A Multi-Line Brush Based Tyre Model to Study the Rolling Resistance and Energy Loss

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Introduction and background

Reducing rolling resistance and consequently the fuel consumption is a major development goal for vehicle and tire manufactures.

How the contribution of vehicle dynamics can be investigated and further be evaluated?

A tyre model that can be integrated in vehicle dynamics simulations and facilitate the energy studies is needed.
Model description

Finite number of lines & bristles

Flexible carcass

Rubber model

Initialisation

Tyre
Rubber
Time

Inputs

Side slip angle \( \alpha \)
Camber angle \( \gamma \)
Slip ratio \( K \)
Vertical force \( F_z \)
Longitudinal speed \( V_x \)

Bristle deflection \( \delta \)

Rubber model

Friction observer

Friction ellipse

MDRM

Bristle force

Updating Time and Bristle deflection

\( f_x \)
\( f_y \)
\( f_z \)
Validation of global forces

The structural behaviour of the tyre model represented by the global forces shows good fit with measured data and Magic Formula.
Simulation results

![Graph 1: In-plane rolling resistance coefficient vs. Velocity [m/s]](image1)

![Graph 2: In-plane rolling resistance coefficient vs. Vertical force [N]](image2)

![Graph 3: In-plane rolling resistance coefficient vs. Side slip angle [deg]](image3)

![Graph 4: Rolling resistance coefficient vs. Side slip angle [deg]](image4)
Simulation results

Contact patch behaviour shows same behaviour as actual measurement.
Conclusion

• A tyre model to investigate the rolling resistance and energy dissipation is developed based on the viscoelastic characteristics of the tyre.

• The validation of the global forces have been conducted using Magic Formula and experimental data.

• The dependency of the in-plane rolling resistance on wheel alignment, velocity and vertical load is investigated.

• The contact patch behaviour can be studied in detail.

• Introducing a platform for investigating rolling loss, energy dissipation, and effect of road roughness as well as tyre wear within vehicle dynamic simulations.
Thank you for your attention!

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Question?

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