Friction contact of a smooth slider and viscoelastic half-space
Irina G. Goryacheva¹, Fedor I. Stepanov² and Elena V. Torskaya³

A. Ishlinsky Institute for Problems in Mechanics of Russian Academy of Sciences, Prosp. Vernadskogo, 101-1, Moscow, 119526 Russia,
¹goryache@ipmnet.ru
²fedia-chiter@mail.ru
³torskaya@mail.ru

Key Words: Sliding contact, viscoelastic solid, hysteretic losses.

Imperfect elasticity of contacting materials generates hysteretic losses during the deformation. For the case of sliding contact the losses increase a motion resistance. Linearly viscoelastic solid is one of the models of an imperfectly elastic material.

The contact pressure distribution, its dependence on velocity and friction force are obtained in [1] for 3-D sliding contact without friction. contact problems; for the case of indentation processes are presented in [2].

In this study the sliding friction contact is considered for a smooth indenter and a viscoelastic half-space. The material properties are characterized by the spectrum of relaxation times.

The indenter is loaded by a vertical force $Q$ and moves with a constant velocity $V$ over the viscoelastic half-space in the direction of the axis $0x$. The coefficient of friction between the bodies is $\mu$. Coordinates $(x, y, z)$ are related to the slider; boundary and equilibrium conditions are the following:

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\begin{align*}
    w(x, y) &= f(x, y) + D_s(x, y) \in \Omega; \\
    \tau_{xz}(x, y) &= \mu p(x, y), \quad (x, y) \in \Omega; \\
    p &= 0, \tau_{xz} = 0, \tau_{yz} = 0, \quad (x, y) \notin \Omega; \\
    Q &= \iint_{\Omega} p(x, y) dx dy
\end{align*}
$$

Here $\Omega$ is the unknown contact region, $w(x, y)$ is the normal displacement of the half-space surface, $D_s$ is the indenter penetration, and $p$, $\tau_{xz}$, and $\tau_{yz}$ are the normal and shear stresses. The indenter shape is described by the function $f(x, y)$.

The problem is solved in the quasi-static formulation; the Green’s function for a concentrated force sliding over a viscoelastic half-space has been reduced and used to find the relationship between the contact pressure $p(x, y)$ and the normal surface displacement $w(x, y)$ in the following form [1]:

(1)
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\[ w(x,y,0) = \frac{1-2\nu}{4\pi G} \int_{\Omega} \mu p(\xi,\eta) \left[ \frac{\xi-x}{R^2} + \frac{1}{R} \int_{-\infty}^{0} K(-\tau) \frac{\xi-x-V\tau}{R^2} d\tau \right] d\xi d\eta - \frac{1-\nu}{2\pi G} \int_{\Omega} p(\xi,\eta) \left[ \frac{1}{R} + \int_{-\infty}^{0} \frac{1}{R} \frac{1}{R} d\tau \right] d\xi d\eta. \] (2)

\[ R = \sqrt{(\xi-x)^2 + (\eta-y)^2}, \quad R_i = \sqrt{(\xi-x-V\tau)^2 + (\eta-y)^2} \quad K(t) = \sum_{i=1}^{n} k_i \exp(-\frac{t}{\lambda_i}) \]

Here \( G \) and \( \nu \) are the shear modulus and the Poisson ratio of the half-space material, \( K(t) \) is the creep kernel with parameters \( k_i \) and \( \lambda_i \).

The boundary element method is used to find the contact pressure distribution. The contact area is divided into squares, and the pressure is assumed to be constant in each square. The number of the squares along the axes 0x and 0y are \( N_1 \) and \( N_2 \), respectively. The normal displacement of the surface in the center of an arbitrary square is obtained by summation of displacements caused by the loads inside each square. The matrix dimension is \( N_1 \times N_2 \). The resulting matrix, which is used to calculate the contact pressure, has the dimension of \( (N_1 \times N_2)^2 \). Equations (1) are satisfied by the iteration method.

The hysteretic losses coefficient \( \mu^* \) is determined by:

\[ \mu^* = \frac{1}{QR} \int_{\Omega} xp(x,y) dx dy. \] (3)

The dependence of hysteretic losses from sliding velocity (a) and the example of contact pressure distribution (b) are presented at Fig. 1. The value of the coefficient of hysteretic losses is in good correlation with the asymmetry of contact pressure distribution. Adhesive friction increases motion resistance due to hysteretic losses.

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**Fig.1**

**a**

**b**

**REFERENCES**
