In operando characterization by X-ray tomography of the real contact area in tribological systems

Vito ACITO[1) 2)*], Julien SCHEIBERT[1)], Christophe LE BOURLOT[2)], Eric MAIRE[2)], Sylvain DANCETTE[2)] and Davy DALMAS[1)]

[1)] Laboratoire de Tribologie et Dynamique des Systèmes LTDS UMR5513, Univ Lyon, Ecole Centrale de Lyon, ENISE, ENTPE, CNRS, Ecully, France
[2)] MATEIS, UMR CNRS 5510, Univ. Lyon, INSA Lyon, F-69621 Villeurbanne, France

The morphological parameters describing both the real contact between two rough surfaces (in particular the area of real contact) and the deformation state of the contacting solids are first order elements that control the dynamical and frictional response of a contact interface. While there are many models predicting those quantities, experimental measurements are much scarcer, and are most often made thanks to materials with very specific surface and/or bulk properties (smooth surfaces and/or transparent materials). Within this project, we propose to overcome those current experimental limitations and access, thanks to X-ray tomography, the full morphology of dry rough/rough contacts.

Keywords: in situ experiments, X-ray tomography, contact area, rough surfaces.

1. Introduction

Since the pioneering work of Bowden and Tabor [1], it is well established that the friction properties of the contact interface between rough solids are essentially governed by the real contact area A_R rather than by the apparent contact area A_A. Thus, the evolution of this real contact area as a function of load, time and shearing is one of the main parameters controlling the frictional response of a contact interface. The limitations of the experimental measurement of A_R, especially in realistic systems, are mainly related to the difficulty to access the buried interface and the fact that the measurement must be carried out *in operando*, with, if possible, a control of the normal and tangential loading.

In a collaborative project between the LTDS and MAtéIS laboratories, we propose to overcome those experimental limitations and to access the complete morphology of the real contact interface between opaque, dry and rough solids, by X-ray tomography, under normal and/or tangential loading.

2. Methods

The strategy adopted will be to start from model systems already mastered at LTDS and to validate tomographic measurements by comparison with conventional optical measurements.

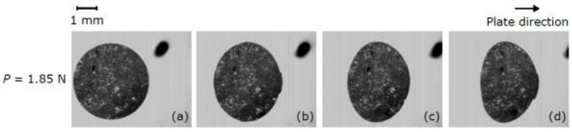

Figure 1: Analysis of the evolution of the contact area through contact imaging. The white particles are used to follow the displacement field using Digital Image Correlation.

In a first step we analyse the evolution of the real contact area through tribology experiments based on *in situ* contact imaging (fig. 1). The PDMS specimen is filled with particles in order to follow them using Digital Image Correlation technique. This allow us to determine with accuracy the displacement and velocity field within the contact area. We repeat these experiments for different normal loads and adding a quasi-static tangential load.

The obtained results will be compared with those coming from an X-ray scanning using Tomography. The idea is to validate this new method for the analysis of the real contact area as already attempted in previous works (fig. 2). Furthermore, we will be able to go more into details in the analysis of 3D deformation of the bodies in contact. In this case too, we will include the effects of normal and quasi-static tangential load in the framework of incipient sliding. An important effort is to understand the limits in terms of accuracy and contrast between the different materials involved (particles and bodies in contact).

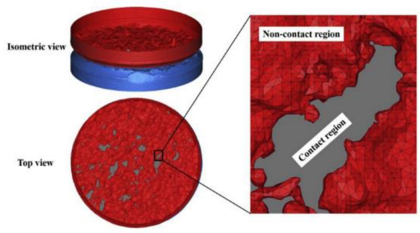

Figure 2: Geometrical model from contact experiments using Tomography (from [2]).

3. References

[1] Bowden, F. P. *et al., "Mechanism of Metallic Friction"*, Nature, 150, 19, 1942, 198-199.

[2] Zhang, F. *et al.*, *"A discussion on the capability of X-ray computed tomography for contact mechanics investigations"*, Tribology International, 145, 2020, 106167.