Lehrstuhl für Statik und Dynamik

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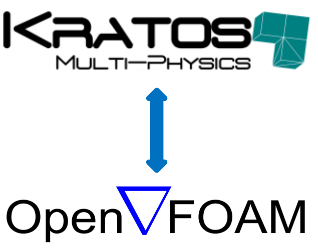
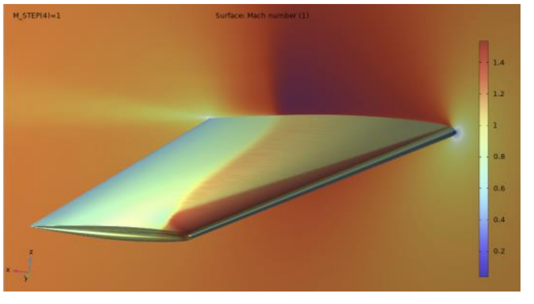
Study Project:

Coupling Kratos Multiphysics with OpenFOAM Compressible Solvers for Strongly Coupled FSI Problems

This study project aims to extend the coupling framework between Kratos Multiphysics and OpenFOAM to support compressible flow solvers and strong (implicit) coupling within the Kratos CoSimulationApplication. Building on previous work that developed a general adapter for incompressible solvers, the present study enhances the interoperability between the two open-source platforms to enable accurate and stable fluid–structure interaction (FSI) simulations in the compressible flow regime.





The coupling framework adopts a partitioned approach, where OpenFOAM serves as the fluid solver and Kratos handles the structural domain. Communication between solvers is managed via CoSimIO, using file-based data exchange with full MPI parallelism for distributed-memory execution.
As part of this work, the developed coupling will be validated through benchmark with incompressible and compressible FSI cases and applied to the analysis of transonic flow over a flexible wing structure, assessing aerodynamic–structural coupling effects, convergence behavior, and computational performance.

Recommended working steps:

1) Familiarization with theoretical background

- Study the concepts of partitioned simulations, co-simulation strategies, and data mapping techniques between non-matching meshes.
- Review weak vs. strong coupling approaches and their implications for stability and convergence in FSI problems.

2) Study of Kratos CoSimulationApplication

- Explore the architecture and workflow of the CoSimulationApplication in Kratos.

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- Review the existing OpenFOAM solver wrapper and adapter for incompressible solvers to understand data flow and communication mechanisms.

3) Software setup and verification
- Install and compile Kratos Multiphysics and OpenFOAM (latest compatible versions).
- Verify the installation by running basic standalone cases in both frameworks.

4) Reproduction of existing incompressible FSI cases
- Run benchmark incompressible FSI simulations (e.g., flow-induced vibration of a flexible beam) using the existing Kratos–OpenFOAM coupling setup.
- Analyze the coupling workflow, data exchange mechanism, and solver synchronization.

5) Exploration of compressible flow solvers in OpenFOAM
- Review and test different compressible solvers (e.g., rhoPimpleFoam, rhoCentralFoam, sonicFoam).
- Perform standalone compressible simulations to gain experience with transonic and supersonic regimes, turbulence models, and boundary conditions.

6) Assessment of the current coupling framework
- Study whether the existing Kratos–OpenFOAM adapter and solver wrapper are suitable for performing strongly coupled compressible FSI simulations.
- Identify potential limitations in data handling, time synchronization, or convergence control that could affect strong coupling performance.

7) Application case: Transonic flow over a flexible wing
- Set up and run a transonic aeroelastic simulation using the coupled Kratos–OpenFOAM framework.

8) Documentation and dissemination
- Document the methodology, implementation details, and validation results.
- Provide recommendations for further development and current limitations in the framework

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