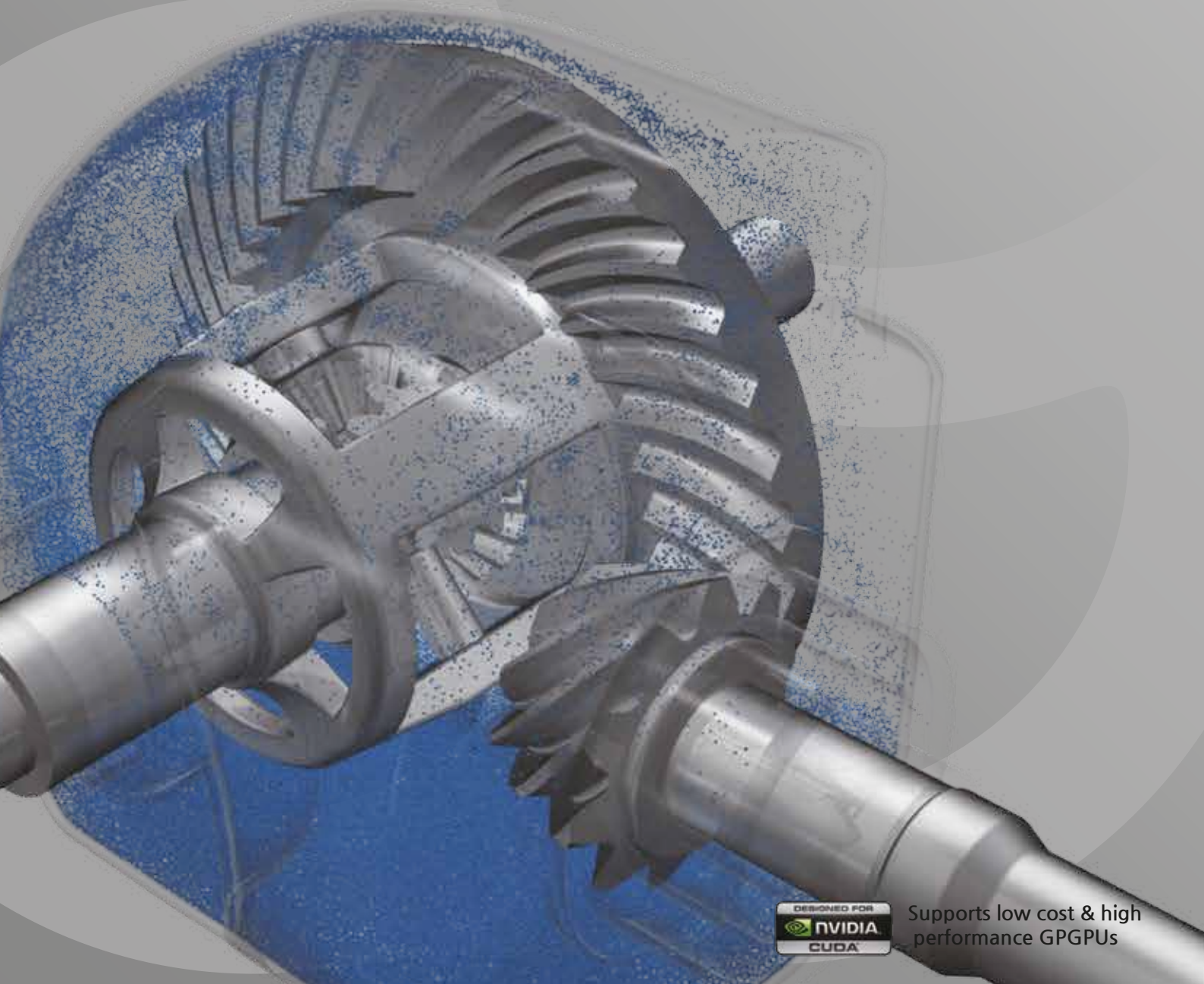
FunctionBay

Particleworks® 6

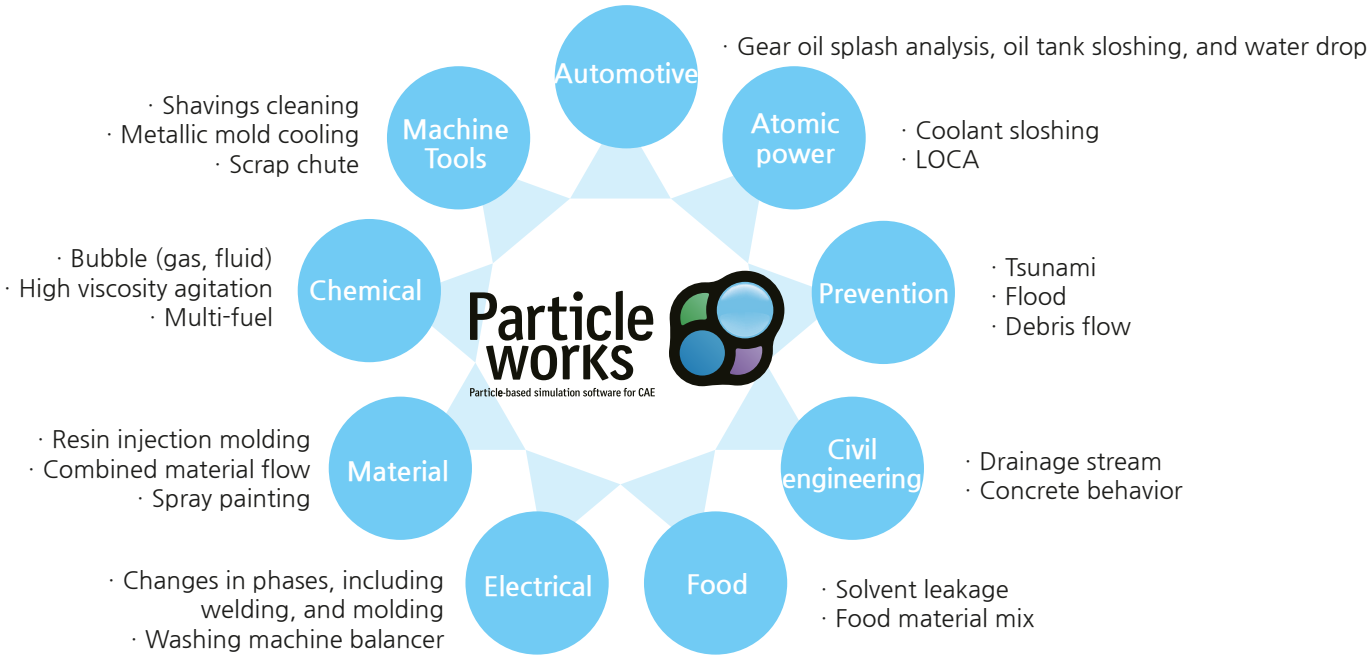
Particle-based simulation software for CAE



Supports low cost & high performance GPGPUs

The Next Generation of Particle-Based CAE Solutions

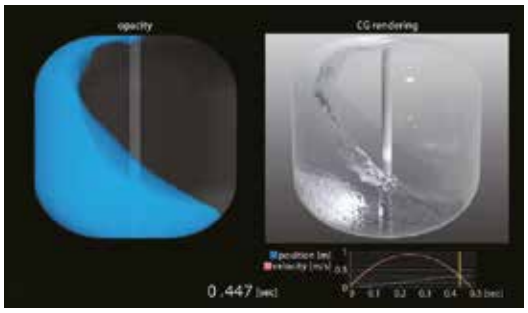
Particleworks is fluid dynamics simulation software based on the recently developed MPS (Moving Particle Simulation) formulation. This method is especially useful for simulations that involve free fluid surfaces. It represents the fluid as a very large collection of particles, and therefore, it does not require a complex mesh. Particleworks achieves very high computational efficiency through the use of gradient and Laplacian models of the Navier-Stokes equations, which are the fundamental equations of fluid dynamics. Particleworks is already used by a large number of industries in various fields.



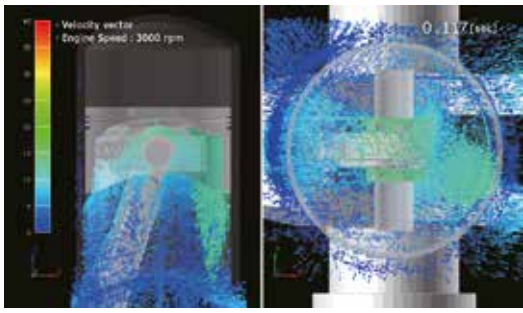
Examples

* Some images produced using 3rd party rendering software

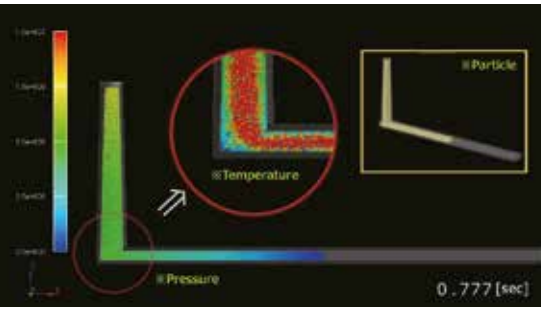
△ Oil splash in a Gear System



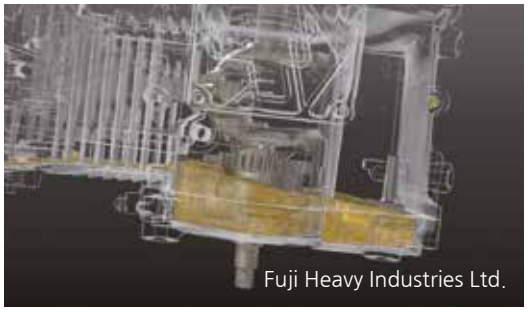
△ Tank slosh



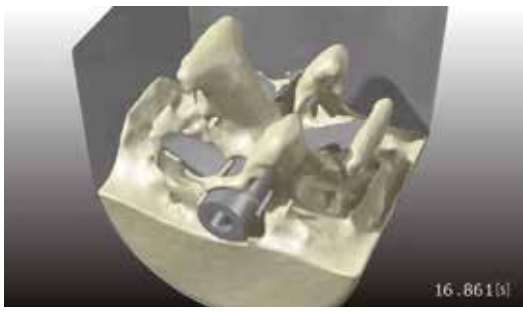
△ Connecting rod oil injection



△ Resin injection molding

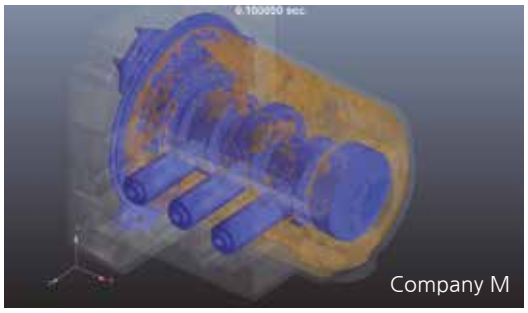


△ Crankcase slosh

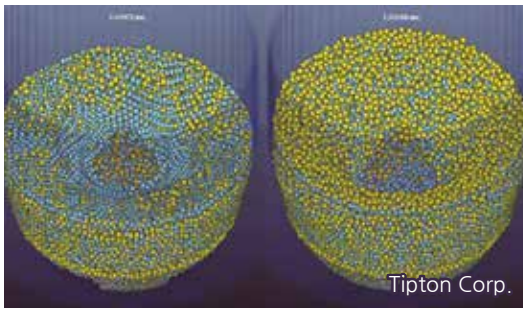


△ High-viscosity agitation

△ Twin axis screw extrusion molding



△ Crankcase oil splash

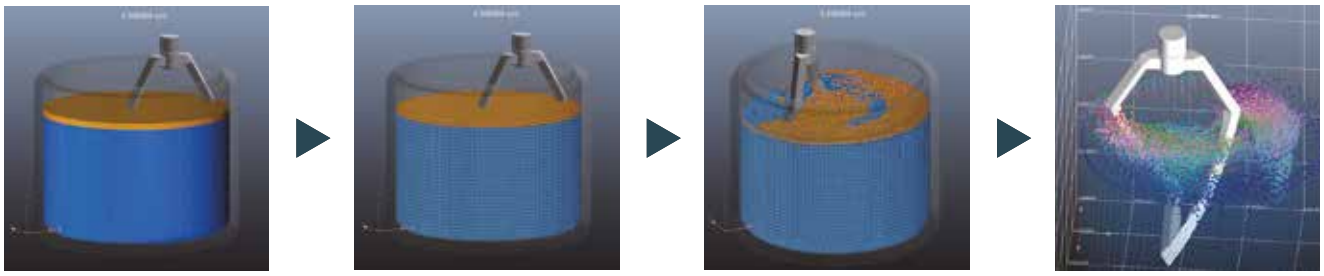


△ Vortex barrel

Pre-Processing, Analysis, and Post-Processing in One Seamless Environment

Particleworks allows you to control the pre-processing, analysis, and post-processing stages through a single GUI. Furthermore, GPUs can be utilized to improve the calculation speed.

Analysis using Particleworks



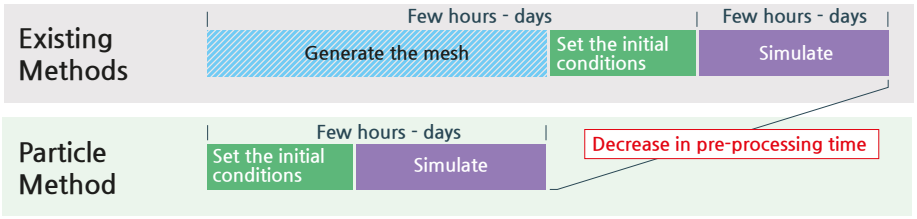
Import geometry data

Prepare particle data
(pre-processing)

Set initial conditions and simulate
(High-speed computation using GPUs)

Evaluate analysis results
(post-processing)

Dramatically reduces pre-processing time



- Dramatic reduction in time to produce results because mesh generation is not required.
- Expertise in fluid dynamics not required to generate meaningful results.

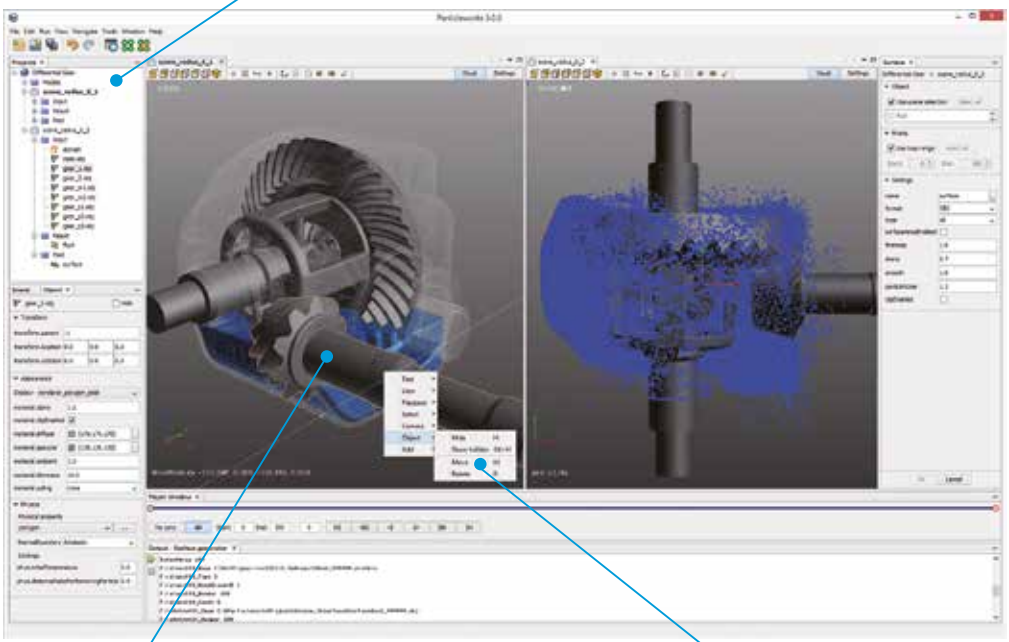
Redesigned User Interface with Increased Functionality and Higher Performance

All functionality previously available in Windows is now also available in Linux. Now, pre-processing, analysis, and post-processing can all be carried out directly in Linux.

Undo/Redo
Undo/Redo supports every form user input, including all parameters, camera controls, and object controls.

Project management efficiency
Analysis cases can be managed from within the project.

Fast Rendering and I/O
Through improvements to file reading and cache management, complex geometry or very large files can be input quickly.

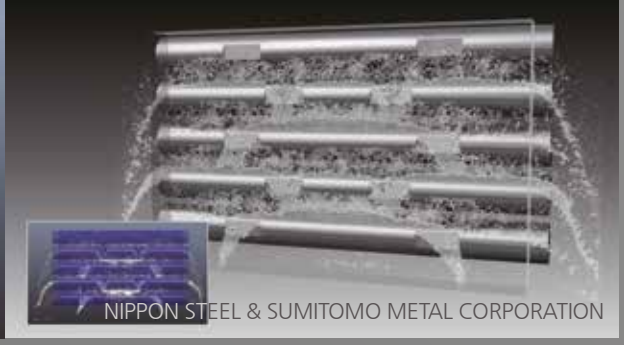


Direct Object Control
Intuitive mouse controls for object editing.

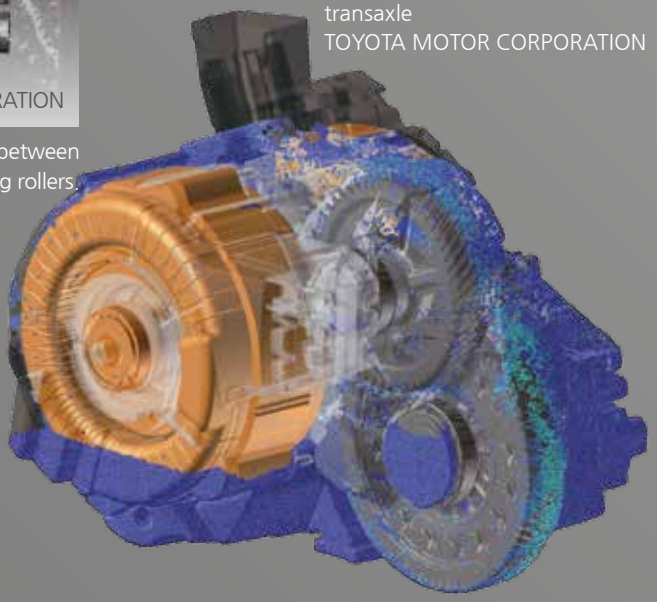
Context menus
Provides quick access to various commands, including animation controls.


Mitsubishi Chemical Corporation

△ Analysis of an agitator tank with a deep vortex


NIPPON STEEL & SUMITOMO METAL CORPORATION

△ Analysis of the spray behavior between continuous casting rollers.

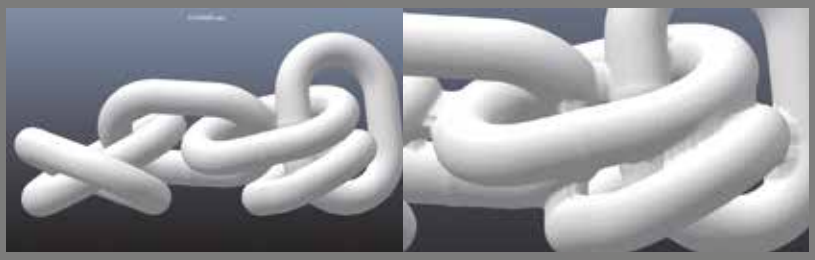

Analysis of oil flow in an HV transaxle
TOYOTA MOTOR CORPORATION

Robust analysis of nonlinear flows with free surfaces

Particleworks provides benefits for problems such as engine gear oil splatter analyses and resin mixing analyses that normally require a mesh that takes a large amount of labor to create.

Improved management of complex shapes

Complex polygon shapes can be automatically simplified using an improved pre-processing distance function algorithm. The manual work required to prevent particles from becoming trapped in small gaps or errors in the geometry has been dramatically reduced.



Improved pre-processing speed through multicore computing.

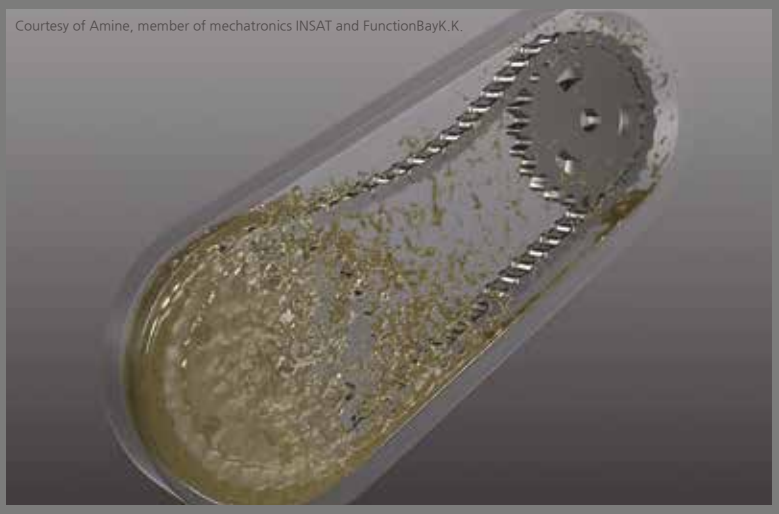
The computation time required in pre-processing has been reduced by up 2 times on a quad-core CPU compared to Particleworks Ver. 4.0.

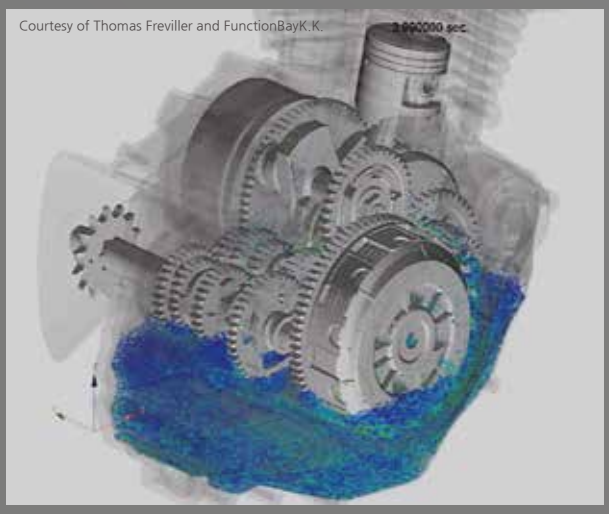
Increase in variety of inlet boundary shapes

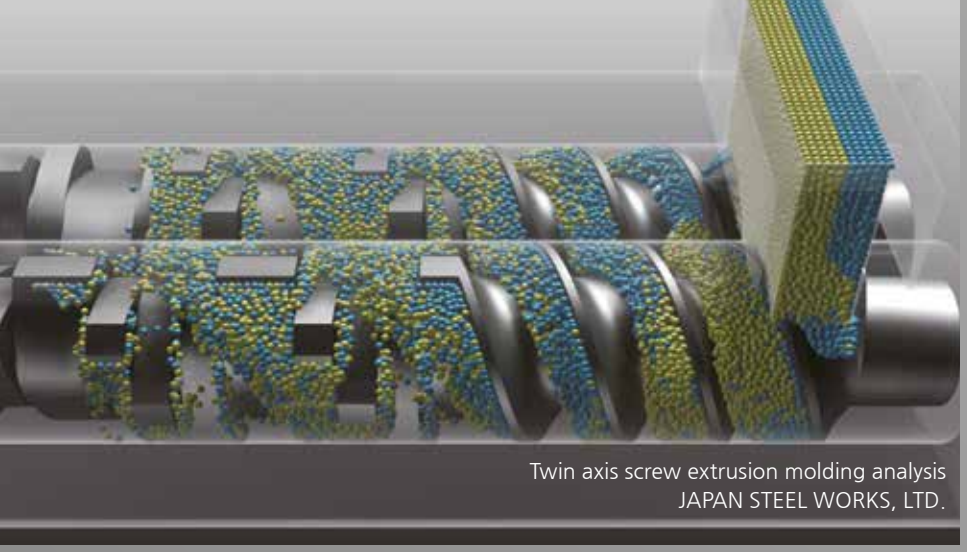
Various inlets shapes, including circular, quadrangle, elliptical, doughnut, and user-specified, can be used to suit the user's need.

Co-simulation of Particleworks (Fluid Dynamics Software) with RecurDyn (Multibody Dynamics Software)

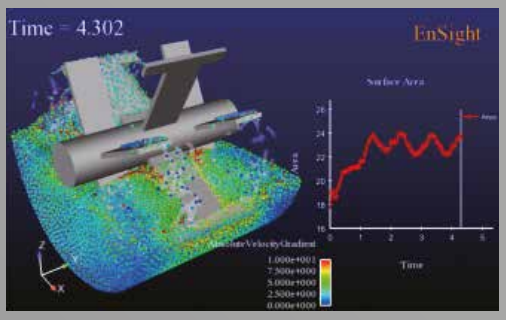
Co-simulation of Particleworks with RecurDyn allows for more realistic analyses of systems in which the fluid influences the motion of the mechanical system. For example, co-simulation can accurately simulate oil leakage and scattering when analyzing the behavior of lubricating oil in a chain system housing.


Courtesy of Amine, member of mechatronics INSAT and FunctionBayK.K.


Courtesy of Thomas Freviller and FunctionBayK.K.



Twin axis screw extrusion molding analysis
JAPAN STEEL WORKS, LTD.



EnSight Output Example

* EnSight: multi-use post processor from CEI software Co., Ltd.
* A separate tool is required to transfer the Particleworks data into EnSight.

Excellent for material agitation, mixing analysis, and moving boundaries

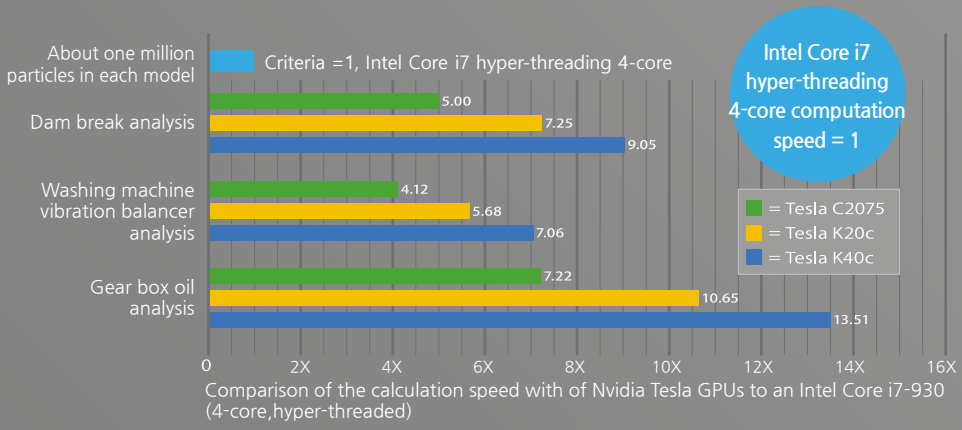
The geometry for an agitation blade created using CAD software can be directly used as boundary geometry for the analysis, so problems with complex boundary geometry can be easily analyzed.

High-speed and accurate simulation is available through cutting-edge GPUs

Rapid, accurate simulations through Cutting-edge GPUs using GPUs, Particleworks can dramatically improve the speed of its computation. The time required for analysis, which is often a bottleneck, can be greatly reduced. Therefore, analysis can be performed using regular PCs instead of expensive supercomputer or HPC servers. (Note: GPU usage is optional.)

Approximately 10x speed increase by using a single GPU

* Particleworks requires about 6 GB of GPU memory to analyze one million particles.
* The number of analyzable particles can be increased by using multiple GPUs at the same time.

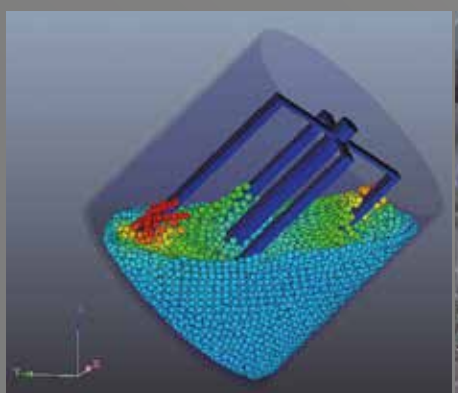


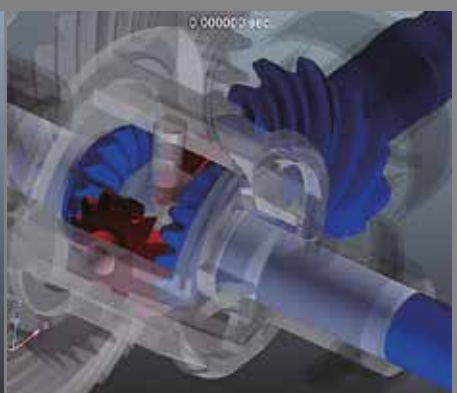
Comparison of the calculation speed with of Nvidia Tesla GPUs to an Intel Core i7-930 (4-core,hyper-threaded)

△ NVIDIA Tesla K40c GPU Accelerator Board

Rotational motion around arbitrary axes

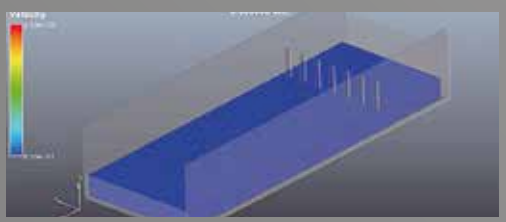
The axis of the rotation of rigid boundary geometry can be defined around arbitrary axes. Therefore, rotation is not limited to rotation around coordinate axes. Furthermore, motion can also easily be defined relative to another pre-defined motion.

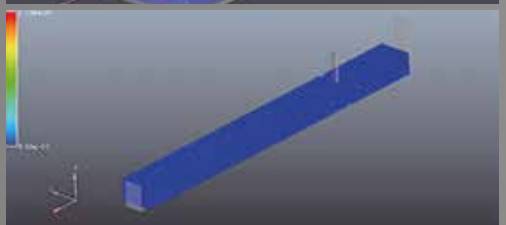




Variations of Boundary Conditions

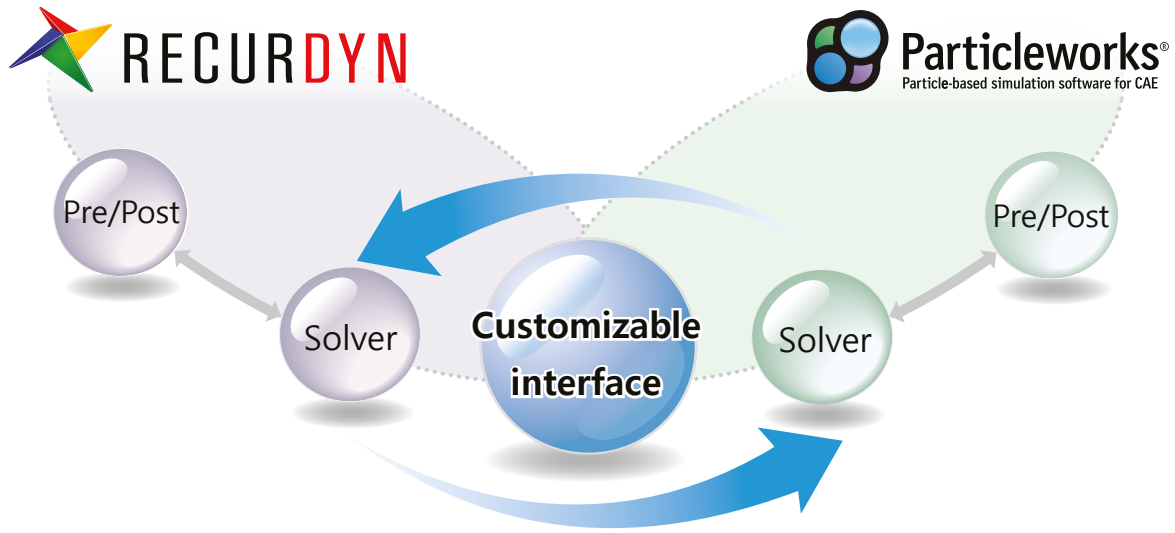
When a model has a repeating shape or symmetry, it is possible to simplify the model using special boundary conditions to isolate a single instance of the shape to increase the speed of the simulation.



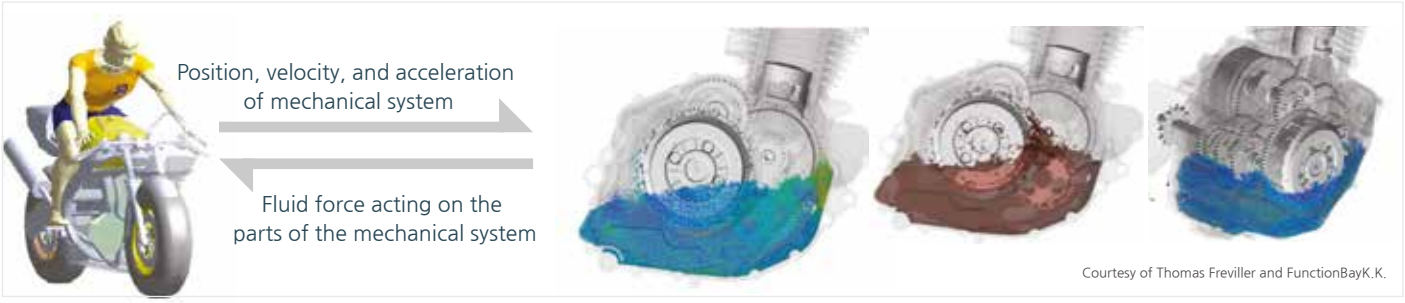


World's First CFD-Specific Multibody and Fluid Dynamics Co-simulation Interface

RecurDyn, powerful multibody dynamics software, supports Co-simulation with Particleworks through a Particleworks-specific interface. Through this interface, mechanical systems and fluids can interact directly. Previously, it was not easy to simulate the interaction of the dynamics of solid components and the fluids. Now, through Co-simulation between RecurDyn and Particleworks, the motion of the mechanical components and the fluid can influence each other.



RecurDyn - Particleworks Co-Simulation



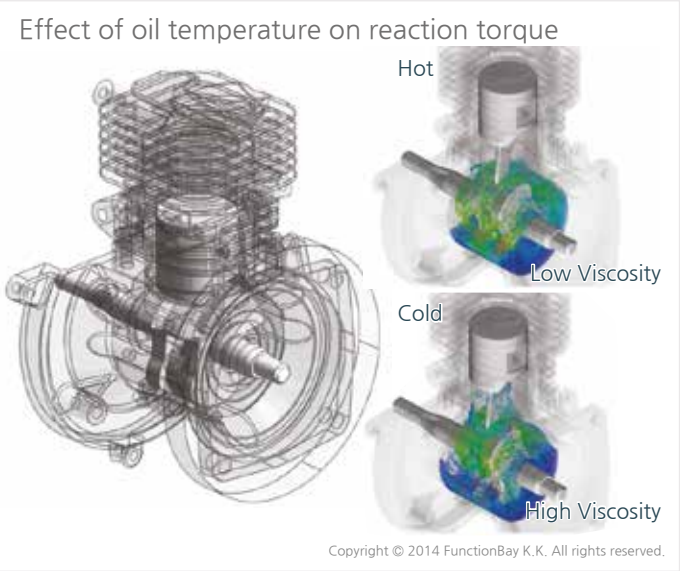
· Captures the effects of the motion of the mechanical system on the fluid.
· Captures the effects of fluid behavior on the mechanical system.
· The effect of the behavior of the mechanical system can be seen in the surfaces and turbulence of the fluid.

▶ Benefits for RecurDyn of Co-simulation with Particleworks

	Analysis using RecurDyn Alone	RecurDyn-Particleworks Co-simulation
Resistive Fluid Force (Gear oil splash)	Use simplified analytical or empirical force model	Use realistic fluid force directly on the mechanical system parts
Fluid Momentum (Washing machine balancer)	Use small number of rigid spheres	
Propulsive Fluid Force (Hydraulic torque converter)	Use simplified analytical or empirical force model	
Buoyant Fluid Force (Boat, buoy)	Use simplified analytical or empirical force model	

Co-simulation example

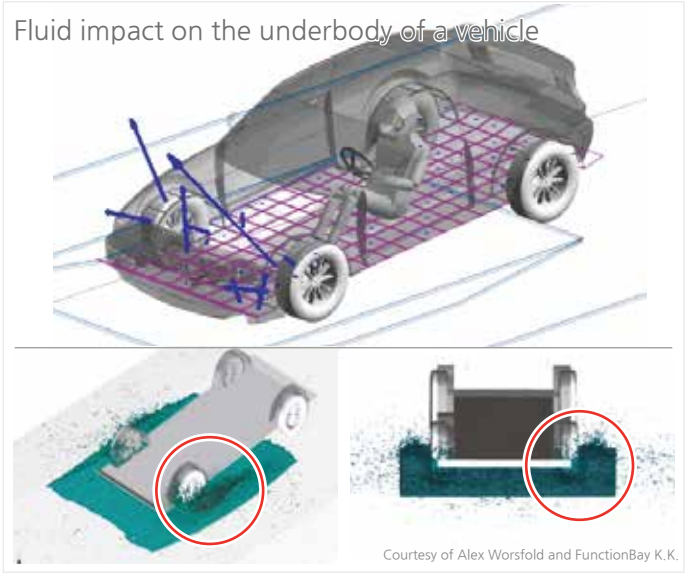
Reaction torque from lubrication oil on a single cylinder engine at various temperatures



· Demonstrates the relation between the viscosity and reaction torque caused by the lubricating oil at various temperatures.
· Predicts the differences in deceleration at different lubrication oil viscosities caused by variations in temperature.

Co-simulation example

Fluid impact on the underbody of a vehicle when driving through a puddle



· Simulates the fluid impact on the underbody of a vehicle.
· Shows the flow of the splashed water around parts accessible from the underside of the car, which is especially important for electric and hybrid cars.

Co-simulation example

Oil sloshing in a vehicle's fuel tank

· Predicts realistic fluid behavior during severe tank sloshing and the influence of the fluid dynamics of the fuel on the vehicle.
· The fluid slosh can be visualized in the GUI of Particleworks.
· Allows for the analysis of the interaction between the vehicle and the fuel tank.

▶ Benefits for Paricleworks of Co-simulation with RecurDyn

	Analysis using Particleworks alone	RecurDyn-Particleworks Co-simulation
Buoyancy forces	Simplified body of floating object	Realistic mechanical system bodies
Fluid forces	Output is simple color-based, contour plot	Output is vector-based display of output, x-y plots Fluid load can dynamically affect the motion of the mechanical system
Moving boundaries	Scripted motion of boundaries only	Boundaries dynamically driven by fluids and the mechanical system The bodies of mechanical system can interact using joints and contact forces Can also be used to design controllers for the mechanical system
Flexible bodies	Not possible	Pseudo-flexible bodies approximated as collections of rigid bodies Flexible parts not in contact with fluids can be represented as flexible bodies

Particleworks Specifications and Functionality

· Solver

Analysis Type / Functionality	CPU Analysis	GPU Analysis	2D Analysis
· Free surface flow/abnormal flow	◉	◉	◉
· MPS-DEM ductility analysis	◉	◉	—
· Fluid-robust analysis	◉	—	◉
· Pressure calculation formulation (explicit/implicit)	◉	◉	◉
· Negative pressure model	◉	—	—
· Viscosity calculation formulation (explicit/implicit methods)	◉	◉	◉
· Surface tension (potential model/CSF model)	◉	◉	◉
· Non-Newtonian fluid model (Bingham/Power law/Cross Arrhenius/ user defined [through table or function])	◉	◉	◉
· Turbulence analysis (LES + surface model)	◉	◉	—
· Air resistance model	◉	◉	—
· Parallel computation methodology (SMP/MPP/Hybrid)	◉	—	◉

Boundary condition options
- Moving influx boundaries
- Moving polygon tessellated boundaries

Optional capabilities:
- GPU computing for high-speed computation
- Two-dimensional analysis

· Pre-post

Pre-Processing
- Setting analysis conditions (Identifying geometry as defining fluid particles or polygonal geometry)
- Generating inlet geometry (circular/quadrangle/ elliptical /user-defined)
- Importing geometry data (STL, OBJ, and Nastran file formats supported)
- Importing tabular data (csv file format supported)

Post-processing
- Rendering functionality (contour, path of particle, equivalent surface, animation, surface)
- Computed output (position, velocity, pressure, shear strain rate, torque, etc.)
- Binary file output (screen display image (JPEG/PNG), video (MPEG/AVI), surface (STL format), simulation result data ASCII conversion (prof))
- Text file output (csv format)

System Requirements
- Supported OSs: Windows Vista / Windows 7 / Windows 8 / RedHat Enterprise Linux WS5.6 (64bit) / SuSE Linux Enterprise Desktop10 (64bit)
- OpenGL: 3.0 or Later
- RAM: Minimum 2GB
- HDD: Minimum 5GB

Supported GPUs
- NVIDIA Tesla C2050 (3GB) / C2070, C2075,
- M2090 (6GB) / K20 (5GB) / K40 ATLAS (12GB)
- NVIDIA GeForce GTX 480, 580 (1.5GB) / TITAN (6GB)

FunctionBay

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