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ANALYSIS OF WEAR PROCESSES FOR MONOTONIC OR PERIODIC SLIDING AND LOADING CONDITIONS

I. Páczelt[1], Z. Mróz[2], S. Kucharski[2] and A. Baksa[1]
[1]*Institute of Applied Mechanics, University of Miskolc, Hungary*
[2]*Institute of Fundamental Technological Research, Warsaw, Poland*

1. Introduction

The wear process on the contact interface of two bodies in a relative sliding motion induces shape evolution. In many cases the wear process tends to a steady state. The simulation of contact shape evolution is performed by numerical integration of the modified Archard wear rule. The steady state is reached when the contact pressure is fixed on the moving contact zone and the rigid body wear velocity is constant in time. It is important, that in general contact conditions the vector of wear rate is not normal to the contact surface and has tangential component. A fundamental assumption was introduced, namely, *in the steady state the wear rate vector is collinear with the rigid body wear velocity of a sliding body, allowed by boundary constraints* [1]. The quasi-steady wear state corresponds to contact pressure distribution dependent on a slowly varying contact zone $S_c(t)$ size and shape, cf. [2].

Several classes of wear problems can be distinguished for specified loading and support conditions for two bodies in the relative sliding motion: *Case 1*: The contact zone S_c is fixed on one of sliding bodies (like punch) and translates on the surface of the other body (substrate). The relative velocity between the bodies is constant in time, or periodically changing. The normal load is assumed as fixed or varying periodically. After a transient braking process, a steady wear state is reached for periodic load in-phase with the periodic sliding motion. *Case 2*: The contact zone $S_c(t)$ varies slowly with the sliding distance for the same loading conditions as in *Case 1*.

2. Variational method applied to steady wear state conditions

At constant load and relative sliding velocity the contact pressure distribution in the steady state can be derived by minimization of the wear dissipation power [1,2,3], that is without time integration of the Archard wear rule can be determined contact pressure.

For the cases of periodic normal loading and monotonic relative sliding between two bodies, the averaged contact wear form and the pressure distribution in a steady state can be specified in terms of the averaged load from minimization of the wear dissipation work during one period [4].

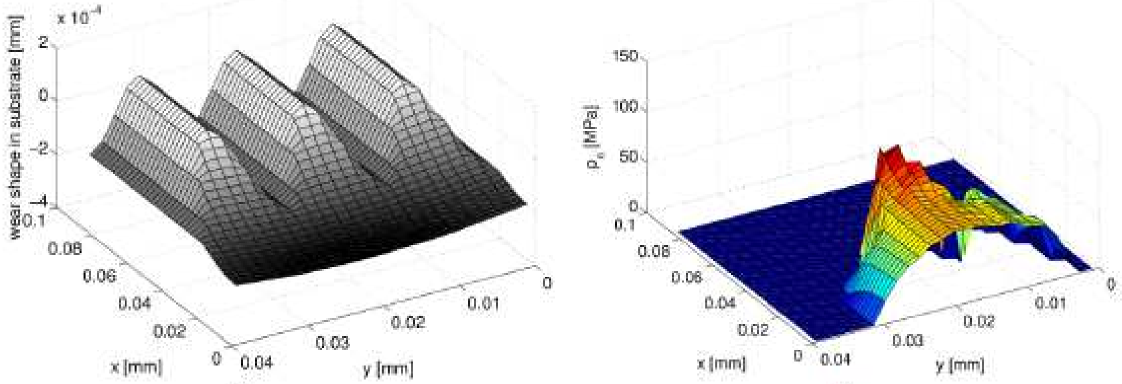
Numerical examples for braking system confirm the validity of prediction of the averaged shape in the contact zone for the case of monotonic strip sliding and also for the case of periodic sliding in phase with the normal load variation.

3. Numerical experiments

1. The steady state of wear process of drum brake is considered. The contact pressure distribution and the pin reaction forces are specified from the optimization problem of the local or global wear dissipation rate.

2. Convergence of the numerical solution for mechanical and thermal fields with *p*-version finite element method [5] will be demonstrated for periodic punch loading and monotonic sliding of the substrate without and with account for heat generation [6].

3. The anisotropic friction and wear modes are analyzed assuming varying friction coefficients. cf. [7]. The wear tests have been executed by means of the ball-on-disk wear tester by applying the reciprocal ball motion. Numerical analysis is performed assuming sliding along longitudinal and transversal sinosoidal roughness ridges. When in the transversal direction x the initial roughness of the substrate is: $g_0 = 0.000125 \cos(\frac{2\pi}{l_g}(y - y_c))$ [mm], where $l_g = 0.0128$ mm, $y_c = 0.02$ mm (see Fig.1) then the shape evolution is presented in Fig.1a and the contact pressure at the ball position $y_{sphere} = y_c$ in Fig 1b.



a) b)

Fig. 1. Evolution of the a) wear shape after $n_{cycle} = 120$ periodic cycles, b) distribution of contact pressure at the middle position of the ball translating along the y-axis (y=0.02 mm),

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References

[1] I. Páczelt and Z. Mróz (2009). On the analysis of steady sliding wear process, *Tribology International,* **42**, 275-283.

[2] I. Páczelt, S. Kucharski and Z. Mróz (2012). The experimental and numerical analysis of quasi-steady wear processes for a sliding spherical indenter, *Wear*, **274-275**, 127-148.

[3] I. Páczelt and Z. Mróz (2012). Solution of wear problems for monotonic and periodic sliding with p-version of the finite element method, *Comput. Methods Appl. Mech. Engng,* **249-252**, 75-103.

[4] I. Páczelt and Z. Mróz (2015). Analysis of wear processes for periodic loading, *Key Engineering Materials,* **681**, 117-141.

[5] B. Szabó and I. Babuska (1991). Finite element analysis, Wiley-Interscience, New York.

[6] I. Páczelt and Z. Mróz (2015). Analysis of thermo-mechanical wear problems for reciprocal punch sliding, *Adv. Eng. Softw.*, **80**, 139-155.

[7] Z. Mróz and S. Stupkiewicz (1994). An anisotropic friction and wear model, *Int. J. Solids Struct.*, **31**, 1113-1131.