Flow and Noise Control of a Supersonic Impinging Jet on a Carrier Deck

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Abstract:

Supersonic impinging jets and their control is an important and interesting research area for the design of future aircraft configurations involving short-takeoff and vertical-landing (STOVL). These lift-producing jets result in a high temperature, turbulent and highly oscillatory flow field which may lead to severe ground erosion of the landing surface, lift loss due to entrainment of high-speed flow near the nozzle exit, very high unsteady loads on the nearby structures and hot gas ingestion into the engine inlets. Flowfield properties of cold supersonic impinging jets have been investigated by many researchers in the past, and it has been demonstrated that generation of large-scale structures in the jet shear layer induces high entrainment velocity near the nozzle exit and, in turn, significant lift loss during hover. It is now well known that the highly unsteady behavior of the impinging jets is due to a feedback loop between the flow and acoustic fields, which leads to the aforementioned adverse effects.

Objectives:

The main objective of this research is to study the flowfield and heat transfer characteristics of supersonic impinging jets at *realistic flow conditions*. Another objective is to develop, test and refine promising *Active, Passive* and *Hybrid* flow control methods.

Experimental Setup:

- STOVL supersonic jet facility
- Mach Number (M) = 1.5
- Nozzle Pressure Ratio (NPR) = 3.7
- Reynolds number = 7×10^5
- Temperature Ratio (TR) = 1.0 and 1.4
- Porosity $\beta = 0.29$

Results:

Noise and flowfield characteristics of a supersonic impinging jet investigated

- Passive control using a porous surface
- Active control with microjet injection
- Hybrid Control using both

Both control methods effective in reducing noise and flow unsteadiness, however, the type of noise reduction different.

- Passive control - broadband noise reduction
- Microjet injection - attenuates high amplitude impinging tones
- Hybrid control - reduces both broadband and impinging tones and its effectiveness more than the additive affect of the two control techniques

PIV measurements:

- With passive control the streamwise mean velocity is significantly reduced downstream of the porous surface
- Flow unsteadiness significantly reduced with hybrid control over the entire measurement region consistent with nearfield acoustic and unsteady pressure reductions

Based on these preliminary results a proposal is submitted to the Office of Naval Research (ONR) for further development of hybrid control technique.

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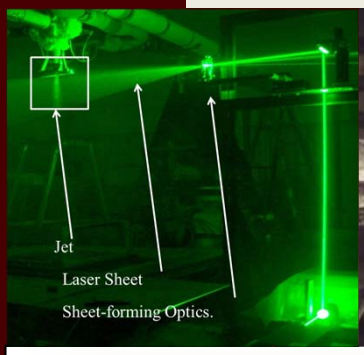
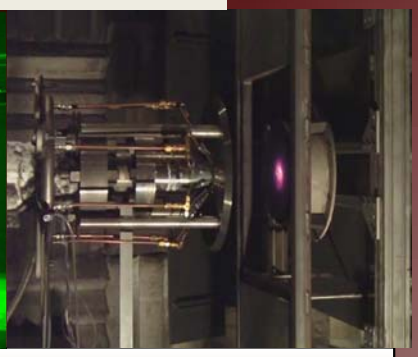
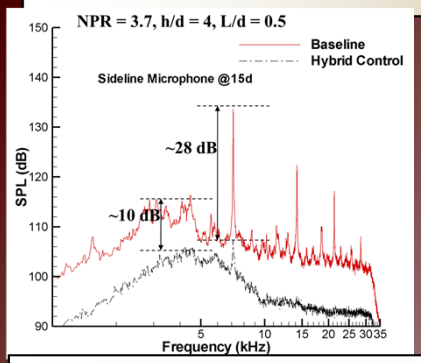
Impingement on Jet Blast Deflector

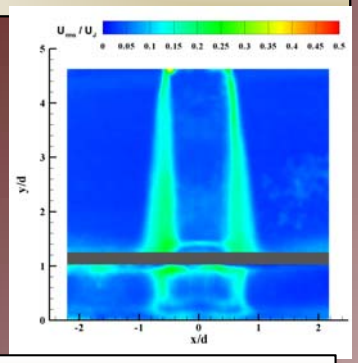


Particle Image Velocimetry



High Temperature Impinging Jet





Noise Reduction with Hybrid flow control

Future Plans:

Aircraft Carrier Deck Simulation

7% scale deck environment in vicinity of JBD - 6' long x 7' wide

- Based on existing 7% scale twin nozzle, T_o = 300 – 1360 K (70 – 2000 °F)
- Retractable JBD - allows for examination of JBD effects

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