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TRANSONIC TONES AND EXCESS BROADBAND NOISE IN OVEREXPANDED SUPERSONIC JETS

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ABSTRACT

Noise characteristics of convergent-divergent (C-D) nozzles in the overexpanded regime are the focus of this paper. The flow regime is encountered during takeoff and landing of certain airplanes and also with rocket nozzles in launch-pad environment. Experimental results from laboratory-scale single nozzles are discussed. The flow often undergoes a resonance accompanied by emission of tones (referred to as 'transonic' tones). The phenomenon is different from the well-known screech tones. Unlike screech, the frequency increases with increasing supply pressure. There is a staging behavior – odd harmonic stages occur at lower pressures while the fundamental occurs in a range of relatively higher pressures. A striking feature is that tripping of the nozzle's internal boundary layer tends to suppress the resonance. However, even in the absence of tones the broadband levels are found to be high. That is, relative to a convergent case and at same pressure ratio, the C-D nozzles are found to be noisier, often by more than 10dB. This excess broadband noise (referred to as 'EBBN') is further explored. Its characteristics are found to be different from the well-known broadband shock-associated noise ('BBSN'). For example, while the frequency of the BBSN peak varies with observation angle no such variation is noted with EBBN. The mechanisms of the transonic tone and the EBBN are not completely understood yet. They appear to be due to unsteady shock motion inside the nozzle. The shock drives the flow downstream like a vibrating diaphragm, and resonance takes place similarly as with acoustic resonance of a conical section having one end closed and the other end open. When the boundary layer is tripped, apparently a breakdown of azimuthal coherence suppresses the resonance. However, there is still unsteady shock motion albeit with superimposed randomness. Such random motion of the internal shock and its interaction with the separated boundary layer produces the EBBN.

Keywords: Transonic Tones, Supersonic Jet, Broadband Noise.