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A computational model to investigate the sound radiation from rolling tires

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ABSTRACT

The tire/road noise is one of the most urgent problems in traffic noise abatement and therefore of particular concern in the design process of new tires and road surfaces. To support the overall development of low noise systems, the usage of appropriate computational tools, accounting for the most relevant effects of the noise generation and radiation, seems to be essential. However, up to now no physically-base and validated model exists that can be employed to determine the sound radiation of rolling vehicle tires within the relevant frequency range and with reasonable accuracy.
A promising numerical model to handle the complete tire/road system is suggested by the current authors et al. in [1]. It is based on a simulation process that may be split into several analysis steps (see figure 1): the computation of the non-linear stationary rolling process, the analysis of the tire dynamics caused by the road roughness, and the computation of the sound radiation.

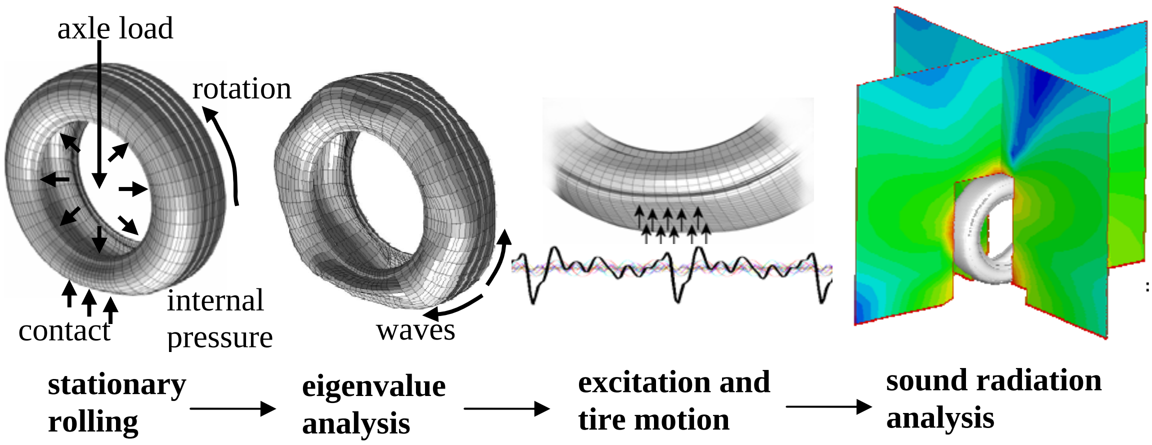

Figure 1: Analysis steps inthe simulation process of tire rolling noise

In the current contribution, emphasis will be placed on last step of the analysis procedure, namely on its improvement with respect to applicability and accuracy.
For the sound radiation analysis a model based on a finite/infinite element approach is suggested. In order to be able to simulate an extended frequency range as well as tires of larger size, e.g. truck tires, efficient numerical methods have to be used. Here, for

instance, improved acoustical finite elements based on Bernstein polynomials [2] and an efficient variant of the so-called Astley-Leis elements [3] are applied. It will be shown that, compared to conventional formulations, a gain of computational efficiency by a factor of two may be achieved.

In order to demonstrate the applicability and accuracy of the new model, it has been validated first for a stationary tire with a defined excitation. An excellent agreement with corresponding measurement data could be achieved [4]. For a tire rolling on a real road surface it was found that if the stationary road texture spectrum was used for the excitation of the structural model [5], the acoustical response of the tire could not be represented with the desired accuracy. Hence it could be concluded that the local dynamic effects in the tire/road contact zone need to be incorporated into the model. To investigate the physical behavior in more detail, simulations have been performed in order to reveal the local effects in the contact patch region. The results of these investigations will be presented and discussed.

Besides the improvements of the vibro-acoustical model, the incorporation of air-pumping effects is aspired. Generally, in the literature the air-pumping is considered to be the second most important noise mechanism. It is distinguished between air-pumping due to the profile and due to road surface cavities. Concerning the latter effect, hardly any research results can be found in the literature (see, e.g. [6], [7]). First investigations on this type of noise source will be part of the current study.

Finally, an overview will be given discussing different applications of the current computational model. This will include the investigation of the influence of sound absorption in wheelhouse casings, the acoustical influence of circumferential tire grooves, and the investigation of the sound radiation of truck tires.

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