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间隙高度对自发射流抑制叶尖泄漏的影响

Effect of clearance height on tip leakage reduced by spontaneous tip injection

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中文摘要:

通过数值求解三维定常黏性雷诺时均N-S方程, 获得了单孔叶尖自发射流条件下不同叶顶间隙的叶栅流场, 对比分析了间隙高度对自发射流与叶尖泄漏流相互作用特性、叶尖泄漏流量以及叶片载荷的影响. 结果表明: 当叶顶间隙高度为1mm ($t/H=0.5\%$) 时, 自发射流对泄漏流有明显的阻挡作用, 泄漏流量比减少0.06%, 同时叶片载荷增加1.39%. 当叶顶间隙高度增大到4mm ($t/H=2\%$) 时, 自发射流的阻挡作用及对叶片载荷的增加作用基本消失; 减小间隙高度可以有效提高自发射流的控制效果, 同时降低因分离造成的流动损失; 自发射流的存在显著改变了间隙流场分布及叶尖吸力面附近静压系数分布, 计算发现当泄漏流绕自发射流流过时, 下游流场出现类似卡门涡街的涡分布现象.

英文摘要:

The steady cascade flow field with different tip clearance height was obtained by numerically solving three-dimensional Reynolds-averaged N-S equations(RANS)and energy equations under the condition of single-hole spontaneous tip injection.The influences of clearance height on the interaction characteristics of the spontaneous injection with the tip leakage flow,the mass flow rate of leakage flow and the blade load were analyzed.The results show that the spontaneous jet has significant blocking effect on the leakage flow, the leakage ratio decreases by 0.06% with 1mm($t/H=0.5\%$) tip clearance,and meanwhile the blade load increases by 1.39%.The blocking effect decays with the increasing clearance height and can be ignored when the clearance height rises to 4 mm ($t/H=2\%$);decreasing clearance height can effectively improve the controlling effect of spontaneous jet on leakage flow and reduce the flow losses caused by flow separation;the presence of spontaneous tip injection significantly changes the flow field of tip gap and the distribution of static pressure coefficient near the suction.The calculation results show that a vortex similar to the Karman vortex street appears downstream the jet flow when the leakage flow moves around the spontaneous jet.