Multi-Body Simulation of Rail Vehicles with SIMPACK Rail

Today nearly every modern rail vehicle is designed and analysed with the help of multi-body simulation before it travels its first meter on a real track. This is true for every type of rail vehicle including tramcars, commuter trains, freight trains and high-speed trains. SIMPACK Rail, on the market since 1996, has become the premier worldwide simulation tool for all of these vehicles.

THE HISTORY OF SIMPACK RAIL

The DLR (German Aerospace Centre), the centre of SIMPACK development until 2001, was entrusted by Siemens Transportation in 1993 to develop a module for the simulation of railed vehicles. In 1996, SIMPACK 6.0 was the first release to offer SIMPACK Rail to all customers. From that time to the present the number of licenses has increased exponentially. The "Big Three": Siemens Mobility, Bombardier Transportation and Alstom Transport, as well as many other companies all around Europe, use SIMPACK Rail as their standard multi-body simulation (MBS) tool. It has become the most important commercial tool for high-end rail vehicle engineering in Asia, too.

STATE OF THE ART

"SIMPACK Rail has become the premier worldwide simulation tool for all rail vehicles"

Today's MBS models of railway vehicles can be extremely intricate and therefore large. When a complete articulated high-speed train is modelled, with ten or more cars having flexible carbodies, then the number of degrees of freedom can reach several thousand. Additionally, the frequency range of NVH (noise, vibration, harshness) models of drivetrains ranges easily up to several thousand Hertz.
The typical safety and homologation analyses performed by MBS require integrators that are both highly efficient and accurate, as well as a rail-to-wheel contact model which describes precisely the most complicated contact situations. Currently SIMPACK Rail is undergoing a complete redesign that brings many improvements in handling and reliability of the rail-to-wheel contact. With release 8.902, the new functionality has already been successfully tested and used in a number of projects.

CIRCLE OF USERS

MBS is an indispensable tool for vehicle and component manufacturers, operators, universities, research institutes and, of course, consulting and engineering service providers. Homologation authorities usually do not perform simulations themselves but must be able to understand and interpret the simulation results provided by the manufacturers.
MBS is applied during the entire product lifecycle. During the offer phase, long before the final data of the vehicle are known, it is easy to set up simple models or to reuse existing models from other projects.
Once the order has arrived the models are extended step by step and refined according to the design progress. The modular substructuring concept allows you to start with one bogie or car and to assemble complete trainsets from these elements.
Additionally, SIMPACK is also a general MBS software: the user can analyse detailed models of complete drivetrains, door mechanisms or couplers separately and include them later, if necessary, into the complete model.

TYPICAL FIELDS OF APPLICATION

There are numerous fields of application for MBS of railed vehicles. For vehicle homologation there are the linear methods: eigenmode calculation, root locus analysis for determining the critical speed, frequency response and spectral analysis for comfort assessment; and the non-linear time domain calculations: critical speed, comfort, curving forces, derailment, gauging, sidewind, track damage, and crashworthiness of couplers and shock absorbers. Additional applications are:

- design and analysis of drivetrains with electric or Diesel motor,
- analysis of passive and active steering mechanisms,
- optimisation of brake systems,
- stress prediction and fatigue lifetime,
- automatic control systems such as traction controllers, active suspension or tilting mechanisms,
- optimisation of the pantograph-catenary contact dynamics,
- risk and accident analysis.

ADVANCED TOPICS AND VEHICLES

Other topics are available in MBS although they are still in the status of ongoing research, for example:

- simulation of rail and wheel wear and related mechanisms,
- acoustics,
- post-derailment simulation,
- track quality analysis from acceleration measurements.

Last but not least, there are a number of unconventional vehicle concepts like roller coasters, maglev or people movers on tyres that can be designed and analysed with MBS.

Today, MBS is an indispensable tool for reducing costs of vehicle design and track maintenance and for increasing the already high inherent safety of railway vehicles. In the future, these topics — and hence, MBS with SIMPACK — will become even more important.

LITERATURE

Weidemann, C., 'State-of-the-Art Railway Vehicle Design with Multibody Simulation', keynote lecture STECH, Niigata. JSME 2009.