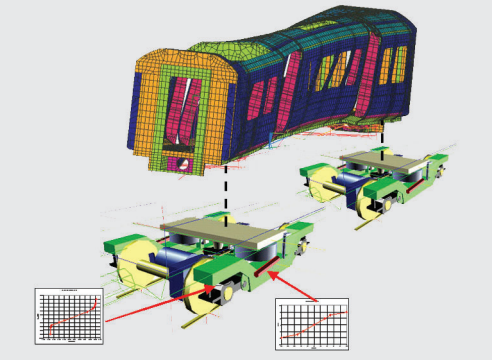
Roger Gansekow
Siemens Transportation Systems, Krefeld

Approval of the Siemens Desiro Series Vehicle Dynamics for Use in Great Britain

Desiro UK for South West Trains



Simulation model of Desiro UK-eigenmode from ANSYS is scaled up

The approval of railway vehicles requires extensive verification, both theoretical and practical testing. The Siemens Desiro series has been approved according to the British regulations. The approval of the vehicle dynamics was achieved through theoretical testing, with the help of multi-body simulation, and practically, through applied static and dynamic testing. The close co-operation of the calculation and test divisions is essential for the use of the test results for further analyses.

APPROVAL OF SIEMENS DESIRO

Different versions of the Siemens Desiro Family have been developed for regional service in Great Britain. The Desiro UK is an electrical multiple unit (EMU) operating at speeds up to 160km/h in direct and alternating current networks. Siemens was contractually required deliver approved trains.
In Great Britain a „Safety case" has to be produced prior to a new train coming into service. The safety case must demonstrate that, during the design and manufacture of the train, the customer requisites and the standards and laws in force are observed and the best available technology has been used. The safety case must prove the requirements of the Rail Group Standards (RGS) are complied with, with the verification provided by theoretical and practical testing. Results provided from calculations performed with validated calculation models are accepted for the approval of the vehicle.

REQUIREMENTS FOR THE VEHICLE DYNAMICS

The following points are defined by the RGS as criteria for the approval to international standards:
– resistance against derailment
– wheel/rail-force
– bogie stability
– gauging
– pantograph sway
A catalogue of calculations and tests is then created, from these criteria, to be used for the vehicles compliance analysis. Desiro UK has been subjected to the following investigations:
– wheel unloading on twisted track (calculation and test)
– bogie rotational resistance (calculation and test)
– wheel/rail-forces (calculation)
– bogie stability (calculation and test)
– running safety and ride comfort on track (calculation and test)
– sway test (calculation and test).

SIMPACK SIMULATION MODEL

At Siemens TS TR calculations of the vehicle dynamics are performed with SIMPACK. The Desiro UK is modelled as multi body system with concentrated masses, stiffnesses and damping. Wheelsets and bogie frame are stiff bodies, while the car body is elastic with additional structural degrees of freedom up to 40 Hz; the body is imported from ANSYS via the FEMBS interface.
Springs, dampers and bumpstops have linear or non-linear characteristics. Dependent upon the calculation, linear or non-linear contact mechanics including theoretical wheel and rail profiles, are used. The track model has dynamic masses, stiffnesses and damping.
This model is used for the calculation of eigenmodes, static equilibrium, linear and non-linear stability analyses and non-linear time integration. The specific operating conditions relating to track irregularities and wheel/rail profiles or conicity are also considered.
The results generated included the coupling of eigenmodes, compliance with stability requirements, wheel/rail-forces, suspension travel and accelerations of components and of the car body.

SWAY CALCULATION FOR GAUGING PURPOSES

A particularly demanding criterion in Great Britain is the compliance with the vehicle gauge. As the clearances along the track are very tight every millimetre counts. The goal is to achieve the largest vehicle possible with the smallest gap between the

Roger Gansekow
Siemens Transportation Systems, Krefeld

vehicle and platform. The compliance with standard gauges in most cases does not provide the required space for the passengers. Therefore realistic movements of the vehicle have to be determined by calculation. These consist of quasi-static and dynamic sway movements and vertical suspension travel.

The sway is calculated by a dedicated sway model. Since the required cant values and subsequently the suspension travel is quite large, particularly in the secondary springs (air springs), these need to be modelled in detail. The offset of the coupling points in the force element result in additional torques (r x F – terms). By means of a weighting factor the torque is distributed between the two coupling points. It has to be pointed out that due to this approach, the applied and opposing forces and torques are not necessarily the same at the two coupling points. This modelling requires specialised force elements.

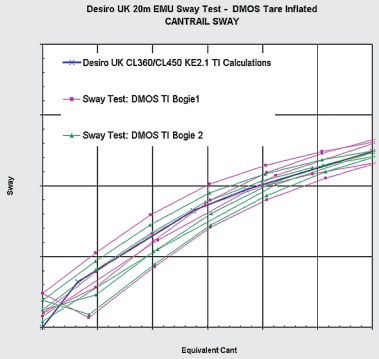
VERIFICATION OF THE SWAY CALCULATION

The results of the calculations alone cannot be accepted for the vehicles' approval. Because testing of all vehicle types and load cases would be impractical, a close interaction between calculation and tests is applied. The most critical vehicle types and load cases, according to the calculation results, are selected for the tests. In a special test rig, the basis (the track) is canted by defined cant values. The movements of the vehicle are measured by optical means; the identified movements are then compared with the calculation predictions. By virtue of the good correlation of the sway test results, the extensive calculations, which were carried out, could be used for the verification of vehicle gauging.

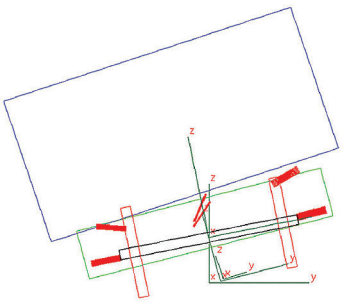
CONCLUSION

The vehicles of the Desiro UK family have been approved in Great Britain from the calculations and tests performed. The compliance with the criteria for derailment safety, wheel/rail forces, bogie stability, gauging and pantograph sway has been verified. In addition the predictions from the simulations performed were confirmed by tests that were carried out. After the completion of the tests in Great Britain, no further optimisation of the vehicles was necessary.

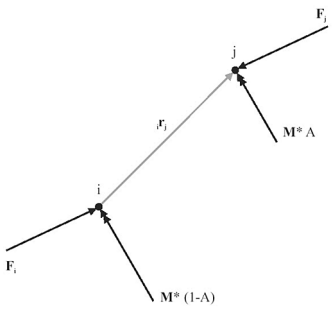
Sway Test in the Validation Center Wildenrath



Comparison of calculation and test results



Sway model



Spring modelling: distribution of the torques on the two coupling points