7th World Tribology Congress, WTC 2022
July 10-15, 2022, Lyon, France

Study of flange-seal rough interface for high-sealing applications

Yvan Marthouret[1)2)], Guillaume Kermouche[1)], András Borbély[1)], Florent Ledrappier[3)] and Tony Zaouter[2)]

[1)] Laboratory of Materials Science and Structure, Ecole Mines Saint-Etienne, France
[2)] maestral Sealing Applications Laboratory, CEA Marcoule, France.
[3)] TECHNETICS Group France, Saint-Etienne, France
*Corresponding author: y.marthouret@emse.fr

Gap distribution and the true contact area significantly affect sealing performance and tribological properties of rough surfaces in contact. Models predicting deformation of surfaces in contact already exist but are limited to average parameters or small deformations. For design considerations it is necessary to predict the interface aperture field resulting of the seal large deformation after application of a given load. Therefore a reduced model has been developed for that purpose. It is based on the extension of indentation theory to multi-asperity interactions through the use of finite element analysis

Keywords: sealing, indentation, FEM, reduced model, large strain

1. Introduction

High-performance sealing applications rely on metallic seals. In this case, material permeability can be neglected. Leakage is only related to the residual aperture field at the gasket/flange interface (roughness scale) and can be computed [1]. We aim to develop a simplified model as [2] to predict locally this aperture field. In the frame of large deformation, we focus on improving the description of interaction of asperities and hardening thanks to FEM simulations.

2. Methods

2.1. Finite Element Method

A 2D plane strain model with hardening, no friction and a simplified geometry is used to study asperities interaction (Fig.2). Materials follow a Hollomon's hardening law.

2.2. Synchrotron tomography

A specific device (Fig.1) is conceived to validate results thanks to synchrotron X-ray tomography [3]. The aim is to observe the deformation of a soft surface indented by a rough rigid surface machined on purpose.

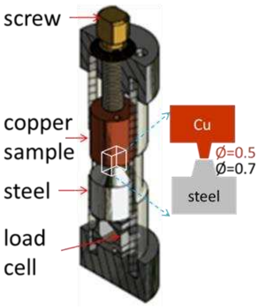

Figure 1: Device for tomography of a contact interface, here copper (deformable) and steel (rigid)

2.3. Results

The results are plotted through an apparent hardness that accounts of asperity interactions (Fig. 2). Dimensional analysis is used to reduce the number of parameters. A "master curve" of the apparent hardness is finally derived. It is shown to account for both geometry and materials properties.

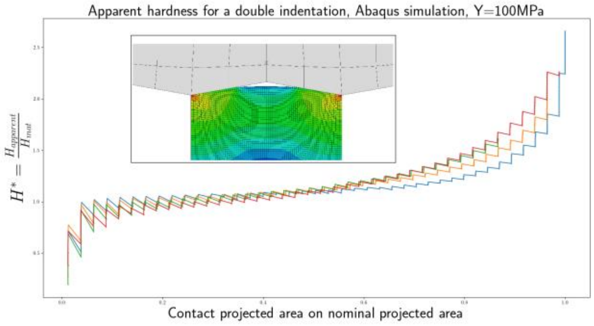

Figure 2: Apparent hardness normalized by material hardness plotted against normalized contact area during double indentation loading.

3. Conclusion

A "master curve" is available for updating hardness in model such as [2] to account for interaction and hardening. Hence, extensive numerical simulation is able to enhance a simplified theoretical model. The results will be compared to experimental measurement in the coming months. These coupled experimental and numerical investigations will be of help in developing a model for contact mechanics of rough surfaces accounting for large deformations.

4. References

[1] Zaouter, T. et al., "Determination of the Transmissivity of a Heterogeneous Anisotropic Fracture in Slip Flow Conditions", Physical Review E, 100, 3, 2019, 033115.

[2] Tian, X. et al., " A Numerical Three-Dimensional Model for the Contact of Rough Surfaces by Variational Principle", Journal of Tribology, 118, 1, 1996, 33-42

[3] Zhang, F. et al., "A Discussion on the Capability of X-ray Computed Tomography for Contact Mechanics Investigations", Tribology International, 145, 2020