

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

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Motivation:

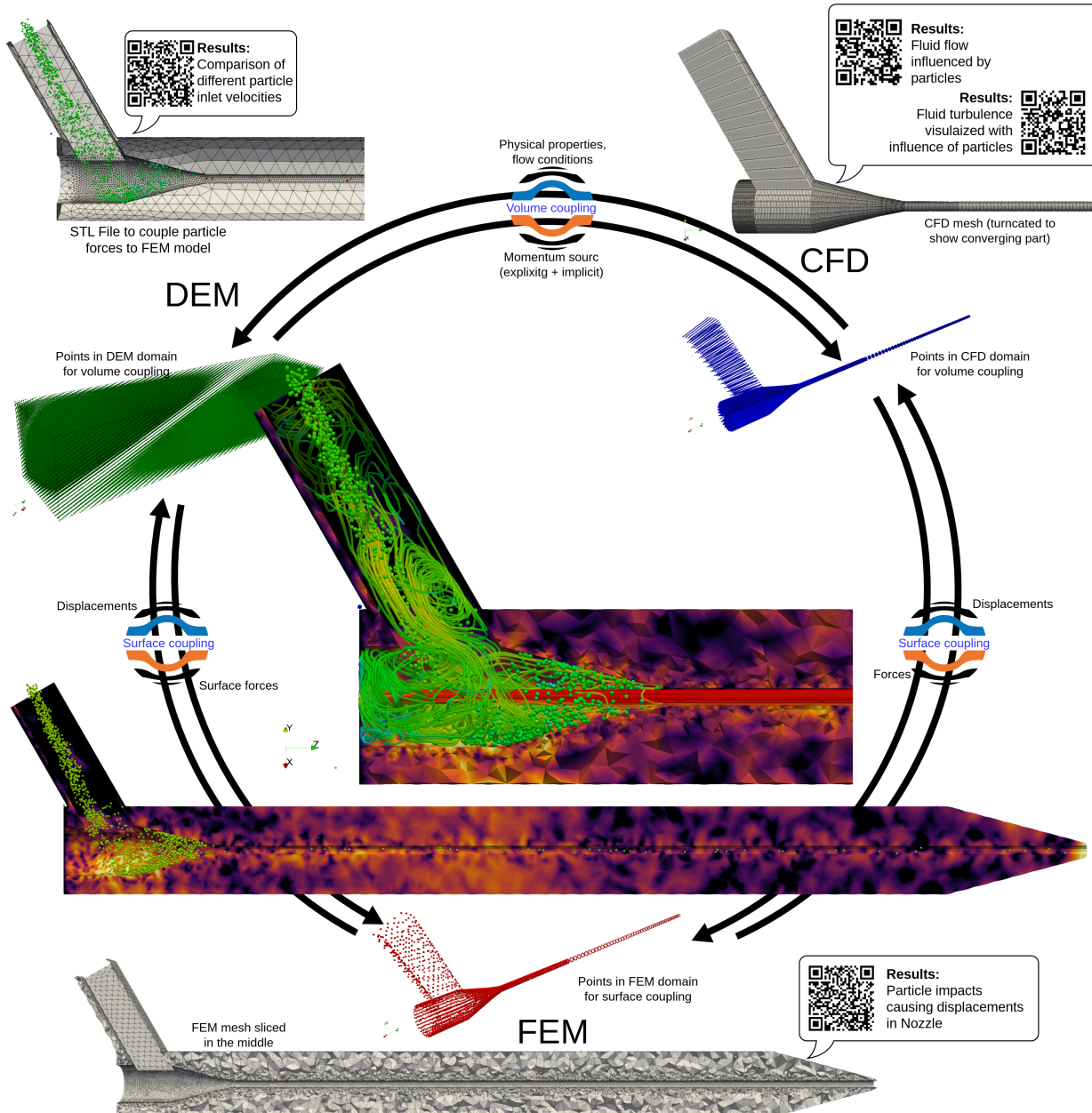
- Abrasive Water Jet Cutting Nozzle used for various applications requiring thermal residual free cutting
- Nozzle is the first target of abrasive particles leading to erosion
- The evolution of erosion is difficult to capture due to a hostile environment inside the nozzle

Solution:

- Acoustic and displacement data available from experiments
- CFD-DEM can identify erosion concentration zones
- Need to couple FEM to get the displacement of the Nozzle
- Vibrational analysis to get the acoustic spectra

Implementation

- Use preCICE[1] for black box coupling
- Couple XDEM[2], OpenFOAM[3] & CalculiX[4]
- CFD-DEM volume coupling
- CFD-FEM, DEM-FEM surface coupling



Conclusion:

- Developed XDEM preCICE adapter to couple with CFD & FEM
- Adapted OpenFOAM preCICE adapter for volume coupling
- Achieved 6way CFD-DEM-FEM momentum coupling
- Particle-laden flow characteristics in the Nozzle same as the literature
- Post-process & compare displacements with experimental observations
- Predict erosion inside the focusing tube (Nozzle)

References:

- [1] Chourdakis, Gerasimos, et al. "preCICE v2: A sustainable and user-friendly coupling library." *Open Research Europe* 2 (2022).
- [2] Peters, Bernhard, et al. "XDEM multi-physics and multi-scale simulation technology: Review of DEM-CFD coupling, methodology and engineering applications." *Particology* 44 (2019): 176-193.
- [3] OpenFOAM <https://openfoam.org/>
- [4] Dondt, G. "The Finite Element Method for Three-Dimensional Thermomechanical Applications", Wiley, 2004
- [5] Nanduri, Madhusarathi, David G. Taggart, and Thomas J. Kim. "The effects of system and geometric parameters on abrasive water jet nozzle wear." *International Journal of Machine Tools and Manufacture* 42.5 (2002): 615-623.