Temperature Effect on Acoustics of Supersonic Impinging Jet

Jonas P. R. Gustavsson[1]
Florida Center for Advanced Aero-Propulsion,
Florida A&M University/Florida State University College of Engineering,
Tallahassee, FL 32310

Paul A. Ragaller[2]
Department of Mechanical Engineering
Massachusetts Institute of Technology, Cambridge, MA 02139

and

Rajan Kumar[3] and Farrukh S. Alvi[4]
Florida Center for Advanced Aero-Propulsion,
Florida A&M University/Florida State University College of Engineering,
Tallahassee, FL 32310

Supersonic impinging jets have been of interest both from an applications and a fundamental fluid mechanics point of view for several decades. The vertical hot jet used by aircraft capable of vertical landing or take-off during hover is perhaps the most significant application. When the distance between the ground and the aircraft is small, the impinging jet has been shown to produce lift loss, hot gas ingestion and a highly unsteady flow field producing ground erosion and damaging vibrational loads on aircraft, structures and personnel in the vicinity. Previous tests using an ideally-expanded, axisymmetric Mach 1.5 primary jet heated up electrically to a total temperature of up to 500K have been carried out to establish both baseline acoustic features of this flowfield and noise suppression using microjets. Pressure spectra acquired in this setup showed discrete, high-amplitude acoustic tones (generally known as impinging tones) at frequencies varying with jet temperature. These tones were found to grow more pronounced at elevated versus ambient conditions. In these tests, microjets produced substantial suppression of both tones and broadband. Given this success, the scalability of these techniques was to be assessed in a facility providing test conditions closer to those of the relevant applications. The present paper describes baseline experiments carried out in a larger-scale facility where a 36.2 mm diameter jet heated through ethylene combustion to total temperatures of up to 1030K is allowed to impinge on an instrumented ground plane. The test setup is mounted in an anechoic facility where, in addition to validation and extension of the smaller-scale test results, far-field acoustic measurements have been made. The results show that tones are still present in higher temperatures and Powell's formula still appears to be valid for predicting the frequency of these. The total amplitude of the ground plane pressure fluctuations near the centerline decreases as the temperature is increased while the amplitude remains constant farther away. The spectral distribution of energy shifts away from the impingement tones to higher frequency broadband noise.

---

[1] Assistant Research Scientist, Mechanical Engineering, AIAA Senior Member
[2] Graduate Research Assistant, Mechanical Engineering, AIAA Student Member
[3] Research Scientist, Mechanical Engineering, AIAA Member
[4] Professor, Mechanical Engineering, AIAA Associate Fellow