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THIRD BODY EFFECT ON INTERNAL STRESSES IN ROLLING OF ELASTIC SOLIDS

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The three-dimensional contact problem of an elastic sphere rolling along an elastic half-space covered with a viscoelastic layer is considered. The mechanical behavior of the intermediate viscoelastic layer is described by the Maxwell model. The numerical method based on the variational principle is used to calculate the contact shear stresses. The effect of the sliding friction coefficient, the creepages and the layer properties on the internal stresses within an elastic half-space is studied. The developed model can be used to determine the regions of internal stress concentration as possible crack initiation under rolling friction conditions.

Keywords: rolling contact, stick and slip subregions, elastic half-space, viscoelastic layer, internal stresses.

1. Introduction

The use of lubricants in rolling friction units is one of the ways to reduce the wear of surfaces. According to the selected criterion, the accumulation of contact fatigue damage in rolling contact is often determined by the peak values of principal shear stresses. These stresses in turn strongly depend on the sliding friction coefficient between the contacting surfaces, lubricant properties, the creepage, mechanical properties and the geometry of contacting bodies. In this study the model is developed to calculate the contact and internal stresses in rolling with the longitudinal, lateral and spin creepages of the elastic sphere over the elastic half-space from the same material taking into account the third body mechanical properties.

2. Problem formulation and the method of its solution

2.1. Contact stress analysis

The rolling contact of the elastic sphere on the elastic half-space taking into consideration the compliance of the intermediate viscoelastic layer in tangential direction is considered. The Maxwell model is used to describe the layer properties. Assuming that the rolling body and the half-space have the same elastic properties and neglecting the layer compliance in the normal direction, the contact pressure is calculated according to the Hertz contact theory. In rolling the contact region consists of stick and slip subregions, which boundaries are unknown in advance. To determine the contact shear stresses and position and areas of stick and slip subregions the variational formulation is used [1]. The numerical solution of the variational problem of minimizing functional was obtained using the gradient projection method [2].

2.2. Internal stresses calculation

The contact pressure and the shear stresses are used to calculate the internal stresses within the elastic half-space. The components of the stress tensor at each point of the elastic half-space are calculated using the superposition method and the Boussinesq and Cerruti solutions for a concentrated force acting on the elastic half-space in normal and tangential directions.

3. Results and discussions

The numerical calculations have been carried out to analyze the influence of the sliding friction coefficient, the longitudinal, lateral and spin creepages and the layer properties on the contact and internal stresses. Analysis of contact shear stresses at fixed values of the longitudinal creepage shows that the presence of the layer leads to the increase of the stick subregion area. The effect of the layer mechanical properties on the tensile-compressive and principal shear stress distributions under the contact region has also been studied. In particular, the results indicate (Fig. 1) that in rolling contact of elastic bodies the intermediate viscoelastic layer decreases the peak values of the principal shear stresses both under and at the surface.

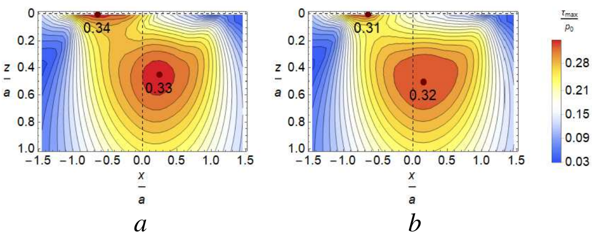

Figure 1: Isolines of the principal shear stresses within an elastic half-space under a rolling sphere ($y=0$) without layer (a) and in the presence of intermediate layer (b)

It has been shown that the peak values of the principal shear stresses increase with increasing the creepages. Based on this study the influence of the interface and rolling conditions on the contact fatigue crack formation is also discussed.

4. References

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