THE DANG VAN FATIGUE CRITERION OF 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. It is related to three main loadings, i.e. fretting-wear, fretting-fatigue and fretting corrosion. 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.[1], [2], [3] In this paper we approach the fretting-fatigue obtaining a quantification of cracks appearance using the Dang Van fatigue criterion. In the study, a sphere-plane contact is considered, subjected to a state of tension [4,5]

Keywords: tension, criteria, friction coefficient, fissures

1.INTRODUCTION

The fretting phenomenon is a very complex deterioration phenomenon including, broadly speaking, two distinct processes: a process of fretting-wear which means areas deterioration with or without material detachment from the friction surfaces, and a process of fretting-fatigue which mainly involves the appearance of cracks within the friction surfaces. In this paper we approach the fretting-fatigue obtaining a quantification of cracks appearance using the Dang Van fatigue criterion. In the study, a sphere-plane contact is considered, subjected to a state of tension [7,8,9].

2. DANG VAN FATIGUE CRITERION

For the characterization of the tension state at the contact level, respectively in order to determine the fissure risk the Dang Van criteria can be used.

In this way, for a pressure imposed on the contact:

$$p = \frac{1}{3}\left(p_{xx} + p_{yy} + p_{zz}\right) \quad (1.a)$$

$$p_e = \frac{1}{3}\left(p_{xxe} + p_{yye} + p_{zze}\right) \quad (1.b)$$

$$p_z = \frac{1}{3}\left(p_{nzxx} + p_{nzzz}\right) \quad (1.c)$$

and a tangential tension :

$$\tau = \frac{1}{2} p_{fxx} \quad (2.a)$$

$$\tau_e = \frac{1}{2} p_{fxxe} \quad (2.b)$$

$$\tau_z = \frac{1}{2} p_{fzxz} \quad (2.c)$$

The Van Dang criteria can be written:

$$d = \frac{\tau}{\beta - \alpha p} = \frac{\tau}{\beta - \left(3c_D - 1.5\right)p} \quad (3)$$

with:

$$\beta = \frac{c_D}{k_{ad}}, c_D = \frac{\tau_D}{\sigma_D}, k_{ad} = \frac{p_0}{\sigma_D}$$

k_{ad}, σ_D, τ_D - the characteristics of the elements materials in contact

In equation (1) and (2) the pressures and the tangential tensions are represented for a point in the interior of the charged surface as well as for a point outside the charging zone, respectively on axe z

The size of these normal pressures and tangential tensions as well as their dependency to diverse parameters is represented in the following figures. In Fig.1, the dependency of pressure p for different values of r is represented (corresponding with the different positions of the point in the charged zone) and maintaining the μ coefficient at a 0.6 value.

A movement of the minimum pressure towards the exterior of the charged zone is observed as well as a decreasement of this value, with the increasement of coefficient μ.

In the exterior of the charged zone, the pressure varies with the position of the determined point as in fig.2. [10,11].

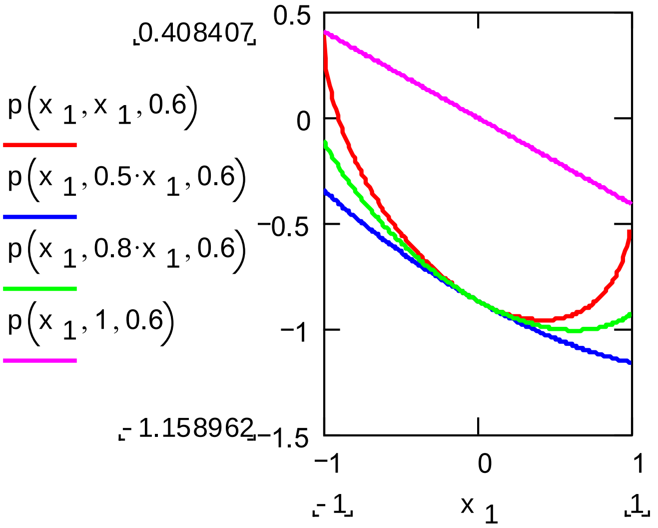

Figure 1.The dependency of pressure p(x,r,μ), (μ=0.6)

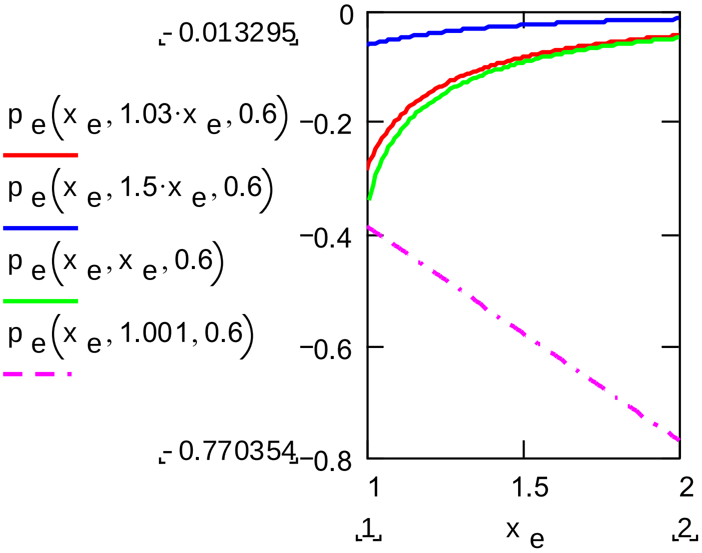

Figure 2. The dependency of pressure $p_e(x,r,\mu)$ (μ=0.6)

In fig. the dependency of pressure from the exterior of the zone charged by coefficient μ is represented. An increase of the pressure is observed at the rise of the friction coefficient.

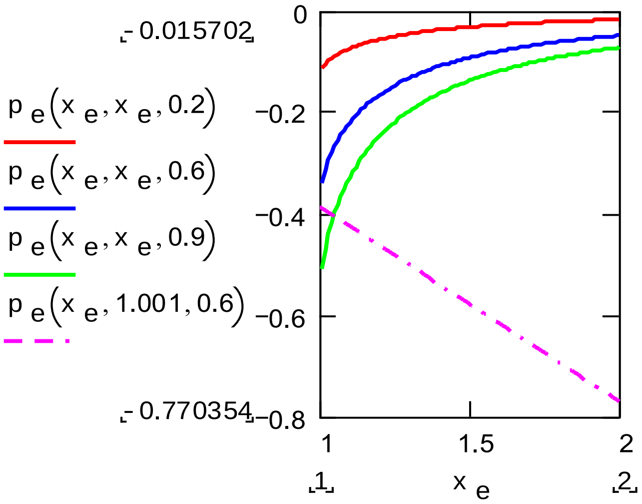

Figure 4. The dependency of pressure $p_e(x,r,\mu)$ (r=x$_e$

For the zone outside the charged area the variation of τ_e with coefficient μ is made as in fig.5, an increase in the tension with the rise of μ being observed. In order to have better imagine of the state of tension at the level of contact the dependency between the normal pressure p and the tangential tension τ (fig.6).[12,13]

The Dang Van criteria can be written as:

$$d=\frac{\tau}{\tau_a}=\frac{\tau}{\frac{c_D}{k_{aD}}-(3c_D-1.5)p} \qquad (4)$$

respectively:

$$d_z=\frac{\tau_z}{\tau_a}=\frac{\tau_z}{\frac{c_D}{k_{aD}}-(3c_D-1.5)p} \qquad (5)$$

Where: τ_a represents the admissible tangential tension dependent on the characteristics of the couples materials in contact

In order to understand the deterioration process both the tangential tension as well as the admissible tangential tension are represented in the same graphic (fig.7), in this way being able to make considerations regarding the deteriorations stasis of a contact depending on the appeared tensions. Based on this graphic the next considerations can be made[14]:

- for coefficient k_{aD} <0.6 the tangential tension inside the charged zone is inferior to the admissible tension for any value of coefficient μ;
- for k_{aD} =0.6 the admissible tangential tension is exceeded for a big value of coefficient μ (μ=0.9);
- for a value of the coefficient k_{aD} =0.9 the admissible tension is exceeded for μ=0.5.

The representation in fig.7 can be used in order to diagnose the state of a contact when the couple materials and its solicitation are known

The Dang Van Criteria can be written as: „ if coefficient d is bigger than 1 then there is a fissure risk, in other case there is no such risk”[15]

In fig 8 and 9, the Dang Van Criteria for different friction couples inside the charged area is represented

In this way it can be observed that for k_{aD} =0.7 the friction risk appears for a coefficient μ=0.7, which confirms previous statements.

For a coefficient k_{aD} =0.6 the fissure risk appears for a coefficient μ=0.9. In fig.10 the Dang Van criteria for existing tensions after axe z is represented

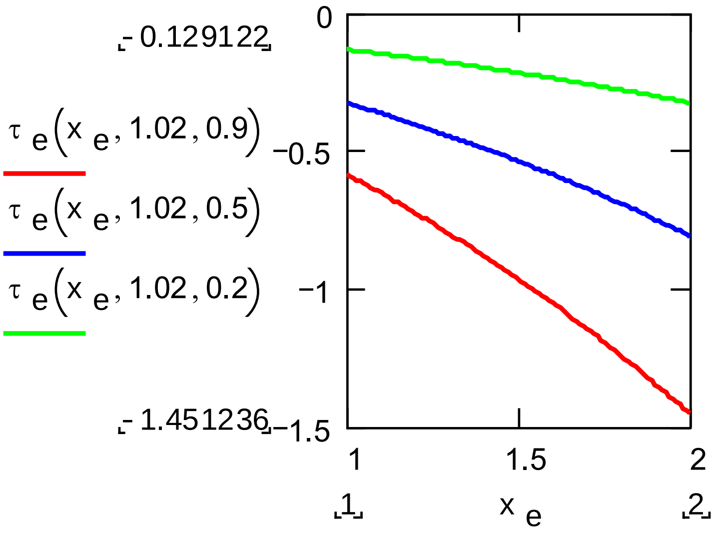

Figure 5. The dependency of the tangential tension $\tau_e\ (x,r,\mu)$ (r=x$_e$) to coefficient μ

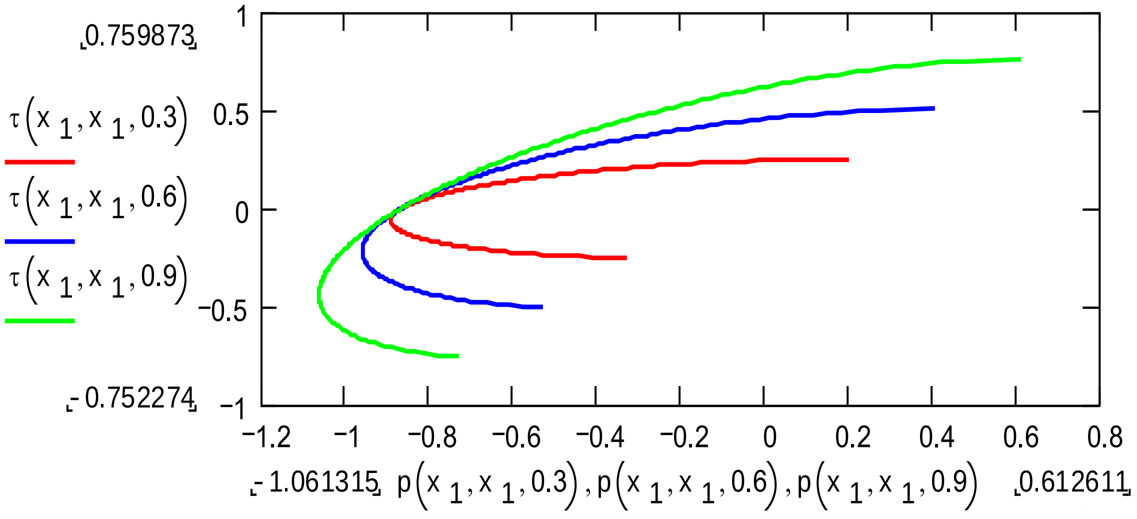

Figure 6.The variation of the tangential tension $\tau\ (x,r,\mu)$

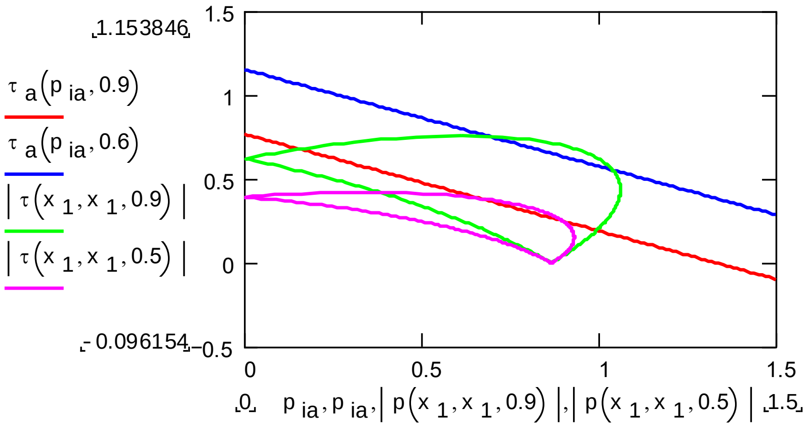

Figure 7. The variation of the tangential tension

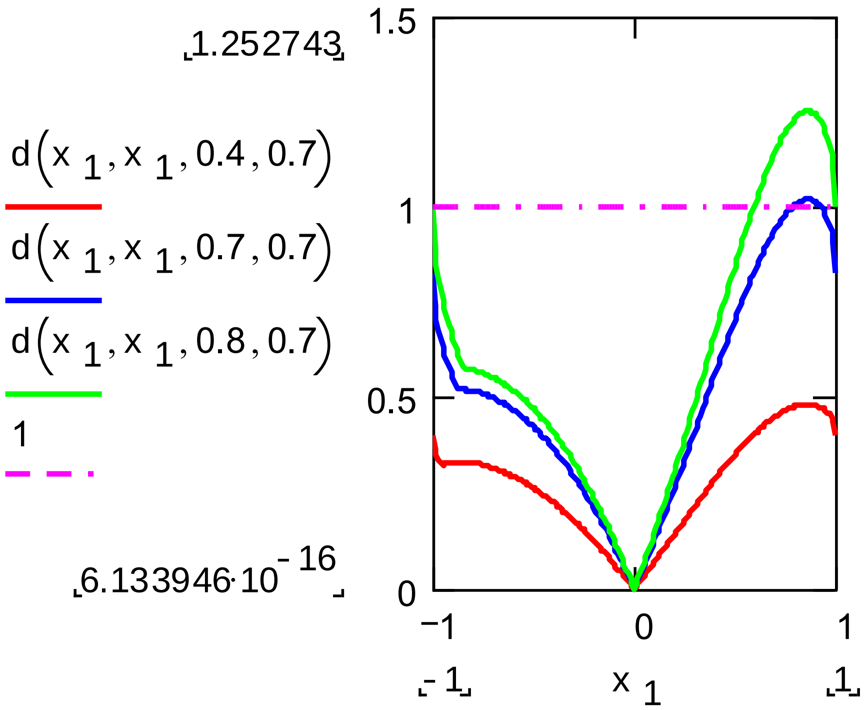

Figure 8 Dang Van Criteria $d(x, r, \mu, k_{aD})$ inside the charged area

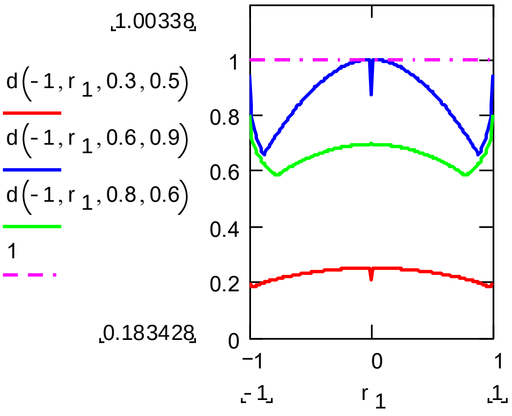

Figure 9 Dang Van Criteria $d(x, r, \mu, k_{aD})$ inside the charged area

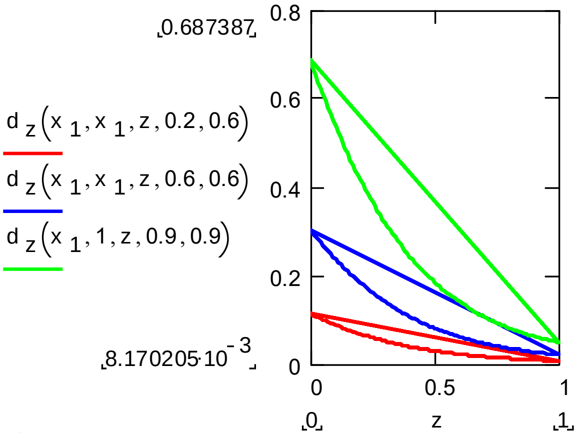

Figure 10 Dang Van Criteria $d_z(x, r, z, \mu, k_{aD})$ after axe z

3. CONCLUSION

The study of tensions for the contact sphere-plane as well as the representation of the fatigue criteria's for this contact are making possible the understanding of the state of tension at the contact level, respectively permits the projection of the contacts in order to avoid the apparition of fissures at the contact level.

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