THE DIFFERENTIAL CRITERIONOF THE TRANSITION 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. It is related to three main loadings, i.e. fretting-wear, fretting-fatigue and fretting corrosion. Three fretting regimes will be considered: stick regime, slip regime and mixed regime. 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.*

Keywords*:* wear, frettin, transition, differential criteria.

1.Introduction

Fretting is now fully identified as a small amplitude oscilatory 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 displasement, 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.[1,2]

This papers proposes several criteria to determine the transition between partial slip and gross slip. A theoretical expression of the transition depending on the applied normal force and the tangential displacement will be introduced in order to plot fretting maps. All the relations exposed in the present paper obey the restrictive conditions exposed by Mindlin[3]. A ball on flat contact will be considered with a constant normal force P and a varying tangential force Q. All the relations were written using Johnson's notation [4]

2.Transition differential criteria

The transitions between partial slip and gross slip can also obtained using a derivation of the function Q=f(δ) and $W_d = f(\delta)$ with regard to the displacement amplitude δ.[5]
Two different expressions are introduced for each of these functions depending on the sliding condition. Demonstration will only be given in the case of partial slip and for the force approach.

2.1.The case of the partial sliding

In this case we analyzed the transition criterions both friction with constant coefficient and for the case of one variable friction coefficient between surfaces.

a) Constant friction coefficient

In this case the relative displace will be:

$$\delta_{ars}(\mu,k_{as}) = \delta_{ar}(\mu,k_{as}) \tag{1}$$

The first derivative is:

$$D_{er}(\mu,k_{as})=\frac{d}{dk_{as}}\delta_{ars}(\mu,k_{as}) \quad (2)$$

Respectively the second:

$$D_{er2}(\mu,k_{as})=\frac{d^2}{dk_{as}^2}\delta_{ars}(\mu,k_{as}) \quad (3)$$

The graphic representation of the two derivatives in relation with the contact loading is in fig.1

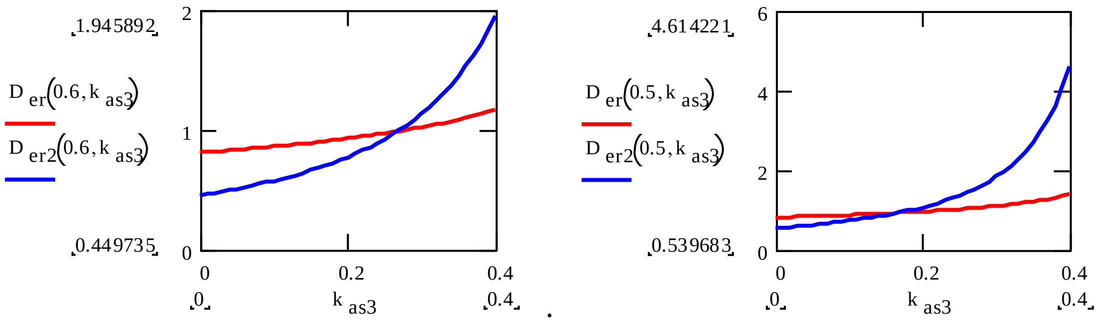

***Fig.1**.The dependence of the differential criterion* $D_{er2}(\mu,k_{as})$

b) Variable friction coefficient

In this case the two derivatives of the sliding will be:

$$D_{era}(\tau_0,\beta,k_{ad},r_a,k_{as},\alpha)=\frac{d}{dk_{as}}\delta_{frs}(\tau_0,\beta,k_{ad},r_a,k_{as},\alpha) \quad (4)$$

$$D_{er2a}(\tau_0,\beta,k_{ad},r_a,k_{as},\alpha)=\frac{d^2}{dk_{as}^2}\delta_{frs}(\tau_0,\beta,k_{ad},r_a,k_{as},\alpha) \quad (5)$$

The graphic representation of the two derivatives in relation with the contact loading is in fig.2.

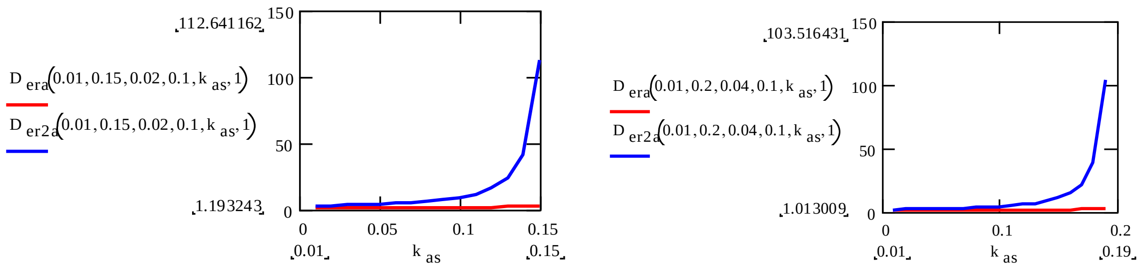

***Fig.2.**The dependence of the differential criterion* $D_{er2a}(\tau_0,\beta,k_{ad},r_a,k_{as},\alpha)$

2.2.Theenergetical case

a)constant friction coefficient

The first derivative of the energy in relation with the load is:

$$D_{ee1}(k_{as},\mu)=\frac{d}{dk_{as}}\Delta E_a(k_{as},\mu) \quad (6)$$

Respectively the second:

$$D_{ee2}(k_{as},\mu)=\frac{d^2}{dk_{as}^2}\Delta E_a(k_{as},\mu) \quad (7)$$

The graphic reperesentation of this criterion in relation with the load is in fig.3.

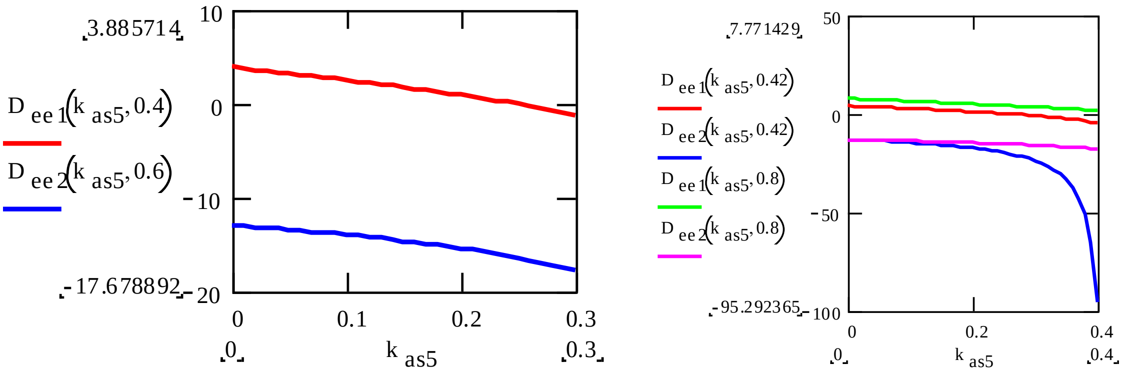

Fig.3 *The dependence of the differential energetical criterion* $D_{ee2}(k_{as},\mu)$

b) variable friction coefficient

In this case the two derivatives will be:

$$D_{eea1}(\tau_0,\beta,k_{ad},r_a,k_{as},\alpha)=\frac{d}{dk_{as}}\Delta E_{ad}(\tau_0,\beta,k_{ad},r_a,k_{as},\alpha) \tag{8}$$

$$D_{eea2}(\tau_0,\beta,k_{ad},r_a,k_{as},\alpha)=\frac{d^2}{dk_{as}^2}\Delta E_{ad}(\tau_0,\beta,k_{ad},r_a,k_{as},\alpha) \tag{9}$$

The graphic representation of the two derivatives is in fig.4

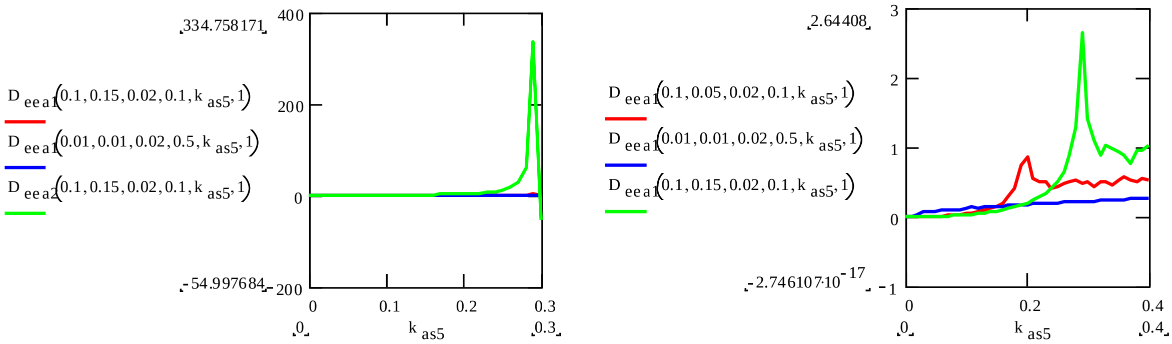

Fig.4.*The dependence of the differential energetically criterion* $D_{eea2}(\tau_0,\beta,k_{ad},r_a,k_{as},\alpha)$

The transition can be seen like a discord observed for the second derivative. For the presented case the discord is observed for k_{as}=0.28.

4. Conclusion

The definition of this transition criterion is useful in the knowledge of fretting phenomenon through the possibility of the established by a limit between the partial sliding and the total total sliding.

The differential criterion permits the quantification of the dynamical evolution of different parameters. The introduction of the transition criterions with the consideration of the adhesion phenomenon existent at the contact level and the consideration of the friction coefficient between the contact areas being variable represents a progress in the knowledge of the fretting phenomenon.

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