Bicycle and Motorcycle Dynamics 2010
Symposium on the Dynamics and Control of Single Track Vehicles,
20 - 22 October 2010, Delft, The Netherlands

Application of the rigid ring model for simulating the dynamics of motorcycle tyres on uneven roads

A.J.C. Schmeitz and S.T.H. Jansen
TNO Science and Industry, Business Unit Automotive
P.O. Box 756, 5700 AT Helmond, The Netherlands
e-mail: antoine.schmeitz@tno.nl

Yoshitaka Tezuka, Makoto Hasegawa and Syunichi Miyagishi
Honda R&D Co., Ltd. Motorcycle R&D Center

Abstract

Active control systems find their way into motorcycle technology for support of the rider, often aimed to enhance the safety without reducing driving pleasure. In order to develop these new systems in the virtual environment an extended description of the tyre behaviour is required. More specific, the higher order tyre dynamics needs to be modelled for the full range of driving conditions. This includes large lean angles, combinations of lateral and longitudinal slip, and various road unevenness. This publication describes the adaptations of a passenger car rigid ring model for uneven road simulations (i.e. TNO's MF-Swift) for motorcycle tyres in order to simulate cornering on uneven roads. The main extensions are related to the quasi-static tyre behaviour for rolling over obstacles. Further, the effects on the high frequency response are discussed.

Background

Due to the different construction and the large inclination angles that may occur, motorcycle tyres behave different from passenger car tyres. For this reason, the modelling techniques developed for passenger car tyres may not be directly applied. For instance de Vries and Pacejka [1] had adapted the well-known Magic Formula model for motorcycle tyres, which formed the basis for the widely used MF-MCTyre model of TNO [2]. Later Besselink et. al [3] adapted the original Magic Formula model for passenger car tyres in a different way to handle large inclination angles for both passenger car and motorcycle tyres resulting in a single Magic Formula for large camber angles, without making sacrifices with respect to accuracy for either normal passenger car or motorcycle tyres.

To be able to simulate the tyre dynamic behaviour at higher frequencies than is possible with a 'standard' Magic Formula tyre model, TNO and Delft University of Technology developed the MF-Swift [4] tyre model for passenger cars. The MF-Swift model is a rigid ring tyre model that consists of the following four components:

- Magic Formula
- Contact patch slip model
- Rigid ring
- Obstacle enveloping model

New developments

To investigate the applicability of the MF-Swift concept for motorcycle tyres a joint research project between TNO, Honda and Eindhoven University of Technology has been carried out. This research has lead to adjustments of the basic MF-Swift model so that it can be applied for motorcycle tyres. The main extensions concern the tyre-road contact under larger camber angles.

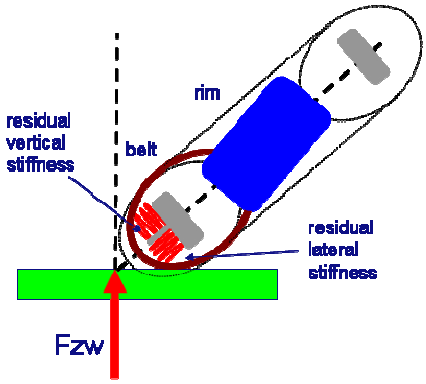

Figure 1. Schematic representation of the adapted MF-Swift model for motorcycle tyres.

Results

In this paper the adapted MF-Swift model for motorcycle tyres (cf. Fig. 1) is described and comparisons with existing models (MF-Swift and MF-MCTyre) are made to clarify the added value of the new model. Further, parameter identification and experimental validation of the model is discussed. Finally, it is concluded that the new model shows a significantly improved response for uneven road simulations for a motorcycle tyre due to modelling of the belt dynamics and the extended contact description. By comparison to MF-MCTyre and MF-Swift the improvements are quantified. As an example some results of a high speed cleat simulation are shown for longitudinal and vertical forces in Fig. 2.

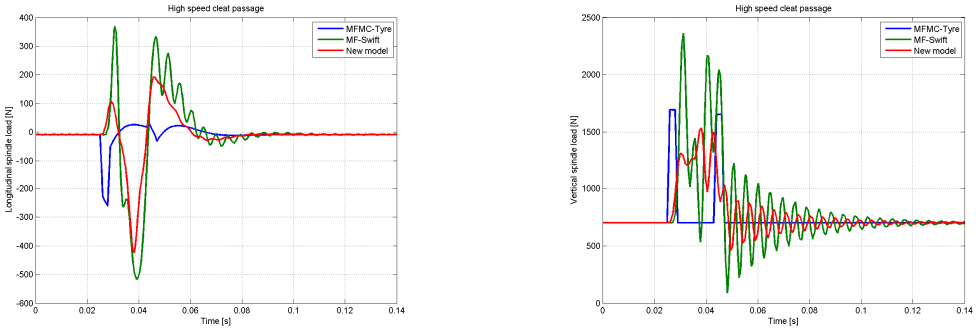

Figure 2. High speed cleat test simulation results for different models.

References

[1] E.J.H. de Vries and H.B. Pacejka, "Motorcycle Tyre Measurements and Models", *Proceedings of the 15th symposium Dynamics of Vehicles on road and tracks*, IAVSD, August 1997, Budapest.

[2] TNO Delft-Tyre, website: www.delft-tyre.nl.

[3] I.J.M. Besselink, A.J.C. Schmeitz and H.B. Pacejka, An improved Magic Formula/SWIFT tyre model that can handle inflation pressure changes", *Proceedings of IAVSD 09*, IAVSD, August 2009, Stockholm.

[4] H.B. Pacejka, *Tyre and Vehicle Dynamics – second edition*, Butterworth and Heinemann, Oxford, 2006.