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A thermodynamically compatible rate type fluid to describe the response of asphalt

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Abstract

In this paper, we consider two models that have been recently developed from a thermodynamic standpoint and that are capable of describing the response of nonlinear viscoelastic fluids. We test the efficacy of both models by comparing their predictions against torsion experiments conducted for asphalt, a material that is notoriously difficult to model. Both the models seem to describe the response adequately, though neither is really very accurate. This should not be surprising as asphalt is a heterogenous material comprising of many components which is being homogenized and modeled as a single constituent viscoelastic fluid.

Keywords: Rate type fluid; Large deformation; Numerical simulation

1. Introduction

Though asphalts have been used extensively from prehistoric times (see Agricola [1], Connan [7], Boëda et al. [4], Boëda et al. [3] and Krishnan and Rajagopal [12]) to date there is no model that can predict the behavior of asphalt with acceptable accuracy. The problem stems from asphalts being a very complex class of mixtures of hydrocarbons, their structure and hence their response being shaped by the way in which they were formed, where they were formed, the exposure to ultraviolet radiation, etc. Given their importance in being a significant part of the transportation network that is essential to economic well being there has been considerable effort expended in trying to understand its complex nonlinear response characteristics. A useful tool in the development of models for asphalt is a recent thermodynamic framework that has been put into to place to describe the nonlinear response of bodies such as asphalt.

The thermodynamic framework has been developed that recognizes the fact that in many bodies the natural configuration (usually stress free configuration, or the configuration the body attains on the removal of the external stimuli; it could also be a configuration wherein the driving force is zero, see Rajagopal [23] and Rajagopal and Srinivasa [24]) evolves when the body is subject to a thermodynamic process and its evolution is determined by a thermodynamic criterion that is discussed later. This evolution of the natural configuration leads to rate type constitutive relations for such bodies.

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