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Aerodynamic Performance of a Small Flying Wing UAV Using Passive Bio-Inspired Microfibers

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Abstract
The aerodynamics of the Switchblade reconfigurable unmanned aerial vehicle (UAV) is validated using ANSYS Fluent and wind tunnel testing. A low-speed high endurance (LSHE) and high speed long range (HSLR) UAV variant are designed to cruise at Mach 0.06 and Mach 0.1 respectively. High-fidelity computational fluid dynamics analysis was performed to obtain better predictions on the aerodynamic coefficients of four wing variants. The inclusion of a winglet and a motor nacelle is analyzed, and its effect is more pronounced for the LSHE variant with a higher aspect ratio wing. A passive flow control coating in the form of bio-inspired microfibers were applied to the suction wing surface of the HSLR variant wind tunnel model and its control surface in order to improve passive stall performance and control surface moments. The aerodynamics and control surface performance is measured and analyzed based on test variables including microfiber height, coverage area, flow regime and angle of attack. Taller microfibers with a height of 140 μm when compared to the smooth wing, provide a drag reduction of up to 24.7% for C_L = 0.9 at a higher Reynolds number of 3.7×10^5. Shorter fibers of 70 μm perform better at a lower Reynolds number of 2.1×10^5, representing the stall speed of the HSLR variant, with a 24.2% C_D reduction for the same C_L. Control surface results shows that when applying microfibers to the elevon and its upstream wing region, there is an improvement in pitch moment authority at higher angles of attack, with an increase in C_M magnitude of up to 22.4%. Microfiber coating films, while being incredibly practical for use, have the potential to improve the performance of small flying vehicles in certain conditions.

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