Numerical investigation of homogeneous blowing and suction on transonic airfoils

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Prompted by the need to reduce emissions and energy consumption, active flow control aimed at friction drag reduction in wall-bounded turbulent flows is being considered to improve the aerodynamic efficiency in civil aviation. In the present study, we address the potential of wall-normal homogeneous blowing and suction (HBS) in improving the aerodynamic efficiency of airfoils. Such control strategy has been mostly investigated so far in canonical flows such as zero-pressure gradient turbulent boundary layers[1,2]. Already for the incompressible flow around an airfoil, the boundary layer developing at its surface is subject to significant pressure gradients. Recent studies[3,4] showed that in this case HBS can lead to drag reduction. With a parametric study of the effect of wall-normal HBS on the compressible, transonic flow around a RAE2822 airfoil we want to answer the question of whether HBS is capable of improving the aerodynamic efficiency in a scenario relevant to civil aviation.

The Reynolds Averaged Navier-Stokes equations were simulated by the steady-state solver from the open-source CFD code SU2. The k-ω-SST model was employed as a turbulence model. Figure 1a) shows the different control regimes. The shock position of the uncontrolled flow around a RAE2822 can be identified at $x/c = 0.5$, see figure 1b). Blowing on the suction side (SS) shifts the shock position towards the leading edge and decreases the shock's magnitude. An opposite behavior can be observed for the case of suction on the SS, where the shock is shifted towards the trailing edge and an increase in the shock magnitude is present. Whereas blowing on the pressure side (PS) does not influence the shock. An increase in the aerodynamic efficiency can be observed for blowing on the PS and suction on the SS.

The final presentation will contain detailed results of the parametric study with a focus on the influence of the parameters on the shock position and magnitude, and on the net drag saving potential of HBS.

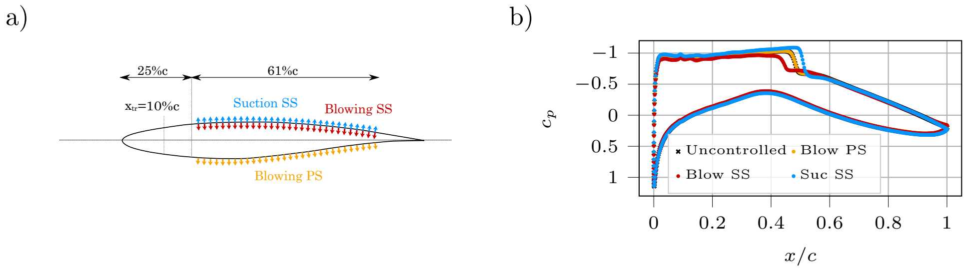

Figure 1: (a) Sketch of RAE2822 with different control regimes and (b) pressure coefficient for $Re = 5 \cdot 10^6$, $Ma = 0.4$, $\alpha = 2^\circ$ and $v_{blc} = 0.1\% U_\infty$.

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[2] Stroh et al., *Physics of Fluids* **27**, 075101 (2015).

[3] Fahland et al., *AIAA Journal* **59**, 4422 (2015).

[4] Atzori et al., *Flow, Turbulence and Combustion* **105**, 735 (2015).