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后缘襟翼对直升机旋翼翼型动态失速特性的影响

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Effect of the Trailing Edge Flap on Dynamic Stall Performance of Helicopter Rotor Airfoil

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摘要

针对带后缘襟翼的智能旋翼直升机典型襟翼参数对翼型动态失速特性的影响进行了研究。建立了带后缘襟翼的桨叶动态失速模型,考虑了襟翼与桨叶之间的缝隙和襟翼在运动过程中相对桨叶的凸起,采用计算流体力学(CFD)方法,研究了不同襟翼转轴位置和襟翼与桨叶的缝隙情况下的翼型动态失速特性,探讨了后缘襟翼激励幅值、时长和起始时刻对升力和俯仰力矩系数的影响。研究结果表明:后缘襟翼能够较好地改善翼型动态失速时的气流环境,并减缓动态失速发生;襟翼激励最优幅值在25°附近,最优激励范围在方位角为240°~360°之间;襟翼转轴后移导致襟翼运动时产生的凸起会使襟翼控制效果减弱;襟翼与桨叶的缝隙会影响翼型动态失速特性,但是缝隙的长度(弦长的2%以内)对襟翼控制效果的影响很小。

关键词: 直升机 旋翼 后缘襟翼 动态失速 数值模拟

Abstract:

Impact of the trailing edge flap parameters on the characteristics of dynamic stall is investigated for the smart rotor. The model is established for the dynamic stall of the rotor blade with the trailing edge flap. The overhang and the gap between the trailing edge flap and the blade are considered. Through the method of computational fluid dynamics (CFD), the effects of the gap size and the location of flap hinge have been studied, and the effect of flap deflection, flap duration, and flap start time has also been calculated. The result shows that the flap control can effectively improve the flow condition under dynamic stall conditions and delay dynamic stall. The optimization design of the flap actuation is that the amplitude of flap deflection is designated to 25°, whereas the flap duration azimuth angle is chosen from 240° to 360°. There are overhang and gap between the trailing edge flap and rotor blade. It is indicated that the overhang reduces the control effect of trailing edge flap. The gap also affects the control effect, but its length (≤2%) has little effect on the result.

Keywords: helicopters rotors trailing edge flaps dynamic stall numerical simulation

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