MECHANICAL ENGINEERING STUDENT SEMINAR

Thursday, July 25 2024 at 13:30, D. Dan and Betty Kahn Building, Room 217.
Online: https://technion.zoom.us/j/97944056454

Flight Model with Closed-Loop DBD Plasma Stall Control

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Fixed-wing aircraft stall – characterized by a sudden loss of lift – is still a prevalent problem in general aviation, accounting for 36% of loss-of-control accidents and more than 40% of all fatalities. Several wind tunnel studies have demonstrated stall-control effectiveness using pulse-modulated dielectric barrier discharge (DBD) plasma actuators, deployed at the leading-edges of airfoils. Despite this, no serious attempt has been made to evaluate DBD plasma stall control effectiveness on flight vehicles. In this research, we implemented DBD plasma actuators on the leading-edges of 6:1-scale battery-powered Cessna 172 RC model, and conducted a three-phase experimental program, namely: a proof-of-concept, open-jet, full-model, risk-reduction study; a series of flight experiments with on-board data-logging and telemetry; and a semi-span closed-loop control wind tunnel investigation. In the first phase, it was observed that inboard stall was effectively ameliorated, to produce increases in the maximum lift coefficient, while post-stall lift coefficients up to 10° beyond the stall angle never dropped below the baseline (non-actuated) maximum. Second phase flight experiments, performed while gliding, showed that actuation dramatically reduced uncontrolled pitch, roll and yaw. In addition to improving flight safety, a cost-benefit endurance analysis showed that net endurance benefits can be obtained on air vehicles with a large aspect-ratio and parasitic drag coefficient product. In the third phase, a simple closed-loop system was implemented where sensing of incipient stall was achieved by means of a pressure port located just below the leading-edge, inspired by the conventional Cessna 172 stall-warning system. Lift and drag coefficient results, based on closed-loop control, were compared with open loop (continuously actuated) plasma pulsations under static and dynamic—harmonic and pitch-and-hold—angle-of-attack variations. Under all conditions, negligible differences were observed between open- and closed-loop control, thereby demonstrating viability of the closed-loop system. Closed-loop flight experiments are presently being planned.

Seminars Coordinator: Assoc. Prof. Gal Shmuel.

Note: the seminar will be given in English.