
Physical origin of friction relaxation after interrupted sliding

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Abstract

One of the most generic friction laws is the so-called rate-and-state friction law (1). It combines the time-evolution of the static friction coefficient and the sliding-velocity-dependence of the dynamic friction coefficient. It is parametrized by two empirical parameters, which can be calibrated using macroscopic tests: the slide-hold slide and the velocity step tests.

In the slide-hold-slide test, the friction coefficient relaxes during hold (when the contact is left at rest after interrupting full sliding). The physical origin of the relaxation remains unclear: is it a bulk relaxation, an interfacial slip-based relaxation or a mixture of both? In this work, we address this fundamental question in the case of dry elastomer/glass contacts. Our strategy is to monitor experimentally the displacement field at the contact interface when sliding is stopped, based on image correlation techniques. Doing this, the amount of slip that occurs after stopping the motion can be quantified.

We performed experiments on an elastomer sphere / glass plane contact during interrupted shear tests for different waiting times. The sphere is made, for optical purposes, of polydimethylsiloxane (PDMS), and has a curvature radius $R=9.42$ mm. As close as possible to the PDMS sphere surface, a thin subsurface layer of particles is added to enable in operando evaluation of the shear displacement field thanks to digital image correlation (DIC) analysis (2) and/or particle tracking (3). The obtained fields allow to study the local behavior at the contact interface and in particular to identify the sticking and slipping zones during the post-shearing relaxation.

We have quantified the time-dependence of the contact area and of the slip field, as functions of the normal force and of the shear distance before the stop. We could thus conclude about the combination of mechanisms involved in post-shear relaxation, shedding fundamental light into the origin and contact history dependence of the static friction force.

References:

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