The EDEM BulkSim Solution: Maximizing the Reliability and Performance of Conveyor Transfer Equipment

A white paper from DEM Solutions
INTRODUCTION

Put yourself in the place of a mine operator who is responsible for ensuring production targets are met. Within your operation, will your conveyor transfer equipment perform to the standards necessary? Can you operate until the next planned maintenance period without problems arising with conveyor transfer?

What is the situation at your mine? Are you commissioning the conveyors following a transfer refit or mine expansion project? Are you commissioning a new mine? Or maybe you are replacing equipment as part of a maintenance cycle or for improved operations. In any of these scenarios, are you confident that the transfer points will operate as needed?

Previously, the potential concerns pertaining to transfer points have had few design options in advance of deployment. This situation causes some uncertainty. What if a transfer point causes a production interruption soon after being put into operation? What if a chute or conveyor belt wears out within a matter of weeks? What if conveyor belt loading is misaligned resulting in problems with processing equipment further down the line? You may already be in the middle of unscheduled downtime or feeling at risk as you read this paper.

How could planning and engineering design tools reduce these risks? Prior to installation, was it possible to verify that the transfer points and chutes wouldn’t plug when handling the actual ore or coal from your mine? Before the equipment was commissioned, could you confirm that the delivery to receiving belts would be properly aligned and not cause excessive wear of the belts? Was the wear protection located correctly?
Now consider the challenges facing the design engineers who are responsible for ensuring that these problems do not occur. What methods and tools were available to help them make design decisions? Empirical calculations? Personal experience? Modification of a design which worked well at a different mine? Until recently these have been the only tools available to aid engineers with design for optimal flow of bulk materials.

By bringing properly-deployed Discrete Element Method (DEM) simulation and analysis into the design workflow, engineers can verify their design effectiveness and virtually test for reliability—early in the design process. DEM Solutions offers software tools and services tailored to meet demands for maximizing the reliability of conveyor transfer and increasing the productivity of mine assets.

In this paper, DEM Solutions describes the EDEM BulkSim Solution™ for simulation-based design of conveyor transfer equipment in mine operations. This is an enterprise-wide, scalable engineering solution enabling engineers to deliver superior designs. As a result, mining companies are able to deploy more reliable and robust conveyor transfer equipment and processes.

THE COST OF TRADITIONAL DESIGN METHODS

In mine operations, conveyor transfer equipment typically goes through its first test when it is put into operation in the field.

Until recently, Engineering Procurement and Construction Management companies (EPCMs), equipment designers and manufacturers had no reliable way to test the performance of transfer points prior to installation. The traditional approach to designing conveyor transfer equipment is grounded in empirical design methods. These approaches are very limited in predicting how well a design will perform under the range of material types, moisture content and operating conditions expected during the life of the mine. Similarly, no quantitative method has existed to support decisions regarding the location and extent of wear protection.

Limited Information on Operational Envelope

As a result, mining companies have typically received only vague estimates of the limits on throughput. Additionally, they have not been able to gauge the sensitivity of equipment performance to operating conditions and variation in throughput to support predictable operations. They have had no confirmation that the equipment could handle changes in material characteristics nor a
way to estimate, quantitatively, where and when a design will require maintenance due to equipment wear.

Transfer Point Failures
Failure of a transfer point due to poor design usually entails substantial loss of production, as illustrated in Figure 1. If this occurs at mine start-up, there are major financial consequences from delays in delivery of product and in cost of redesign and replacement. If it occurs during production, it can result in costly unscheduled downtime while the problem is remedied—if indeed it can be remedied, when using the same methods employed in its original design.

Expensive Contingency Measures
To hedge against the impact of unplanned stoppages during the life of a mine, operators often maintain levels of buffer stocks and a fleet of mobile loading equipment to ensure continuous feed to process plant and to meet contracted loading and shipping schedules. Additionally, multiple conveying lines may be installed to maintain continuous production along with large stocks of expensive spare parts for emergency response to unscheduled downtime. Mining companies have endured these extraneous and, sometimes, exorbitant costs because of limitations with traditional design methods.

SIMULATION-BASED DESIGN USING DEM

Delivering Better-Designed Equipment
Discrete Element Method (DEM) simulation, when properly deployed, offers designers of conveyor transfer equipment the tool that has been missing from traditional conveyor design—a way to virtually test and troubleshoot the performance of conveyor transfer equipment before it is commissioned (see Figure 2).

Risk Mitigation and Improved Planning
Using a simulation-based approach to design significantly increases the likelihood that equipment will perform to specification. This approach can be used to:

- **Determine** reliable operating envelopes for each transfer point
- **Consider** scenarios for varying moisture content, tonnage and belt speeds
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- Identify areas experiencing the highest impact and abrasion forces and
- Compare projected wear patterns between different designs or operational scenarios

Properly-deployed DEM simulation provides mining companies with the assurance that the equipment will not only perform as required at start-up, but also that it will be able to handle any differences in flow behavior arising from changes in the properties of the material being extracted over the life of the mine.

It allows mining companies to ask those engineering the equipment—ahead of manufacture and installation—questions such as:

- What will happen if we increase the throughput by 20%?
- What happens if our material is more wet, more dry, or a different grade?
- Is the wear protection sized and positioned to account for the bulk material flow behavior and any anticipated changes in operating conditions?

This ability to evaluate equipment performance early in development cycles provides mining companies with a lower risk alternative to traditional design methods.

Design with Confidence

To gain any value out of simulation-based design, it is imperative that the simulated material behavior reflects the real material behavior.

Physical measurements of bulk flow behavior for the actual material are needed to make this connection between the real bulk material and the model material in the simulation. This testing information is used to define and calibrate the computational model of the material (the “DEM Material Model”).

Appropriate calibration is essential to ensuring that a DEM simulation will provide information of engineering quality. If calibration is not carried out correctly or, worse, is not carried out at all, it’s unlikely that such simulations will adequately represent the real material flow behavior.

Figures 3 and 4 illustrate the contrast between the predicted flow behavior from a DEM simulation using a non-calibrated material model and a properly calibrated model. The large, free-flowing spheres used in the non-calibrated model are all too typical of the poor application of DEM simulation. No effort has been made to link the virtual material with the real product to be conveyed.
When faced with the design of a transfer that is carrying 5,000 tons of moist run-of-mine ore it is hard to have any confidence in simulations that are based on these types of crude approximations. This best-effort approach is often necessitated when using DEM software that is not powerful enough to simulate large tonnage.

The simulation in Figure 4, which uses a calibrated material model developed using the EDEM BulkSim Solution, shows a strikingly different material behavior. Where the uncalibrated model indicates that the transfer point will perform well, the calibrated model—which was based on the dynamic testing of material sampled from site—shows that there are serious flow issues within the transfer during operation.

DEM Solutions provides a robust set of material testing, material model calibration, and simulation solution deployment services that are specifically designed for simulation of bulk materials handling equipment in mine operations.

THE EDEM BULKSIM SOLUTION

An Enterprise-wide, Scalable Engineering Solution

The project management and design challenges in deploying DEM simulation and integrating it into existing engineering workflows vary from project to project. The need may be to answer a specific question, such as, “Will this proposed transfer point handle the target throughput for which it’s been designed?” Or it may be desirable to simulate all transfer points in a conveying line to ensure there are no surprises.

DEM Solutions has worked with mining companies and EPCMs to develop and refine EDEM software and simulation services to meet their specific challenges in the design and optimization of bulk materials handling equipment for mine operations.

The culmination of this collaboration is a new approach that combines dedicated software (EDEM BulkSim®), physical testing of materials, and DEM Material Model calibration—to provide a complete solution that gives engineers the ability to accurately evaluate equipment performance, quickly and early, in the engineering design cycle (Figure 5).
If simulation has not previously been used in design of your bulk materials handling equipment, it could appear challenging to integrate simulation software and calibration services into the workflow across projects or organizations. Mining companies may, or may not, have engineers involved in equipment design or performance analysis. Engineering companies may, or may not, have their own in-house bulk materials experts available to work on projects at locations around the globe.

Whatever your in-house resources and expertise, DEM Solutions will work with you to find the right mix of software and services to support project goals and engineering workflows. The DEM Solutions team is very experienced in collaborating with engineering design and production departments to ensure successful integration of EDEM simulation into their operations.

Sometimes this solution may be to contract a series of DEM Solutions consulting projects to help a company explore what if scenarios; sometimes it may be to contract material model calibration services for existing EDEM BulkSim users; or
sometimes an engineering team may want to integrate the complete EDEM BulkSim Solution into their engineering design workflow so that a particular in-house team can leverage the benefits of deploying the solution throughout their company.

The basic components of DEM Solutions’ services and software for the EDEM BulkSim Solution include Physical Material Testing, Material Model Calibration Services, EDEM BulkSim software, and Solution Deployment Services.

**Physical Material Testing Services**

Material testing provides the basis for calibrating the material models used in EDEM BulkSim simulations. These tests measure how actual mine site samples behave in dynamic flow conditions—to ensure that equipment designers can develop properly calibrated material models for use in EDEM BulkSim simulations.

These tests differ from the conventional consolidated stress tests often carried out to provide design data for engineering of silos and hoppers, which should not be used in the design of conveyor transfer equipment. Such tests are of limited use since they provide only static and quasi-static material data, and poorly represent the inherently dynamic nature of material flow through bulk materials handling equipment. In addition, the physical scale of such tests means the actual particle size distribution is typically size-reduced to fit into the shear tester.

DEM Solutions works closely with clients to obtain bulk material samples from site of the material that the conveyor transfer will handle, and manages the testing logistics with partners who are experts in dynamic flow testing of bulk solids.

**Material Model Calibration Services**

Fundamental to any bulk materials handling simulation is the need to describe the physical material in the form of a mathematical model. Through its Material Model Calibration Services, DEM Solutions uses large-scale grid computing and mathematical optimization techniques to define and calibrate the best DEM Material Model for the particular material—so that it accurately represents the behaviors observed in dynamic flow testing. Importantly, this calibrated DEM Material Model is based on measured physical properties and is used to represent the real material in an EDEM BulkSim simulation (see Figure 6).
The link formed with the real material behavior during calibration means design decisions based on the simulated transfer performance can be made with confidence. Customers can build a library of their calibrated EDEM BulkSim Material Models for use in future redesign or expansion work, as required.

**EDEM BulkSim Software**

EDEM BulkSim® software gives its users the power to evaluate equipment performance virtually (see Figures 7 and 8). It has been developed for use by transfer point design engineers, not DEM simulation experts. The EDEM BulkSim Material Models have the know-how built-in—thanks to the robust testing and calibration procedures. Using these models, EDEM BulkSim can reproduce the flow behaviors of a wide variety of bulk material products: from fine, dry powders to high moisture-content, run-of-mine ores and coal.

**Figure 7**

To maximize the lifespan of conveying equipment, material must be presented onto conveyor belts in a controlled manner. EDEM BulkSim allows evaluation of the flow behavior of material as they are loaded onto a receiving conveyor belt.

EDEM BulkSim allows equipment designers to virtually test the performance of a design. They can identify and modify areas of equipment that are at risk of plugging; identify where flow is diverging and dispersing; check that material flow onto receiving conveyors is correctly aligned and delivered at the correct velocity relative to belt speed; or adjust the flow from conveyors feeding crushers and other comminution plant to ensure balanced loading.
Based on how the materials interact with the equipment, the software also provides the designer with the information needed when choosing the optimum location and type of wear protection required.

**Figure 8**

*EDEM BulkSim allows material flow behavior to be evaluated in all parts of a transfer point and potential issues, for example non-symmetrical flow and dead zones, to be identified.*

*Courtesy of A. Grima, Bulk Materials Engineering Australia*

Sensitivity analysis of each transfer point’s capabilities provides a means to reduce risk of future malfunction as operators anticipate the range of material flow characteristics which could be experienced during the life of the mine. Equipment designers employing EDEM BulkSim software benefit from a much more robust design methodology when compared to reliance solely on traditional methods and also ensure a quality engineering delivery to their clients.

**Solution Deployment Services**

Combining extensive bulk materials simulation know-how with our experience helping clients with mining applications, DEM Solutions provides guidance to ensure design engineers are able to get the insight that they need—right from the start. For teams interested in integrating EDEM BulkSim into their workflow, we provide training and technical support for best use of the software. For projects that
require full outsourcing, DEM Solutions provides full project execution and engineering support.

DEM Solutions can help determine what mix of these services is right for the design challenges at hand. We assist with individual engineering team or enterprise-wide deployments of various combinations of these software and services offerings.

CONCLUSION

Using simulation in the design and evaluation of bulk materials handling equipment for mine operations addresses a critical gap in previous approaches. Simulation-based design of equipment is well established in other industries. Now, with EDEM BulkSim software and supporting methodologies, simulation-based design of bulk materials handling equipment is available for the mining industry as well.

Mine operators stand to reap significant strategic and operational benefits with the use of this simulation approach. They can substantially decrease the risk of unscheduled downtime and avoid systemic production loss as well. Importantly, maintenance of expensive buffer stock can be reduced. By simulating multiple transfer point scenarios in advance, equipment repair and replacement can be avoided or deferred. Simulation gives mining companies access to powerful decision support metrics, such as equipment through-put limits, estimates of system lifetime, and likely performance under different operating conditions—before making final purchase or build decisions.

When mining companies, EPCMs, or equipment manufacturers deploy the EDEM BulkSim solution, they can be confident that they are using a high quality system designed specifically for their demanding environments. With over a decade of experience in developing DEM software and working with industry to successfully deploy it, DEM Solutions provides unmatched simulation capability backed by extensive applications know-how. Customers are supported worldwide by a dedicated team of engineers who are experienced in the application of DEM to design bulk materials handling equipment used in mine operations. Growing in awareness and use, EDEM BulkSim is establishing a new standard for the design of critical conveyor transfer points.
ABOUT DEM SOLUTIONS

DEM Solutions leads the market in DEM simulation, providing software, deployment and consulting services to a wide range of industries. Headquartered in Edinburgh, Scotland, with offices in Denver, USA and Yokohama, Japan, our international sales and engineering staff support clients worldwide who use our simulation solutions to increase productivity, reduce operational costs, shorten product development cycles and drive product innovation.

We uniquely offer DEM simulation technology supported by expert advice on deployment, in addition to full material model calibration and engineering simulation services. DEM Solutions has the product, the know-how and the vision to deliver the world’s leading simulation solutions for bulk materials handling and processing.

FOR MORE INFORMATION

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