PhD Proposal 2017

School: Ecole Centrale de Lille	
Laboratory: Laboratoire de Mécanique de Lille LML UMR CNRS 8107	**Web site: lml.univ-lille1.fr**
Team: LaMCube - µFrein	**Head of the team: Jian Fu Shao**
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Collaboration with other partner during this PhD: **In France: Institut Pasteur, Lille**	**In China:**

Title: Localizing the submicronic particles emissions during braking: towards a better understanding of the generation of particles pollution.
Scientific field: Materials Science, Mechanics, Tribology,
Key words: tribology, braking, airborne wear particle emission, pollution

Details for the subject:

Background, Context:

Braking by friction, especially in rail and road transport vehicles, is responsible for a growing menace on the environment. The nature of friction induces wear from the pads and discs, and the particles that wear off can stay airborne for some time, and eventually be found in wastewater and rivers.

Many studies have shown that braking wear particles are small enough to be toxic to human cells. Whether this toxicity is only dependant on the size of the particle is still unclear, and the relation between contact load, induced frictional conditions occurring during braking and particle emissions is still unknown.

The Laboratory of Mechanics of Lille (LML) has a long experience on phenomena induced by friction, especially in the field of braking applications. Based on a multi-physic and multi-scale approach, researches focus on couplings between phenomena (thermal, mechanical, chemical …) and scale effects from the contact to the structure. The LML braking team has developed in the past ten years an original approach based on model lining formulations and dedicated friction tests specially designed to analyse couplings between mechanical behaviour and physical friction and wear mechanisms involved at the rubbing interface.

Research subject, work plan:

The LML braking team undertakes to understand the friction mechanisms that lead to the emission of nanoparticles during braking. In this approach, a constant link will be made all along the chain of events: the fabrication process of the pads, the mechanic system of friction, the various phenomena that occur during friction, including the formation of the third body [1-2], the airborne emissions of wear particles and the toxicity of these particles.

The successful applicant will specifically study the link between the friction phenomena and the emission of nanoparticles. Working on a reduced formulation at first, he or she will perform friction [3-4] and braking tests [5] on devices developed in the lab. Compiling the results of *in situ* particles emissions given by a particle size analyser and a mass spectrometer, mechanical data (contact forces, rotating and sliding velocities, vibrations, etc.), and thermal field history (disc surface emissivity and temperature [6]), the Ph.D. student will give new understanding of the mechanisms of emission of nanosized particles, and of the conditions that lead to critical situations. High temperature and thermal localizations [7], deformation of the disc, chemical nature of the two first bodies, chemical and mechanical behaviour of the third body are examples of important parameters that will be followed during the tests.

In a second part, connections between wear particle emissions and the toxicity will be made in collaboration with the Institut Pasteur in Lille. Determining the impact of parameters such as the size of particles, their chemical nature or their shape will be paramount in this part. A standard protocol may be used to determine the toxicity of nanoparticles gathered in known conditions.

Finally, the student will focus on suggesting and testing solutions to improve the environmental footprint of braking pads, whether the solutions rest on chemistry of the friction parts, their fabrication process, the friction system itself or any other aspect of the contact.

References:

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[4] R. Gilardi, L. Alzati, M. THIAM, J-F. BRUNEL, Y. DESPLANQUES, P. DUFRENOY, S. SHARM, J. BIJWE, Copper Substitution and Noise Reduction in Brake Pads: Graphite Type Selection, Materials 5 (2012) 2258-2269.

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