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含有SMA弹簧驱动器的可变倾斜角翼梢小翼研究

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Research on Variable Cant Angle Winglets with Shape Memory Alloy Spring Actuators

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摘要 针对传统翼梢小翼在非设计状态减阻效果不佳的缺点,提出一种含有形状记忆合金(SMA)弹簧驱动器的变体翼梢小翼结构,它能根据飞行状态主动调整小翼的倾斜角,实时优化飞机的阻力特性.采用力-热-应变耦合法设计了所需的SMA弹簧驱动器,并通过有限元仿真与风洞试验验证了变体翼梢小翼的变形能力,最后初步研究了变体翼梢小翼的闭环控制方法.研究结果表明,在飞机的起飞阶段(自由来流流速为26 m/s,迎角为3°),变体翼梢小翼的倾斜角能在1 min内自主完成预定变化过程,倾斜角的最大变化量为23°,控制精度的最大误差为12%,各项指标均符合设计要求.

关键词: 减阻技术 自适应系统 机翼 形状记忆效应 弹簧 驱动器

Abstract: To improve the drag reduction efficiency of a winglet under off-design conditions, this paper presents a morphing winglet concept that utilizes shape memory alloy (SMA) spring actuators to change the cant angle of the winglet and optimize the drag characteristics of an aircraft under various flight conditions. The required SMA spring actuators are designed through a coupling design method, and the morphing capability of the morphing winglet is validated by finite element analysis and wind tunnel test. Finally, a closed-loop control for the morphing winglet is presented. The results show that an active cant angle of 23° can be achieved within 1 min in the takeoff phase of a flight (with the freestream velocity is 26 m/s and the angle of attack is 3°). The maximum error of control precision is less than 12%. The testing results agree well with the design specifications.

Keywords: drag reduction adaptive system wing shape memory effect spring actuator

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