# 6-way CFD-DEM-FEM partitioned momentum coupling using preCICE

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## ABSTRACT

Many real-life complex phenomena can be described using momentum between fluids, particles, and solids. These descriptions can be used to represent countless applications in industrial sectors such as manufacturing & production, aerospace, medical & pharmaceutical, energy, and waste management. It is expensive and difficult if not impossible to create experimental tests for such complex processes. Hence it is crucial to perform numerical simulations. To achieve simulations for such applications, diverse simulation platforms among them Computational Fluid Dynamics (CFD), Discrete Element Methods (DEM), and/or  Finite Element Methods (FEM) need to be coupled with each other to represent a multi-physics application.

Our prototype uses the preCICE[1] coupling library to couple 3 numerical solvers: eXtended Discrete Element Method[2] (XDEM) (for DEM), OpenFOAM[3] (for CFD), and CalculiX[4] (for FEM). The XDEM solver receives various CFD data fields such as fluid domain properties, and flow conditions exchanged through preCICE, which are used to set boundary conditions for particles. XDEM handles the particle motion, forces on structures, chemical reactions, and HMT source terms. Various drag transfer laws have been implemented in XDEM to steer source term computations. The source terms computed by XDEM are transferred to the CFD solver and added as source terms that represent particle contribution to CFD. CalculiX uses the forces coming from the fluid solver and XDEM as boundary conditions to solve for the displacements.

This work demonstrates the rapid development of a simulation environment to achieve momentum coupling capabilities through various test cases. We demonstrate the 6-way coupling between CFD-DEM-FEM, where CFD-DEM Eulerian-Lagrangian coupling is achieved over a volumetric mesh, while CFD-FEM and DEM-FEM are coupled over a surface mesh. The generic coupling interface of preCICE, XDEM, and its adapter allows us to get closer to a digital twin for the Abrasive Water Jet Cutting (AWJC) Nozzle where we simulate the water jet, entrained particles, as well as the solid nozzle. The results for the AWJC Nozzle are presented.

## REFERENCES

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