Industrial application of DEM: Capabilities and Challenges

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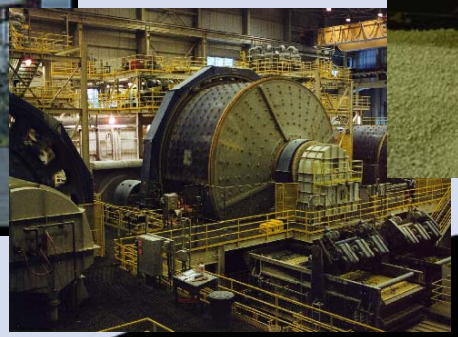
DEM Solutions Ltd



www.dem-solutions.com

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Discrete Element Modeling

About DEM Solutions

- Founded in 2002
- Headquarters in Edinburgh, UK
- Office in Lebanon, New Hampshire, USA
- Developers of EDEM software for DEM simulation and analysis
- EDEM 1.0 released Oct 2005
- EDEM 1.1 released June 2006
- EDEM-FLUENT Coupling Module released June 2006

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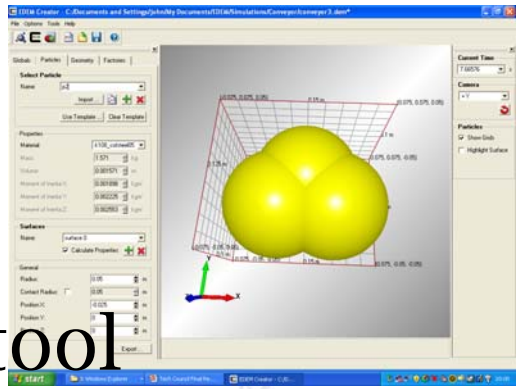
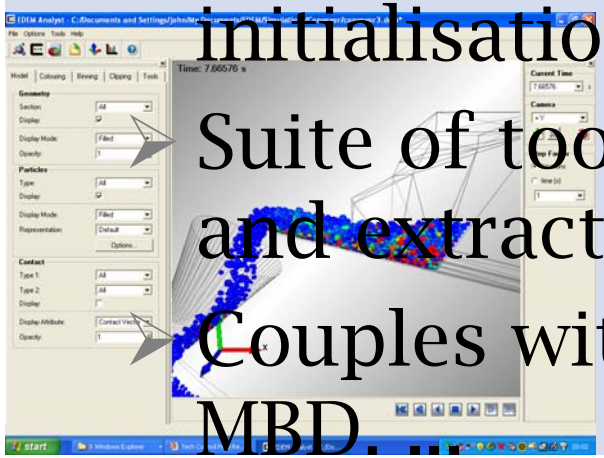
EDEM™



- 3D DEM simulation and analysis tool
- Fully functional GUI for pre- and post-processing
- CAD compatible for import of particle and equipment geometry
- Applications interface for user programmable control of particle initialisation, contact physics, body forces
- Suite of tools for data visualisation, analysis and extraction
- Couples with other C… MBD, …



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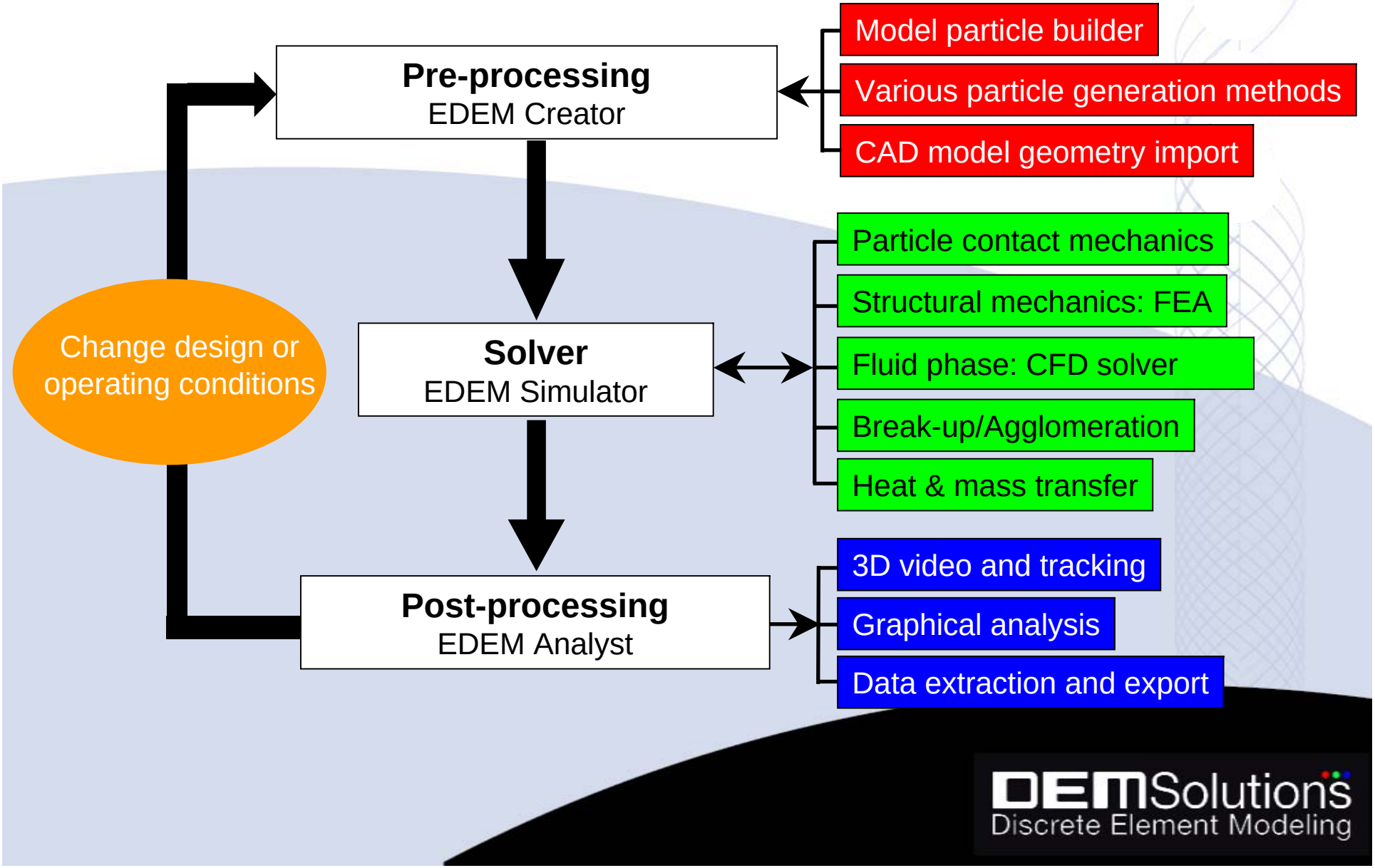
EDEM Modelling Pipeline



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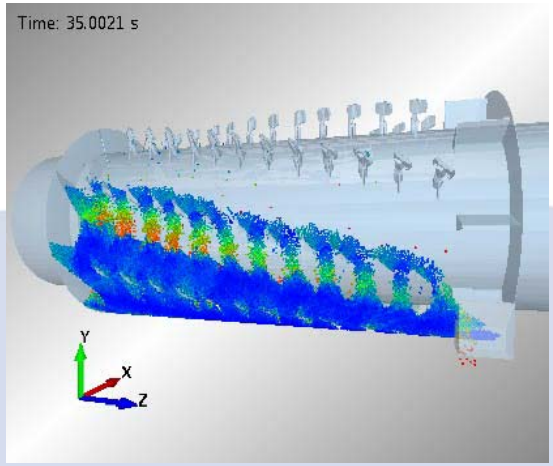
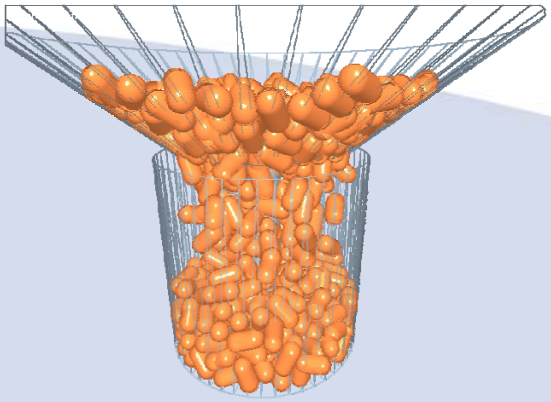
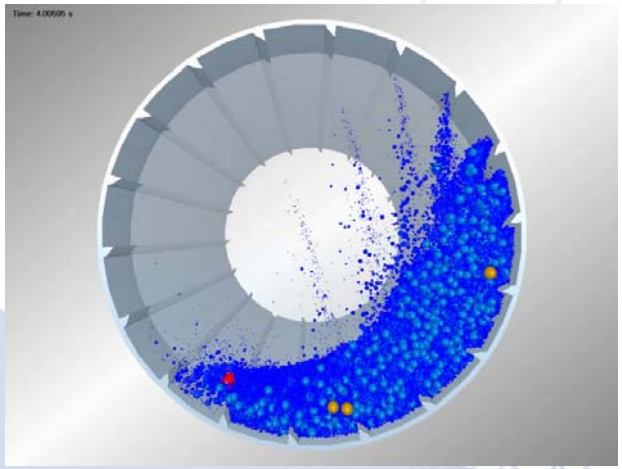
Some examples of industrial application



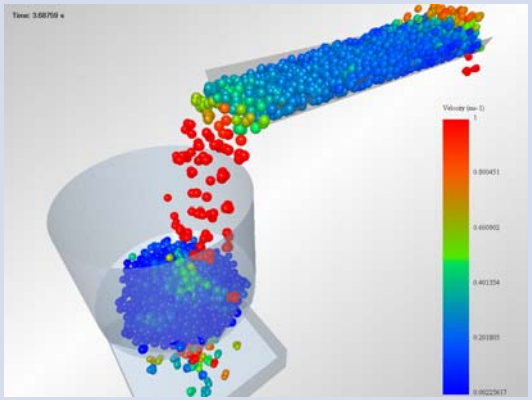
Mixing/coating of aggregates

Dispensing capsules



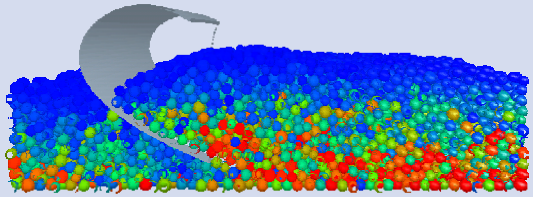


Ball milling of mineral rock

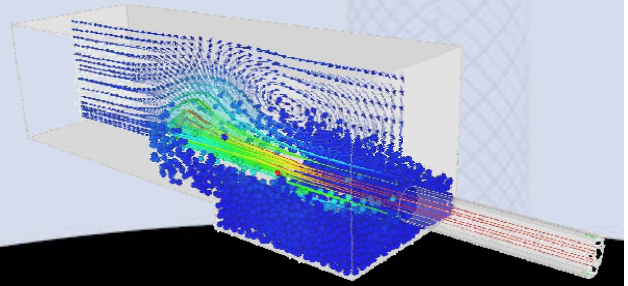


Conveying

Bucket loader



Entrainment of particles
(EDEM-FLUENT co-simulation)



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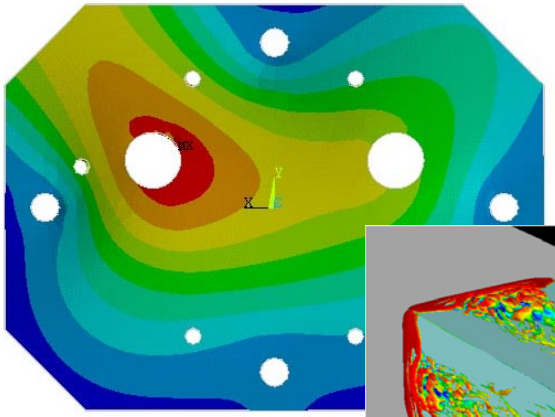
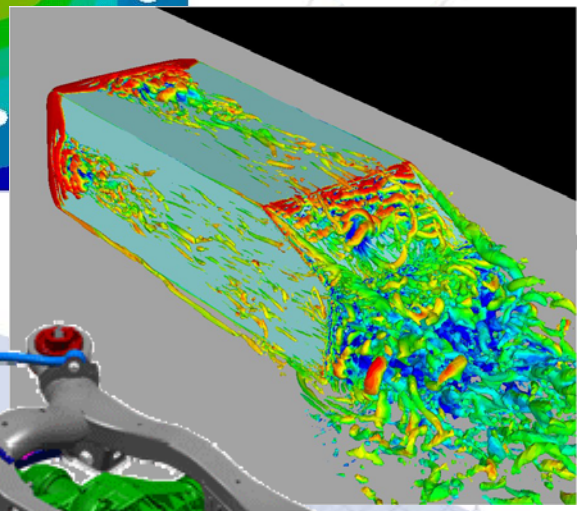
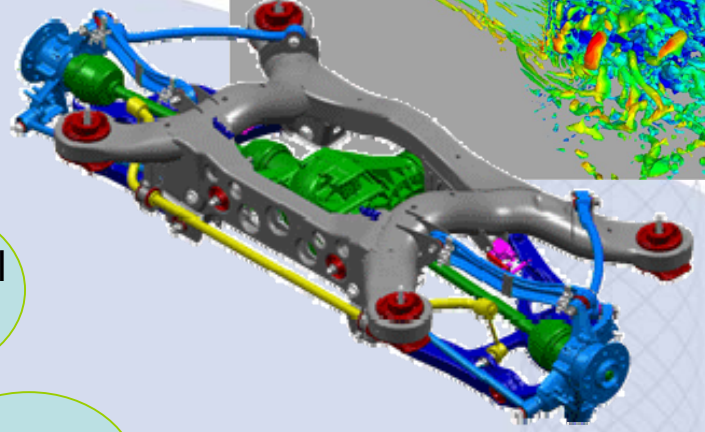
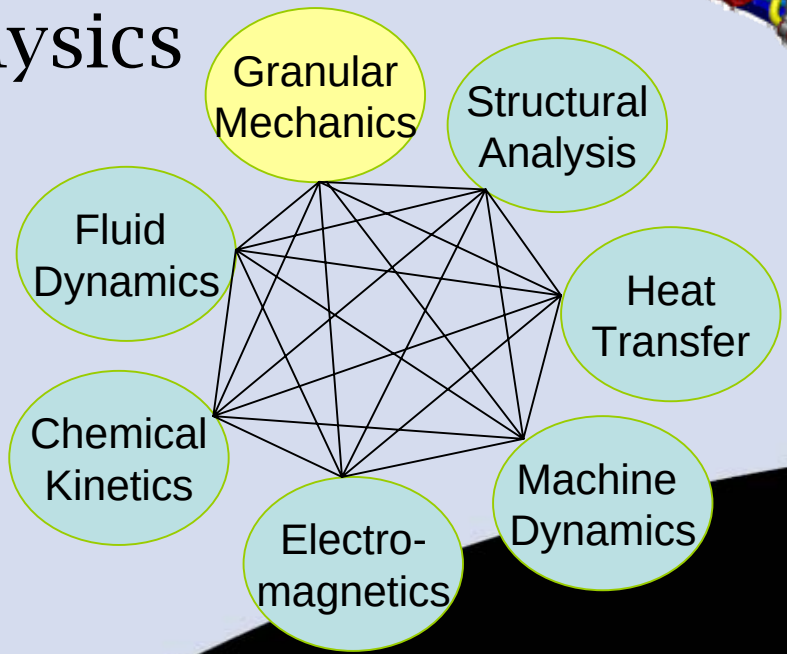
Trends in CAE







- Mature technology
  - Finite Element Analysis – 40
  - Computational Fluid Dynamics – 30 yrs
  - Multi-Body Dynamics – 20 yrs
- Integration with CAD
- Multi-physics



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Drivers for application of CAE

- Engineering
  - Higher and more consistent quality product
  - Faster production
  - Lower energy usage
  - Design of new products and processes
- Business
  - Better return on investment
  - Shorter time to market
  - Technical advanta

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Drivers for application of DEM

- Engineering
  - Provides information about internal bulk behaviour
  - Expanding range of industrial applications and application know-how
  - Discrete methods required to advance quality of predictive simulation of granular systems
- Computational
  - Faster computing
  - Improving performance/cost of hardware
  - Coupling of DEM with other nu
    methods

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Characteristics of particulate solids handling and processing operations

Range of particle shape and size

- Usually non-spherical particles

Complex machine geometry

- Moving machine components

May have interactions which involve mass, momentum, and heat transfer

- Between particles
- Between particles and machinery
- Between particles and fluids

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What information can DEM provide?

Particle

Particle kinematics

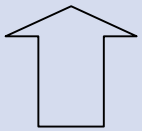
Particle size/mass/temperature

Particle-particle contact forces

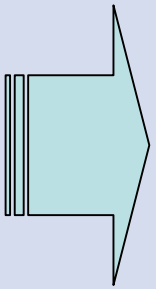
Particle-boundary contact forces

Particle body forces: gravitational, fluid, electro-magnetic

New particle formation



DEM results



Bulk

Mixing dynamics

Uniformity of flow

Bridging

Granulation

Agglomeration

Mechanical energy consumption

Particle-machine interaction

Pneumatic transport

Segregation

Residence time/ hold-up

Damage/attrition

Breakage

Surface coating

Erosion

Heat transfer

Fluidization

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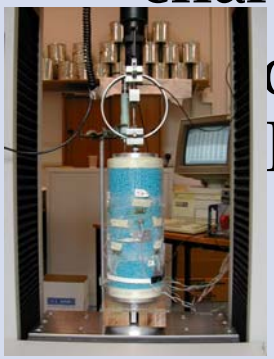
Challenges for industrial application of DEM

1. Methods to determine DEM parameters from bulk as well as individual particle measurements
   - Correlation between bulk test and process characteristics



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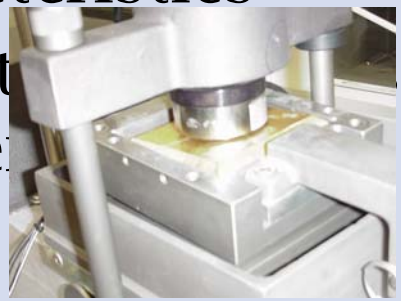
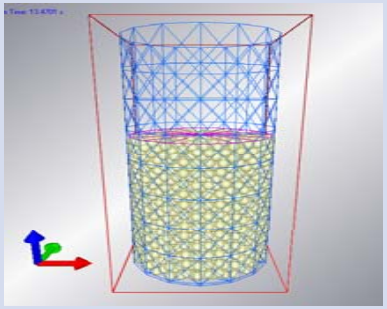
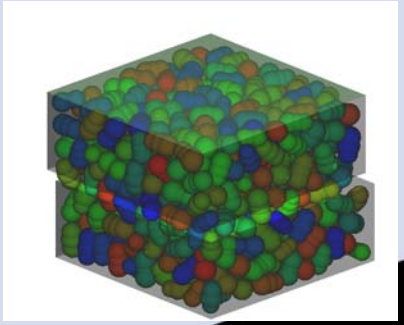


- DOE
- Back calculation
- Response surface fitting
- More than one test required





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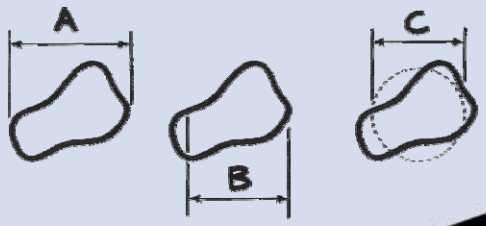
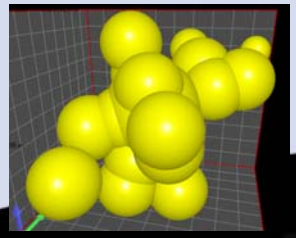
Challenges for industrial application of DEM

2. Methods to determine suitable particle shape representation
   - What is the effect of particle shape on bulk behaviour?
   - What are the best correlating metrics between real shape and model particle shape?





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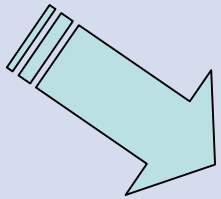
Challenges for industrial application of DEM

3. Parametric studies of DEM contact algorithms
   - Sensitivity
   - Scaling



Optimisation procedures

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Challenges for industrial application of DEM

4. Establishment of benchmarking for DEM codes
   - Validation against standard tests
   - Relate DEM model to continuum model benchmarks
   - Relate DEM simulation to alternative techniques
   - Reference point for the “layman”

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Conclusions

- DEM is now a viable simulation tool for industrial particulate processes
- More DEM validation and benchmarking is required to increase acceptance by industry
- Integration with other CAE tools is advancing and will widen the use of DEM
- DEM is an valuable addition to the engineers toolkit which compliments experiment and physical testing

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