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重型燃气轮机压气机高雷诺数前转捩叶型设计

Design of high Reynolds number compressor airfoil with early transition for heavy-duty gas turbine

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中文摘要:

针对重型燃气轮机压气机雷诺数高而导致的转捩位置前移,开发了一种比可控扩散叶型(CDA)损失更小、工作范围更宽的前转捩叶型.采用正问题优化设计方法,将叶型几何参数化、叶片到叶片流场分析与遗传算法相结合,实现了叶型的自动优化.优化目标综合权衡了叶型损失和攻角范围,为减少优化变量的数目,应用了一种特别的叶型几何模型,将厚度分布与中弧线之间进行了一定的关联.优化得到的前转捩叶型的主要特征是吸力面速度峰值的位置前移至距前缘约10%弦长处,叶型中后部的速度变化更为平缓.最后根据优化结果总结了前转捩叶型的设计规律.

英文摘要:

A type of compressor airfoil, characterized by lower losses and wider operating range than conventional controlled diffusion airfoil (CDA), was developed for use in heavy-duty gas turbines, which considered the early boundary layer transition on blade surface induced by high Reynolds number. Direct design process was adopted, in which the parameterization of airfoil geometry and the blade to blade flow solver were integrated into genetic algorithm to facilitate automatic optimization of airfoil. The optimization object was considered as a compromise of airfoil loss and operating range of incidence, and a special airfoil geometry model correlating the thickness distribution with camber line was applied to reduce optimzation variables. The main characteristics of early transition airfoil by optimization are as follows: the suction side velocity maximum moves forward to around 10% of chord, and the velocity distribution in the rear portion is flat. Finally, the design strategy of this type of early transition airfoil was summarized according to the optimization results.

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