Case Study

MINING DUMP TRUCKS ROLL ON FOR THE LONG HAUL WITH ABAQUS

DT HiLoad simulates payloads and fatigue on steel truck trays for lightweight, durable designs

Mines are a demanding environment for workers—and for their dump trucks as well. These behemoth machines, designed to be exceptionally rugged, face daunting environments and challenges.

"Dump trucks for mining sometimes travel over terribly uneven road-haul surfaces," says Ray Sun, Senior Engineer, DT HiLoad Australia (Perth, West Australia), a leading global manufacturer of customized truck trays. "They carry enormously heavy payloads—sometimes overly so—and they undergo continual fatigue and wear." Obviously, strength and durability are prime considerations in designing truck bodies.

And there's another vital design criterion for the trucks: Their bodies must be as lightweight as possible. A lighter body can devote more weight to its payloads and also save fuel, improving mining efficiency and productivity as well as potentially reducing the size of a company's truck fleet.

The tray is to a mining truck what a bed is to a pickup truck: its reason for existing. DT HiLoad's trays are like works of art, with sleek front walls that jut above the driver's cab and culminate in a guard canopy that extends protectively over the cab, looking as streamlined and graceful as the prow of a ship.

But it's not the aesthetics that sell the truck trays: It's their ability to be customized for, and hold up under, all manner of loads and environments. DT HiLoad's Hercules high-performance dump truck trays operate worldwide on nearly all makes and models of mining trucks in a varied range of mines—usually open-pit—from coal to gold and even diamonds.

Load characteristics such as density and stability are often quite different from site to site. "Usually, every customer and even every mine has different trucking conditions," Sun says. "For instance, material composition, site restriction, and haul road surface can vary a great deal. That's why each tray project can be different." In addition, overloaded haulages are a fact of life in mining, providing additional load and fatigue on the trays.

Designing a tray is no small endeavor. The largest one the company supplies is for a Caterpillar 797F with a maximum capable payload of 380,000 kg (418 tons) and an overall truck length of nearly 50 feet. "The strains that heavy payloads put on a truck body are considerable," Sun says. "And it changes with every turn, start-up and application of the brakes."

Given the drive to achieve light weight in a truck tray without sacrificing strength and long life, computer simulation of these components under loads is a must. The company has used finite element analysis (FEA) since its founding in 2003. Their tool of choice? Abaqus software from Dassault Systèmes SIMULIA.

The dump truck tray extends over the driver's cab and can be as long as the entire vehicle.

LOADING UP FOR ANALYSIS

"Abaqus was introduced to us by our initial FEA contractor," Sun says. "They proposed it as the most suitable analysis software for our application. It provides us with almost full control of the objects we simulate." It was also a plus that Abaqus is compatible with SolidWorks and fits seamlessly into product development at DT HiLoad.

DT HiLoad purchased Abaqus software through Simuserv Pty Ltd., which is headquartered in Melbourne and has offices in Perth. "Since 2002, Simuserv has provided high-quality simulation consulting services to a range of industries," says Gerd Diegelmann, director at Simuserv. "The Abaqus Unified FEA product suite offers powerful and complete solutions for both routine and sophisticated engineering problems, and we both recommend it and offer support. Simuserv has worked closely with us to help us get the most out of our FEA," says Sun, "They've helped us achieve a high degree of confidence in the accuracy of our analyses. Their Perth office has been extremely convenient to work with."

DT HiLoad currently uses Abaqus to design truck trays, and in the future they envision expanding their analyses to other tasks, including service. "When we have time, we hope to apply Abaqus to the Wear Management Program," Sun says. This maintenance program greatly reduces body operating costs and eliminates the installation of traditional, time-consuming, expensive liner plates that increase truck weight

unnecessarily and thereby reduce the payload. At some point, engineers at the company want to apply in the Wear Management Program the lessons learned by analyzing truck trays.

FINITE ELEMENTS AND FLEXIBILITY

With truck-tray design, a crucial task is ensuring continuous transition of stiffness throughout the tray, eliminating highly stressed areas as much as possible and keeping fatigue buildup to a minimum. "We couldn't build quality truck trays without simulating their performance," Sun says. "FEA is crucial to helping us find the optimum design configuration for each new application."

The unique design concept for a DT truck tray differs greatly from conventional dump-truck beds. Other manufacturers' trays are often rigid and bulky to bear up under the loads imposed by payloads. By contrast, DT HiLoad's Hercules curved truck tray is made entirely from flexible, hard-wearing steel plate, offering greater fatigue management than its stiffer counterparts. "The DT tray uses its flexibility to help dissipate excessive energy—both dynamic and static—throughout the tray," Sun says.

Abaqus FEA analysis of a truck tray.

Engineers model the entire truck tray, but some areas are of special interest. "The transverse beams and rear support rails are the most important features to simulate," Sun says. "This is because, though the tray body with its curved floor front wall and canopy acts as a flexible structure and mitigates excessive localized loads, the tray requires some stiffness to carry a payload."

The main frame—the beams and rails—compensate for that stiffness, resulting in their undergoing more loading, and more fatigue. "They are the hardest-working components of the tray," Sun says. One of the tasks for the Abaqus analysis is double-checking to confirm that they are still strong enough after lightweighting. Another area of interest is the joint at which the front wall of the tray meets the truck bed floor.

Analyses are nonlinear and static, primarily concerned with the highest downward loads on the tray. The loads applied are based on field data such as service reports and specific customer feedback and requests, as well as the experience that DT HiLoad has gained from having over 1,000 truck bodies in use around the world. The largest vertical load simulated recently is 360,000 kg (about 397 tons) under 1-2Gs. "We compared the 1G results to those from a physical strain gauge test performed on the same tray," Sun says. "We found very satisfactory correlation, ensuring that the simulation process is accurate."

Their analyses enable engineers at DT HiLoad to prove out truck tray flexibility, check for points of rigidity, and calculate fatigue loads for points that need reinforcement.

ROLLING OUT RESULTS

The Hercules truck tray has now evolved to the Phase X body. Using Abaqus, DT HiLoad has been able to reduce truck tray weight up to an astonishing 50 percent. The new designs cut fuel costs, lower fatigue and loads on the tray and, most importantly, increase the payload the trucks can carry.

"Increased payload is the major benefit our customers value," Sun says. "If they can move the same amount of material with fewer trucks, their savings in both outlay and energy costs are considerable. Under these circumstances, ROI on a truck is arrived at faster and can be significantly increased."

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