

EXPERIMENTAL CHARACTERISATION OF PROTOTYPE WING FOR REFLEXED AIRFOIL MORPHING

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ABSTRACT

This paper presents experimental results demonstrating the aerostructural performance of a morphing wing prototype. The wing features three novel camber-twist morphing flaps capable of reflexed airfoil morphing. This functionality is achieved by means of two spanwise discontinuities in the pressure side skin, thereby allowing chordwise translation of the skin. Trailing edge morphing is induced as a result of skin translation. The prototype wing was developed for testing in the Low-Speed Tunnel (LST) of the German-Dutch Wind Tunnels (DNW). The tunnel has a test section of 2.25m by 3m and a maximum free stream velocity of 80m/s. Given a span length of 2.25m and a chord length of 0.8m, wind tunnel test runs reaching a Reynold's number of up to $4 \cdot 10^6$ demonstrate the morphing wing technology at large scale. Two separate test campaigns investigate the prototype's aerostructural performance. Static bench test results characterise the morphing functionality. By imposing actuator strokes, the prototype is morphed into a range of shapes, measuring the set of required actuator forces and resulting trailing edge shape in the process. In camber morphing each measured shape is translated into a coefficient of lift C_l and a coefficient of moment with respect to the aerodynamic centre C_{mac} . Graphs of C_l - C_{mac} demonstrate the reflexed airfoil morphing functionality in terms of the range of attainable C_{mac} for a given value of C_l . In addition, the quality of the construction is assessed in terms of shape repeatability for given actuator strokes as well as symmetry between the two spanwise ends of the morphing flap. The twist morphing functionality is assessed in terms of the range of attainable shapes by one end of the flap, for given constant actuator strokes on the other end. Wind tunnel test results investigate the developed morphing wing's aerodynamic performance. The reflexed airfoil morphing functionality is validated by means of clusters of attainable C_l - C_{mac} combinations over a range of angles of attack α . Testing over a range of α , the optimal lift-to-drag ratio is found to maintain a value above 80. The optimal airfoil shapes exhibit high-degree camber in the low- α range, gradually decambering as α increases. Finally, the attention is focused on the wake velocity deficit aft of the transition region between adjacent flaps, in the presence of asymmetric morphing. Two transition region designs are compared. The first design features a seamless connection between flaps, labelled Transition Region – Seamless (TRS). The second design represents a conventional discontinuous transition, labelled Transition Region – Discontinuous (TRD). Heatmaps of the wake velocity deficit, as well as the consolidated drag coefficient, indicate how the TRS outperforms the TRD.

Contributions to the state-of-the-art:

1. Experimental validation of novel morphing flap design at large scale.
2. Demonstration of reflexed airfoil morphing functionality.
3. Investigation of the effect of asymmetric morphing between flaps on the wake velocity deficit.