



JENIKE[®]
& J O H A N S O N
S C I E N C E E N G I N E E R I N G D E S I G N

Bulk Solids Virtual Simulations vs. Real World Performance

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OUTLINE

- Who is J&J?
- Perfect Production Day versus Average
- Common flow problems and the application of simulation to each problem



WHO IS J&J?

A specialized engineering firm focused on providing clients solutions to material handling applications

- 55+ years experience, all industries
- 13,000+ materials tested, 7,500+ projects
- 650+ accumulated years of solids experience
- Offices in Australia, Brazil, Canada, Chile, Boston, Houston, California



JENIKE & JOHANSON – Our Approach

Scientific approach – based on your materials

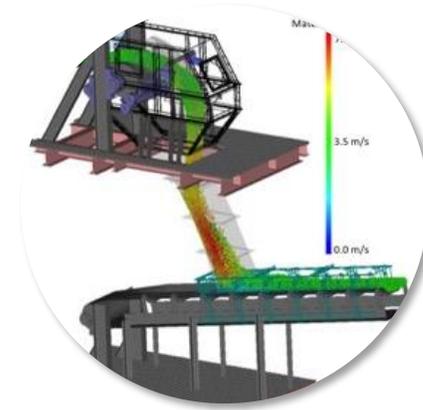
Not a trial and error approach



On-site
Assessments &
Inspections



Testing & Physical
Modeling

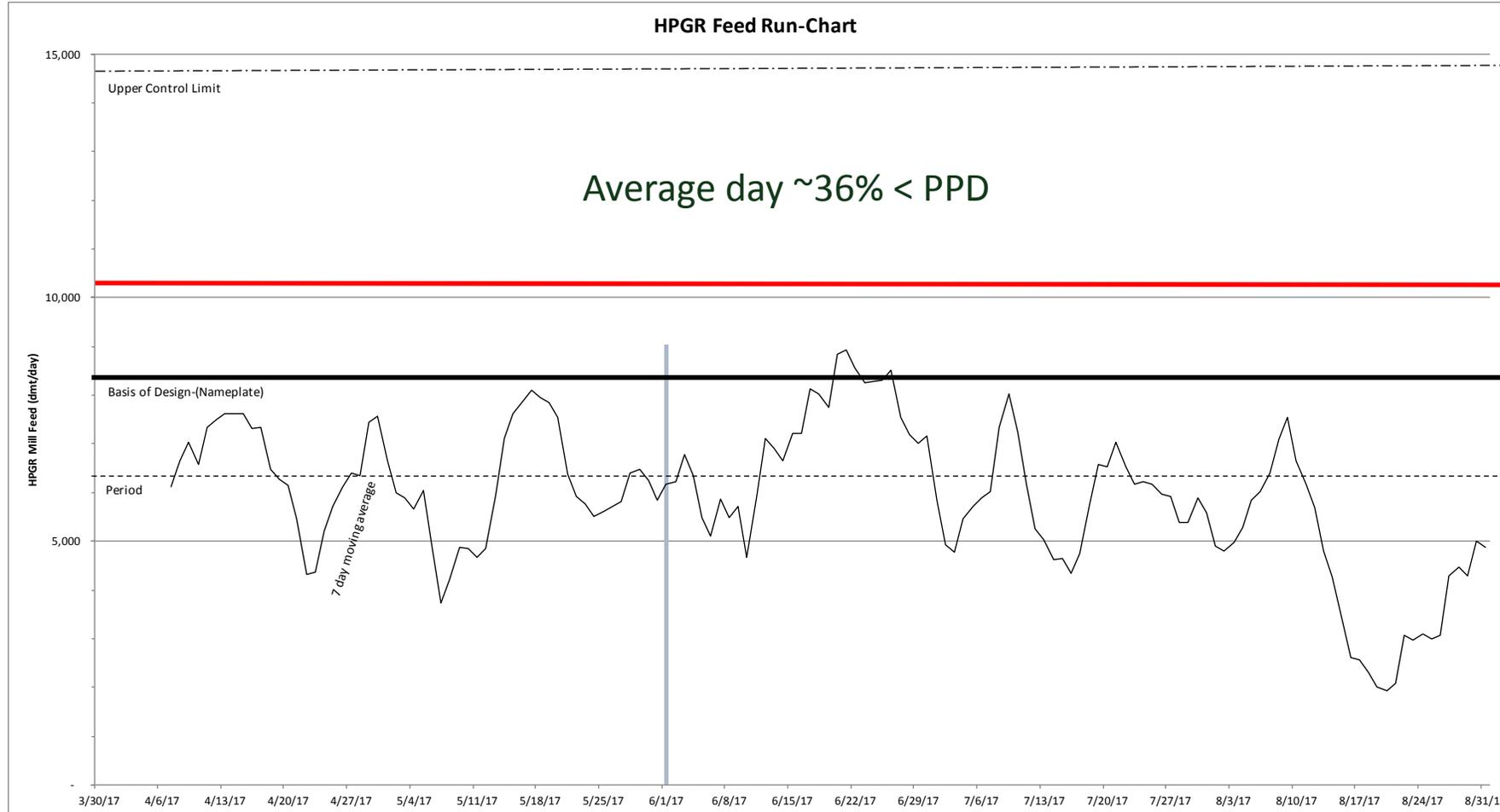


Technology,
Computer
Simulations

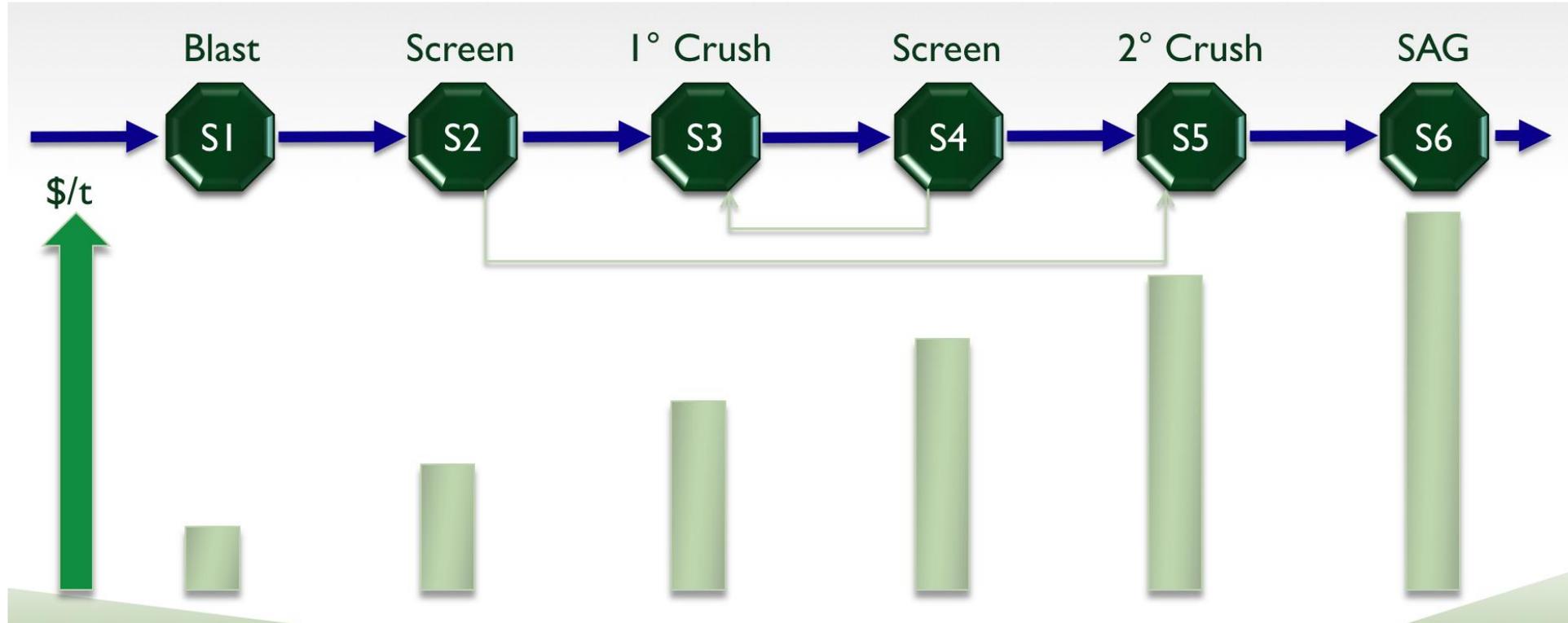


Conceptual Engineering →
Detailed Design

Perfect Production Day (PPD) versus Average



ADDING VALUE



But what if your material doesn't FLOW through the process?

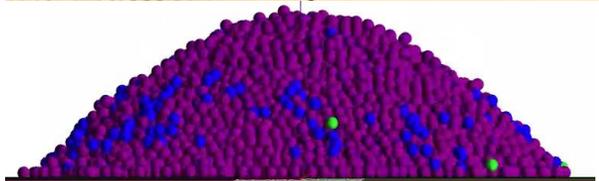


FAMILIAR?

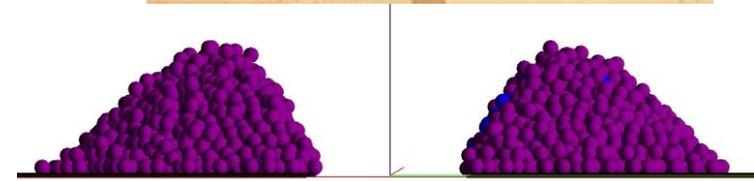
FLOW PROPERTIES TESTS

- Cohesive strength
- Coefficient of sliding friction
- Bulk density
- Particle size
- Particle density
- Chute tests
- Angle of repose
- Drawdown angle
- Wear tests
- Angle of internal friction

Angle of repose



Drawdown angle



WHAT AFFECTS FLOW PROPERTIES?

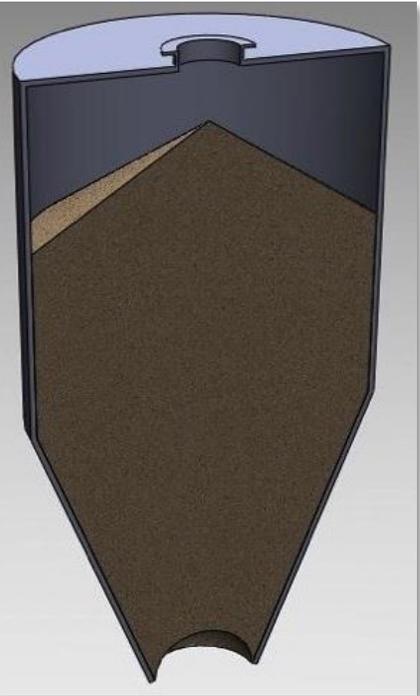
- Particle size and distribution
 - E.g. % of ultrafines <100 μm
- Particle shape
- Aspect ratio
- Moisture
- Time at rest
- Temperature
- Relative humidity
- Chemical composition (e.g. clay content)

**It's critical to match
your process
conditions!**



GRAVITY FLOW SYSTEMS

FLOW PROBLEMS – NO FLOW/ERRATIC FLOW



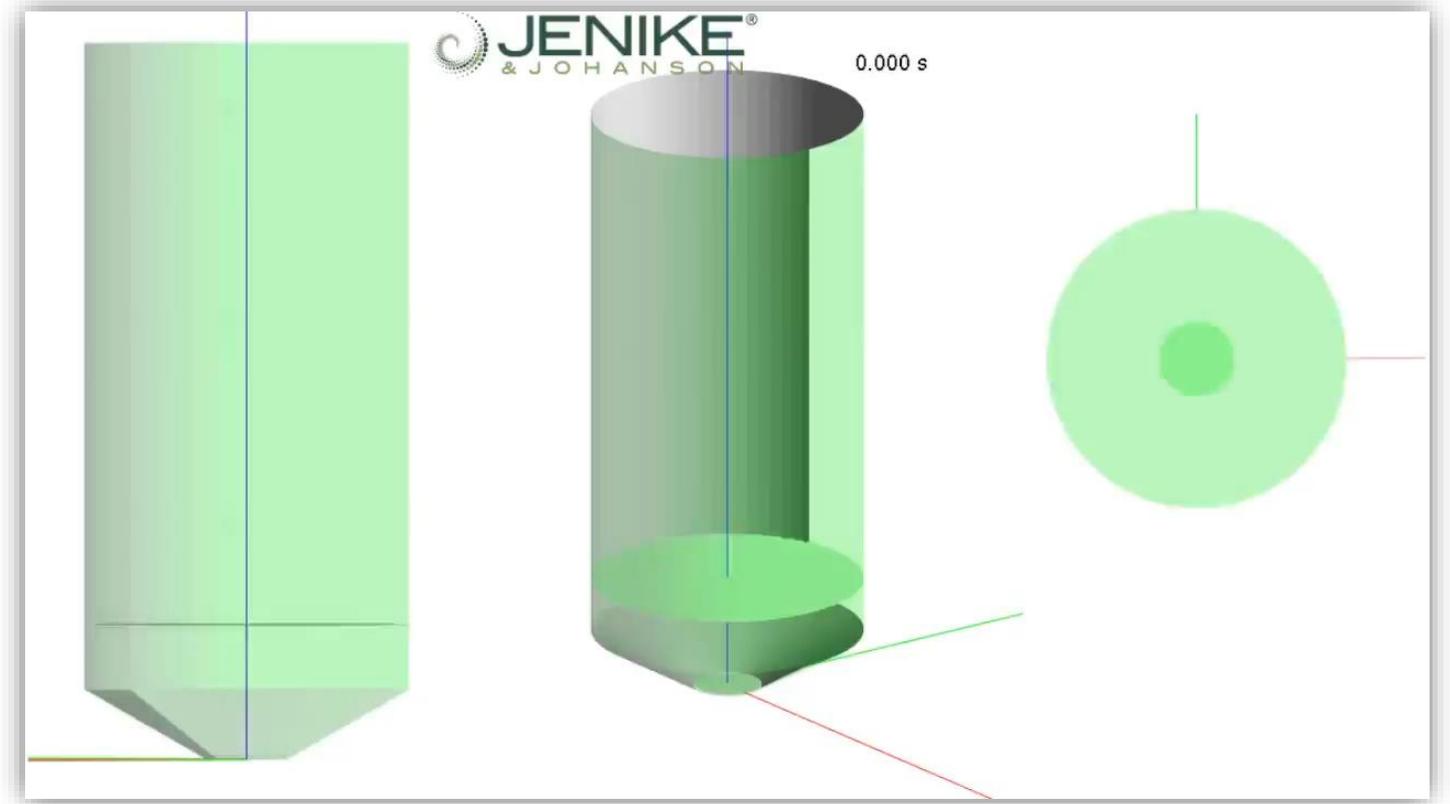
Arching



Ratholing



DEM APPLIED TO BIN DESIGN



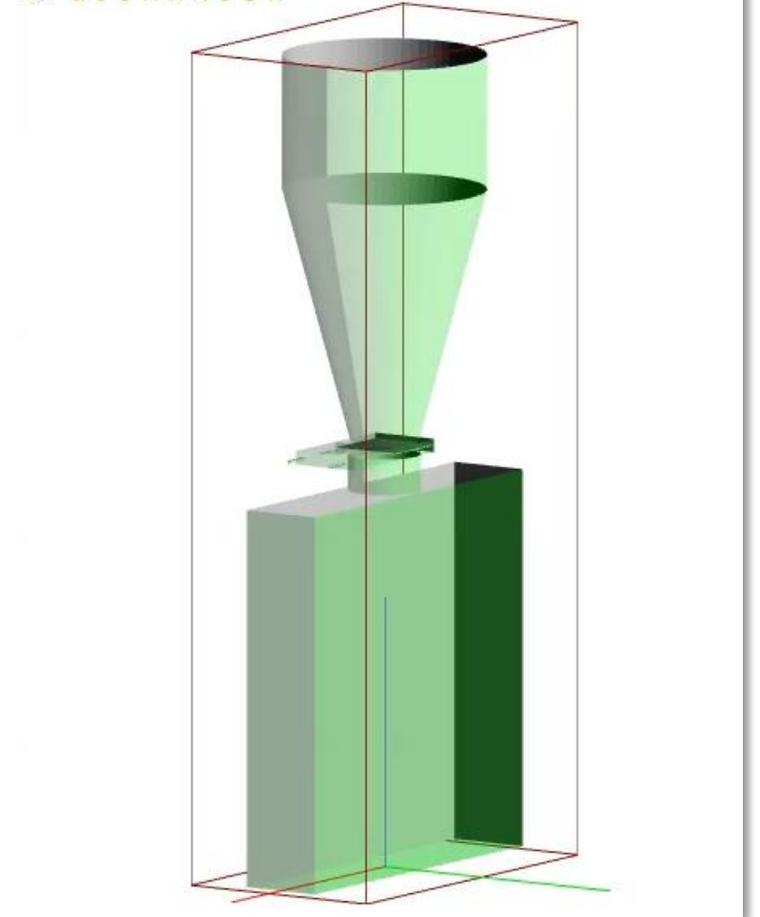
Rathole in a silo using Discrete Element Modeling (DEM)

DEM APPLIED TO SEGREGATION



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STOCKPILES – Common Problem



Stockpile ratholes

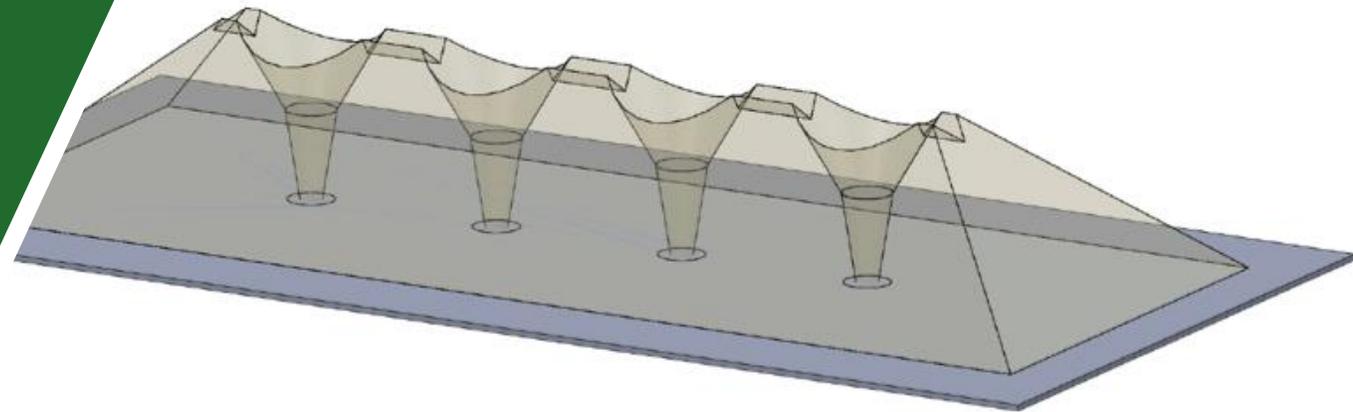


Limited live capacity

3D MODELING OF STOCKPILE RATHOLES

Example – evaluating stockpile capacity

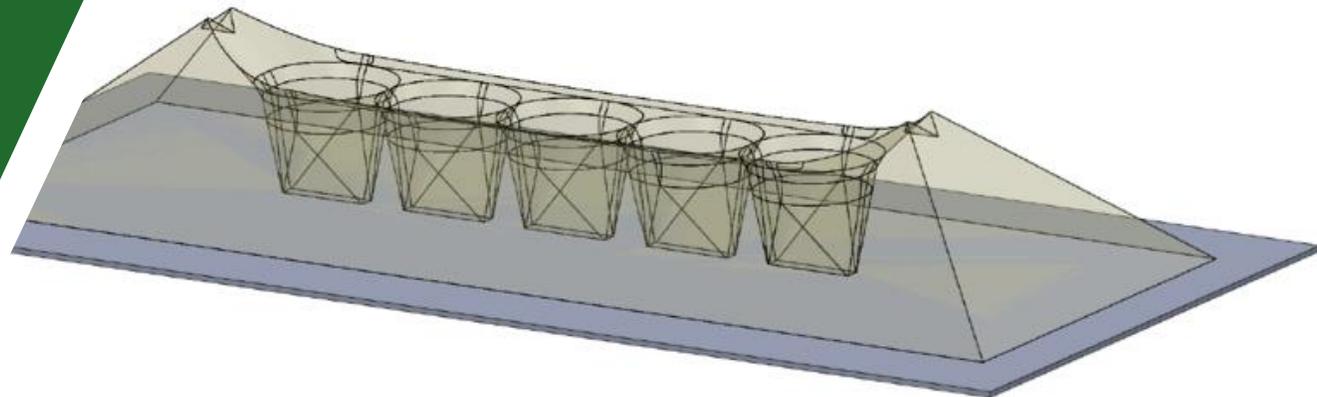
- Based on flow properties and real world performance, 3D models can be built of existing stockpiles.



3D MODELING OF STOCKPILE RATHOLES

Example – evaluating stockpile capacity

- Based on flow properties and real world performance, 3D models can be built of existing stockpiles.
- Then alternative configurations evaluated and live capacity calculated

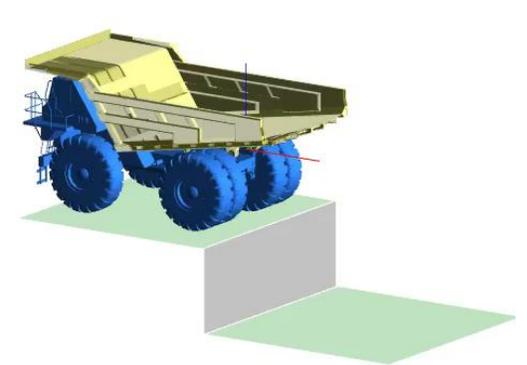
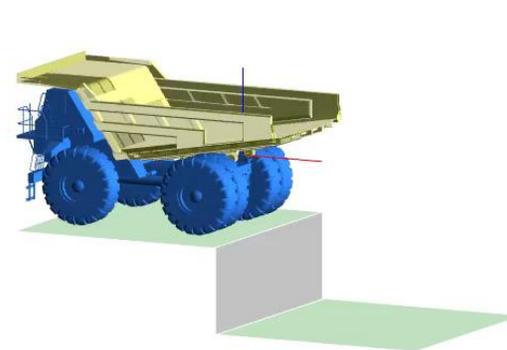
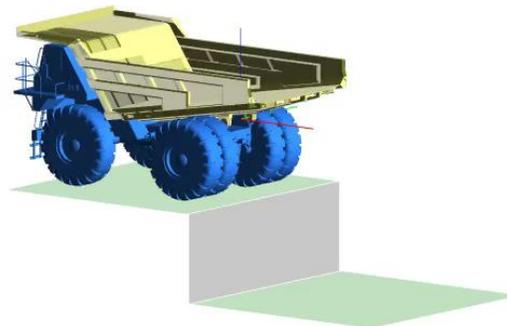
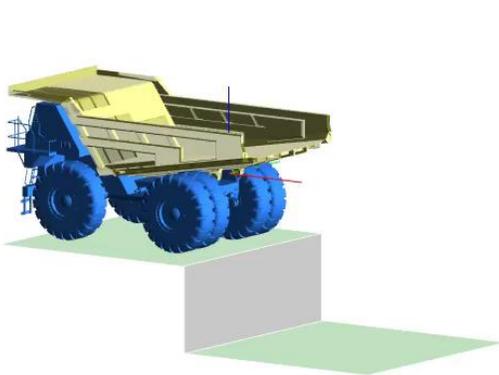


MINE TRUCKS – Common Problem

- Carry-back reduced live capacity (total mine production) of the trucks – wanted to reduce carry-back



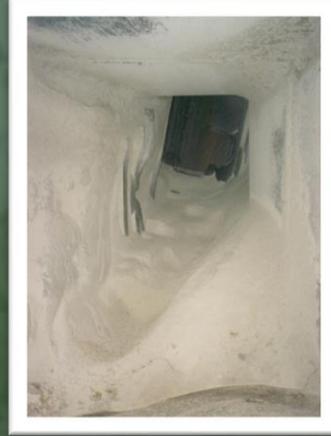
Solving carrying-back issues with mining trucks



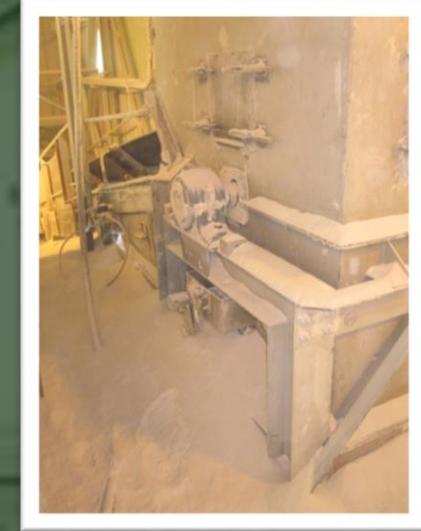
TRANSFER CUTES - Common Problems



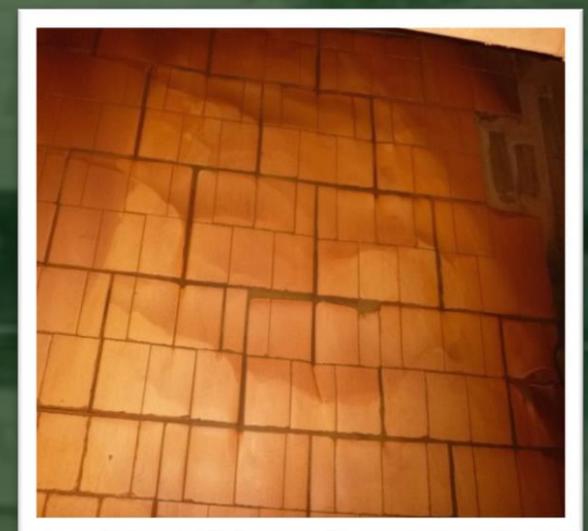
Buildup and Plugging



Spillage



Dust generation

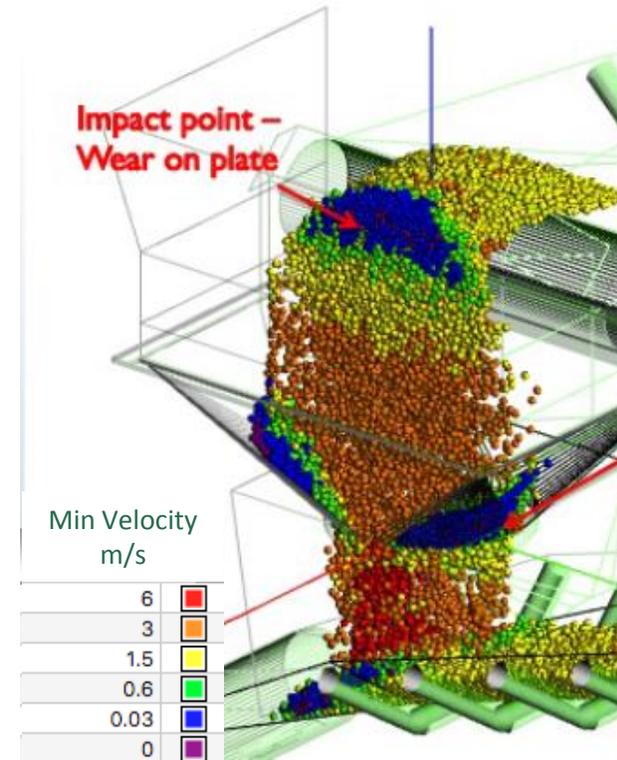


Wear

Discrete Element Method (DEM) Modeling

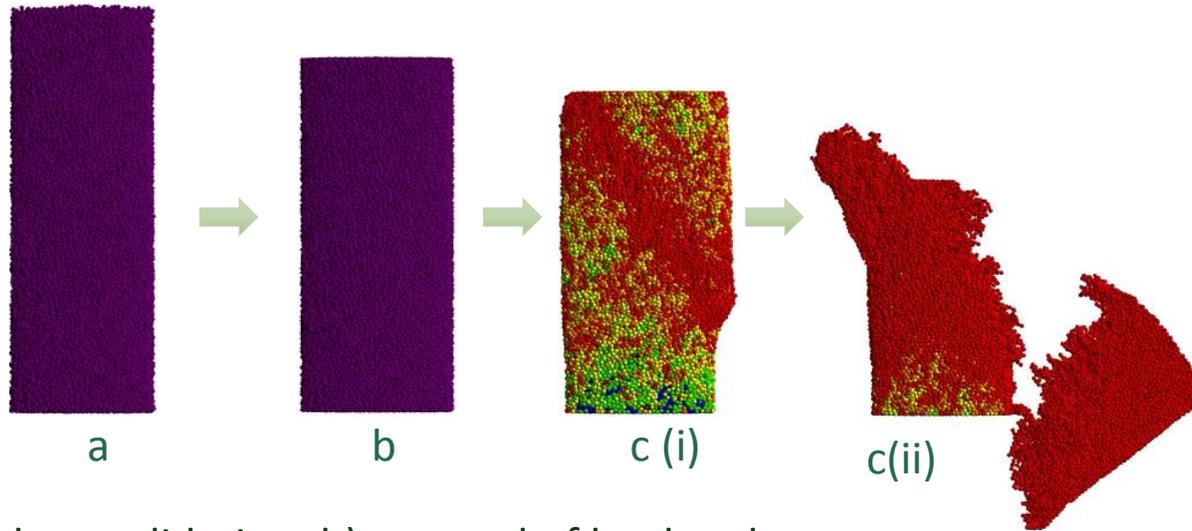
WHY USE IT?

- Typically lower cost in the virtual world
- Some quantities are difficult to measure in a physical experiment
 - Forces on boundaries
- What-if scenarios are easily done on the computer
 - Changes to material properties, retrofits etc..



Barge hold conveyor head chute

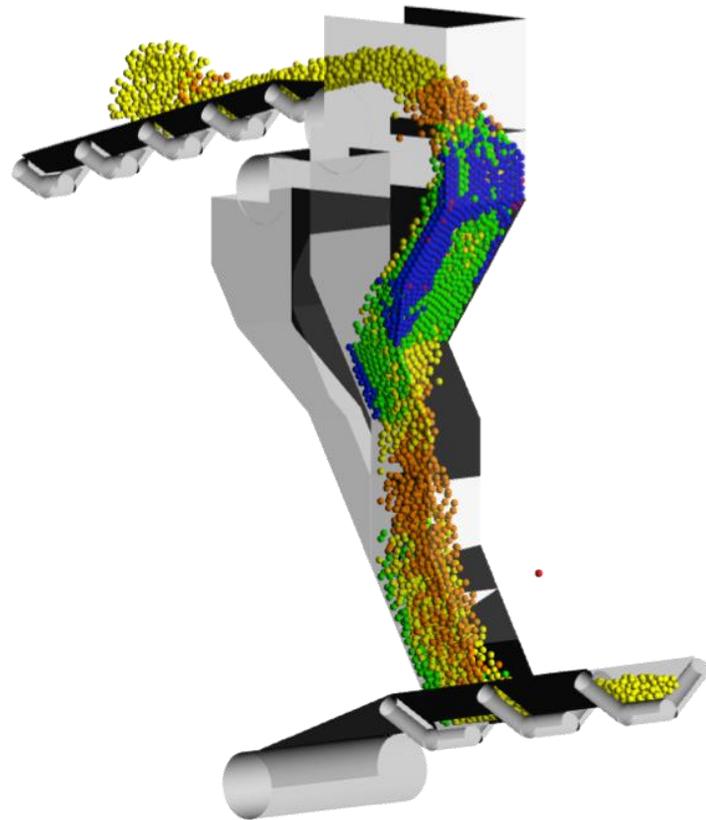
CONTACT MODEL CALIBRATION



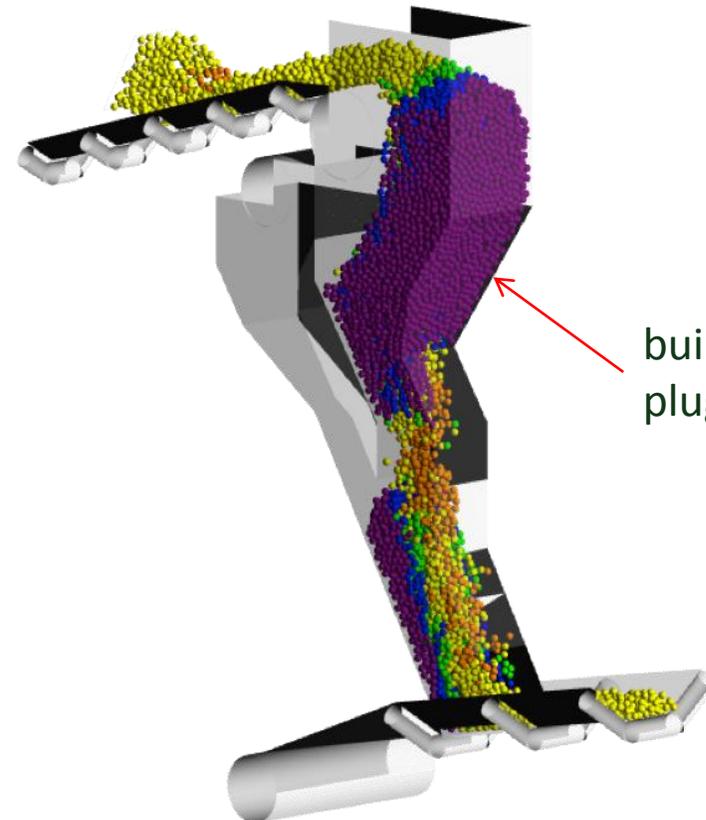
a) Confined consolidation; b) removal of load and confinement; c) unconfined shearing

- ▶ Contact model must allow for realistic representation of failure mode; particularly for cohesive materials
- ▶ Without an accurate contact model, DEM becomes a “pretty picture generator”

CONTACT MODEL SELECTION – CRITICAL

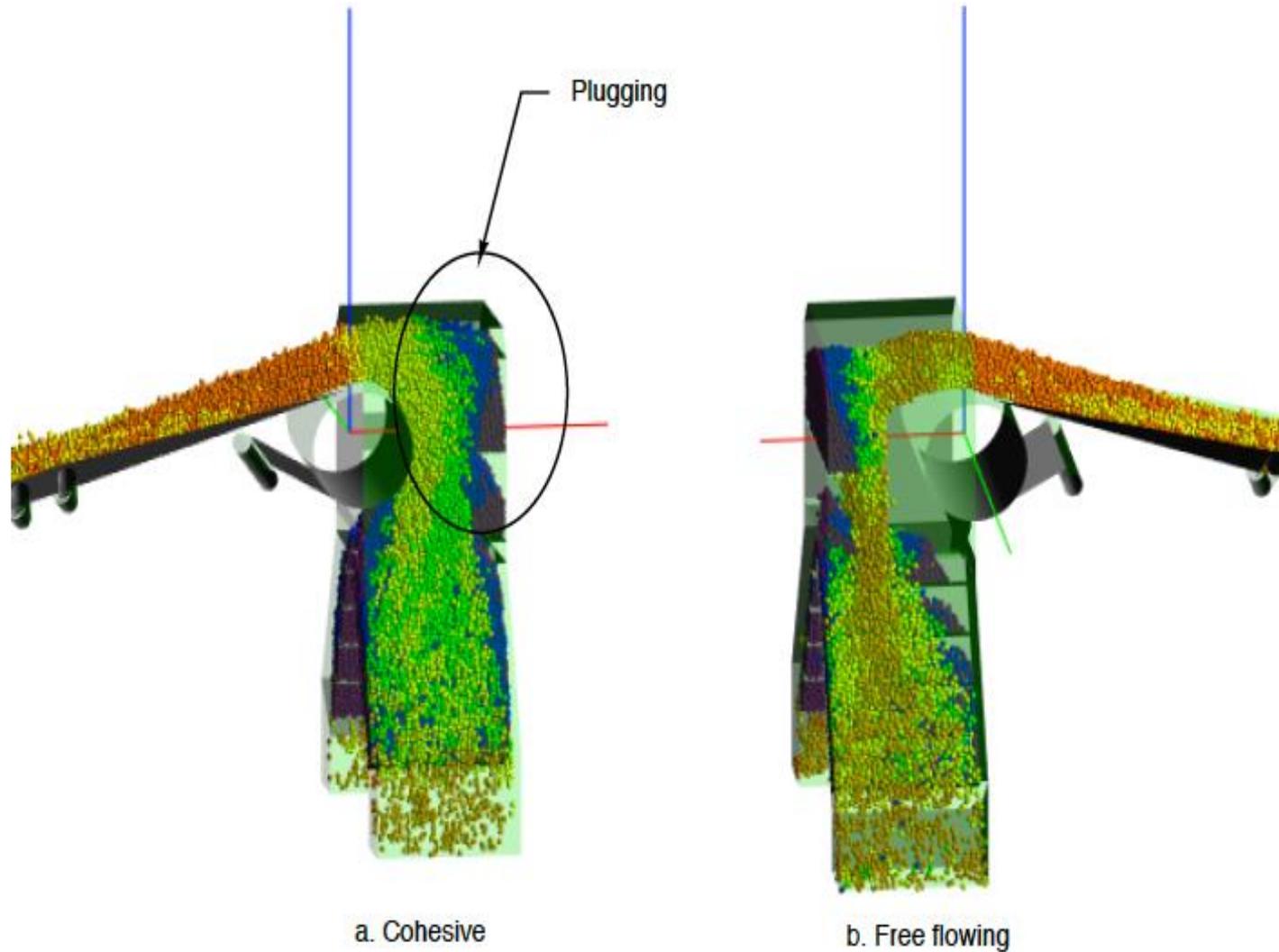


Contact model without cohesion
(not calibrated)



Contact model with cohesion
(calibrated)

Be aware of your material and contact model – details matter!

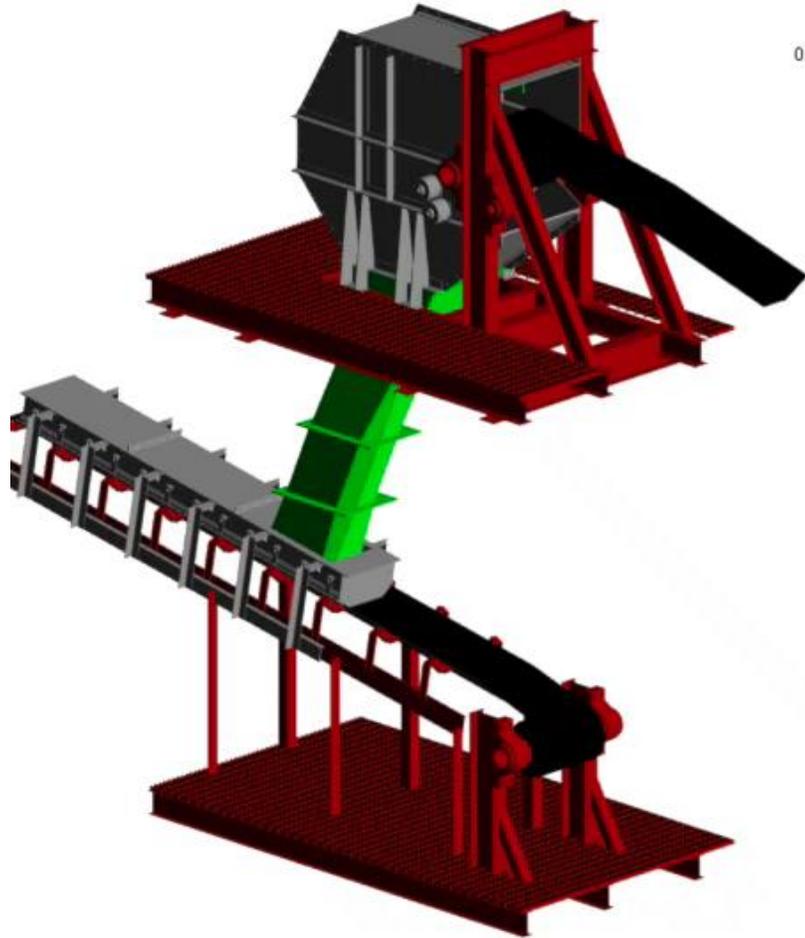


CONTACT MODEL SELECTION – CRITICAL

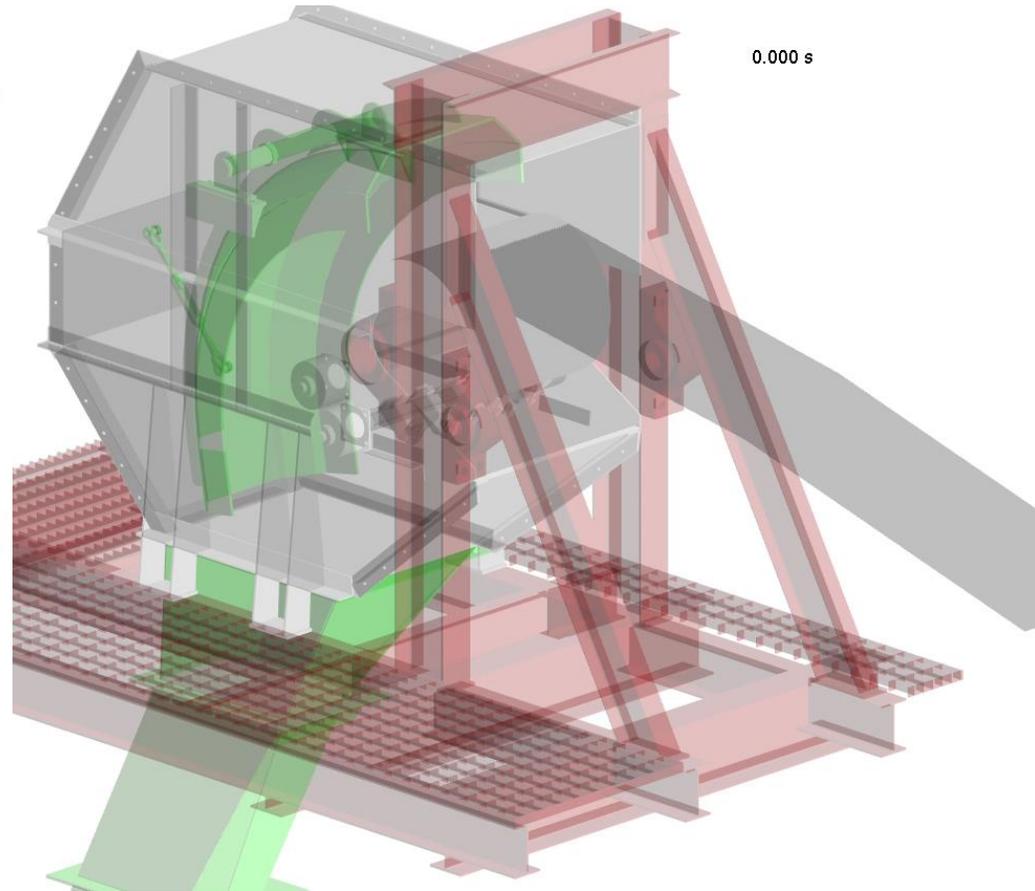
Caution with changing materials

- Example: Using magnetite in hematite handling systems with rock boxes
- Cycle times of fine, sticky material versus lump ore needs to be evaluated

DEM APPLIED TO CHUTE DESIGN



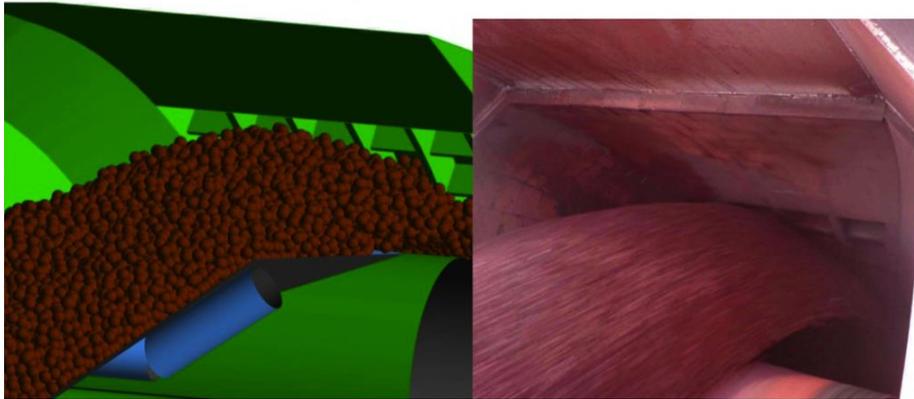
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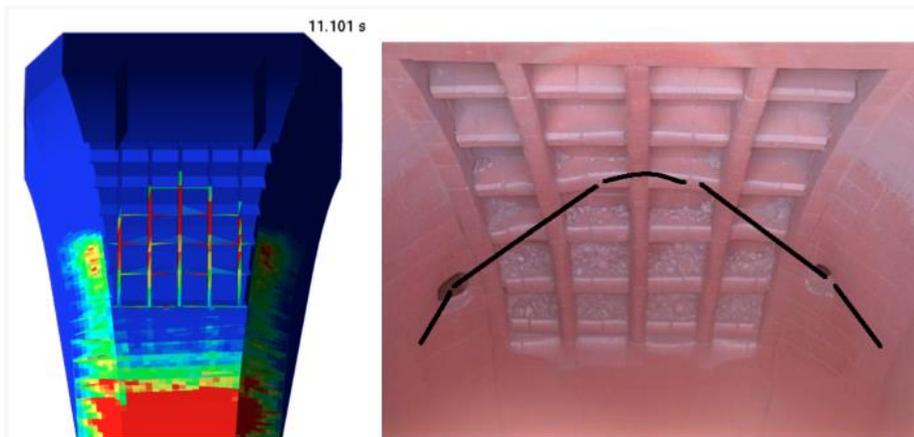
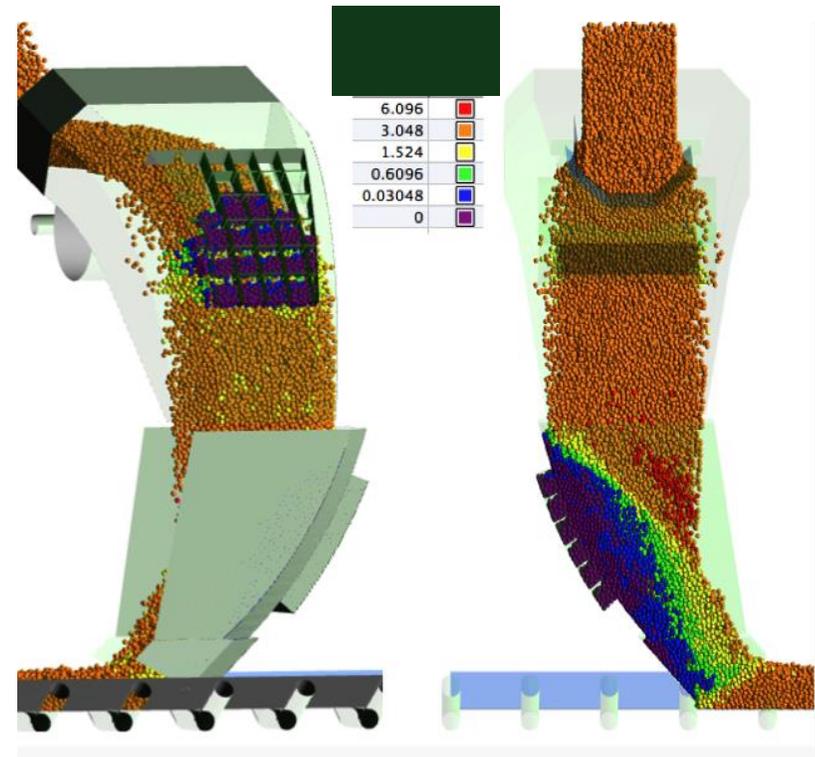
DEM ANALYSIS OF IRON ORE CHUTE

Iron ore handling: *controlled* stream transfer with hood



Jenike & Johanson *calibrated* DEM model

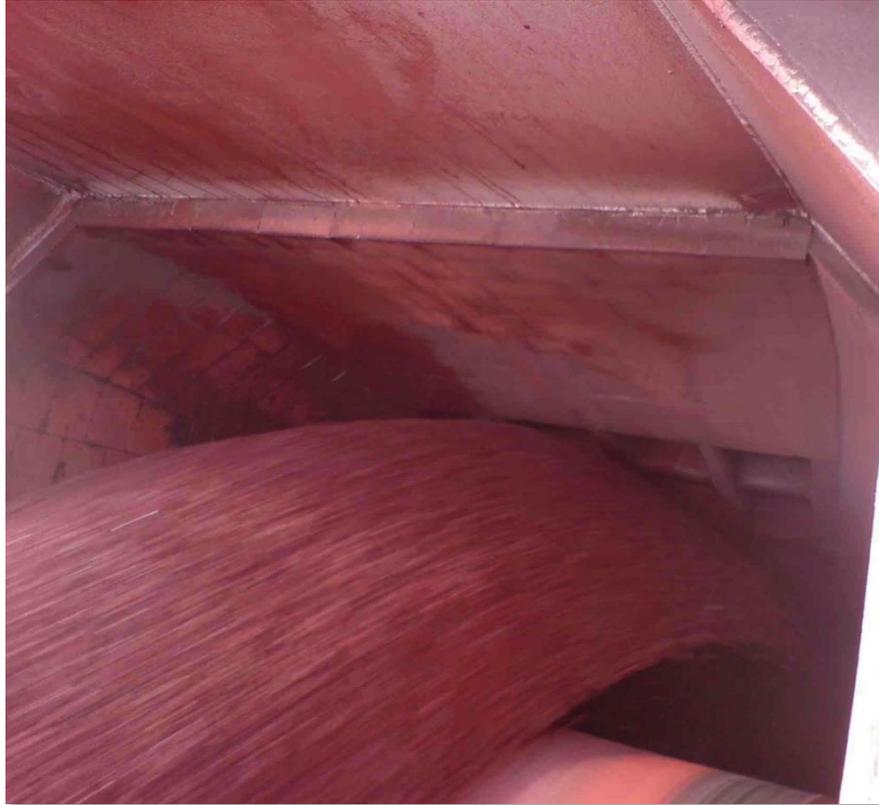
As-built chute operating at design capacity



DEM analysis of wear

Actual ceramic lined chute

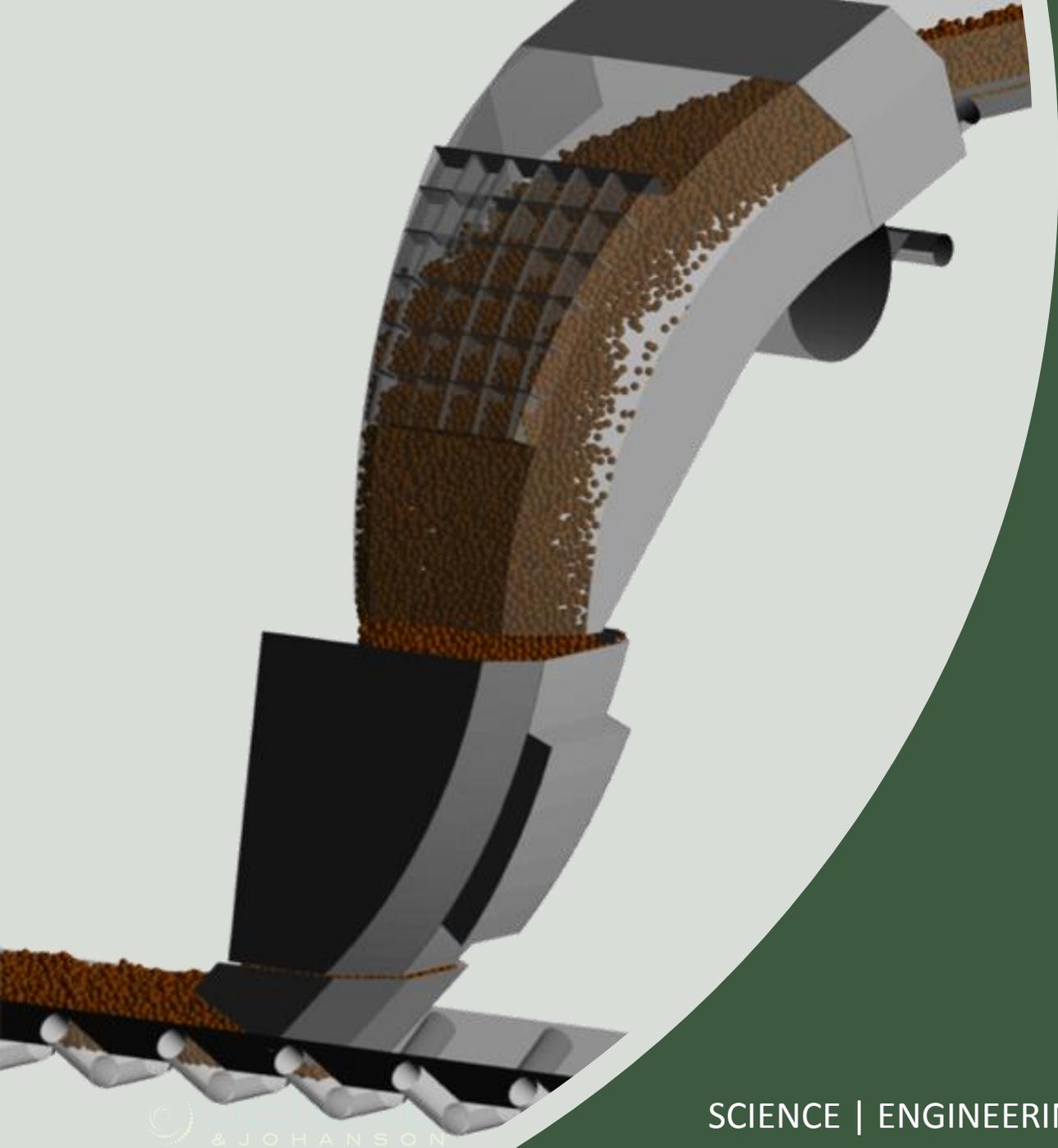
HOOD AND SPOON DESIGN



Proper stream capture
with hood

Proper belt loading
with spoon





CONCLUSION

Material testing and DEM are good predictive tools to analyze the feasibility of a usage change.



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SCIENCE ENGINEERING DESIGN

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