FSI of rocket nozzles – On the influence of simplified modeling of structural boundary conditions for a complex FSI experiment & scalable solvers for strongly coupled problems

Abstract:
The influence of boundary conditions (BC) of the structure in a complex FSI experiment are investigated and different simple models for the BC are presented to accurately capture the behavior of the experiment. The interaction of a shock wave with a supersonic boundary layer on an elastic panel was investigated experimentally in order to validate the numerical tools developed within the SFB/TRR 40. During numerical analysis of the fluid-structure interaction (FSI), the support of the panel was assumed to be fully fixed which turned out to be inappropriate. As the focus of the investigations is on the FSI, it is not desirable to consider the panel clamping region with its rivets where a complex contact and prestressing scenario occurs. Hence, an elegant modeling approach is developed which accounts for the relevant aspects of the clamping while reducing its complexity by far. Translational and rotational springs are included to surrogate the “soft” behavior observed in both in static and dynamic experiments. Additionally, the compressibility of the air enclosed in the cavity below the panel turned out to
influence the eigenfrequency of the panel yielding a Robin-type boundary condition. Besides the modeling of boundary conditions, a second aspect in this work is the improvement of the linear solver for monolithic coupled multi-field problems as they occur in thermo-structure interaction. Different preconditioning strategies for the linear systems are applied to the test case which consists of the temperature dependent deformation of a rocket nozzle. Good scalability can be achieved using the developed preconditioning strategies.