ANSYS AND ROCKY GENERATE SAVINGS FOR VALE

Images Courtesy of Vale

The largest producer of iron ore in the world uses simulation to optimize machinery, increasing production and reducing costs by 80%

Simulation with ANSYS Showing Impact Force on the Rotating Disks

A major challenge in the mining industry is to develop projects that decrease required budgets and loss of raw materials by reducing equipment maintenance and wear. These costs can be minimized with the aid of computer simulation software, such as ANSYS and Rocky which are capable of modeling key variables of the processes and products, ultimately reducing failures and improving durability of the equipment.

The combined use of ANSYS software with Rocky developed by Rocky DEM, Inc., a simulation software company results in efficiencies in process and equipment development in various sectors of the mining industry. Vale, the world's largest producer of iron ore, has used these coupled solutions for the past year and has achieved positive results in the Carajás iron mine, located in the state of Pará, Brazil.

"ROCKY is helping us to improve various processes. The use of simulation tools can quantify the design improvements and gains; this is advantageous because mining uses large equipment that without computer simulation can cost millions for prototype development and testing. Accurate simulation results can advocate for necessary changes and updates, with the assurance of a return on investment."

Ueld Jose de Nobrega
Senior Engineer of Maintenance Engineering and Industrial Automation at Vale

"Last year and early this year we implemented some projects developed with the aid of simulation for the protection system of plants from inputs 1 and 2. The deployment of these projects cost was about US$18,2 million. In just three months the operation of each project achieved an economic return of over US$100 million," says Ueld José da Nobrega, senior engineer of the Management of Maintenance Engineering and Industrial Automation (GAAUN) at Vale. He also reports the results observed after the implementation of the projects were similar to those estimated in computational simulation.

PROBLEM

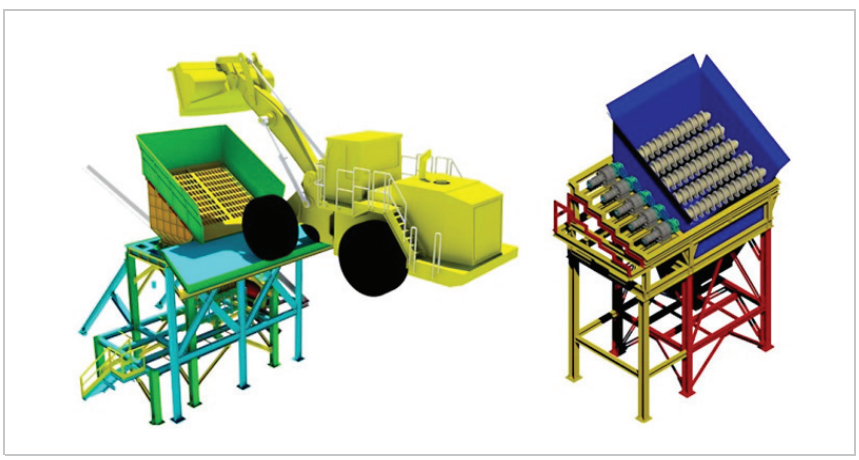
The solution mentioned by Ueld was developed to improve the efficiency and reduce the need for frequent grid cleaning at the hoppers' screen from plants 3 and 4. Plant 3 and plant 4 has two input lines each. They are responsible for separating the rocks by size and sift through the ore. The smaller stones and the sieved ore are sent to courtyards and storage silos, while the larger rocks return to go through the crushing mill process to achieve the proper size.

Because of the high degree of complexity, the engineering team at the Carajás plant required the use of ANSYS together with Rocky (coupled solution) in order to study the behavior and flow of rocks deposited on the grid. With the aid of the Rocky software, they could simulate together the behavior of spherical and non-spherical particles of different sizes, measure the impact forces from the rocks on equipment, and calculate the runoff speed of ore. "The simulations are more accurate with the use of non-spherical particles, this is needed because our mineral has a high content of iron," explains Ueld.

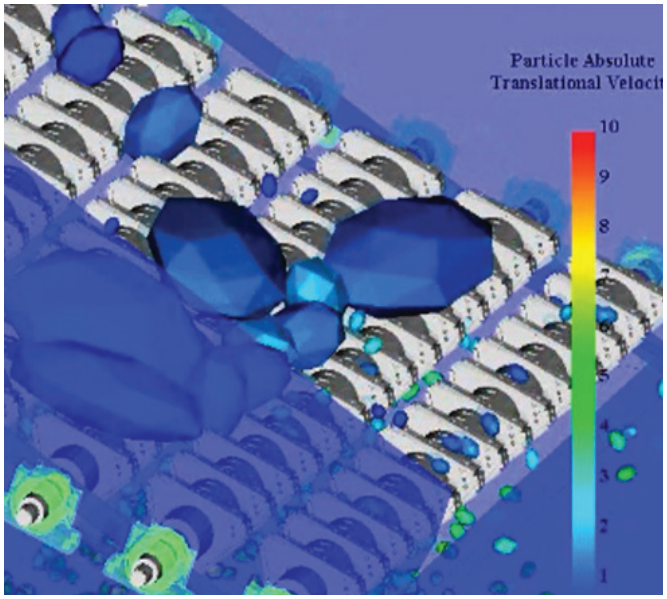
The data extracted from Rocky was used in combination with ANSYS tools to conduct structural analysis of the equipment. Engineers were able to virtually test the effect of proposed changes on the machine and how the ore would behave within the new structure. With the use of a coupled solution, Vale reduced the time spent by its staff on the development of this project by approximately 70%.

OPTIMIZATION

The solution proposed by Vale engineers was based on the operation of moving screens. They have evaluated different configurations and decided to develop a new system of rotating disks, similar to the roller system widely used in coal operations.



Separating Equipment



Simulation with Rocky Showing Various Size and Shape ore Falling Through and Going Over the Rotating Disks

Based on the simulation results of ANSYS and ROCKY, they defined rotational speed, tilt angle, distance and profile of the disks for operation, which changed from conventional circular shape to triangular shape.

In order to meet the new specifications, other changes had to be made to the equipment. The transmission system used in the project had to be redesigned and the support structure adapted accordingly. These changes will exceed the estimated gain of productivity in Plants 3 and 4 at Carajás, increasing production by 11.4% after the full implementation of the project.

THE BEST ORE IN WORLD!

Large-Scale Mining Equipment Being Directed by a Caraja's Worker

A Vale Giant Truck Being Loaded With Ore at the Carajas Iron Mine

Carajás Vale is the largest open mine in the world and is responsible for injecting into the market millions of tons of the best iron ore in the world. The plant produces 400 thousand tons of ore a day. The flow of daily production is carried out by more than 100 off-road trucks.

These vehicles are also known as 'Vale´s giant trucks' and are noticeable, standing eight meters tall, fifteen meters long, and with wheels that are twice as tall as a person.

Each truck has the capacity to carry up to 400 tons each - the same volume as a Boeing 747 airplane with a 415 person capacity.

According to a recent Sustainability Report of Vale, Carajás produced 109,8 million tons - enough to make approximately 15 thousand replicas of the Eiffel Tower. Next year Vale aims to increase production to 130 million tons. To reach that number, the company plans to invest in research and development, along with improved equipment.

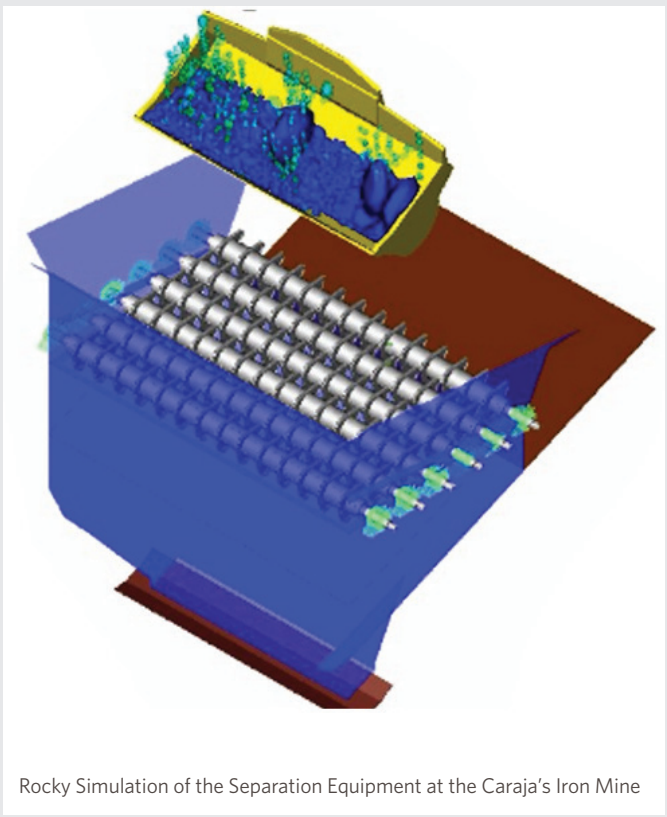
In light of this scenario, Vale´s engineers need to optimize processes, reduce waste, and develop more efficient equipment. They rely on simulation tools, which according to Ueld, have become a valuable reference as they allow Vale to estimate the gain and timeline to recover their investment. 'Here in Carajás we do not accept any project that is not simulated first. Computer simulation has become almost like a seal of quality engineering!' reveals Ueld.

The application of simulation tools, such as ANSYS and Rocky, during the development of processes and equipment makes a substantial difference in the mining area. This occurs because of the scale, as the equipment sizes in this sector are generally large. Prototype fabrication and testing of new projects would cost millions. According to Ueld, simulation is essential for the industry as it allows testing different possibilities without spending millions to develop prototypes. "With simulation it was possible to justify the changes and upgrading of equipment, because we know that all the money invested would generate a significant return,' he explains.

ROCKY AND THE DISCRETE ELEMENT METHOD

The Discrete Element Method (DEM) is a relatively new technique which is gaining great popularity with the advancements of computer technology. This approach is mainly used for the simulation of granular materials, which consist of a large number of solid particles. Continuum equations for this type of material are very difficult to derive for a general flow case. To avoid this problem, the Discrete Element Method relies on simulation of the motion of every solid particle in the system of interest. The interaction of granular particles with each other and system boundaries are traced at every time step of the simulation.

Rocky is a powerful DEM package that takes advantage of GPU or CPU capabilities of existing hardware allowing for the fast solution ofgranular mechanics problems. It also enables the use of true non-round particles in simulations. Shapes like faceted, polyhedrons, briquettes, and cylinders are able to compact, settle, and behave just like real-world particles, which provide a more realistic



Rocky Simulation of the Separation Equipment at the Caraja's Iron Mine

result. Because each particle is calculated as a single item, compared to sphere clumps, which are calculated as many individual spheres stuck together, it takes less time to calculate. This reduces the overall processing time. Rocky can simulate more than 5 million particles in nearly limitless shape and size distributions. It also realizes the ability to simulate in different environments, through variable wet, dry, anddust-like conditions. Rocky's capabilities includemoving boundaries and vibrating surfaces, replicating nearly any type of material and handling environment.

ANSYS AND FINITE ELEMENT ANALYSIS (FEA)

The FEA tools from ANSYS are used to simulate structural aspects of a product, including stress points, deformations, and vibration characteristics. This enables engineers to understand the results and the impact of design variations on the model.

ROCKY AND ANSYS WORKING TOGETHER

As illustrated in the above example from the Carajas iron mine, coupling the Discrete Element Method (DEM) of Rocky with the Finite Element Method (FEM) of ANSYS produces a powerful set of tools capable of predicting not only the flow of particles through equipment, but also how particle flow affects the structural integrity of the materials that make up that equipment.

Vale engineers first used Rocky to calculate the forces acting upon each meshed surface within the simulation, then analyzed that data with ANSYS to determine the overall forces acting upon the equipment. The results of these coupled tools enabled the engineers and designers at Vale to determine the exact locations that should be changed to achieve the best performance of the equipment. In this way, Rocky and ANSYS working together generated savings for Vale.