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FE modeling of rubber friction on rough roads

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ABSTRACT

The cornering, braking, traction, rolling resistance and wear performance of tires depend on the generated friction forces. These friction forces depend not only on a specific compound, but also on the underlying road surface. One of the challenges in numerical simulations is a correct prediction of these frictional forces. In commercial FEM packages, where usually only the Coulomb friction model is present, the surface roughness is not accounted for. It is well-known that for cornering under high slip angles the results with a Coulomb friction model are less accurate. By incorporating surface roughness a more realistic friction model can be obtained, which should provide a better correlation between FEA and real road experiments.

Recently a theory for contact mechanics and sliding friction of rubber has been developed (see Persson [1], [2]). In this work hysteresis friction is assumed, which is caused by the viscoelastic modulus of the rubber and the excitation of the road surface. It is possible to calculate a friction coefficient for a set of sliding velocities considering the mechanical-dynamical material properties and the specific roughness of the interacting surface.

To illustrate this approach an Laboratory Abrasion and skid Tester (LAT 100, [3]) is used, see figure 1. In this setup a small solid tire, with adjustable slip angle, is pressed on an abrasive disk. The applied normal force on the tire, temperature, speed and surface texture of the disk can be controlled. The present friction between the abrasive disk and tire drives the tire and the resulting forces are measured with a tri-axial force sensor.

The relevant parts of this setup are modeled in *ABAQUS* [4], taking into account the non-linear material behavior, see figure 2. A 2D cross section of the tire is revolved to create the 3D model. To evaluate the steady state performance of the wheel under different slip angles, the steady state transport capability of *ABAQUS* is used. Therefore only a dense mesh in the contact area is required, which makes this an efficient approach to calculate the responses.

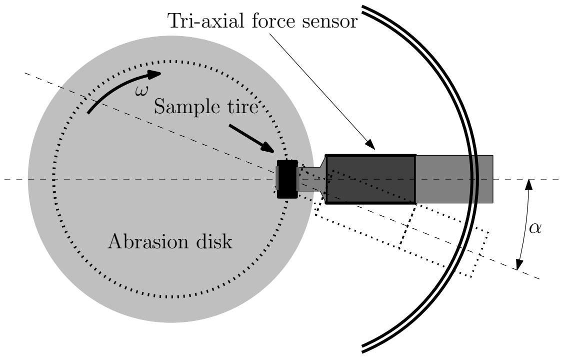

Figure 1: Schematic overview of the LAT 100.

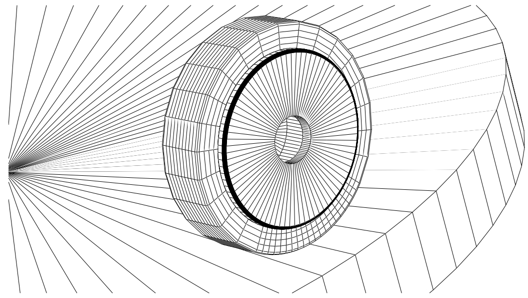

Figure 2: 3D FE model of the solid tire.

For the contacting surface in the FE model a smooth rigid surface is used. The effect of surface roughness is incorporated in the obtained friction model, using the method proposed by Persson, and is implemented into the user-subroutine *FRIC*. The implementation of the friction law itself is done analogous to a plasticity material model by using a return mapping algorithm. Therefore the sliding velocity is split into a small elastic and an inelastic part [5].

Finally the results of this method are compared with the available Coulomb model in *ABAQUS* and measured side-force characteristics on the LAT 100.

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