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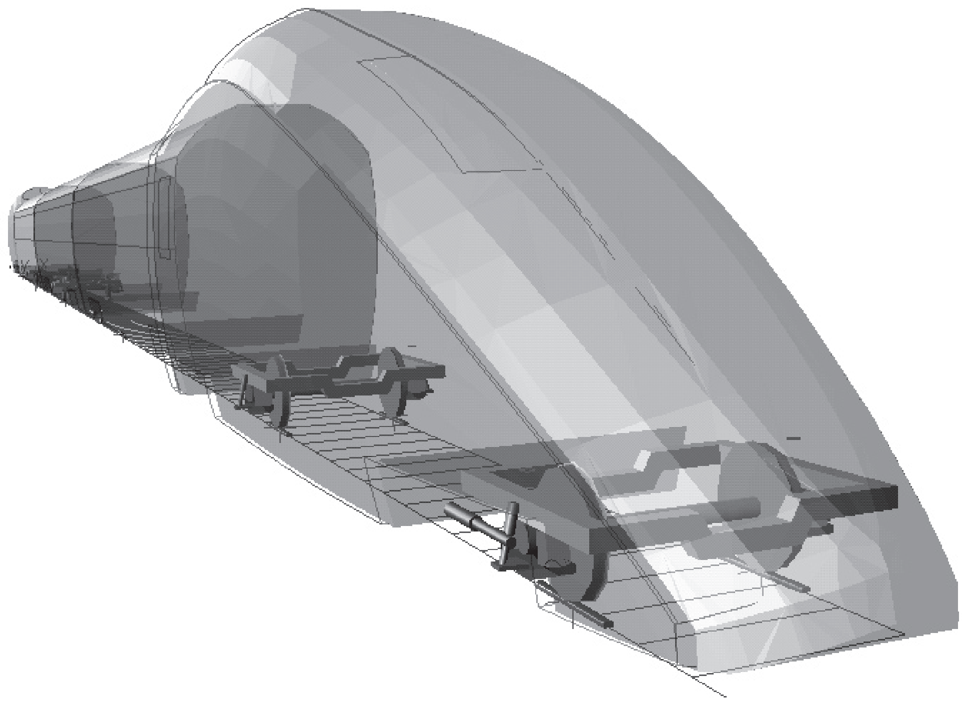
Modular Train-Models Using Substructures

Modern trains for city and local transport are constructed as a combination of sub-components to create an optimal configuration for different scenarios. Tailor-made vehicles are required for specific applications and track conditions. However, the price and design efforts have to be kept to a minimum. This is were SIMPACK's database concept offers a distinct advantage for users in a highly competitive industry. SIMPACK offers new methods to minimise the planning and interpretation effort that is required for modelling vehicles with a large range of variations.



The vehicle dynamics depend largely on the global vehicle concept and its major components as determined during an early stage in the design process. However, when for example ride comfort and handling have to be optimised, minor details and components can have a very significant influence. Therefore simulation models must be easily adaptable to various global vehicle configurations whilst reflecting on detailed changes to minor components. The use of modular concepts increases the complexity of simulation models. To cover all the detailed variations in vehicle configurations requires a much larger computational effort than a fixed configuration would. Therefore an intelligent approach to data handling and collection is needed.

Substructures

Models of bogies for instance can be saved as substructures within SIMPACK and can be used within several complete vehicle models simultaneously. Changes made to the substructures will reflect on all the main models that use that particular substructure. This is an fully integrated feature of SIMPACK. The user can decide whether a model should be further subdivided into functional elements (wheelset, bogie, vehicle body, etc.) and model specific elements or perhaps into standard components and project specific components that need to be optimised. An important characteristic of the SIMPACK database concept is its wide range. Almost every modelling element that can be used within SIMPACK can be added to the database. Substructures used in Wheel/Rail models are completely self-sufficient SIMPACK models and are fully compatible with all the standard elements from a general multi-body system. Not only is it possible to use a complete bogie in several vehicle models, but every detail like a car body element, an airspring, a bump stop, a drive train or an anti roll bar can be treated as an independent user specific substructure. This concept provides an ideal tool for building a company specific simulation environment.

Data Base Projects

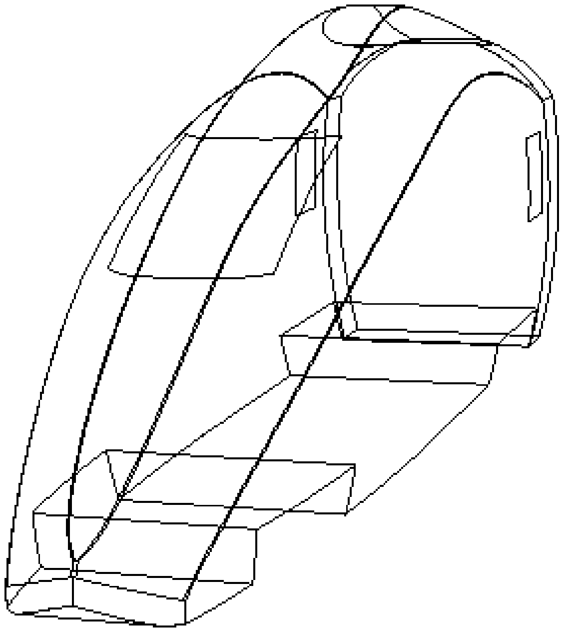
As an example, one or more wheelsets and the bogie frame can be modelled as a single substructure. The advantages of the SIMPACK database become apparent when one wishes to model several different versions of this bogie, choosing for example either steel springs or airsprings. The different levels within the SIMPACK database allow the user to select precisely those modelling elements that have to be used within a specific model. Another substructure for instance contains sub-models of either steel springs or airsprings that act between two so-called dummy bodies. The main model contains a link to either the steel spring or airspring sub-model, depending on which is currently required. The dummy bodies of the sub-model are linked to bodies in the main model by zero degree of freedom joints. This type of joint is fully integrated into SIMPACK, which means that adding a zero degree of freedom joint to a model will not increase the required computational effort.

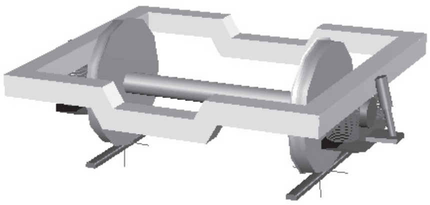
A further example is the use of lateral bump stops in trams to limit the lateral movement. Bump stops with a small clearance usually reduce the ride comfort. However the amount of clearance that is allowed is often limited because the space available to the train is often reduced by features like tunnels, signs and platforms - typical quantities that differ from one customer to the other. The same bump stop can be modelled as separate substructures with different levels of detail. One substructure might be modelled as a force element with a specific force-displacement curve while another substructure consists of a three dimensional contact model between arbitrarily shaped bodies. The first bump stop model can be used for ride comfort calculations, while the second is used for a detailed calculation of the bump stop dimensions and shape to satisfy any space requirements - based on one and the same vehicle model.

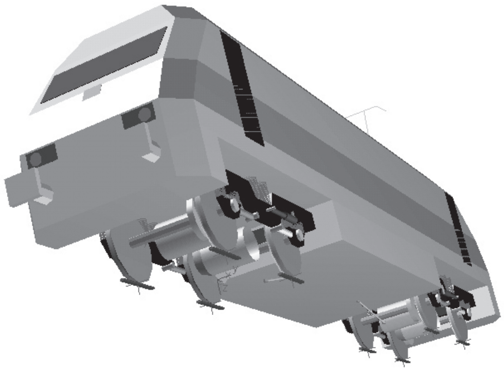
So the database concept can not only be used to model separate types of vehicle configurations but also to select different types of models for different types of calculation. If one suspects that the configuration of the drive line will influence the ride through a twisted track, extra substructures that model these elements can be added with just a few mouse clicks, while these elements are omitted for other types of calculations.

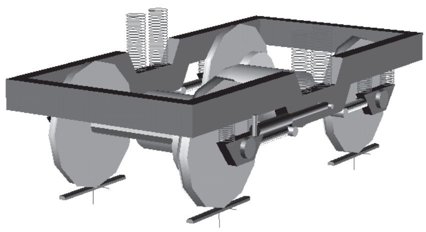
Experience has shown that creating a sub-structured model will not require much more effort than creating a model in conventional technique. Concentrating on modelling small substructures and analysing these substructures separately before using them in the main models actually offers distinct advantages that compensate for the effort required for effectively organising the database. Different simulation scenarios complete with totally different vehicle configuration can be modelled efficiently and quickly once a database is completed.

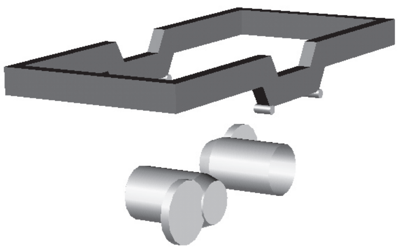
The flexibility offered by SIMPACK

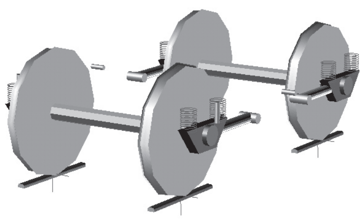












that users are accustomed to remains fully intact when applying the database concept. Almost any parameter that is defined within a substructure can be overwritten and saved locally in the main model. It is also possible to update the complete model by setting the global vehicle parameters like track gauge and rail profiles in the main model.

The SIMPACK database concept in combination with SIMPACK Wheel/Rail provides a modelling technique that truly supports the modular structure of real train vehicle design.

Ready to Use Models

SIMPACK Wheel/Rail is designed for optimum flexibility to support any leading edge technological solution for modern railway systems. However, the user can also access a broad range of standard models provided by the Wheel/Rail database. Parameterised models of a two axle bogie for passenger cars, a freight train bogie and a single axis bogie are available, as well as the according complete vehicle models that take full advantage of the described database features. These models can be used by adapting their design parameters or can be modified at one's discretion and thereby serve as starting point for the creation of a company specific data base.

Summary

Which are the major advantages in applying the SIMPACK database concepts to modular train vehicle design? First of all it is important to realise that SIMPACK Wheel/Rail is not a stand-alone product, but is seemlessly integrated into SIMPACK and its wide range of modelling and analysis tools. SIMPACK models of train vehicles are regular multi-body models supplemented by additional elements to model the contact between wheel and rail. This enables the realisation of innovative solutions for train vehicles from kinematic wheel guiding to active suspension systems, without any limitations which might arise from predefined models. The database fully supports the adaptation of SIMPACK Wheel/Rail to company specific and customer specific requirements as well as to user's specific working style.

Worried about the reliability of the described extensive functionality? SIMPACK Wheel/Rail has been in use in industry and universities for five years and has become the world wide market leader for multi-body simulation in the railway sector. SIMPACK Wheel/Rail has been successfully used for the design of more than fifty different railway vehicles. Furthermore, the continuous further development of SIMPACK is aimed at satisfying all the users wishes and demands.