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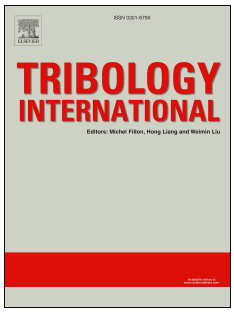

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ACCEPTED MANUSCRIPT

A Model Based Method to Determine Rubber Friction Data Based on Rubber Sample Measurements

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Abstract

Rubber friction characteristics, which specify the dynamic (sliding) friction coefficient as a function of sliding speed, contact pressure etc., are required for tire models and have a substantial influence on their results. Classically, friction characteristics are determined based on sliding body measurements. In this paper, a new method is presented, which can be used to determine friction data for wet track conditions based on Grosch-wheel (solid rubber wheel) measurements. The aim is to represent more realistic contact conditions due to the rolling contact of such a wheel. When modeling tire characteristics, we show, that compared to friction characteristics obtained from sliding body measurements better results can be achieved by using the characteristics of the method mentioned in this paper.

Keywords: Pavement; Rubber Friction; Wet Grip; Grosch-Wheel;

1 Introduction

The quality of model based tire characteristics strongly depends on the used rubber friction data. Typically, such friction values are determined as a function of the contact pressure, the temperature and the sliding speed. There exist experimental but also theoretical approaches to determine these values.

Theoretical approaches, which describe the hysteresis and adhesion of rubber have been developed and mainly influenced by Persson [1–4] as well as by Heinrich and Klüppel [5–7]. There have also been approaches to describe the hydrodynamic effect of water on the friction characteristic, see e.g. Moore [8,9], Persson et al. [10–12] or Kane et al. [13].

A large number of different testing facilities exist, used to investigate such friction characteristics. The test benches varies regarding their rubber sample geometry, their possible track surfaces (corundum surfaces, asphalt, snow, ice) and the adjustable operating parameters (speed, load, temperature, lubrication). We can classify the test bench setups into linear tribometer (different test benches and investigations see [14–34]) and rotary tribometer (see [27,28,35–41]). Regarding the rubber samples, usually sliding bodies or Grosch-wheels (solid rubber wheel with a width of 18 mm and a diameter of 80 mm) are used. Grosch-wheels are typically running under a certain slip angle and/or longitudinal slip, depending on the test rig configuration.

The experimentally determined coefficients of friction with rubber samples can be distinguished into stationary and non-stationary friction coefficients. Stationary coefficients are determined from an average value over a fixed test duration with constant operating parameters. The so-called running-in phase, necessary to reach a stationary coefficient of friction (due to conditioning and temperature effects), is not taken into account. The investigation of transient, non-stationary friction coefficients is carried out by changing the operating parameters during one measurement, e.g. speed. Transient measurements allow to obtain entire friction grids (friction coefficient as function of the sliding velocity, contact pressure, temperature etc.) with a, compared to stationary measurements, small number of tests. Due to different temperature conditions and dynamic effects, the stationary results can deviate from the non-stationary ones. [14]

Measurements with rolling Grosch-wheels have, compared to sliding bodies, a higher similarity to the contact conditions on a vehicle tire. The Grosch-wheel has, similar to vehicle tires, a contact surface which depends on the load. In comparison to sliding bodies, we have a much better cooling of the Grosch-wheel, since the rubber elements, which are in contact, continuously changes. [30,32]

Measurements with a Grosch-wheel on the *Reibmobil* (engl. Friction Mobile) of the Leibniz University Hannover yields in measuring μ-slip characteristics. Parameters, such as the maximum coefficient of friction and the dynamic (sliding) friction coefficient at 100% slip is determined [30]. By means of variations of the driving speed and the contact pressure, an entire friction grid under rolling conditions is obtained. Gutzeit and Kröger [34] determine parameters of a Coulomb friction law by means of Grosch-wheel measurement on the *Reibmobil*. The friction law is used in a finite element method model of the Grosch-wheel. Van der Steen et al. [37] determine the coefficient of friction depending on the velocity and the contact pressure with Grosch-wheels on a commercial *LAT100* [38] at a slip angle of ± 40 °.

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