How third-body accommodation regime controls dry friction

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In this communication, we investigate the regimes of velocity accommodation and of load transmission within a dry sliding interface, in the presence of third body. A numerical study is performed in order to analyze the influence of the mechanical properties of the third body on the interfacial solid flow regimes, on the friction coefficient, and on the modes of energy dissipation. Numerical results demonstrate that friction in the interface is limited by changes in the kinematics of the shear accommodation in the third-body layer and by the activation of different modes of energy dissipation.

Keywords (from 3 to 5 max): Dry Friction, Third Body, Multibody Meshfree Modelling

1. Introduction

Post-mortem observations of mature dry contacts always reveal the existence of a third body layer separating the contacting surfaces and accommodating sliding. The study of its rheology is thus pivotal in understanding dry friction, and yet this rheology remains largely out of reach for experiments because of the confined nature of mechanical contacts. What is commonly observed, however, is that this layer can exhibit vey various aspects: powdery, plastic, agglomerated, pasty, etc.

2. Methods

To represent explicitly the third body, we employ a multibody meshfree approach, which is a recent evolution of the discrete element method (DEM, [1]) towards highly deformable grains [2]. Third body particles are seen as deformable grains with a certain stiffness and a certain cohesion (which are both normalized by the normal stress on the third body). This layer is then sheared between two rough walls. Typical outputs are the time series of the coefficient of friction of the interface, the emerging accommodation regimes, the energy dissipation budget, etc. A large number of simulations are performed to map this outputs on the whole parametric space of normalized cohesion and stiffness.

3. Discussion

The simulation campaign reveals [3] that a large variety of accommodation regimes can take place in the interface depending on the third body properties (Figure 1):

(i) For low cohesion and large stiffness, the layer behaves in a granular way, with little grain deformation, large porosity, load transmission by force-chains, Couette-like velocity gradient, and moderate friction.

(ii) For low cohesion and low stiffness, the interface has a plastic, quasi-fluid behavior, with almost no porosity, homogeneous load transmission, and a very low and stable friction in time.

(iii) For large values of the cohesion and low-to moderate stiffness, third body shows a natural tendency to agglomeration, with the formation of rolling clusters and important stress concentrations. Friction in that case is high and strongly fluctuates in time.

(iv) A certain combination of a cohesion and stiffness leads to a maximum value of the friction coefficient. In that case, the third body self-organizes in anisotropic "column-like" structures and third body grains get elongated in the minor stress direction, thus maximizing the resistance of the interface to shearing.

It is interesting to notice that no dependence to normal stress was implemented in any of the contact and constitutive laws of the model, and yet the resulting coefficient of friction remains within the common observed range for dry friction (i.e. 0.1 to 1.1) for the whole campaign. It indicates that Coulomb-like friction is an emerging phenomenon related to self-adapting accommodation regimes in the third body layer.

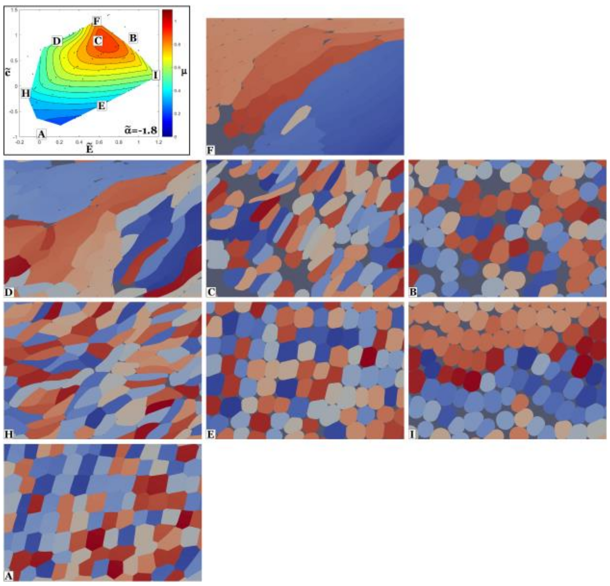

Figure 1: Typical third body textures depending on normalized stiffness and cohesion

4. References

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