Accepted Manuscript

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PII: S0749-6419(16)30304-7

DOI: 10.1016/j.ijplas.2017.04.004

Reference: INTPLA 2182

To appear in: *International Journal of Plasticity*

Received Date: 27 November 2016

Revised Date: 29 March 2017

Accepted Date: 5 April 2017

Please cite this article as: Li, Y., He, Y., Liu, Z., A viscoelastic constitutive model for shape memory polymers based on multiplicative decompositions of the deformation gradient, *International Journal of Plasticity* (2017), doi: 10.1016/j.ijplas.2017.04.004.

A Viscoelastic Constitutive Model for Shape Memory Polymers Based on multiplicative decompositions of the deformation gradient

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Abstract

Shape memory polymers (SMPs) are a class of polymeric smart materials that have the capacity to return from a deformed state (impermanent shape) to their original state (permanent shape) by temperature stimulus. In this work, we propose a novel phase-transition-based viscoelastic model including the time factor for shape memory polymers (SMPs), which has a clearer physical significance. To describe the phase transition phenomenon of SMPs, our new model defines different constitutive structures for above and below transformation temperature separately. As the proposed viscoelastic model is based on multiplicative thermoviscoelasticity, it can not only be used for different types of SMP materials, but also can be used to treat large strain problems. To validate the model's availability and show the model's capability of reproducing the shape memory effect (SME), two testing examples are predicted with this new constitutive model. The prediction results of the simulation are in good agreement with the available experimental results.

Keywords: Constitutive model; Large strain; Phase transition; Shape memory polymers; Viscoelastic

1. Introduction

Shape memory polymers (SMPs) are a kind of soft and smart materials that can maintain a deformed state (impermanent shape) with a pre-deformation at a high temperature and subsequently cooling it down to a lower temperature. The memorized original state (permanent shape) can be recovered by rising the temperature. Compared with traditional shape memory materials (*e.g.*, shape memory alloys (SMAs) (Ashrafi et al., 2016; Oliveira et al., 2014; Poorasadion et al., 2015; Yu et al.,