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Simulation of the flow-acoustic-structural interaction in flow ducts using a partitioned approach in the time domain

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Duct systems confining a subsonic air flow, such as ventilation ducts, often have a lightweight design. These lightweight constructions are easily excited by unsteady pressure fluctuations in the flow, causing structural vibrations and noise emissions. Designing effective solutions for this problem requires a better understanding of the multi-physical interaction and efficient modelling tools. For modelling the convective effects influencing the noise propagation in the flow-acoustic domain, it suffices to solve the linearized Navier-Stokes equations, describing the propagation of first-order fluctuations through a known and steady mean flow. The structural domain can be described by the Mindlin-Reissner shell theory. Due to the confined configuration, the vibro-acoustic interaction is a strong two-way interaction and is included in the model by coupling a flow-acoustic solver with a structural solver. The kinematic and dynamic continuity at the interface is ensured in this partitioned approach by a data exchange during runtime between the solvers.

This partitioned simulation approach is used to study the flow-acoustic-structural interaction for different flow configurations. The flow-acoustic solver solves the time domain Linearized Euler Equations and uses a higher-order discontinuous Galerkin method for the spatial discretization and an explicit Runge-Kutta scheme for time marching. The structural solver for linear elasto-dynamics applies the Finite Element method and the implicit Newmark-Beta scheme. The data exchange is carried out using the Conventional Serial Staggered scheme and the Nearest Projection mapping algorithm of the open-source library preCICE [1]. The analysis of the flow-acoustic-structural interaction in a flexible flow duct with rectangular cross section was given in [2]. In this work, also the energy conservation during the data exchange between the two physical domains will be verified.

REFERENCES

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