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Microjet Based Active Flow Control on a Fixed Wing UAV

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A system of microjet arrays has been implemented to a fixed wing unmanned air vehicle (UAV) to test microjet efficacy for flow control during flight. Wind tunnel tests, including surface flow visualization and particle image velocimetry (PIV), have been conducted at the Low-Speed Wind Tunnel Facility in FSU's Advanced Aero Propulsion Laboratory (AAPL). The results show that the microjet actuators are an effective means of active flow control with fairly low supply pressure and flow rates, and can increase the critical angle of attack by 3 degrees. Since PIV cannot be conducted on the UAV during flight, tufts were installed to the aircraft to serve as a qualitative way of measuring the microjet efficacy. In addition, ground speed, air speed, altitude, and other parameters were also recorded during flight using a miniature data acquisition system. The results from the flight tests also conclude that the system is capable of delaying or eliminating flow separation.

Nomenclature

A_{jet} = exit area of one microjet, $\frac{1}{4}\pi D_{mj}^2$
b = span
c = chord
C_μ = steady momentum coefficient, $(N\rho_{jet}v_{jet}^2A_{jet})/(\frac{1}{2}\rho_\infty u_\infty^2 bc)$
D_{mj} = microjet exit diameter
N = number of microjets
n = normal distance from airfoil
Re_C = Reynolds number based on chord
U_{mean} = time-averaged streamwise velocity over airfoil
U_{rms} = root mean squared streamwise velocity fluctuations
u_∞ = freestream velocity
v_{jet} = microjet exit velocity
V_t = tangential velocity magnitude
x = streamwise location
α = angle of attack
ρ_{jet} = microjet density
ρ_∞ = freestream density

I. Introduction

MICROJET based actuators have been proven useful in a number of active flow and noise control applications. These actuators are capable of reducing oscillations in the shear layers of supersonic cavities[1], reducing or eliminating flow oscillations and acoustic disturbances in supersonic impinging jets[2], and delaying/eliminating flow separation induced by adverse pressure gradients, such as that over airfoils.[3,4] Flow separation over airfoils, such as those on unmanned air vehicles (UAVs), can lead to an increase in drag and a reduction in lift that may lead to aerodynamic stall and loss of control. Eliminating such flow separation should enhance the aerodynamic efficiency, by increasing lift and/or reducing drag, thereby also increasing the operating range of the aircraft. Microjets have shown very promising results towards separation control[3]; their effectiveness in energizing the boundary layer

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