc does not lead to conditions necessary for local transformation of austenite to martensite in surfaced layers. That leads to conclusion that this widely used standard tribological test of wear resistance is not suitable for manganese steel [2, 3, 4, 5].

It is notable to emphasize that during these model testing, very high wear resistance had filled wire FILTUB DUR 16, which is comparable with coated electrodes with similar purposes. Having in minds that quantity of deposited material, using that electrode wire, considerably excesses quantity of deposited material of coated electrodes, which, beside to technological, leads to economical advantages, whish can not be neglected.

4.3 Hard facing of real working parts

Hard facing of tested specimen leads to determination of optimal technology which than may be applied to real working parts. Thickness of both base material and surfaced layer as well as electrode diameter have influence on decision which thickness of hard faced layer should be. That may be achieved by application of various techniques. Such hard faced parts sometimes may be processed to final dimensions and, thus, be ready for final service.

5. CONCLUSION

Suitable choice of hard facing technology leads to many advantages in comparison to installation of new parts. Advantages are extension of life cycle of hard faced parts, rise of productivity, decrease of delay time, decrease of cost of stockpiles, and techno economic justification of applied technology. Guides for suitable choice of fill materials, depending on kind and type of wear, are given in present paper. Measuring of micro hardness, examination of microstructure, and check of wear resistance led to determination of hard face quality. Model testing leads to data necessary for all choice of best fill material, most suitable hard facing technology and relation between input output parameters of hard facing process.

In spite of good agreement of data obtained in model and real examination, for final acceptance of reparation technology it is sometime necessary to record behavior of repaired parts in real working conditions. After certain time period the most suitable hard facing technology may be specified.

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