Squeeze and Nanomechanics of Boundary Layers in a Lubricated Interface

Van-Vuong Lai , Francois Sidoroff , Denis Mazuyer , and Juliette Cayer-Barrioz*[1]

[1]Laboratoire de Tribologie et Dynamique des Systèmes – CNRS : UMR5513, Ecole Centrale de Lyon, CNRS – France

Abstract

Due to environmental concerns, the use of low-viscosity fluids to reduce viscous losses in lubricated contacts, the use of low-viscosity fluids has increased, resulting in smaller surface separation.

In order to simulate the squeeze of a confined thin film between two adsorbed layers on antagonistic solid surfaces, a numerical model based on continuum mechanics has been developed using the generalized œdometric Reynolds equations extended to the case of heterogeneous films such as two adsorbed layers separated by a fluid film. This model takes into account the film compressibility and the substrate deformation for a sphere/plane configuration in both static and dynamic situations, under small amplitude oscillations as used for example in non-contact dynamic surface force or AFM measurements.

For the static contact resolution, an explicit approach based on small incremental displacements of the sphere with respect to the plane was chosen. For the dynamic situation, the generalized Reynolds model was assumed to be still valid with a harmonic solicitation and a complex solution was obtained. The numerical solution of the governing equations was carried out thanks to the Finite Element-Method in Matlab.

After a short description of the numerical solution method, the validation of the model was confirmed by confronting numerical results with theoretical and experimental ones. Our model was able to predict such parameters as contact stress or complex stiffness as well as to provide physical insights of the squeeze mechanisms. The application of our numerical model to experimental squeeze of low-viscosity fluid between fatty acid monolayers and polymer brush layers allowed to evaluate the mechanical properties of the adsorbed boundary layers and to discuss the molecular organization within the squeezed interface.

This method opens new perspectives for measuring the viscoelastic properties of adsorbed layers and their evolution under confinement and pressure.

*Speaker