Bending shape memory process of a fabric-reinforced shape memory polymer composite plate: experimental investigation and numerical simulation

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ABSTRACT

Fabric-reinforced shape memory polymer composite plate (FSMPCP) with high levels of stiffness, strength and shape memory property are important stimuli-controlled smart materials which have significant potential to be applied in large size smart structures. Shape memory property and the corresponding mechanical constitutive model of FSMPCP are the essential issues to be addressed before utilizing the material. In this work, a long carbon-fiber reinforced FSMPCP was developed via vacuum infiltration molding process (VIMP) to investigate the shape memory process and further to establish the constitutive model. Basic mechanical experiments including tension and compression were carried out firstly, where the anisotropy and the tension-compression asymmetry were detected. Then, the thermal shape memory property in bending case was investigated through a typical four-step shape memory experiments. To establish an effective shape memory constitutive model of FSMPCP, a bi-phasic description was used where the stiffness was considered to be contributed by an active-phase and a frozen-phase. A homogenization process using representative volume element (RVE) was conducted to obtain the effective elastic properties. Besides, a linear two-modulus model was applied to depict the asymmetry of tension-compression. To validate the constitutive model, numerical simulation method was also developed based on the UMAT in ABAQUS. Finally, finite element simulations of bending shape memory experiments were carried out using the proposed constitutive model. The comparison between numerical and experimental results revealed that the constitutive model was effective to depict the anisotropy, the tension-compression asymmetry and the shape memory process of the FSMPCP.

Key words: Fabric-reinforced shape memory polymer composite plate (FSMPCP); Shape memory constitutive model; Stiffness homogenization, Tension-compression asymmetry.

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