Quantification of Aerodynamic Flow Control with Synthetic Jets through the Momentum Coefficient

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The influence of periodic excitation from synthetic jet actuators, SJA, on boundary layer separation and reattachment over a NACA 0025 airfoil at a low Reynolds number is studied. All experiments were performed in a low-turbulence recirculating wind tunnel at a Reynolds number of $100,000$ and angle of attack of $\alpha = 5°$. Mounted below the surface of the airfoil, the SJA consists of four (32.77mm diameter) piezo-electric ceramic diaphragms positioned in a single row. Initial flow visualization and hot–wire tests were conducted in quiescent environmental conditions to characterize the exit flow from the SJA. Flow visualization results showed a vertical jet pulse accompanied by two counter rotating vortices being produced at the exit of the simulated slot, with the vortices shed at the excitation frequency. Hot-wire measurements determined the maximum jet velocity for a range of excitation frequencies ($f_e = 50$Hz - 2.7kHz) and voltages ($V_{app} = 50 - 300 V_{p-p}$), which were used to characterize the excitation amplitude in terms of the momentum coefficient (C_μ). With the SJA installed in the airfoil, flow visualization results showed a reattachment of the boundary layer and a significant reduction in wake width. Wake velocity profiles were obtained two chord lengths downstream of the trailing edge to assess the excitation effect on drag and wake characteristics. A spectral analysis was conducted in the wake region and showed the presence of vortex shedding at a frequency of 22 Hz. When excitation was applied at 935 Hz and 250 V_{p-p}, the shedding frequency shifted to 50Hz. The results suggest it is possible to get substantial improvement in airfoil performance at lower input power.

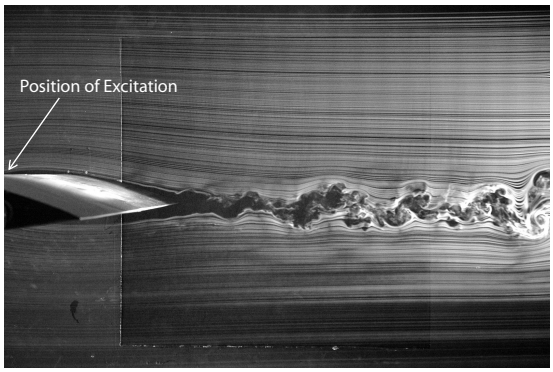

Figure 1: Flow visualization at $Re_c = 100 \times 10^3$ and $\alpha = 5^o$ with a single upstream smoke wire. Controlled (Reattached Boundary Layer), $f_e = 935$Hz, $C_\mu = 1.24 \times 10^{-2}$