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Comparison between two multibody codes for the simulation of a railway vehicle dynamics

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ABSTRACT

The paper summarizes the studies concerning the numerical simulation of the multibody analysis of a railway vehicle. Numerical simulation of system dynamics is today a standard in the design of railway vehicles: several commercial or customized software simulators of the railway dynamics have been developed over the last years; their typical applications are the suspension kinematics, handling performance and ride comfort as well as the generation of load data for lifetime prediction.

Furthermore, over the last years the MBS (Multibody Simulation) method has then been established in the real–time simulation domain, typically for the design of vehicle control systems and the test of electronic control units. One typical application of real time simulator is related to the control of the Hardware in- the-Loop (HIL) test units, that has extensively been introduced in the design of vehicle control systems and the test of electronic control units, also in the railway field.

The reliability of this type of tests is strictly related to the properties of the numerical model that simulates the condition that the tested device would meet in real operative conditions. The numerical model is a representation of the dynamics of the system in which the tested unit is inserted (single vehicle, entire train etc.). In order to obtain on this type of test rigs reliable results the availability of a realistic real time model of the system dynamics is then necessary.

One of the key points in this type of simulations is the model of the wheel/rail interaction, in other terms the definition of the forces exchanged between the wheels and the rail in the contact points. The direction and the magnitude of the contact forces depends on the number and the location of the contact points. The procedure that allows to define the geometry of the contact, in other terms the research of the contact points, has then a significant effect on the reliability of the simulation. Once the location of the contact points is defined, the component of the contact force normal to the contact surfaces can be defined as a function of the relative indentation between the surfaces, with a procedure developed on the basis of Hertz theory. The component of the contact force tangent to the contact surfaces depends on the relative speeds between the surfaces in the contact area (wheel sliding), according to Kalker theory.

The authors have been working on the definition of efficient and reliable models of the interactions between the wheels and the rails and in particular for the definition of the contact points. Different algorithms have been analyzed and compared. In this paper the presented results have been obtained with a method based on the analytical representation of the wheel and rail surfaces: the contact points are located in correspondence of the minima of the surface defined as the difference between the wheel and the rail surface. During the simulation the relative displacement between the wheel and the rail changes then for each simulation step the difference surface and its minima have to be re-calculated. The details of the definition of the difference surface, the problems related to the research of the minima, and the implementation of the model will be detailed in the paper.

The paper will summarize the results obtained from the simulation of two different sceneries. The vehicle simulated in both the tests is the Manchester Wagon, that is often used as a benchmark to test performance of the multibody simulators, and whose features are available in the literature.

In the first simulation the vehicle carries out an S-curve with no irregularities and no superelevation, with a low speed (40 km/h). In the second one the track has a single curve with superelevation and medium irregularities, the vehicle speed is 200 km/h.

Two different models have been used in this test: the first one was realized with a commercial software (Intec Simpack©) with its conventional contact models, while the second one was developed and implemented by the authors in the Matlab/Simulink© environment.

Concerning the kinematics variables (displacements, rotations), the comparison shows a very good agreement between the models. Concerning the contact forces, there is a global agreement between the models, some differences can be seen during the transients, due to the differences between the algorithms for the calculation of the contact points and to the different integration methods.