



ROCKY



thyssenkrupp

Particle simulation by using Rocky DEM optimizes plants for cement production



FROM QUARRY TO CEMENT

thyssenkrupp is one of the world's leading suppliers to the cement industry. The company offers innovative technologies, processes and machines that address a variety of industrial issues, from processing raw materials via clinker and cement production to automation solutions.

thyssenkrupp provides customers with reliable systems from a single source, which results in state-of-the-art production processes that conserve resources and environment as well as guarantee maximum productivity and profitability for operators. The company relies on particle simulation with DEM (discrete element modeling) to simulate a variety of processes, from crushing and grinding, via transporting and mixing, to storage and loading. Two important thyssenkrupp DEM applications are ball mills and the POLYTRACK conveyor system.

In cement production, the ground raw material is burned to clinker, then broken up again and ground to cement. Thyssenkrupp's POLYTRACK conveyor system cools and transports the cement clinker, which initially comes out of the kiln at over 1,000 degrees C. The system incorporates an aeration floor and conveyor skids arranged above that optimally distribute

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Lisa Schrader
R&D at thyssenkrupp

the material, ensuring uniform and effective cooling of all grain fractions over the entire cooler width. The robust, low-wear and easy-to-maintain design has been optimized using structural mechanics simulation, resulting in durable, around-the-clock operation. To further optimize transport and cooling from a process engineering perspective, thyssenkrupp leverages Rocky DEM software for particle simulation.

LEARNING MORE

Lisa Schrader, R&D Engineer at thyssenkrupp, said that through Rocky particle simulations her team can now better understand how processes in the POLYTRACK actually work. “We are most interested in conveyor efficiency. Therefore, we investigate whether track movement in another pattern or at other speeds will transport particles faster. We suspect additional potential with regard to the output, and we want to increase that as extensively as possible using Rocky.”

In introducing the Rocky software, Ms. Schrader explained: “As our R&D colleagues commissioned more and more DEM simulations over the past few years, we needed to look for new, powerful and easy-to-use software. To help us react more quickly to these needs and work more efficiently, we chose Rocky DEM, a software with comprehensive functionality as well as a mature and proven user interface.” Team members found it invaluable that they could choose various particle shapes, because in the past they could work only with spherical or diced particles.

COMPLEX REQUIREMENTS

For grinding and drying a wide range of materials, the most suitable application is a pipe mill. This equipment is affected by many factors: for example, feed particle size, grindability, moisture and drying properties.

In one project from thyssenkrupp’s service sector, the DEM expert was commissioned to carry out a particle simulation comparison of three different mill linings of a ball mill 7 meters diameter and 5-plus meters long. The liner profile in the inner wall of the mill’s cylindrical drum lifts up the balls and particles to be comminuted; they then follow specific discharge curves. At the same time, the liner profile serves as wear protection — wear is dependent on particle and ball size as well as particle speed and coefficient of friction.



Figure 1: State-of-the-art technologies are used to conserve resources and environment and to guarantee maximum productivity and profitability for operators.



Figure 2: thyssenkrupp’s POLYTRACK conveyor system cools and transports the cement clinker.

INSIGHT NOT POSSIBLE ANY OTHER WAY

“For both the R&D team and our customers, it is always interesting to see how the material or balls behave in the mill,” emphasized Lisa Schrader. “This gives us insights that we cannot reach with other means, such as cameras and sensors. Our calculations, then, are based on the degree of comminution and lining wear realized through simulations. In this way, we can recommend the best variant with the least wear to our customers.”

By using Rocky, Ms. Schrader said it is easy to see how the movement behavior develops at different speeds and respective liner profiles, for example, to compare the ejection curves of liner variants. The specific tendencies can be unequivocally identified, so a qualitative comparative assessment of loads needs to be done. “In addition, the software can illustrate grinding with the simulation methods,”



Figure 3: The grinding of the cement by means of balls in a pipe mills.

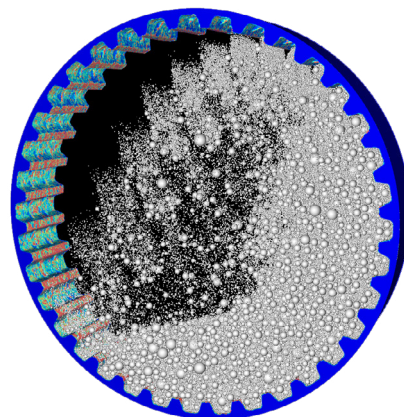


Figure 5: By using ROCKY it is also possible to calculate the wear of the lining, which is shown in the left part of the picture.

Ms. Shrader explained. "At low speeds, the particles roll only in a so-called kidney; as speed increases, lifting and corresponding collision with comminution takes place." At around 90 percent of critical speed — with 100 percent of particles pressed against the mill wall by centrifugal force — the particles are dropped from a considerable height.

SIMPLIFICATION SPEEDS UP CALCULATION

Since the simulation model is based on periodic boundary conditions along the mill axis, only a 1-meter-long section of the real ball mill can be depicted, depending on the particle size. Further acceleration is achieved by the geometric shape of the ore, because the more complex the particle shape, the longer the calculation takes. If the ore is also represented in spherical form, the computation time is considerably shortened. (In the figure 4, the green balls are steel, and the white balls represent ore.) For control purposes, grinding was also calculated with faceted ore particles.

Based on calculated impact energies, the team could draw conclusions about the effectiveness of cement grinding and expected wear on the mill lining. "Using the recently released Rocky DEM version 4.0, we were able to output the desired particle energy spectra as diagrams," said Schrader. Within the scope of the ball mills investigation, the team considered the number of contacts per second as a function of contact energy for the particle–particle and particle–wall contacts in the normal and tangential directions, respectively. In principle, thyssenkrupp R&D found that the highest contact number occurs in the case of particle–particle impacts in the normal direction, the contact number and its energy rising with increasing size.

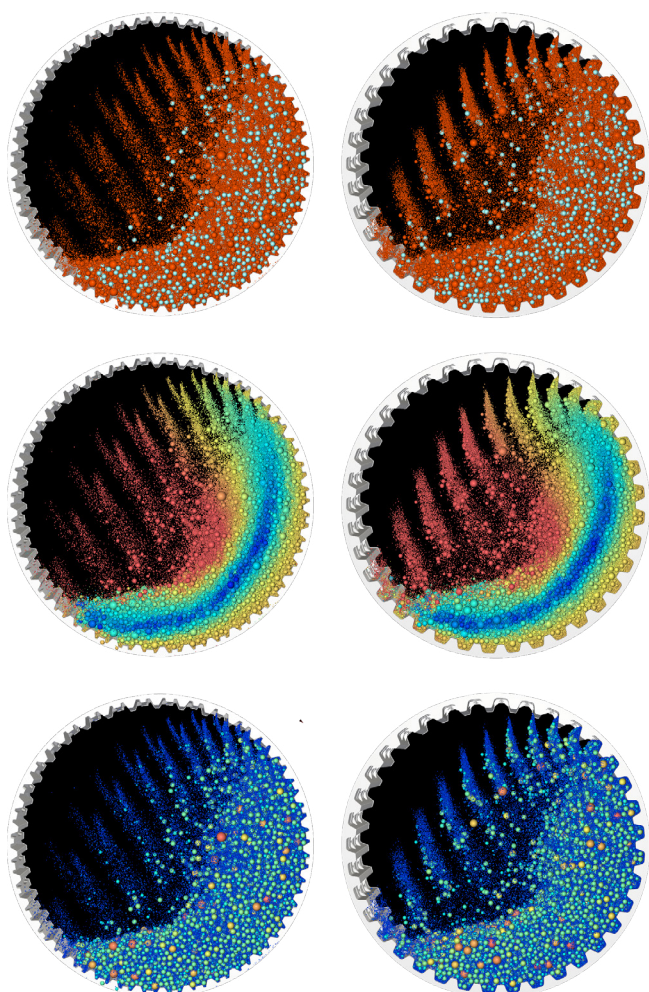


Figure 4: The particle simulation shows the movement of particles and spheres (top), the velocity (center) and the size of the particles (bottom) for two different mill linings each.

GPUS FASTER RESULTS

A hardware platform feature available in Rocky 4.0 is the use of several GPUs (graphics processing units) for the calculation — in addition to CPUs (central processing units). Schrader explains: “We started with eight CPUs about a year ago and then expanded relatively quickly to 16 CPUs. With the new Rocky version, we invested in a new computer with 36 CPUs and a GPU, which resulted in considerable time savings. This allows us to perform more calculations more quickly.”

Schrader and her colleagues value a definite advantage in the elegant CFD and FEM interface from Rocky to ANSYS® software, since the thyssenkrupp team has used structural mechanics calculations, including welding applications, for many years. Rocky results can be integrated into structural mechanics simulations or flow analysis to carry out further calculations. As an example, for a tower mill consisting of an upright cylinder with an internally rotating screw, the team examined the grinding process with balls. The occurring forces on the screw (which could not have been determined otherwise to this point) were integrated into the structural-mechanics calculation from the DEM simulation.

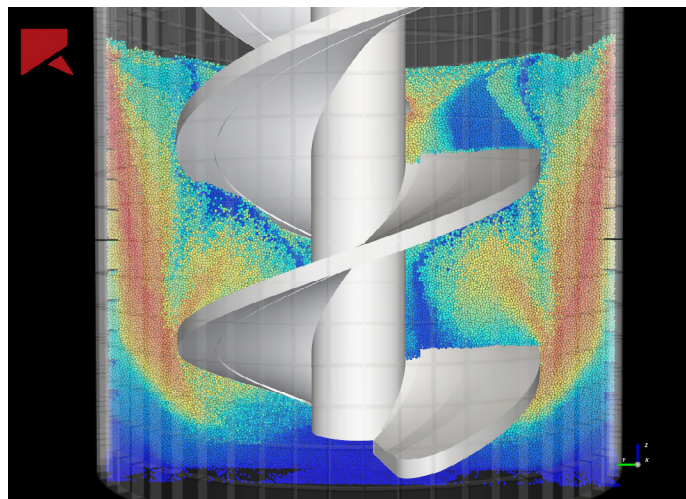


Figure 6: The results calculated using ROCKY were integrated among other things into structural mechanical simulations of a tower mill.

OPTIMIZING JAW AND GYRATORY CRUSHERS

In the field of crushers for raw material preparation, the first analysis steps used Rocky DEM. In the case of a gyratory crusher for ores, a conical inner part, which is driven eccentrically, ensures the crushing of the rock. The DEM simulation provides more insight into throughput and particle size distribution, and it also make clear which parameters have the greatest influence.



ABOUT THYSSENKRUPP

thyssenkrupp AG is a German multinational conglomerate, based in Duisburg and Essen and divided into 670 subsidiaries worldwide. It is one of the world's largest steel producers. In addition to steel production, thyssenkrupp's products range from machines and industrial services to high-speed trains, elevators and shipbuilding.



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