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二维翼型绕流计算中预处理和多重网格方法的应用

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Application of Preconditioning and Multi-grid Technique to Two-Dimensional Flow Calculation

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摘要

结合Turkel矩阵预处理方法和多重网格方法，发展一种适合低速粘性流动计算的高效数值方法.通过对Navier-Stokes方程的时间导数项实施Turkel矩阵预处理，使得可压缩Navier-Stokes方程在低速情况下的系统刚性得到改善.为进一步加速收敛,提高计算效率，采用多重网格的3层V循环方式，对RAE2822超临界翼型的低速粘性绕流流场进行数值模拟.计算结果表明，该预处理及多重网格方法能够大幅度地提高低速粘性流场的收敛性能，具有较高的计算精度，能够将可压缩Navier-Stokes方程的马赫数计算区域扩展到低速不可压缩区域，对于低速粘性流场的计算非常有效.

关键词： 低速流动；多重网格；预处理；隐式求解

Abstract:

Turkel preconditioning matrix and multi-grid technique are combined to develop an efficient method suitable for numerical computation of low-speed viscous flow. Rigidity of the system of compressible Navier-Stokes equations is improved using the Turkel preconditioning matrix, thus the compressible range of Mach of two-dimensional flow is extended for low-speed flows. By using the LU-SGS (lower-upper symmetric Gauss-Seidel) implicit method and introducing preconditioning methods together with a multigrid scheme, an RAE2822 airfoil is simulated at low Reynolds number and a small angle of attack. Numerical results show that the preconditioning methods and multi-grid technique can greatly improve convergence of viscous flows. Besides, the above method can extend the computational domain of Mach number of compressible Navier-Stokes equations to a low-speed incompressible area, which is effective in calculating low-speed viscous flows.

Keywords: low speed flow; multi-grid; preconditioning method; implicit method

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