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Issues on tyre-road interaction at Vredestein Tyres

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1 INTRODUCTION

1.1 *Tyres*

Passenger car tyres (PCT) should be economical and provide safety and comfort. At present the concept of a tubeless pneumatic tyre is used for this purpose. For PCT a relatively low pressure is used of typically two to three bar. The tyre consists of sulphur vulcanized rubbers in combination with typically a radial orientated textile carcass, steel belts and steel beads. In the different area's of the tyre, different rubber mixtures are used to meet specific needs.

Looking at tyre-road contact, at macro level the contact area between the tyre and road would be mainly influenced by the inflation pressure and is in the order of 10^4 mm^2 per tyre. However when zooming to micrometer level, the contact area is typically a factor 1000 less. Beside tyre inflation pressure and road roughness, also tyre tread rubber, tread pattern and tyre construction play an important role in tyre-road contact.

1.2 *Modeling of the tyre*

To model a tyre especially the modeling of the rubber material is not trivial. Rubber is an incompressible and viscoelastic material. This can be modeled, however, the behavior is strongly dependent on temperature, frequency and strain. Because the hysteresis will generate heat, we also face a thermo-mechanical problem. To make it even worse, the Mullins and Payne effects make the material behavior history dependent.

For analytical parametric studies sometimes elastic material models will suffice. In FEM analysis, typical a stress-strain curve is fitted for an estimated temperature and the hysteresis part is determined by an estimated temperature, frequency and dynamic strain.

Besides the rubber material, also the modeling of the friction, the road and the reinforcement layers in the tyre are important. Especially when looking at topics related to tyre-road contact each of these aspects needs to be looked at closely.

2 ISSUES ON TYRE-ROAD INTERACTION AT VREDESTEIN TYRES

2.1 *Friction*

Different friction laws are known from literature going from empirical fits to a fundamental approach. One of these fundamental approaches is the Persson approach[1], which we have implemented at Vredestein. This approach looks at steady state sliding friction. Because of the sliding, the hysteresis part of the friction is claimed to be dominant over the adhesion. In the Persson approach, the road is described as a self-affine fractal and the dynamic elastic and loss modulus of rubber are a function of both temperature and frequency, but not of strain.

Validation is difficult, as measuring frictional behavior of rubber on lab scale has three main difficulties: The smearing of the rubber, the deformation of the specimen and the unknown heating at the surface of the rubber. This makes it difficult to perform reproducible measurements at the one side, and correctly interpret the results on the other side. On laboratory scale we use the so called LAT-100 to measure friction and wear[2]. This is a machine that runs a solid rubber wheel under a slip angle on a disk and measures the forces at the wheel's axle.

2.2 *Wear*

For optimizing tyre wear, at Vredestein a simple FEM approach is used. A tyre is modeled with a detailed tread rolling on a flat surface. The contact is a Newtion friction law and the rubbers are modeled with hyper elastic material models. An implicit solver is used. Using the total work due to sliding of a node when passing through contact as a measure for the wear, good correlation is found with wear patterns that are measured on the road. This correlation exists for driven and non-driven wheels.

To understand the physics, a brush model was developed at TUe[3] to explain the difference in wear propagation between driven and non-driven axles. This model also points to important factors in tyre uniformity on uneven tyre wear.

On lab scale LAT-100 is used to study wear behavior of rubber compounds, facing similar experimental difficulties as when measuring friction.

3 CONCLUSIONS

Tyre-road contact is a challenging area. With the current state of the art modeling techniques we are able to understand tyres better. Step by step improvement on contact and material modeling are made. This is essential as wet grip, rolling resistance rating and noise legislation asks for parallel improvement on these related aspects.

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