CASE STUDY

MSC Software: Case Study - Scania

Scania Improves Heavy Truck Designs

by Using Simulation to Evaluate Alternatives Early in Process

Scania is a leading manufacturer of trucks, buses and coaches and industrial and marine engines. Scania's modular vehicle configuration system enables the company to build vehicles that are optimized to a customer's application from pre-engineered main components with standardized interfaces. A key challenge is ensuring that the different subsystems used in each unique vehicle design such as the engine, transmission, frame and suspension, perform together in a full vehicle assembly. In the past, there was no way to validate the performance of a unique truck design prior to building the vehicle and evaluating its performance on a road simulator test rig and test track.

Figure 1: Scania is a leading producer of heavy over-the-road trucks

If the performance of the vehicle was not satisfactory, then the vehicle needed to be redesigned, rebuilt and re-tested, driving up costs and pushing back the delivery date of the vehicle. Scania has improved on this process by utilizing, MSC Adams/Car to simulate the performance of alternative vehicle designs on both the test rig and test track. "Simulation gives us the ability to explore design alternatives in the early stages of the design process," said Anders Ahlström, PhD, Structural and Vehicle Dynamics Engineer for Scania. "The result is that we have been able to significantly improve the handling, comfort and fatigue life of our vehicles."

Key Highlights:

Industry

Automotive

Challenge

To provide the required handling and comfort of each unique vehicle configuration and to deliver the promised fatigue life, while keeping costs throughout the value chain at a competitive level.

MSC Software Solutions

Adams/Car

Benefits

- Significantly improve the handling, comfort and fatigue life of vehicles
- Reduced stress levels in many parts, resulting in improvements in component life
- Identify potential problems early in the design process and make corrections on the virtual model

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Anders Ahlström, PhD, Structural and Vehicle Dynamics Engineer, Scania.

Optimizing Each Vehicle to the Application

Scania delivers optimized heavy trucks and buses, engines and services, that enable its customers to achieve the best operating economy. Scania's modular vehicle configuration system, which has been developed over several decades, makes it possible for the company to create individual configurations for a large number of different customers by using a limited number of standardized components. This approach makes it possible to provide each customer with an optimized product, while keeping costs throughout the value chain at a competitive level.

Providing a vehicle that is optimized for the application has enormous advantages for customers but creates challenges for Scania. The company must ensure that each unique vehicle configuration provides the required handling and comfort and also delivers the promised fatigue life under the wide range of conditions under which the company's vehicles are used. In the past, the first point at which the company could evaluate the vehicle performance was when it was built and could be tested on a test rig or test track.

The problem with the traditional approach is by the time that feedback is received a considerable amount of time and money has already been invested in the design. Testing is expensive because of the need to outfit trucks with custom hardware and because a considerable amount of time is required on the part of highly-skilled employees or contractors to set up and run the tests. There is only rarely time available to evaluate different vehicle configurations in terms of their ability to provide the desired results.

Simulation Provides Feedback Early in Design Process

"We use simulation because it allows us to evaluate a much greater number of vehicle configurations than was possible in the past," Ahlström said. "We selected MSC Adams/Car because Adams provides the premier solver technology and has become the de fact standard in the automotive industry," Ahlström said. "MSC Adams/ Car supports Scania's modular vehicle configuration strategy by enabling us to model and simulate different vehicle configurations in a small fraction of time that would be required to build and test them."

Adams/Car enables engineering teams to quickly evaluate functional virtual prototypes of complete vehicles and vehicle subsystems. Working in the Adams/Car simulation environment, automotive engineering teams can exercise their vehicle designs under various road conditions, performing the same tests they normally run in a test lab or on a test track, but in a fraction of the time. Modifications can easily be done in the virtual world, which saves a significant amount of time and money in the design process.

Scania has already developed Adams/Car models of many of their vehicle modules. So in most cases engineers can create the model of a new vehicle configuration simply by selecting models of the appropriate modules and connecting them together. Figure 2 shows an Adams/Car model of typical truck tractor, the R420 LA4x2MNA, a two axle tractor design for long haul applications. The tractor is equipped with an R Highline cab and a 420 hp six cylinder diesel engine. A two-bellow air suspension is used in the rear while a parabolic leaf suspension is used in the front. It is an articulated tractor which means the payload is carried in a semi trailer connected to a fifth wheel on the truck. A load frame was added to the virtual as well as the physical truck in this study to represent the weight of the trailer. Scania engineers also often model the trailer.

The frame, load frame and front axle are modeled as flexible bodies using MSC Nastran to create the finite element (FE) models. The load frame shown in Figure 3 was modeled using shell elements while the weights are modeled using solid elements. The attachment between the frame and load frame was modeled using bushings because the connection is not entirely stiff. The use of bushings makes it possible to modify the stiffness and damping of the attachment to act similarly to the physical connection.

Figure 2: Virtual model of typical truck tractor

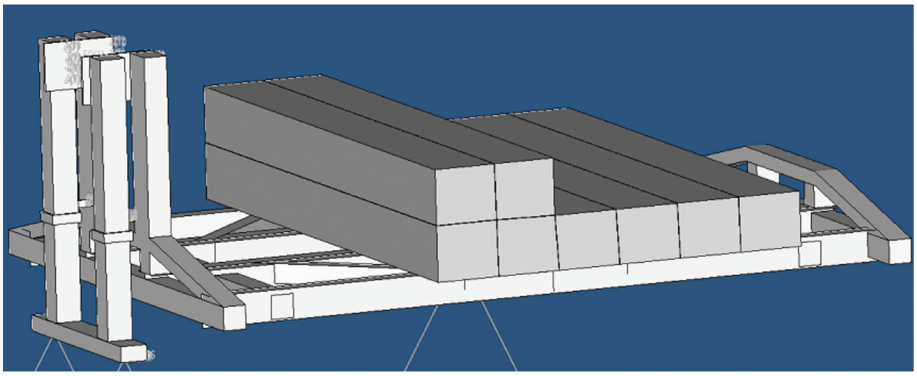

Figure 3: Model of load frame and weights used to represent trailer

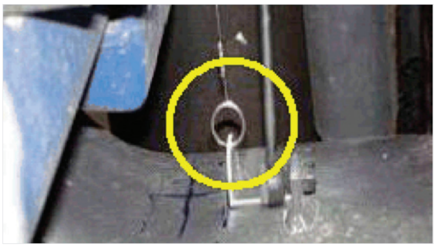

Figure 4: Sensor installed in truck prior to physical testing

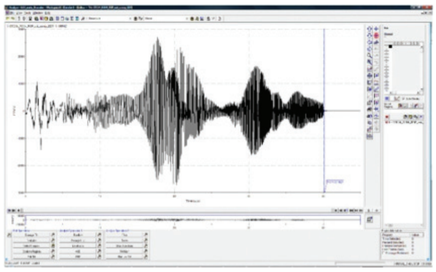

Figure 5: Sensor output during physical testing

Ensuring the Accuracy of Simulation Results

Scania engineers have also modeled their 10-channel test rig and their test track and use Adams/Car to evaluate vehicle designs being excited by the simulator and driven over the test track. The vehicle is equipped with sensors at selected points when evaluated on the test rig or test track as shown in Figure 4. Markers were incorporated into the Adams/Car model to capture the same data that was measured in the physical vehicles, such as accelerations in three different axes, distance between the axle and frame, and hub forces.

An iterative process is used to determine a drive signal for the test rig that produces the same forces in the vehicle as were induced by driving on the test track as shown in Figure 6. First, a random noise is used as the drive signal while measuring the responses of the sensors on the truck model to derive the transfer functions. The transfer functions and the sensor responses are then used in an iterative procedure in which the model is excited with the drive signal and the response is compared to the measured response. Based on the error, the drive signal is then adjusted to bring the simulation response closer to the measured response. This iterative procedure continues until the model response matches the measured signal within an acceptable value of error.

Typically, Scania engineers are able to achieve simulation results that are within 5% of physical measurements on the test rig. If the model performs well on the test rig, the next step is to add wheels and simulate the model over 3D road. The Ftire (Flexible Ring Tire Model) nonlinear tire model is used. Simulation of the full vehicle on the test track is more challenging because of the difficulty in accurately modeling the tires and other interconnecting parts. However, in this case, Scania engineers are still able to achieve predictions that are within 20% of physical measurements.

Using Simulation to Compare Design Alternatives

Once the model has been validated it can be used to evaluate the handling of the vehicle, comfort of the driver and loads applied to various components, which can in turn be used to estimate their fatigue life. “On a new vehicle configuration, we typically simulate the vehicle performing steering maneuvers on a flat surface to evaluate steering and handling,” Ahlström said. “We drive the vehicle over a number of different road obstacles and study the vehicle behavior and driver experience.”

Scania engineers also evaluate alternative vehicle configurations, such as comparing the performance of several different suspension designs. Simulation makes it possible to evaluate the performance of the vehicle under very demanding conditions that would be difficult to duplicate with physical testing because they would require travel to a distant location or because they might involve damage to the vehicle or danger to the driver. These simulations also generate loads on the components that can then be used for stress analysis or fatigue life analysis. Finally, engineers perform failure mode analysis. For example, they simulate a situation in which the power steering becomes inoperable and evaluate the ability of the driver to steer the truck out of danger.

“MSC Adams/Car helps us understand how the multiple moving parts of the chassis interact with each other and their environment,” Ahlström concluded. “This knowledge helps us to identify potential problems early in the design process and make corrections on the virtual model at a much lower cost and in less time than would be required to correct the physical truck. Simulation helps encourage innovative design methods because engineers can easily explore alternative design concepts in very little time or expense. As a result, we have made significant improvements in handling and comfort of many of our designs. We have also reduced stress levels in many parts, resulting in improvements in component life.”

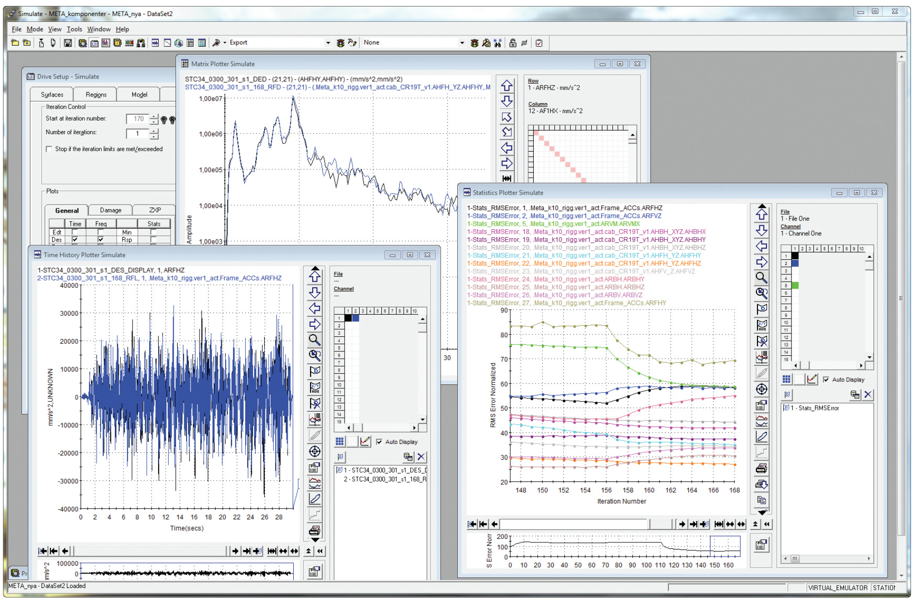

Figure 6: Iterative process to derive drive signals to the test rig.

About MSC Software

MSC Software is one of the ten original software companies and the worldwide leader in multidiscipline simulation. As a trusted partner, MSC Software helps companies improve quality, save time and reduce costs associated with design and test of manufactured products. Academic institutions, researchers, and students employ MSC technology to expand individual knowledge as well as expand the horizon of simulation. MSC Software employs 1,000 professionals in 20 countries. For additional information about MSC Software's products and services, please visit www.mscsoftware.com.

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About Adams

Multibody Dynamics Simulation

Adams is the most widely used multibody dynamics and motion analysis software in the world. Adams helps engineers to study the dynamics of moving parts, how loads and forces are distributed throughout mechanical systems, and to improve and optimize the performance of their products.

Traditional "build and test" design methods are expensive, time consuming, and impossible to do sometimes. CAD-based tools help to evaluate things like interference between parts, and basic kinematic motion, but neglect the true physics-based dynamics of complex mechanical systems. FEA is suited for studying linear vibration and transient dynamics, but inefficient at analyzing large rotations and other highly nonlinear motion of full mechanical systems.

Adams multibody dynamics software enables engineers to easily create and test virtual prototypes of mechanical systems in a fraction of the time and cost required for physical build and test. Unlike most CAD embedded tools, Adams incorporates real physics by simultaneously solving equations for kinematics, statics, quasi-statics, and dynamics.

Utilizing multibody dynamics solution technology, Adams runs nonlinear dynamics in a fraction of the time required by FEA solutions. Loads and forces computed by Adams simulations improve the accuracy of FEA by providing better assessment of how they vary throughout a full range of motion and operating environments.

Optional modules available with Adams allow users to integrate mechanical components, pneumatics, hydraulics, electronics, and control systems technologies to build and test virtual prototypes that accurately account for the interactions between these subsystems.

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