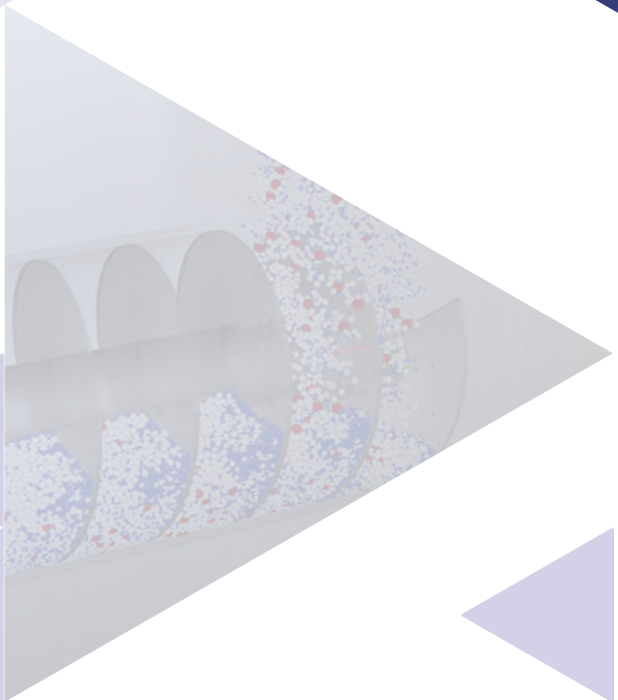
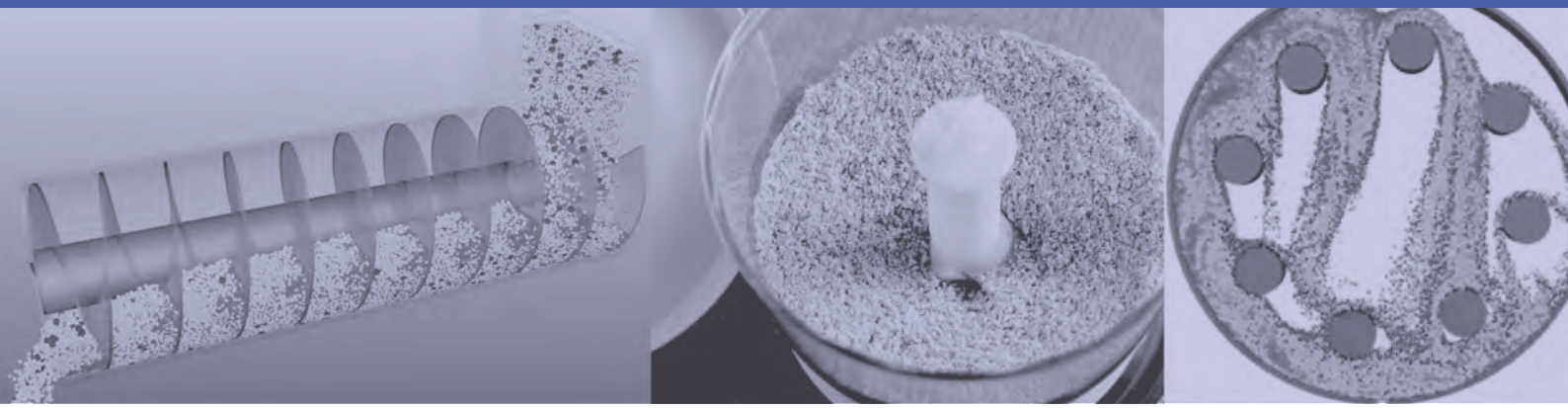
Granuleworks™

Advanced Simulator for Granular Materials



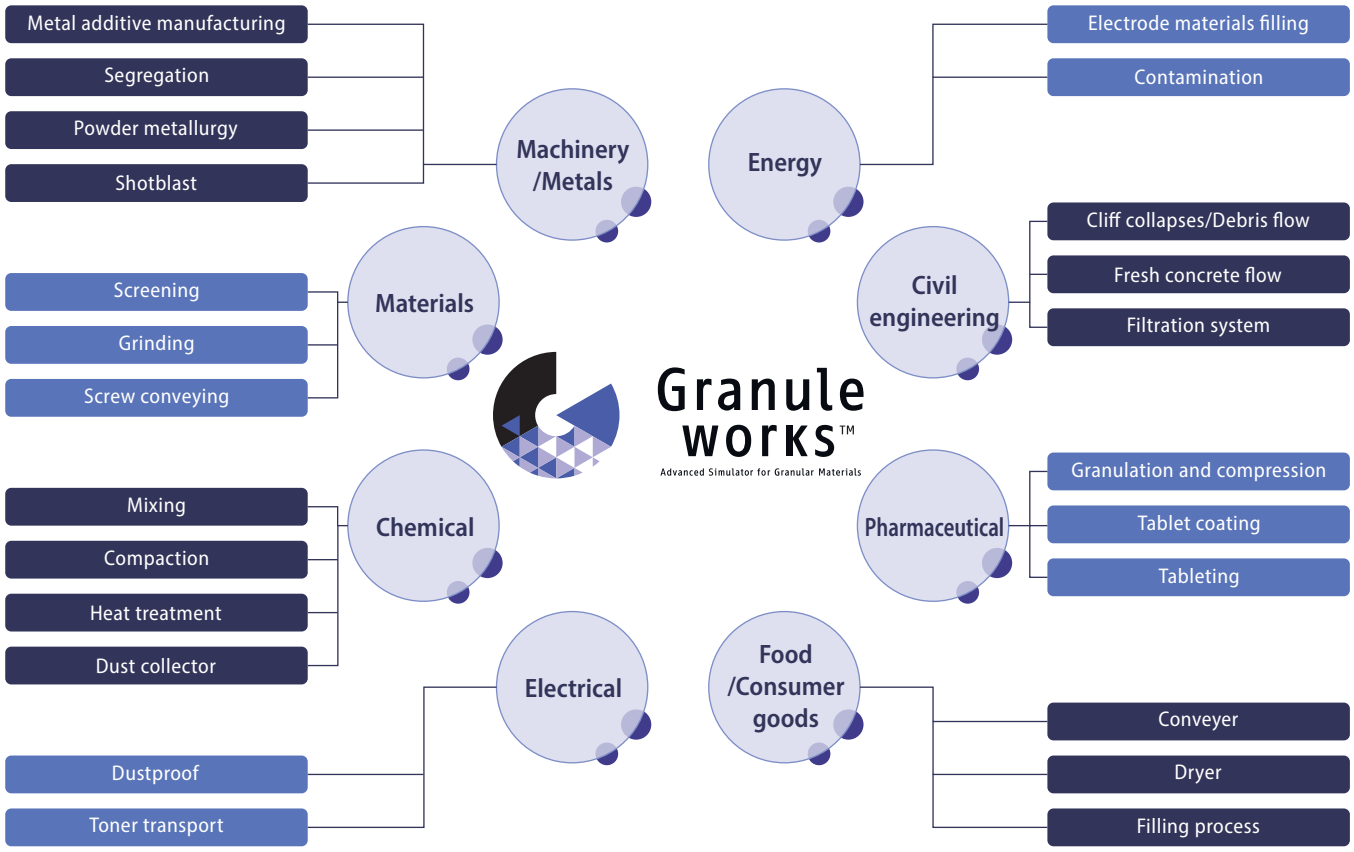
PROMETECH.

What is Granuleworks?



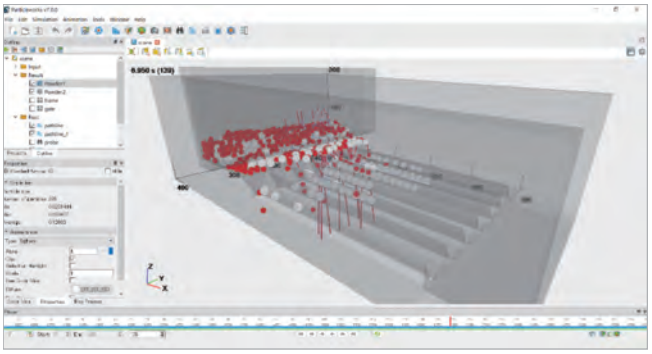
Granuleworks is a granular material simulation software based on the discrete element method (DEM) theory. It can be used for manufacturing processes using powders, powder processing, and design and improvement of powder equipment for various fields including food, pharmaceuticals, chemicals, transport equipment, and electronic materials. Granuleworks can easily simulate the phenomena of powder mixing, transport, filling, etc.

Granuleworks Applications



Operability

GUI

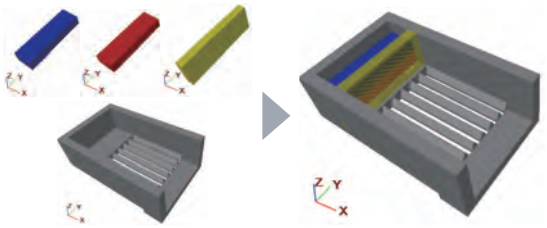


Granuleworks' intuitive user interface lets you handle an entire simulation, from pre-processing through post-processing. You don't have to be an expert to edit simulation parameters or keep track of multiple projects.

The 3D view window features ultra-fast, high-quality OpenGL rendering optimized for large-scale simulation with millions of particles. The window system is highly customizable, letting users compare multiple results side by side. Both Windows and Linux are supported.

Simulation Flow

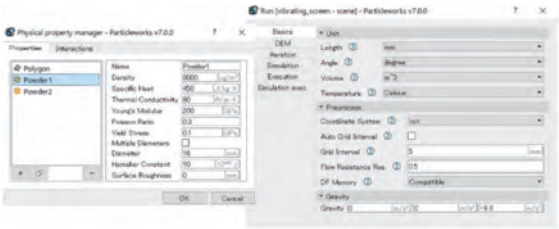
Modeling



Import CAD data and define the resolution for pre-processing.

The STL, OBJ, and Nastran formats are supported.

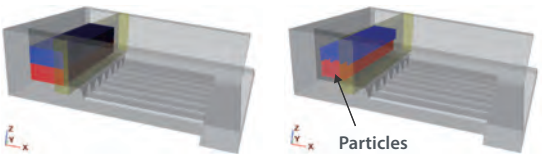
Condition Setting



Set material properties (e.g. density, particle size, etc.), physical models (e.g. friction, rolling resistance, liquid bridging force, etc.) and calculation conditions (e.g. initial time increments, output physical quantities, end time for analysis, etc.).

Pre-Processing

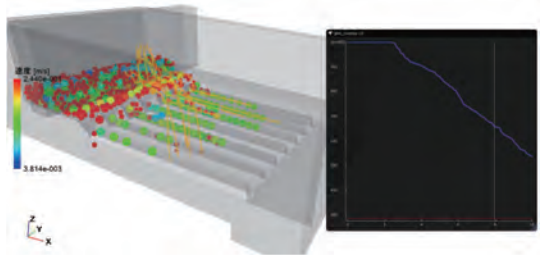
Simulation



Geometry model　　Simulation model

Generating particles at the initial placement conditions (particle size) you set.

Post-Processing



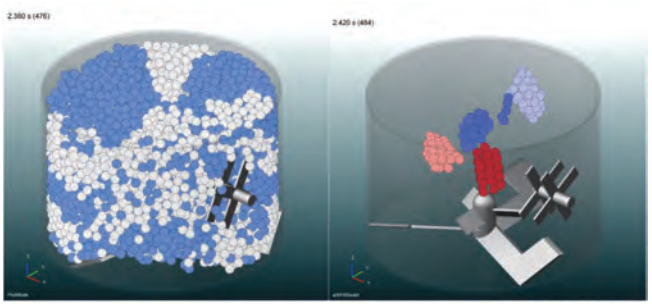
Velocity contour　　Graph

Post-processing capabilities:

- Animation
- Contour
  (Coordinate systems, Velocity)
- Trajectory lines
- ASCII transformation of simulation data
- Video files (MP4、WMV), Image files (JPEG/PNG)

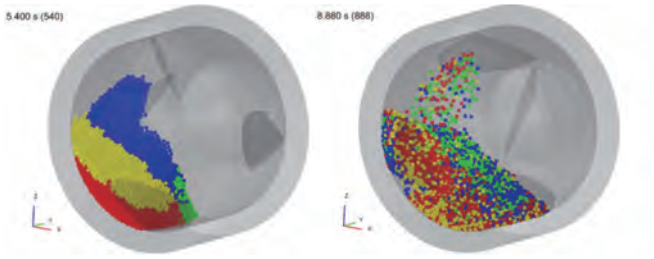
Applications of Granuleworks

Mixing



High Speed Mixer

Simulating mixing process in which the fine powder with cohesiveness to be mixed uniformly. The tendency of the aggregates to be unraveled is captured by the agitator (horizontal blade) that promotes convective/diffusive mixing and the chopper (vertical blade) that promotes shear mixing.
*The right image shows the aggregates only.

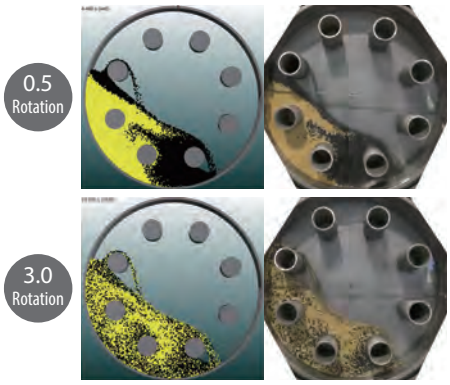


Rotary-type Mixer

Mixing simulation that mixes mildly without applying strong force to powder. The simulation result captures the tendency that the internal flight promotes mixing.

V Blender

Mixing simulation that represents the behavior of mild mixing without applying strong force to powder.



Courtesy of TSUKISHIMA KIKAI

Rotary-type Mixer

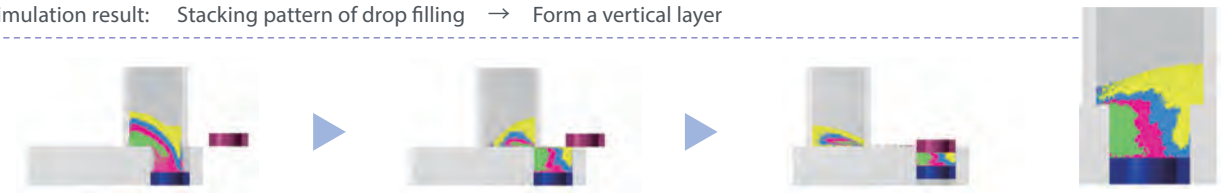
Simulation of mixing two types of particles with different particle sizes. Compared with experiments for validation, it was confirmed that the simulation result (i.e. behavior of particles and the degree of mixing) matches the experimental data with high accuracy.

Filling

Powder Filling Simulation into a Mold

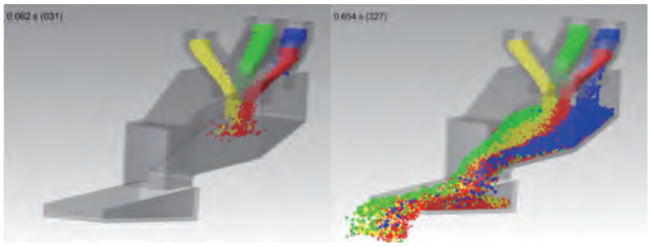
Simulating a series of processes in which high stress is applied to powder to form it. The simulation result indicates the segregation, which is considered to affect the finished product quality.

Simulation result: Stacking pattern of drop filling → Form a vertical layer



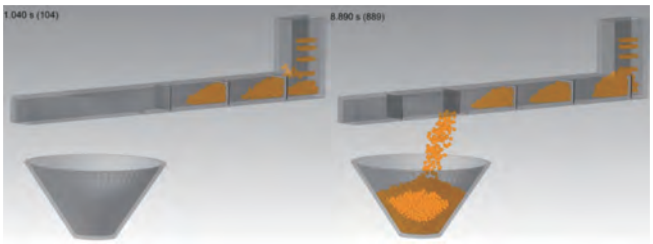
Simulation result: Stacking pattern of suction filling → Form a horizontal layer

Conveying



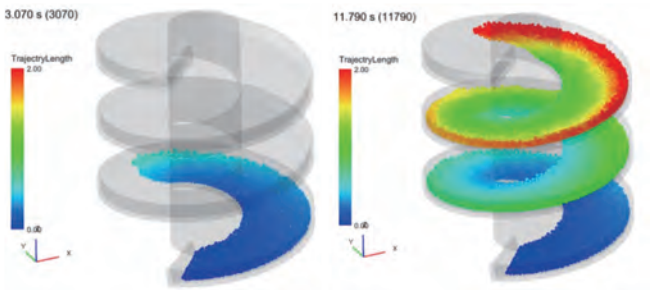
Pipe Junction Flow

Simulating the flow at a pipe junction with complex ducts that convey powder and granules.



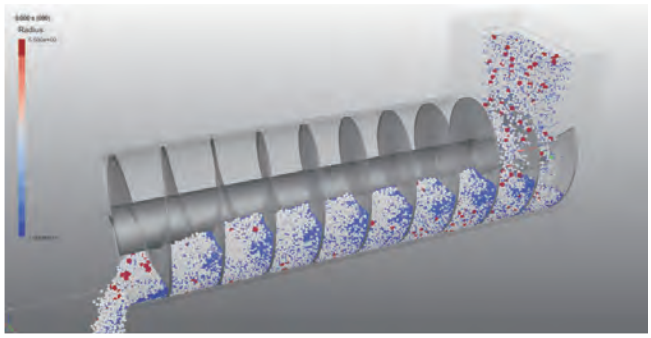
Flight Conveyor

Simulating a flight-type conveyor which is widely used for conveying powder.

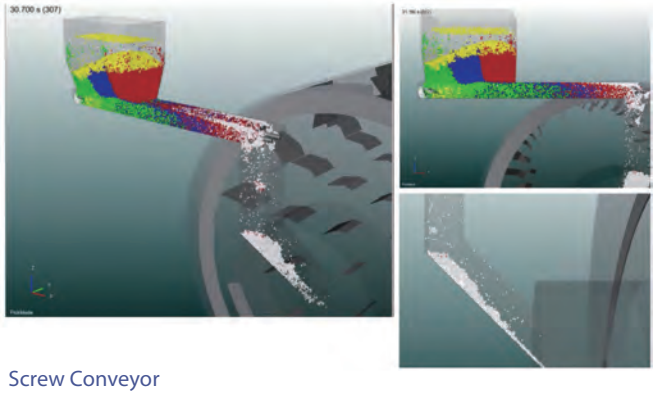


Vibrating Conveyor

Simulating fine particles moving up a path due to slight vibration.

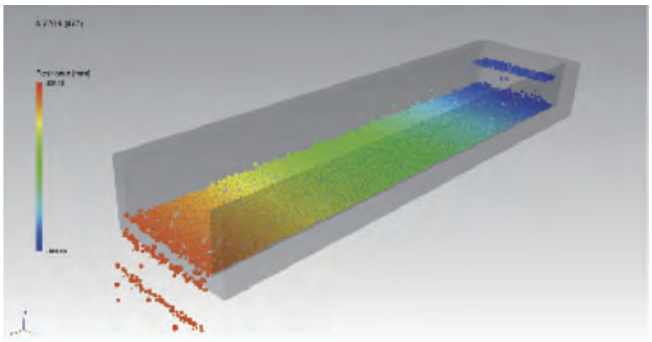


Single Axis Screw Conveyor



Screw Conveyor

Simulating the conveying of sticky powder after dehydration of slurry. Although the twin-screw cuts out the powder, the simulation indicates that the powder is accumulated in the duct below and will eventually block it up.

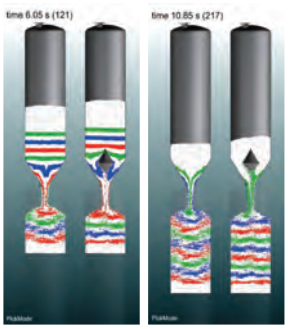


Vibrating Conveyor

Storage

Granular Flow through a Hopper

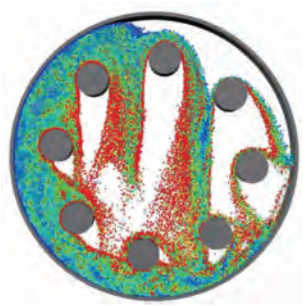
Simulation to evaluate the mass flow in the powder storage tank. The powder is colored in the form of stripes for visual representation. The simulation result indicates the right funnel has a uniform flow due to the rectifying cone inside when the left one has a typical funnel flow.



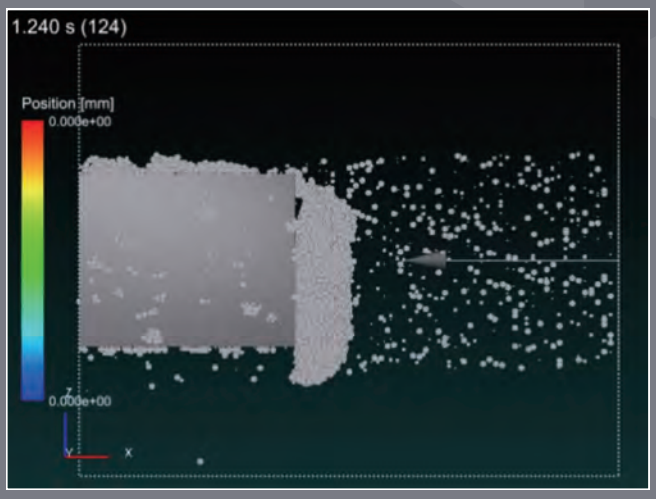
Heat Transfer

Dryer with Heating Tubes

Simulation of heating powder. It represents how the temperature of the powder that contacts the heat source (i.e. the heating pipes placed inside the cylindrical container) rises due to heat transfer.

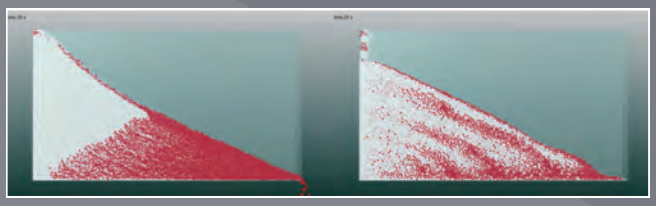


Simulation of Various Phenomena Using DEM



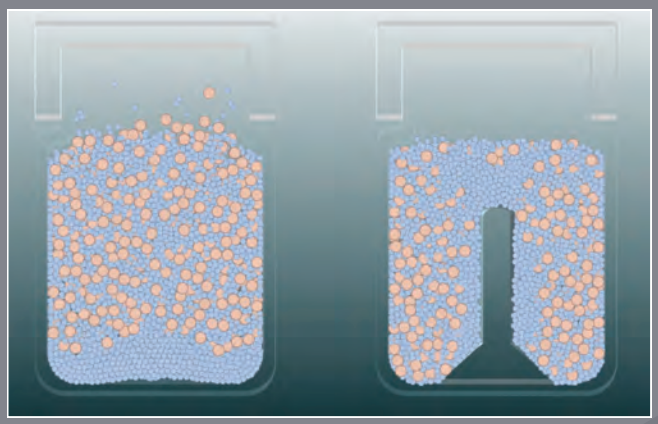
Snow Adhesion and Accumulation on a Wall

The simulation result represents the behavior of snow adhering to the wall surface, growing, and then falling under by its weight.



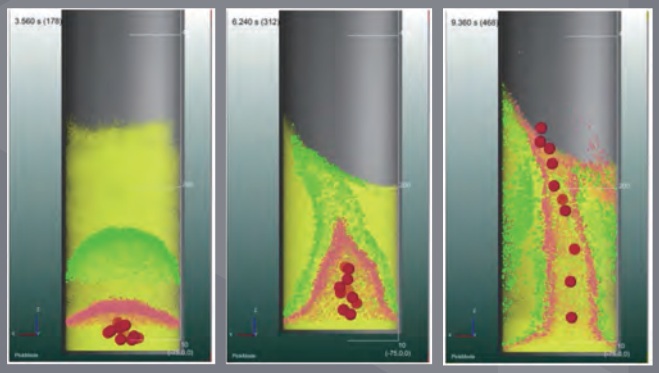
Segregation Phenomena in a Hopper

Simulates segregation phenomena that occur in powder deposited by gravity. The red particles have a large diameter size, while white ones have a smaller particle size. The typical segregation phenomenon is as shown in the left. The right one shows particular segregation that occurs under certain conditions.



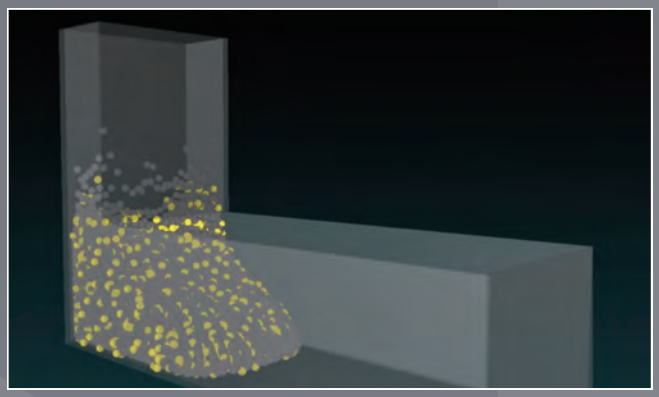
Container design to prevent segregation due to vibration during transportation

A glass container with spherical granules was studied by simulating the behavior of the container when it was subjected to vibrations that resembled shaking during transport.
In the left image, the granules segregate at the bottom. When the shape of the container was changed, no segregation was observed at the bottom and center of the container as shown in the right.



Granular Convection in a Vibrating Device

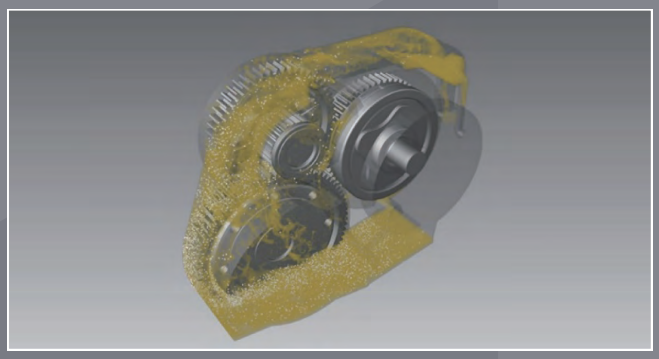
Simulation of granular convection, also known as "Brazil nut effect", in which large particles rise in the layer. A familiar example of this phenomenon is seen in a bag of muesli.



Concrete Flow Simulation with Aggregate

The model is created with mortar with coarse aggregate and Bingham fluids with granules.
The simulation result would help you predict and evaluate the flowability of fresh concrete based on the L flow value, the velocity distribution, the viscosity distribution, the shear rate distribution, and the shear stress distribution.

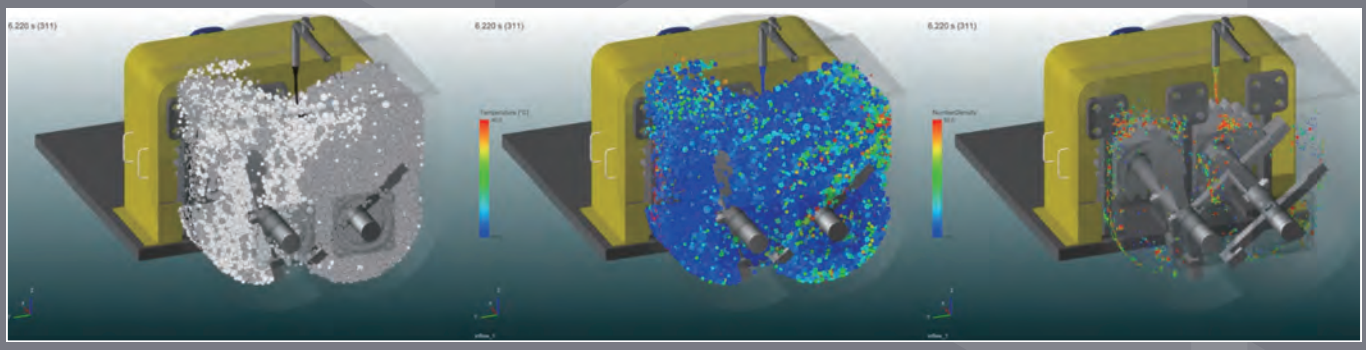
Granuleworks™ Advanced Simulator for Granular Materials × Particleworks™ Particle-based simulation software for CAE



Aeration

By modeling bubbles using DEM, bubble behavior can be evaluated to predict engine oil behavior and chemical processes in stirring tanks.

Granuleworks™ Advanced Simulator for Granular Materials × Particleworks™ Particle-based simulation software for CAE



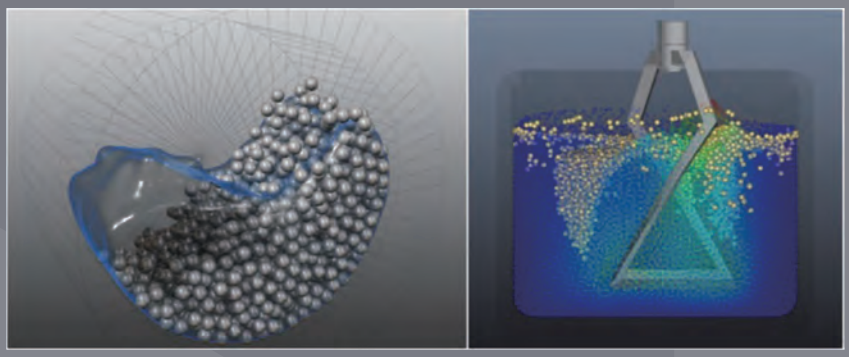
Paddle Kneader Simulation

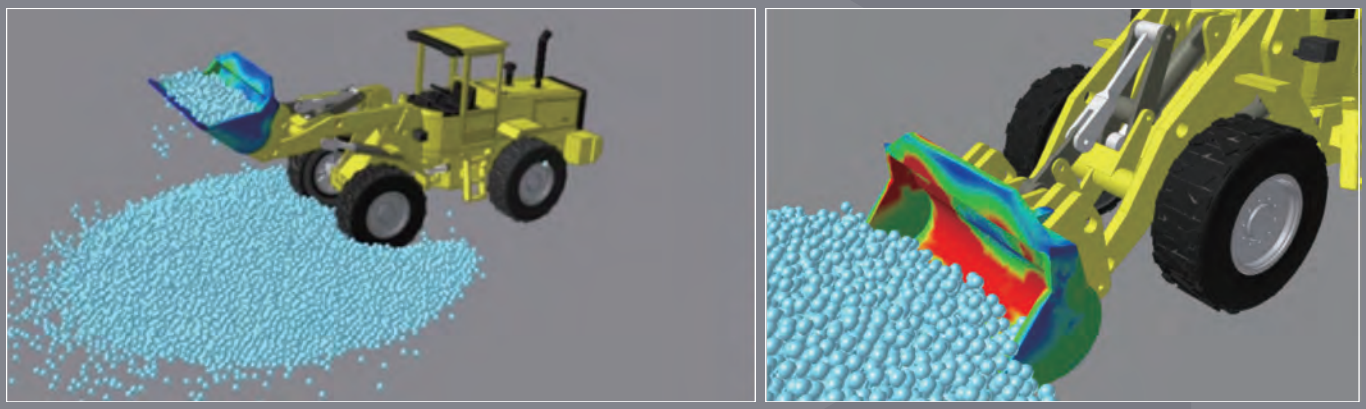
Simulates a process of moisture control of powder using a paddle kneader. The high-viscosity liquid is added while the powder is stirred, and it is shown how the liquid is evenly mixed with the powder. Dispersion of the liquid into the powder is a difficult operation, but the result of this simulation also shows that the liquid does not disperse sufficiently, resulting in adhesion of the liquid to the wall.

Granuleworks™ Advanced Simulator for Granular Materials × Particleworks™ Particle-based simulation software for CAE

Powder-Liquid Mixing

Granuleworks™ Advanced Simulator for Granular Materials × Particleworks™ Particle-based simulation software for CAE





Coupled simulation with RecurDyn (Motion and powder coupling)

By combining Granuleworks with RecurDyn, a Multi-Body Dynamics Simulation software of FunctionBay, Inc., it is possible to simulate the powder behavior in consideration of the motion of the mechanism according to reality. Sending the mechanical model behavior (position and velocity information) calculated by RecurDyn to Granuleworks, and returning the powder simulation results (powder force) from Granuleworks back to RecurDyn, realizes a bidirectional coupling analysis of both motion and powder.

RecurDyn supports fluid interaction with both rigid and flexible bodies. This permits powder interaction with bodies experiencing large deformation, and it permits the calculation of deformation, stresses, and strains imparted to bodies by powder forces.

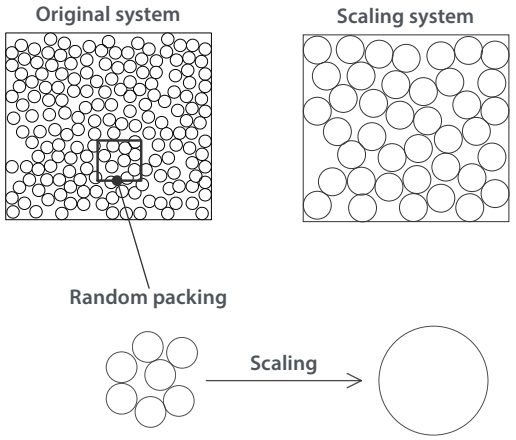
Granuleworks™ Advanced Simulator for Granular Materials × RECURDYN

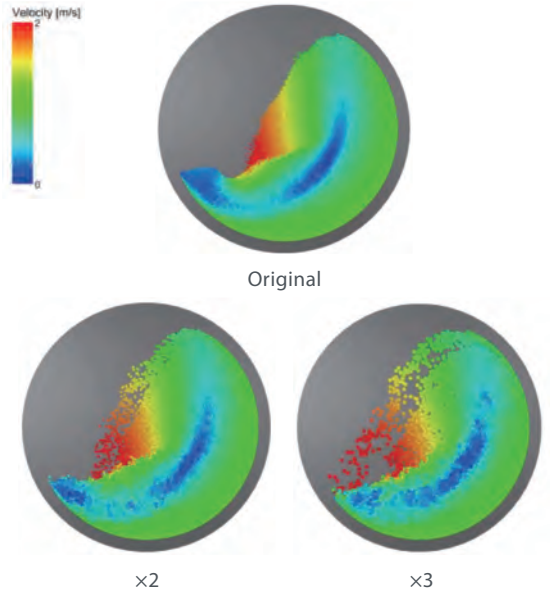
Find out more with Granuleworks videos :
https://www.granuleworks.com/case_example_en.html

Features

SDEM (Scalable DEM)

A technique that reduces the number of particles and improves calculation speeds by replacing multiple original particles in a granular system by large particles (coarse-grained particles) is called coarse-graining technology. **SDEM (Scalable DEM)**, which is one of the coarse-graining technology, is implemented in Granuleworks. By using SDEM, bulk density can be considered in scale particles, and setting parameters at one scale will give similar behavior at other scales. It demonstrates power in DEM simulation of actual machines, as it supports particle size distribution, as well as rotational resistance model and van der Waals force.

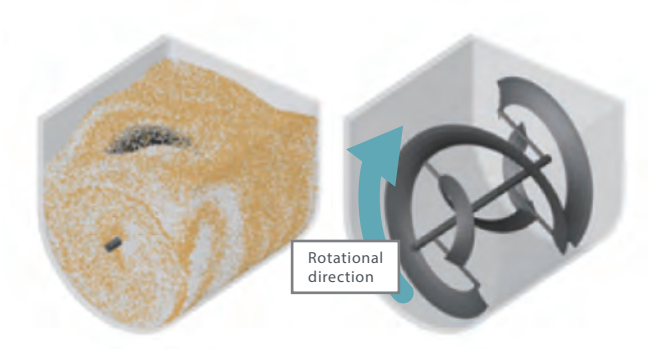




Powder behavior simulation in a rotational container

GPU/CPU High Performance Computing

With the addition of the GPU option feature, it enables fast simulations that take advantage of NVIDIA's CUDA GPU boards. This can significantly reduce computation time and allow you to perform high-speed calculations on a desktop PC, which is equivalent to supercomputers and HPC servers. Also, a new HPC Pack is available to expand the number of cores for parallel computing. The number of cores can be increased efficiently based on 1 Pack (16 cores). You can also install multiple packs, which allows you to assign packs to different jobs. Also, multiple packs can be installed, allowing you to assign a pack to each job.

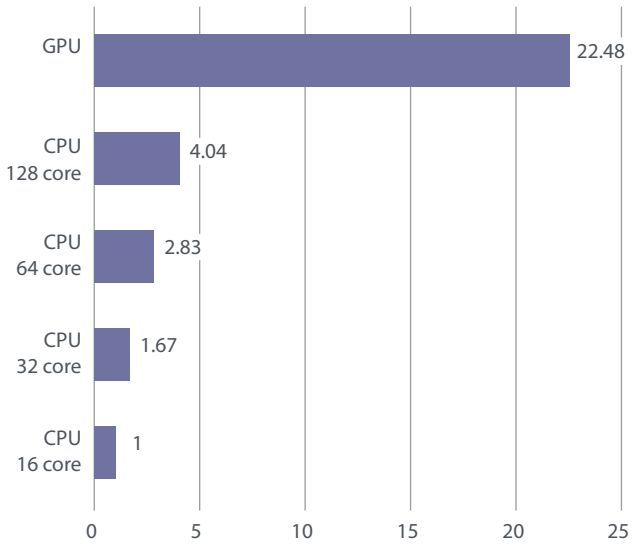


Number of particles: 1.7 million

Simulation condition	
Volume	1000 L
Number of rotations	20 rpm

Material property	
Density	1200 kg / m³
Diameter	10 mm

Computational speed ratio with 16 cores of CPU as 1



CPU: Intel Xeon E5-2660v3
GPU: Tesla V100

Granule works™

Advanced Simulator for Granular Materials

PROMETECH.

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