Contact induced vibrations and noise of rolling tyres

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Introduction

The interaction of rolling tyres with road surfaces is one of the major contributions to road traffic noise. The generation mechanisms are usually separated in structure borne and airborne noise. In order to reduce tyre/road noise, accurate (numerical) prediction models are needed, which are developed in the current project.

Development of a numerical model

A structural tyre model based on finite elements, including complex rubber material behaviour, tread profiles and detailed tyre constructions, is being built in Abaqus. Explicit time integration is used to model a tyre rolling on a road surface. Tyre responses, which heavily depend on the way the contact zone is modelled, are the output of the structural model.
A sound radiation model based on the boundary element method [1] is then used to calculate tyre/road noise. Aerodynamic noise sources can be modelled as equivalent sources near the contact patch.

Kloosterzande experiments

To validate the numerical model, external sound pressure measurements have been performed at a special track near Kloosterzande. A total of 8 different tyres have been tested on 40 different road surfaces at 5 different speeds.

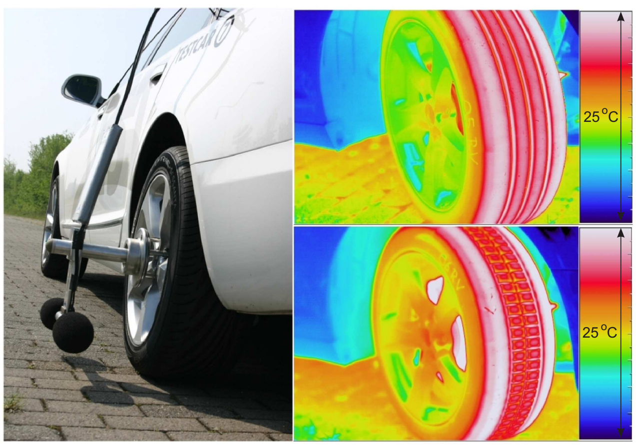

Figure 1 : Experimental setup mounted on the car (left) and infrared pictures of the grooved tyre (above) and block pattern tyre (below) to indicate the temperatures.

The left hand side of figure 1 shows the specially designed experimental setup mounted on the car. The right hand side shows infrared pictures of two tyres, which were specially designed for the validation: a circumferential grooved tyre and a block pattern tyre. Three different road surfaces have been considered: ISO asphalt, two-layer porous asphalt concrete (PAC) and a rubber surface. As an example of the results, figure 2 shows the normalized sound pressure levels of the front microphone at a driving speed of 100 km/h. The figure shows that repetitive profiles cause tonal noise at the tread block passing frequency (1000 Hz) and higher harmonics. Porous asphalt largely reduces the noise at these peaks.

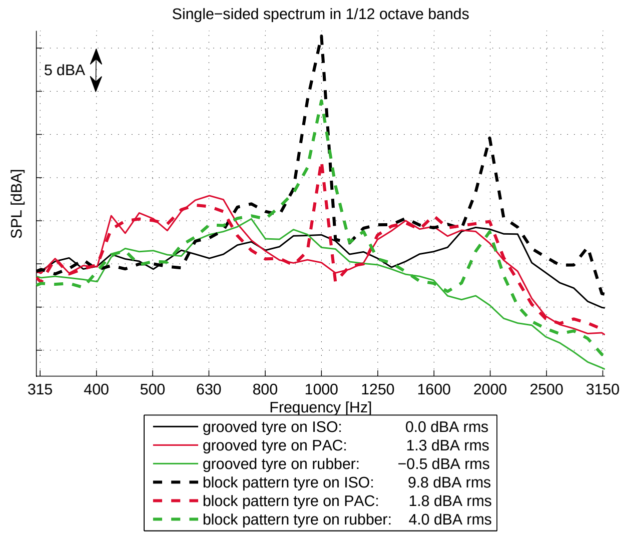

Figure 2 : Normalized experimental sound pressure levels of the front microphone at 100 km/h.

Conclusions and future work

A large number of experiments have been performed, which allow a proper validation of the numerical model in the near future.

References

1. Visser, R. (2004) A boundary element approach to acoustic radiation and source identification. PhD thesis, University of Twente, Enschede, The Netherlands.

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