Active Boundary-Layer Control for Mitigating Shock Wave-Induced Separation and Drag in Transonic Flight for Blended Wing Aircraft

Buscu, Andru (School: International Computer High School of Bucharest)
Negreanu, Diana (School: International Computer High School of Bucharest)
Suna, Andrei (School: International Computer High School of Bucharest)

In the context of modern aviation, aerodynamic efficiency and reduced fuel consumption are critical priorities. Nowadays, modern airliners travel relatively close to the speed of sound (Mach 1) because of the favorable ratio between speed and efficiency. Flying at these speeds raises some challenges, such as the formation of shock waves that can decrease the aerodynamic performance of the aircraft. Our research studies the effects of active boundary layer control systems on blended wing body aircraft (BWB) designs, which integrate the fuselage and wings into a single lifting surface. We choose this type of aircraft as our testing base because of its superior aerodynamic efficiency and high passenger capacity compared to conventional designs, being the most promising design of the next decade. Our first proposed active boundary layer control system consists of a permeable material with small perforations that create significant pressure difference under the formation of shockwaves. The system will be powered by a pressure inducing outlet or an electric compressor. Consequently, we will analyze the effects of other boundary layer control systems, such as a belt-like surface system circling around the airfoil across critical areas along the aircraft's wingspan. This enables us to control the relative velocity of airflow on the wing surface, thus improving flight performance. We will study the ionic flow control system in multiple configurations. It will be positioned near both the leading and trailing edge in order to assess its effects on the aerodynamic performance and boundary layer control of the aircraft near Mach 0.9. We believe this system can minimize flow separation by actively changing the speed around the airfoil, in the scope of drag reduction.

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