VI International Conference on Adaptive Modeling and Simulation
ADMOS 2013
J. P. Moitinho de Almeida, P. Díez, C. Tiago and N. Parés (Eds)

AIRFOIL OPTIMIZATION WITH TRANSITION CURVE AS OBJECTIVE FUNCTION

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Key words: Airfoil, Optimization, Low Reynolds, Aerodynamic Optimization, Transition Curve, Long Endurance UAV.

Abstract. In all conventional subsonic aircraft with medium/high aspect ratio wings (>6) the major single contribution to the overall aerodynamic performance of the vehicle comes from the wing airfoil and therefore its careful design is paramount. In the case of the fast growing market of UAV applications, the need for cost reduction is driving the designs to smaller scale and lower airspeeds. This brings the low Reynolds (60,000<Re<500,000) airfoil aerodynamic problem, where the boundary layer laminar separation bubble and transition in the upper surface influences decisively the drag polar merit [1]. Most formal approaches in the design of airfoils try to change the airfoil geometry in order to directly minimize the drag coefficient for a given flight condition or to match a given pressure distribution known to be favourable for a given application. The upper surface transition ramp manipulation is an example of such a methodology. Often, besides the resulting drag polar, the corresponding transition curve on the upper surface is shown as a representation of the effect of a prescribed pressure recovery/transition ramp. The present work describes the design optimization of a high lift airfoil where the objective function is that curve defined by the lift coefficient variation with the boundary layer transition position along the upper surface of the airfoil. An aerodynamic shape optimization program using XFOIL [2] as the solver, a viscous two-dimensional panel method formulation code, and a sequential quadratic programming optimization routine, solves a minimization problem to determine the optimal airfoil geometry which minimizes the difference between its transition curve and the specified objective curve while subject to geometric constraints and constant product of Reynolds number with the square root of lift coefficient for a given interval of lift coefficient values. The airfoil design variables are b-spline control points which define the airfoil camber line and the airfoil thickness distribution. A case study is presented for an airfoil design suitable for a long endurance UAV demonstrating the capability of the approach in producing an optimized design. Comparisons with other objective functions are also shown.

REFERENCES

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