Case Study: **Leyland Trucks, Ltd.**

Building Better Trucks - Simulation at Leyland Trucks Expands Analysis, Cuts Design Time, and Reduces Physical Prototypes

Overview

Leyland Trucks Ltd., a wholly owned subsidiary of PACCAR Inc., has become the company's established center for light- and medium-size truck design, development, and manufacture, producing trucks from six to 44 tonnes for each of PACCAR's established international brands – Kenworth, Peterbilt, DAF, and Foden.

Leyland has been using MSC Software solutions for quite some time, including MSC Nastran for 10 years and Adams since 1997. Like many companies, they started using simulation software for discrete components, then assemblies, and ultimately for the dynamic simulation of assemblies. According to Dr. Jim Henderson, senior engineer, dynamics, at Leyland Trucks, "Technology has reached a point now where it would be impossible to do the variety of load case checks and dynamic simulations any other way than using advanced simulation software."

"My job is about solving problems in the real world. Adams is powerful and flexible enough to let me model exactly what I need."

James Patterson, PhD. Principal Vehical Systems Engineer

Keeping Up with Design Changes

The basic truck ladder chassis is a relatively simple structure. Because of the need to provide a variety of different body configurations, it is unlikely that trucks will ever move to the more unitary, integrated construction commonly used for cars. Consequently, the essential design configuration of the truck has been very similar since the 1900s. But as design technology has improved, the details of the truck have evolved almost beyond recognition. For instance, new materials have been introduced in recent years, leading to global initiatives to reduce weight through the use of these advanced high-strength steels. Other design details are changing – trucks are now using disc brakes rather than drums – and Leyland engineers must balance incorporating these details while improving quality and still keeping costs under control.

Before adopting Adams, Leyland engineers validated their designs using standard static load cases and traditional finite element analysis, which would approximate some of the situations they now simulate dynamically. "For instance, in cornering situations, we would use a set of static loads to simulate cornering at specific 'G' loads or accelerations," says Henderson. "However, in those days engineering judgement played a much greater part in trying to identify the worst cases. Now that we have the ability to simulate a variety of different manoeuvres dynamically, a fuller set of load cases can be simulated, so we have a better chance of finding the less obvious but critical conditions."

A full Adams truck model contains a flexible body and chassis, springs, roll bars, axles, cab and engine suspension, the steering mechanism, and any frequencydependent rubber mounts. Extra detail, such as brakes, propeller shafts, and out-of-balance engine forces can be included on an 'as needed' basis. Simulation also allows several aspects of the operation of crane-bodied vehicles to be better understood, such as vehicle stability on slopes and uneven surfaces, the need for stabilising legs, and the effects of loading and unloading.

When an articulated vehicle is coupling the trailer to the tractor, variables such as tractor speed, tractor alignment, and trailer height (legs can sink into loose ground) have a critical impact on the operation. Being able to simulate the whole process provides accurate load cases for improving traditional lead-up ramp designs by finite element techniques.

Simulating Difficult Manoeuvers

Tilt table simulations improve safety when operating tipper-bodied vehicles on sloping or uneven surfaces. For instance, simulation can run through a situation in which the full payload is inside the vehicle body, the body is elevated to its full extent, and the vehicle is tilted incrementally until its first wheel lifts. It is extremely expensive and time-consuming to perform this test physically because it requires both a real vehicle and the use of a tilt table. By contrast, the simulation is quick, accurate, and allows rapid comparison of alternative configurations.

From analysis of a lane-change manoeuvre, Leyland Trucks dynamics engineers discovered that on a recent vehicle, a military concept truck, rollover could only be achieved using an unrealistically high payload centre of gravity and extreme speed in excess of 60 mph. Because of the potential danger, this is not a test that would ever be carried out physically, so Leyland's engineers appreciate being able to determine the ultimate performance characteristics of the vehicles they design without having to take physical risks.

Detailed procedures such as cab tilt that could not be properly analysed before can now be investigated with Adams simulations. The virtual cab is lifted by a hydraulic ram until the centre of gravity passes over its pivot point, at which time the cab falls forward and the ram cylinder acts like a damper to slow and control the motion. The simulations help to determine the ram forcerequirements, identify potential panel interference, and ensure that locks locate correctly.

Typical vehicle handling analyses include steady-state cornering, lane changing, 'J' turns, and straight-line braking. Adams simulation allows rapid assessment of the effect of minute changes in suspension, wheelbase, tyres, or payload position.

Key Highlights:

Product: Adams

Industry: Automotive

Benefits:

- Find critical operating conditions by performing dynamic simulations

- Replace the extremely expensive and time-consuming physical tests with fast and accurate simulation

- Reduce the design cycle from 6 years to 4 years

Each truck is significantly different from the previous one, so there are very few opportunities to modify and reuse previous physical prototypes. One of the critical areas for trucks is the cab. Because of the greater design sophistication demanded by truck users, cab design and development is becoming prohibitively expensive. This often leads to collaborative ventures between several manufacturers.

Ride comfort is important for the driver and for delicate payloads such as computers. With Adams, Leyland engineers can simulate a variety of ride conditions on highways, secondary roads, pavé surfaces (cobblestones) and also discrete surface events such as potholes and speed bumps. Truck-specific factors that affect ride include cab suspension, chassis flexibility, and payload, all of which can be easily varied with Adams.

Part of improving the ride of the vehicle involves softening the cab suspension. This results in a compliant ride, which initially may not be to all truck drivers' taste, but after about a month or so they are generally reluctant to go back to more traditional suspension systems.

Speeding the Design Cycle

Simulation represents a significant benefit in terms of final design quality, as well as considerable time savings. A recent project named LF was completed two years faster than the previous equivalent one – in a four-year design cycle rather than six. As always when technology is brought to bear on design, although it is possible to identify benefits, it is unfair to suggest that the comparison is truly 'like for like' as there are inevitable process changes as a consequence of the new technology.

"There are definitely areas where modelling and simulation have helped," says Henderson, "particularly along the lines of reducing the amount of time wasted building physical prototypes with real parts. In the past we would test things, find that they didn't work, and modify them using trial-and-error. This was considerably unstructured and very much the opposite of the 'design of experiments' approach we take today, to vary things in a structured fashion to identify where the trends lie. There are far more benefits of 3D CAD and sophisticated analysis and simulation so that the LF vehicle, as well as being finished in two-thirds of the time of its predecessor, is of considerably better quality."

Leyland engineers manipulate and analyse significant amounts of data. One of their approaches is to test the vehicle on the track and then 'drive' the Adams model with the measured accelerations. Consequently, the input files are quite large. The correlation between the track testing and the Adams simulations is good. "Again, it's difficult to quantify the quality of the correlation," said Henderson. "In a time-variant simulation you're never going to match the rise and fall of any particular acceleration exactly, but when you look at the results in the frequency domain you can see that the spikes line up fairly well at the same kinds of frequency. This is more important to us than getting the level exactly right because it's dependent on so many different variables."

Design teams at Leyland Trucks are still focused on getting drawings or parts out – the design process hasn't reached the required level of maturity where it can be simulation-driven. While everyone is keen to move forward, the deadlines are such that tried-and-tested techniques take precedence. Also, there are a limited number of people in CAE and many more in design.

"From my own point of view, I would like to see more people in the company using simulation, not just the CAE department," says Henderson. "It would be useful if more simulation model- building could be done outside the CAE department. There is still quite a lot of repetitive and unnecessary duplication of geometry generation, manipulation, and cleaning. To improve this, CAD and CAE tools need to be linked more closely together."

A prototype vehicle early in the development cycle can prove to be very expensive. "It's fair to say that the use of simulation software has eliminated at least one of these prototypes," explains Henderson. "So the software has certainly paid for itself on the first project. My job is about solving problems in the real world. Adams is powerful and flexible enough to let me model exactly what I need, without getting too deep into software issues."