Strengthening machine elements working under abrasive environment by alloying with hard layers and their estimation

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1. Introduction

Reliability of machines can be achieved by applying various means, e.g. using materials possessing special properties, developing strength by alloying or spraying surfaces, etc. [1, 2]. Resistance to wear of agricultural machine elements depends on the composition and heat treatment of applied steel. The machine parts life is seldom increased by alloying them with hard layers because of high costs. This method was probably expedient under the USSR economic conditions, whereas in the market economy it is less efficient.

The well-known seven kinds of abrasive wear [2, 3] do not fully reflect the wear in the ground. There, several wear types act simultaneously – wear in abrasive mass, wear to embedded abrasive particles, impact abrasive wear. Abrasive wear is affected by a number of factors: alloy nature and structure, abrasive material, its hardness and moisture, dimensions and shape of abrasive particles, particles mobility and motion rate, surface pressure on an abrasive particle [1-4].

Agricultural machine parts working in abrasive environment are made of carbon special steels. In CIS (Commonwealth of Independent States) countries popular steels are: spring 65Г (0.65 %) and plough - Л53 and Л65 steels [1, 2, 4], in EU countries - lower carbon (0.34-0.4 %) boron micro-alloyed steels – Lubor 024/034/044 (produced by SSAB Svensk Stal AB), SB27M12CB (Fundia), Hardox 400/450/500/600 (SSAB Oxelosung AB), Domex Wear (SSAB Tunnplat AB), Raex B27 (Rautaruuki steel), etc. [6-12] and also multilayer steels.

The life of parts made of the above-mentioned steels is rather short when working under abrasive wear conditions. Due to their difference one plough can reclaim the area of 2 hectares (in sandy-stony) to 80 hectares (in mould/loam ground) [13].

Increase in wear resistance by increasing carbon content in steels, their alloyage and hardness has been proved by scientists Khruschiov M.M., Tkachiov V.N. and Vinogradov V.N. The hardness ratio of abradant and steel has the greatest effect on abrasive steel [1–4].

The following technologies are applied for the increase in agricultural machine parts life:

- heat and heat-chemical treatment, i.e. hardening, cementation [2 –10];
- electric arc alloying of the greatest loaded surfaces by coating electrodes [9, 10, 12];
- continuous coating with abrasive wear resistant layers [12, 14];
- mounting of tungsten carbide and other hard alloy segments on working parts [11].

The review of Western scientific and technical literature renders little information on the application of hard layers for strengthening the surfaces of agricultural machine elements [15, 16]. Modern investigations of hard layers properties are concentrated on mono-component WC, TiC, CrC, etc. coatings [17-21]. For this reason, their results do not reflect the properties of multi-compositional covers.

The ground is full of abrasive materials – quartz sand (1350 HV) and granite (1410 HV) [11]. Wear may be slowed down by cementation of strengthened surfaces, continuous alloying with chromium carbide (CrC 13-16 GPa) [9, 10, 22], tungsten carbide (WC 17.5 GPa, W_2C 30 GPa) [2].

Having made the abrasive wear resistance tests (Fig. 1, Table 1), Khruschiov M.M. et al., scientists of the former USSR, have determined that hardness does not have a direct effect on wear resistance [1]. Fig. 1 presents the hardness and wear resistance relation of hard layers (18 names) produced in CIS countries. This relation in steels and pure metals is direct, however, it practically does not exist in hard layers.

The structure of hard alloys is two-phase, i.e. hard solution matrix with carbide inserts [1-4]. The structure consists of the low-disperse eutectic mixture of solution and carbides with likely excess carbides inserts. Wear resistance of these alloys increases with an increase in carbides amount and hardness and also in ductile base strength [1-3]. If it is too low, carbides fall out [1].

Table 1 gives the composition of a part of analyzed layers in Fig. 1.

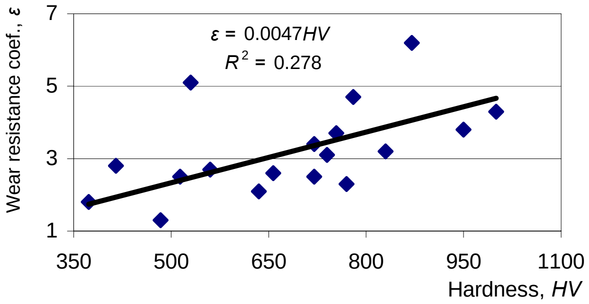

Fig. 1 Hardness (HV) and relative wear resistance ε relation of hard layers materials produced in CIS countries [1]

The effect of CIS produced materials on wear intensity is well known [1–3]. Out of 25 marks of alloying electrodes produced in CIS countries only one T-590 is imported to Lithuania [23]. Russian materials are seldom used due to their rising cost and unstable quality. They are replaced by EU products.

Electrodes producers emphasize the machine element surfaces to be strengthened, nevertheless the optimal application of electrodes is based on minimal expenses for their usage. Hard layer composition of EU products differs from that made in CIS countries [23-25]. This fact causes the difference in the efficiency of materials application.

Table 1

Composition of hard layers alloyed by electrodes produced in some CIS countries (residual quantity Fe) [1, 3]

Mark of electrode, composition	Quantity of alloying elements, %			
	C	Cr	Mn	Other
КБХ	2.5	25	0.5	B - 1.0
ХР-19	3.0	28	0.5	B - 1.0
Т-620	3.0	23	0.7	B - 1.0;Ti - 1.0
Relit'as	2.0	-	-	W - 30.0
ЭН-60М	0.9	2.5	0.8	-
УС	4.5	8.0	9.0	-
ЭТН-2	2.8	6.0	6.0	-
ЭТН-1	2.5	-	21	-
ОЗИ-1	0.9	4.0	1.0	W - 14.0;V - 1.0
ВСН-6	>1.2	15.0	-	W - 14.0;V - 2.0
Note: Research conditions – wear on a fixed abrasive (corundum abrasive paper ЧАЗ-180), standard steel Ст 3, 150 HV				

The research objective is hard layers alloyed by electroarc coating electrodes.

The aim of the research is both to determine the possibilities of an increase in life of machine elements working in an abrasive environment by arc alloying them and to develop the methods of alloying materials selection.

To achieve the aim the following research tasks have been set:

- to analyse the plough point wear;
- to develop the methods of analytical estimation of strengthening by means of alloying;
- to investigate the composition, hardness and wear resistance of layers (according to ASTM G65-94);
- to recommend the most efficient materials for strengthening agricultural machine working elements.

2. Testing procedures

Research has been carried out by analysing scientific literature sources, applying analytical, data processing and other methods.

The state of new and worn plough points made by AGROLUX (No 94611) has been analysed by the method of micrometreage (callipers ШЦ 3-400-0.1) and masses (scales SK 5001, with 1g accuracy).

The layers alloyed with EU and CIS production electrodes were researched. The boron micro-alloyed steel Lubor 044 (C-0.06 %, Si-0.25 %, Mn-1.18 %, Cr-0.23 %, B-0.003 %, 47±1.0 HRC) has been used as a standard. As a likely material for alloying the working parts surfaces by cooling a specimen of chromium alloyed cast iron has been used [12, 14]. The specimens (steel Ст3 - C 0.14-0.22 %, Si 0.05-0.17 %, Mn 0.40-0.65 %) of 80×40×8 mm have been alloyed by 1 and 2 layers obtaining a different chemical composition (Table 2).

Table 2 presents the composition of alloyed layers, while an electrode producer and an electrode are encoded (e.g. X–7): I, II, III, V – materials produced in EU countries; IV materials produced in CIS; VI – chromium alloyed cast iron (C>5 %, Si–0.87 %, Mn–0.52 %, Cr–16.5 %).

The wear intensity change is expressed by relative wear resistance coefficient $\varepsilon_{X.RELATIV}$, calculated as a ratio of steel $I_{LUBOR\ 044}$ and alloyed layer $I_{X.COATED}$, wear

$$\varepsilon_{X.RELATIV} = \frac{I_{LUBOR044}}{I_{X.COATED}} \tag{1}$$

The layers composition is determined by Belec Spektrometrie Opto-Elektronik GmbH harmonic analyzer Belec compact lab.

The wear resistance has been measured according to the standard ASTM G65-94 with a rubber coated wheel forming a slight pressure of abrasive particles on the surface (Fig. 2). It simulates the action of particles in a relatively soft ground. Due to layers hardness (52-70 HRC) the load of a specimen has been taken to be 130 N and time-span –20 min [26]. The experiments have been made on quartz sand "Anykščių kvarcas" (fraction 0.25–0.4 mm).

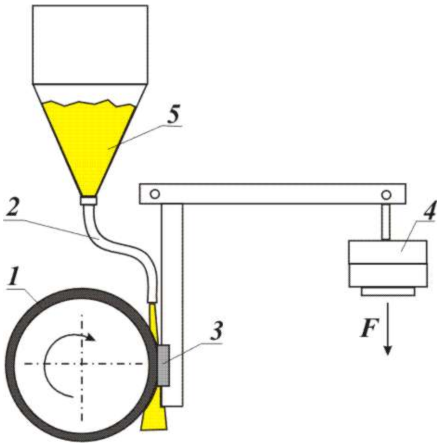

Fig. 2 Schematic diagram of the mechanism abrasive wear estimation (according to ASTM G65) [26]: *1* -rubber coated wheel; *2* - abrasive supply channel; *3* - specimen; *4* - load; *5* - quartz sand

The alloyed specimens have been polished up to $R_a = 2.0$ µm, their hardness has been measured by hardometer TK-2M.

The wear has been estimated by weighing the specimens with scales Sartorius AC210S (0.1mg) before and after the test.

The coefficient of electrode application η has been estimated as a ratio of differences of specimens and electrodes masses used for their alloying before and after the test. The measurement has been done by scales SCALTEC SPO 51 (0.01g).

3. Experimental results and discussions

AGROLUX plough points (No. 94610/94611) are profile machine elements of parallelogram shape (273 mm length, 85 mm width, 12 mm thick), 43 HRC hardness.

The analysis of new and used AGROLUX plough pins has indicated that:

- average mass of new plough pins is 2088 g, that of worn to the margin – 1204 g;
- average length of new plough pins is 273 mm, diago-

nals –338.5 mm and 239.5 mm, while those of worn to the margin are 220.9 mm, 268.5 mm and 188.2 mm, respectively;

- average worn down to the marginal is 884 g (average worn down – 42.3 % of mass), the length of a plough pin decreases 52.1 mm, while that of diagonal – 70 mm and 51.3 mm.

The expedience of repair (renewal) of machine elements is estimated according to the expression [27]

$$S_{REP.(REN.)} \leq K_{L.COEF.} S_{NEW.M.EL.} \tag{2}$$

where $S_{REP.(REN.)}$, $S_{NEW.M.EL.}$ are costs of repair (renewal) and new machine element, respectively; $K_{L.COEF.}$ is coefficient of life.

The analysis shows that Eq. (2) is not to be used for strengthening because strengthening is one of production (repair) technology stages. Strengthening is expedient if a comparative cost of a machine element is higher than that of a strengthening layer (coating)

$$S'_{COMP.M.EL.} > S'_{COMP.COAT.} \tag{3}$$

$$S'_{COMP.M.EL.} = S_{M.EL.} / M_{M.EL.} \tag{4}$$

$$S_{M.EL.} = S_{N.M.EL.} - S_{W.M.EL.} \tag{5}$$

$$M_{EF.M.EL.} = M_{N.M.EL.} - M_{W.M.EL.} \tag{6}$$

where $S'_{COMP.M.EL.}$, $S'_{COMP.COAT.}$ are comparative costs of a machine element and coating, respectively; $S_{N.M.EL.}$, $S_{W.M.EL.}$ are costs of a new machine element and worn machine element, respectively; $M_{N.M.EL.}$, $M_{W.M.EL.}$ are masses of new and worn machine elements, respectively.

In fact, only the wearing part of a machine element is efficiently used. In the analysed case $M_{EF.M.EL.}$= 884 g. The cost of a machine element $S_{N.M.EL.}$, = 30.2 Lt (1 EUR=3.45 Lt), therefore the comparative cost of a wearing machine element $S'_{COMP.M.EL.}$ = 34.2 Lt/kg. This value is to be compared to the cost of coating being alloyed, estimating the cost of materials and labour, wear intensity change, material loss

$$S'_{COMP.COATING} = \frac{KS_{ALL.MAT.}}{\eta \varepsilon_{RELATIV}} \tag{7}$$

where $S_{ALL.MAT.}$ is cost of alloying materials (Table 2); K is coefficient of alloying expenses (K = 1.1, when $S_{ALL.MAT.}$ = 70 Lt/kg, K = 1.2, when $S_{ALL.MAT.}$ = 30-70 Lt/kg, K = 1.3, when $S_{ALL.MAT.}$ = 30 Lt/kg); η is coefficient of applied electrode (Table 2).

To estimate the expedience of strengthening by alloying, the following expression is recommended

$$\frac{S_{N.M.EL.} - S_{W.M.EL.}}{M_{N.M.EL.} - M_{W.M.EL.}} > \frac{KS_{ALL.MAT.}}{\eta \varepsilon_{RELATIV}} \tag{8}$$

The composition of investigated alloyed layers and a standard is given in Table 2. The specimens alloyed by one (1.5-2 mm) and two (3.0-4.0 mm) layers differed in their chemical composition. The composition of a two layer alloy was close to that indicated by the producer (Table 2, [23-25]).

Hardness spreads rather little (up to 5 HRA). Hardness of alloyed layers, change of wear resistance are given in Table 2.

In the analysed case $S'_{COMP.M.EL.}$ = 34.2 Lt/kg. If the cost of an alloyed layer does not exceed this value, alloying is expedient even in cases of equal wear intensity of a machine element and the layer.

The coating cost in Table 2 indicates that three alloying materials IV-1, IV-2, III-2 are recommended for application if an alloyed layer and plough point wear out uniformly. The wear resistance of these materials, however, differs considerably 2.9-3.58 (IV-1, IV-2) and 0.79 (III-2). Estimation of comparative cost of alloyed layers (Table 2) indicates that the application of III-2 material is detrimental (it is cheaper to buy new plough points), while IV-1 and IV-2 materials are the most efficient (their comparative coating cost being 7.79 and 5.59 Lt/kg, respectively).

The magnitudes of the coefficient of hard layers wear resistance are given in Table 2.

The analysis of the results obtained in one-layer and two-layers alloying cases have made it possible to determine that alloying by electrodes I-2, I-4, IV-1, IV-1, and chromium alloyed cast iron substantially reduce abrasive wear (Fig. 3, Table 2). These results appear to be promising for continuous working parts alloying by cooling them (by crystallizing the layer of proper thickness on machine elements dipping them into molten cast iron).

Five alloying materials (I-1, II-1, III-1, IV-1, IV-2) used in the investigation increase relative wear resistance of a layer by alloying it with the second one.

According to the layer composition hard layers can be divided into groups (Table 2):

- A group – (Fe-C-Cr) hard layers of small C (0.32-0.60 %) and Cr (4-9 %) quantities;
- B group – (Fe-C-Cr) hard layers of large C (3-5 %) and Cr (30-35 %) quantities;
- C group – (Fe-C-Cr-Si-B) layers alloyed with large quantity of C and abundantly with Cr, Si, B;
- D group - (Fe-C-Cr-Si-V-W-Mo-B) layers alloyed with large quantity of C and abundantly with Cr, Si, Nb, Mo, W, Ti, V.

On the results of wear resistance experiments the following properties of hard layers have been established:

1. Very high resistance to wear – C and D groups of materials (Table 2);
2. Medium resistance to wear – B group of materials (Table 2);
3. Low resistance to wear – A group of materials (Table 2).

Wear resistance of hard layers alloyed with low quantities of carbon (0.32–0.6 %) and chromium (4-9 %) is lower than boron micro-alloyed steel ($\varepsilon_{RELATIV}$ - 0.65-0.83), therefore these materials do not suit for strengthening machine parts working in sandy ground. The second layer of these materials increases the wear- from 1 to 19 % (compared to the first layer).

The composition of three out of four materials from B group used in experiments is equivalent, they are I-1, I-2, II-1 and III-1. In the layers alloyed with them Cr 33-35 %, C 3-5 %, Si 0.5-1.05 % ($\varepsilon_{RELATIV}$ - 1.29-1.65) except I-2 material with high Si (3.4–5 %) content. Owing to high alloying with silicon, this material distinguishes itself by high resistance to abrasive wear $\varepsilon_{RELATIV}$ - 7.6.

Table 2

Composition, hardness and relative wear resistance $\varepsilon_{RELATIV}$ of alloyed hard layers and their technical/economic estimation

Electrode, material code	Composition of analyzed surface, %		1 / 2 layer		Retail cost of electrodes, $S_{ALL.MAT.}$, Lt/kg	Coef. of electrode applica-tion η	Coef. of extra expen-ses, K	Coating cost $S_{COATING}$, Lt/kg	Comparative coat. cost $S'_{COMP.COATING}$, Lt/kg
	Single-layer	Double-layer	Hard-ness, HRC	Wear resis-tance coef. $\varepsilon_{RELATIV}$					
A group - (Fe-C-Cr-Si) with low carbon (0.32 –0.65 %) and chromium (4-9 %) amount									
I-3	C-0.38; Si-1.47; Mn-0.48; Cr-7.57; Ni-0.07; Ti-0.054; B-0.001	C-0.40; Si-1.74; Mn-0.52; Cr-8.12; Ni-0.07; Ti-0.069; B-0.001	61.5 / 63	0.76 / 0.64	32	0.671	1.2	57.2	75.26
II-2	C-0.38; Si-0.34; Mn-0.38; Cr-4.22; Mo-0.48; V-0.08; Ni-0.08; Cu-0.06	C-0.37; Si-0.35; Mn-0.37; Cr-5.41; Mo-0.54; V-0.08; Ni-0.08; Cu-0.05	60 / 57	0.83 / 0.74	30	0.49	1.3	79.6	95.9
V-1	C-0.32; Si-1.37; Mn-0.55; Cr-6.01; Cu-0.07; Ni-0.06; B-0.001	C-0.44; Si-2.28; Mn-0.61; Cr-8.96; Ni-0.08; Cu-0.08; B-0.001	53 / 57	0.74 / 0.67	19.8	0.69	1.3	37.3	50.4
III-2	C-0.35; Si-0.38; Mn-0.98; Cr-3.27; Ni-0.06; V-0.06; Mo-0.05; B-0.001	C-0.48; Si-0.58; Mn-1.28; Cr-4.71; V-0.08; Ni-0.07; Mo-0.07; B-0.001	63 / 62	0.79 / 0.78	11.8	0.56	1.3	27.4	34.68
B group – (Fe-C-Cr-Si) with high carbon (3-5 %) and chromium (30-35 %) amount									
I-1	C-3.54; Si-0.92; Mn-0.39; Cr-30.62; V-0.17; B-0.002	C-3.35; Si-0.65; Mn-0.31; Cr-30.48; V-0.19; B-0.002	54 / 56	1.54 / 1.79	38	0.675	1.2	67.5	43.83
I-2	C>5; Si-3.36; Cr>33; Ni-0.15; V-0.13; Mo-0.10; Cu-0.06; B-0.002	C>5; Si>5; Mn-0.41; Cr>33; Ni-0.19; V-0.16; Mo-0.14; Cu-0.07; B-0.004	54 / 61.5	7.6 / 5.14	49.5	0.846	1.2	70.2	9.24
II-1	C-4.62; Si-1.05; Mn-1.68; Cr-21; Ti-0.24;Ni-0.20; V-0.19; Mo-0.13; B-0.003	C>5; Si-0.74; Mn-1.61; Cr-32.6; Ni-0.24; V-0.22; Ti-0.14; Mo-0.14; B-0.003	65 / 65	1.65 / 15.6	30.00	0.641	1.3	60.8	36.85
III-1	C-2.45; Si-0.50; Mn-0.34; Cr-18.76; V-0.09; Ti-0.088; B-0.001	C-3.96; Si-0.65; Mn-0.32; Cr-23.96; Ti-0.123; V-0.12; B-0.001	52 / 61	1.29 / 1.57	23.7	0.60	1.3	51.3	39.77
C group – abundantly alloyed (Fe-C-Cr-Si-B) with C (3-5 %), Cr (24-27%), Si (0.8-1.2 %) *B* (1-1.5 %)									
IV-1	C-3.91; Si-0.79; Mn-0.42; Cr-16.94; Ti-0.301; Ni-0.16; Cu-0.13; B>0.1	C>5; Si-1.09; Mn-0.38; Cr-26.54; Ti-0.462; Ni-0.23; Cu-0.2; B>0.1	63 / 67	2.9 / 4.24	13.00	0.747	1.3	22.6	7.79
IV-2	C-3.64; Si-0.85; Mn-0.47; Cr-13.41; Ti-0.52; Al-0.226; Cu-0.16; B>0.1	C>5; Si-1.16; Mn-0.42; Cr-17.64; Ti-0.77; Al-0.358; B>0.1	58 / 65	3.58 / 6.61	13.00	0.843	1.3	20.0	5.59
D group – abundantly alloyed (Fe-C-Cr-Si-V/Ti-W-Mo-B) with Cr, Si, Nb, Mo, Ti and/or V, W, B									
II-3	C-2.99; Si-1.55; Mn-0.35; Cr-4.9; V-4.03; Ti>2; Al>0.37; B-0.058	C-3.11; Si-1.96; Mn-0.33; Cr-6.07; V-5.11; Ti>2; Al-0.408; B-0.067	62 / 65	6.39 / 3.51	70.8	0.77	1.1	101.1	15.82
I-4	C-3.82; Si-3.21; Mn-0.46; Cr-10.89; W-3.79; Mo-6.10; Nb>1.5; V-0.64; B>0.1	C>5; Si>5; Mn-0.4; Cr-15.27; W-4.38; Mo>8; Nb>1.5; V-0.67; B>0.1	70 / 67	9.68 / 9.65	92.00	0.826	1.1	122.5	12.65
VII	C>5; Si-0.87; Mn-0.52; Cr-16.52; Ni-0.14; Cu-0.14; B-0.011		52	2.84					
Standard	C-0.06; Si-0.25; Mn-1.18; Cr-0.23, B-0.003		47	1.00				34.2	34.2
Note. C>5 – element amount exceeds the capabilities of spectrum analyzer Belec compact lab.									

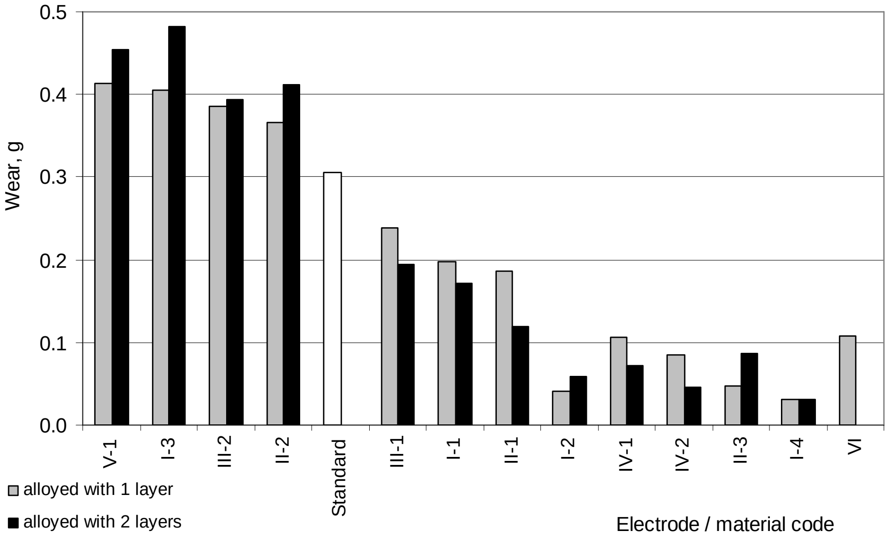

Fig. 3 Wear out of alloyed layers in ASTM G65 investigation (F = 130N, t = 1200s; S = 2880m). Materials: Standard – LUBOR 044; V-1, I-3, III-2, II-2 - (Fe-C-Cr-Si) layers with low carbon and chromium amount; III-1, I-1, II-1, I-2 – (Fe-C-Cr-Si) layers with high carbon and chromium amount; IV-1, IV-2 – (Fe-C-Cr-C-Si-B) layers abundantly alloyed with carbon, chromium, boron; II-3, I-4 – (Fe-C-Cr-Si-V-W-Mo-B) layers abundantly alloyed with chromium, niobium, molybdenum, tungsten etc.; VI – molten alloyed cast iron

Under abrasive wear conditions, (Fe-C-Cr-Si-B) layers alloyed with carbon, chromium, silicon, boron obtained by IV-1, IV-2 materials are of high quality, and the ratio of the costs of CIS produced materials and relative wear resistance ($\varepsilon_{RELATIV}$ - 2.9-6.6) (Table 2) is exceptional favorable.

4. Conclusions

On the research results the following conclusions can be made:

1. Soil reclamation machine elements wear out 40-44% of their mass and shorten more than 50 mm.
2. Wear resistance of hard layers alloyed with low carbon (0.32-0.6 %) and chromium (4-9 %) content is lower ($\varepsilon_{RELATIV}$ -0.64-0.83) than that of boron micro-alloyed steel, therefore these materials do not suit to machine elements working in the sandy ground.
3. The layers abundantly alloyed with chromium – silicon – boron or silicon – silicon – vanadium – tungsten – molybdenum - boron are the most efficient materials for reducing the wear of machine parts working in the quartz sand ground; according to ASTM G65-94 research results the alloying with these layers reduces wear intensity up to 9.7 times.
4. Minimum exploitation expenses of machine parts working under abrasive wear conditions are warranted by hard layers alloyed with carbon, chromium, silicon, boron by the electrodes produced in CIS countries.
5. Efficiency of materials produced in EU countries for work under abrasive wear conditions is higher the higher is alloying with chromium - silicon or chromium - silicon - vanadium - tungsten - molybdenum - boron. The efficiency is proportional to the cost of materials – the more expensive material the more efficient it is.

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ABRAZYVO APLINKOJE NAUDOJAMŲ MAŠINŲ ELEMENTŲ STIPRINIMO APLYDANT KIETAISIAIS SLUOKSNIAIS VERTINIMAS

Reziumė

Darbe analizuojamos galimybės padidinti mašinų elementų, naudojamų intensyvaus abrazyvinio dilimo sąlygomis, ilgaamžiškumą aplydant lankiniu būdu glaistytaisias elektrodais. Tyrimo objektu pasirinkti plūgų kaltai, kaip detalės, dirbančios esant intensyviam abrazyviniam dilimui. Pateikta sudilusių kaltų analizė. Parengta intensyviai dylančių dalių sustiprinimo medžiagų parinkimo metodika, įvertinanti dangos kainą ir dilimo intensyvumo pokytį. Nustatyta, kad žemės dirbimo elementams aplydyti netikslinga naudoti medžiagas, formuojančias paviršiuje mažai ir vidutiniškai legiruotus sluoksnius. Atlikti laboratoriniai aplydytų sluoksnių atsparumo abrazyviniam dilimui tyrimai, nustatyta aplydytų dangų cheminė sudėtis, kietis. Nustatyta, kad tinkamai pasirenkant medžiagas kvarcinio smėlio terpėje dylantiems paviršiams sustiprinti, jų nudilimą, palyginti su boru mikrolegiruoto plieno nudilimu, galima sumažinti 9.7 karto.

V. Jankauskas

STRENGTHENING MACHINE ELEMENTS WORKING UNDER ABRASIVE ENVIRONMENT BY ALLOYING WITH HARD LAYERS AND THEIR ESTIMATION

Summary

The possibilities of the life increase of machine elements working under intensive abrasive wear conditions by alloying with electric arc coating electrodes are analysed. The research objective is plough points – the elements working under intensive abrasive wear. The analysis of worn points is presented. Methods of both choosing strengthening materials of intensively wearing parts and estimating coating cost and varying wear intensity are developed. The materials forming low or medium alloy layers on surfaces are found to be unsuitable for coating of agricultural machine elements. The resistance to abrasive wear of alloyed layers has been experimentally tested and their chemical composition, hardness have been determined. A proper choice of the materials strengthening surfaces working under quartz sand environment compared to boron micro-alloyed steel is estimated to reduce wear up to 9.7 times.

В. Янкаускас

ОЦЕНКА УПРОЧНЕНИЯ НАПЛАВКОЙ ТВЕРДЫМИ СЛОЯМИ ЭЛЕМЕНТОВ МАШИН, ИСПОЛЬЗУЕМЫХ В АБРАЗИВНОЙ СРЕДЕ

Резюме

В данной работе проведены исследования возможностей увеличения долговечности элементов машин, используемых в абразивной среде путем ручной электродуговой наплавки. Объектом исследования выбраны долота плугов, как детали, работающие в условиях интенсивного абразивного изнашивания. Приведен анализ состояния износившихся деталей. В работе приведена методика оценки целесообразности упрочнения изнашиваемых деталей машин, правила подбора материала, учитывающие стоимость упрочняющего покрытия и изменение интенсивности изнашивания. Определено, что для наплавки рабочих элементов почвообрабатывающих машин нецелесообразно применять материалы формирующие на поверхностях мало и средне легированные слои. Проведены лабораторные исследования износостойкости наплавленных слоев различного химического состава, определен химический состав и твердость. Определено, что при правильном подборе наплавочного материала для упрочнения в среде кварцевого песка работающих поверхностей, изнашивание по сравнению с закаленной бором микролегированной сталью, можно уменьшить до 9.7 раза.

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