Thesis subject proposal

Février 2020

Call for application for a three-year doctoral fellowship
In the framework of the transportation challenge at INSA

Title: In situ study of tribological interfaces behaviour under various thermo-mechanical paths

In the context of transportation, it has been estimated that 30% of the energy use goes to overcome friction [1]. New developments such as electric vehicles, new environmental standards (regulation on particulate emissions, drastic reduction of (micro-) plastics, restriction or elimination of the use of specific metals (Cr, Cu, …))… emerge in the aim to emphasize energy-saving and respect for the environment. Those require to understand in detail the operating algorithm of tribological components involved in transportation and therefore of the interface of the contact.

Contacts between two bodies, whether static or dynamic, exist in mechanisms. Micro-sliding or sliding occur at the interface, damage of the surfaces then the creation of an interface (third body) constituted of particles, while accommodating most of the speed difference between the first bodies. The dynamic behaviour of this tribological interface in the case of dry contacts is difficult to study in situ; a contact being a confined system, direct local measurements are most of the time unreachable. The development of a multi-scale methodology for quantitative analysis of the behaviour of interfaces is a missing link in the understanding process and modelling of the thermomechanical processes involved in the contacts. This innovative approach is required to increase their energy performance, reduce environmental nuisances while maintaining their reliability.

The thesis is part of a multi-physical and multi-scale approach that has to go through: the understanding of the kinetics of tribological interfaces evolution, the identification of key parameters of influence on their rheological behaviour, and the identification of preponderant physical phenomena. It is proposed therefor to study this interface outside of a contact but under thermomechanical conditions, representative of those in a contact.

Recent developments, both experimental and in modelling, now allow to envision a strong coupling between experiments and model. It is expected to study in operando the behaviour of model granular media subjected to various thermomechanical loadings (deformation paths, deformation rate, thermal gradients...). From an experimental point of view, different reference granular third bodies will be formulated in a controlled manner taking into account several criteria:

- the chemistry, shape, size, mechanical properties, etc of the particles, in connection with real contacts (for example wheel-rail or tire-road contact),
- constraints related to rheological and (micro) structural characterization tools allowing *in operando* measurements.

This correlative experimental approach is thus implemented using original tools for *in operando* tribological and rheological characterization (shearing under compression, X tomography, environmental scanning electron and atomic force microscopies, EDX analysis).

The rheological, mechanical properties and microstructural organization will be analysed as a function of deformation paths, temperature and gaseous environments. The third body will be modeled using a numerical framework recently developed at LaMCoS: a multibody meshfree model allows to take into account the deformability, by integrating visco-elastoplastic properties, and the heterogeneity of the constituents of the third body. The experimental - numerical coupling will allow us to study the effect of pressure, shear, thermal gradients on material flows according to the different reference third bodies, therefore to study the dynamic response of the third body, the mechanisms involved and their effects on friction.

[1] Holmberg et al, Friction 5 (3) 263-284 (2017)

Keywords : tribology, advanced characterization methods, discrete elements modelling, numerical and experimental data processing and analysis.

Required skills and profile: solid knowledge in mechanics and materials science. Experience in tribology will be appreciated, as well as motivation for both experimental and modelling. Teamwork skills. Rigour and autonomy.

Location and practical aspects: At laboratory LaMCoS (INSA de Lyon, France) in the tribology team. The laboratory LaMCoS is classified in Restricted Zone, therefore recruitment is subjected to prior authorization from the Defense Security Officer.

Funding: doctoral fellowship – application is necessary
If successful, start: September 2020

Application: Candidates holding a master degree or engineer diploma, in solid mechanics / material engineering are expected. Interested candidates should send their CV, a cover letter and official transcripts of the last two years, **before March 17, 2020,** to:

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