15th AIAA/CEAS Aeroacoustics Conference (30th AIAA Aeroacoustics Conference)
11 - 13 May 2009, Miami, Florida

AIAA 2009-3247

Control of Supersonic Resonant Flows Using High Bandwidth Micro-actuators

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Practical application of active flow control of high speed flows is dependent upon the development of simple and robust actuators that can produce high momentum and are reliable, low cost, and responsive and can be easily integrated. This paper presents an experimental investigation of the characterization and implementation of high bandwidth micro-actuators for the control of supersonic resonant flows. The striking feature of this micro-actuator is its high momentum mean flow along with high amplitude and a tunable frequency unsteady component. First generation micro-actuators are designed and their performance is tested in controlling the highly unsteady impinging jet flow field. The results show that the impinging tones are completely eliminated with the actuation of these micro-actuators, whereas, new peaks at a frequency different from the actuation frequency and its harmonics are observed in the spectra, the occurrence of which need to be further explored. A reduction of 3-4 dB in overall sound pressure levels (OASPL) is achieved over the range of test conditions.

I. Introduction

Active Control of shear and boundary layer flows have seen much attention by many researchers in recent years due to the potentially substantial benefits derived out of such control schemes. Unresolved flow control challenges persist in the diverging domain of aerodynamic applications that demand innovative strategies for more efficient operation of many high speed aerodynamic systems. The subsonic applications range from controlling flow separation and transition over various external aircraft components (including MAVs) to active control of flow over turbine and compressor blades/airfoils and active management of separation/flow distortion in engine inlets and S-ducts. In high-speed flows, control of flow oscillations in cavity flows, supersonic impinging jets and jet noise control are areas where various active control methods may lead to dramatic gains in performance. Effective control of flow and noise requires the use of efficient and robust actuators, which can be adapted for specific applications. Although various types of actuators have and are being explored, most designs have shown some limitations; either in terms of performance and range of operation in the lab or in the total 'cost' of performance – accounting for added weight and complexity, for eventual full-scale implementation. There is a clear need for actuators that produce *high-amplitude disturbances, over a broad range of frequencies.* Furthermore, the output of an ideal actuator should be 'tunable', both in terms of amplitude and frequency over a large dynamic range. Such actuators would

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