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燃气轮机压气机涡量动力学理论及分析方法

Theory and analysis method based on vorticity dynamics for gas turbine compressor

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英文关键词:compressor aerodynamic analysis and optimization vorticity dynamics boundary vorticity flux circumferential vorticity

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中文摘要:

阐述了压气机涡量动力学理论及分析方法,建立了压气机总性能参数与两个重要的涡量参数(边界涡量流(BVF)和周向涡量)的直接数学物理关系,研究了基于BVF和周向涡量的分析优化方法.将该方法应用于燃气轮机多级轴流压气机中进行涡量动力学分析,从涡量角度指出了改进的方向.结果表明:周向涡量能反映近壁面的高损失区,使周向涡量峰值束缚在近壁区有利于降低端区损失,在通流设计中可通过优化环量分布控制周向涡量分布,算例中基于周向涡量优化可使跨声压气机转子效率提高1.13%;边界涡量流BVF能反映旋涡的壁面根源,通过优化BVF的分布可控制涡量壁面根源,有利于抑制旋涡和流动分离,基于BVF优化可使转子效率提高1.12%.

英文摘要:

Vorticity dynamics theory and analysis method for compressor of gas turbine was described, and the mathematical and physical relations of total performance parameters and two important vorticity parameters was constructed based on vortictity dynamics theory. The analysis and optimization method based on boundary vorticity flux(BVF) and circumferential vorticity(CV) was researched. The multi-stage axial compressor of gas turbine was designed firstly and then analyzed using this theory and method, and the improving way for the designed compressor was found. It is demonstrated that CV can probe the high loss region near solid boundary, and the loss will be controlled if CV peaks can be restricted in the region near solid boundary. The swirl distribution can be optimized to control CV distribution, and in the optimization of the transonic compressor rotor based on CV the peak efficiency is improved by 1.13%. On the other hand, it is shown that BVF can reflect the vorticity source on solid boundary, and the vorticity and flow separation are suppressed through controlling BVF, and the rotor peak efficiency can be increased by 1.12% in the optimization based on BVF.

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