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EXPERIMENTAL STUDIES ON AEROTHERMAL FLUID-STRUCTURE INTERACTION WITH PLASTIC DEFORMATION

Abstract

From the early days of aviation to today's ventures into hypersonics and reusable launch vehicles, mastering fluid-structure interaction (FSI) has always been a prerequisite to progress while failure to sufficiently address these issues has oftentimes caused major setbacks.

Vehicles travelling earth's atmosphere at high speeds are subject to severe aerothermal loads from the surrounding flow field and in many cases also from their propulsion system. Obtaining a sufficient payload mass fraction requires very light weight design inherently prone to structural deformation that can in turn alter the flow field and aerothermal loads. Thus, reliable coupled design tools to predict such behavior are crucial for launcher development, especially considering the current interest in reusable systems. These tools require reliable experimental data sets for validation.

The proposed paper presents current experimental work on aerothermal fluid-structure interaction with plastic deformation. The goal of the present study is to investigate thin panels under aerothermal loads that lead to significant plastic buckling under single and repeated load cycles. This experimental data can be used for validation of fluid-structure coupled simulations.

The experiments are conducted in the arc-heated wind tunnel L3K at DLR, Cologne. Due to the high temperature environment and constraints of the wind tunnel test section, mounting the test specimens and instrumenting the model present numerous challenges. The dynamic changes in panel deformation are measured by digital image correlation (DIC) and laser distance sensors, avoiding thermal and mechanical disturbance of the panel by intrusive sensors. The time-resolved temperature distribution during the experiment is measured by IR thermography and thermocouples. A detailed study on the test specimen emissivity was conducted to reduce uncertainty.

The obtained time-resolved results on deformation and structural heating will be analyzed and discussed in detail, especially with regard to coupled effects, plastic deformation and the behavior under repeated load cycles.

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