Evaluating Transfer Chutes with Increased Throughput or Different Material

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OUTLINE

- Who is J&J?
- Review common transfer chute designs
- Discuss typical transfer chute problems
- Evaluate increasing throughput with existing infrastructure
  - What about different material handled through an existing system?

WE ARE

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

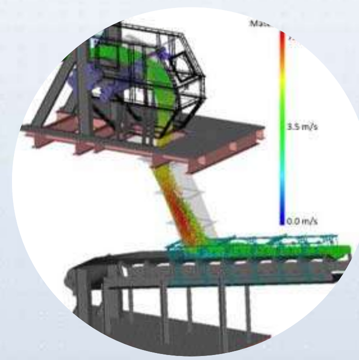
PROJECT APPROACH

Scientific – based on your materials

Not a trial-and-error approach!

On-site Inspections

Testing



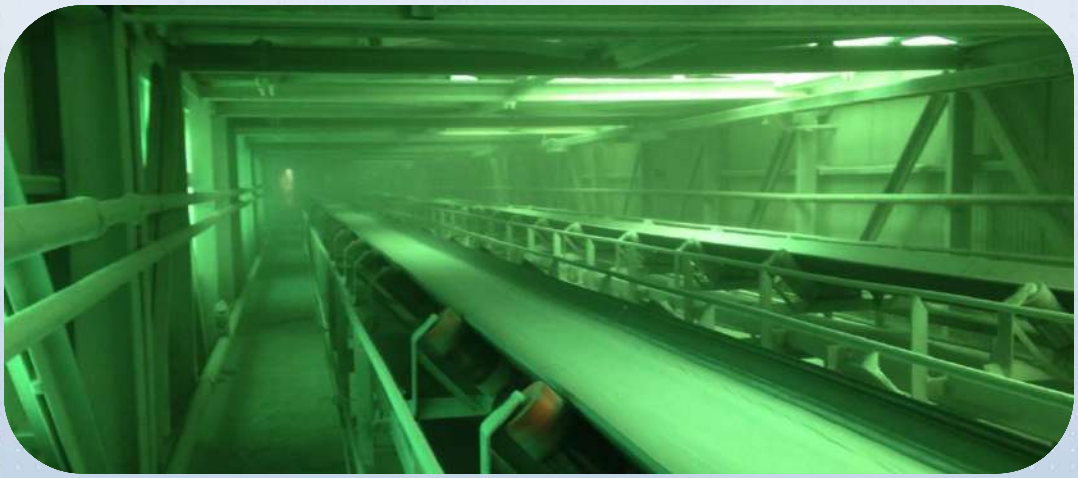
Technology

Engineering

COMMON CHUTE FLOW PROBLEMS

Buildup and Plugging

Spillage



Dust generation

Wear

VARIOUS CHUTE DESIGNS

For free-flowing rocky material:

- Rock box
- Micro-ledges

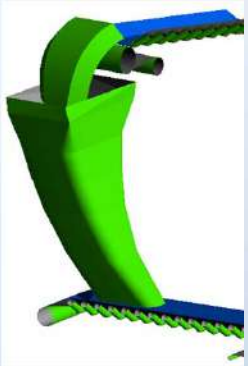
Minimize wear.

For fine, sticky material:

- Hood and spoon
- No ledges

Prevent plugging and minimize buildup.

US Patent 4,646,910



What if the material is rocky <u>and</u> fine and sticky?

- Prevent plugging and minimize wear

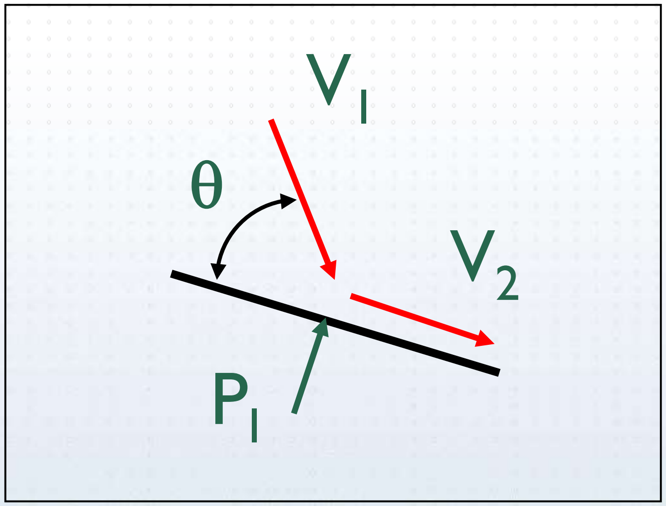
TRANSFER CHUTE DESIGN

- Prevent plugging
- Sufficient cross sectional area
- Control the stream
- Minimize wear
- Minimize dust generation
- Minimize particle attrition

TRANSFER CHUTES: PREVENT PLUGGING

Mitigate stalling:

$$\frac{V_2}{V_1} = \cos\theta - \sin\theta \tan\phi'$$



Function of impact pressure:

$$P_1 = \frac{\gamma V_1^2 \sin^2\theta}{g}$$

V_2 = Velocity along chute after impact
V_1 = Impact velocity
θ = Impact angle
ϕ' = Wall friction angle
P_1 = Impact pressure
γ = Bulk density

Impact angle ***and*** *sliding friction is critical in chute design:*

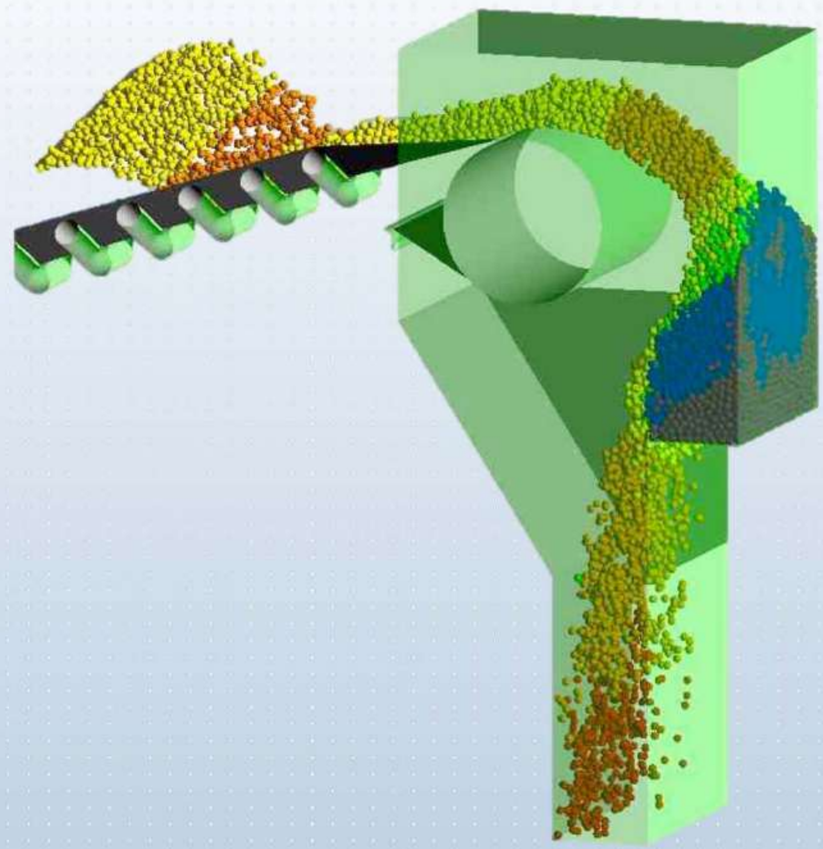
If $\theta + \varphi' = 90°$, no resultant velocity

QUESTIONS ASKED TO MAXIMIZE USAGE OF EXISTING PORT INFRASTRUCTURE

- Can we increase the throughput of the <u>same material</u> through the existing design? Consider:
  - Belt sizing and speed
  - Loads on the belt
  - Support structure
  - Material flow through the chutes
- Can we put a <u>different material</u> through the existing transfer chutes?
  - Example: handling magnetite concentrate in iron ore transfer chutes
- What are the implications?
  - Will material flow through the chutes?

CASE STUDY

- Iron ore export terminal in South Africa
  - Belt width: 1650 mm wide
  - Belt speed: 5.5 m/s
  - Flow rate: 10,000 tph
  - Right angle transfer chute
- Rock box used to minimize wear
- Client needed to increase throughput.



PROGRESSION OF PROBLEMS

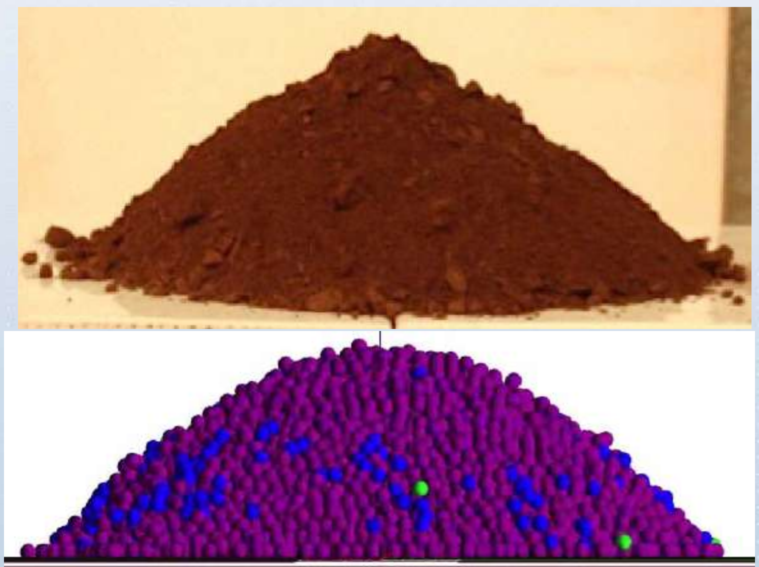
Increase in fines, mc, & flow rate → Buildup in the chute (eventual plugging) → Changed the flow path through the chute → Changed the way material exited the chute → Spillage, dusting, & premature belt wear

Iron Ore

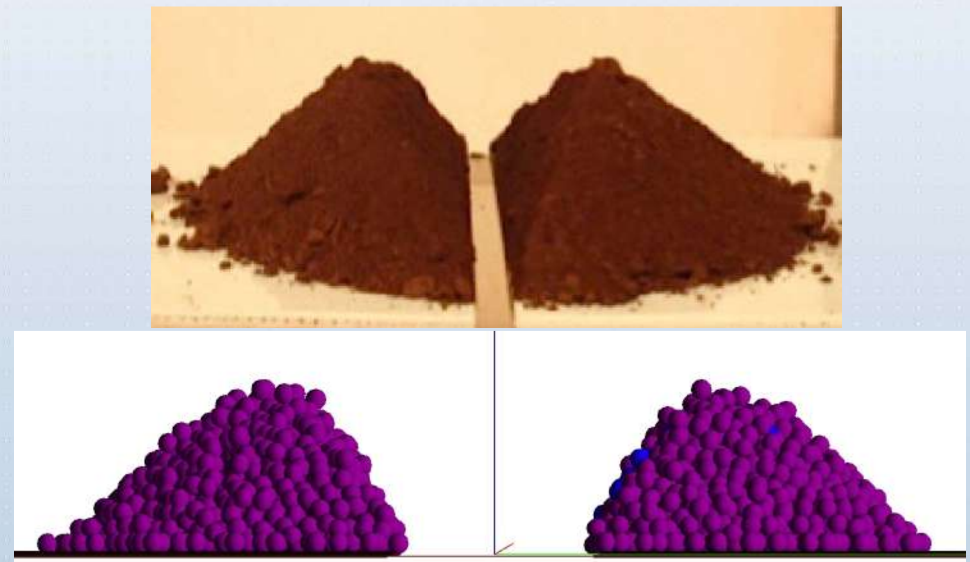
TO ANALYZE AND DESIGN CHUTES

Flow properties tests needed:

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



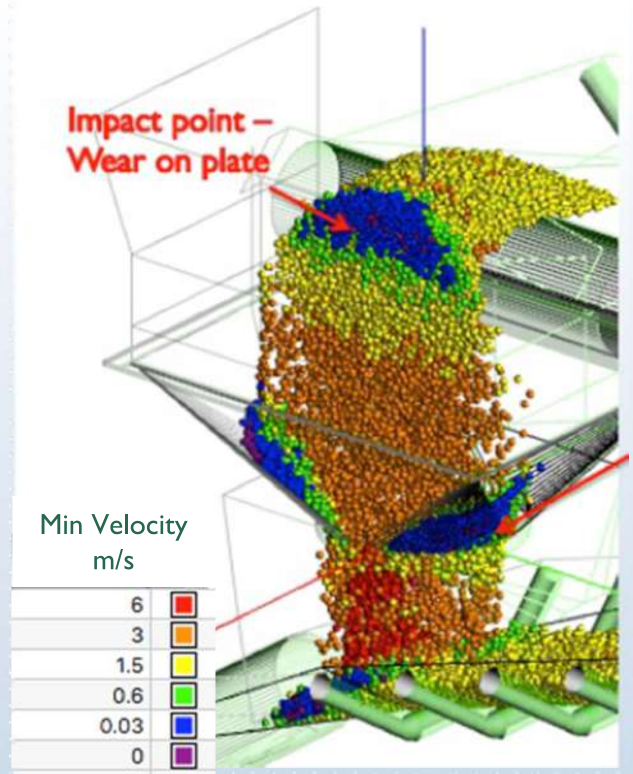
Angle of repose



Drawdown angle

Discrete Element Modeling (DEM) WHY USE IT?

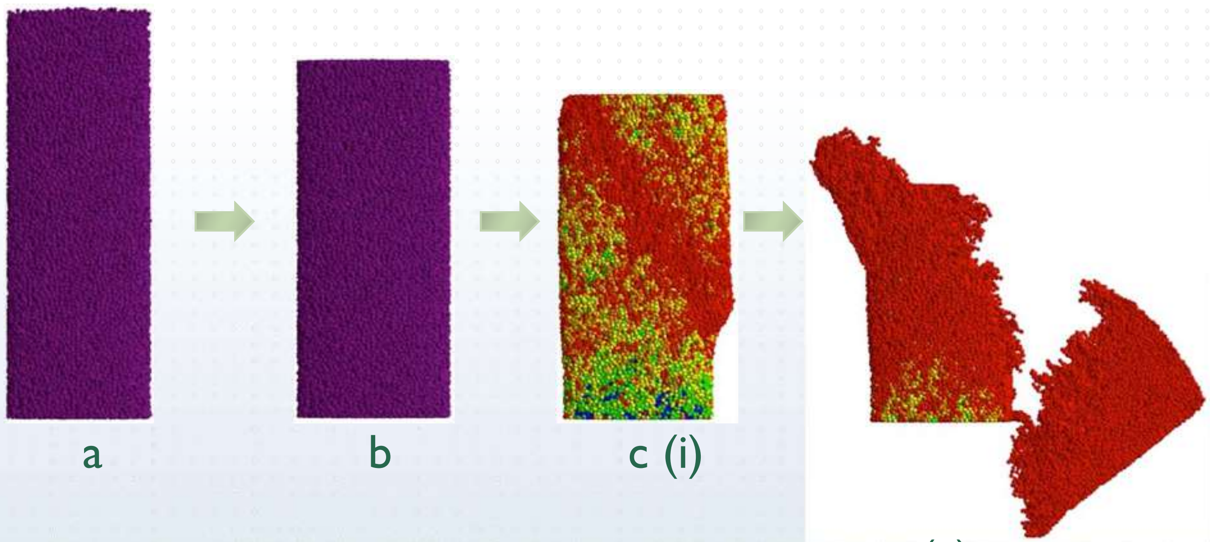
- Typically lower cost in the virtual world
- Some quantities are difficult to measure in a physical experiment
  - Forces on boundaries
- What-if scenarios are easily done on the computer
  - Changes to material properties, retrofits etc..



Barge hold conveyor head chute

CONTACT MODEL CALIBRATION

0.000 s

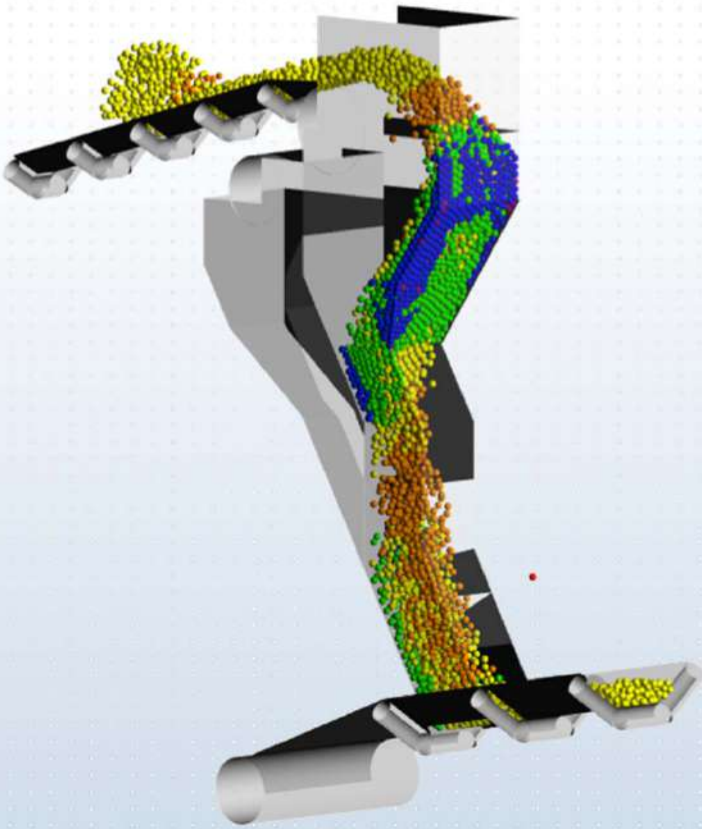


c(ii)

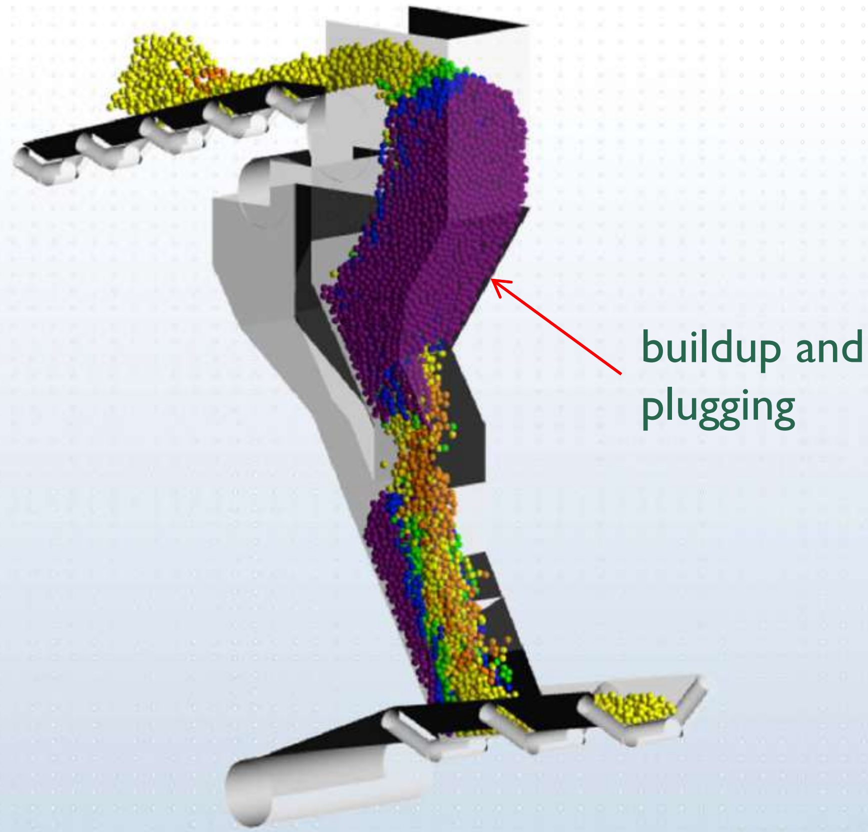
a) Confined consolidation; b) removal of load and confinement; c) unconfined shearing

- 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



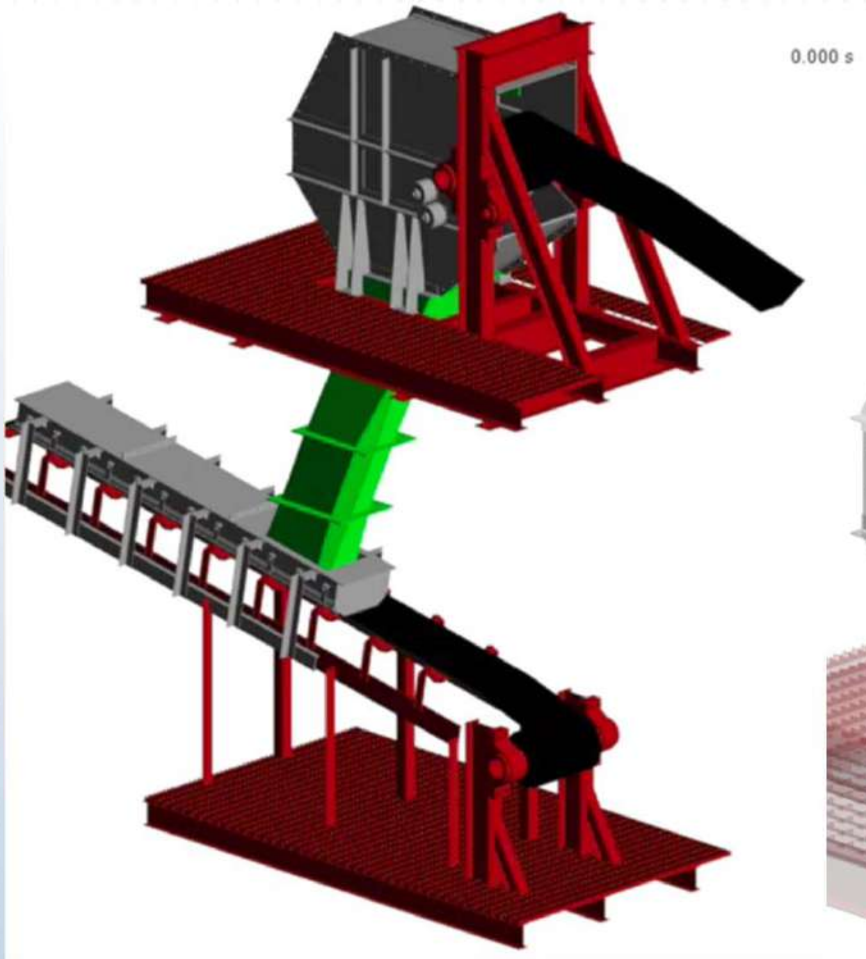
Contact model without cohesion
(not calibrated)

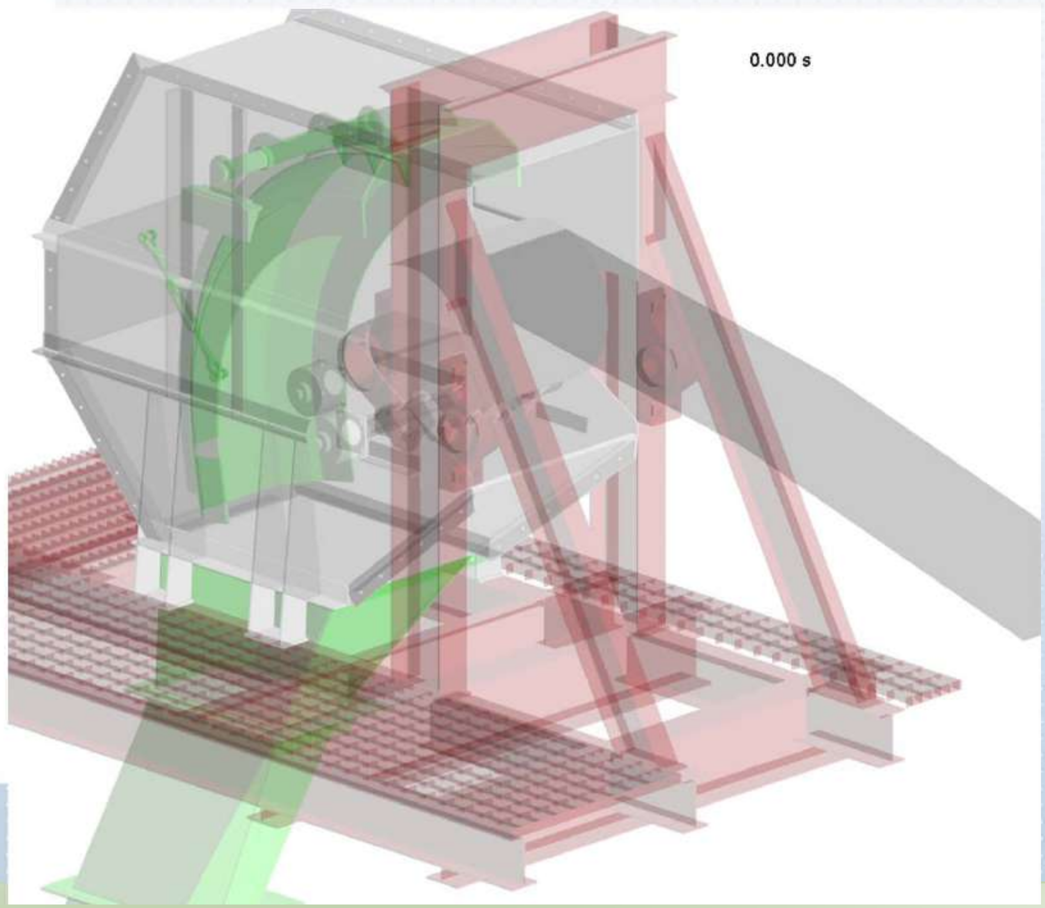


Contact model with cohesion
(calibrated)

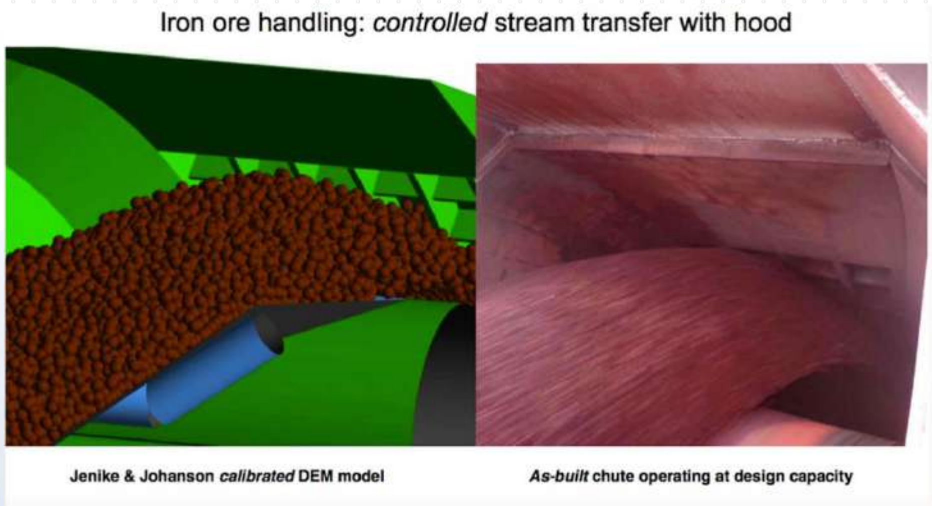
Be aware of your material, contact model.
Implementation details matter!

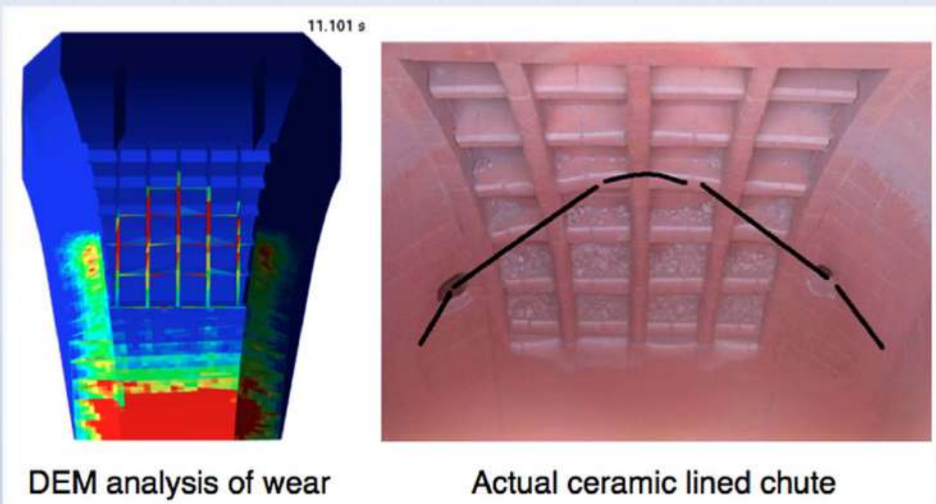
DEM APPLIED TO CHUTE DESIGN

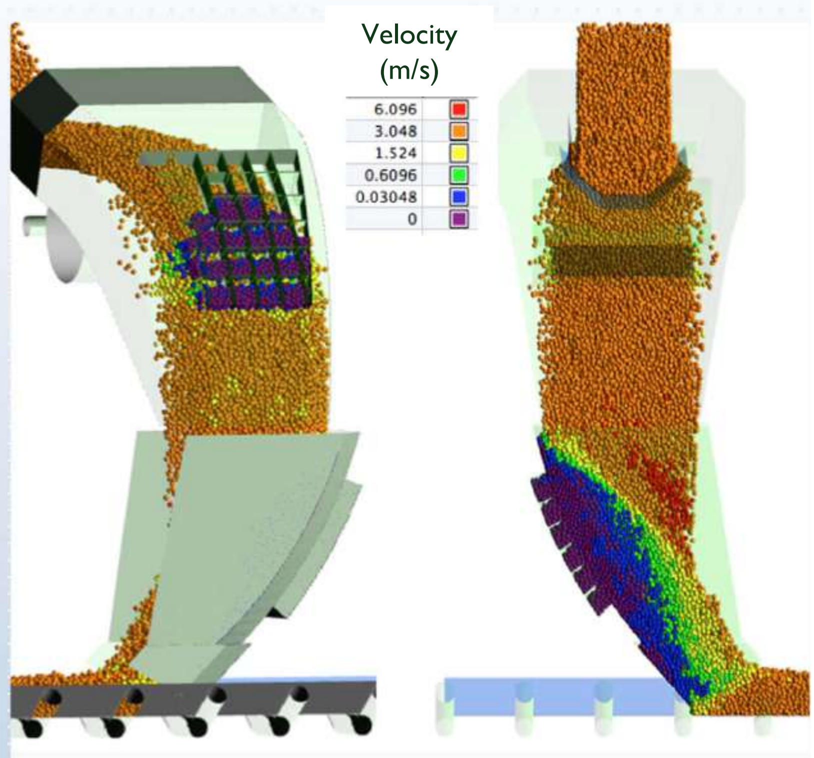




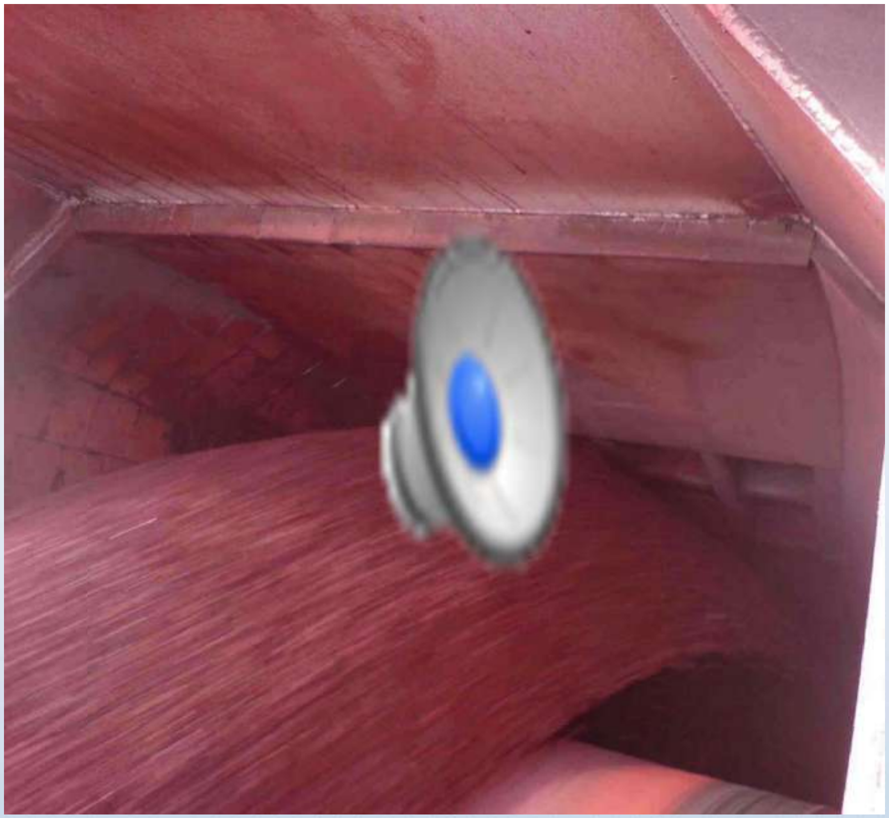
DEM ANALYSIS OF IRON ORE CHUTE







HOOD AND SPOON DESIGN



Proper stream capture with hood

Proper belt loading with spoon

HOOD AND SPOON DESIGN

Other benefits:

- Minimal downtown – chute went 2.5 years before changing out the head chute, still not much wear in the spoon.
- Eliminated belt tracking problems
- No spillage
- Reduced dusting significantly
- Obtained desired throughput

OTHER ISSUES FROM INCREASED FLOWRATE

- Example: Material flies over the head chute

Head chute height was set based on cross sectional area of material on belt and material trajectory.

→

Belt speed and cross-sectional area of material on the belt increased to increase throughput.

→

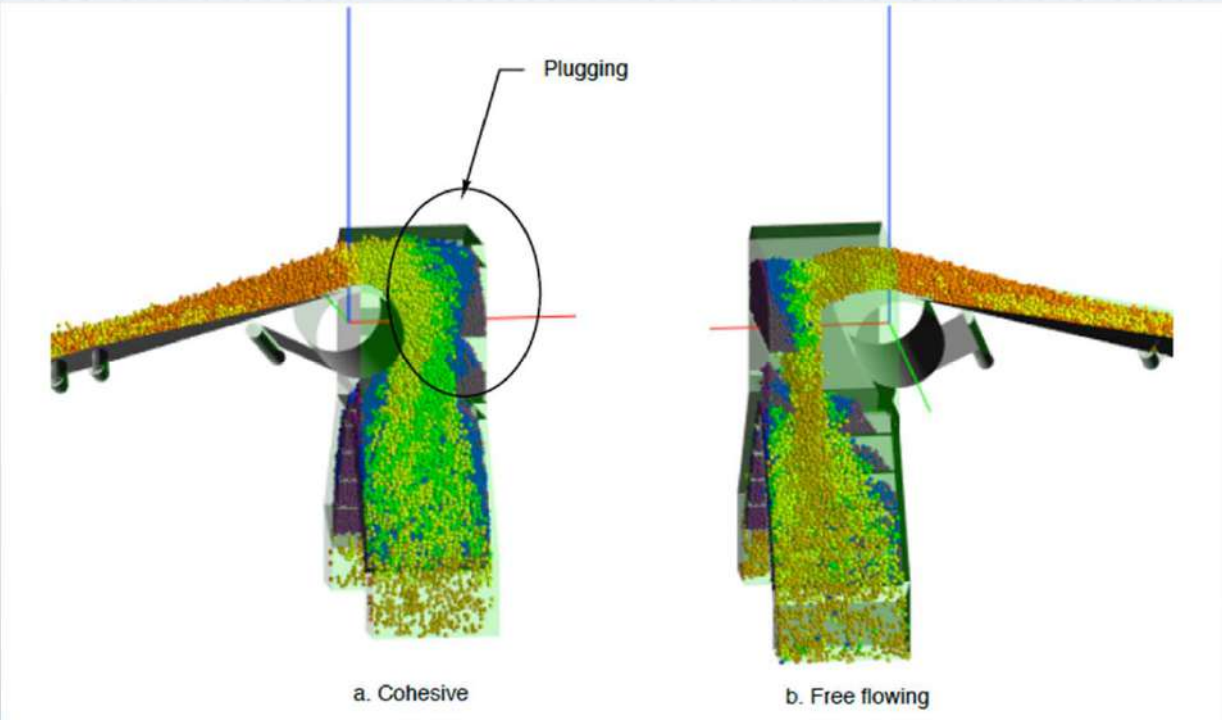
Caused some material to fly over the head chute. Chute was also fuller than designed for.

→

Resulted in increased spillage and higher plugging potential.

CHANGING MATERIAL

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



CONCLUSION

- Increasing throughput and/or handling different material through existing infrastructure can have significant financial benefits.
- Material testing and DEM are good predictive tools to analyze the feasibility of a usage change.

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SCIENCE ENGINEERING DESIGN

QUESTIONS?

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