Aerodynamic Flow Control in Cruise using Hybrid Surface Actuators

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Abstract

Novel approach to the control of the aerodynamic performance of lifting surfaces by fluidic modification of their apparent aerodynamic shape, or *virtual aerosurface shaping* using concentrations of trapped vorticity is reviewed. This flow control approach emphasizes fluidic modification of the "apparent" aerodynamic shape of the surface with the objective of altering or prescribing the streamwise pressure gradient. Trapped vorticity concentrations are effected by the interactions of arrays of hybrid actuators (each comprised of a miniature passive obstruction [O(0.01c)] integrated with a synthetic jet) with the cross flow. An important feature of this approach is that the actuation frequency is deliberately selected to be well above and therefore *decoupled from* the unstable frequencies of the base flow, and therefore it can be used in the absence of flow separation (e.g., low angles of attack or cruise conditions). The present paper reviews recent work on global modifications of the aerodynamic characteristics of a commercial transport swept airfoil at cruise at (low) angles of attack (when the baseline flow is fully attached) that are achieved without moving control surfaces using hybrid actuators mounted on the pressure side of the airfoil. Two configurations are considered, namely manipulations of the Kutta condition by using a hybrid Gurney flap near the trailing edge, and substantial reduction in the overall drag by using trapped vorticity near the leading edge.