Discrete Element Modelling (DEM) on a System Level

Generating ROMs with Rocky DEM and ANSYS

Presented by:

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Agenda

- Introduction (What\Why ROM)
- Example Case Background
- ROM Setup
- ROM Results & Validation
- Shortfalls
- Where To Next

- Q&A

Introduction

Introduction

- ROM = Reduced Order Model

- What: Mathematical representation of physics system.

- Why: Estimate results in continuous space by using quick equations instead of doing full physics solve.

- Process: Design of Experiments > Response Surface Generation > ROM Export

Introduction

- ANSYS can be a powerful tool in generating ROMs and digital twins.

- Structural, Fluid and Emag ROMs covered by ANSYS.

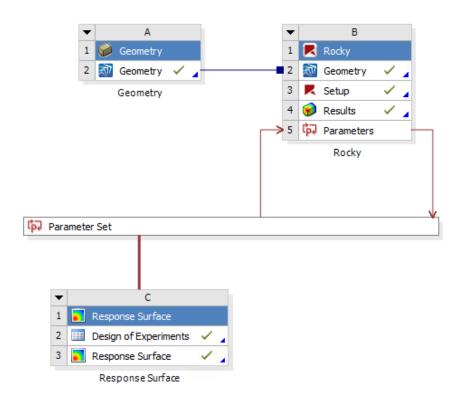- What about bulk flow applications?

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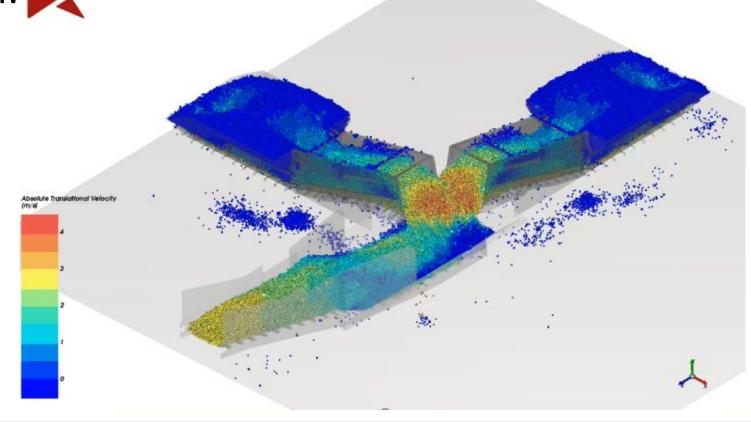
- What about bulk flow applications?

ROCKY

Introduction

- Rocky integrates into ANSYS DesignXplorer (DX).

- This enables the generation of ROMs/digital twins for bulk flow applications.

Example Case
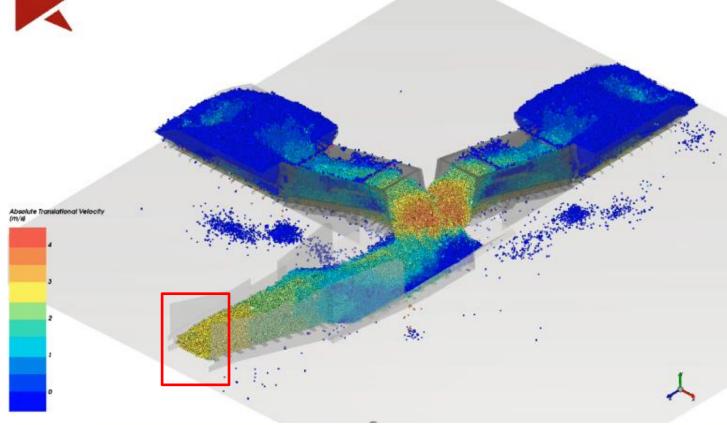
Example Case

- Real world test case: Shuttle cars offloading to a feeder.

Example Case
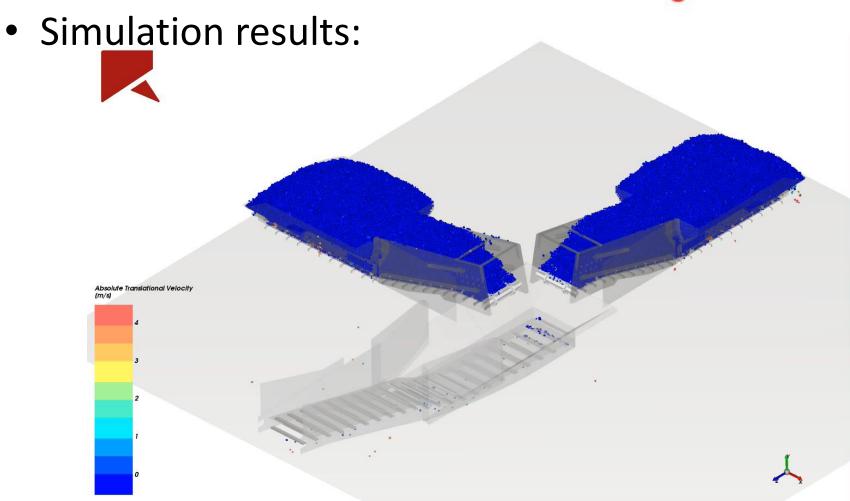
- Concern: Restriction on mass flow from feeder.

Absolute Translational Velocity (m/s)

Example Case

- Simulation results:
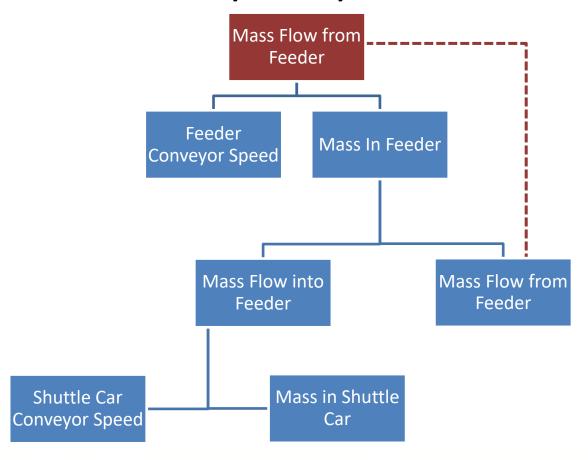
Example Case

- Outflow affected by many variables:

Example Case

- DEM answer:
  - Accurate answer.
  - New solve for each set of inputs.
  - Good for system with fixed inputs.

- ROM answer:
  - Estimated answer.
  - Instant answer for any inputs.
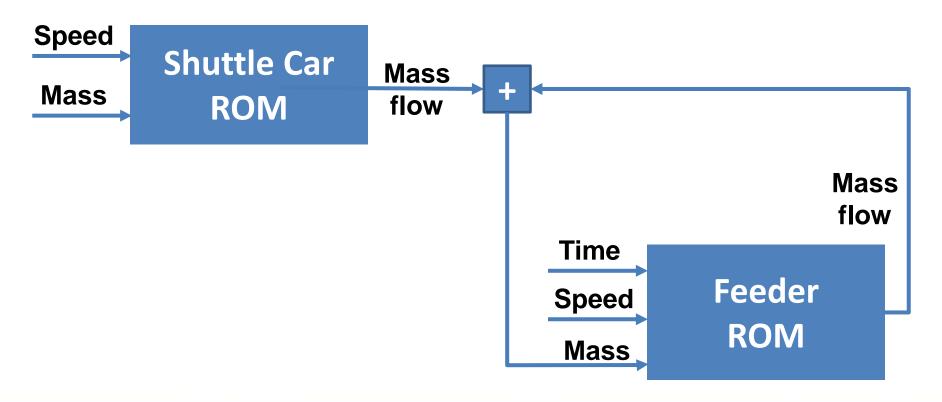 - More favourable for highly variable system.
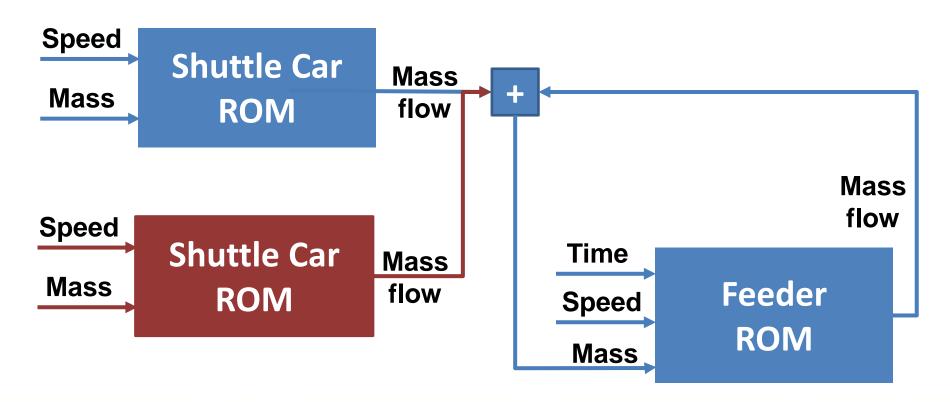
ROM Setup

ROM Strategy

- Separate ROMs for shuttle cars and feeder:

ROM Strategy

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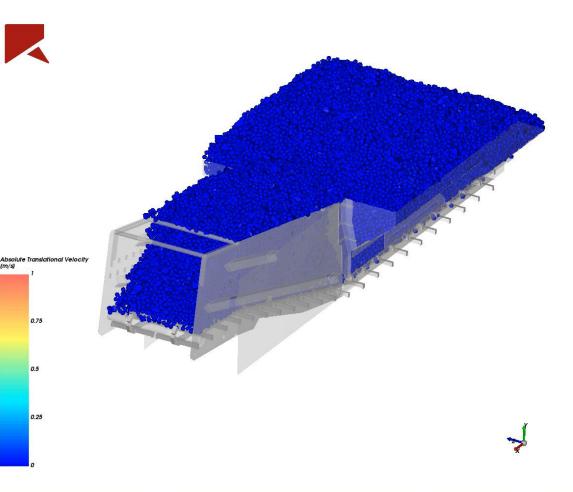 - Allows for easy expansion of model.

ROM Setup

- ## Shuttle car setup:

  - – 20 tons of material.

  - – Different conveyor speeds tested.

Absolute Translational Velocity
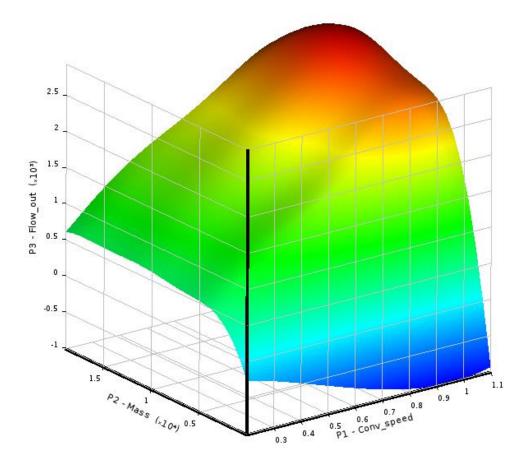(m/s)

1

0.75

0.5

0.25

0

Shuttle Car ROM

- Shuttle car response surface:
  - Inputs:
    - Conveyor speed
    - Mass in car
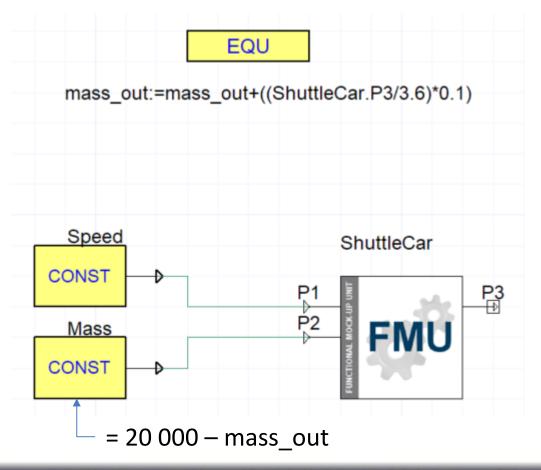
  - Output:
    - Mass flow from car
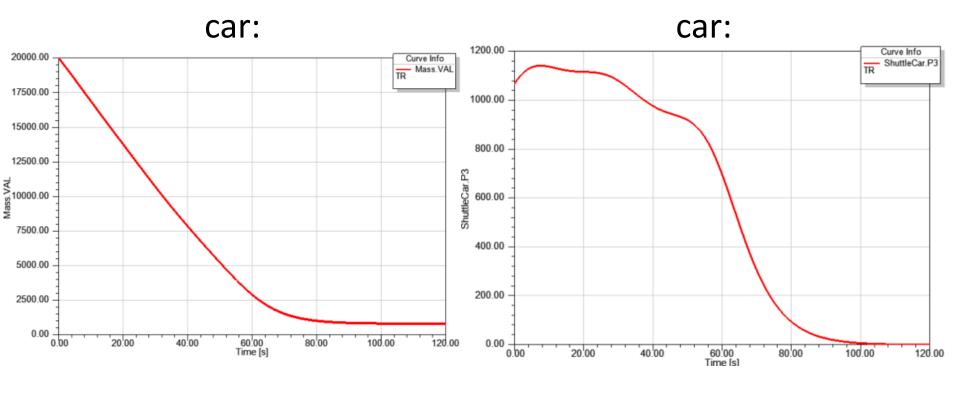
Shuttle Car ROM

- Shuttle car in ANSYS Twin Builder

EQU

$$mass\_out := mass\_out + ((ShuttleCar.P3/3.6)*0.1)$$

Speed
CONST

Mass
CONST

ShuttleCar

P1
P2

FMU

FUNCTIONAL MOCK UP UNIT

P3

= 20 000 − mass_out

Shuttle Car ROM Results

Particle mass in shuttle car:

Mass flow from shuttle car:

Feeder ROM
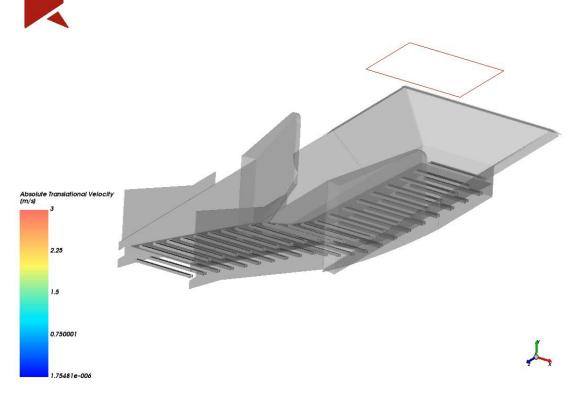
- Feeder setup:
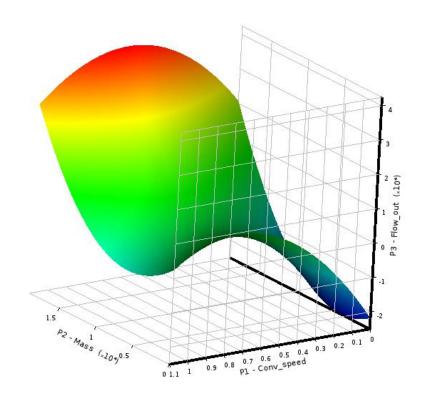
  - Flow into feeder.

  - Different conveyor speeds tested.

Absolute Translational Velocity (m/s)

3

2.25

1.5

0.750001

1.75481e-006
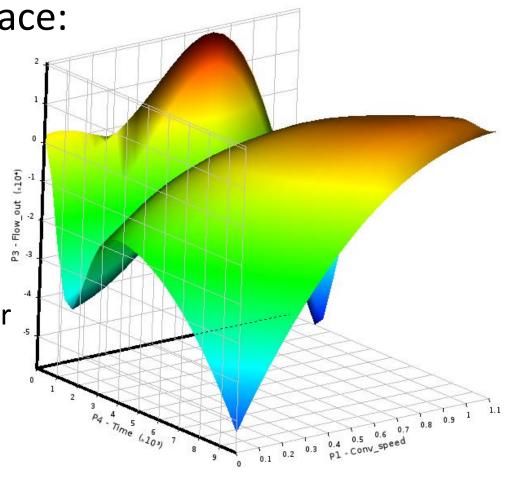
Feeder ROM

- Feeder response surface:
  - Inputs:
    - Conveyor speed
    - Mass in feeder

  - Output:
    - Mass flow from feeder

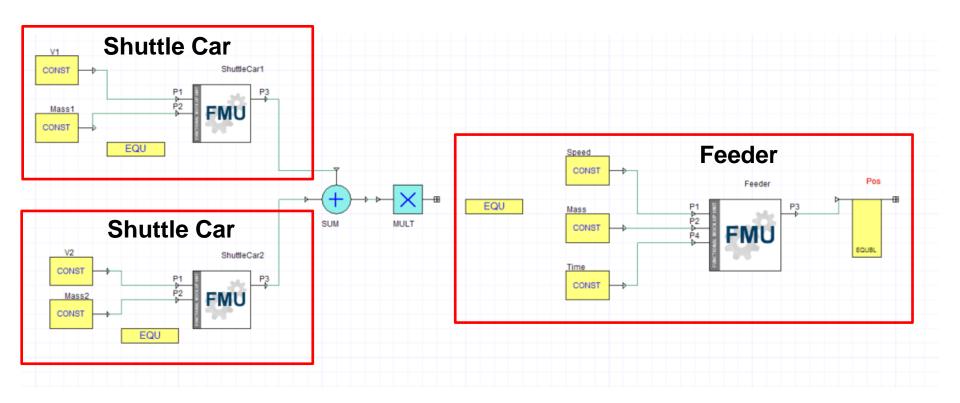# Feeder ROM

- Feeder response surface:
  - Inputs:
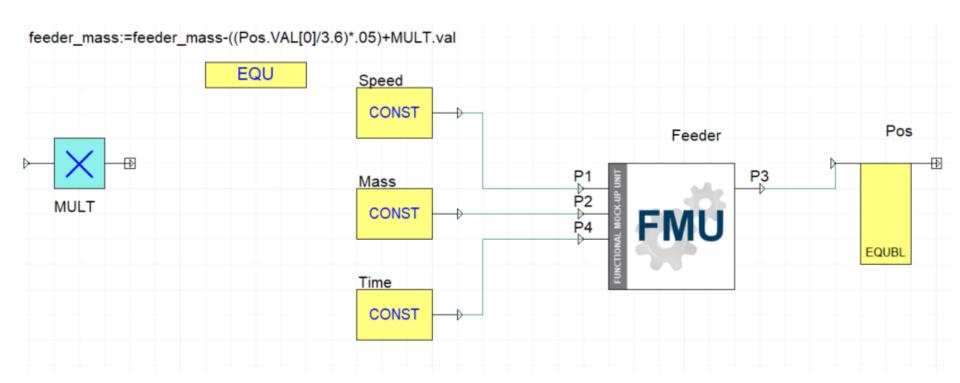   - Conveyor speed
    - Time

  - Output:
    - Mass flow from feeder

Feeder ROM

- Feeder in ANSYS Twin Builder

ROM Setup

- Feeder in ANSYS Twin Builder

feeder_mass:=feeder_mass-((Pos.VAL[0]/3.6)*.05)+MULT.val
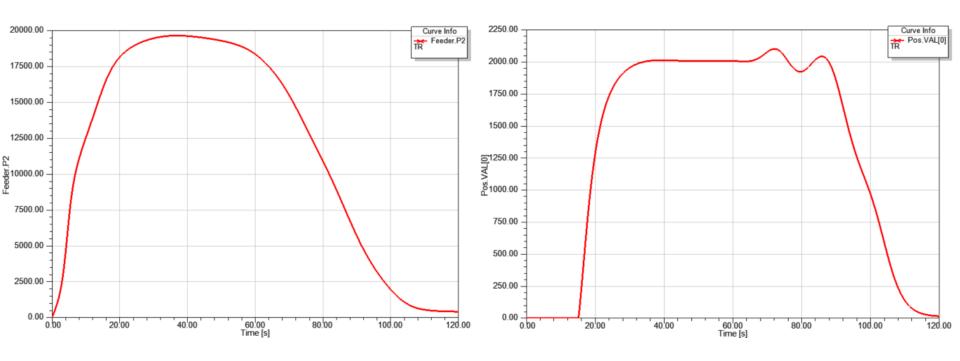
ROM Results & Validation

Feeder ROM Results

Particle mass in feeder: Mass flow from feeder:

ROM Validation

- Validation Case:

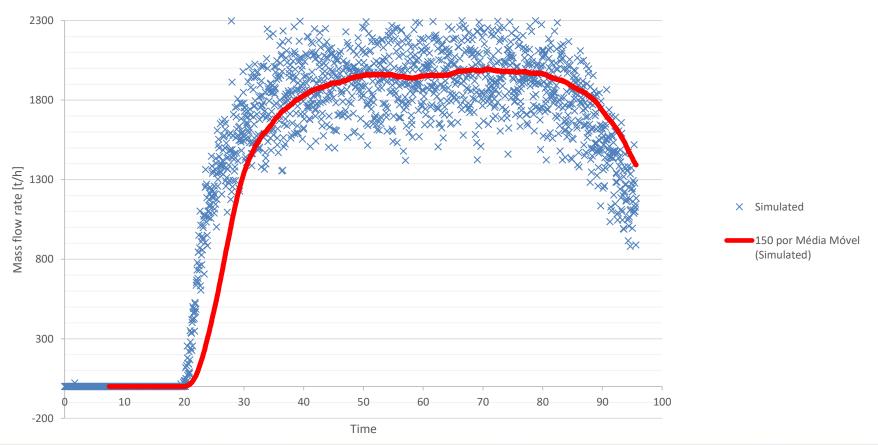 - 2 x 20 ton Shuttle cars at a conveyor speed of 0.35 m/s.

  - Feeder with conveyor speed at 0.46m/s.

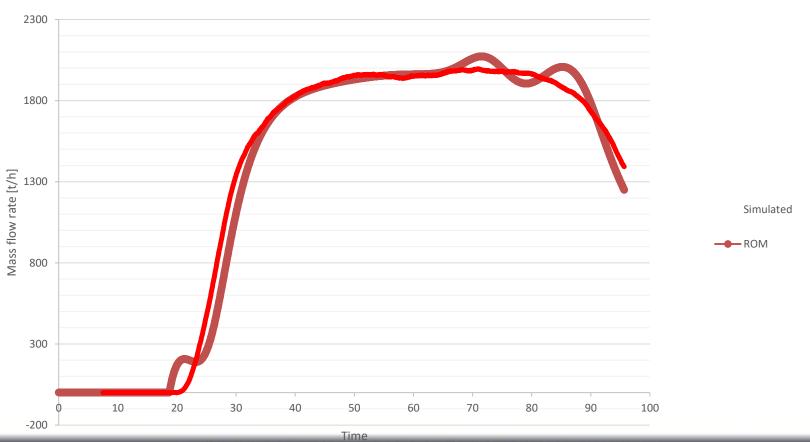# ROM Validation

- Simulation results:

Simulated: Feeder Out Flow

ROM Validation

- Result comparison:

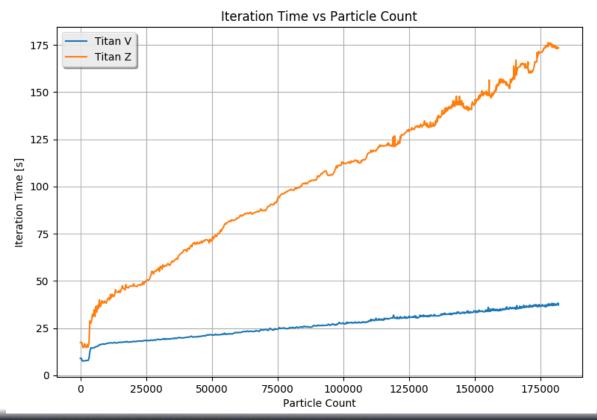ROM vs Simulated: Feeder Out Flow
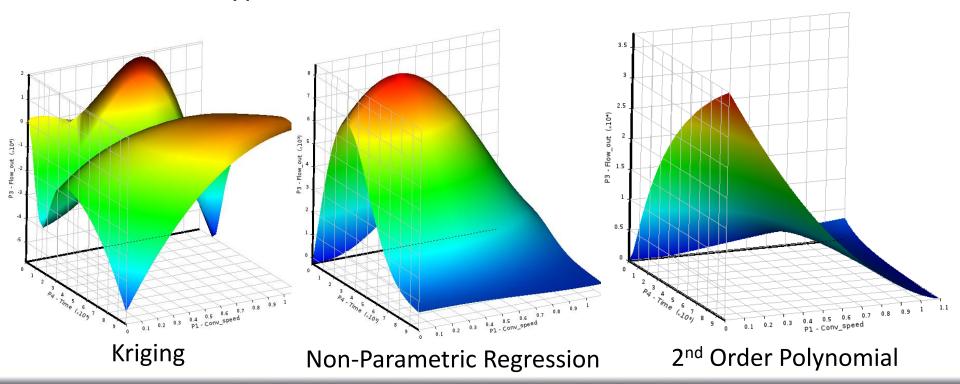
Shortfalls

Shortfalls

- DEM solving time can cause DOE generation to take large amounts of time:

    - GPU solving capabilities and advancing GPU technologies improve this issue.

Shortfalls

- ## Sensitive to response surface type.
  - It is quick to test the effectiveness of different response surface types with ANSYS DX and Twin Builder.

Kriging

Non-Parametric Regression

2nd Order Polynomial

Where To Now

- Use ROM to predict effects of system changes.

- Modify ROM to include calculation of spilled mass.

- Use ROM to optimize the system.

- Link to IOT platform to predict overloading, damage and spillage.

- Use ROM in PLC to automate conveyor speeds.