8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

Finite element simulation of contact between rough surfaces and sealing behavior

C. Feng* and J.F. Molinari

Computational Solid Mechanics Laboratory, Ecole Polytechnique Federale de Lausanne
CH-1015 Lausanne, Switzerland
chen.feng@epfl.ch

Key Words: *Contact mechanics, rough surface, Percolation, Finite element method.*

ABSTRACT

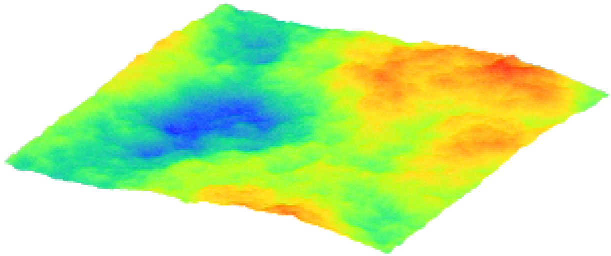
In this work, we are interested in the mechanical sealing process during contact. We propose a new approach to qualify the sealing efficiency and to evaluate the critical load that ensures the sealing state of a contact system.

The contacting surface topology is the critical issue in this problem, as the sealing can be obtained only if the asperities are sufficiently compressed to close all potential leakage paths across the contacting surface. Thus little change on asperity-scale contact can dramatically modify sealing status. Since the leakage paths formed during contact can be extremely tortuous, the definition of sealing condition is a common difficulty in the field. It is our suggestion to consider the contact interface as a connected network of asperities, so that the sealing onset can be qualified by applying a percolation model.

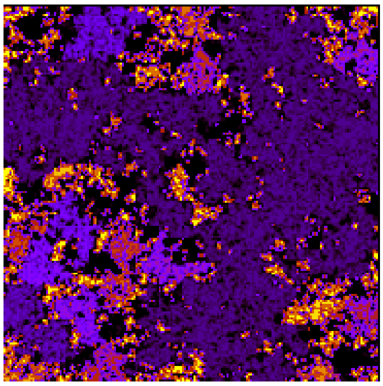
As a primary approach, we focus on the normal contact. In analytic contact mechanics, many asperity-models exist to determine the contact area for a given load. However, all models are commonly formulated under the assumption that there is no interaction between deforming asperities. Namely, the Hertz solution is applied on each asperity independently and the contact area is determined by overlap cutting-off method. The rough surface is cut by a horizontal plane and define all the valleys below the plane to be in contact. Then the surface/plane intersecting regions is the contact area. It has been noticed that the analytical models can provide the relationship between given load and contact area fraction, but fail to predict the exact morphology, thus leading to a poor estimate of the sealing threshold.

Highlighted in a number of numerical studies [1,2], the asperity interaction has great influence on the morphology of the real contact area. To reproduce the mechanics of the interface, we generate fractal surfaces and solve the rough contact problem using the finite element method. We apply the percolation model within the simulation and obtain a statistical distribution of the critical pressure by several hundreds realisations.

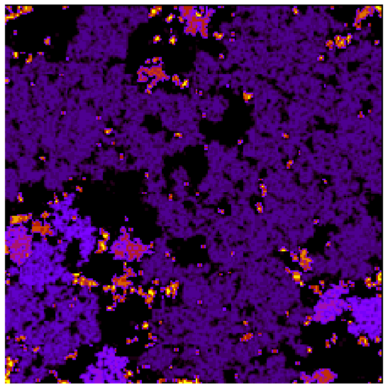
The remarkable feature here is that about 90% of elastic percolation events are observed when the contact area fraction is between 55% and 60%. In the case of elaso-plastic contact, the percolation event occurances appear to be much more sparsed. With increasing load, the plastic behavior of the material tend to grow existing contact clusters rather than create new clusters, so that the interface morphology tends to be less fractal-like than in the pure elastic case. In the following figure, the effect of material properties on the geometry of percolation clusters can be clearly seen.



Fractal surface generated with a Hurst exponent of 0.7 (size 256)



Elastic contact



Elasto-plastic contact

Figure 1: Contact clusters at the sealing transition.

A pressure load is applied on the surface. Color contours represent contacting areas obtained by finite element simulation, using elastic or elasto-plastic material properties. Different colors label different contact clusters. A lighter color indicates smaller cluster. Less and bigger clusters emerge during elasto-plastic contact.

REFERENCES

[1] S. Hyun, L. Pei, J.F. Molinari and M. Robbins. “Finite element analysis of contact between elastic self-affine surfaces”. *Phy. Rev. E*, Vol. **70**, 026117, 2004.

[2] L. Pei, S. Hyun, J.F. Molinari and M. Robbins. “Finite element modeling of elasto-plastic contact between rough surfaces”. *J. Mec. Phy. Solids.*, Vol. **53**, 2385–2409, 2005.