STUDY REGARDING THE SCRATCH WEAR OF THE COUPLINGS WITH TRANSLATION MOTION IN INDUSTRIAL

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Abstract
In present conditions, due to heavier exploitation of the different machines, apparatus, equipment, the mentality of the problems of friction, lubrication and wear was forced changed, in the context of the urgent need for saving energy and materials.
In the fall of these concerns appear issues of abrasive wear of the friction couplings that make the machines and equipment used in various production processes. Assessment and evaluation of specific parameters of abrasive wear is of importance both in terms of maximizing calculations of machine design and to determine remedial measures to be taken if they were damaged before the term sustainability is required. The scratch or abrasion is known as a mechanical process of degradation of the friction coupling that involves material removal from the softer areas being in contact with the abrasive particles or harder asperities of one of the areas.
The estimation and evaluation of the parameters specific to the scratch wear are important both from the point of view of the optimization the designing calculation of the machine mechanisms and with the view of establishing the remedy measures that arc to be performed in case they have deteriorated during the exploitation ahead of the imposed durability term.
The present work goal is to establish a new model that can be applied to the couplings with specialized literature.

Keywords: friction couple, wear from abrasion, the asperities, deformation, wear intensity, wear coefficient

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1. INTRODUCTION

The problems related to the scratch wear of the friction couplings are among the subjects concerned with the phenomena of friction lubrication and wear.

The estimation and evaluation of the parameters specific to the scratch wear are important both from the point of view of the optimization the designing calculation of the machine mechanisms and with the view of establishing the remedy measures that arc to be performed in case they have deteriorated during the exploitation ahead of the imposed durability term. It is imported to be pointed out that practically the scratch wear does not occur singularly but generally it is associated with other types of wear and also depends on factors specific to the medium the friction coupling is working in.

That is why the phenomena characteristic to the scratch wear cannot be completely understood interdependence with the adjacent domains.

Above all it is necessary to introduce you the types of wear and their ways they manifest for the friction couplings with translation motion:

- ploughing the strictest form of abrasion with wide and deep scratches where the material is moved laterally. The material loss occurs with fatigue for a short requested cycle;
- the microcutting where the material loss is equal to the volume of the wear slot produced by the abrasive particle while sliding on the surface;
- the fatigue that appears in case of the adhesive type wear, as well is characterized by the material exfoliation caused by great repeated requested of the area;
- the scratch the mildest form of wear by microcutting that manifests through linear, parallel, isolated scratch.

2. THEORETICAL MODEL REGARDING THE SCRATCH WEAR

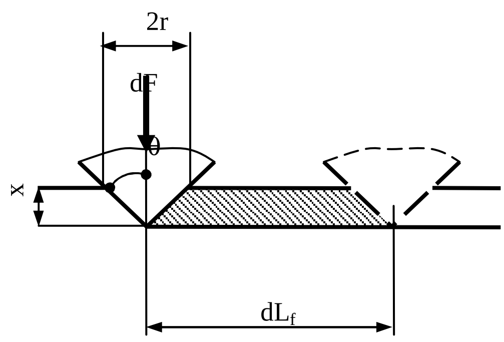
Taking into consideration the complexity of the phenomena that occur during the abrasion, different shapes of the abrasive particles that can be found in the interstices, the rugosities shapes, the hardness of the friction coupling material, lubrication status etc, more opinions (mathematical models) will be synthetically shown, they being designed to the study of the abrasive wear, opinions that were found as a results of a detailed bibliographical research (Magnee, 1993; Kopalinsky and Oxlky, 1995; Lancey and Torrance, 1991; Torrance, 1996; Xie and Williams, 1996).

1. The Rabinowicz-Dunn-Russel model (Kopalinsky and Oxlky, 1995; Lancey and Torrance, 1991) - is a model of wear caused by micro cutting in which the particle is tapered shaped (fig. 1)

The relation ship between the wear elementary intensity:

$$\frac{dV}{dL_f} = \frac{dF \cdot \cos\theta}{\pi \cdot HB} \quad (1)$$

where:
dV - the removed material volume;
HB - the hardness of the softer material surface
This model is being characterized by:
- the connection between the relationship that was got and Archard ecuation for the adhesive wear.
- not taking into consideration the particle motion kinematics;
- the lock of some studies regarding the strain status inside the particle.



x – penetration depth
θ - the half of the angle at the toper top
dL_f – the friction elementary length
dF - the elementary normal load

Figure 1 The model wear by micro cutting

2. The Lancy-Torrance model (Lancey and Torrance, 1991) - is a wear model of deforming considering that when a tapered abrasive particle is passing over an asperity of the softer material of the part a deformed layer is formed having the "h" depth (fig.2).

The relationship of the removed volume of the material:

$$V = \frac{K_\alpha \cdot N_f \cdot p_r}{1{,}732 \cdot K_s \cdot n} \quad (2)$$

where:
K_α - the under unit coefficient describing the probability of producing one wear particle;
K_D - the strength resistance of the materiel

$$N_f = \left(\frac{\gamma_c}{\gamma}\right)^2$$

yc - the deformation needed for the crocking at one posing (experimentally established);
y - the strength deformation value

$$\gamma = \frac{L \cdot f \cdot v}{h \cdot V}$$

L - the length of the deformed part DE;
f - the friction coefficient;
v - the sliding speed on direction;
U - the relative speed of the to pared particle;
h - deformation depth;
p_r - contact pressure;
n - number of asperities.
This model is characterized by:
- designation of the a relationship between the volume or the removed material and the kinematics of the part-particle motion;
- taking into consideration the material characteristics;
- the thing that it tokes into consideration the strain status between the particle and the layer deformation by this one.

3. The Magnee model (Magnee, 1993) - is based on the ecuation of Archard and is proposing a relationship showing the volume of the worn material under the following form:

$$V = \frac{K}{3}\left(\frac{F \cdot L_f}{HB_m}\right) \qquad (3)$$

where:
K - the subunit coefficient describing the possibility of producing an abrasive particle, depending on the elastic-plastic features of the material and of the flow way of this one and of the abrasive particle;
Lf – friction length;
F - normal force;
HB_m - the hardness of the softer material.

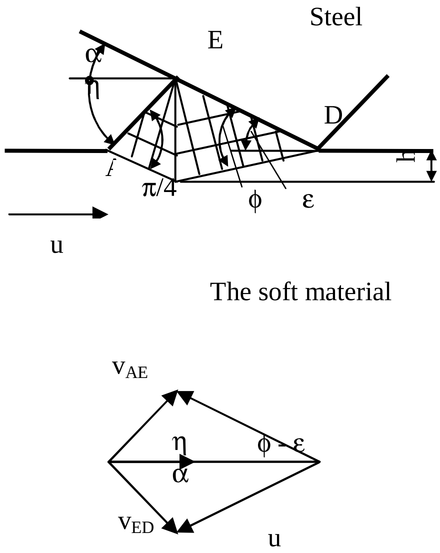


Figure 2 The plastical deformation of the schematical case

Characteristic for this model is that:
- a connection with the relationship got by Archard adhesive for the wear is established;
- it is taking into consideration the material features established that for a ratio of the abrasion material hardness $\frac{HB_a}{Hb_m} = 0,7....1,1$ a reduced wear occurs and for values the wear is a maximum one.

3. THE PROPOSED THEORETICAL MODEL REGARDING THE STUDY OF THE ABRASIVE WEAR

By analyzing the models that were shown and more over a similitude was noticed to exist with the relationship concerned the adhesive wear. There is one issue that was not pointed out namely the number of asperities (particles) and their geometry that can lead either to the material deformation, to the cutting (micro cutting) or to the simultaneous micro cutting-deformation, function of the abrasive geometry. Starting from the model proposed by Lancy Torrance (fig.2) an Archard type relationship for the wear coefficient is established depending

On the penetrating component angle (roughness) in case it occurs (Lancey and Torrance, 1991; Torrance, 1996; Xie and Williams, 1996):
- the plastic deformation of the material (fig.3):

$$k_A = I_{uz} = 1,5 \cdot \sqrt{3} \cdot \frac{\sin^2 \alpha + 0,5 \sin 2\alpha}{1 + 2 \sin \alpha} \qquad (4)$$

- cutting (microcutting) of the material (fig. 4)

$$k_{Aa} = I_{uza} = \frac{3\sqrt{3}}{C_n + tg\theta \cdot ctg\Phi - 1} \qquad (5)$$

where:
I_{uz}, I_{uza} - the wear intensity at plastic deformation respectively the wear intensity when microcutting;
α - the "attack" angle of the surface which was considered a rigid one;
C_n - the hardening characteristic "strengthening" of the material experimentally established ($C_n \approx 0,8....1,2$).
θ - chip angle (determinable size)
ϕ - angle of the shearing plan

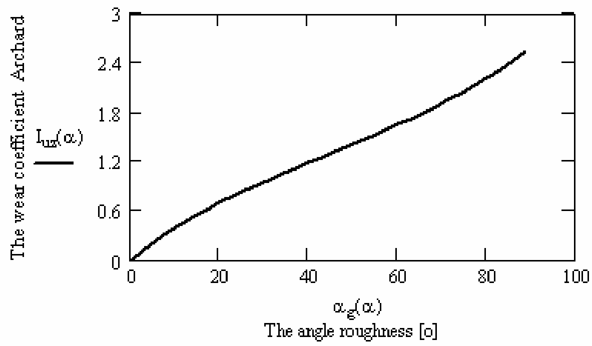


Figure 3 Variation of the wear coefficient Archard type for plastic deformation function of the inclination angle of the roughness

It can be pointed out that the chip forming occurs if the shearing angle $\phi \geq 0$ and the micro cutting appears if the angle of the roughness exceeds a critical value α_{cr}.

In the paragraph II the inconveniences of the shown models are mentioned namely these models do not take into consideration the number of asperities and the dimension of the angle from which one of the scratch wear form appears (local deformation, cutting – micro cutting or both).

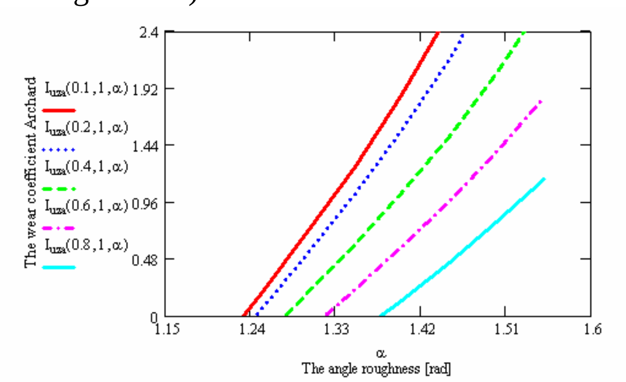


Figure 4 Variation of the wear coefficient Archard type for the cutting (micro cutting) function of the inclination angle of the roughness

Taking into consideration this idea, the proposed model considers that all the roughness can deformable plan but the frequency function of the inclination angle $p_{r(\alpha)}$ of them is a random variable withim the interval α_{min}, α_{max}.

Taking into consideration a variation of the frequency function of the inclination angle) $p_{r(\alpha)}$ of being constant, linear, exponential and/or Gauss normal the form of the medium wear coefficient can be established:

$$I_{uzm} = \int_{\alpha_{min}}^{\alpha_{max}} I_{uz}(\alpha) \cdot p_r(\alpha) d\alpha \qquad (6)$$

With this form of the medium wear coefficient, the variation way of it can be established function of the size of the inclination angle as follows:

- fig. 5 - shows the variation of the medium wear coefficint for an inclination angle $\alpha < \alpha_{cr}$ for which plastic deformation only will appear without appearing cutting (microcutting) processes;
- fig.6 - shows the variation of the medium wear coefficient for an angle $\alpha_{cr} < \alpha < \pi/2$ from which the cutting (microcutting) appears;
- fig. 7 - shows the variation of the medium wear coefficient for an angle $\alpha_{min} < \alpha < \pi/2$ from which some of the roughness (penetration) will plastically deform the material and others will cut (microcut).

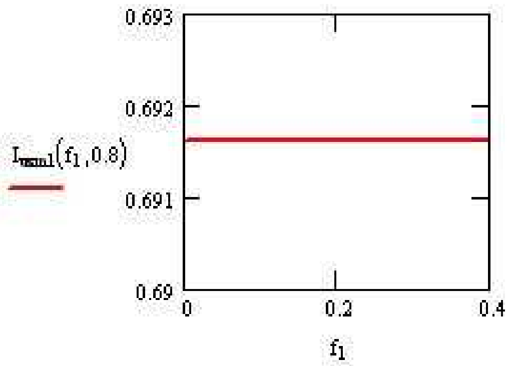


Figure 5 The variation of the medium coefficient for an inclination angle $\alpha < \alpha_{cr}$ for which plastic deformation only will appear without appearing cutting (micro cutting) processes;

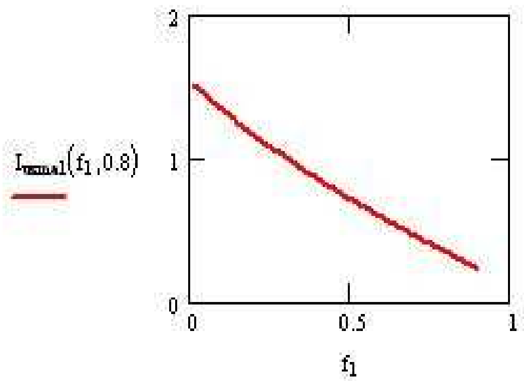


Figure 6 The variation of the medium wear coefficient for an angle $\alpha_{cr} < \alpha < \pi/2$ from which the cutting (micro cutting) appears;

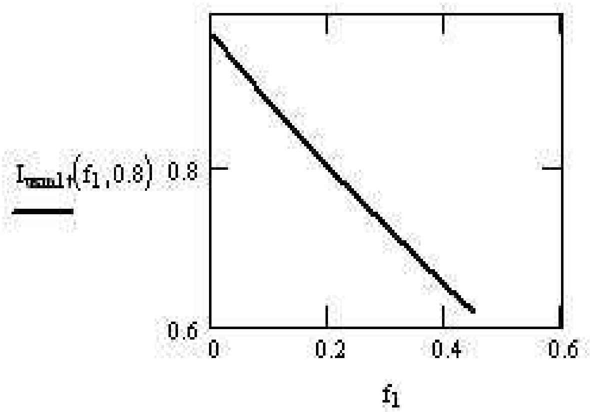


Figure 7 The variation of the medium wear coefficient for an angle $\alpha_{min} < \alpha < \pi/2$ from which the cutting (micro cutting) appears

4. CONCLUSION

The new model that has been created is a complete and complex model establishing the evolution of the wear intensity starting from de relationship of the wear coefficient described by Archard (for the adhesion wear) and confirmed by other researchers for the scratch wear:

- the number of the asperities (penetrators) in contact with the less hardened material;
- the inclination angle of the roughness from which different forms of the schratch wear can appear (deformation, cutting etc.);
- the material characteristics (resistance to shearing, hardness etc.);
- the adhesion coefficient of the materials;
- the displacement speed of the penetrator.

By analysis the graphics shown in this work we can conclude that in case the material is deformed under a wave form, the wear coefficient Archard type increases and in case of the material cutting (micro cutting) this coefficient decreases by the adhesion coefficient of the material thing which was experimentally noticed in different special articles.

5. REFERENCES

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