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A MULTI-SCALE APPROACH ON THE TRANSIENT DYNAMICS OF ROLLING TIRES

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ABSTRACT

The transient dynamic response of rolling tires, which is excited from the tread impact and the road surface texture, is a major source of traffic noise. Detailed finite element methods for a better understanding of the mechanism and for optimization of the system are under development since a couple of years [1]. The overall problem is computed efficiently within a spatially fixed Arbitrary Lagrangian Eulerian framework, cf. [2]. The global approach is as follows: In a first step the non-linear stationary rolling process is solved within a spatial (ALE) framework, where a numerically efficient solution for the treatment of the tangential contact problem has been suggested recently [3]. Based on this result an eigenvalue–analysis is performed for the prestressed gyroscopic system, for details it is referred to [4]. The transient operational modes are computed by a modal superposition technique, see [5], and in a final step the sound radiation is analyzed by an infinite element approach.

This presentation deals with a detailed analysis of the excitation mechanism of a slick tire in rolling contact with a rough road surface. A weekly coupled two–scale approach is introduced, the overall procedure is sketched in figure 1. The tire structure is modeled by circumstantial finite element models for a frequency band up to 1.5 kHz. The material properties for this transient dynamics model are approximated by frequency dependent stiffness and related modal damping. The tire road contact is approximated by a representative part of the tread rubber discretized with fine spatial resolution such that the road roughness is resolved in a suitable manner. This model is loaded with the pressure distribution obtained from the stationary rolling approach in a cyclic manner, such that a transient dynamic rolling process is simulated. The material properties are described by a non-linear constitutive model including damage and visco–elastic effects within a large deformation framework. A Newmark-type schema is introduced for the transient dynamic response analysis. This detailed contact analysis with rough surface profiles which are obtained from measurements leads to filter descriptions (enveloping) to be used for the excitation of the modal tire model. In addition, from the computed hysteresis curves a damping coefficient is estimated for the excitation model.

The presented approach provides a more detailed view into the mechanism of rolling noise generation, which is an essential step for validated models. The practicability for industrial use is demonstrated on quite detailed tire models.

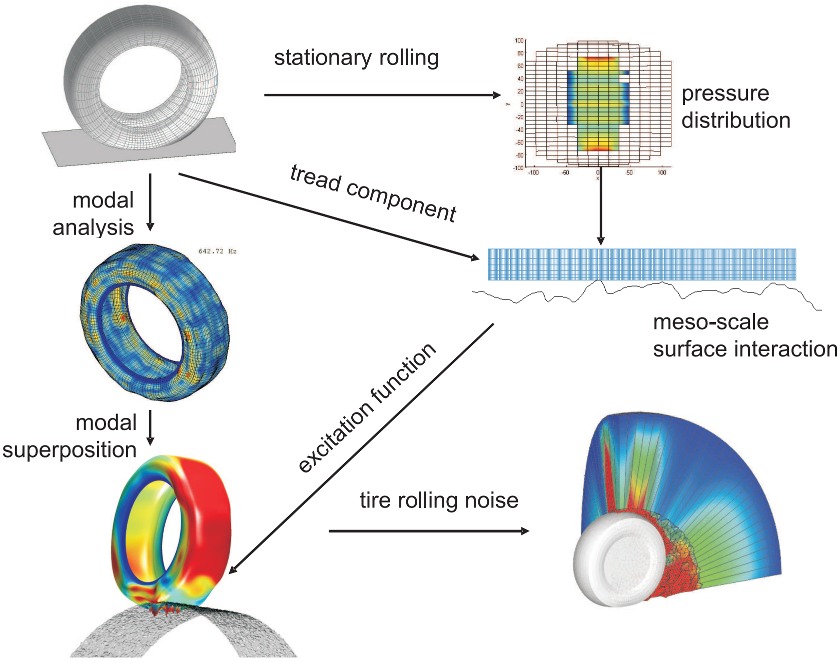

Figure 1: Schematic sketch on the overall simulation procedure. The focus of this presentation will be laid onto the rough surface contact approach.

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