A conceptual study of airfoil performance enhancements using CFD

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A conceptual study of performance enhancing devices for an airfoil is performed using Computational Fluid Dynamics. Three simple, passive devices are examined to explore alternate methods for stall control and lift-to-drag improvement. The motivation behind this research is to study effective techniques to improve performance with fewer drawbacks than previously existing methods. An evaluation scheme is presented to compute airfoil lift, drag and pitching moment for a range of angles-of-attack up to stall. NACA 641-212 single-element and slatted airfoil CFD results are compared with experimental data to validate the computational model. Evaluations on the first conceptual design (Stall vane) show elimination of the separation at 15 degrees of angle-of-attack where the flow reversal normally starts at 86% - chord. A total drag increase of 22% is detected because of the sharp leading-edge of the device, but the main element drag has a reduction of 43%. The maximum lift coefficient does not show a significant change on the same model. The second device (Cylinder) has a negative effect, initiating flow separation and causing a significant decrease in lift-to-drag ratio at a given lift coefficient. The third device (Dimples) demonstrates the potential of lift-to-drag ratio improvement at the higher angle-of-attack.