SIMULATIONS WITH MESHFREE

MESHRFREE is an innovative software tool in fluid and continuum mechanics developed by Fraunhofer ITWM and Fraunhofer SCAI. It joins the meshfree Finite Pointset Method (FPM) with the scalable as well as robust linear solvers of the SAMG library in an optimal way.

In contrast to classical CFD methods, it is a meshfree method based on a cloud of numerical points without the need of meshing and re-meshing. One of its fundamental features is the Lagrangian formulation that enables the point cloud to move with the flow, thus, transporting all physical information in a natural way. Hence, MESHFREE is able to overcome the drawbacks of existing meshbased CFD methods like Finite Element (FEM), Finite Volume (FVM), or Finite Difference Methods (FDM). In particular, transient flows with moving geometry parts, free surfaces, phase boundaries as well as large deformations are handled efficiently.

Compared to standard software packages, the complete absence of a mesh reduces the preprocessing effort in MESHFREE as the geometry can be directly imported from CAD tools. Only initial and boundary conditions together with appropriate material modeling must be provided by the user. The preparation of the simulation setup is supported by an intuitive user interface including a graphical highlighting of the addressed geometry parts.

MESHFREE offers the users numerous possibilities to customize their setup, e.g. by adding custom partial differential equations or automatic refinement and coarsening criteria for the point cloud.

The software is fully parallelized (shared and distributed memory) reducing the computation time. A visualization tool specifically developed for MESHFREE is included in the package.
1 Turning gear wheels in an oil bath
2 Mixing of dough
3 Pointcloud refinement due to error analysis triggered by velocity gradient (Karman vortex street)

Fields of application

Due to its general character, MESHFREE is suitable for the simulation of compressible and incompressible flow processes in various applications:

- Deployment of complex folded airbags
- Chip formation
- Glass forming
- Fluid-Structure-Interaction
- Mixing
- Phase transitions (e.g. freezing)
- Re-fueling of motor vehicles
- Solid mechanics
- Water crossing of motor vehicles
- General free surface and multiphase problems
- Water management
- Granular material flow
- Sloshing in tanks

Models

The basic set of partial differential equations consists of conservation of mass, momentum, and energy. It is solved by a generalized finite difference approach. Additionally, MESHFREE provides the following models:

- Turbulence (k-epsilon)
- Foam
- Freezing (latent heat, expansion)
- Population balances
- Material models: linear elastic, elasto-plastic, visco-elastic, hypoplastic/barodetic
- Thin-film approximations (shallow water)
- Granular material flow

The multitude of material models emphasizes MESHFREE as a multipurpose tool, able to model Newtonian and non-Newtonian flows as well as solid material behavior.

Features

The most important features of MESHFREE are:

- CAD interface
- Model customization
- Parallelization
- Graphical User Interface
- Robust and scalable linear solvers
- Specific postprocessing tool

Cooperation partners

- ESI Group
- Cummins
- VW Group
- Hilite
- Voith Hydro
- Schott