Liebherr Group

Mining equipment manufacturer uses LMS Virtual.Lab to optimize a weight-efficient truck

Product
LMS

Business challenges
Reduce the weight of the vehicle so it can carry a bigger payload
Integrate advanced features into a truck that can withstand harsh mining conditions

Keys to success
Use LMS Virtual.Lab to study behavior on various terrain
Predict vehicle behavior with reasonable accuracy for a variety of load cases
Easily explore design alternatives

Results
Optimized truck weight
Created an accurate full-vehicle simulation
Generated multibody models significantly faster and with fewer errors than building from scratch
Explored design alternatives that would be impractical to study with physical mockups
Enabled quick, accurate fatigue life studies

Siemens PLM Software solution enables Liebherr to explore design alternatives with full-vehicle simulation

Designing monster mining trucks
Ultra-class mining trucks are big. Average load capacities run to the hundreds of tons, an enormous amount compared to a typical construction-site hauler that carries 50 tons or less. These vehicles can travel up to 64 kilometers (km) per hour while hauling huge loads of iron, copper, gold ore and other raw materials over flat terrain, or spiral for kilometers up and down haul roads of the world’s largest open-pit mines reaching depths of more than 600 meters.

Demand for metals commodities has risen sharply in recent years – as have prices – so mine operators have strong financial incentive to invest in new equipment to get these precious resources out of the ground faster. Companies are particularly drawn to trucks with electrically-driven wheels powered by diesel generators instead of mechanical powertrains with gearboxes and

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drive shafts. Diesel-electric trucks are often easier to operate and they generally outperform mechanical trucks, especially on steep grades. They also are less expensive and easier to maintain so, in remote locations, Liebherr mining trucks are just where they need to be: in the mines and not in the repair shop.

Biggest of the big
Liebherr’s flagship product is the T 282 C. With a load capacity of 363 metric tons (equivalent to the weight of more than 210 minivans), it is 8.3 meters high and 15.7 meters long, runs on a set of six 4-meter tires and is powered by a 3,750-horsepower diesel engine.

“It’s like driving a two-story house,” says Dr. Vladimir Pokras, manager of Liebherr mining equipment analysis and simulation.

One of the primary requirements when designing these giant machines is that total vehicle weight cannot exceed tire capacity.

Every kilogram shaved from the vehicle structure can be added to the payload.

Tire wear is also minimized by the kinematics of the Liebherr dual parallel control arm arrangement and by a drive system that automatically adjusts the torque and speed of the traction motors when turning.

The engineering challenge is integrating advanced features like the drive system into a lightweight truck strong enough to withstand the mining operating conditions. As one could imagine, this is no easy feat.

For example, take the PT Kaltim Prima Coal mine in Indonesia. Situated one degree north of the equator in a remote rainforest, where hip-deep mud is common, this mine relies on more than 30 Liebherr trucks to get the job done. Likewise, Liebherr trucks are being used to mine gold in Nevada, copper in Chile, coal in Australia and iron ore in South Africa and Brazil.

Trucks are also put to work traversing layers of clay and waterlogged peat — a cushioned terrain that is described as “like driving on a mattress” — to mine oil sands in northern Canada. Containing a thick form of petroleum that can be extracted and upgraded to useable products, oil sands are a sought-after commodity in light of rising crude oil prices and are estimated to represent as much as two-thirds of the world’s total petroleum resources. At least 1.7 trillion barrels of petroleum are estimated to be in the Canadian Athabasca Oil Sands, where Liebherr trucks are in increasingly heavy demand.
The critical role of multibody dynamics

Considering the millions of dollars and months of work that would go into just one round of physical testing, Liebherr relied heavily on engineering analysis to design the T 282 C to operate efficiently under such heavy-duty conditions. In particular, LMS Virtual.Lab™ software from product lifecycle management (PLM) specialist Siemens PLM Software was used to conduct full-vehicle simulations to study the truck's behavior on various terrain with a variety of load examples, including acceleration, braking, turns, bumps, holes, washboarding and traveling up and down steep grades.

To refine the design as early as possible, multibody simulation models were created in the conceptual stage by the analysis and simulation group, and modified as more information became available. The initial geometries of major truck parts and assemblies were estimated from preliminary solid models, and pieced together as rigid bodies into a first-pass, full-vehicle multibody model. Then, loads from a multibody simulation were generated for the structural group to perform finite element analysis (FEA) for computing stresses on the frame and other structural components. The mechanical group re-used these same loads to design the vehicle hydraulics, suspension, the powertrain and other systems.

A central point for unified full-vehicle model design

“In this way, LMS Virtual.Lab serves as a central point, where all the designs of individual major components and subsystems come together into a single, unified, full-vehicle model,” says Pokras.

As component and subsystem designs proceed, these engineering groups update their individual solid and finite element models. The new information is imported into the multibody model, where the analysis and simulation group can also add greater detail such as stiffness, damping and mass properties.

“Links with finite element codes streamline the iterative process of updating LMS models,” says Pokras. “With the ability to quickly enter additional details, we can generate new multibody models much more quickly and with fewer errors than building them from scratch each time. The capability to import finite element models as flexible bodies in the LMS multibody software lets us explore alternatives that would be entirely impractical to study with physical mockups.”

Dr. Vladimir Pokras
Mining Equipment Analysis and Simulation Manager
Liebherr Mining Equipment
solution is critical to accurate full-vehicle simulation."

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“Exploring “what if” scenarios
“The detailed multibody model created with LMS software predicts vehicle behavior to a reasonable accuracy for a variety of load cases,” Pokras states. “The beauty of the approach is that when simulation indicates a potential trouble spot, it is really quite simple to modify the model to investigate other design options. In this way, LMS simulation software lets us explore alternatives that would be entirely impractical to study with physical mockups.”

The multibody dynamics approach was especially helpful in studying many different what-if scenarios for the redesign of an axle box to save weight and allow for easier service accessibility.

After a number of simulation iterations, multibody loads for the final design were entered into LMS Virtual.Lab™ Durability software to determine the fatigue life of the critical structural components and assemblies, such as the frame and axle box. Tight integration between LMS multibody and...
Customer’s primary business
Liebherr Group’s mining division supplies the international mining industry with large machines for the extraction of raw materials in surface mining environments. The loading and hauling equipment for raw material extraction is manufactured in Colmar, France and Newport News, Virginia, United States.

Customer location
Bulle
Switzerland

Solutions/Services
LMS Virtual.Lab
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durability software enable fatigue life studies to be performed quickly and accurately, thus providing engineers with valuable feedback for developing lightweight parts to withstand expected operational loads without under- or over-designing them. The final step in the development cycle is prototype testing to validate the design before production begins.

Maintaining mining market leadership
“Simulation gives engineers an insight into the behavior and performance of the components, assemblies and full vehicle that isn’t practical otherwise,” explains James Whitfield, general manager of research and development at Liebherr Mining Equipment. He notes that the role of simulation at Liebherr has shifted from that of a verification tool at the end of design to an upfront development tool that is now totally integrated into day-to-day engineering processes.

“It’s not impossible to design mining trucks without using simulation; other companies do it all the time,” says Whitfield. “But the only way to design a market-leading, optimally weight-efficient truck is with advanced simulation tools like LMS durability and multibody software, tools that we not only should use, but must use. We can’t maintain our market leadership any other way.”