6-way CFD-DEM-FEM momentum & HMT coupling using preCICE

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Many real life complex phenomena can be described using momentum and/or Heat & Mass Transfer (HMT) 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 numeircal 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 (for CFD), and CalculiX (for FEM). XDEM handles the particle motion, forces on structures, chemical reactions and HMT source terms. Various drag, heat and mass 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 the heat, mass and momentum coupling capabilities through various test cases and then compare them with our legacy XDEM-OpenFOAM coupling and experimental results. We demonstrate CFD-DEM Eulerian-Lagrangian volumetric coupling, and CFD-FEM, DEM-FEM surface coupling.

References:

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