Shape optimization of corrugated airfoils

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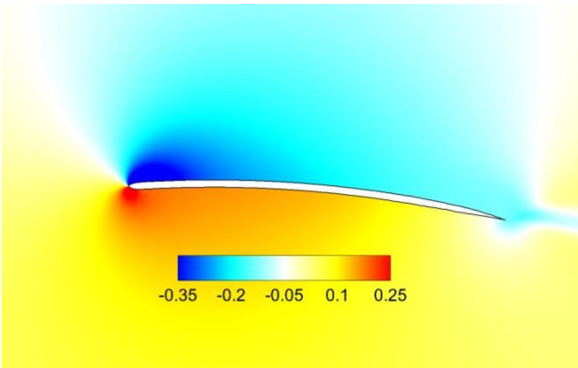
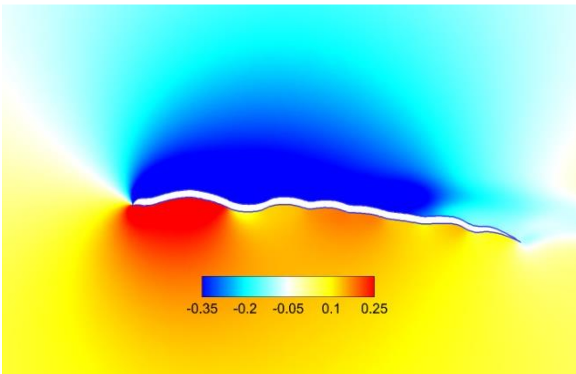
The effect of corrugations on the aerodynamic performance of a Mueller C4 airfoil, placed at a 5° angle of attack, is investigated via 2D computations. The flow is governed by the incompressible Navier Stokes equations. A stabilized finite element method [5] is employed. The Reynolds number based on the chord length of the airfoil and free stream speed of the flow is 10,000. The computations are carried out for different location and number (n) of corrugations keeping the height of the corrugation (h=1.5%c) fixed. The effect of these corrugations on the aerodynamic performance of the airfoil is investigated. The first corrugation causes an increase in lift and drag. The later corrugations contribute towards reduction in drag. The aerodynamic efficiency of the Mueller C4 airfoil is 15.76. The aerodynamic efficiency corresponding to the airfoil with one leading edge corrugation and three downstream corrugations is 21% higher compared to Mueller C4 airfoil.





(a) **(b)**

Figure 1: Pressure distribution for flow past ***(a)*** *Mueller C4 airfoil and* ***(b)*** *Optimal airfoil obtained through PTOC strategy using optimal lift airfoil as initial guess.*

Next, shape optimization is performed on the Mueller C4 airfoil using various objective functions and various optimization strategies. The different optimization strategies used for optimization are referred to as PCOT (Preserve camber, optimize thickness), PTOC (Preserve thickness, optimize camber) and NCCT (No constraint on camber or thickness). The objective functions for which optimization is done are lift maximization, drag minimization and maximize aerodynamic efficiency. The highest lift coefficient and aerodynamic efficiency of optimal shape by PTOC optimization strategy are 0.997 and 16.9, respectively. An increase in lift and aerodynamic efficiency of the optimal shape over the Mueller C4 airfoil are 42 % and 7%, respectively. The lowest drag coefficient of 0.0425 is obtained through PTOC optimization strategy which corresponds to 5 % reduction in drag compared to the Mueller C4 airfoil. Shape optimization is performed using the optimal shape for lift maximization as a new initial guess for maximization of aerodynamic efficiency. Optimal shape aerodynamic efficiency is 23.5 % higher than the Mueller C4 airfoil. The optimal shape is shown in Figure 1(b).

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