The Use of Discrete Element Modelling (DEM) for Armored Face Conveyor Applications

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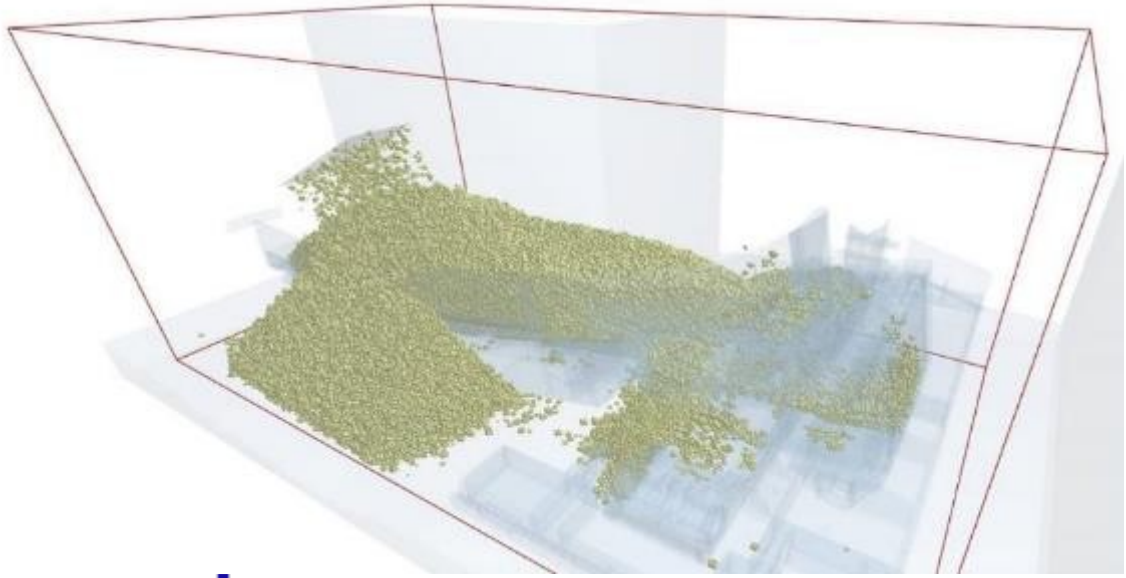
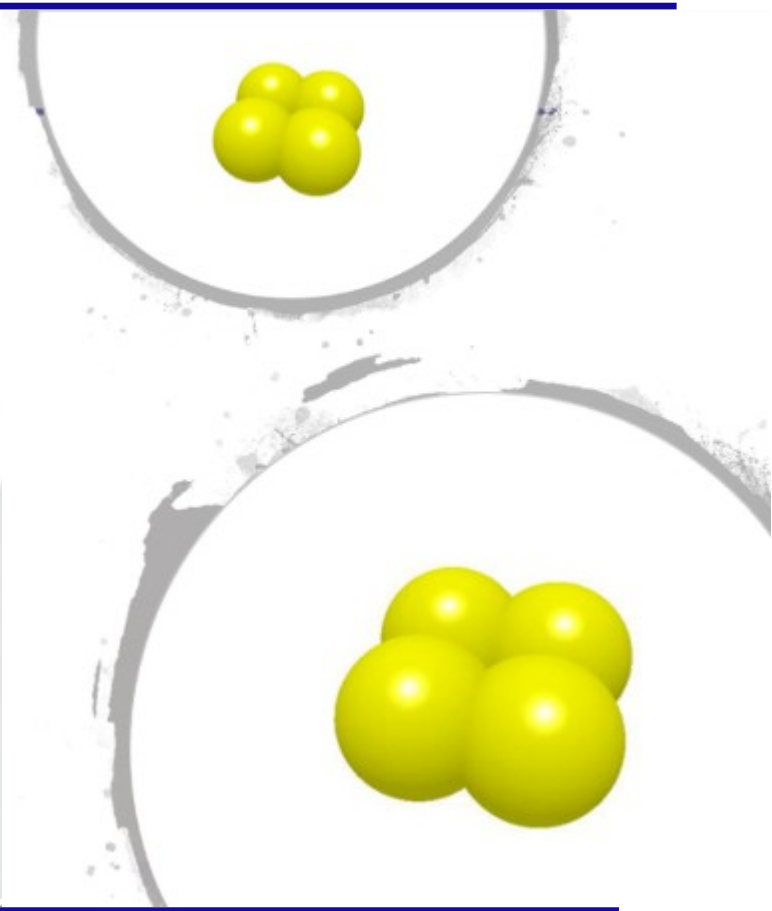
What is DEM?

“The Discrete Element Method (DEM) is a particle-scale numerical method for modelling the bulk behaviour of granular materials and many geomaterials such as coal, ores, soil, rocks, aggregates, pellets, tablets and powders.”





History of Flow Calculations

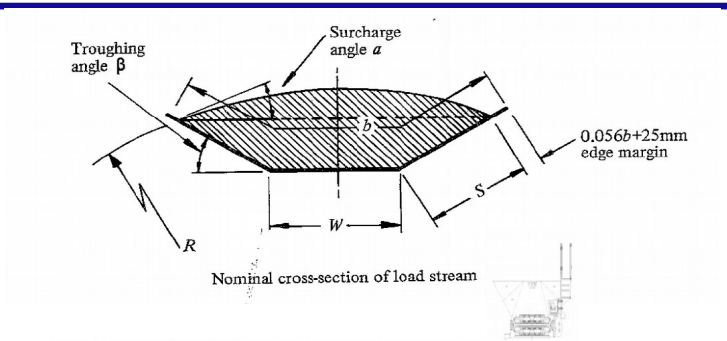
Flow calculations used to be limited to belt conveyors due to the complex nature of AFC dynamics.

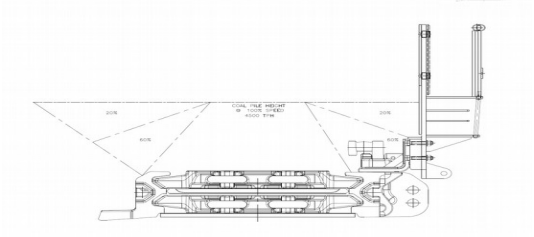
Greater operational experience allowed broad understandings of system capacities and bottlenecks.

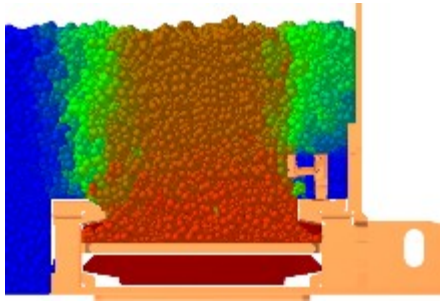
Basic simulations allowed simple, low particle demonstrations.

With improving computing power, increasingly complex simulations are possible with a greater degree of confidence.

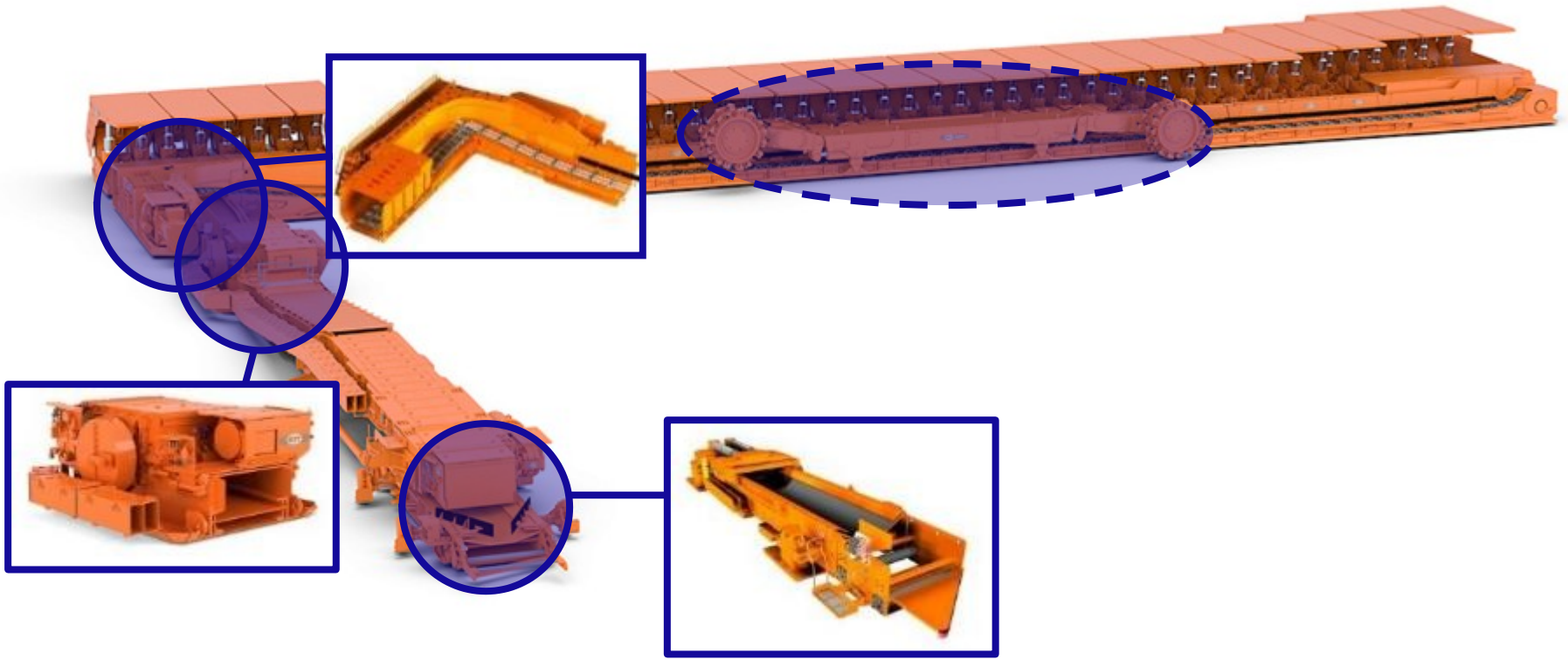
Simulations have added an extra validation tool alongside decades of experience and intuition.







Where do we apply DEM?

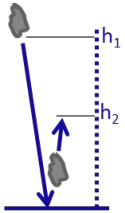


Calibration Testing

Aim:

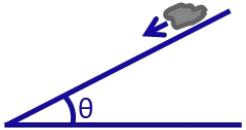
To physically measure the properties of a material by testing, and subsequently replicating those properties through iterative simulations.

Testing:



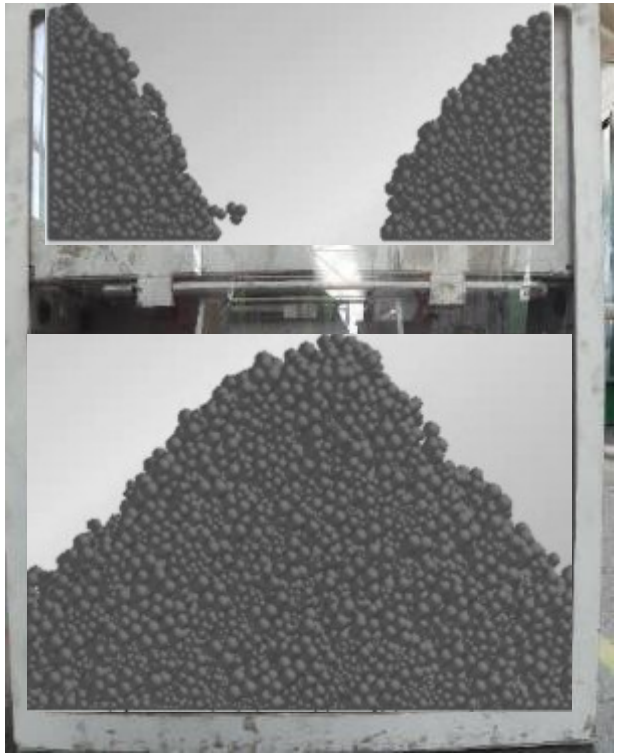
Coefficient of Restitution

Angle of Repose



Coefficient of Static Friction

Particle properties are not necessarily identical to those in reality…



Uses of DEM

DESIGN VALIDATION

PROBLEM SOLVING TOOL

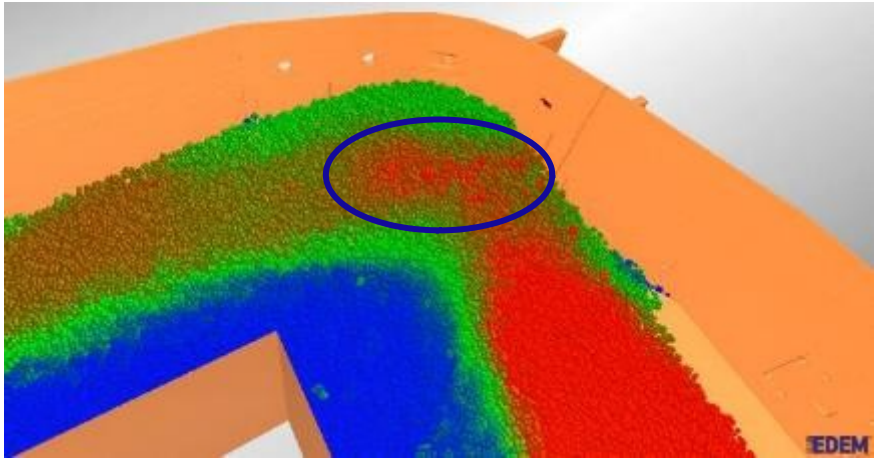
PRODUCT DEVELOPMENT

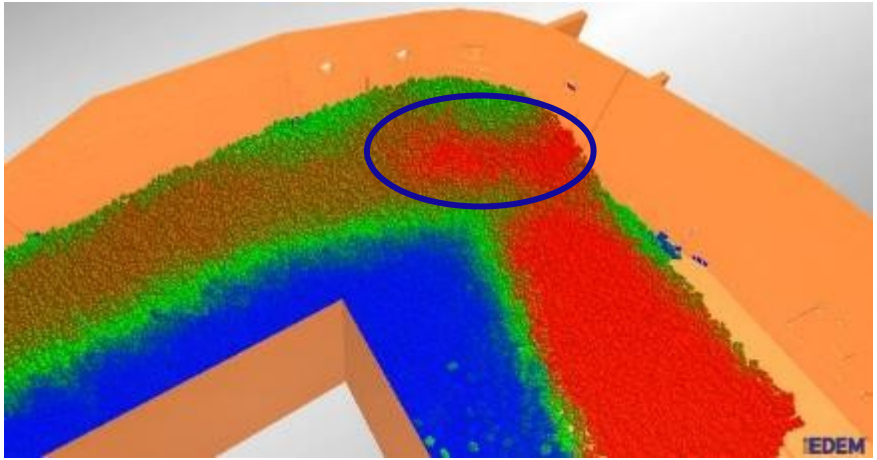
Bulk Flow – Maingate Corner

The transition of material around the Maingate corner is a potential bottleneck in the system. Simulations can test the capacity of the conveyor during regular flow conditions, as well as the effect of design changes on flow and carryback.

Key Design Considerations:

- Veranda
- Flightbar Pitch
- Lumpbreaker



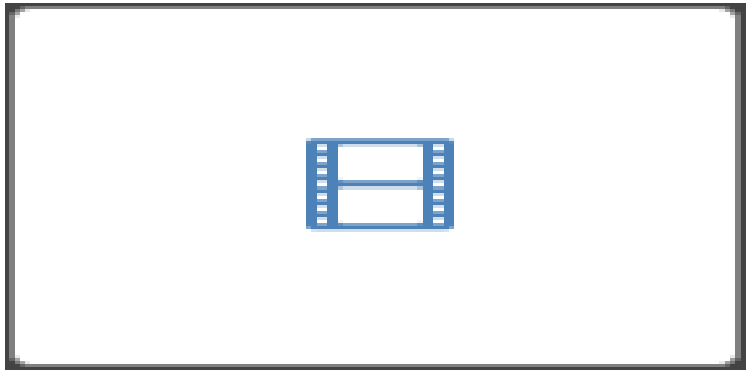


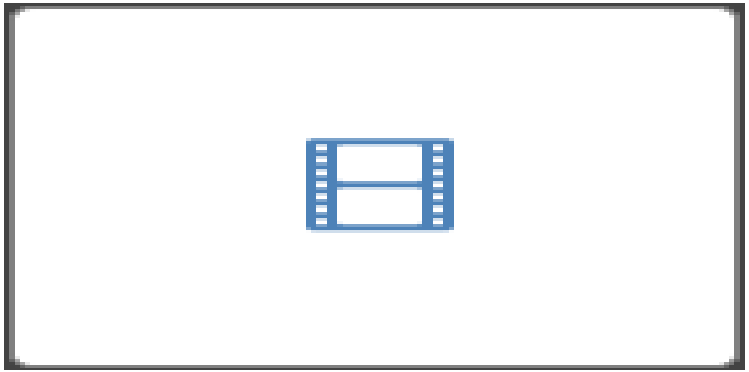
Pepperpot Simulations

Pepperpot Function:

The goal of the pepperpot is to allow material to pass through holes in the deckplate onto the BSL top race to mitigate transfer in the return race back up the face. This has implications for power consumption and wear.

Design solutions included a consideration of the plough design for improved flightbar clean-up and comparative simulations of pepperpot designs.



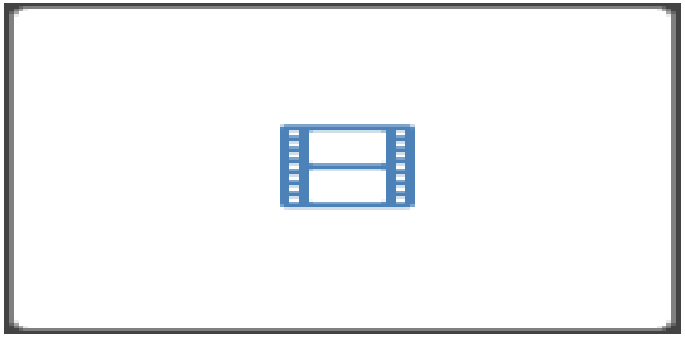


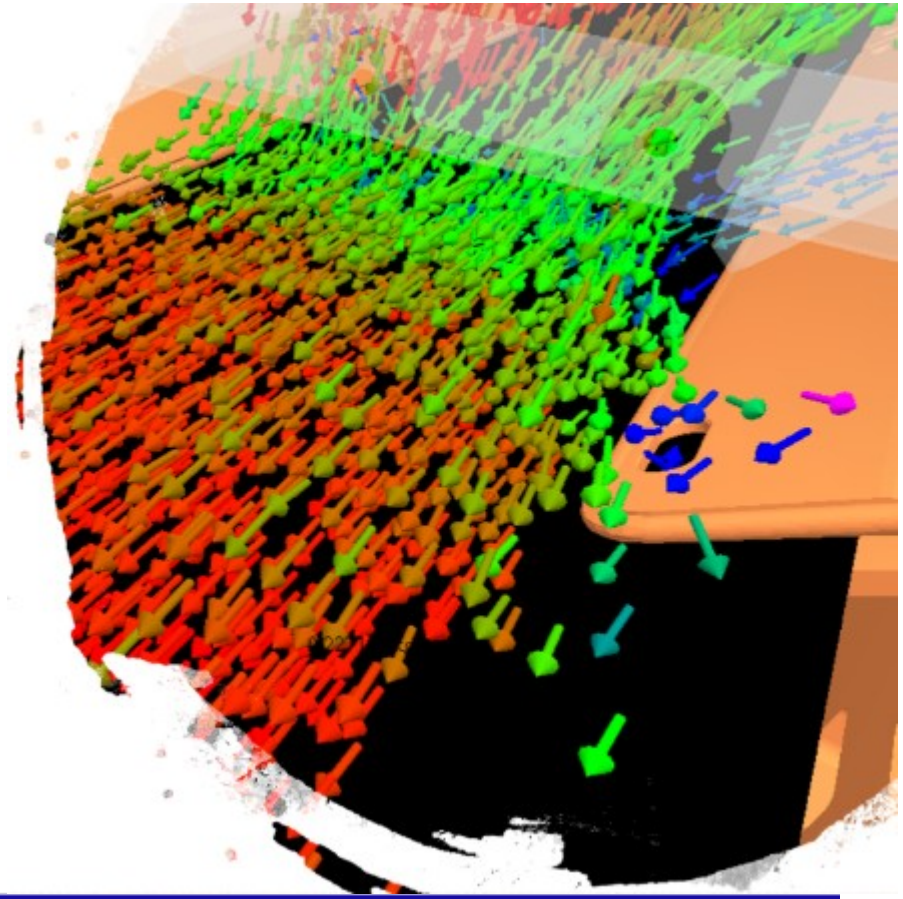
Bulk Flow - BSL Discharge

Simulation Goals:

- To simulate the discharge onto the belt at extreme articulations of the BSL.
- To make subtle changes to reduce the volume of material spilling off the belt.

Changes to the Louvre plate design and configuration significantly reduced material spillage across the articulations simulated.





How Valid is the Data?

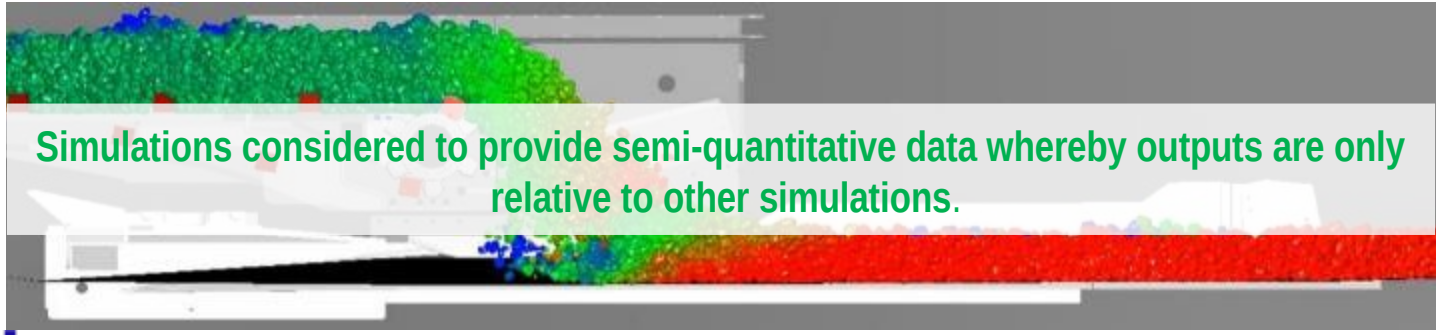
Simulations allow for quantitative analysis of various parameters:

HOWEVER

- Mass of Carryback
- Spillage on BSL discharge to belt conveyor

Several key considerations when considering numerical outputs of the simulations:

- Particle size distribution
- Particle density
- Particle shape
- Fixed geometry dynamics



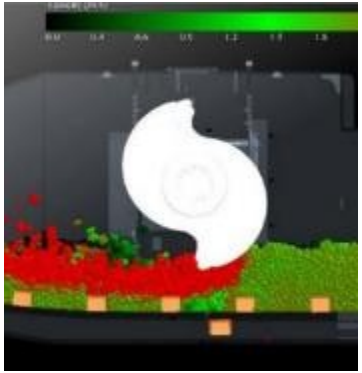
DEM as a New Product Development Tool

Simulations have the ability to produce a significant amount of data in a relatively short period of time.

Minor design changes can be simulated iteratively to find the optimum configuration in certain areas.

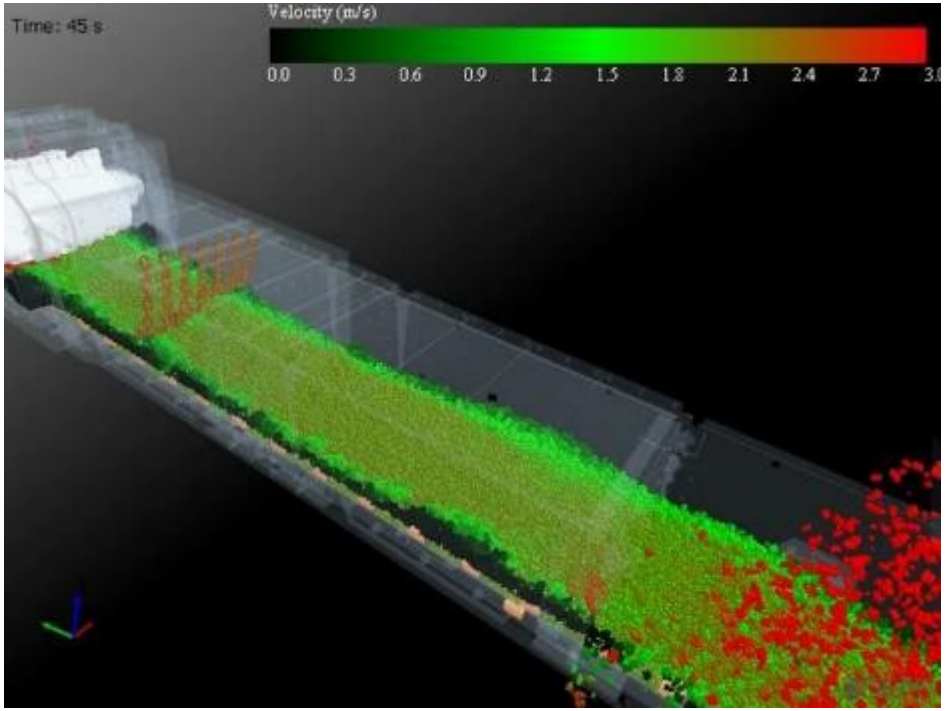
Areas of development:

- Material Calibration
- Simulation of Large Particles
- Inclined Seams
- Proactive Design

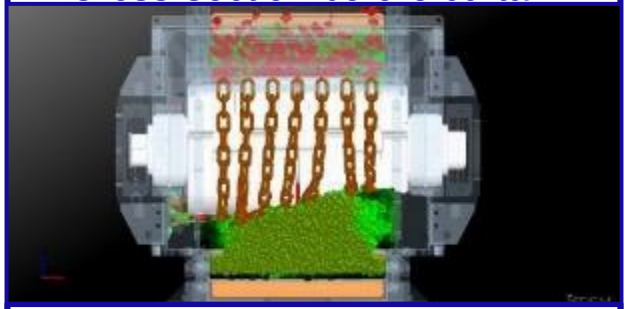



Crusher Simulations

Goal: To explore different crusher rotor configurations and design changes to level out material pile height before entering the crusher envelope.



Cross-section before curtain

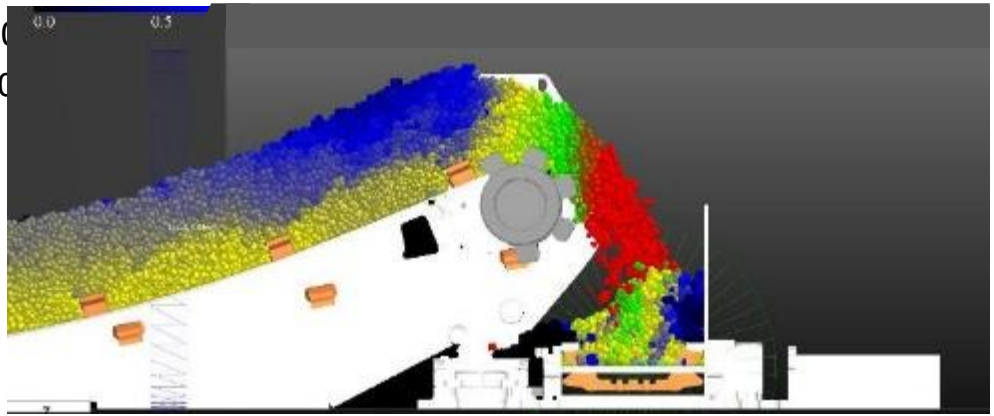


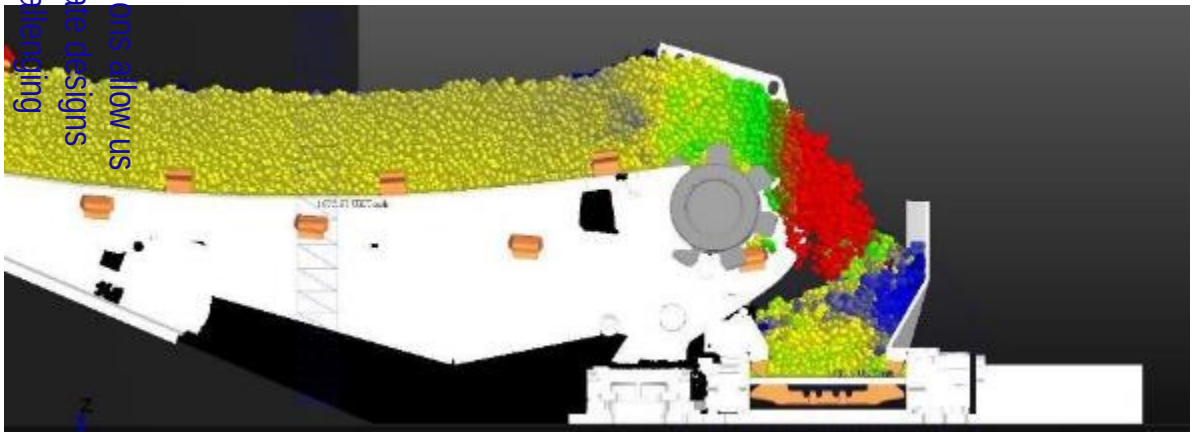
Cross-section after curtain

Inclined Seams

Goal: To simulate operations in steeply inclined and assess the performance of flow-critical sec equipment at different inclinations.

- Simulations allow us to validate designs in challenging operating conditions.
- Able to simulate extremes of underground operations.
- Takes us further down the design process prior to final manufacture and installation.





Future Applications

Simulating Wear

- Simulations have the capability to track particle-geometry contacts. Mapping these can already give indications of wear-zones, but work is needed to quantify this.

Particle Residence Time

- The amount of time a particle stays in the system can be tracked during simulations. This can show the implications of design changes on system efficiency.

Particle Breakage

- Particles in the software can be bonded together with a predetermined bond strength, that when exceeded allows the particle to break into smaller pieces.

Multiple Material Compositions

- Current simulations account for only a single calibrated material on the conveyor representing the bulk flow of the entire mix. Future simulations accounting for a more accurate representation of the material would be able to simulate scenarios in which a different product/dilution mix was present.

Summary

- Discrete Element Method is a particle simulation technique Komatsu applied to AFC design validation, product development and can be used as a problem solving tool.
- Custom, calibrated material is replicated in the software to best simulate a customers conditions.
- Simulations are becoming increasingly reliable, however care needs to be taken in terms of interpreting simulation results.
- Newly applied technology – opportunities lie ahead.

Questions?