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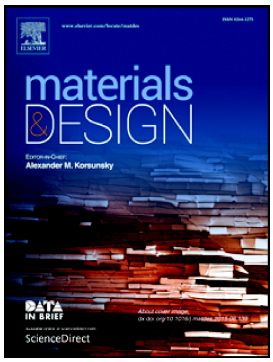

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PII: S0264-1275(18)30540-9
DOI: doi:10.1016/j.matdes.2018.07.010
Reference: JMADE 4043

To appear in: *Materials & Design*

Received date: 16 May 2018
Revised date: 5 July 2018
Accepted date: 6 July 2018

Please cite this article as: Balint Fazekas, Tibor J. Goda , Determination of the hyper-viscoelastic model parameters of open-cell polymer foams and rubber-like materials with high accuracy. Jmade (2018), doi:10.1016/j.matdes.2018.07.010

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Determination of the hyper-viscoelastic model parameters of open-cell polymer foams and rubber-like materials with high accuracy

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Declarations of interest: none

Abstract

This paper focuses on a newly-developed method for the extraction of the accurate hyper-viscoelastic model parameters of open-cell polymer foams and rubber-like materials. Although the parameter identification method is developed for strain-controlled uniaxial tension/compression, the finite time increment-based approach used can be extended to other experimental loading modes, such as simple and pure shear, biaxial tension/compression, confined compression, etc. Furthermore, the method makes it possible to use any hyperelastic material model and to extract the constitutive model parameters of both compressible and incompressible hyper-viscoelastic solids subjected to arbitrary strain (stretch) history. The applicability of the method and the reliability of the constitutive model parameters determined from the numerical prediction of the stress response are proved through the comparison of finite element and measurement results. Finally, the material model parameters of an incompressible isoprene rubber and a compressible polyurethane foam extracted with the proposed method and those determined with the two-step and the direct (closed-form) method are used to compare the accuracy of the predicted behaviours. It clearly revealed that the constitutive constants extracted using the proposed direct (numerical) method result in the best agreement between the measurement and the simulation.

Keywords

Hyper-viscoelasticity; Prony series; Compressible/incompressible solids; Parameter identification; Numerical method

1 Introduction

Polymer foams and rubber-like materials are well-known representatives of the compressible/incompressible hyper-viscoelastic solids. Although their material behaviour is dissimilar, both exhibit large deformation, highly nonlinear stress-strain relation and time-dependent material properties [1–4]. Filled rubbers are typical polymer composites and can be regarded as hybrid systems composing of three components, i.e., the polymer matrix, the fillers and the polymer-filler interface [5]. In order to improve the mechanical and functional properties, various fillers (carbon black, carbon nanofibers or nanotubes, etc.) can be added to the polymer matrix. However, the filler materials have different enhancing effect on macroscopic mechanical properties (e.g. the ability of materials to resist elastic and viscous (creep) deformation, the ability of materials to dissipate energy, etc.). In [5], it is found that the uniform distribution (homogeneous dispersion) of the filler material results in better macroscale enhancement effect. Furthermore, the enhancement effect of the fillers

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