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RESEARCH

Choosing of the Most Suitable Technology of Hard Facing of Mixer Blades Used in Asphalt Bases

Possibility of both blade hard facing of deteriorated cast blades in asphalt mixers and fabrication of new hard faced blades made of low carbon steel overlaid with hard alloys, are presented. Special attention has been devoted to abrasion wear of both models and working parts considering hardness, microstructure and damage in exploitation of new weld surfaced blades as well as of new cast blades. Analysis of results of tested models has led to conclusions that these may easy be applied to real parts.

Both hard faced and regular blades were installed in asphalt mixer in working conditions with periodic visual control of level of blade damage during service. By the end of constructional work season, comparison of damage levels of blades, made by hard facing with different additional materials achieved with different technologies, has been made. Results clearly show techno-economic advantages of replacement damaged blades with hard faced blades instead of with new cast blades.

Keywords: Hard facing, construction mechanization, mixer blades, wear resistance

1. INTRODUCTION

Almost all parts of construction mechanization are exposed to surface deterioration and corrosion as shown in [1, 2, 3, 4, 5, 6]. Conditions of intermediate level of deterioration have working environments of spiral conveyers, elevators, parts of material classifiers, drums used to comminute les hard materials, parts of shaking screens, *blades for asphalt mixers*, blades for concrete mixers, bodies of loading spoons, blades and flashings of stone driers, parts of mixers and presses for brick production, cutters in constructional machineries for ground leveling and planning of construction materials, box shelters of equipments for transportation and storage of asphalt and cement, etc, as shown in [1, 2, 3]. Here we are reporting extensive damage study of asphalt mixer blades, because their excessive damage, which causes drop quality of produced asphalt, must not be tolerated.

Mixer blades have role to facilitate high quality mixing of dry stone grains and bitumen to achieve good quality of wetting and bonding of bitumen to stone grains. Blades were installed, with holders and hold screws, on two shafts, which rotate in opposite sense directions. In Figure 1 are shown both used and new blades.

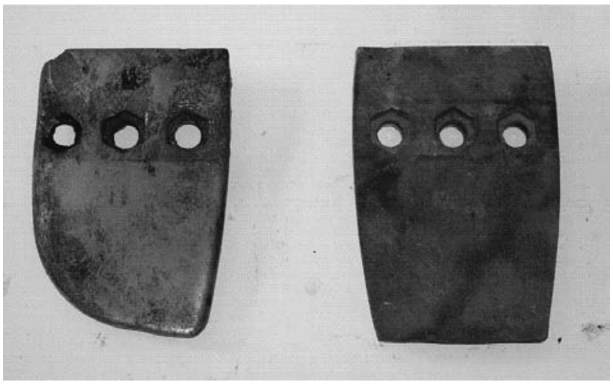

Figure 1. *Illustration of used and new mixer blade*

Depending on mixer capacity blade number varies, but in present case on both shafts there were 64 (each of them had mass of 3 *kg*). Working temperature of hot asphalt production is about 200°C in carbohydrate environment [6].

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It is observed that cast blades have uniform deterioration, these are brittle, and have relatively short lifetime. Frequent replacements of blades cause delays in asphalt base and disorganize working parameters of facility, increase energy consumption, and decrease productivity. In practice, replacement of deteriorated blades is usually postponed and it causes both further losses due to overheating of bitumen and decrease of asphalt quality.

2. BASE MATERIALS AND THEIR WELDABILITY

In past time mixer blades were made of cast steel ČL4150-JUS (G-X190Cr10 - DIN) which has high strength and corrosion resistance, but because of its high rigidity it is not recommend for parts subject to impact loads. That is one of the reasons why we have decided to examine replacement of cast blades with hard faced (base material-B.M.-Č0361-JUS, R St 37-2-DIN). Chemical compositions of examined materials, and their purposes, are given in Table 1, whereas all comparative markings, mechanical properties, and microstructure are given in Table 2.

Cast steel - G-X190Cr10 is hard for welding and very suitable for tempering. That is why hard facing of that cast steel demands special technology to achieve hard facing of satisfactory quality. Continuos-cooling diagram of that steel (Fig. 2) may be used for estimation of properties of heat affected zone (HAZ). Continuos-cooling diagram displays characteristic temperatures, moments of beginning and finishing of phase changes, and percentage contribution of phases that depend on rate of cooling and achieved maximum temperatures [6, 8]. Cast steel - G-X190Cr10 contains maximum quantity of carbon and it is doped with carbide generating elements which separate pearlite and bainite austenite's conversion, improve austenite stability and decrease temperature of martensite transformation of austenite.

Theoretical time of continuous cooling from 800 to 500ºC ($t_{8/5}$) may be determined following [5, 6] leading to best agreement with experimental results. For present case of steel weld surfacing it has been obtained mixed structure of HAZ which contains austenite with carbides, martensite, bainite and pearlite, with hardness of 600 HV. Suitable structure of HAZ increase plasticity of certain weld surfaced zones, and low level of residual stresses may be achieved by annealing, although that thermal treatment is very expensive.

Table 1. *Chemical composition and purpose of ČL4150 and Č0361 [8]*

Base material	Chemical composition, %								Application
	C	Si	Mn	Cr	V	P	S	N	
ČL4150	2.00	0.4	0.3	12.0	0.1	0.035	0.035	-	For parts exposed to deterioration and to lower intensity impact.
Č0361	0.17	-	-	-	-	0.05	0.05	0.07	For fabrication of liable parts, welded structures, and hammered parts that are not exposed to brittle cracks.

Table 2. *Comparative marking, mechanical properties, and microstructure of ČL4150 and Č0361 [8]*

Comparative marking		Mechanical properties					Microstructure
JUS	DIN	R_m, *MPa*	R_{eH}, *MPa*	A_5, %	KV, *J*	Hardness, HB	
ČL4150	G-X190Cr10	-	-	-	-	552-555 after tempering	Ledeburit
Č0361	RSt 37-2	370-450	220-240	18-25	27	130-145	Ferrite + pearlite

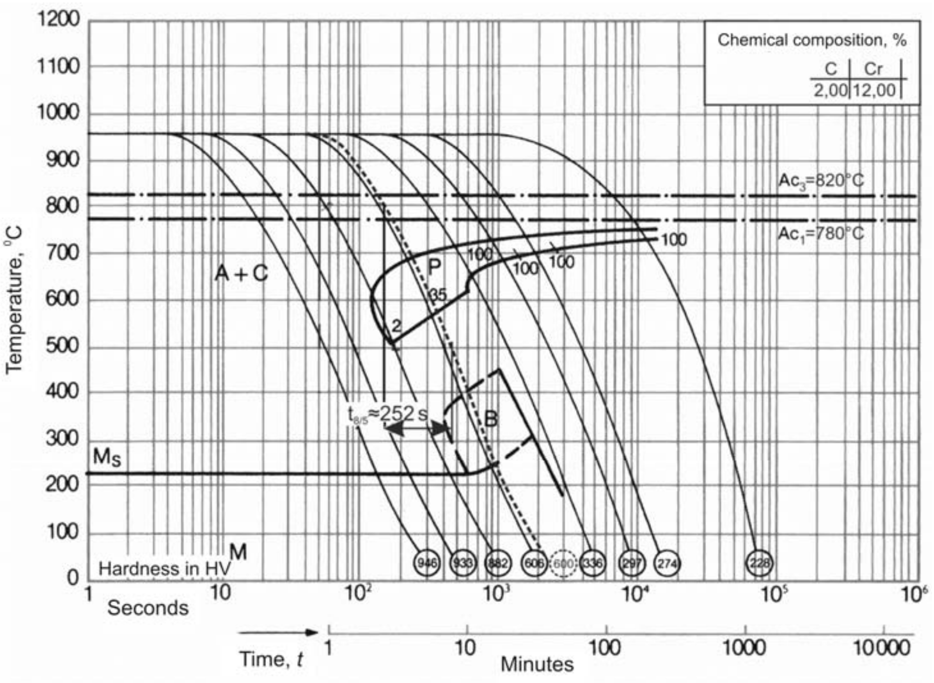


Figure 2. *Continuos-cooling diagram for a steel ČL4150*

3. CHOOSING OF FILLER MATERIAL AND PARAMETERS OF HARD FACING

Filler material for hard facing may be chosen between number of commercial products available on the market. Check of additional materials such as E DUR 600 (E 6-UM-55, DIN 8555), CrWC 600, (E 10-UM-60-C, DIN 8555), ABRADUR 58 (E 10-UM-60-GR, DIN 8555) and obtained results will be presented here following procedure used in [1, 2, 5, 6, 7, 8].

Selection of technological parameters of hard facing has been made from test of steel R St 37-2 of thickness s = 10 *mm*, instead from real material of cast blade. Reasons for such choice are that this steel may be heated without preheating giving same conditions for ranking of different additional materials. That experiment led to original idea to produce new blades made of Č0361 with hard faced working edges [8]. Hard facing on model was achieved by Manual Metal-Arc (MMA) welding method, following technology given in Table 3.

Table 3. *Technological parameters of hard facing of model by MMA welding method [6, 8]*

Thickness BM. s, *mm*	Label of electrode: Fiprom-Jesenice (DIN)	Electrode core diameter d_e, *mm*	Weld current I, *A*	Working voltage U, V	Hard facing speed v_z, *cm/s*	Hard facing energy q_l, *J/cm*
10-25	INOX B 18/8/6 (E18 8MnB20+, DIN 8556)	3.25	100	24	0.136	14118
	E DUR 600 (E 6-UM-55, DIN 8555)	3.25	120	25	0.119	20168
	CrWC 600 (E 10-UM-60-C, DIN 8555),	3.25	125	25	0.116	21552
	ABRADUR 58 (E 10-UM-60-GR, DIN 8555)	3.25	130	25	0.124	20968

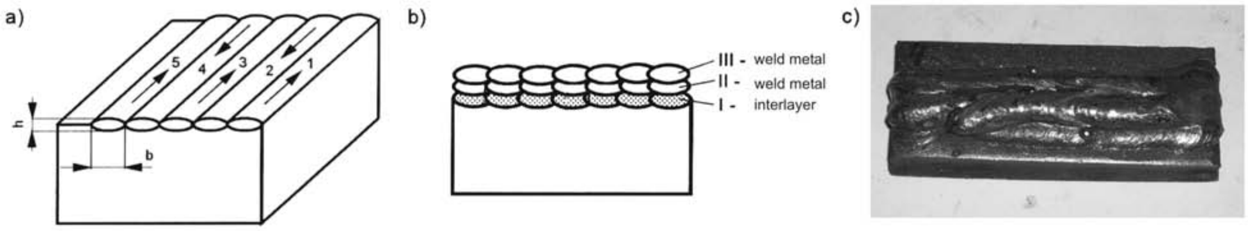


Figure 3. *Manner and layers arrangement of hard faced model: a) manner of placing of layers, b) arrangement of layes placement and c) model picture [1, 5, 6]*

Hard facing manner, arrangement and number of layers and shape of model are shown in Figure 3.

Models are made, by placement of plastic interlayer followed by placement of layer of additional wear resistant material [6]. Single pass facing layer had width b= 8–10 *mm* and height h= 3.2–3.5 *mm*. After facing, specimens have run cool in still air, and then it has ground part of material of top layer. Expensive preheating and additional thermal treatment are avoided.

4. METALLOGRAPHIC INSPECTIONS AND HARDNESS MEASURING ON MODELS

Hardness measuring (direction I-I, Fig. 4) and inspection of new structures, in individual surfacing zones has been made on specially prepared metallographic samples. Figure 4 shows hardness distribution of hard facing manner, arrangement and number of layers, and characteristic microstructures of certain weld zones [6].

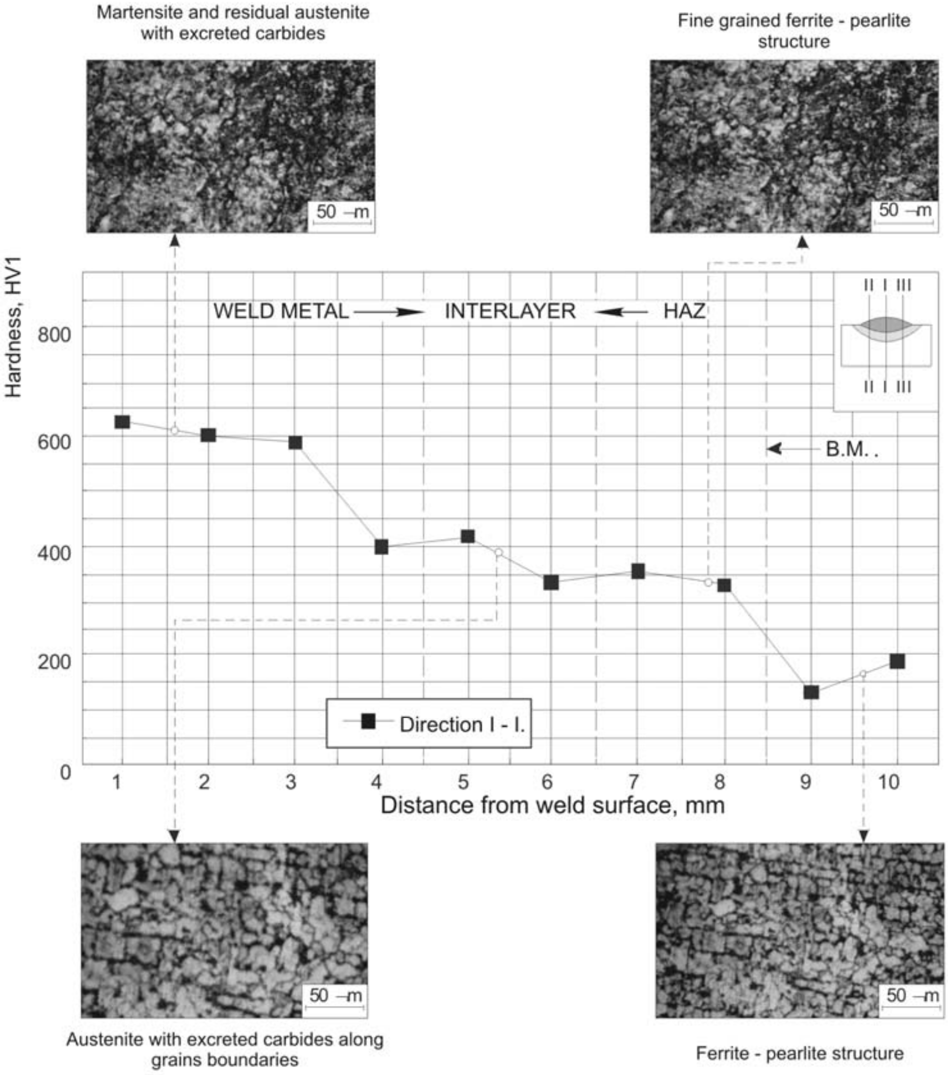


Figure 4. *Microstructure of some hard faced zones: B.M.-Č0361, interlayer-INOX B 18/8/6 and hard faced - E DUR 600*

5. TRIBOLOGICAL TESTINGS

5.1. Preparation blocks and discs

Tribologic testings are performed on prismatic blocks adapted to match requirements of available tribometer in Laboratory of Faculty of Mechanical Engineering at Kragujevac University (Fig. 5). It was necessary to prepare five blocks, three sampled from hard faced material (ABRADUR 58, E DUR 600 and CrWC 600), and two sampled from base material-B.M. (ČL4150 and Č0361) [1, 5]. Line contact “block on disc” has been achieved during tribologycal test in which all contact forces, sliding speeds, and lubricants are external variables.

Prior to any test, disc contact surfaces have been grinded to eliminate traces of prior wear and to measure their roughness to be able to compare it to blocks roughness. To lubricate contact between disc and block we have used engine oil GLX 2 SAE 15 W-40.

5.2. Distribution of hardness and microstructure of blocks and discs

On prepared blocks, cat from hard faced part, hardness is measured in three directions, whereas on prepared blocks, cat from base material, hardness is measured in number of places with different distances from contact surfaces.

Microstructures of hard faced blocks have no difference in comparison to samples (Fig. 6), whereas microstructures of base material before and after hard facing show slight difference.

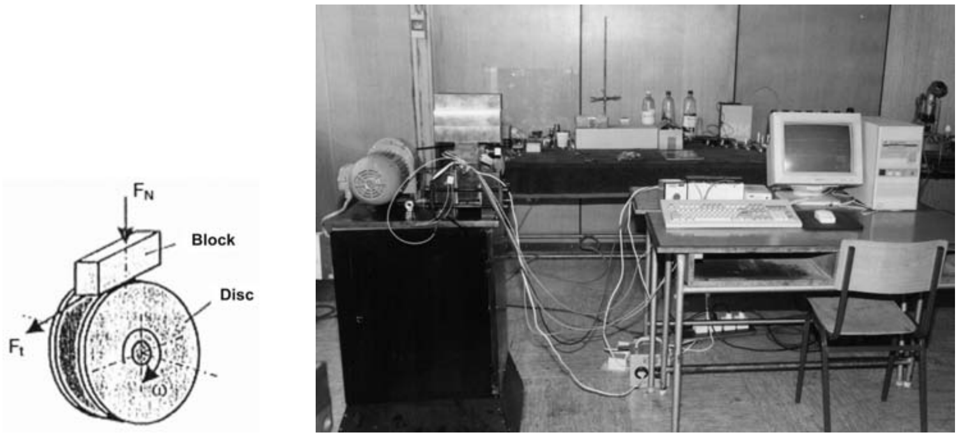
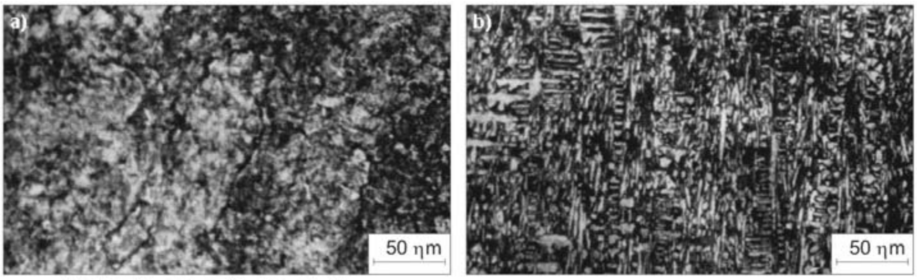
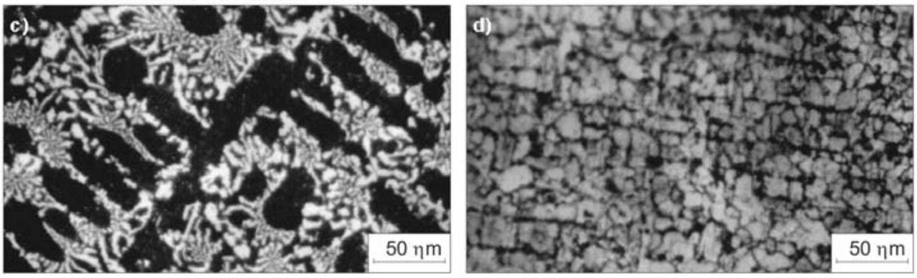


Figure 5. *Tribometar TPD – 93 and mesuring equipments for tribological testings*



Martensite and residual austenite with excreted carbides

Ledeburit



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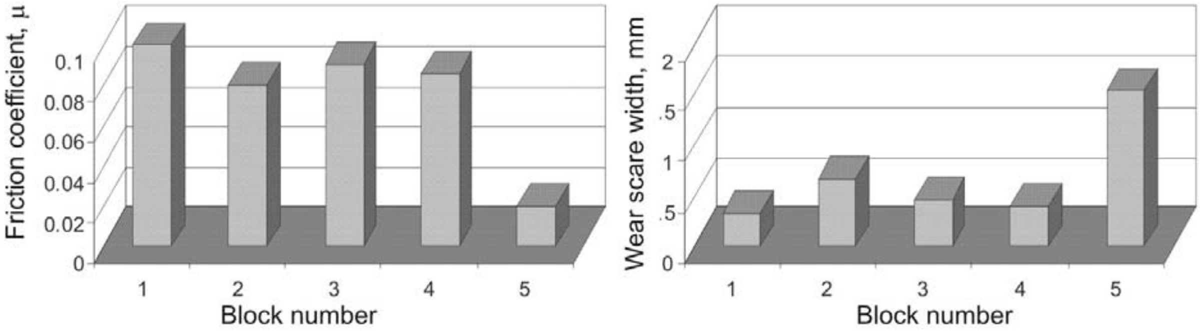
Ferrite - pearlite structure

Figure 6. *Microstructures of some hard faced blocks and base materials:*
a) F.M.-E DUR 600, b) F.M.-CrWC 600, c) B.M.-ČL4150, and d) B.M.-Č0361 [6]

5.3. Results of tribological testings of hard faced material and base materials

The aim of present research is to choose the most suitable filling material for hard facing for reparation or production of mixer blades as well as for other construction mechanization, exposed to wear and corrosion. Prior to tribological test it has been determined roughness of contact surfaces on three discs and five blocks, which allow us to calculate mean deviation of roughness R_a. After test both, width of roughness trace and roughness profile along roughness trace, have been measured. Wear resistance has been estimated using wear scare width b_{sr} and coefficient of friction μ. Coefficients of friction on all blocks are measured during contacts that run on 60 *min* each [6].

Finally, topography of contact surfaces and traces of wear have been determined. Figure 7 shows, for examined materials, histogram plot of friction coefficient change and mean width of wear.



a) b)

Block number: 1- ABRADUR 58, 2- CrWC 600, 3- E DUR 600, 4- ČL4150, 5- Č0361

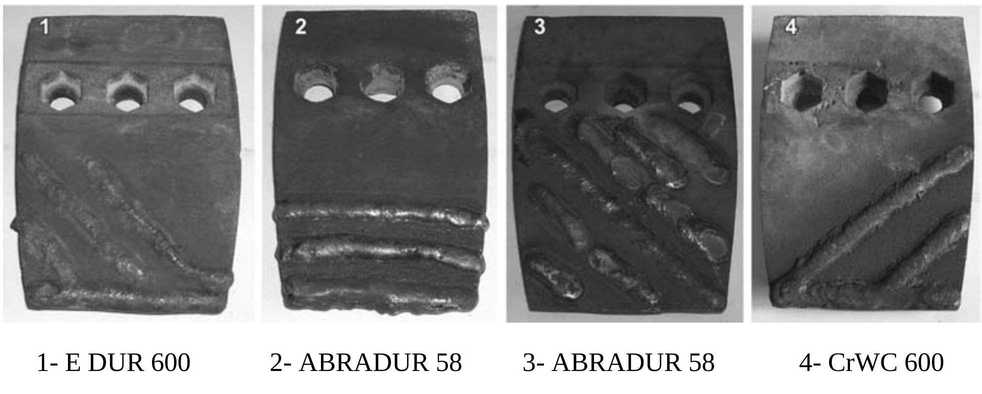
Figure 7. *Mean values of friction coefficient (a) and wear scare width (b) after 60 minutes contact [6]*

6. HARD FACING OF REAL PARTS AND THEIR WEAR RESISTANCE

To determine real resistance to wear and to corrosion of mixer blades it was necessary to examine their service in real environment that is in an asphalt base. To have comparable data three blades are hard faced by applying same procedure as during model fabrication.

Tentative hard facing showed that successful hard facing of B.M.-ČL4150 may be achieved by preheating (to T_p = 500ºC), further heat up followed by slow cooling of welded parts in thermal treatment oven. Blades hard facing is achieved by performing interface welding prior to double layered welds, as illustrated in Figure 8. After that, external layers of all hard faced blades have been partly grinded in same manner as during model making process.

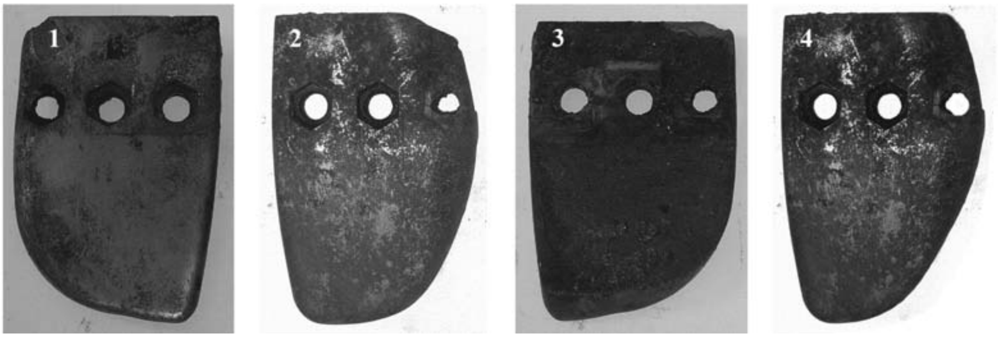
Fabricated hard faced blades are assembled together with new blades, which are not hard faced, and placed on the most critical places for wear, as shown in Figure 9.



1- E DUR 600 2- ABRADUR 58 3- ABRADUR 58 4- CrWC 600

Figure 8. *View of hard faced blade samples*

Figure 9. *Interior view of blades installed in asphalt mixer*



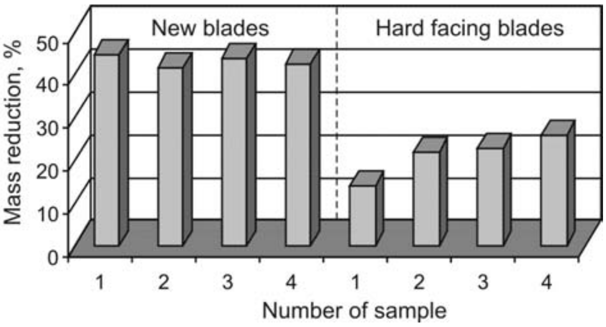
1- E DUR 600 2- ABRADUR 58 3- ABRADUR 58 4- CrWC 600

Figure 10. *Damages of work surfaces of fabricated hard faced blades after 720 working hours*

Effective working hours are recorded with control timer built in mixer. Wear intensity during service is evidenced visually only, but during short pauses top mixer cover was opened to have more precise evidence.

Positive effect of hard facing has been noticed after 240 working hours, that is after production of 25000 ton of asphalt, and examination of dismantled blades is performed after 720 working hours, that is after production of 86000 ton of asphalt. Figure 10 shows appearance of wore mixer blades.

Mass reduction of examined samples is calculated as mass difference of new blades before and after production service, and is shown in Figure 11.



Hard facing blades: 1- E DUR 600, 2- ABRADUR 58, 3- ABRADUR 58, 4- CrWC 600

Figure 11. *Plot of material endurance of examined samples in real working conditions [6]*

On the basis of mass reduction of examined samples is concluded that hard faced blades had better wear resistance than blades without hard facing. Hard faced blades had lower mass reduction in spite of filler material and independent on weld technique. It is hard to estimate reliable which filler material has the best wear resistance, because difference of mass reduction of hard faced blades negligible. To estimate the best filler material it is necessary to follow wear intensity in longer period.

7. CONCLUSION

Examination performed here show that life cycle of optimal hard faced blades of asphalt mixer is many times longed than life cycle of new blades. That leads to conclusion that hard facing technique leads to significant saving, productivity increase, decrease of equipments delays, and availability of spare parts. In fact, life cycle of new blades is considerably shorter than one construction season, and wear is so high that it is not possible to repair it. Contrary, fabricated hard faced blades have longer life cycle, smaller wear, more efficient asphalt mixing, and rises its quality.

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