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EXPERIMENTAL STUDIES ON SUPERSONIC AEROTHERMAL FLUID-STRUCTURE INTERACTION

Abstract

From the very beginning of aviation to today's ventures into hypersonics and reusable launch vehicles, mastering fluid structure-interaction has always been a prerequisite to progress while failure to sufficiently understand these issues oftentimes caused major setbacks. The failure of Ariane flight 157 is a fairly recent example. Vehicles traversing earth's atmosphere at high speeds are subject to a combination of severe thermal and mechanical loads on their surface and especially also in the engine. In addition, obtaining even a modest payload mass fraction requires very light weight design inherently prone to structural deformation. Thus, reliable design tools to predict such behavior are crucial for launcher development.

The Collaborative Research Center Transregio 40 (SFB/TRR40) of the German Research Foundation (DFG) is working on fundamental technologies for the development of future launcher components under high thermal and mechanical loads. In many cases, these problems involve a coupling of fluid and structure. The approach often taken in SFB/TRR40 to improve understanding of such demanding coupled problems is to develop modelling and experiments designed for validation in cooperative projects.

The proposed paper presents the current work in SFB/TRR40 on supersonic fluid-structure interaction with regard to the finished, ongoing, and planned experimental studies. For validation of numerical models, well designed and instrumented experiments are of utmost importance. We consider three different experimental setups at different flow conditions in different facilities. A study of a "cold" case yielded results on shock wave/boundary layer interaction and the response of an elastic structure. A "hot" case with a buckling structure showing plastic deformation is currently investigated and first results will be presented. A case with combined thermal and mechanical loads is under preparation. Obtaining and mounting high quality structural specimens and their instrumentation as well as instrumentation for the flow field of the various cases is quite demanding with respect to the aims of the experiments and boundary conditions due to the wind tunnel facilities. We measure structural deformations using high speed capacitive and laser distance sensors as well as stereo optical tracking. The flow field is studied using high speed pressure sensors and high speed schlieren optics to allow combined analysis of structural dynamics and flow field.