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INCREASING OF WEAR RESISTANCE OF PARTS AND JUNCTIONS OF METAL CUTTING MACHINES, MADE FROM ALUMINIUM AND ALUMINIUM ALLOYS

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Abstract
The static and dynamic behavior the parts and junctions of the metal cutting machines to grater extend depend on the tribological characteristic of their working parts (axle, carriage, saddle, table, etc) The friction power influences mostly the amplitude of the self-stimulating vibrations of the rectilinear moving parts [1]. It is formed by the contact processes in the friction surfaces [2].
The tribological behaviour of a friction couple is determined by the specific speed between the friction surfaces, the specific properties of the lubrication materials, the pressure in the contact surfaces, the topography of the working surfaces as well as the present working conditions (such as temperature and pressure).
In order to improve the productivity and the quality of processing of a metal cutting machine, as well as its static and dynamic behavior [6], it is necessary to improve the tribological characteristic of their working parts-minimum friction power; high wear resistance and improved lubrication of their friction surfaces.
To decrease the inertia powers and moment of inertia, especially for high speed metal cutting machines, we start using different materials to produce parts with smaller weight and mass. Recent tendency is to use aluminium and aluminium alloys. Disadvantage of those parts and junctions is their low tribological characteristic, especially of their wear resistance.
Major efforts are made for the development of effective and functional ingredients of roofing coating materials, which could be used in the highly loaded tribological systems [3,4]. The alternative methods improve the tribological characteristics to a lower extend, but for their implementations high investment is not required. Coating materials with reduced friction and wear factors are of a particular interest.
Key words: *Wear resistance, metal cutting, tribological system*

1. Purpose of the research

The purpose of the present research is to offer methods, means and technology for increasing the wear resistance of parts, produced from aluminium and aluminium alloys, used in the construction of metal-cutting machines. For archieving this goal, it is necessary to solve the following tasks:

1. Establishing of methods for experimental research of the metal wear resistance.
2. Coating of the samples with hard-alloys;
3. Conducting of experimental research;
4. Analysis of the results, conclusions and recommendations.

2. Establishing of methods for experimental research of the metal wear resistance.

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- cleaning and skimming of the samples;
- measuring the weight of the samples and the antagonist on a electronic balance;
- for each sample tree experiments are performed with the following work

parameters of the stand conditions of the experiment:

- time of mutual work of the sample and the antagonist – *5 min.*;
- contact area – $S=200\ mm^2$;
- covered distance – $L=47{,}74.10^{-3}$ *km.*
- normal loading – *F=10 N;*

- measuring the weight of the samples and the antagonist after the experiment on a electronic balance;
- Determination of the quality of the removed metal from the wear-out- *Q[gr];*
- Determination of the intensity of wear with the formula:

$$I_h = \frac{Q}{L.S} \quad gr/mm^2.km \qquad (1)$$

- Determination of the relative wear – it is calculated compared to standard sample;

Such is an unroofed part and the formula is:

$$\Delta I_h = \frac{I_h}{I_{h_{et}}}.100, \quad \% \qquad (2)$$

Where

I_h - is intensity of roofing wear (formula 1)

$I_{h_{et}}$ - intensity of wear of standard sample.

3. Coating of the samples with hard-alloys;

For carrying out of the experimental research tes t samples were made (fig.3.1)

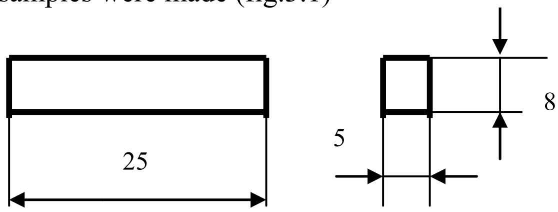

Fig. 3.1

The test samples were made from the following types of aluminium alloys:

- Sample A and B – Aluminium A6;
- Sample C and D – effective aluminum alloy AlSi12.

The quality of the machining surfaces after the mechanical treatment are given in the Table 3.1:

Table 3.1

samples	A	Б	B	Г
R_a, µm	0,32	0,16	1,62	2,38

Samples were anodized mith $(COOH)_2$. Pure Aluminum was used as anode and the sample to be tegument was used as cathode.

The process went as follows:

- The voltage was constant – *U = 60 V = const;*
- The intensity of electric *I (A/dm²)* current constantly increased from *2 A/dm²* to *40 A/dm²* in the period of $t_1=45$ *min*;
- After the intensity of electric current reached $I=40A/dm^2$ it remained constant for the period of (Fig.3.2)
  - $t_1t_2 = 45$ *min*;
  - $t_1t_3 = 75$ *min.*

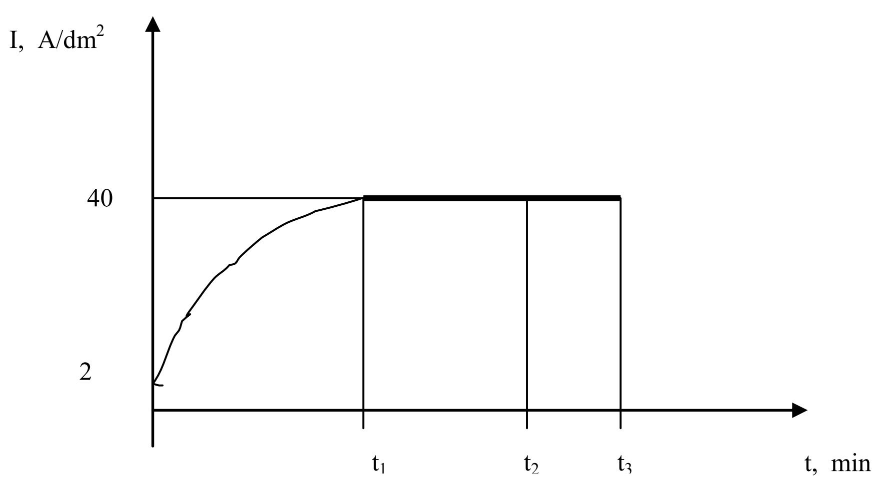

Fig. 3.2

The roughness of the sample surfaces R_a after being anoded, thickness of the layer Δ and the microhardness $HV_{5/10}$ are given in Table 3.2..

Table 3.2

samples	**A₁**	**A₂**	**A₃**	**A₄**	**Б₁**	**Б₂**	**Б₃**	**Б₄**
R_a **, µm**	0,33	0,92	0,41	1,32	0,86	0,61	0,81	2,5
Δ, µm	16	13	-	5	13	-	21	-
$HV_{5/10}$	132,5	114,3	122,9	123	135,5	156,5	177,5	145,5
samples	**B₁**	**B₂**	**B₃**	**B₄**	**Г₁**	**Г₂**	**Г₃**	**Г₄**
R_a **, µm**	2,13	1,87	1,82	1,69	1,41	2,41	2,08	1,94
Δ, µm	32	6	22	10	-	-	8	14
$HV_{5/10}$	42,4	35,8	37,1	132,5	37,9	39,4	40,6	29,4

4. Experimental research and results:

Two series of experimental research were done: in the first one samples B1; B3; C2; C3 were tested. The experimental results are shown in table 4.1.

Table 4.1

samples	standard sample	$Б_1$	$Б_3$	B_2	B_3
Q, gr.	35.10^{-3}	$1,8.10^{-3}$	$11,6.10^{-3}$	1.10^{-3}	$0,83.10^{-3}$

The period for anodizing, calculated values of wear intensity I_h , relevant wear and the increase of the wear-resistance are shown in Table 4.2.

In the second series of experimental tests, samples: A_2; A_4; B_1; B_4; $Г_3$; $Г_4$ were tested.. The experiments went under the following friction conditions:

- dry friction;
- sliding speed: *V, mm/s*;
- normal loading: *1,6 N*;
- friction duration: *from 5 to 60 min*.

The following tribological characteristics were defined :

- wear intensity I_w *[gr/N.m]*;
- friction coefficient *f*.

Table 4.2

samples	period for anodizing *t, min*	I_h, $gr/mm^2.km$	relevant wear %	increase of the wear-resistance
standard sample	-	$36,66.10^{-4}$	1	1
$Б_1$	45	$1,89.10^{-4}$	5,2	19,4
$Б_3$	45	$12,15.10^{-4}$	33,1	3
B_2	75	$1,05.10^{-4}$	2,9	35
B_3	45	$0,87.10^{-4}$	2,4	42

The wear intensity of the different samples and duration of anodizing are given in table 4.3, and the changing of the friction coefficient depending on friction time – in table 4.4.

Table 4.3

samples	A_2	A_4	B_1	B_4	$Г_3$	$Г_4$
I_W*, gr/N.m*	$2,778.10^{-3}$	$5,787.10^{-4}$	$2,315.10^{-3}$	$1,042.10^{-2}$	$8,681.10^{-4}$	$5,387.10^{-4}$
duration of ano-dizing, *t, min*	75	45	45	75	45	75

Table 4.4

A_2	friction time, *min*	5	15	30	45	60
	friction coefficient, *f*	0,3875	0,4210	0,8750	0,8752	1,0000
A_4	friction time, *min*	5	15	30	45	60
	friction coefficient, *f*	0,6250	0,6352	0,6875	0,7813	0,9688
B_1	friction time, *min*	5	15	30	45	60
	friction coefficient, *f*	0,6875	0,8750	0,9644	0,9688	1,0437
B_4	friction time, *min*	5	15	30	45	60
	friction coefficient, *f*	1,050	1,081	1,100	1,150	1,250
Γ_3	friction time, *min*	5	15	30	45	60
	friction coefficient, *f*	0,5042	0,7812	1,125	-	-
Γ_4	friction time, *min*	5	15	30	45	60
	friction coefficient, *f*	0,5000	0,5313	0,5315	0,5289	0,5312

On fig.4.1 is shown the graphical dependence of the friction coefficient of the time for joint work of the tribo-couple. It could be seen from the figure that for samples B_4 and Γ_4 the friction coefficient stays constant during the time of joint work of the tribo-couple.

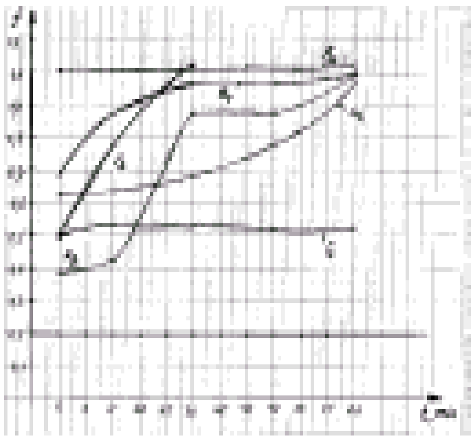

Fig. 4.1

5. Results analysis, conclusions and recommendations

From the analysis of the received experimental results, the following conclusions could be done:

1. The time for anodizing plays essential role on the quality of the roofing. For roofing, received by anodizing for period of *t=75 min*, For roofing, received by anodizing for period of B_2 and Γ_4;
2. Friction coefficient *f* for many samples (A_2; A_4; B_1; Γ_3) is changing dynamically in the course of the joint work of the tribo-couple.. This proves that the properties of the roofing depending on the time of work is unstable. This results are obtained for roofings, received by anodizing for period *t=45 min*;
3. For samples, received by anodizing for period *t=75 min* (Γ_4; B_4), friction coefficient *f* is constant for the whole

period of joint work of the tribo-couple. This proves indirectly that the roofing is with higher quality than those, received by anodizing for period of $t=45$ *min*;

4. Samples B_2 and $Г_4$, demonstrated best wear resistance, which proves once again the thesis, that roofng with better quality are received when the time for anodizing $t=75$ *min*.

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