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Aerodynamically-Adaptive Aerostructures using Flow-Interactive Control by Distributed Bleed Actuation[1]

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Controlled interactions between a 3-D flexible wing model and the embedding cross flow are explored in wind tunnel investigations for modification of its aeroelastic characteristics using variable aerodynamic loads effected by active flow control. The aerodynamic loads are regulated using distributed air bleed that is driven through surface ports and the wing's structure by flow-induced pressure differences between its pressure and suction surfaces and is varied by surface louvers on the pressure surface of the wing. The present investigations have explored both quasi-static and transitory coupling between bleed-induced aerodynamic loads and wing's aeroelastic properties with several bleed configurations using direct load measurements, surface motion analysis, and distributed accelerometers. In addition, stereo particle image velocimetry (PIV) in the spanwise cross-stream (y-z) plane in the near wake reveal the topology of the wake flow and the tip vortex and concentrations of streamwise vorticity are used for assessing spanwise distribution of sectional lift (using Prandtl's Lifting Line Theory). A constitutive, multiscale structural model for the bleed-actuated wing shows that the bleed-controlled aerodynamic loads effectively vary the wing's apparent stiffness.

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