Politecnico di Milano
Department of Mechanical Engineering
Applied Mechanics Group

Proposed MSc thesis topics
(for more information please contact the underlined professor)

TIRES

1. Development of a thermo-mechanical model for high performance tyres (Prof. Braghin)
numerical-experimental thesis
Hysteretic properties of rubber compounds are significantly affected by temperature. And temperature does vary during manoeuvres due to the generated heat at tyre-road interface. The present thesis aims at developing a simplified thermo - mechanical model that is able to account for the rubber compound deformation imposed by the road roughness as well as for the temperature distribution inside the tread compound due to the heat generated at tyre – road interface as well as to the energy dissipated by the viscoelastic behaviour of rubber. Moreover, also nonlinear viscoelastic contributions could be included in the model.

2. Characterization of the elastic and damping properties of tire tread design (Prof. Braghin)
numerical thesis
Tread design significantly influences not only aquaplaning or hydroplaning but also its overall handling and comfort performances. It is therefore of great importance to have a numerical tool able to predict how tread design influences the tire stiffness and damping characteristics. Most of the work will be done using FEA software.

3. Tire tread wear model (Prof. Braghin)
numerical-experimental thesis
Tread wear is affected by a great amount of local parameters (local contact friction, flash temperatures, …) that are difficult to measure. Thus, predicting tread wear is presently impossible and abrasive tests are carried out on both rubber samples and tire prototypes. The aim of the thesis is to setup a model, based on experimental tests, that is able to predict tread wear as a function of the tire working conditions and of the rubber mechanical and thermal characteristics.

4. Deformable tire model for vehicle dynamic simulations (Prof. Braghin)
numerical thesis
Deformable tire models available in the literature typically require high computational cost and are therefore not suited for vehicle dynamic simulations. The idea is to carry out a dynamic condensation of the first eigenmodes of an inflated tire thus reducing the computational cost to its minimum but still being able to simulate high frequency phenomena such as cleat tests.

5. Tire – deformable ground interaction model for agricultural vehicle simulations (Prof. Braghin)
numerical thesis
Being able to predict tractive forces as well as ground compaction is still one of the most complex tasks in tire modelling due to the interaction of tire and ground highly nonlinear models. The aim of this thesis is to couple such model in order to optimize tread design.

6. Silent Tyre: numerical and experimental analysis of the elements affecting the rolling noise (Prof. Corradi)

numerical\experimental thesis

It has been estimated that approximately 80 million people in European Union are exposed to high traffic noise level. The main vehicle exterior noise sources are the engine/drivetrain and the rolling tyre, but it is worth to highlight that, for driving speed above 60 Km/h, tyre noise is dominant. Furthermore, the European Commission recently proposed a draft law for the vehicles noise reduction and tyre manufacturers want to deal with it in time. For this reason, the Pirelli Tyre S.p.A. and the Mechanics Department of the Politecnico di Milano are developing a joint research project in order to evaluate the main noise sources of a rolling tyre. The experimental acoustical mapping, performed with extremely wide microphone motorised arrays (more than 1 thousands of nodes) is actually exploring these phenomena. The numerical analysis will be carried out according to two different acoustical techniques (Acoustic Holography and Beamforming). Besides experiments in semi-anechoic room, outdoor tests on Pirelli track at Vizzola Ticino are scheduled.

7. **Development of a smart tires to collect information around contact patch dynamics (**Prof. Melzi)

numerical/experimental thesis (cooperation with Pirelli Tyre S.p.A.).

The activity is focused on the analysis of the signals recorded by sensors introduced inside the tire to detect the approaching of the limit in terms of maximum longitudinal/lateral contact force. Data collected in indoor tests performed with MTS flat-trac and outdoor tests carried out on vehicles equipped with smart tires will be analysed to recognize early signs of saturation of tangential force under different contact conditions (friction, road texture, compound characteristics etc.). Mathematical models of tires will support the analysis to provide a better understanding of contact patch dynamics. On the basis of mathematical models and using signal processing techniques, algorithms will be designed to extract the required information.

8. Contact patch monitoring through smart tires

numerical/experimental thesis (cooperation with Pirelli Tyre S.p.A.).

As well known, the performance of a road vehicle is deeply affected by tires. Tires response is in turn influenced by parameters like: size, carcass stiffness, tread compound properties and tread design.

The choice of the “best” tire for a passenger car is usually made through a series of experimental tests where tire manufacturers modify tire design to match the requirements of test drivers. Unfortunately, feedback of test drivers is usually in terms of global response of the vehicle (understeer, oversteer) or tire cornering stiffness of an axle or global grip; these indications do not have a univocal corresponding design parameter and this causes the process to be iterative and rather long.

The activity to be developed in this work aims at using smart tires as tools to narrow the gap between test divers and tire manufacturers. Experimental tests sessions on different vehicles equipped with different tires are planned to a) characterize vehicle’s response through handling manoeuvres, b) monitor the contact patch dynamics through smart tires. Analysis of experimental outputs should allow to understand how different design parameters of tires relate to different contact patch dynamics and thus to different performances of the vehicle.