

Simplified Modelling of Visco-Elastic Fluids for Use in Recoil Damping Systems

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Abstract : Visco-elastic materials combine the stress response properties of both solids and fluids and have found use in a variety of damping applications - both vibrational and acoustic. Defense and automotive applications, in particular, are subject to high impact and shock loading - for example: aircraft landing gear, firearms, and shock absorbers. Field responsive fluids - a class of smart materials - are the preferred choice of energy absorbents because of their controllability. These fluids' stress response can be controlled by the application of a magnetic or electric field, in a closed loop. Their rheological properties - elasticity, plasticity, and viscosity - can be varied all the way from that of a liquid such as water to a hard solid. This work presents a simplified model to study the impulse response behavior of such fluids for use in recoil damping systems. The well-known Burger's equation, in conjunction with various visco-elastic constitutive models, is used to represent fluid behavior. The Kelvin-Voigt, Upper Convected Maxwell (UCM), and Oldroyd-B constitutive models are implemented in this study. Using these models in a one-dimensional framework eliminates additional complexities due to geometry, pressure, body forces, and other source terms. Using a finite difference formulation to numerically solve the governing equation(s), the response to an initial impulse is studied. The disturbance is confined within the problem domain with no-inflow, no-outflow boundary conditions, and its decay characteristics studied. Visco-elastic fluids typically involve a time-dependent stress relaxation which gives rise to interesting behavior when subjected to an impulsive load. For particular values of viscous damping and elastic modulus, the fluid settles into a stable oscillatory state, absorbing and releasing energy without much decay. The simplified formulation enables a comprehensive study of different modes of system response, by varying relevant parameters. Using the insights gained from this study, extension to a more detailed multi-dimensional model is considered.

Keywords : Burgers Equation, Impulse Response, Recoil Damping Systems, Visco-elastic Fluids

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