PARTIAL SLIDING OF THE FRETTING PHENOMENON

Prof.dr.eng. Ştefan GHIMIŞI, Constantin Brâncuşi University of Târgu Jiu, Romania
ssghimisi@gmail.com

Abstract: *Fretting damage is often the origin catastrophic failures or loss of functionality in many industrial applications. Considered as a plague for modern industry, fretting is encountered in all quasi-static loadings submitted to vibration and thus concerns many industrial branches. The main parameters were reported to be amplitude displacement, normal load, frequency, surface roughness and morphology, and residual stresses. 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.*

Keywords: fretting, wear, experiment

1. Introduction

Fretting is now fully identified as a small amplitude oscillatory motion which induces a harmonic tangential force between two surfaces in contact. It is related to three main loadings, i.e. fretting-wear, fretting-fatigue and fretting corrosion.

The main parameters were reported to be amplitude displacement, normal load, frequency, surface roughness and morphology, and residual stresses. More recently fretting has been discussed using the third-body concept and using the means of the velocity accommodation mechanisms introduced by Godet et al.

Fretting regimes were first mapped by Vingsbo[1]. In a similar way, three fretting regimes will be considered: stick regime, slip regime and mixed regime. The mixed regime was made up of initial gross slip followed by partial slip condition after a few hundred cycles. Obviously the partial slip transition develops the highest stress levels which can induce fatigue crack nucleation depending on the fatigue properties of the two contacting first bodies. Therefore prediction of the frontier between partial slip and gross slip is required.

The type of surface damage that occurs in fretting contact depends on the magnitude of the surface normal and tangential tractions. In existing fretting models the relative displacement is assumed to be accommodated mainly microslip in the contact surface [2], [3], [4].

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 simultaneously applied tangential force and normal into contact appears a adhesion force. A tangential force whose magnitude is less equal on greater than the force of limiting friction will not give rise on give rise to a sliding motion. It is determined the energy loss dissipated per fretting cycle.

2.Experimental means

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],[6], [7].
The stall permits testing for one slide and for spring slides with multiple sheets, too.

2.1. Description of the stall

On the rigid support the elastic lamella (6) is assembling through the agency of the superior plate (4) and of the screws (1).
The assemblage is made through the agency of 8 balls (4 balls inferior and 4 superior balls)(5) who assure a point contact between the ball and the lamella.

The elastic lamella (6) oscillates because of the rod crank mechanism with eccentric (8).This mechanism is actioned with the electrical engine (7) assuring the necessary conditions for producing the fretting phenomenon.
The contact is charged with the assistance of 4 screws (1) through the agency of some helicoidally springs (2) and through the agency of some radial-axial bearings with conic rolls.

The helicoidally springs beforehand standard permit a charge with a normal and known force, the presence of the radial-axial bearings (3) assuring the eliminate of friction between the screw and the superior plate.

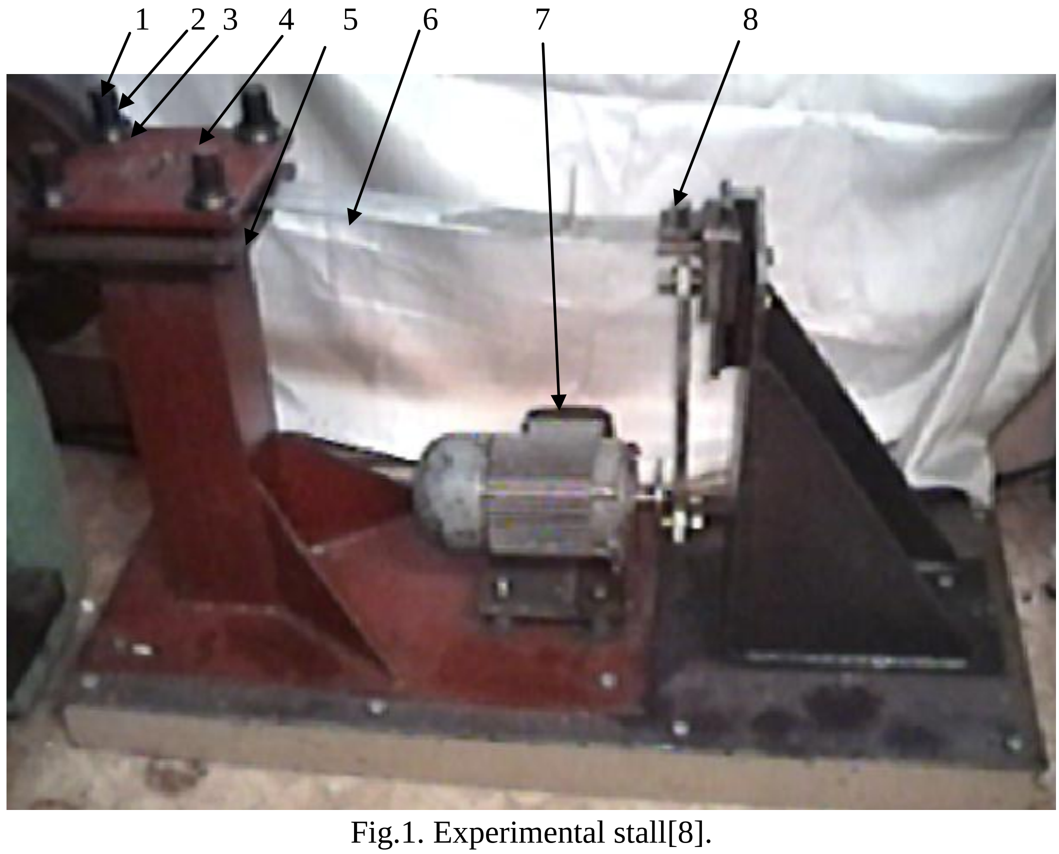


Fig.1. Experimental stall[8].

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 (fig.2) in superior side the charge of the contact is made through the agency of 4 balls. The rod-crank mechanism permits adisplace at the end (extremity) of the 20 mm lamella and can modify this displace by changing of the system eccentricity (Fig.3). The system is actioned through the agency of electrical engine having revolution of 750 rot/min.

Fig.2 Inferior side

Fig.3.The system excentricity

Helping with this experimental stall we can made fretting tries for normales and different forces for different numbers of solicitation cycles.
We obtained different wear traces corresponding fretting wear. So, we find the dependence of the normal charging force, and we can compare the different fretting traces by comparing of different fretting zones for certain conditions of contact.

Therewith we can compare the theoretical results previously presented with the experimental results. Traces wear obtained was assumed with a video camera and processing on the computer. The displacement at the contact level was determined, like we shown previously helping with the video camera and computer.

The determination of displacement was made for the two ranges of balls.

In the table 1. are the traces wear obtained for a normal charcing of 150 N on the each screw.

For comparing the traces wear obtained with the theoretical results obtained for the fretting phenomenon we determined the central area and the annular adjacent area, and the results are in the table 2 for the front balls and in the table 3, for the back balls. In fig.4. and 5 are the dependence of the wear traces by the cycles numbers for a normal force by 150 N and for the two position of the balls in front and back. [9], [10].

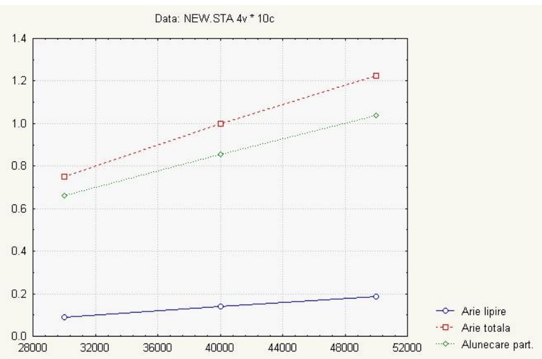


Fig.4. The dependence of the wear traces by the numbers of cycles for F= 150N; in front

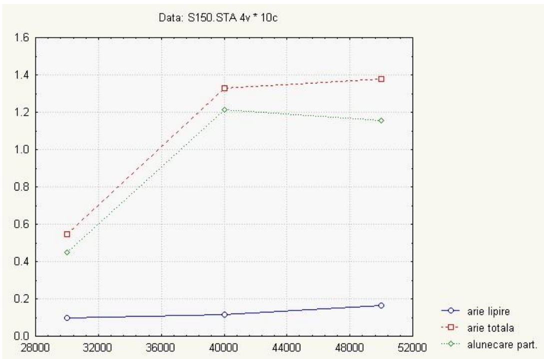


Fig.5. The dependence of the wear traces by the numbers of cycles for F= 150N;back

In fig.6,7,8,9,10,11 are the dependence of the partial sliding by the cycles numbers for a normal force by 150 N, 200N and respectively 250N for the two position of the balls in front and back. [11].

Table 1

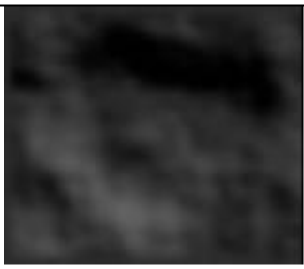
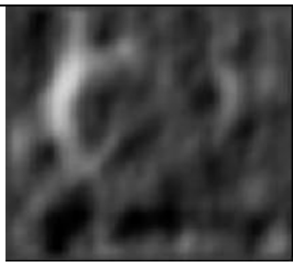
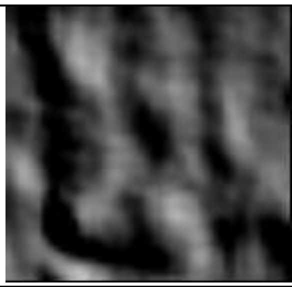
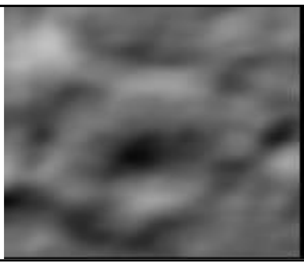
Number of cycles	Pozition of balls	
	face	back
30000		
40000		
50000		

Table 2

Nr. crt.	Loading [N]	Number of cycles	Area central [mm^2]	Radius central [mm]	Area ext. [mm^2]	Radius ext. [mm]	Area annular [mm^2]
1	150	30000	0.09087	0.17007	0.75040	0.4887	0.65953
2	150	40000	0.14207	0.21265	0.99770	0.5635	0.85563
3	150	50000	0.18636	0.24356	1.22522	0.6245	1.03886

Table 3

Nr. crt.	Loading [N]	Number of cycles	Area central [mm^2]	Radius central [mm]	Area ext. [mm^2]	Radius ext. [mm]	Area annular [mm^2]
1	150	30000	0.09610	0.17489	0.54559	0.4167	0.44949
2	150	40000	0.11547	0.19172	1.32867	0.6503	1.21320
3	150	50000	0.16672	0.23037	1.37761	0.6622	1.21089

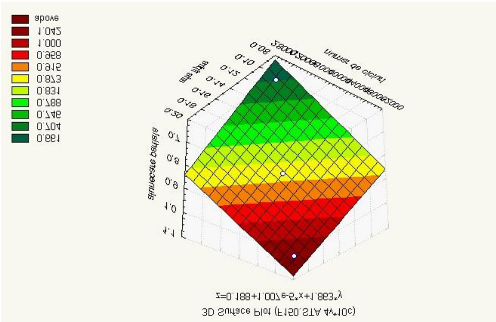


Fig.6 Partial sliding from F=150N - front

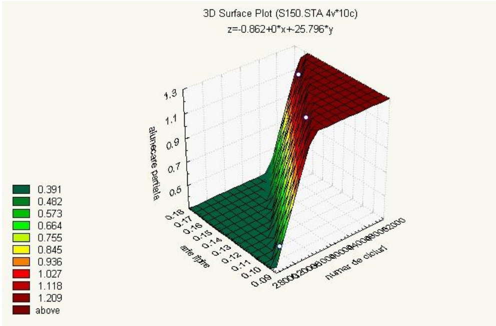


Fig.7 Partial sliding from F=150N – back

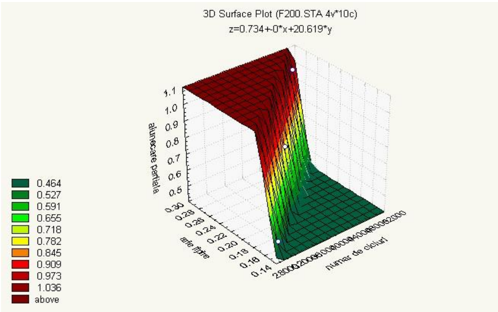


Fig.8 Partial sliding from F=200N - front

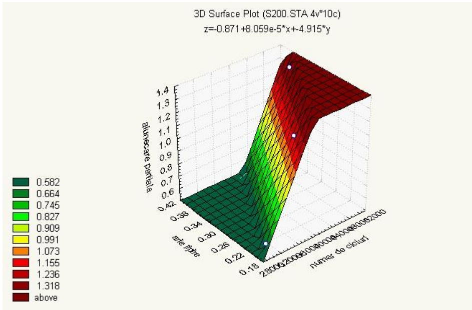


Fig.9 Partial sliding from F=200N – back

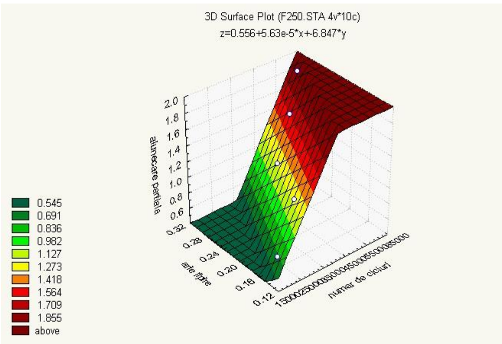


Fig.10 Partial sliding from F=250N - front

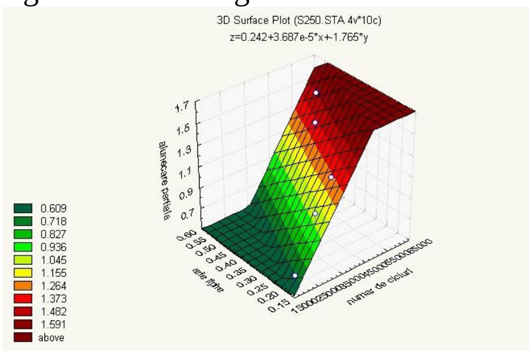


Fig.11 Partial sliding from F=250N – back

In fig.12, 13 and 114 are the dependence of the partial sliding by the cycles numbers for a normal force by 150 N

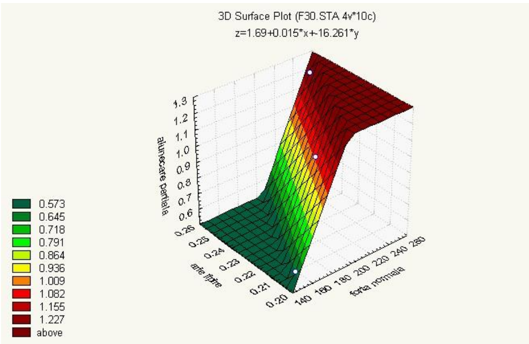


Fig.12 Partial sliding from Nc=30000 cycles

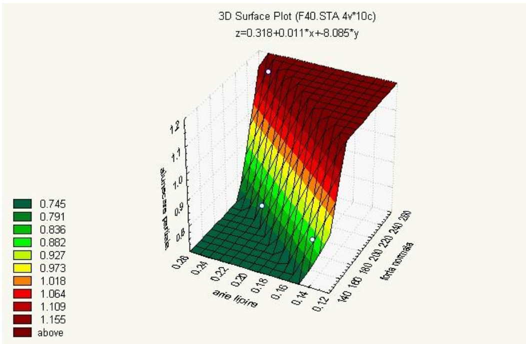


Fig.13 Partial sliding from Nc=40000 cycles

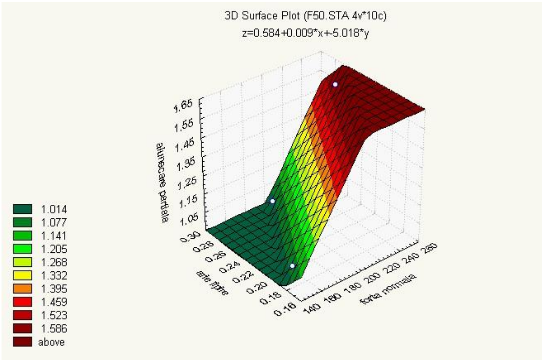


Fig.14 Partial sliding from Nc=50000 cycles

3.Conclusions

The experimental stall permits realization of the experimental tries for the study of fretting. We can determine the different size of the fretting areas and we can compare these with the theoretical results.

Can be made considerations for existence of one friction coefficient who is variable between the surfaces corresponding by one fretting contact.

References

[1] O.Vingsbo and M.Soderberg,*On fretting maps,*Wear, 126 (1988) 131-147

[2].Ghimisi, S., *Analysis of fatigue stress in a hertzian form.* Fiability & Durability/Fiabilitate si Durabilitate, 2011, 1.

[3] D.W.Hoeppner,*Mechanisms of fretting fatigue and their impact on test methoda development*,ASTM-STP 1159(1992) 23-32

[4]. Fouvry, S., Kapsa, Ph, Vincent, L.,1995,*Analysis of sliding behaviour for fretting loadings: determination of transition criteria*,*Wear*,185 p. 35-46

[5]. Ghimisi, S., *An elastic-plastic adhesion model for fretting*, 15 Th. In: Symposium “Danubia Adria”, Bertinoro, Italia. p. 181-183.

[6].Ghimisi, S., *Contribution regarding the wear by fretting with applications at the elastic assembling.* Teză de doctorat, Universitatea Politehnica Bucuresti, 2000.

[7].Ghimisi, S., *Test stands and methods for investigating the fretting phenomenon*. Fiability & Durability/Fiabilitate si Durabilitate, 2018, 2.

[8].Ghimisi, S., *Experimental investigation of the fretting phenomenon-dependence of number cycles*, Baltrib’09. In: V International Scientific Conference PROCEEDINGS. 1822. p. 226-230.

[9].Ghimisi, S.; Luca, L.; Popescu, G., *Transition in the fretting phenomenon based on the variabile coefficient of friction*. In: Advanced Materials Research. Trans Tech Publications, 2012. p. 343-346.

[10].Ghimisi, S., *Analysis of fatigue stress in a hertzian form.* Fiability & Durability/Fiabilitate si Durabilitate, 2011, 1.

[11].Ghimisi, S., *Study of the transition in the fretting phenomenon*. Baltrib, 9, 2009, pp.19-21.

[12].Ghimisi, S., *Elemente de tribologie*, MATRIXROM, 2005.