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电控旋翼气动特性建模与风洞试验验证

Aerodynamic characteristic modeling of electrically controlled rotor and wind tunnel test verification

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中文摘要：

首先建立了带襟翼翼型的非定常气动力模型,继而基于Peters-He广义动态尾迹理论,考虑襟翼偏转对电控旋翼叶素环境的影响,建立了电控旋翼有限状态尾迹模型;进一步基于Theodorsen理论推导出电控旋翼桨叶挥舞响应与桨叶变距和襟翼操纵量的关系,综合以上建立了电控旋翼气动特性分析模型.以改进型电控旋翼试验系统为平台进行了风洞试验,测量了不同风速、不同襟翼操纵条件下的电控旋翼气动力、桨距、襟翼偏角及旋翼挥舞角的变化情况.理论计算结果与试验数据符合情况良好,验证了所建立的分析模型的正确性,并得出以下结论:旋翼转速一定时,桨叶变距与襟翼操纵基本呈线性关系;旋翼拉力随襟翼总距的增加而逐渐减小,襟翼总距较大时,其实际气动效率略有下降;前飞状态时,襟翼总距操纵会引起桨叶的纵向周期变距.

英文摘要：

Firstly, the unsteady aerodynamic model of the airfoil with trailing-edge flap was developed. Secondly, the finite state wake model of electrically controlled rotor(ECR) based on the Peters-He generalized dynamic wake theory was developed, in which the effect of the trailing-edge flap on the rotor aerodynamic environment was considered. Combined with the relationship among the blade flapping angle, the blade pitch and the deflection angle of the trailing-edge flap, the model of calculating the aerodynamic characteristics of ECR was established finally. Then, wind tunnel tests were conducted, in which the aerodynamic force, the blade pitch, the deflection angle of the trailing-edge flap and the blade flapping angle varying with different test statuses were measured. Theoretical results basically coincided with the experimental data, which verified the correction of the theoretical model. Conclusions are drawn as follows: with the fixed rotor speed, there is a linear relationship between blade pitch response and flap control; rotor thrust decreases with the increase of flap collective control, and actual aerodynamic efficiency of the flap decreases under large collective control; in forward flight, flap collective control can cause changes of blade cyclic pitch.