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Manipulating forces by interactive separation and circulation control HASSAN NAGIB, PAUL REINHARD, PAUL ROZIER, IIT, Chicago — Steady, unsteady and intermittent suction and blowing from localized or distributed slots are used to reveal the physical mechanisms and their interaction in order to manipulate (enhance or reduce) the forces on various aerodynamic bodies and surfaces. Performance under ideal inviscid conditions is used as a standard of performance to compare the outcomes to. While high-lift airfoils were part of the focus, flow over humps which lead to large separation zones was also investigated. Surface pressure measurements, wake surveys and surface visualization were utilized over a wide range of operating conditions in the NDF at IIT. Velocities ranged from 20 to 110 m/s ($0.06 < M < 0.31$), corresponding to chord Reynolds numbers from $500,000$ to $3,700,000$, and included a full range of airfoil angles of attack with flap deflections from 10 to 55 degrees and various leading edge configurations. Steady suction control was more effective at eliminating the large separation bubble created by the model, requiring a pressure ratio between the applied force and inviscid force of approximately unity, whereas blowing required a two to one ratio. Pulsed suction was superior and enhanced by the operating frequency or duty cycle. Separation control (SC) was modified by the presence of circulation control (CC). Steady-blowing SC near the leading edge reduced the effect of blown-flap CC, whereas steady-suction SC increased the performance gain.

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