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ASPECTS ON COUNTERRACE HARDNESS INFLUENCE OVER THE TRIBOLOGIC INDICATORS TO ABRASION IN ELASTOPLASTIC REGIME OF A COUPLE TYPE SPFERE – PLANE

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Abstract

A diamond part intents and abases in regime a counterpart made of steel. The intention is to influence the counterpart hardness improvement, over the tribologic indicators.

INTRODUCTION

It has been accomplished laboratory experimental researches with the objective: elementary processes study resulted in a tribo system developed on a couple sphere – plane type with abrasion by sliding, without lubrication.
The study is including the following stages:

- experiments type "scratch-test" on two types of friction, in pre established conditions;
- extraction of optical microscopic images in electronics, used as graphic support for analyzes and evaluations;
- profile configuration of the in dental imprints generated on the counterparts surface;
- analyzes, evaluations and qualitative determinations on wear processes particularities of the part and quantity on micro geometry of the resulted imprints.

EXPERIMENTS CONDITIONS

Couple for friction, type sphere – plane, having the following components:

- part, an intender made of natural, polished, conic diamond with spherical edge, of about 1 carat. Active geometrical parameters: the cone angle…in orig…; the sphere ray at the top r = 0,02 mm;
- counterpart made of steel with plane surface. The material characteristics are presented in table 1.

Table 1. Materials for the counterpart

Material sort	Chemical composition (%)				Status	Hardness HV30
	C	Mn	Cr 5	Nimax		
C 120	1,80 - 2,20	0,15 - 0,45	11,0 - 13,0	0,35	not treated	210
C 120 T	2,20				thermal treated	511

The experimental conditions are presented in table 2.

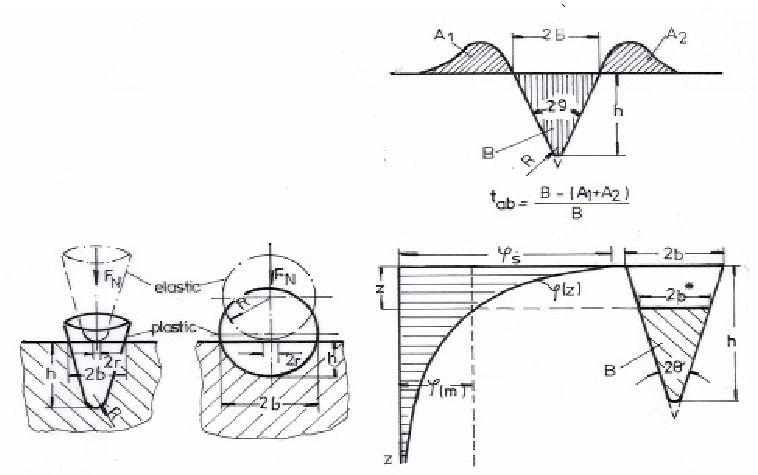
Table 2. Experimental conditions

Experiment no.	couple for friction		indental regime		
	part	counterpart	relative in dental speed **Vmax (m · min^{-1})**	path length **l (mm)**	normal stress force **F (N)**
1	indental made of polished, natural diamond	C 120	0,1	10	10
2					20
3					40
4		C 120 T			20
5					40
6					80

The mathematic model used is including the process indicators and it is presented in table 3, with explanations in fig. 1 and 2.

Table 3. Process indicators

Indicator name	symbol	**UM**	calculation relation
coefficient for free wear	f_{ab}	-	$f_{ab} = \frac{B-(A_1-A_2)}{B}$
wear coefficient	f_{ab}	-	$K_{ab} = f_{ab} \cdot \frac{B \cdot H}{F}$
counterpart volume wear	V_ω	mm^3	$V_\omega = S \cdot K_{ab} \cdot \frac{F}{H}$
linear wear intensity	$W_{l/s}$	$mm \cdot s^{-1}$	$W_{l/s} = K_{ab} \cdot \frac{p}{H}$
contact pressure	p	$N \cdot mm^{-2}$	$p = \frac{F}{A}$
wear surface	A	mm^2	$A = \frac{\pi}{2} \cdot \left[R^2 - (R-h)^2\right]$
volume wear intensity	$W_{v/s}$	$mm \cdot s^{-1}$	$W_{v/s} = f_{ab} \cdot B$



b)

A_1, A_2 – the aria of the released material at the imprint margin/edge
B – the reside aria
fab – the coefficient for free wear

Fig. 1. The geometry of the imprint resulted on the counterpart

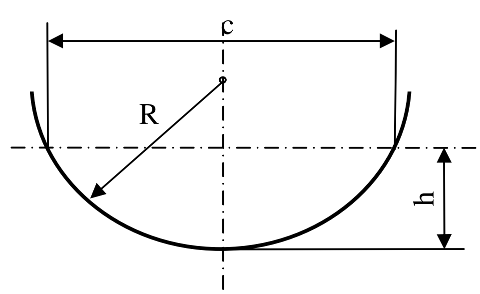


Fig.2 The topography of the imprint resulted at the spherical in dental

THE EXPERIMENTS RESULTS

The experiments results, the measurements and determinations are presented in tables 4 and 5. By their help have been determined process indicators (table 6), graphical representation in fig.3, 4, 5, 6.

Table 4. The experiments results (measured values)

Material	normal force F (N)	Parametrii amprentelor				R (mm)
		A_1 (10^{-3} mm)	**A_2 (10^{-3} mm)**	**B (10^{-3} mm)**	**R (mm)**	
C 120	10	0,095	0,118	0,250	0,00275	0,2
C 120	20	0,120	0,150	0,226	0,00400	0,2
C 120	40	0,108	0,158	0,156	0,01100	0,2
C 120 T	20	0,057	0,075	0,144	0,00225	0,2
C 120 T	40	0,094	0,095	0,269	0,00500	0,2
C 120 T	80	0,123	0,060	0,359	0,01400	0,2

Table 5. The experiments results (calculated values)

Material	normal force (N)	**B (10^{-3} mm)**	**S (-)**	**$(R - h)^2$**	**C^2 (mm^2)**	**A_{cs} (mm^2)**	**A (mm^2)**	**p ($N \cdot mm^2$)**
C 120	10	0,250	20	0,03891	0,00437	0,00688	0,003442	2905,181
C 120	20	0,226	20	0,03842	0,00634	0,01000	0,004999	4000,896
C 120	40	0,156	20	0,03572	0,01712	0,02725	0,013626	2935,558
C 120 T	20	0,144	20	0,03911	0,00358	0,00564	0,002818	7097,101
C 120 T	40	0,269	20	0,03803	0,00790	0,01248	0,006241	6409,486
C 120 T	80	0,359	20	0,03460	0,02962	0,03455	0,017276	4630,627

Table 6. The resulted tribological indicators

Material	normal force **F (N)**	**f_{ab} (-)**	**K_{ab} (-)**	**W_4 (mm^3)**	**$W_{l/s}$ ($mm \cdot s^{-1}$)**	**$W_{v/s}$ ($mm^3 \cdot s^{-1}$)**
C 120	10	0,148	0,781	0,740	10,75330	0,0370
C 120	20	-0,194	-0,463		-8,77992	-0,0430
C 120	40	-0,705	-0,580		-8,06930	-0,1090
C 120 T	20	0,083	0,306	0,239	4,24162	0,0119
C 120 T	40	0,297	1,023	1,598	12,80645	0,0798
C 120 T	80	0,490	1,126	3,519	10,18376	0,1759

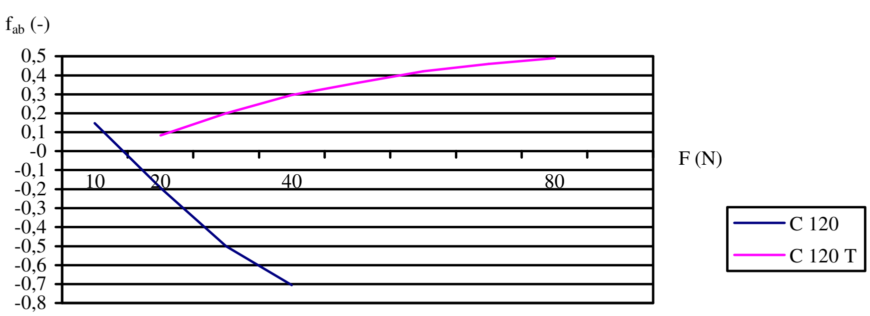


Fig.3 The influence of the counterpart material hardness and of the applied stress over the free wear coefficient

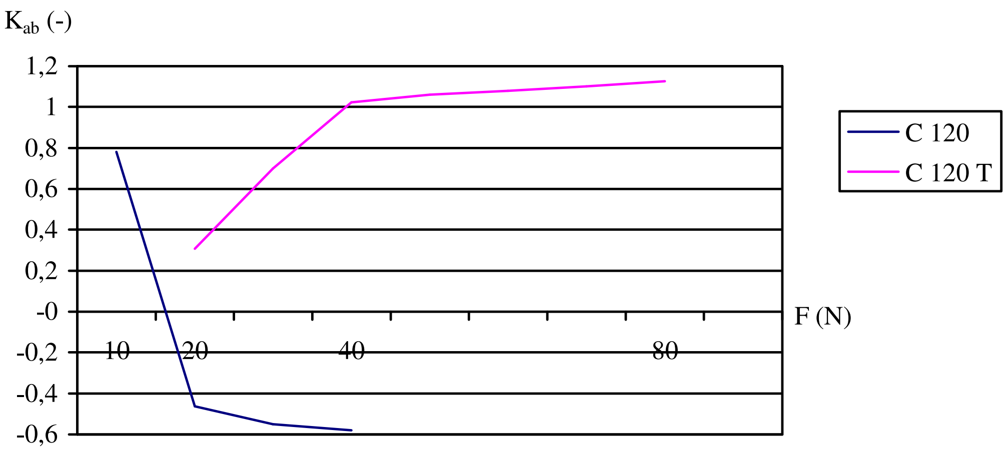


Fig.4 The influence of the counterpart material hardness and of the applied stress over the free wear coefficient

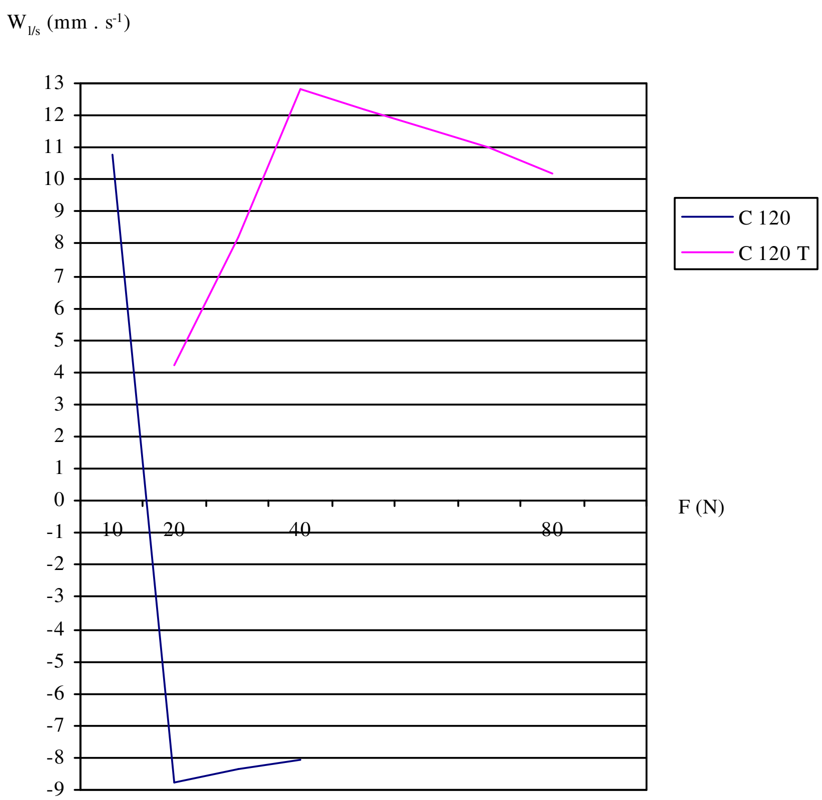


Fig.5 The influence of the counterpart material hardness and of the applied stress over the free linear wear coefficient

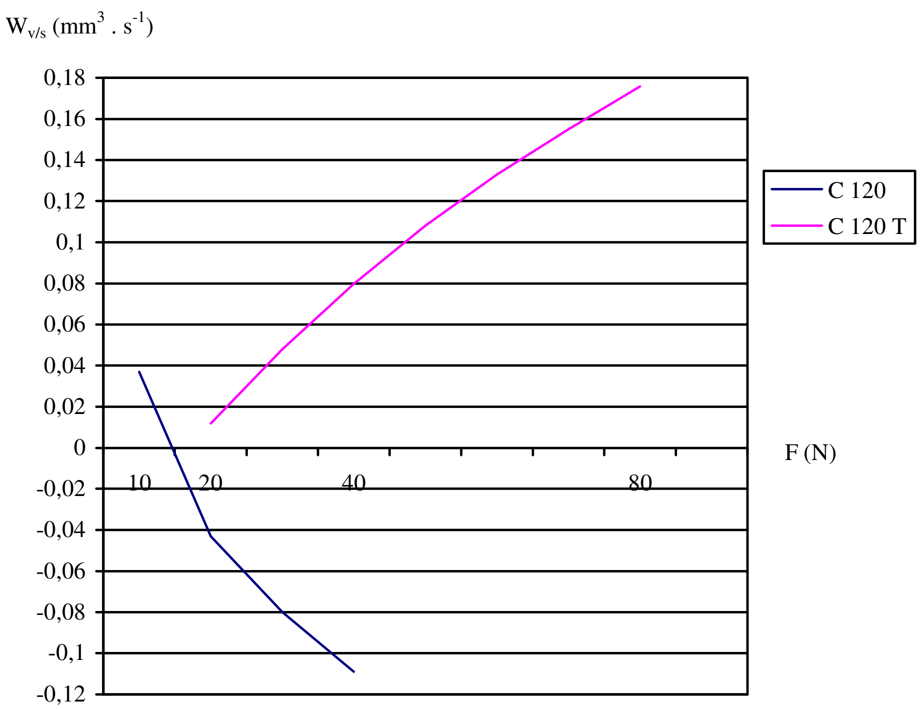


Fig.6 The influence of the counterpart material hardness and of the applied stress over the volume wears intensity

In fig. 7 (a, b, c) and 8 (a, b, c) are illustrated pro philometry aspects of the imprints realized during the two types of counterparts abrasion.

a) F = 10 N b) F = 20 N c) F = 40 N

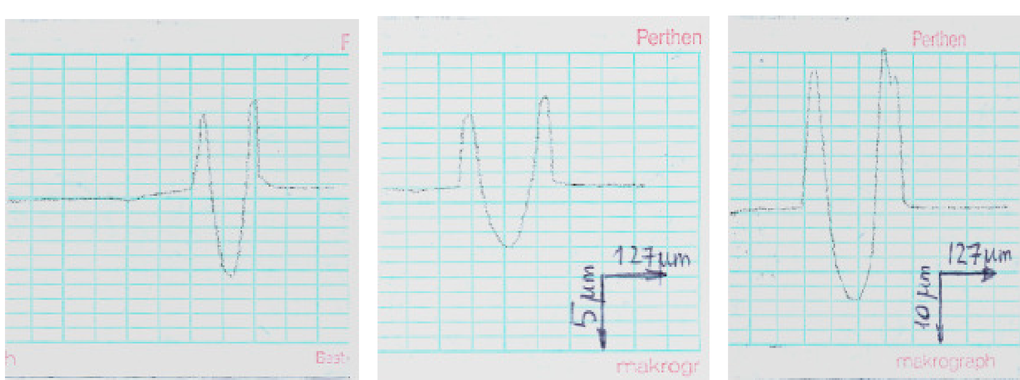
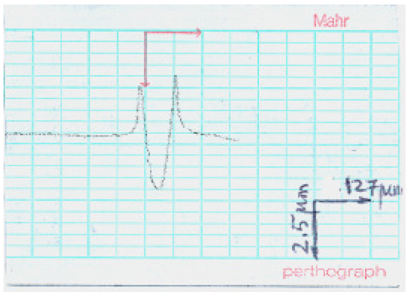
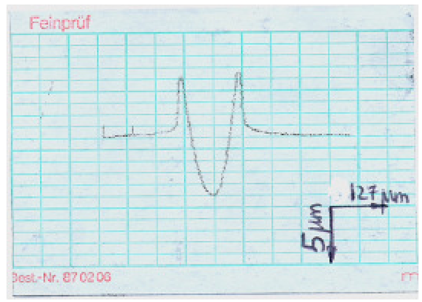


Fig.7 The imprint profile for steel C 120

a) F = 20 N b) F = 40 N





c) F = 80 N

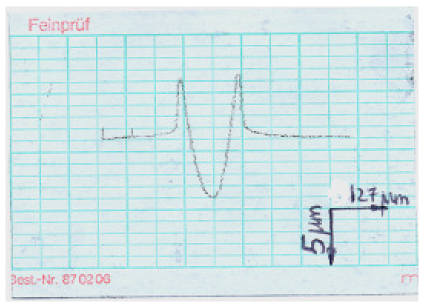


Fig.8 The imprint profile for steel C 120 T

EVALUATIONS AND INTERPRETATIONS

The main wear mechanism is the abrasion, having as identified wear forms: a rare and micro splintering as it is observed in the electronic and optic microscopy sequences (fig. 9, 10, 11, 12) for both types of counterpart materials.

Fig. 9 Optic microscopy C 120

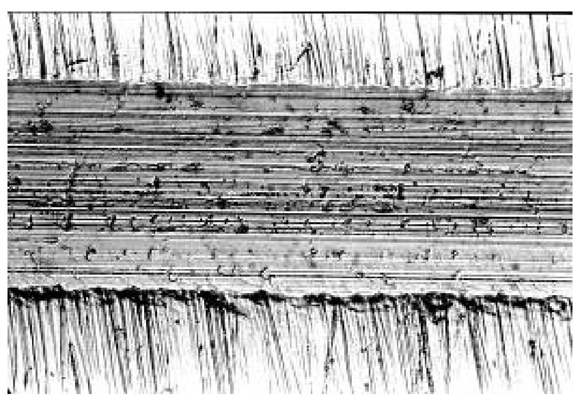
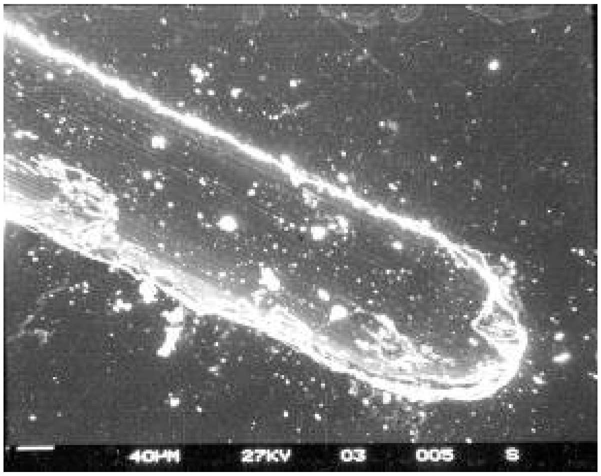


Fig. 10 Optic microscopy C 120 T



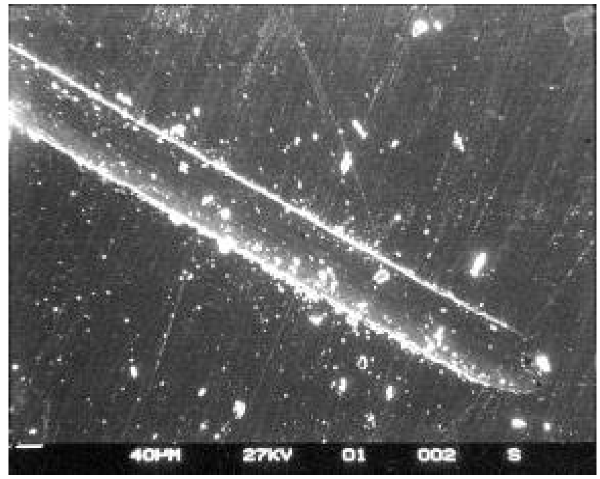


Fig. 11 Electronic microscopy C 120

Fig. 12 Electronic microscopy C 120 T

It is obvious the interdependence between the material characteristics, the applied strain and the tribologic indicators variation.

For the softer material (steel C 120) the free wear coefficient size varies inverse proportionally with the strain, while for the harder ones (steel C 120 T) the variation is direct proportionally.

For big in dental strains the counterpart material receives a strong plastic deformation and is reflected out of the wear channel (a rare typical evolution). It was registered an apparently a typical behavior: the reflected surfaces A_1 şi A_2 are improving in a better rate than the one of the channel section, providing a negative free wear coefficient.

During the in dental route, as a result of the in dental small attack angle($\alpha = 30^{o}$), it follows a strong stress over the material, providing the change from micro splintering to splintering, for the soft materials. For the hard ones the micro splintering is maintained with or without total separation of the splinter from the deformed metal mass.

The deformation degree is constant allover the in dental route, for all the experiments.

CONCLUSIONS

- The reflection degree varies proportionally with the strain dimension, influencing in a different way the wear coefficients
- Improving the in dental force the taking out coefficient improves
- The counterpart material hardness brings the linear and volume wear intensification
- The main revealed wear mechanism is the abrasion one, generating identifiable wear forms: micro arare and micro splintering
- The wear characteristics are maintained constant during the in dental process route

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