Title: Pulse Propagation in Felt and Its Dependence on Relaxation Time
Authors: Dmitri Kartofelev, Maria M. Vuin
Affiliation: Laboratory of Solid Mechanics, Department of Cybernetics, School of Science, Tallinn University of Technology, Tallinn, Estonia
Corresponding Author: Dmitri Kartofelev
Email: dmitri.kartofelev@taltech.ee
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Abstract: This study presents a theoretical and numerical analysis of acoustic wave behavior in felt-like fibrous porous viscoelastic materials. The proposed and analyzed models are derived using experimentally verified constitutive relationship. The question of material relaxation time and its effects on the resulting model equations and simulated wave evolution are discussed. In addition to the characteristic temporal scale—the relaxation time—the presented results are examined in the context of corresponding characteristic spatial scales, such as, fiber lengths, fiber diameters, empty void sizes, etc. Unsurprisingly, the findings suggest that when time scale associated with material loading and unloading is significantly different from the material relaxation time, the resulting wave dynamics are strongly influenced. Provided models allow for exact quantification of these differences. The findings presented here are relevant to a wide range of industries. Felt's anisotropic structure and nonlinear viscoelastic behavior make it particularly valuable in applications such as musical instrument manufacturing—where e.g. its memory effects influence the performance of piano hammers—and in the automotive and machinery sectors, where it is widely used for its excellent noise and vibration damping properties.

Keywords: felt, relaxation time, nonlinear wave propagation, material with memory, material with microstructure.