An innovative wheel and rail wear model to study profiles evolution in presence of conformal contact conditions

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EXTENDED ABSTRACT

1 Introduction with state of art and problem description

One of the issues in the railway field is the damage caused by wear, which deeply affects wheel and rail. In railway applications the estimation of wear at the wheel–rail interface is an important field of study, mainly correlated to the planning of maintenance interventions, vehicle stability and the possibility of carrying out specific strategies for the wheel and rail profiles optimization. For this reason, the development of an efficient and accurate wear model capable of predicting the evolution of wheel and rail profiles is one of the most important fields of study in railway engineering. One of the most important problem during the development of a wear model specifically designed for the multibody applications, is the wheel – rail contact model. More in details, many of the models that are available in literature [1] [2] to study the wheel and rail profiles evolution due to wear are based on the FASTSIM algorithm [3], where the normal problem is solved using Hertz theory [4], and the tangential problem is solved by an iterative strip algorithm. With this kind of approach, it is possible to solve the contact problem very quickly and efficiently, but this solution is based on some fundamental hypothesis, as flat and elliptical contact patch. For this reason, FASTSIM algorithm is not recommended in presence of conformal contact conditions. To extend the study of the wheel – rail contact and so to extend the study of the wheel and rail profiles evolution, even in presence of conformal contact conditions, the authors propose an innovative wheel and rail wear model based on an innovative and efficient conformal contact model. In this way the proposed model is able to evaluate the wheel and rail profile evolution even in presence of not flat and not elliptical contact patch and so in presence of conformal contact conditions.

2 Methodology

The general layout of the proposed wear model developed in this research work is made up of two main parts: the dynamic system and the wear model (see Fig. 1). The dynamic block consists of a multibody model of the benchmark vehicle, built in Simpack Rail environment, and of a conformal contact model built in MATLAB/Simulink. During the dynamical simulation these models interact online creating a loop. Generally, the resolution of wheel-rail contact is divided into three phases: detection of contact points, calculation of normal pressure distribution and calculation of tangential pressure distribution. Simpack Rail software already includes several wheel-rail contact models but, in this work, to extend the wear model even in presence of conformal contact conditions, a conformal contact model is adopted. Then, for each contact point, the model calculates contact forces (normal and tangential) and the global creepages of the contact patch.

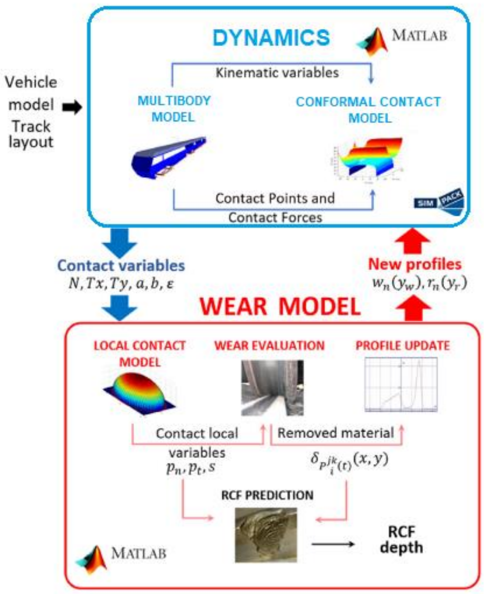

Fig.1 Architecture of the proposed model

The global contact variables are then passed to the multibody model to carry on the simulation of the vehicle dynamics. The tramway track and the multibody model of the considered vehicle are the main inputs of the dynamic block. The wear model consists of three distinct phases: the local contact model, the wear evaluation, and the profile update. The local contact model, based on the proposed conformal contact model, starting from the global contact variables (outputs of multibody simulation), evaluates the local contact variables (contact pressures and local creepages inside the curved contact patch) and divides the contact patch into adhesion area and slip area. Then, the distribution of removed material is calculated on the wheel and rail surface only within the slip area using an experimental law connecting the removal material to the energy dissipated by friction at the contact interface [5]. Finally, the wheel and rail worn profiles are obtained from the original ones through an innovative update strategy. The new updated wheel and rail profiles are then fed back as inputs to the vehicle model and the whole model architecture can proceed towards the next discrete step.

3 Discussion and Results

From a result point of view, the model has been tested in the Milano subway line 5 and the output of the model have been compared with the experimental data. In this way it was possible to evaluate the accuracy of the model. Wear evolution on the wheel profiles is presented in figure 2. The figure shows the main localization of the material removed on the wheel flange due to the quite sharp curves characterizing the Milano subway line 5.

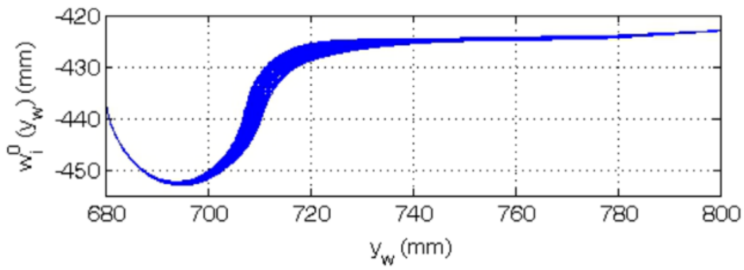

Fig.2 Wheel profile evolution

The evolution of the rail profile, for a specific curve section of the Milano subway line 5, obtained with the proposed and innovative wear model is presented in figure 3.

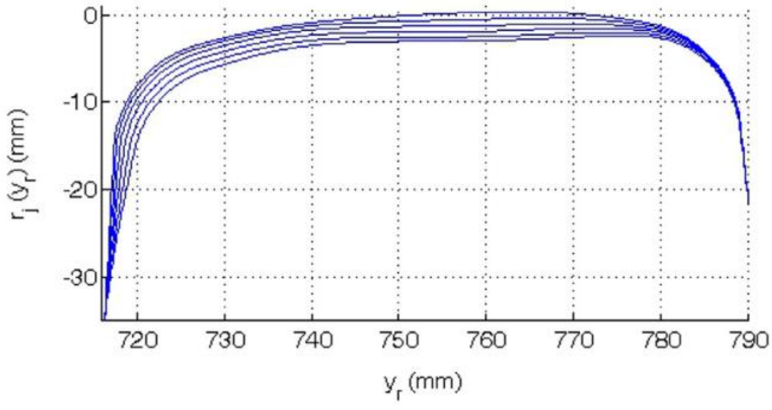

Fig.3 Rail profile evolution

4 Conclusions

During the present activity a new and efficient wear model, able to evaluate the wheel and rail profile evolution even in presence of conformal contact conditions has been development. Subsequently the model has been validated by referring to the experimental data available for the Milano metro line 5. Results, shown that the model is able to evaluate the wheel and rail profile evolution very efficiently and the calculation time shown even that the proposed model is very quick and so designed for multibody applications.

5 References

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