EFFECT OF PARTICLE SIZE ON HIGH AND LOW RATE RESPONSES OF SHEAR THICKENING SUSPENSION OF HARD-SPHERE PARTICLES

K. Forrest , E. Head III, J. W. Gillespie Jr., and N. J. Wagner

University of Delaware . Center for Composite Materials . Department of Materials Science and Engineering

MOTIVATION

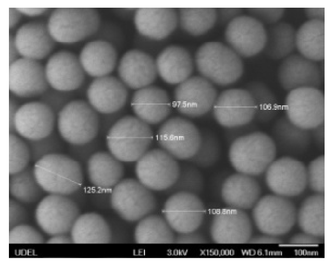
- **Goal**: To characterize and synthesize STF-fabric composites.
  - Evaluate the effect of particle size on high and low rate responses of shear thickening suspensions of hard-sphere particles

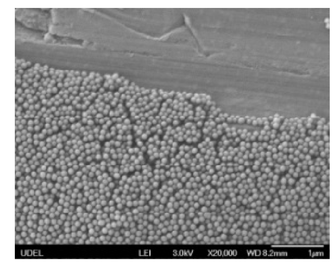
INTRODUCTION

- **Shear Thickening Fluid (STF)**
  - Non-Newtonian fluid that undergoes viscosity increase at critical shear stress/strain rate
  - Generally used in protective material applications to improve stab resistance

MATERIALS

- **Synthesis**
  - Spherical Silica Particles (100 nm)
  - Polyethylene glycol (PEG, 200 MW)
  - Roll mixed at room temperature for 24 hours



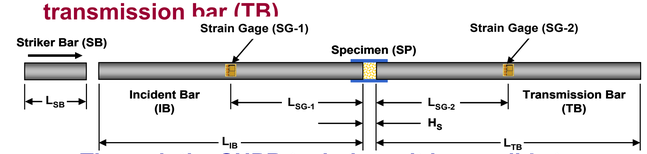


- STF suspension characterized at 52, 50, 45, 40, and 20 percent silica particles to liquid.

METHOD

- **Rheology**
  - AR-2000 used to determine the viscosity of the STF suspension
  - Measured with a 40 mm cone plate with a 62 truncation gap and 2 degree angle

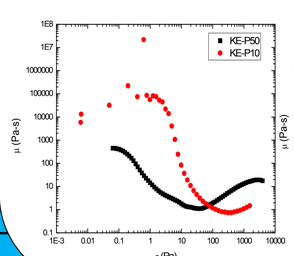
- **Split-Hopkinson Pressure Bar**
  - The SHPB consists of a gas gun and three cylindrical bars
  - Striker bar (SB), incident bar (IB), and transmission bar (TB)

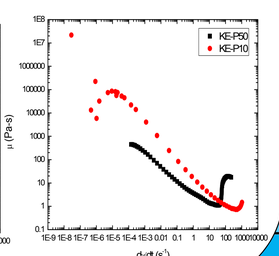


- Through the SHPB technique, it is possible to evaluate the overall response of a STF fluid specimen at shear rates over 10^5 s^{-1} and at high stress levels

RESULTS

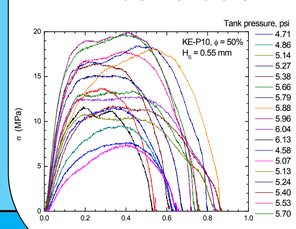
- **Rheology**
  - Comparison of 500 nm and 100 nm silica particles (φ = 50%).
  - Shear thickening occurs at higher (1 order of magnitude) critical shear rates/stresses for smaller particle

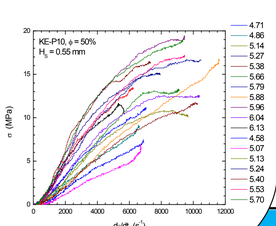




SHPB RESULTS

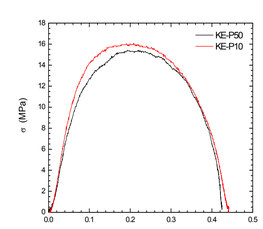
- Axial stress-strain and stress-strain rate response of the 50% silica suspension after transition shows:
  - Rate dependant elasticity
  - Viscous behavior
  - High stress and strain rates are achievable

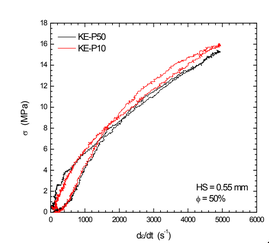




SHPB RESULTS

- Comparison of KE-PE10 and KE-P50 (initial thickness of 0.55mm)
- Small particles increase stiffness and peak stress achievable in STF in stress-strain plot
- Small particles change the stress-strain rate response at high stress/strain rate





CONCLUSIONS

- In the rheological data, particle size significantly affected viscosity and transition shear stress/strain rate conditions
- In SHPB post-transition regime at high stress and strain rate, particle size affected elastic and viscous response but to a lesser degree

ACKNOWLEDGEMENTS

This work is funded through the Army Research Office grant #W911NF-05-2-0006.

John W. Gillespie Jr. (UD-CCM)
Norman J. Wagner (UD-ChE)
Eric D. Wetzel (ARL)
Amanda Lim (UD- PhDMSEG)
Dennis Kalman (UD-PhDChE)

© 2009, University of Delaware, all rights reserved