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Phased-array Measurements of Single Flow Hot Jets

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A 16 microphone phased-array system has been successfully applied to measure jet noise source distributions. In this study, a round convergent nozzle was tested at various hot and cold flow conditions: acoustic Mach numbers are between 0.35 and 1.6 and static temperature ratios are varied from cold to 2.7. The classical beamforming method was applied on narrowband frequencies. From the measured source distributions locations of peak strength were tracked and found to be very consistent between adjacent narrowband frequencies. In low speed heated and unheated jets, the peak source locations vary smoothly from the nozzle exit to downstream as the frequency is decreased. When the static temperature ratio was kept constant, the peak source position moved downstream with increasing acoustic Mach number for the Strouhal numbers smaller than about 1.5. It was also noted that the peak source locations of low frequencies occurs farther downstream than the end of potential core.

I. Introduction

This report presents the results of a recent phased-array test sponsored by the NASA Quiet Aircraft Technology program. This test was conducted on the Small Hot Jet Acoustic Rig (SHJAR) at the NASA Glenn Research Center.

It is important to know the noise source locations of a jet flow in order to develop successful jet noise prediction methods. Many techniques that can find the frequency dependent source locations along the jet direction have been published. Among these techniques are: the acoustic mirror method[1,2], the cross-correlation technique[3], the polar correlation method[4], the two microphone minimum phase method[5], and the phased-array beamforming method[6,7,14,15]. The phased array beamforming methods are summarized in detail by Dougherty[8] and Underbrink[9]. Some of these methods can only find a single 'source location' for a given frequency band, while phased arrays produce maps of source strength, convolved with the point spread function of the array.

As a part of the NASA jet noise database program[10,11,12] that includes detailed flow and acoustic measurements, the one-dimensional phased-array system is used to determine the jet noise source locations. The linear array is composed of 16 microphones positioned on the floor at unequal intervals. A simple round convergent nozzle was tested at various acoustic Mach numbers from 0.35 to 1.6 and static temperature ratios from cold to 2.7. Classical beamforming methods have been used in the image processing.

In the following sections, we will show the array patterns of the linear array and the noise source locations of heated and cold jets. The effects of acoustic Mach numbers and of static temperature ratios on the noise source locations will also be discussed.

II. Test hardware, linear array and data processing

The Small Hot Jet Acoustic Rig (SHJAR) at the NASA Glenn Research Center is a single stream jet rig with a hydrogen combustor. The maximum Mach number is about 2 and the maximum static temperature ratio is about 2.8. The centerline of the jet is 10 feet above the floor. The SHJAR is located within the

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