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含有SMA弹簧驱动器的可变倾斜角翼梢小翼研究

李伟¹, 熊克¹, 陈宏², 张绪², 苏永刚¹, 任智毅³

- 1. 南京航空航天大学 机械结构力学与控制国家重点实验室, 江苏 南京 210016;
- 2. 中国商飞上海飞机设计研究院, 上海 200232;
- 3. 南京航空航天大学 飞机设计技术研究所, 江苏 南京 210016

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

LI Wei¹, XIONG Ke¹, CHEN Hong², ZHANG Xu², SU Yonggang¹, REN Zhiyi³

- 1. State Key Laboratory of Mechanics and Control of Mechanical Structures, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China;
- 2. Shanghai Aircraft Design and Research Institute, Shanghai 200232, China;
- 3. Institute of Aircraft Design, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China

摘要

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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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Corresponding Authors: 熊克 Email: kxiong@nuaa.edu.cn

About author: 李伟 男,博士研究生.主要研究方向: 智能材料与结构、变体机翼驱动技术. Tel: 025-84892834 E-mail:

weili@nuaa.edu.cn

熊克 男,博士,教授,博士生导师.主要研究方向: 飞行器自适应结构中的驱动技术、飞行器复合材料结构的损伤检测、应变电测与力学量传感器技术. Tel: 025-84891502 E-mail: kxiong@nuaa.edu.cn

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