Rheo-physics of Shear Thickening Fluids for applications in ballistic impact protection technology

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INTRODUCTION

- Previous work has investigated STFs using rheology and SHPB techniques
- Extension to ballistic events requires a means for predicting the STF response at high impulse pressures and small time steps
- Goals toward incorporating STF in an armored vehicle interlayer
- Understand a STF’s response during a transient deformation
- Effectively predict the response of a STF during a ballistic impact

STF MICROSTRUCTURE

Our current understanding for the microstructure of a material during deformation provides the tools to propose a constitutive model that describes the macroscopic stress response based on the underlying microstructural rearrangements.

CONSTITUTIVE MODEL DEVELOPMENT

Hydrodynamic component associated with forces acting between particles due to motion through the suspending fluid.

Thermodynamic component associated with the Brownian motion of the particles.

LARGE AMPLITUDE OSCILLATORY SHEAR (LAOS) RHEOLOGY

LAOS results

LAOS rheology allows us to probe the stress, strain and strain rate relationship

CONSTITUTIVE MODEL: SHEAR THINNING REGIME

Giesekus constitutive equation:

\[ \tau = \tau_0 + \eta \dot{\gamma} \]

Where \( \alpha \) is the anisotropy parameter originally defined as a flow alignment parameter for polymers systems.

Motivates for a multi-mode \( G \) Giesekus constitutive equation

CONCLUSIONS AND FUTURE RESEARCH

- Complete constitutive model development
- Predict responses of STF in SHPB
- Implement STF into technology designed to protect against transient impacts

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