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基于控制轴向速度变化的1.5级涡轮压力可控涡设计

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Pressure Controlled Vortex Design of 1.5-stage Turbine Based on the Method of Controlling Axial Velocity Variation

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摘要 考虑了可控涡级内流面弯曲,通过寻找可控涡设计合适的轴向速度分布,采用给定压力分布求解环量分布的可控涡设计方法,首先对1.5级轴流亚声速试验涡轮进行了设计;然后进行参数化造型;最后运用三维黏性数值模拟,对所设计的1.5级涡轮进行了数值研究。数值结果表明:采用可控涡设计方法减缓了叶栅通道内的横向压力梯度;遏制了低能流体向吸力面堆积;消除了动叶栅根部沿径向方向的负压力梯度;降低了下通道涡核能量。与自由涡设计相比,可控涡设计涡轮效率提高了0.67%,功率提高了3.47%。研究还表明,采用这种压力可控涡设计方法,不仅可以提高动静叶匹配,还可以避免级后气流参数不均匀,最大程度地减少叶栅出口掺混损失。

关键词： 涡轮 涡轮设计 叶片造型 可控涡设计 压力可控涡 数值模拟

Abstract: Considering distortions of the stream surface and through the search for suitable axial velocity distributions in controlled vortex design stage, a 1.5-stage subsonic axial flow turbine is designed by controlled vortex design method with the given pressure distributions to resolve circulation distributions. The turbine blades are then obtained through parameterization design and are numerically studied through 3D viscous simulation finally. The results show that this controlled vortex design method relieves the transverse pressure gradient in cascade passage to keep the low-energy fluid from moving towards the blade suction. Also, it removes the negative pressure gradient along radial direction which could reduce the passage vortex core energy. Compared with free vortex design, the controlled vortex design turbine efficiency is increased by 0.67%, and the power, 3.47%. The results also indicate that the pressure controlled vortex design method not only enhances the stage match but also prevents the blade outlet flow parameters from non-uniform to reduce mixing losses to the greatest extent.

Keywords: turbine turbine design blade modeling controlled vortex design pressure controlled vortex numerical simulation

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