Investigation of CFD-DEM-FEM momentum coupling results for AWJC Nozzle using preCICE

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ABSTRACT

Abrasive Water Jet Cutting (AWJC) Nozzle uses a high-speed water jet as its momentum source. This momentum is transferred to the abrasive particles and the air within the nozzle. This leads to turbulent and complex particle-laden flow. The flow conditions influence the impacts of the particle on the nozzle, thus influencing erosion. Hence it is imperative to predict this complex particle-laden flow correctly.

We develop a multi-physics partitioned simulation environment [4] using preCICE [2] for coupling of eXtended Discrete Element Method (XDEM) [1] (for the particle motion), OpenFOAM [3] (for the fluid), and CalculiX [7] (for the solid displacements/vibrations). XDEM uses the fluid flow conditions to compute the forces acting on particles. It also computes the particle momentum source that is communicated to the fluid solver using the preCICE library and its adapters. It is then injected into the fluid solver as a source term in the momentum equation. CalculiX uses the forces coming from the fluid solver and XDEM as boundary conditions to solve for the displacements. It is also used for computing the vibrations induced by particle impacts.

We achieve CFD-DEM coupling on a volumetric coupling and CFD-FEM, DEM-FEM surface coupling. We investigate the coupled CFD-DEM results as the momentum exchange can come directly from the water jet to the particles or indirectly through the airflow. Subsequently, the particles also influence and alter the fluid flow inside the nozzle.

We also study the effect of different particle inlet conditions on the particle-laden flow. Our coupled simulation results align with the literature [5]. As the particle-laden flow is captured correctly. The FEM module of the coupled simulations captures the particle impacts on the Nozzle which are influenced by the flow conditions. The FEM results gives us displacements of the Nozzle due to these impacts. These numerical results are to be compared with the experimental observations [6].

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