Introduction

Semi-empirical tyre models are models that require tyre measurements for parameterisation. These models are typically used for vehicle dynamic simulations. Two well-known semi-empirical tyre models are the Magic Formula and SWIFT models. The Magic Formula is a tyre handling model that is capable of dealing with slip, camber and transient responses up to about 8 Hz. The SWIFT model is a dynamic model to describe tyre behaviour for in-plane (longitudinal and vertical) and out-of-plane (lateral and steering) motions up to about 60-100 Hz and it can deal with arbitrary road unevenness. Currently, research is focussed on improving the models for motorcycle tyres and on extending the models so that inflation pressure changes can be considered.

Methods

To investigate the behaviour of motorcycle tyres and the effect of inflation pressure for passenger car tyres, experiments have been carried out with the TNO Tyres Test Trailer and the TUE Flat Plank Tyre Test Facility. Besides these experiments, various simulation models have been used: multibody models (motorcycle and test facilities) and an advanced semi-empirical brush model to investigate the tyre behaviour more physically.

Results

As an example, simulations are compared with measurements for a tyre rolling over an obstacle at three inflation pressures at a constant vertical load of 4 kN. As can be observed, the effect of various inflation pressures is represented well by the model.

Below, another example is shown. The Magic Formula slip characteristics of a passenger car tyre for three inflation pressures and three vertical loads (2, 4 and 6 kN) are compared with measurements from the Tyre Test Trailer. It is shown that simulation results agree well with measurements. The overall fit error of the Magic Formula has been improved with 60 % with regard to the ‘original’ Magic Formula that does not account for inflation pressure changes.

For more validation results, test rig descriptions and model details, it is referred to the publications listed below.

Conclusions

The Magic Formula model has been significantly improved for motorcycle tyres. With the new model the wheel centre height, the forces and moments and the wheel rotational velocity can be described better. With regard to inflation pressure changes, the Magic Formula model and the SWIFT contact model have been extended so that it is now possible to consider inflation pressure changes. Future research is focussed on: (1) improving the SWIFT model for motorcycle tyres, (2) extending the complete SWIFT model for inflation pressure changes.

Recent publications*


* A more complete overview of publications regarding the Magic Formula and SWIFT models can be found in reference [3].