Experimental Analysis of High Reynolds Number
Aero-Structural Dynamics in ETW

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Abstract: The paper reports about the aero-structural dynamical experiments with an elastic wing model which were conducted during the High Reynolds Number Aero-Structural Dynamics project by RWTH Aachen University in the cryogenic European Transonic Windtunnel, with funding from the German Research Foundation. The static and dynamic experiments have been performed in transonic flow at different windtunnel conditions concerning Reynolds number (up to 73 millions) and dynamic pressure (up to 0.13MPa). Starting with the description of the wing model, the measuring equipment and envelopes of the experiments, selected results of static and dynamic experiments are presented, partly in comparison with results obtained from numerical predictions during the preparation phase of the specimen and the experiments. For this the Computational Aero-Structural Dynamics package SOFIA of RWTH Aachen University was used. Results have been collected in a database which will be made freely accessible to the aerodynamic and aeroelastic community in the near future.
Aero-structural Dynamics Experiments at High Reynolds Numbers

Abstract. The elastic wing model, its excitation and comprehensive high frequency measuring equipment for the High Reynolds Number Aero-Structural Dynamics (HIRENASD) tests in the European Transonic Windtunnel (ETW) are shortly described. Some of the stationary polars are presented in terms of wing deformation, as well as aerodynamic coefficients and pressure distributions. Then unsteady processes observed in the measurements of static aerodynamic coefficients, are regarded with focus on small amplitude pressure waves travelling upstream from the trailing edge and triggering periodically breakdown and redeployment of the local supersonic domains with transonic shock waves to run upstream and to disappear. Another focus is on stochastic vibrations excitation while moving forward during nominally static experiments. Emphasis is put on measured variations of pressure distribution on the wing surface caused by defined vibration excitation applying internal force couples at the wing root, whereby the exciter frequencies were chosen close to natural frequencies of the wing model. Phase and magnitude of measured local lift fluctuations as well as real and imaginary parts of pressure distributions are presented.
Aero-Structural Wind Tunnel Experiments with Elastic Wing Models at High Reynolds Numbers (HIRENASD - ASDMAD)

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Abstract: The SFB 401 Flow Modulation and Fluid-Structure Interaction at Airplane Wings at RWTH Aachen has first performed experiments in the European Transonic Windtunnel (ETW) with a swept elastic clean wing model in its central project High Reynolds Number Aero-Structural Dynamics (HIRENASD). Mach numbers were in the transonic regime. The model has been excited for vibration applying span-wise acting interior force couples in the wing root region. The structure is made from linear elastic material and consists of the wing model and its suspension in the wind tunnel. In the follower project ASDMAD the model has been shortened in the tip range to be equipped and tested in ETW in succession with two different winglets. Data from one series of experiments is already available and is used to compare with HIRENASD results for corresponding wind tunnel conditions. In the HIRENASD project, the analysis of the raw data for quasi-stationary tests brought to light weak upstream running pressure waves behind shocks or even upstream running shocks forming from steepening compression waves when the transonic regime is still being established. This phenomenon was not observed as clearly in the data from the ASDMAD experiments. For excited vibration the results are more comparable. A convincing argument was elaborated from the HIRENASD data, why artificial transition in aero-elastic experiments at low Reynolds number cannot replace experiments at realistic Reynolds numbers.