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一种滤波SST方法在翼型深失速模拟中的应用

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Application of Filter-SST Method in Airfoil Deep Stall Simulation

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摘要

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摘要

为了提高原始剪切应力运输(SST)湍流模型对于分离流动的求解精度,将大涡模拟(LES)中的滤波因子和SST方程相结合构造出一种滤波SST方法,利用湍流尺度对流场求解区域进行划分,近壁面附近的稳态流动由湍流模型控制,远壁面采用LES方法进行模拟。与传统混合RANS/LES方法相比,该方法的特点是:滤波因子的选取不再依赖于网格尺度,可以有效地降低网格诱导分离现象发生的概率。采用该方法对NACA0021翼型深失速特性进行了仿真研究,对比了非定常雷诺平均Navier-Stokes(URANS)方法和SST-DES方法,从仿真结果可以看出滤波SST方法有效地激活了分离区域的脉动,充分展现了分离的三维特性;同时算例求解结果证明该方法的精度高于URANS方法,与试验结果吻合较好,显示其具有一定的工程应用价值。

关键词: 滤波方法 剪切应力 大涡模拟 雷诺方程 混合RANS/LES方法

Abstract:

To improve the calculation precision of the original shear stress transport (SST) two-equation turbulence model, the filter factor of the large eddy simulation (LES) and SST formula are combined. The computation zone is splitted by the filter factor, through which a stable flow near the wall is controlled by the turbulence model while the flow far from the wall is simulated by LES. The advantage of this method in comparison with the classic hybrid RANS/LES methods is that the filter can be chosen without depending on grid scale, resulting in a decrease of the probability of grid induced separation. The deep stall of NACA0021 airfoil is simulated by using the filter SST, unsteady Reynolds-averaged Navier-Stokes (URANS) and SST-DES. The simulation result demonstrates that the impulse in the separated region can be effectively activated by the filter SST method. The phenomenon shows the three dimension characteristics of separation. Meanwhile, the result of the test case is more precise than that obtained by the URANS method and it matches well with the result obtained by experiment.

Keywords: filter method shear stress large eddy simulation Reynolds equation hybrid RANS/LES method

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