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Development of Track-Friendly Bogies for High Speeds

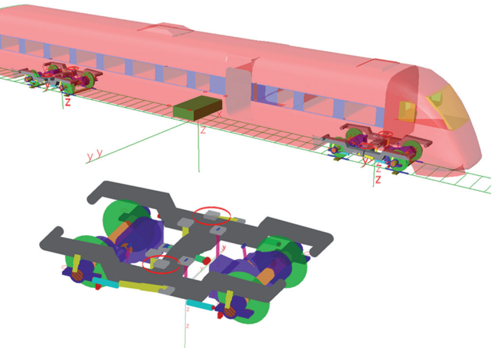

Fig. 1: Vehicle model of a Swedish Regina train

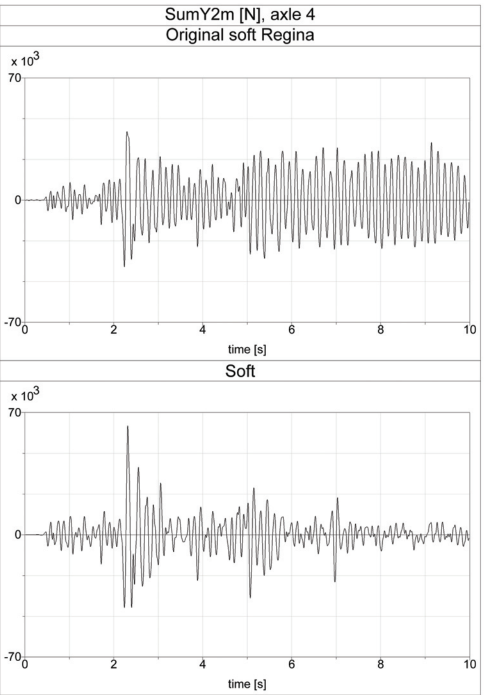

Fig. 2: Simulated track shift force on straight track at 275 km/h for the original soft Regina and the modiefied bogie

In 2004-05 the research and development program "GrönaTåget" (Green-Train), was initiated in Sweden in order to develop the next generation of high-speed trains for Nordic conditions. The expected and desired speed is in the range of 250-300 km/h. One part of the project is to develop a bogie that enables higher speeds and yet is considered to be track-friendly, particularly in curves. Suspension and damping parameters should be developed in order to fulfil the requirements of safety and comfort, according to international standards.

This work has mainly been performed at the Royal Institute of Technology (KTH) in Stockholm, in close co-operation with Bombardier Transportation, using the simulation tool SIMPACK.

THE VEHICLE MODEL

The multi-body dynamics vehicle model used in the present study has originally been developed at Bombardier Transportation and constitutes a one-car vehicle with two motor bogies (fig. 1), and models a Swedish Regina train. The main part of the simulation work has been performed with a rigid carbody, but recently it has been replaced by a flexible carbody.

Two different bogie configurations, with varying stiffness parameters in the wheelset guidance, have been tested in order to evaluate their influence on running stability on straight track and their track friendliness in smaller curves. The two bogie configurations for high speed are referred to as soft and medium.

TRACK GEOMETRY

For the evaluation of running behaviour different cases of track geometry have been implemented in the simulations.

Assessment of the vehicle's stability has been performed at high speed on straight track and in large-radius curves (R≥2400m), whereas track friendliness and wheel/rail wear have been evaluated in curves with smaller radii (R=250-1500m). Track irregularities, originating from .tre-files, have been scaled in order to let peak values and standard deviations reach certain international and national limit values.

The track geometry cases have been defined in SIMPACK according to Standard Railway Track with all appropriate parameters and then saved to the database, in order to be valid for all different vehicle models.

SIMULATION PERFORMANCE

In order to decrease simulation time, particularly when performing curve simulations, elastic one-point contact has been chosen in the vehicle model.

The stiffness in the contact point has been selected in order to obtain a resulting stiffness in the wheel-rail track model according to former research work at KTH.

ASSESSMENT QUANTITIES

In the post-processor General Plots, for assessing running safety, the sum of the guiding forces per axle, ΣY (also known as track shift force, S), is filtered with a sliding mean over 2m in 0.5m increments. Correspondingly, the assessment of running stability is implemented on straight and/or large-radius curve track. The track shift force is band-pass filtered around the instability frequency f_0±2 Hz, in combination with a sliding rms (root mean square) over 100m in 10m increments, according to international standards specified in UIC 518.

The major problems in small-radius curves are the contact conditions combined with high lateral forces, generating fatigue as well as wheel and rail wear. A common way of describing the relative wheel/rail wear for different conditions is to use the wear number, which is the friction energy loss in the wheel/rail contact, not including spin (i.e. rotation).

The ride comfort has been assessed according to Wz-values, evaluated from lateral and vertical accelerations at specific measuring points on the carbody floor. For passenger traffic at longer distances Wz-values in the range of 2.0 to 2.6 are regarded as acceptable.

RESULTS AND VALIDATION

At an early stage of the present study the stiffness in the wheelset guidance was increased from an original soft Regina (bogie for v≤200 km/h) to a modified soft bogie (bogie for v>200 km/h), cf. Figure 2. The result is clear: the guidance stiffness must be increased if stability is desired at higher speeds. On the other hand, with increased stiffness the track friendliness in small-radius curves is decreased. This can be observed in Figure 3, where the dissipated energy (related to wheel/rail wear) of the leading outer wheel is evaluated in small-radius curves for the modified bogies; soft, medium and stiff (the latter added as comparison).

High-speed tests have been performed on various Swedish tracks during the summer 2006, using the soft and the medium bogie configurations, respectively.

Track shift forces, ΣY_{2m}, for tests as well as for simulations have been evaluated and can be observed in Figure 4.

Notable is that test results for the medium bogie in the smallest curve, R=300 m, are missing, due to instrumentation problems. The corresponding simulation results are, however, included in the comparison diagram.

The simulation results from SIMPACK for the track shift forces seem to agree remarkably well with the test results.

SUMMARY

An MBS vehicle model has been developed in SIMPACK in order to perform simulations of running behaviour at higher speeds. The intention is to find a bogie configuration that guarantees stability on straight track and simultaneously acceptably low lateral track forces and hence low wheel/rail wear in curves. Generally, if the stiffness in the wheelset guidance is increased a more stable running behaviour at higher speeds is guaranteed. However, higher stiffness parameters cause higher track forces in small-radius curves.

The difference between the soft and medium bogie stiffness is, however, quite modest according to running behaviour at higher speeds, but more obvious when it comes to small-radius curve negotiation.

Furthermore, comparison between simulated results and results from tests on track shows good agreement.

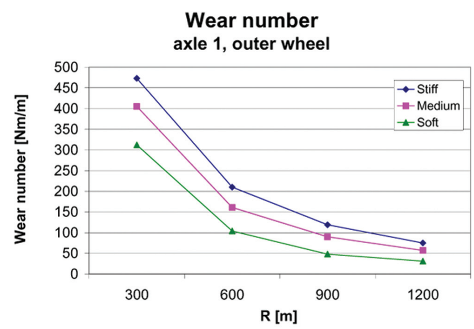

Fig. 3: Wear number for the modified bogies; soft, medium and stiff

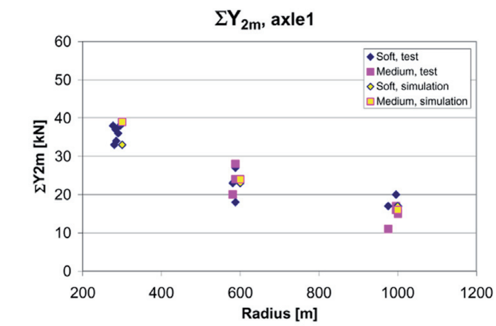

Fig. 4: Track shift forces for test and simulation results in small-radius curves