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Efficient Propeller Noise Prediction Using the Stochastic Noise Generation and Radiation Model with U-RANS Simulations

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ABSTRACT

Prediction of propeller noise is crucial for noise control and stealth design in marine engineering. Highly resolved numerical methods, such as Large Eddy Simulation (LES), currently computationally infeasible for practical engineering applications due to prohibitive computational times (Posa and Balaras, 2020). To address this challenge, we propose a hybrid approach that integrates the stochastic noise generation and radiation (SNGR) model with unsteady Reynolds-averaged Navier-Stokes (U-RANS) simulations, providing an efficient method for propeller noise prediction. The U-RANS captures the large-scale vortices in the unsteady flow field around the propeller, while the SNGR model synthesizes small-scale stochastic turbulent velocity fields (Bailly and Juvé, 1999). Consequently, this approach accounts for both blade passage frequency noise generated by propeller rotation and broadband noise induced by turbulence. Furthermore, the noise sources are formulated using Lighthill's acoustic analogy, and acoustic propagation is analyzed with the finite element method.

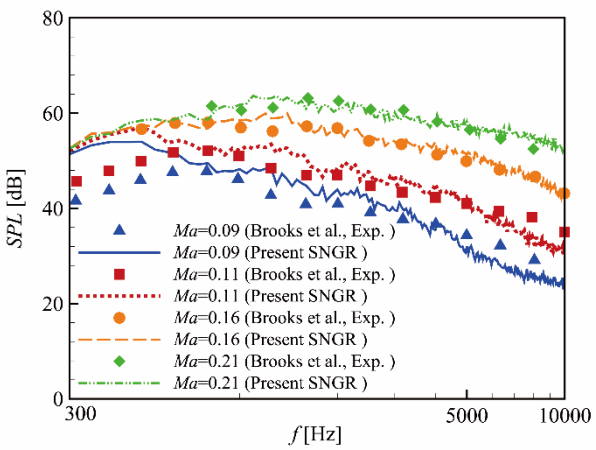

Figure 1: Comparison of the sound pressure level (dB) spectra for NACA0012 airfoil trailing-edge broadband noise.

The SNGR model is first validated through the reconstruction of homogeneous isotropic turbulence and the simulation of NACA0012 airfoil trailing-edge broadband noise, with results demonstrating good agreement with experimental data from the work by Brooks et al. (1989), as shown in Figure 1. The proposed approach is subsequently applied to predict radiated noise from the DARPA SUBOFF model, as well as to propeller noise prediction, analyzing both near-field and far-field noise characteristics under various operational conditions.

References

A. Posa and E. Balaras. A numerical investigation about the effects of Reynolds number on the flow around an appended axisymmetric body of revolution. Journal of Fluid Mechanics, 2020, 884: A41. DOI: 10.1017/jfm.2018.585.

C. Bailly and D. Juvé. A Stochastic Approach to Compute Subsonic Noise Using Linearized Euler's Equations. In 5th AIAA/CEAS Aeroacoustics Conference and Exhibit, 1999. DOI: 10.2514/6.1999-1872.

T. Brooks, D. Pope, and M. Marcolini. Airfoil self-noise and prediction. Technical Report. NASA, Reference Publication 1218, 1989. URL: https://ntrs.nasa.gov/citations/19890016302.