Tone noise of three supersonic helical tip speed propellers in a wind tunnel

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FRIDAY AFTERNOON, 15 JUNE 1979 KRESGE REHEARSAL ROOM A, 2:00 TO 5:00 P.M.

Session AAA. Noise VII: Noise Generation and Control

W. J. Hanson, Chairman

Liberty Mutual Research Center, Hopkinton, Massachusetts 01748

Contributed Papers

2:00

AAA1. Tone generation due to laminar air flow over a cavity mounted in a flat plate. S. A. Elder (Physics Department U.S. Naval Academy, Annapolis, MD 21402) and F. C. De Metz (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD 20084)

Two distinct regimes of tone generation have been isolated for a cavity mounted in a laminar boundary layer in air. The first is a cavity resonance phenomenon similar to that excited by turbulent flow (F. C. De Metz and T. M. Farabee, Paper No. 77-1293, AIAA 4th Aeroacoustics Conference, 1977; S. A. Elder, J. Acoust. Soc. Am. **64**, 877 (1978)]. The second is a species of edgetone oscillation which occurs when sufficient damping material is inserted into the cavity to prevent normal mode excitation. By extension of the methods used in earlier studies of turbulent air flow tones, it is possible to model the feedback coupling mechanism for each regime. For the edgetone case, Strouhal number is found to occur close to the value corresponding to maximum instability of the separated shear layer. In the case of resonant cavity oscillation, Strouhal number is somewhat dependent on aspect ratio of the cavity mouth opening. For narrow slot profiles, the resonant oscillation condition is dominated by ξ_l interface waves, resulting in a simple Strouhal number formula. [Work partially supported by a GHR contract with the Naval Ship Systems Command, administered by the David W. Taylor Naval Ship Research and Development Center, Carderock, Maryland.]

2:15

AAA2. Tone noise of three supersonic helical tip speed propellers in a wind tunnel. J. H. Dittmar, Bernard J. Blaha, and Robert J. Jeracki (NASA Lewis Research Center 21000 Brookpark Road Cleveland, OH 44135)

A high tip speed turboprop is being considered as a future energy conservative airplane. When the turboprop airplane is at cruise, the combination of the airplane forward speed and the propeller rotational speed results in supersonic helical velocities over the other portions of the propeller blades. These supersonic blade sections could generate noise that is a cabin environment problem. Three 0.622 m (24.5 in.) diam propellers were acoustically tested in the NASA Lewis 8-by 6-ft. wind tunnel. This wind tunnel does not have acoustic damping material on its walls and is therefore not an ideal location for taking noise data. However, it was felt that information obtained about the noise differences among the three propellers would be useable. The propellers were tested at tunnel through flow Mach numbers of 0.6, 0.7, 0.75, 0.8, and 0.85 with different rotational speeds and blade setting angles. The three propellers incorporated different plan forms and different amounts of sweep and yielded different noise levels. The acoustically designed propeller had 45° of tip sweep and was significantly quieter than the straight bladed propeller. The intermediate 30° tip sweep propeller exhibited noise that was between the other two blades. Noise trends with varying helical tip Mach number and blade loading were also observed.

2:30

AAA3. Lined ducts in parallel for low-frequency noise reduction. William P. Patrick (United Technologies Research Center, East Hartford, CT 06118) and K. Uno Ingard (Departments of Physics and Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA 02139)

A new method to enhance the low-frequency sound attenuation characteristics of a lined duct is presented. A rigid, longitudinal splitter plate is used to separate the lined duct section into two parallel branch ducts. The phase speed of the fundamental sound mode in each parallel branch is a function of the liner configuration and can differ substantially from the free space phase speed. By lining the parallel branches dissimilarly, destructive interference of the fundamental mode of the transmitted wave occurs downstream of the parallel absorbers at a selected set of frequencies. Strong reflections also occur at the silencer inlet for a larger set of frequencies due to an acoustical impedance mismatch at the junction of the main duct and the parallel branches. These interference effects, which result from placing the rigid splitter plate into the lined duct, can increase the low-frequency transmission loss of the duct by more than two fold over a broad low-frequency band and by as much as 5-dB/unit duct width at selected frequencies.

2:45

AAA4. Higher order mode effects in circular ducts and expansion chambers. L. J. Eriksson (Nelson Industries, Incorporated, Box 428, Stoughton, WI 53589)

The theory of higher order modes in circular ducts is reviewed and applied to expansion chambers. Numerous schemes have been proposed for use in labeling the various higher-order modes in a circular duct. This has led to confusion and, in at least one case, to erroneous descriptions of the higher-order modes. In an attempt to solve this problem, a specific approach, analogous to that used in rectangular ducts, is proposed that has geometric clarity and elegance. The cutoff frequencies for these various modes are discussed with respect to propagation in an expansion chamber. Incomplete and misleading statements in the literature concerning the calculation of cutoff frequencies are reviewed. Higher order mode propagation through an expansion chamber is analyzed for various inlet and outlet locations, and experimental results presented. The interaction between plane wave and higher-order mode effects is discussed.

3:00

AAA5. Assessment at full scale of nozzle/wing geometry effects on OTW aeroacoustic characteristics. D. Groesbeck and U. von Glahn (NASA Lewis Research Center, Cleveland, OH 44135)

The effects on acoustic characteristics of nozzle type and location on a wing for STOL engine over-the-wing configurations are assessed at full scale and equal aerodynamic performance. Three types of nozzle configurations are evaluated: a circular nozzle with external deflector mounted above the wing, a slot nozzle with external deflector mounted on the wing and a slot nozzle mounted on the wing. Nozzle locations with respect to the wing leading edge were varied from 10% to 46% (flaps retracted) with flap angles of 20° (takeoff mode) and 60° (approach mode). Data of PNL as a function of flyover distance at 500 ft are presented for all cases.