Investigation on Elastic Fibers Enforced Shape Memory Polymer Composites

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Abstract

Shape Memory Polymer (SMP) is a kind of polymer with shape memory effect, which is divided to thermoset and thermoplastic [1]. SMP is also considered as a variable stiffness material. The modulus ratio of thermoset SMP can be more than 200, which is can be used in morphing wing structures. The SMP skin can change the wing's construction in low modulus state (rubbery state), and reject to aerodynamic loads in high modulus state (glass state). There are some weaknesses of pure thermoset SMP to limit its practical application. For instance, the pure SMP is brittleness under a bending load in its glass state; and it also tears rapidly along a micro crake under a tensile load in rubbery state. Enhanced fibers were considered to be mixed into the resin to improve the mechanical properties. However, due to the small extension strain of fibers, SMP composites may fracture under a largely extension strain [2, 3]. Elastic materials were mixed into pure SMP to obtain large strain; the toughness can be improved up to 200% [4], which made SMP more riskless and reliable for application.

In this present paper, elastic fibers (20% spandex and 80% nylon) were mixed into the pure SMP in order to improve the mechanical properties. The transition temperature (T_g) of SMP composites is about 63 ^oC obtained from DMA test. From the high temperature tensile tests we can get, elastic fibers enforced SMPCs improved the toughness of pure SMP at room temperature (glass state) with acceptable drop in Young's Modulus. SMPCs developed the strength and Young's Modulus of SMP in high temperature, which means elastic fibers improve the security for using above Tg. The tear strength of SMP was significantly improved by elastic fibers, especially at

high temperature. This makes the SMPCs structure installing easily and safety in application. Elastic fibers used in this research did not affect the thermal conductive performance of SMP. So the SMPCs' performances of recovery rate and heating speed were influenced less.

The 20 vol% elastic fibers enhanced SMPCs, as morphing skins, were installed on a variable camber wing structure to demonstrate their application. 5% per-stretched strain was applied to the SMPCs skins to avoid wrinkle. The morphing skins were heated up by a 9.39W heater for 200s to make sure the whole SMPCs soft enough. The trailing edge of the wing can morph actuated by pneumatic artificial muscles (PAM). The skins kept the surface smooth and dependable in the whole process. Because of the long pre-heating time, the current variable camber wing with SMPC skin can be used for taking off and landing.

Keywords: Shape Memory Polymer, Elastic Fibers, Mechanical Properties

Reference

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