Effects of Morphed Trailing Edges on Aerodynamic and Aeroacoustic Performance

Hasan Kamliya Jawahar*, SH. S. Vemuri† and M. Azarpeyvand*

A numerical investigation was performed to analyse the aerodynamic and aeroacoustic characteristics of a symmetrical NACA 0012 airfoil equipped with a conventional Hinged Trailing Edge (HTE) and a Morphed Trailing Edge (MTE)[1]. The study utilised high-fidelity Large Eddy Simulations (LES) to capture the unsteady flow characteristics over the airfoil surface and at the airfoil wake. The tests were conducted at a freestream velocity of $U_\infty = 20$ m/s, corresponding to a chord-based Reynolds number of $Re = 0.2 \times 10^6$, at two angles of attack $\alpha = 0°$ and $4°$. The c_p and $c_{p_{\mathrm{RMS}}}$ results indicate that the MTE airfoil produces higher values of lift coefficient than the HTE airfoil due to its higher suction peak, which results in a larger pressure difference between the suction and pressure sides. Also, the wall-pressure spectra, wake-flow measurements, and boundary-layer analysis revealed that the MTE airfoil produces higher values of surface pressure fluctuations near the trailing edge, which extend farther into the wake of the trailing edge compared to the HTE airfoil. Consequently, the increased pressure fluctuations at the vicinity of the trailing edge result in higher values of radiated far-field noise for the MTE airfoil. The study provides valuable insights into the impact of MTE flaps on both the aerodynamic and aeroacoustic characteristics and highlights the importance of careful design considerations to minimise noise radiation while optimising lift generation.

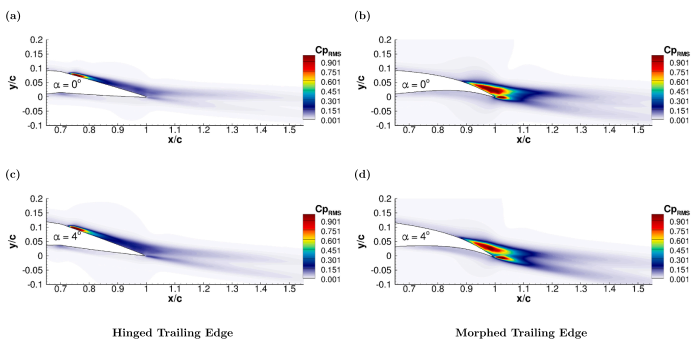

Figure 1: Contours of the $c_{p_{\mathrm{RMS}}}$ over a mid-span slice region for both the HTE [(a) and (c)] and MTE airfoils [(b) and (d)] at $\alpha = 0°$ and $4°$. The results demonstrate the existence of two regions of heightened fluctuations towards the suction side in MTE airfoil. The first, larger region spans from $x/c = 0.9$ to 1.2 and is situated directly above the trailing edge. The second, smaller region, ranging from $x/c = 1$ to 1.2, is aligned with the trailing edge and extends deeper into the wake, up to $x/c \approx 1.3$. Conversely, with respect to the HTE airfoil, the pressure fluctuations increase in the wake region but do not extend beyond $x/c = 1$.

*Dep. Aerospace Engineering, University of Bristol, Bristol BS8 1TR, UK
†Dep. Applied Mechanics, Indian Institute of Technology Delhi, New Delhi 110016, India

[1] Jawahar et al., *Int J. Heat Fluid Flow* **93**, 108892 (2022).