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大小叶片轴流级反问题设计及数值模拟

杨小贺, 单鹏

北京航空航天大学 能源与动力工程学院, 北京 100191

Inverse Design of Splittered Axial Compressor and Numerical Simulation

YANG Xiaohe, SHAN Peng

School of Jet Propulsion, Beihang University, Beijing 100191, China

摘要 在常规轴流级流线曲率法通流设计和任意中弧线叶型造型方法的基础上,引入了适合于大小叶片的当量扩散因子叶型损失模型,发展了用Miller-Lewis-Hartmann(M-L-H)模型分别计算大叶片和小叶片激波损失的复合激波模型,制定了大小叶片装配方法,建立了大小叶片通流反问题设计系统。用该系统对某级增压比为2.20的单级高负荷后掠风扇进行了后掠和前掠大小叶片改型设计。经计算流体力学(CFD)检验,维持后掠造型的改型,在不提高设计点增压比的条件下,级绝热效率相当,流量和失速裕度都得到了提高;而大小叶片结合前掠的改型,当考虑单排静子的最大载荷将设计级增压比提高至2.31时,级绝热效率略微降低约0.3%,流量略减,失速裕度则显著提高。算例也表明通流反问题设计系统适合于大小叶片轴流级的设计。

关键词: 轴流压气机 大小叶片 流线曲率法 损失模型 掠形叶片 数值模拟

Abstract: Based upon a through-flow code of streamline-curvature method and a quasi-3D arbitrary airfoil blading code, a diffusion loss model is employed in terms of the adjusted factor, a compound shock loss model in terms of Miller-lewis-Hartman (M-L-H) model is developed and a splitter blade positioning scheme is established. Thus, an inverse design system for splittered axial compressors is composed. Using this design system, a high-loaded backward swept fan with a stage pressure ratio of 2.20 is redesigned firstly as a backward swept and secondly as a forward swept splittered fan. The numerical simulations of both flow fields are carried out. In the situation of keeping the prescribed pressure ratio, the backward swept splittered fan has a higher flow rate and a higher stall margin with an approximate adiabatic efficiency compared to the original design. When prescribing a higher pressure ratio of 2.31 which is sustainable by the single conventional stator row, the forward swept splittered fan increases greatly the stall margin with a negligible decline of the adiabatic efficiency by about 0.3% and a lower flow rate. The two redesigns also prove the competence of this design system.

Keywords: axial flow compressor splittered rotor streamline-curvature approach loss model swept blade numerical simulation

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Corresponding Authors: Tel: 010-82316372 E-mail:PShan@buaa.edu.cn Email: PShan@buaa.edu.cn

About author: 杨小贺(1984-) 男,博士研究生。主要研究方向:叶轮机械气动热力学。 Tel: 010-82338385 E-mail:xiaocao710181@163.com; 单鹏(1955-) 男,博士,教授,博士生导师。主要研究方向:叶轮机械气动热力学。 Tel: 010-82316372 E-mail:PShan@buaa.edu.cn

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