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基于混合RANS/LES方法与FW-H方程的气动声学计算研究

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Aeroacoustic Noise Prediction Using Hybrid RANS/LES Method and FW-H Equation

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摘要

在气动噪声的数值计算过程中,非定常流动的求解精度对声学计算结果有着重要的影响。以机体噪声计算的标准算例双圆柱绕流气动噪声问题为研究对象,采用基于非线性k-ε湍流模型的限制数值尺度(LNS)方法对双圆柱绕流进行了数值模拟,将计算得到的气动特性和流动特征与相应的试验结果进行了对比分析。为了求解远场观测点处的气动噪声,在精确求解双圆柱绕流流动的基础上结合基于FW-H(Ffowcs Williams-Hawkings)方程的声类比方法进行数值计算,并通过圆柱体的展向相关性对计算结果进行了修正,将得到的最终结果与相应的声学试验结果进行了对比,两者吻合良好,表明该数值方法是准确、可靠的。

关键词： 计算气动声学 非定常流动 涡脱落 Navier-Stokes方程 大涡模拟 限制数值尺度 Ffowcs Williams-Hawkings方程 双圆柱

Abstract:

The computational aeroacoustic result of aerodynamic noise problems is highly dependent on the capturing accuracy of an unsteady flow in the numerical prediction of aerodynamic noise. As a benchmark for airframe noise computation, the noise prediction for tandem cylinders is performed in this paper. The flow around the cylinders is simulated using the limited numerical scale (LNS) method based on a nonlinear *k-ε* model. The aerodynamic results and flow features obtained from the simulation are analyzed and compared with the experimental results. The flow parameters on the sound source surface are also recorded as the preparation data and then are combined with the acoustic analogy based on the FW-H (Ffowcs Williams-Hawkings) equation to predict the aerodynamic noise at the far-field receiver points. Since the spans in the simulation are relatively short, the predicted results have to be corrected for the span length. The final acoustic results are in good agreement with the experimental data, which indicates that the present numerical method is valid for this kind of aerodynamic noise problems.

Keywords: computational aeroacoustics unsteady flow vortex shedding Navier-Stokes equations large eddy simulation limited numerical scale Ffowcs Williams-Hawkings equation tandem cylinders

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