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基于LES方法的平板非定常激波/湍流边界层干扰研究

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LES Application to Unsteady Flat Plate Shock Wave/Turbulent Boundary Layer Interaction

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摘要 以高超声速发动机进气道湍流分离控制为应用背景,采用大涡模拟(LES)方法进行马赫数为3.0(唇口附近马赫数约为3.0)的激波/湍流边界层干扰(SWTBLI)流场机理研究。利用扰动循环引入的方法,先得到充分发展湍流场,然后根据斜激波关系式引入激波的方法进行激波/湍流干扰模拟。研究结果显示:充分发展湍流场在激波作用下产生逆压梯度并发生分离;摩阻系数分布与实验结果一致;湍流可以有效减小分离区长度和强度。该研究结果为下一步进气道分离区湍流控制研究提供了理论依据。

关键词: 湍流 转捩 超声速边界层 激波/湍流边界层干扰 大涡模拟

Abstract: With an aim to realize hypersonic inlet turbulent separation control, a study is made of the inlet shock wave/turbulent boundary layer interaction (SWTBLI). As a sample, a plane flat shock wave reflection flow is simulated by large eddy simulation (LES). Shock wave effect mechanism in Mach number 3.0 conditions is analyzed. In the process of unsteady LES, disturbances that are obtained by direct numerical simulation (DNS) are imposed on the initial laminar boundary layer circularly to achieve full turbulent boundary quickly. When full turbulent boundary is realized, an oblique shock wave is imposed on it to form the SWTBLI. The numerical results indicate that LES can simulate planar SWTBLI well. The separation extent of the shock wave interaction zone is consistent with the experiment data. Owing to the effect of shock wave compression, the thickness and strength of the boundary layer are reduced near the reflecting shock wave.

Keywords: turbulence transition supersonic boundary layer shock wave/turbulent boundary layer interaction large eddy simulation

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