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Session:

High-order Delay Detached-Eddy Simulations of Cylindrical Separated Vortex/Induced Noise Based on Transition Model and Acoustic Analogy

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Abstract

The numerical prediction of transition from laminar to turbulent flow has proven to be an arduous challenge for computational fluid dynamics (CFD), with few approaches providing routine accurate results within the cost confines of engineering applications. The present article describes the application of a $\gamma - Re_\theta$ transition model in combination with the Delay Detached Eddy Simulation (DDES) and Ffowcs Williams & Hawkings (FW-H) acoustic analogy methodologies to cylinder vortex/vortex induced noise at subcritical Reynolds number. In the process of numerical simulation, a traditional DDES based on the full-turbulence model SST is carried out as comparison and a 7th-order weighted compact nonlinear scheme (WCNS-E8T7) is adopted to ensure that the physical models are not infected by numerical dissipation.

In the single cylinder case, the traditional DDES only based on SST model (SST-DDES) delays the instability of the shear layer on sides of the cylinder, which leads to a growth of recirculation zone in mean flow and the increase of induced drag. Moreover, vortex shedding frequency (Table 1) predicted by SST-DDES is larger than the truth, which makes the whole sound pressure level (SPL) spectrum move to high frequency region. However, when combind with the $\gamma - Re_\theta$ transition model, the DDES (called Tran-DDES in present article) can give a good agreement with the experimental data.

Table 1 Statistical results of aerodynamic coefficients for the single cylinder.

	$C_{D,ave}$	$C_{D,rms}$	$C_{L,rms}$	St
SST-DDES	1.08	0.10	0.35	0.202
Tran-DDES	1.21	0.12	0.48	0.192
LES	1.24	0.10	0.54	0.187
Exp.	1.35	0.16	0.45-0.5	0.19

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Second case considers an airfoil in the wake of the cylinder. The issue of SST-DDES in recirculation zone in mean flow is weakened associated with the interaction between the airfoil and cylinder wake, it happens that the predictions of mean flow by SST-DDES are similar to that of the Tran-DDES. But in terms of the root-mean-square (rms) values of turbulent fluctuation components and SPL(Fig. 1), the predictions by Tran-DDES are still better than those of SST-DDES.

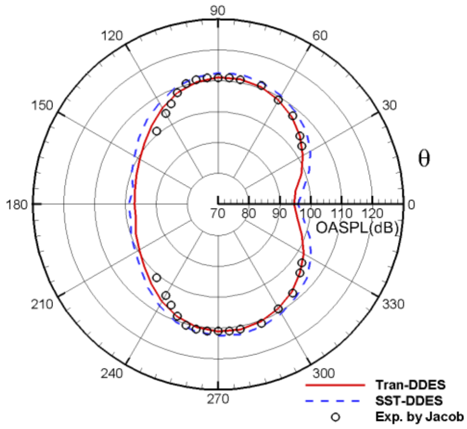

Fig. 1 Directivity curves of OASPL in the flow-field of rod-airfoil.