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# PhD Proposal 2017

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| **School:** ENISE / Ecole Centrale de Lyon | |
| **Laboratory:** LTDS | **Web site:** ltds.ec-lyon.fr |
| **Team:** Mechanics, Materials and Processes | **Head of the team:** Hassan ZAHOUANI |
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| **Collaboration with other partner during this PhD:**<br>**In France:** | **In China:** |

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|---|
| **Title:** 3D numerical modelling of wear phenomena under extreme conditions |
| **Scientific field:** Numerical simulation |
| **Key words:** Numerical modelling, finite element, wear, friction |

**Details for the subject:**

*(Maximal length of 2 pages, including images, list of reference, …The pdf file should not exceed 1Mo)*

**Background, Context:**

Friction and wear affect many mechanical components used every day [1]. Examples range from belt drives, brakes, tires, clutches, gears, bearing or even the motion of a human knee-joint (natural or artificial). Among them, manufacturing dies & tools, represent specific configuration in which the contact occurs under extremely severe conditions, i.e. high contact pressures, sliding velocities and/or elevated temperatures [2-4].

Experimental approaches are commonly employed to investigate the contact properties of a defined material pair. The complete tribological process in a sliding contact is however very complex because it involves simultaneous friction, deformation mechanisms and surface evolutions at different scales [5]. Predicting wear under such conditions is still an important scientific issue especially in many industrial applications where complex geometries are involved.

Today, there is a clear need of a methodology to numerically predict 3D wear phenomena occurring under such conditions.

**Research subject, work plan:**

The objective of the proposed work is to develop a numerical method to 3D predict wear phenomena under extreme conditions.

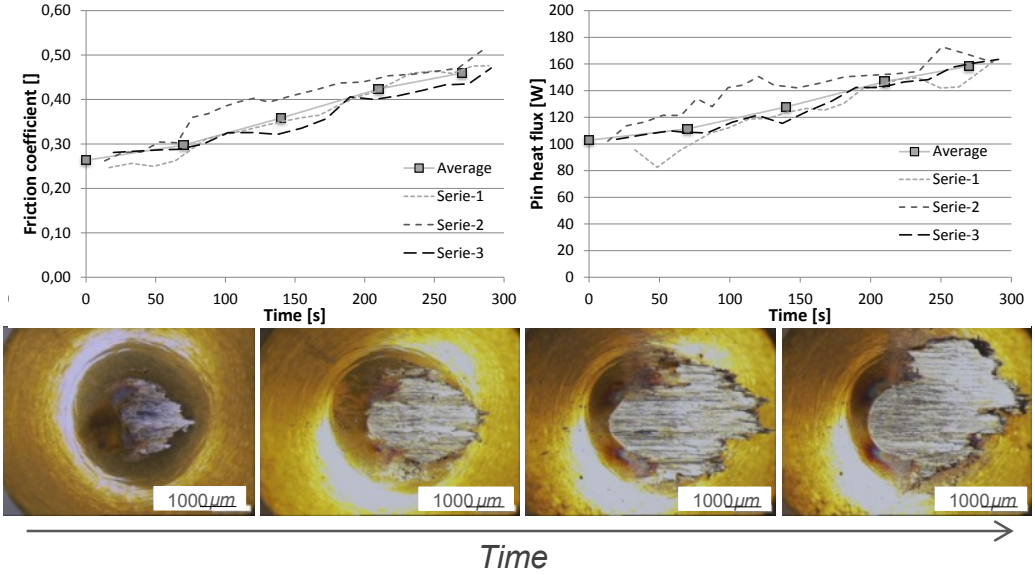


*Fig. 1: Friction coefficient, heat transmitted to the friction pin and wear observed during a pin-on-plate tribological test (1000 N – Vs 3 m/s)*

After a proper literature review on wear modelling, the PhD student will mainly conduct the study in three steps:

- Step 1: Development of a numerical algorithm to update a given 3D geometry based on the local contact conditions (contact, pressure, sliding velocity, temperature). Wear models from the literature will be identified and implemented;
- Step 2: Application to a standard ball-on-plate configuration to 3D predict the wear of a friction pin. Results will be compared to the

experimental database available in the lab thanks to the numerous studies already performed [4,6,7] (Fig.1).

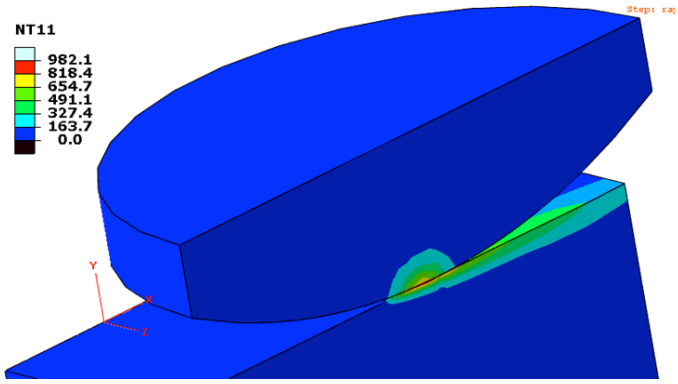


*Fig. 2: Finite element simulation of a pin-on-plate tribological test*

- Step 3: Applications to one or two metalworking processes (forming, punching, stamping or metal cutting) to extend the work to an industrial application. Results from the literature will be used and compared to the numerical results.

The PhD student will be supported by the work initiated in LTDS to deal with 2D configurations [8] and will be extended to 3D complex geometries. Finite element simulations will be performed with ABAQUS Explicit© whereas geometry updating, pre and post-processing will be programmed with Python and Matlab©.

**References:**

**[1] Stachowiak, G. W. & Batchelor, A. W. ; Engineering Tribology; *Butterworth-Heinemann; 2nd edition,* 2001**

**[2] Hardell, J. & Prakash, B.; Tribological performance of surface engineered tool steel at elevated temperatures; *International Journal of Refractory Metals and Hard Materials*, 2010, 28, 106 - 114**

**[3] Courbon et al.; Adhesion tendency of PVD TiAlN coatings at elevated temperatures during reciprocating sliding against quenched and tempered steel; *Wear*, 2015, 330-331, 209-222**

**[4] BenAbdelali et al.; Identification of a Friction Model at the Tool-Chip-Workpiece Interface in Dry Machining of a AISI 1045 Steel With a TiN Coated Carbide Tool; *Journal of Tribology*, ASME, 2011, 133, 042201**

**[5] Hardell et al.; Effect of oxide layers and near surface transformations on friction and wear during tool steel and boron steel interaction at high temperatures; *Wear*, 2015, 330-331, 223-229**

**[6] Rech et al.; Characterisation of friction and heat partition coefficients at the tool-workmaterial interface in machining; *CIRP Annals Manufacturing Technology*, 2013, 62, 79 - 82**

**[7] Courbon et al.; Tribological behaviour of Ti6Al4V and Inconel 718 under dry and cryogenic conditions - Application to the context of machining with carbide tools; *Tribology International*, 2013, 66, 72 - 82**

**[8] Giovenco et al.; A first step towards a tribological approach to investigate cutting tool wear; *Key Engineering Materials*, 2014, 611-612, 452-459**