Structural Optimization of an Aeroelastic Wind Tunnel Model for Unsteady Transonic Testing

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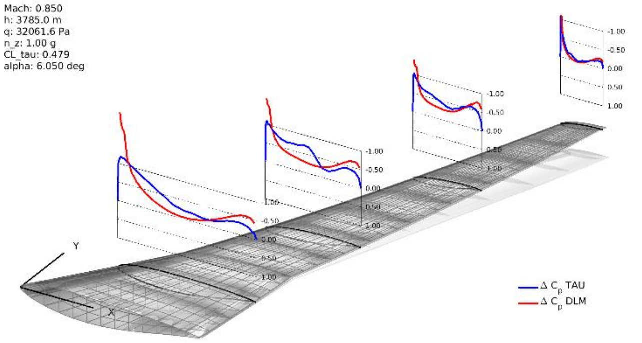
Abstract:



Within the scope of the “DLR – ONERA Partnership in Transport Aircraft Research”, a common research program (CRP) called FIGURE - Flexible Wind Gust Response - was launched in 2018 to investigate means of passive load control in the transonic regime. To this end, the two independently developed aeroelastic tailoring methodologies are to be applied to a common wing model geometry. Aeroelastic tailoring in this respect denotes a targeted application of fibre reinforced materials to optimally perform in the scope of a prescribed objective function.

The test was to be performed at the ONERA S3Ch wind tunnel facility in Meudon, France. The tunnel features a Mach number domain of M = 0.3 to 1.2 along with a rectangular test section of 0.76m x 0.80m. The installation of a gust generator based on two oscillating NACA0012 airfoils, located upstream of the test section, allows for the generation of vertical velocity components and thus angle of attack changes in the range of 0.4° at frequencies of up to 80 Hz in the transonic regime.

A choice was made in favour of the publicly available geometry of the NASA common research model (NASA CRM) wing [1], featuring a comprehensive database with respect to the geometry, as well as analytical and experimental research results. The wing half span was set to 0.55m, limited by the test section dimensions. While wind tunnel testing was part of ONERA’s workshare, the model building was performed by DLR. Experience gained in previous wind tunnel campaigns, [2], [3], led to the decision of building both, the ONERA and the DLR wing, with load carrying wing skins and a foam core to support the skins and prevent buckling. Both wings are equipped with six accelerometers and six pressure sensors at similar positions in the upper skin, allowing for a straightforward comparison of the experimental results. The wings are clamped with identical steel connectors designed by ONERA and glued into the wing root to guarantee an easy interchange during the test campaign.

This paper at hand focusses on the structural, aeroelastic optimization of the DLR wing. It is based on an optimization framework developed and constantly being enhanced and extended at the DLR – Institute of Aeroelasticity (DLR-AE), a detailed description of which can be found in [4]. The report describes the consideration of different structural objective functions, structural and aeroelastic constraint combinations, design field considerations, as well as the application of an aero load correction applied in the course of the optimization. The final results consist of the selection of an appropriate fibre type, optimized fibre layer stacking sequence tables for the upper and lower wing skins, and the corresponding optimized jig twist distribution, required for manufacturing the lamination moulds; eventually, all data required to start the construction of the wind tunnel model.

References

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