THE COEFFICIENT OF FRICȚION IN THE FRETTING PHENOMENON

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Abstract: *Fretting is now fully identified as a small amplitude oscillatory motion which induces a harmonic tangential force between two surfaces in contact. The present paper argues that adhesion forces and elastic deformation in the contact zone may contribute significantly to the relative displacement during fretting of metals A tangential force whose magnitude is less equal on greater than the force of limiting friction will not give rise to a sliding motion. It is determined the energy loss dissipated per fretting cycle*

Keywords: Fretting, adhesion, friction coefficient.

1. Introduction

To study the phenomenon of fretting it is necessary to determine appropriate working arrangements with the establishment of borders between different regions as accurate. You can establish criteria for transition between partial slip and slide, all these criteria depending on normal force and tangential displacement brought on the contact.

Experimental research aimed to determine the size of different existing regions within a sphere-plan contact subjected to tangential displacement of small amplitude [1,2,3].

Following the experimental investigations there was determined the size of the wear resulting from fretting tests. Thus, there were determined the rays of gluing circles obtained in the central regions of the traces of wear, for variable normal pressure forces and for different durations, respectively the size of the ring area of microslip, that surrounds the seams.

In a theoretical approach to the phenomenon of fretting the size of the areas specific to the phenomenon (stick and partial slip) was considered depending on various factors that influence the phenomenon [4].

Also, the fretting phenomenon can be approached by two directions: a direction in which the friction coefficient between surfaces in contact is considered constant (the most common approach) and another approach to the phenomenon, involving variation of the friction coefficient in the fretting contact, variation due to the existence of adhesion between surfaces in contact.

This paper aims to address the phenomenon of fretting in terms of a variable coefficient of friction between the contact area.

For the experimental investigation of the phenomenon of fretting we used an experimental stand that allowed the investigation of four point contact under fretting.

There were thus determined the sizes of different fretting zones depending on the parameters of dependence, in this way being possible to determine the extent of these areas for a given configuration of the fretting contact.

2.Experimental means

Given the experimental stands on which it was tried to approach experimentally the phenomenon of fretting it was taken into account a point contact of I-st class ball / plane contact type. This contact was chosen because the actual contact area is approximately equal to the apparent contact area and for this type of contact there is a fairly comprehensive theory concerning the local tensions in contact and the size of contact area (Hertz, Mindlin, Johnson).

Also the sphere / plan contact highlights (experimental research) the fretting mechanism characterized by three regimes: I-adhesive, II- partial sliding, III total sliding.

For the study of the fretting phenomenon in case of elastics assemblages spring slides with multiple sheets, I used the experimental stall from fig.1[5].

The stall can be used for the testing at fretting of some couples by different materials. This stall can be adapted for study of the lamellar springs with many sheets.

The lamellas used in experiments have the dimensions 560x56x2 mm and are realized by spring steel having hardness 55 HRC.

The balls are spring balls and have 19 mm in diameter. The lamella is supported in inferior side on 4 balls in superior side the charge of the contact is made through the agency of 4 balls. The rod-crank mechanism permits a displace at the end (extremity) of the 20 mm lamella and can modify this displace by changing of the system eccentricity. The system is auctioned through the agency of electrical engine having revolution of 750 rot/min.
Helping with this experimental stall we can made fretting tries for normalness and different forces for different numbers of solicitation cycles.

After conducting various experiments there were obtained different traces of wear that correspond to a fretting wear. Thus, it could be determined the fretting wear dependence on the number of cycles and normal load force, and could be compared different traces of fretting by comparing the size of various areas of contact fretting for some conditions.

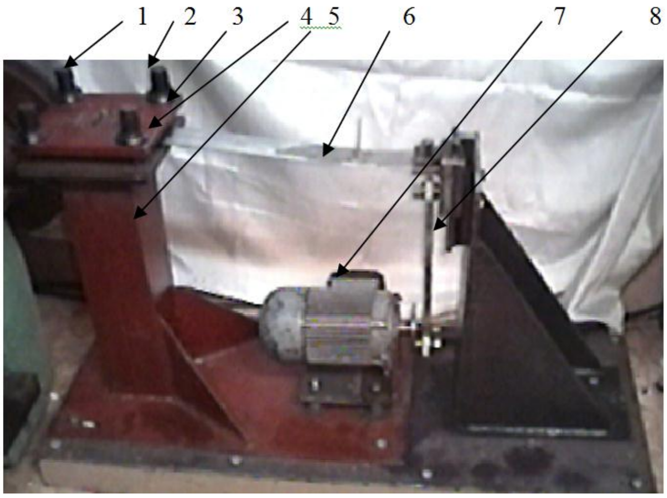

Fig. 1. Experimental stand for the study of fretting. [5]

Traces of wear obtained (Fig. 2) were taken with a video camera, subsequently being processed on the computer. The movement at the contact level was measured by video camera and computer. Measurement of the movement was for the two rows of balls. On these experimental traces obtained it can be observed a central area corresponding to the a central area of adhesion between balls and lamella, and a ring zone surrounding the central area, corresponding to a partial sliding area.

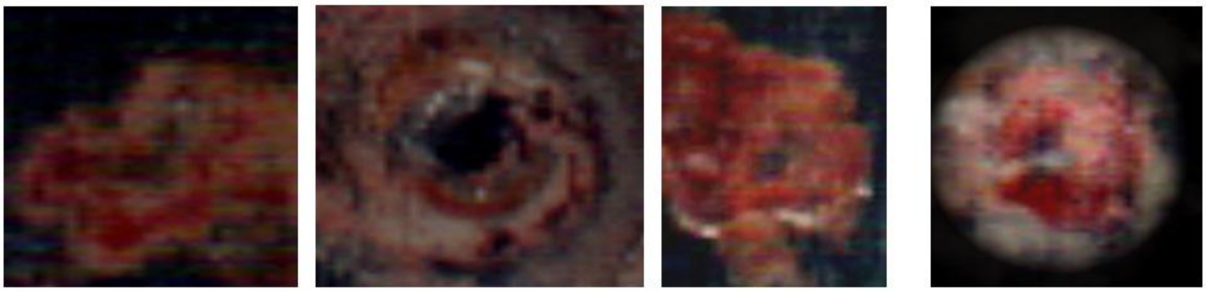

Fig. 2 The wear traces of fretting

The results are obtained with sufficient precision, being thus possible a proper experimental investigation of the fretting phenomenon and being possible to experimentally confirm this theoretical results obtained from investigating of a sphere-plan contact subjected to an oscillatory movement of small amplitude.

3. The dependence of friction coefficient

After experimental tests, the size ratio between the radius of adhesion and the whole radius of the wear trace is shown in Table 1 and Table 2 for a normal pressing force of 250 N. The fretting coefficient between surfaces in contact is not constant but varies according to a law of the form[2]:

$$\mu_{ad} = \frac{\tau_0}{p_{ad}} + \beta \qquad (1)$$

with the normal pressure at adhesion given by a law of the form[6]:

$$p_{ad} = \left(1 - r_a^2\right)^{1/2} - \frac{2}{3}\frac{k_{ad}^{1/2}}{\left(1 - r_a^2\right)^{1/2}} \qquad (2)$$

thus:

$$\mu_{ad} = \frac{\tau_0}{\left(1 - r_a^2\right)^{1/2} - \frac{2}{3}\frac{k_{ad}^{1/2}}{\left(1 - r_a^2\right)^{1/2}}} + \beta \qquad (3)$$

Based on the theoretical diagrams of dependence of the central radius of adhesion the results obtained from experimental investigation of fretting contact can be checked.

So, in Fig.3 there are presented the radius of circles obtained following the fretting test with a normal force of 250N.

The radius of the adhesion circle is represented by load factor "k". It is noted that the adhesion area corresponds to a loading factor approximately equal to 0.24[6].

Table 1.Traces of wear (F = 250N, front)

Nr. crt.	Loading [N]	Number of cycles	Radius central [mm]	Radius ext. [mm]	c_a=c/a	p_{ad}	□
1	250	20000	0.21621	0.5029	0.4299	0.87953	0.21370
2	250	30000	0.22514	0.6518	0.3454	0.91599	0.20917
3	250	40000	0.27878	0.6974	0.3997	0.89365	0.21190
4	250	50000	0.29076	0.7640	0.3805	0.90198	0.21087
5	250	60000	0.30679	0.8329	0.3683	0.90703	0.21025

Table 2. Traces of wear (F = 250N, back)

Nr. crt.	Loading [N]	Number of cycles	Radius central [mm]	Radius ext. [mm]	c_a=c/a	p_{ad}	□
1	250	20000	0.25508	0.4980	0.41048	0.88875	0.21252
2	250	30000	0.26596	0.6285	0.42316	0.88279	0.21328
3	250	40000	0.28529	0.6840	0.41709	0.88567	0.21291
4	250	50000	0.37127	0.7634	0.48633	0.84965	0.21770
5	250	60000	0.41306	0.7970	0.51826	0.83057	0.22040

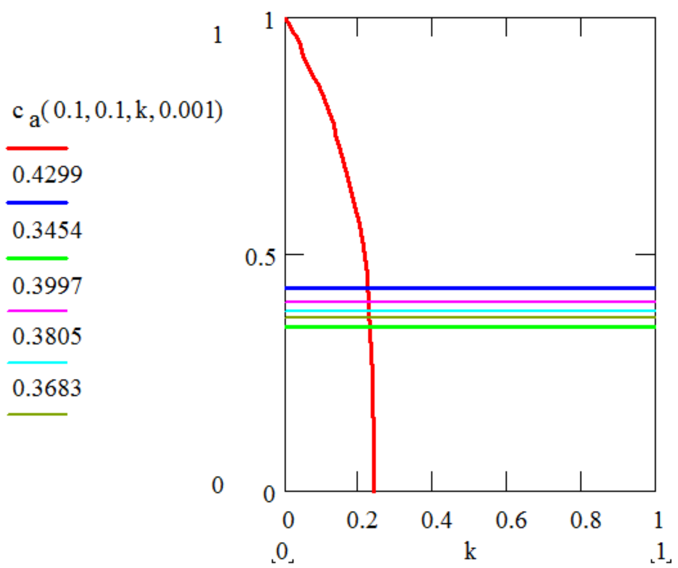

Fig. 3 Radius of the adhesion circle:

$$c_a(\tau_0, \bar{\beta}, k, k_{ad})$$

In Fig.4. and fig.5 are the dependence of friction coefficient of adhesion normal pressure for two cases investigated (normal force of 250N and two ball positions: front and back)

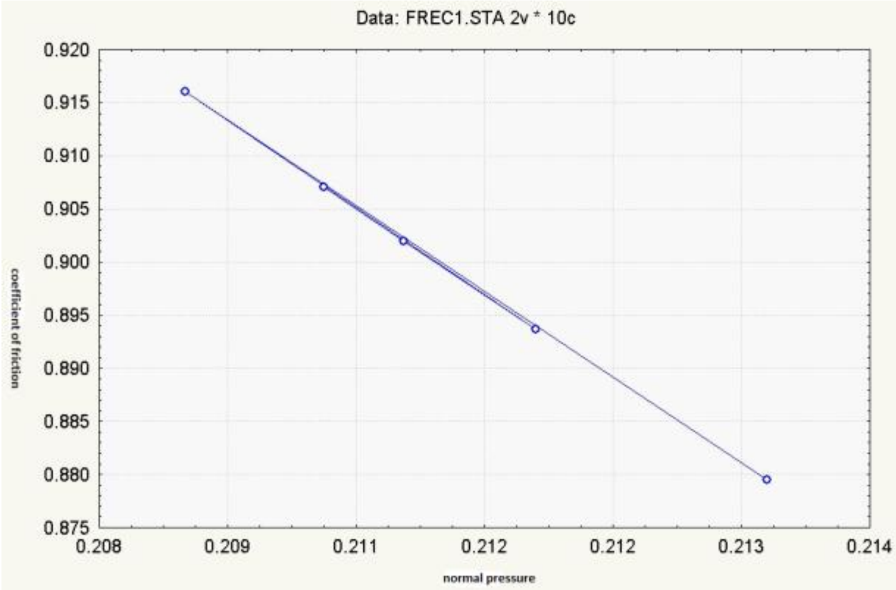

Fig. 4. The coefficient of friction ($\mu=\mu(p_{ad})$-front

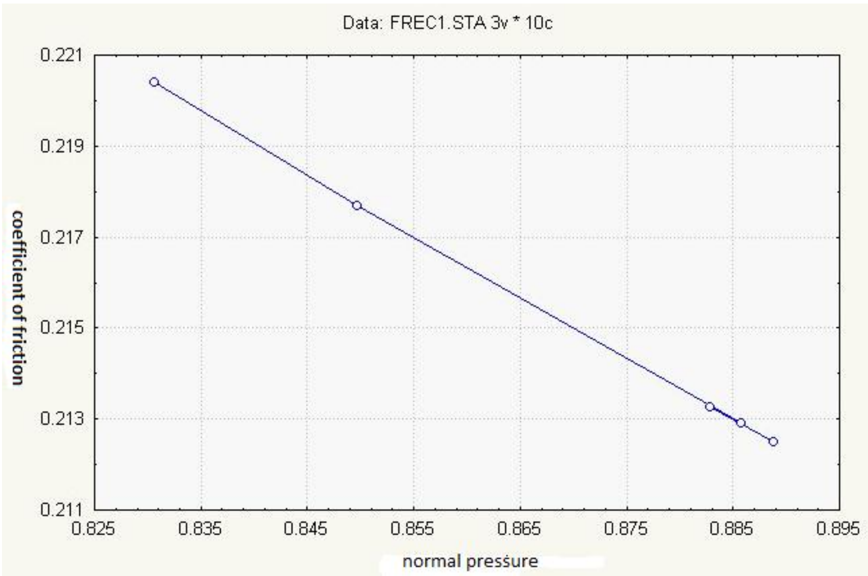

Fig. 5. The coefficient of friction ($\mu=\mu(p_{ad})$-back

3.Conclusion

Experimental tests have confirmed that the coefficient of friction between surfaces is not constant but variable. Variation is explained by the phenomena of adhesion that appear between the surfaces in contact. Thus, the assumption of a variable coefficient of friction between the surfaces was confirmed by experiments, theoretical results obtained in the study of fretting by considering a variable fretting coefficient receiving the confirmation of the experiment.

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