Borsa di studio attivata ai sensi di quanto disposto dal D.M. n. 1061 del 10/08/2021

Titolo del progetto: Advanced material modelling for virtual tyre development

La borsa sarà attivata sul seguente corso di dottorato accreditato per il XXXVII ciclo:
MECCANICA TEORICA E APPLICATA

Responsabile scientifico: Prof. Jacopo Ciambella
Area per la quale si presenta la richiesta: GREEN
Numero di mensilità da svolgere in azienda: 12
Numero di mensilità da svolgere all'estero: 6 presso Institute for Polymer Science IPF Dresden (Germany)
Azienda: BRIDGESTONE Europe N.V./S.A, Via del Fosso del Salceto 13/15, 00128 Roma
Il Dipartimento è disponibile a cofinanziare per un importo pari a euro: 10.000
Dipartimento finanziatore: DIPARTIMENTO DI INGEGNERIA STRUTTURALE E GEOTECNICA con delibera del 20.09.2021

Progetto di ricerca:
Virtual Tyre Development is a technology which allows the design of a digital tyre twin, testing it virtually and fine-tuning it before moving on to physical testing. It’s a process that provides significant benefits in efficiency and sustainability - cutting development time, raw materials use and CO2 emissions - along with offering greater accuracy and flexibility.
The effectiveness of the virtual approach strongly rely on the availability of physical models able to describe accurately each of the more than twenty elastomeric compounds used in a tyre. The performance of a car tyre is mainly influenced by the capability of the compounds of storing elastic energy and partially dissipating it through heat. Rubber are normally tested in the lab through Dynamic Mechanical Analyzers (DMA) which allows the assessment of the mechanical properties up to 100 Hz, however characterization at higher frequencies is necessary for a reliable virtual twin.
The approach usually followed in the literature to overcome the physical limit of most DMA machines used for the large strain testing of rubber is the repetition of the testing at lower temperatures and the extrapolation of the results up to the kHz regime by assuming the material to be thermo-rheological simple, meaning that the frequency-temperature superposition principle applies. However, this indirect characterization is often prone to error and may lead to large deviations from the experimental observations. This is mostly true when the acoustic performances of a complex structure such as a pneumatic tyre must be assessed.
The objective of the PhD will be the experimental evaluation of rubber compounds up to the kHz regime and the formulation of viscoelastic models able to match the observed behaviour in the broad frequency range of interest. Non-stationary testing under large amplitude shear will be considered by setting up an inverse problem for the robust identification of the constitutive parameters based on the available analytical solutions. During the PhD the students will collaborate with Dr. Amit Das at the Institute of Polymer Science in Dresden where state-of-the-art facilities for rubber compounding and testing are in use. A six-months visit at IPF is expected.
Once the most effective experimental technique will be selected, the problem of modelling the viscoelastic material in the entire frequency range of interest will be approached. Viscoelastic models with exponential kernels, i.e., Prony series, or with fractional kernels, i.e., MittagLeffler function, will be evaluated and their performance compared also in terms of their numerical efficiency. The models should also be able describe nonlinear effects, e.g., Payne effect which are peculiar phenomena of synthetic rubber.

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