AWJC Nozzle simulation by 6-way coupling of DEM+CFD+FEM using preCICE coupling library

Prasad ADHAV*, Xavier BESSERON†, Alban ROUSSET× and Bernhard PETERS§

Faculté des Sciences, de la Technologie et Médecine (FSTM)
Université du Luxembourg (Uni LU)
Campus Belval, 2, avenue de l'Université, L-4365 Esch-sur-Alzette
e-mail: *prasad.adhav@uni.lu, †xavier.besseron@uni.lu, ×alban.rousset@uni.lu,
§bernhard.peters@uni.lu, web page: https://luxdem.uni.lu/

ABSTRACT

The objective of this work is to study the particle-laden fluid-structure interaction within an Abrasive Water Jet Cutting Nozzle. Such coupling is needed to study the erosion phenomena caused by the abrasive particles inside the nozzle. So far, the erosion in the nozzle was predicted only through the number of collisions, using only a simple DEM+CFD[1] coupling. To improve these predictions, we extend our model to a 6-way Eulerian-Lagrangian momentum coupling with DEM+CFD+FEM to account for deformations and vibrations in the nozzle.

Our prototype uses the preCICE coupling library[2] to couple 3 numerical solvers: XDEM[3] (for the particle motion), OpenFOAM[4] (for the water jet), and CalculiX[5] (for the nozzle deformation). XDEM handles all the particle motions based on the fluid properties and flow conditions, and it calculates drag terms. In the fluid solver, particles are modeled as drag and are injected in the momentum equation as a source term. 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.

The preliminary 6-way DEM+CFD+FEM coupled simulation is able to capture the complex particle-laden multiphase fluid-structure interaction inside AWJC Nozzle. The erosion concentration zones are identified and are compared to DEM+CFD coupling[1]. The results obtained are planned to be used for predicting erosion intensity in addition to the concentration zones. In the future, we aim to compare the erosions predictions to experimental data in order to evaluate the suitability of our approach. The FEM module of the coupled simulation captures the vibration frequency induced by particles and compares it with the natural frequency of the nozzle. Thus opening up opportunities for further investigation and improvement of the Nozzle design.

Keywords: Multiphysics, Coupled Simulations, Discrete Element Methods, Fluid Structure Interaction, Particle laden flow, Abrasive Water Jet Cutting

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