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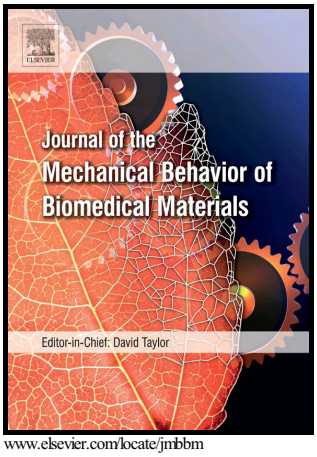
K. Narooei, M. Arman



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Generalization of exponential based hyperelastic to hyper-viscoelastic model for investigation of mechanical behavior of rate dependent materials

K. Narooei*, M. Arman

Department of Materials Science and Engineering, K. N. Toosi University of Technology, Tehran, Iran.

Abstract.

In this research, the exponential stretched based hyperelastic strain energy was generalized to the hyper-viscoelastic model using the heredity integral of deformation history to take into account the strain rate effects on the mechanical behavior of materials. The heredity integral was approximated by the approach of Goh et al to determine the model parameters and the same estimation was used for constitutive modeling. To present the ability of the proposed hyper-viscoelastic model, the stress-strain response of the thermoplastic elastomer gel tissue at different strain rates from 0.001 to 100 /s was studied. In addition to better agreement between the current model and experimental data in comparison to the extended Mooney-Rivlin hyper-viscoelastic model, a stable material behavior was predicted for pure shear and balance biaxial deformation modes. To present the engineering application of current model, the Kolsky bars impact test of gel tissue was simulated and the effects of specimen size and inertia on the uniform deformation were investigated. As the mechanical response of polyurea was provided over wide strain rates of 0.0016 to 6500 /s, the current model was applied to fit the experimental data. The results were shown more accuracy could be expected from the current research than the extended Ogden hyper-viscoelastic model. In the final verification example, the pig skin experimental data was used to determine parameters of the hyper-viscoelastic model. Subsequently, a specimen of pig skin at different strain rates was loaded to a fixed strain and the change of stress with time (stress relaxation) was obtained. The stress relaxation results were revealed the peak stress increases by applied strain rate until the saturated loading rate and the equilibrium stress with magnitude of 0.281 MPa could be reached.

Keywords: Hyper-viscoelastic; TPE gel tissue; Pig skin; Polyurea; Kolsky test; Heredity integral.

1. Introduction

Hyperelastic strain energy functions are widely used to investigate the mechanical behavior of nonlinear elastic materials like soft tissues, carbon nanotubes, rubbery, and elastomeric materials (Allan F. Bower 2010; Ling and Atluri 2007). In addition, generalization to hyper-viscoelasticity has substantial role in the stress analysis of the rate dependent materials. To this goal, selection

* Corresponding Author: Tel.: +982184063283; Fax: +982188785238.
Email: knarooei@kntu.ac.ir