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NASA TECH BRIEF

Marshall Space Flight Center

Evaluation of Jet Engine Noise

The problem:

In the modern designs of aircraft and space vehicles, it is necessary to determine an acoustic environment that will be generated by their propulsion systems. Jet noise, of course, is the main concern.

The solution:

From the advanced theory for supersonic jet noise there are three basic equations that characterize the jet noise environments. These equations are used to predict the magnitude of noise generation.

How it's done:

The three principal modes of jet aircraft noise radiation include an acoustic mode and two Mach modes. The acoustic mode of radiation occurs for convection Mach, M_c, numbers below 0.8 and describes the sound power I(x) as

$$I(x) \sim \rho U^3 \left[\frac{M^2}{(1-M_c\cos\theta)^2 + \alpha^2 M^2} \right] 5/2$$

where ρ and U are the density and exit velocity of jet flow, respectively, M is the Mach number of the jet using ambient speed of sound as reference, M_c is the convection Mach number, θ is the angle between the wave propagation direction and the jet flow direction, and $\alpha^2 \approx 0.10$.

In the Mach modes, the sound power of the jet in the transonic and supersonic speed ranges are, respectively, given by

$$I(x) \sim \rho U^3 \frac{M^2}{(1-M_c\cos\theta)^2 + \alpha^2 M^2}$$

and

$$I(x) \sim \rho U^3 \left[\frac{M^2}{(1-M_c\cos\theta)^2 + \alpha^2 M^2} \right] 5/4$$

An extremely important effect established in this study is the coupled process of refraction and convection. In both the advanced and the conventional noise theory, the Doppler shift factor is defined as

$$f(\theta) = (1-M_c\cos\theta)^{-1}$$

As $M_c\cos\theta$ approaches unity, the Doppler shift factor produces both a large frequency shift and a large increase in noise intensity.

The effect of this factor has been a major disagreement between analysis and data; however, research has shown θ to be close to 90°. Hence, the magnitude of the convection factor is automatically limited to smaller values. Thus, based on this new theory, sound directivity spectrum and intensity can be accurately predicted.

Note:

Requests for further information may be directed to:

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No patent action is contemplated by NASA.

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Category 03