
Inverse Approaches to Dynamic Viscoelastic Material Identification

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Abstract

Polymers are integral to various engineering applications, including defense, aerospace, automotive, and biomedical fields, where materials often experience high strain rates. Traditional high-rate material characterization techniques, such as the Kolsky bar (also known as the split-Hopkinson pressure bar), rely on assumptions like uniform loading and negligible inertial effects, which may not hold under all conditions. This presentation explores optical noninvasive and inverse methods for constitutive parameter identification, focusing on the dynamic behavior of both brittle and non-brittle polymers. The first segment examines open-cell polyurethane foams, commonly used in protective helmet liners, which exhibit significant rate-dependent behavior with low impedance. By employing quantitative microstructural characterization and a non-parametric formulation of the Virtual Fields Method (VFM), we analyze the compressive response of these foams across six orders of magnitude in strain rate, elucidating the relationship between microstructure and bulk mechanical properties as well as the validity of the experimental assumptions. The second segment addresses the viscoelastic behavior of brittle polymers, using polymethyl-methacrylate (PMMA) as a model material. Leveraging the Image-Based Inertial Impact Test (IBII) and numerical simulations based on a generalized Maxwell model, we are able to extract multiple viscoelastic parameters in a single experiment. Experimental validations confirm the method's efficacy in capturing viscoelastic properties across various time constants, offering a more robust approach to dynamic material characterization.

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