Development and validation of a new degraded adhesion model for railway vehicles

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The accurate modelling of the wheel-rail contact plays a fundamental role in the railway field since the contact forces heavily affects wear, vehicle dynamics and vehicle safety. In particular, the development of a realistic adhesion model able to describe degraded adhesion conditions is still an open problem in the academic research, since in the current state of art, few contact models takes into consideration the complex adhesion behaviour and the presence of a third body layer. Indeed, a realistic adhesion law is quite difficult to obtain because of the complex and non-linear behaviour of the adhesion coefficient and the presence of unknown contaminants. The difficulty is enhanced in case of degraded adhesion condition and large sliding on the contact surface. To face these problems an innovative, accurate and efficient degraded adhesion model suitable for multibody applications has been developed by the authors. The presented model takes into account some of the main phenomena characterising the degraded adhesion, such as large sliding at the contact interface, high energy dissipation, the consequent cleaning effect on the contact surfaces and the final adhesion recovery due to the removal of external unknown contaminants. This phenomenon is caused by the high energy dissipation on the contact surfaces and by the consequent cleaning effect due to friction. The final adhesion recovery caused by the removal of external contaminants may deeply affect both the vehicle dynamics and the traction and braking maneuvers.

Since most of the physical characteristics of the contaminants are totally unknown in practice, the approach will have to minimize the number of hardly measurable physical quantities required by the model. Therefore, the model guarantees a good accuracy and, at the same time, a high numerical efficiency and for these reasons it can be implemented directly online (and in real-time) in more general multibody models of railway vehicles.

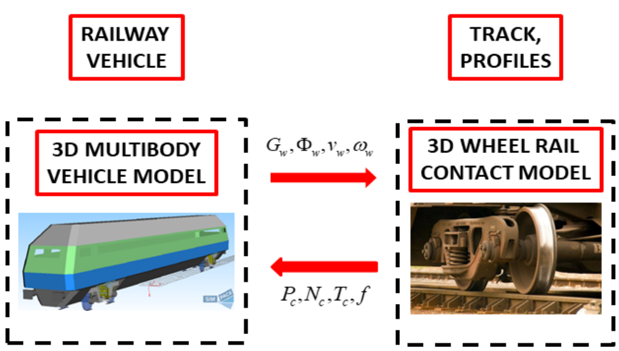

Fig.1: Architecture of the multibody model

From a logical point of view, the multibody model consists of two different parts that mutually interact during the dynamical simulation: the 3D model of the vehicle and the 3D wheel-rail contact model (Fig. 1).

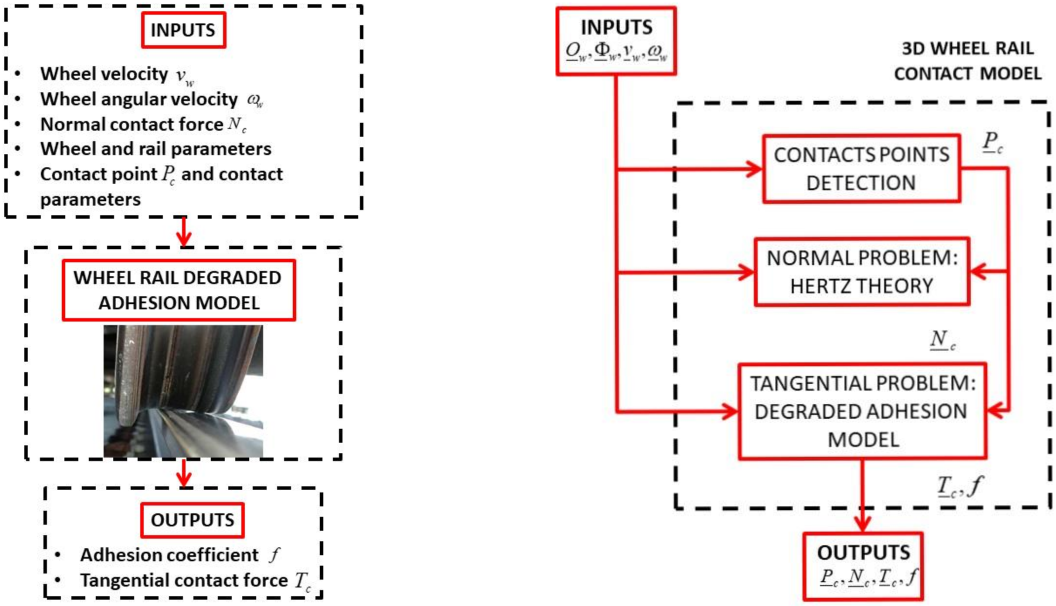

Fig.2: Inputs and outputs of the degraded adhesion model and architecture of the wheel-rail contact model

Typically, simplified and efficient multibody contact models are characterized by three main logical parts: the contact point detection [3], the normal problem solution, the tangential problem solution; the latter part includes also the adhesion model (Fig. 2) [7].

The algorithm FASTSIM created in C++ environment and previously used to solve the tangential problem has now been implemented, and the calculation of pressure and slip is done locally with a discretisation of the contact surface.

The adhesion model presented has then been validated thanks to experimental data provided by Trenitalia S. p. A. coming from on-track tests performed in Velim (Czech Republic) with the railway vehicle UIC-Z1, equipped with a Wheel Slide Protection (WSP) system. The validation highlighted the good performances of the adhesion model in terms of accuracy and numerical efficiency and turned out to be able to well reproduce the complex phenomena behind the degraded adhesion.

References

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