Rough contact of inelastic materials

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Mains trends in mechanical contact of rough surfaces of inelastic materials are relatively well understood. However, in this work, we make an attempt to construct a quantitative link between roughness features (height distribution, fractal dimension) and loading parameters (duration, cycling, normal or tangential loading). Elasto-plastic, visco-elastic and visco-plastic material models are studied by means of advanced finite element simulations. Relevant phenomena such as friction, wear, permeability to fluids, thermal and electric resistance are also discussed in the context of obtained results.

Keywords (from 3 to 5 max): roughness, contact, inelasticity

1. Introduction

Most of engineering systems are designed to operate in elastic regimes at least at the structural scale and within the assumption of homogeneity of materials, the same holds for the mechanical contact between the components of such systems. However, it is not always the case at the microstructural scales at which the surface roughness has to be taken into account. At these scales, the material can experience much higher loads at much higher rates than those nominally computed for homogeneous and smooth surfaces. Such loads often induce stress-strain states far beyond the elastic regime. The objective of this study is to better understand how such an inelastic material behavior influences some fundamental quantities in physics of rough surfaces such as the true contact area, its morphology and its evolution as well as mean gap and its morhology. Moreover, a link between these quantities and interfacial phenomena will be established.

2. Methods

To study the strongly nonlinear emerging problem we use the finite element suite Z-set [1] capable to handle all material non-linearities with the state of the art surface-to-surface contact discretization and advanced monolithic solvers and particular algorithms for treatmetn of such complex coupled non-linear problems. The following materials will be considered: (1) isotropic von Mises elasto-plastic material with both kinematic and isotropic hardening (most of metal and alloys), (2) Drucker-Prager type materials with associated and non-associated flow, (3) visco-elastic material taking into account Payne effect, (4) visco-plastic material with zero threshold non-linear flow, equivalent to Glen's rheology of ice.

3. Discussion

The most interesting results obtained for all these various material models will be presented. In particular, it is very relevant to understand (1) the effect of the hardening in cycling loading of elasto-plastic rough contacts (see Fig. 1); (2) the particular response of Drucker-Prager type materials, such as rocks, under relevant loadings in rock drilling as well as at much larger scales, in faults; (3) non-linear material effects in friction for a charged rubber sliding over a rough substrate; (4) friction models for glacier' sliding over a rough bedrock [3]. All these results will be presented for model roughnesses with controlled parameters. A prospective work aiming at reaching some unified quantitative trends will be also discussed.

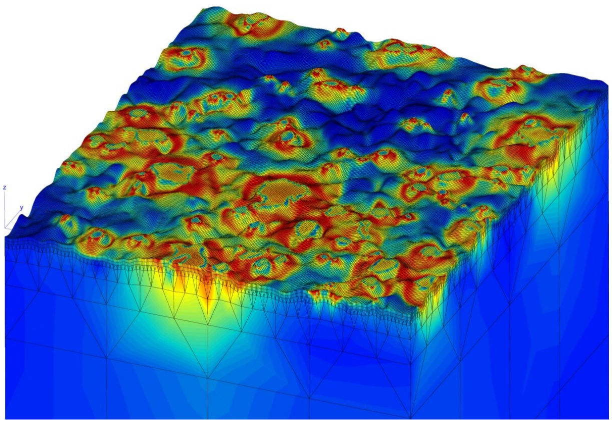

Figure 1: von Mises stress distribution after unloading of a rough metallic surface after contact with a rigid flat [2]

4. References

[1] Finite Element Suite Z-set www.zset-software.com

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