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变工况下超高负荷低压涡轮叶片边界层被动控制

Ultra-high-lift low-pressure turbine blade boundary layer passive control in different flow conditions

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英文关键词:ultra-high-lift low-pressure turbine blade Reynolds number free stream turbulence intensity passive flow control

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中文摘要:

以某超高负荷低压涡轮叶型为研究对象,利用数值模拟的方法通过改变来流雷诺数、自由来流湍流强度和攻角等工况,研究了其对叶片边界层特性的影响,并通过在叶片吸力面加凹槽、矩形拌线、圆形拌线等被动控制方式来改善叶型性能,结果表明:随着雷诺数的增大叶型损失逐渐降低;随着自由来流湍流强度的增加叶型损失先减小后增大;随着攻角向负攻角方向变大叶型损失先减小后增大,向正攻角方向变大时叶型损失迅速增大;在雷诺数和湍流强度变化时表面凹槽的控制方式较好,而攻角变化时加矩形拌线和圆形拌线的控制方式较好.3种被动控制方式促发转捩提前发生抑制分离泡,但都会引起湍流湿面积的增加.

英文摘要:

Effects of Reynolds numbers, free stream turbulence intensities (FSTI) and angle of attack on the steady boundary layer development of an ultra-high-lift low-pressure turbine blade were investigated.The three different types of passive separation control devices, which were dimple, cylindrical wire and rectangular trip, were investigated to further improve the blade performance.Numerical simulation results show that:as the Reynolds increases the profile loss decreases;as the FSTI increases, the profile loss decreases, and then increases;as the attack angle increases in the negative direction, the profile loss decreases, and then increases; as the attack angle increase in the positive direction, the profile loss increases rapidly;when the Reynolds number and the FSTI changes, it is found that the dimple can suppress the separation bubble better and when the attack angle changes, it is found that the wire and strip can suppress the separation bubble better.It is also found that the three passive control methods hasten the transition process so the separation is suppressed, but it increases the turbulent wetted area.