SHEAR FLOW CONTROL
USING
FLUIDIC ACTUATOR TECHNOLOGY

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Abstract

The manipulation of global aerodynamic forces on bluff bodies using surface fluidic actuators based on synthetic jet technology will be discussed. Synthetic jets are zero-mass-flux in nature and are synthesized from the working fluid in the flow system in which they are embedded. Although there is no net mass injection, the jets enable momentum transfer into the flow system to be controlled. The interaction of synthetic jets with an embedding flow near the flow surface results in an apparent modification of the surface shape and enable significant global modification of embedding flow on scales that are one to two orders of magnitude larger than the characteristic length scale of the jets. While conventional excitation methods have been limited to frequency bands tailored to the linear receptivity mechanisms of a given flow, fluidic actuation facilitates exploitation of nonlinear mechanisms for amplification of disturbances in a very broad frequency band.

The utility of fluidic technology based on synthetic jets for dynamic control of flow reattachment and separation has been demonstrated on an unconventional airfoil which, in the absence of control, stalls at $\alpha = 5^0$. With control, full reattachment accompanied by increase in lift and decrease in pressure drag can be achieved up to $\alpha = 15^0$, and partial reattachment is realized up to the maximum angle tested, $\alpha = 25^0$. Both the location and the strength of the control input affect the extent of the reattached flow, and the control is effective throughout the range Reynolds numbers tested (up to $Re_C = 800{,}000$). Control is effected using jet formation frequencies that are well above the natural shedding frequency and when the flow is attached there is no shedding of organized vortical structures. The flow transients associated with the readjustment of circulation around the airfoil during controlled separation and reattachment are investigated using pulsed-modulated excitation and are exploited for enhancement of lift under sub optimal forcing conditions.

Relevant Papers

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3. Parekh, D. E., Kibens V., Glezer, A., Wiltse, J. M., and Smith, D. M. "Innovative Jet Flow Control: Mixing Enhancement Experiments," AIAA Paper 96-0308.

4. Smith, B. L. and Glezer, A. "Vectoring and Small-Scale Motions Effected in Free Shear Flows using Synthetic Jet Actuators," AIAA Paper 97-0213.

5. Amitay, M., Honohan, A., Trautman, M., and Glezer, A. “Modification of the Aerodynamic Characteristics of Bluff Bodies using Fluidic Actuators,” Fourth AIAA Shear Flow Control Conference, AIAA Paper 97-2004.
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7. Smith, B. L. and Glezer, A., "The Formation and Evolution of Synthetic Jets *Physics of Fluids* 10, 2281-2297, 1998.

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