EBOOK

Applications of EDEM for Construction and Mining Equipment Design

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Challenges of Designing Heavy Equipment

Manufacturers of heavy equipment are faced with a wide range of challenges. To meet the demand of the market and stay competitive they need to continuously improve the performance, efficiency, and reliability of their machines but also deliver products quickly while ensuring product innovation. This means shortening the design cycle and ‘getting it right’ the first time is critical.

Machines have to operate in very harsh environments and perform well in a wide range of conditions. Skid steer loaders, excavators, backhoe loaders or truck bodies are all intended to handle bulk materials that can vary in shape and form, from large quarry rocks to cohesive soils, abrasive ores or free flowing granules – to mention a few. These materials and their interaction with the machine parts have a strong effect on the equipment performance.

For instance, an excavator digging through a pile of rocks will require a stronger bucket and much more power than for a pile of dry sand. Designers also have to then account for different deformations on the bucket arm due to the loading. The level of wear on the bucket may also vary based on whether a material is an abrasive sandstone or a soft soil.

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Challenges of Designing Heavy Equipment

Understanding how bulk materials will behave with equipment is therefore critical to ensure high performance. Customers are demanding customized solutions and confidence that equipment will perform as expected for a range of operating conditions.

Predicting bulk material behavior is; however, difficult as sand, gravels, soils, rocks, ores have very diverse properties. Assumptions of the anticipated material behavior is challenging and can lead to expensive mistakes. Physical testing is costly and time-consuming and typically restricted to a small number of available materials and motions.

Computer-aided-engineering (CAE) tools such as Finite Element Analysis and Multi-body Dynamics (MBD) are commonly used in the design process to perform virtual testing of equipment design. These techniques; however, do not include the material itself that the machine is designed to handle.

This is where bulk material simulation comes into play!

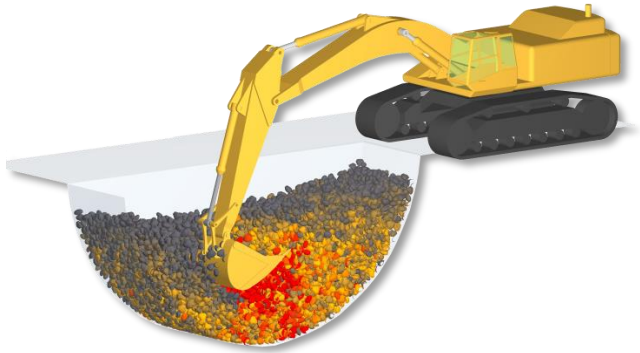
Introducing EDEM simulation technology

EDEM is high-performance software for bulk material simulation.

Powered by the Discrete Element Method (DEM), EDEM simulates and analyzes the behavior of bulk materials such as rocks, soils, ores and gravel.

EDEM provides engineers with crucial insight into how materials will interact with their equipment during a range of operating conditions, and it enables them to use realistic loads in Finite Element Analysis and Multi-body Dynamics simulations for optimal designs.

EDEM simulation technology is used for the design, performance testing, and optimization of mining and construction equipment such as dump trucks, bulldozers, diggers and excavator buckets.



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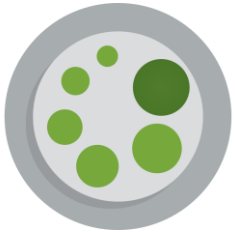
Overview of EDEM components

EDEM CREATOR

Create materials, particles, geometry and physics models

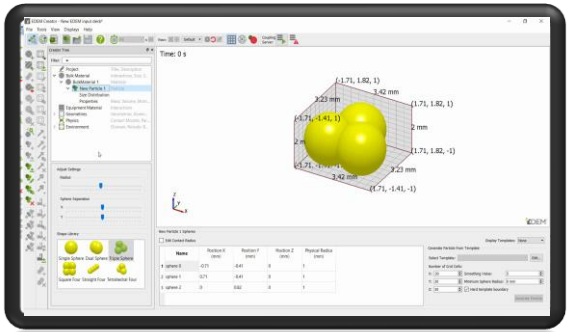


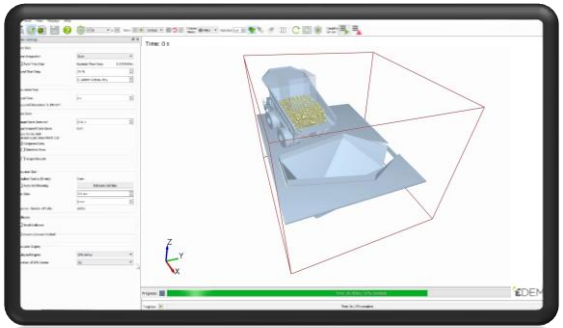
EDEM SIMULATOR

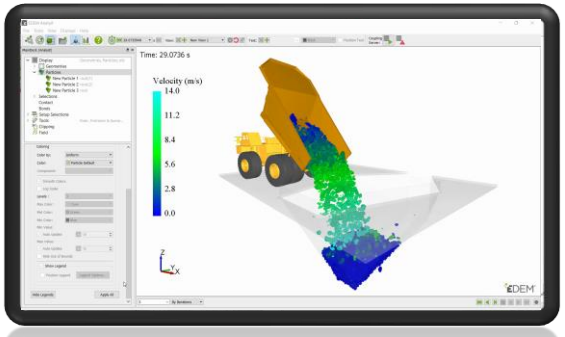
Define run-time and simulation settings and process the simulation on CPU or GPU

EDEM ANALYST

Visualize your results, create videos, graphs and export data







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Integration with CAE tools

EDEM can be coupled with a wide range of other CAE tools:

EDEM®

Multi-body Dynamics (MBD)

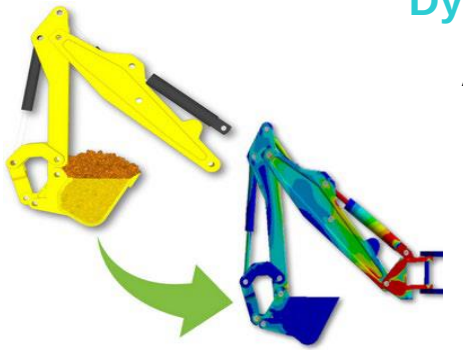
MotionSolve

Adams
RecurDyn
LMS Virtual.Lab Motion

Finite Element Analysis (FEA)

HyperMesh

ANSYS Mechanical
Abaqus



Computational Fluid Dynamics (CFD)

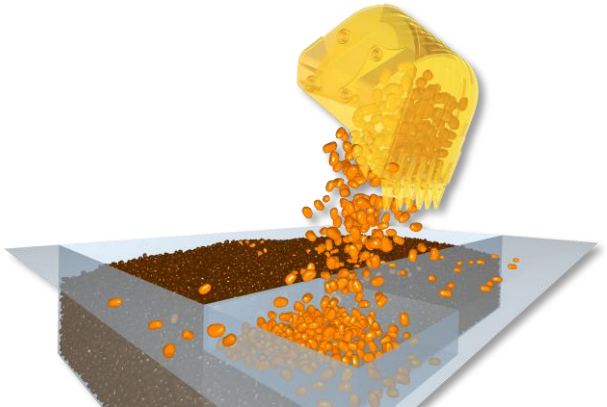
AcuSolve

Fluent
OpenFOAM

Benefits of EDEM simulation

By including EDEM is their design workflow, engineers are able to:

- **Understand** how different materials affect designs
- **Virtually test** designs for a wide range of materials with different properties
- **Predict** bulk material behavior: identify risk of blockages, spillage and wear
- **Get key insight into** equipment-material interactions



- **Shorten** design cycles
- **Reduce** physical prototyping and testing costs
- **Increase** productivity and reliability
- **Design** machines with higher performance

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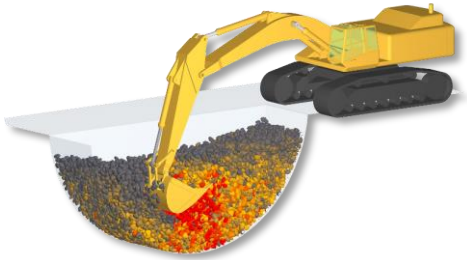
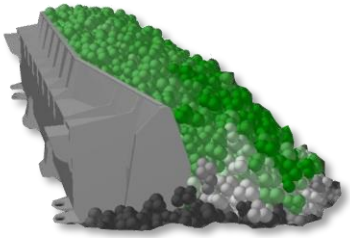
Applications Areas

Dump Trucks

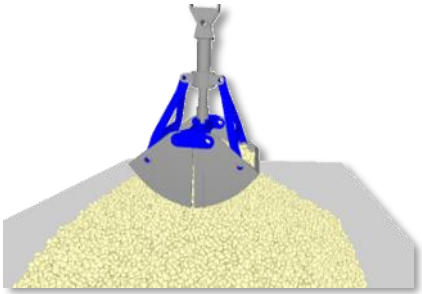


Excavators



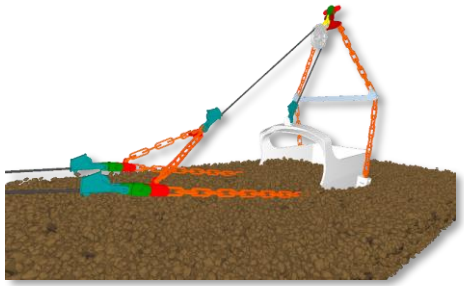
Dozers

Loaders



Grab Buckets

Graders



Dragline Buckets

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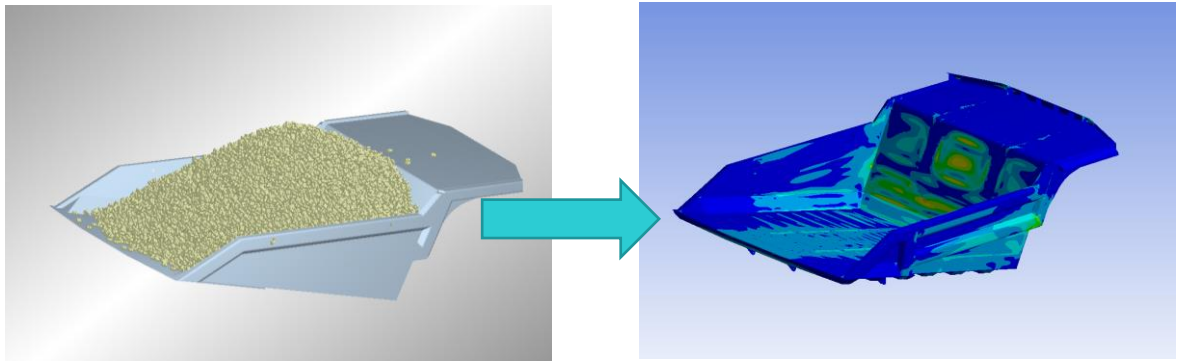
Dump Trucks

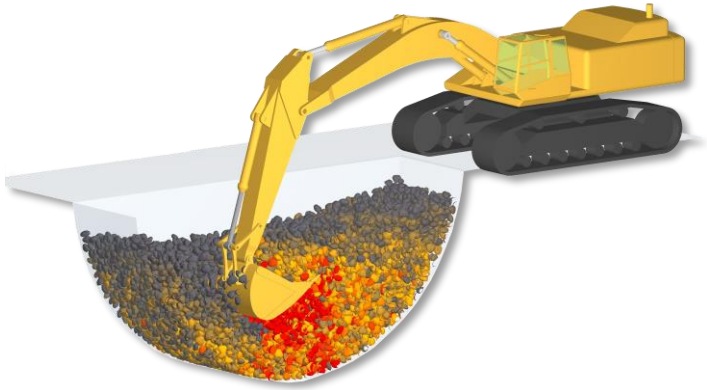
- **Analyze** loading and discharge performance of truck bodies
- **Identify** wear zones
- **Perform** virtual repetitive testing– under the same conditions every time
- **Reduce** load cycle, body mass and fuel usage
- **Get accurate** loads to use in Finite Element Analysis packages
- **Perform** extensive ‘what-if’ analysis of operational scenarios



Example from Austin Engineering: EDEM loads are used as inputs into structural and fatigue analysis to optimize custom truck body performance

Excavators

- **Obtain** accurate prediction of forces acting on equipment
- **Compare** force on bucket for different materials
- **Identify** risk of spillage and areas prone to wear
- **Couple** with Multi-body Dynamics for force feedback



- **Analyze** forces acting on bucket
- **Study** discharge efficiency
- **Assess** spillage and loading time
- **Visualize** loading to maximize filling efficiency
- **Test** design options for handling different types of materials (rocks, gravels, soils…)

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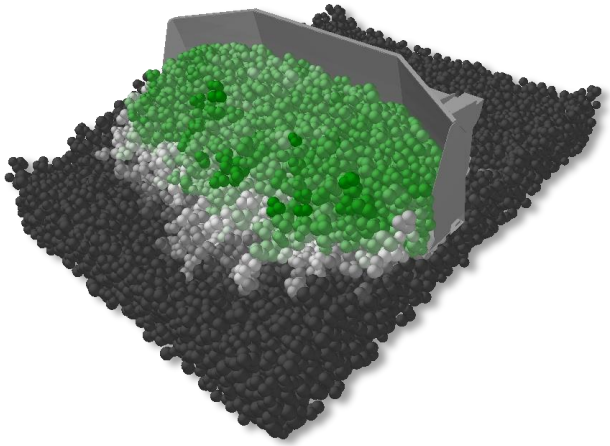
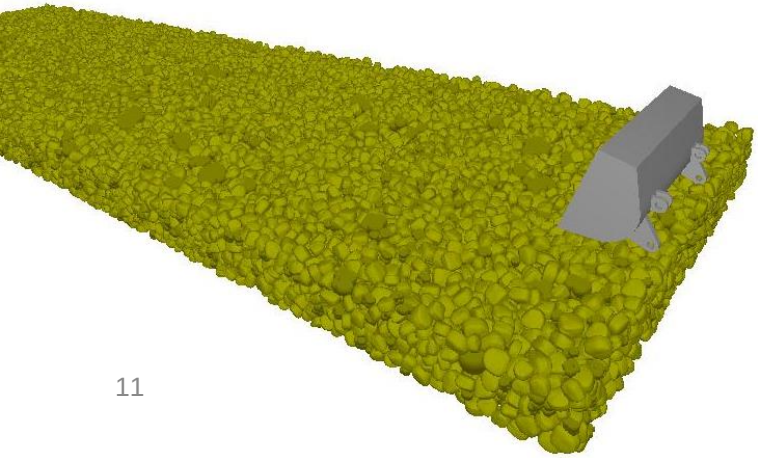
Dozers

- **Understand** loading of bulldozer blade
- **Visualize** material flow profiles
- **Analyze** and quantify amount of material transported and investigate efficiency
- **Compare** different designs with different materials





- **Obtain** high-fidelity forces acting on the blade that can be used to identify loading and power requirement for the dozer
- **Study** the influence of moving through different shaped material beds and channels, design for the most efficient transportation of material

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Loaders

- **Obtain** accurate prediction of forces acting on equipment
- **Compare** force on bucket for different materials
- **Identify** risk of spillage
- **Couple** with Multi-body Dynamics
- **Explore** how the loads due to different materials impact on the design performance

- **Simulate** skid-steer loader in different operating environments
- **Test** loading and unloading cycle with different piles of materials
- **Couple** with Multi-body Dynamics: obtain details of the power required to operate the bucket attachment in varying material types

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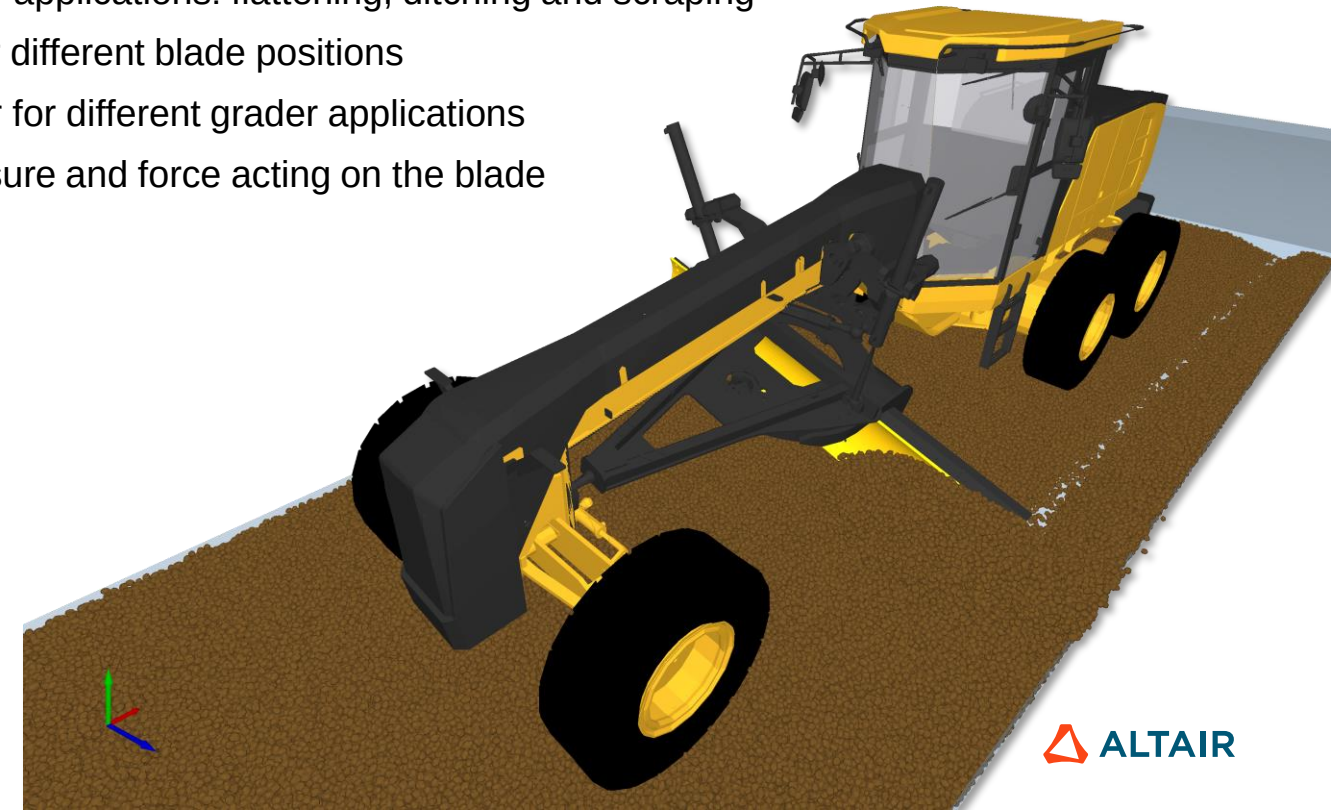
Road Grader

- **Simulate** different grader applications: flattening, ditching and scraping
- **Analyze** soil behavior for different blade positions
- **Compare** the blade wear for different grader applications
- **Obtain** data on the pressure and force acting on the blade



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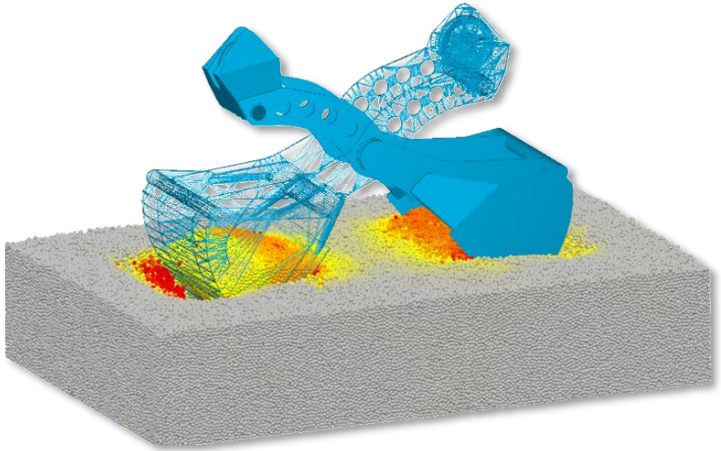
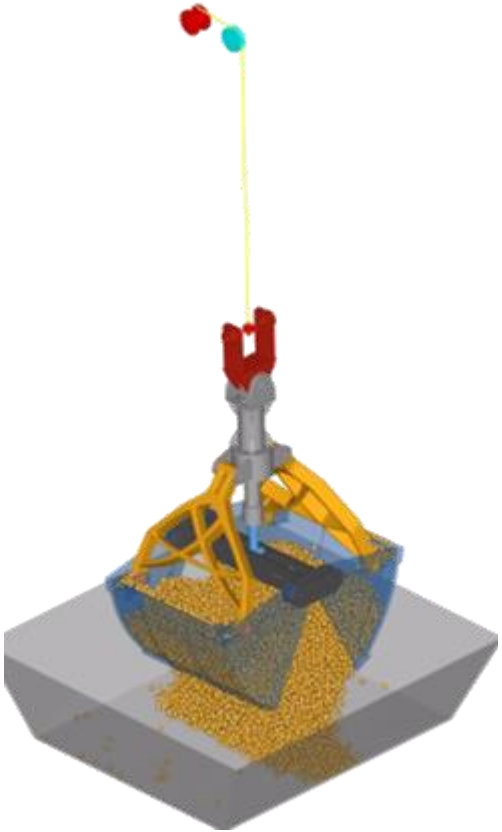
Grab Buckets

- **Model** grab and iron ore interaction
- **Determine** optimal fill level
- **Compare** different shell shapes
- **Increase** payload
- **Speed** unloading process up
- **Couple** with Multi-Body Dynamics to analyse stress on bucket arms based on the type of material handled





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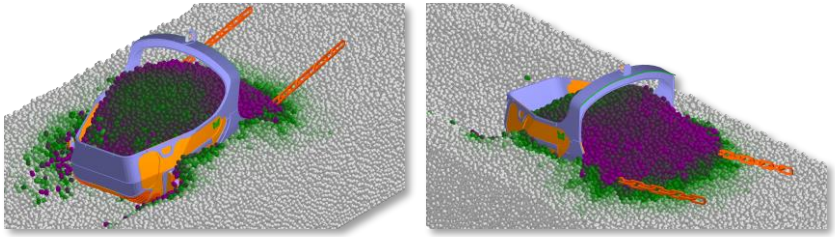
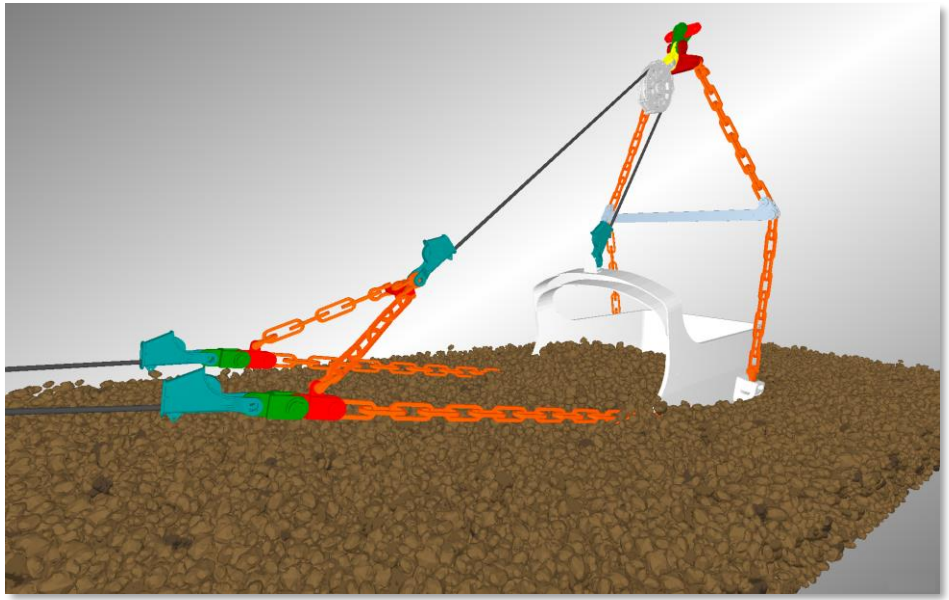
Dragline Buckets

- **Predict** the bucket rate of fill
- **Assess** wear patterns and rates
- **Increase** fill level
- **Shorten** filling cycle
- **Reduce** bucket mass



Images courtesy of VR Steel



CUSTOMER CASE STUDY

INCREASING THE OPERATIONAL PERFORMANCE OF A TRUCK LOAD BODY AT VR STEEL

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Case Study –VR Steel

VR Steel (Pty) Ltd designs, builds, and repairs fabricated mining equipment attachments, including truck load bodies. With EDEM virtual prototypes VR Steel can test new design options, custom designs for specific uses, build fewer physical prototypes, shorten the design cycle and increase customers' productivity.

Challenges

Reduce the mass of a truck load body—while maintaining structural integrity and increasing performance.

VR Steel wanted a simulation tool to help streamline the design process and reduce prototyping costs.

Their customers wanted proof that the new design would:

- unload more quickly
- lower operating costs
- hold up under heavy use

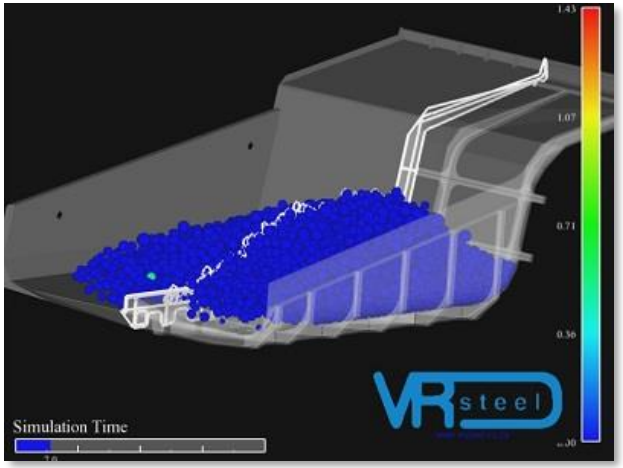
Case Study –VR Steel

Solution

With standard EDEM tools, VR Steel engineers imported 3-D CAD models of the new load body design and generated EDEM material models of various media to use in testing.

Using EDEM simulations as virtual prototypes, VR Steel was able to simulate the loading and unloading patterns of both the conventional load body and their new, lighter design.

EDEM provided a virtual environment for conducting 100% repeatable tests with a variety of materials–at a fraction of traditional physical prototyping and testing costs.



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Case Study –VR Steel

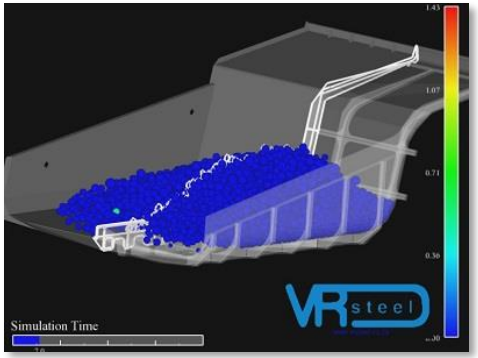
Benefits

EDEM helped VR Steel demonstrate that their new load body design:

- **reduced unloading time**
- **reduced body mass 20%**
- **reduced fuel consumption 11%**
- **fuel savings: ~70,000 L/yr per truck (~ $55K)**

EDEM gave VR Steel the ability to perform virtual repetitive testing– under the same conditions every time. Evaluation of design options in a virtual environment reduced the need for physical prototypes.

Using EDEM also gave VR Steel a distinct market advantage—the ability to quickly design and test a new load body that outperforms competitor designs.



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EDEM made it possible to evaluate and prove our product's loading and unloading patterns and establish the impact it would have on operation efficiency.

Bertus Haasbroek, Chief Design Engineer
VR Steel

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FOR MORE INFORMATION VISIT

www.altair.com/edem

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