MODEL FOR ADHESION-BASED ENERGY DISSIPATION DURING FRICTION

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Adhesion plays a major role in friction, especially at micro/nanoscale. However, the adhesive force is conservative and by itself does not provide with a mechanism for energy dissipation, which takes place during friction. In this paper, a mechanical model is proposed, which suggests the mechanism of energy dissipation due to adhesion or so-called the *adhesion hysteresis*. Under ideal conditions (perfectly smooth rigid surfaces), the work done on bringing two surfaces together is reversible, however, under realistic conditions, the work needed to separate Due to the adhesion hysteresis, a greater amount of energy is required to separate two surfaces is always greater than the energy gained by bringing them together. As a result, the energy is dissipated during the loading-unloading cycles. The adhesion hysteresis exists even for perfectly smooth and homogeneous surfaces supported by perfectly elastic materials. Sliding friction may be considered as continuous bringing of two surfaces into contact (at the leading edge of the contact) and separating them (at the back edge of the contact).

A simple model is proposed, which grasps the main features of energy dissipation during sliding friction. Two-dimensional adhesive contact of a rigid sliding cylinder sliding upon a perfectly elastic surface is considered. The elastic surface is modeled with a bean on elastic foundation. The adhesion potential is modeled by a simple Dugdale potential, which is believed to capture main features of more complicated adhesion potentials (such as the Lennard-Jones potential). It is shown, that during sliding, asymmetry of the leading and back edges arises, since separation of the surfaces takes place at a different distance, than their coming together. As a result of the asymmetry, adhesive force at the back of the cylinder is greater than that at the front, which leads to a shear force component resisting to the motion, which is interpreted as the friction force.

It is shown that the shear force can exist both for sliding and rolling contact, resulting in energy loss due to excitation of elastic oscillations, despite the system being purely elastic and conservative. A similar mechanism of friction in the presence of a liquid meniscus, due to the contact angle hysteresis mechanism (difference of the contact angle between the solid and liquid at the leading and rear edges) is suggested and studied.

Dependence of the friction force upon the elastic parameters and adhesion parameters is discussed. Qualitatively similar results are expected for more complicated cases, i.e., three-dimensional elastic-plastic bodies and more complicated contact potentials.

Keywords: friction, adhesion, nanocontact