Effect of Rotor Wake Structure on Fan Interaction Noise

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The prediction of noise produced by fan-wake interaction with the fan exit guide vane (FEGV) is studied. The acoustic response of the FEGV is computed using LINFLUX, a three-dimensional, frequency-domain, linearized Euler solver for turbomachinery. The research focuses on tonal noise predictions for the advanced ducted propulsor (ADP) and the source diagnostic test (SDT) scaled turbofan rigs. The sensitivity of the 2BPF noise prediction to the inflow specification is quantified. Inflow models are generated based on both experimental and computational fan-wake data. The computational data are provided by four different Reynolds-Averaged Navier Stokes (RANS) computational fluid dynamic (CFD) solutions. When compared to experimental results, the computations provide comparable mean flow solutions but overpredict the wake deficit. The CFD solutions differ more for higher wheel speed cases, especially in the tip region. It is shown that inputs generated from the various experimental and CFD data also differ, but that these differences weakly impact the prediction of the sound power level (PWL) at the lower wheel speed. At the higher wheel speeds, where the differences in the inputs near the tip are greatest, the PWL reflects this difference. For a given wheel speed, the predictions using input values based on the different CFD data and the experimental wake data agree to within 5 dB. However, they vary from the experimentally measured acoustic PWLs by up to 14 dB.

Nomenclature

t	time
r	radial coordinate
$\mathbf{U}_{tot}$	total state vector
$\mathbf{U}$	state vector for mean flow
$\mathbf{u}_1$	perturbation state vector
$\mathbf{u}$	complex amplitudes of perturbation flow
$\mathbf{u_A}$	acoustic portion of perturbation state vector
$\mathbf{V}_0$	mean velocity vector
V_θ	circumferential velocity in fan frame
$V_{\theta,fegv}$	circumferential velocity in vane frame
V_{tot}	streamwise velocity (ignoring radial variation) in fan frame at fixed radius
V_0	magnitude of mean streamwise velocity (ignoring radial variation) in fan frame
$\mathbf{v}'$	perturbation velocity vector
$\mathbf{x}$	spatial coordinate vector
κ	wave number of convected gust
ρ	density
θ	circumferential coordinate in vane frame
θ'	circumferential coordinate in fan frame
ξ	axial coordinate

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