VALIDATING AN EXPERIMENTAL SETUP OF A WING MODEL INSIDE A WIND TUNNEL

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The flow around wings is of great interest, but is challenging to study due to the highly complex flow which exhibits a diverse array of phenomena, including wall-bounded turbulence on curved surfaces, flow subjected to a pressure gradient, incipient flow separation and wake turbulence. The main challenge for both experimental and numerical studies on wings is to establish free-flight conditions due to the theoretically infinite domain required. With advances in high-performance computing, well-resolved simulations that enable detailed investigations of turbulent boundary layers (TBLs) developing over wings are achievable. A recent study by Vinuesa et al. [1] reports high-accuracy boundary-layer data and turbulence statistics on a NACA 4412 wing profile. The reference work for this profile is a set of experiments conducted by Coles and Wadcock [2] and Wadcock [3] in the 1970s and 1980s, where Reynolds numbers of up to 1.64×10^6 were achieved. In conjunction with these studies, the numerical work conducted at the Linné FLOW Centre will be used as a basis to perform new – more detailed – experiments with state-of-the-art measurement techniques. The present study describes experiments planned at the Minimum Turbulence Level (MTL) wind tunnel at KTH, and the flow around the wing is detailed in detail in a companion abstract.

The wind-tunnel wing model has a chord length of 0.5 m in order to achieve a Reynolds-number range similar to those found in the literature. This chord yields a blockage ratio of around 8% and 14% for angles of attack (α) of 5 and 12 degrees, respectively, in the test section, which has a cross-section of 1.2×0.8 m^2. In order to mitigate the effects of blockage on the flow field and model free-flight conditions, wall liners for the side walls of the MTL were designed. The wing model has 64 pressure taps to provide surface pressure measurements. Figure 1 shows the streamwise distribution of the pressure taps, of which 42 are on the suction surface and 22 are on the pressure surface. Although the geometry used in the reference numerical simulations featured a sharp trailing edge, practical considerations to reduce manufacturing complexity required that the wind-tunnel model was designed with a blunt trailing edge with a thickness of 0.1% of the chord. The mechanisms for mounting the model in the wind tunnel were designed with future experimental campaigns in mind: one mounting wall is transparent in order to provide optical access for experiments using particle image velocimetry (PIV), and the other is designed to support a curvilinear traverse mechanism to obtain well-resolved boundary-layer measurements using hot-wire anemometry. In order to be able to conduct these measurements at different α, a mechanism for rotating the wing and the traverse was integrated into the setup. The solution devised is illustrated in Figure 2, which shows the transparent lower panel on the floor of the wind tunnel and the upper panel with the circular insert for α rotation on the ceiling, along with the rail for the planned curvilinear TBL traverse.

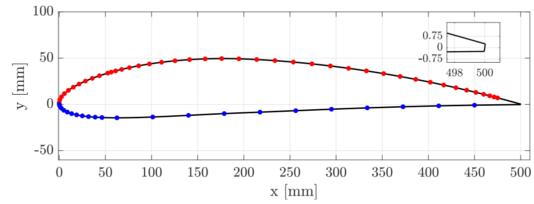

Figure 1: Streamwise distribution of pressure taps on a NACA 4412 airfoil profile with a chord length of 0.5 m.

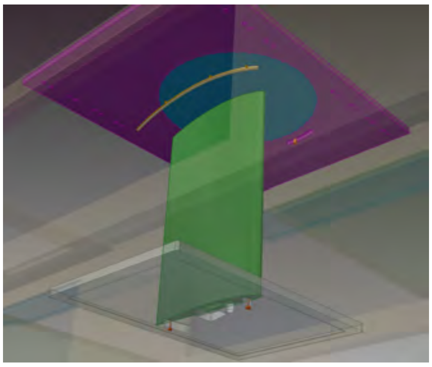

Figure 2: CAD drawing of the wing model mounted in the wind tunnel, with flow from right to left.

The full presentation will detail more design considerations in the experimental setup and present preliminary measurements for cross-validation with the corresponding numerical work.

References

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