

Case Study: **Navistar & Tech Mahindra**

Adams Simulation of Hose Routing Helps Reduce Time to Market by Six Weeks

Based on an interview with:
Stefano Cassara, Manager Vehicle Dynamics Simulation, Navistar
Chinmay Pawaskar, Principal CAE Analyst, Tech Mahindra

Overview

It takes a 450 horsepower truck with an 80,000 lb. load roughly 90 seconds to accelerate to 50 mph but the brakes must be able to stop the truck in less than 5 seconds. Air brakes are used almost exclusively in heavy-duty trucks and trailers because they offer the following advantages. First, the air they run on is free. It only needs to be compressed, cleaned, stored and distributed. The air brake circuit can be easily expanded so trailers can be coupled and uncoupled from it. Besides providing the energy required to stop the vehicle, compressed air also signals when and with how much force the brakes should be applied in any situation. Finally, air brakes can be designed with sufficient fail-safe devices to bring the vehicle safely to a stop, even in the event of an air leak.

Reinforced rubber hoses deliver air from fittings on the frame to brake chambers on the axles. In a typical tandem rear suspension there are typically 8 brake hoses plus additional hoses for the power differential lock and other features for a total of 11. The hoses must be routed through a tight space and accommodate the full range of steering gear and suspension travel. The hoses are required to avoid contact with components with sharp edges that might wear the hoses, maintain a specified minimum bend radius to avoid constricting flow within the hose, and avoid axial forces high enough to pull out the hose out of the fitting.



11 hoses are routed in a typical tandem suspension

“The recent introduction by MSC of FE Part, an Adams native modeling object which is accurate for geometrically nonlinear parts with large deformations, greatly reduces the modeling time and effort required to accurately model very large deformation cases within the Adams environment... The new approach makes it possible to design new hose configurations in only about two weeks.”

Stefano Cassara, Manager Vehicle Dynamics Simulation for Navistar

Challenge

In the past, Navistar engineers had no way to know the deformed shape of the hoses nor their motion profile in response to suspension and steering movement until late in the design process when a prototype was built and tested on an articulation test rig. The suspension was articulated through its full range of motion and the position of each hose was reviewed during these movements to check for problems. Normally the design had to be iterated between two and four times over 6 weeks in order to meet the requirements. This procedure could not be started until late in the design process which meant that in most cases the product introduction had to be delayed until a satisfactory hose routing could be achieved.

Solution/Validation

Navistar engineers worked with consultants from Tech Mahindra to simulate the brake routing shape after assembly and over the full range of suspension and steering gear motion. “This simulation challenge required a combination of multibody dynamics to simulate the motion of the test rig and suspension system and nonlinear finite element analysis to simulate the motion of the hoses,” said Chinmay Pawaskar, Principal CAE Analyst for Tech Mahindra. “Linear finite element analysis capabilities have long been available with Adams discrete flexible link and we have used discretization to extend its capabilities to geometrically nonlinear problems. But the recent introduction by MSC of FE Part, an Adams native modeling object which is accurate for geometrically nonlinear

parts with large deformations, greatly reduces the modeling time and effort required to accurately model very large deformation cases within the Adams environment.”

The Navistar-Tech Mahindra team began by characterizing the material properties of the hoses by placing the fittings in a variety of locations and orientations and capturing the resulting hose shape using 3D optical scanning tools. They iteratively tuned the hose material properties to match the predicted shapes to the actual shapes. They also modeled a 4-step hybrid controller within Adams to simulate the assembly process. The four steps are first to bring the hose to the fitting, second to orient the hose on the same axis as the fitting, third to rotate the hose to attach it to the fitting, and fourth, an optional step, to clip the hose to the suspension or frame.

To validate this approach, the team modeled the test rig and suspension in Adams and developed scripts to drive the rig through the same tests used on the physical test rig. They modeled two hoses, one for the service brake and the other for the parking brake,

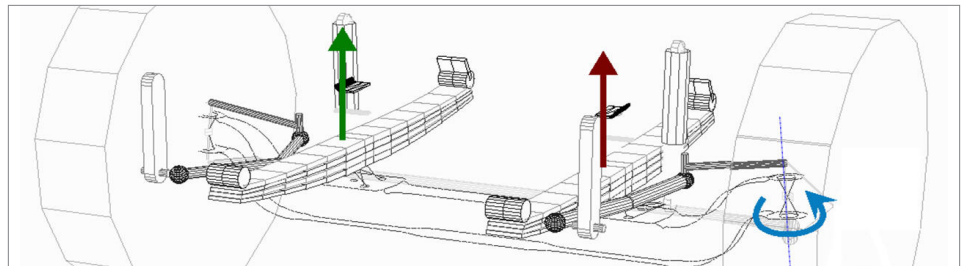
Key Highlights:

Product: Adams

Industry: Automotive

Benefits:

- Simulation of hose routing helps reduce time to market by six weeks
- Adams predictions perfectly matched test results in each steering position
- Simulation provides a much better understanding of how to route the braking hoses to avoid contact with components with sharp edges that might wear the hoses in response to suspension and steering movement
- New Adams FE Part provided a fast and accurate way to predict the large deformation of brake hoses in Adams environment



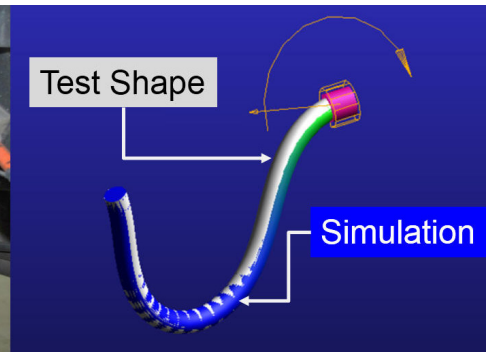
Adams model of suspension and test rig

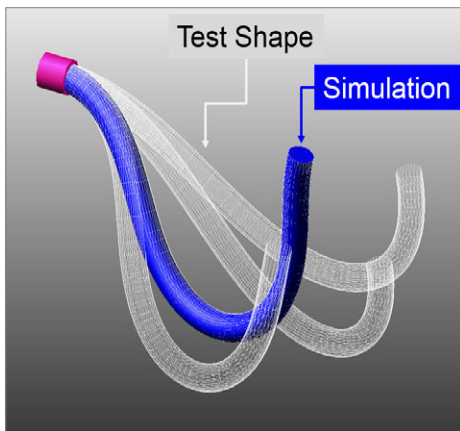


Hose routing configurations are evaluated on a test rig

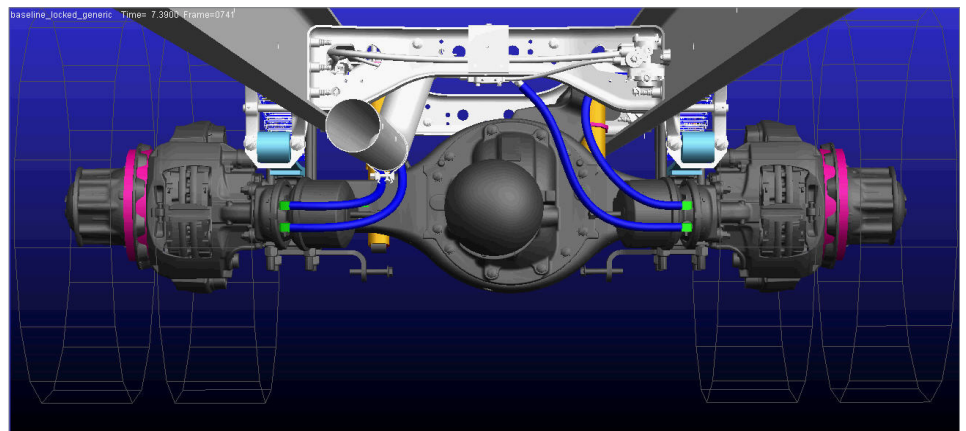


Model predicts actual hose behavior





Simulation predictions (blue) perfectly matched test results (white) in each steering position



Multibody simulation model of a Truck rear suspension including service and emergency hoses

and added them to the model as FE parts. They modeled a variety of different hose routing configurations. The team assembled the hoses the same way on the actual vehicle. They used a portable coordinate measuring machine (CMM) to measure the exact deformed shape of the hose after assembly for each assembly method. Next, they articulated the wheel end to all possible positions such as straight ahead, left turn, right turn and measured the resulting hose shapes with the CMM. In each case, the deformed shape of the hose predicted by the simulation matched the physical test. The engineers also modeled and tested a long hose clipped to the axle and frame and again found excellent correlation.

Results

“Simulation makes it possible to try many different positions, orientations, and clipping options early in the design phase prior to the availability of a prototype,” said Stefano Cassara, Manager Vehicle Dynamics Simulation for Navistar. “New design iterations can be evaluated in a small fraction of the time required for physical testing. The new approach makes it possible to design new hose configurations in only about two weeks. Since the design process will be carried out early and outside the critical path we should

be able to bring new vehicles to market six weeks faster than in the past. Another advantage of the new approach is that we can model loading scenarios, such as braking, that cannot be duplicated on the test rig.”

About Navistar

Navistar International Corporation manufactures and sells commercial and military trucks, diesel engines, and school and commercial buses; and provides service parts for trucks and diesel engines worldwide.

For more information on Adams and for additional Case Studies, please visit www.mscsoftware.com/adams

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