FLEXIBILITY CHARACTERIZATION OF LIQUID BODY ARMOR USING A SHEAR-THICKENING FLUID

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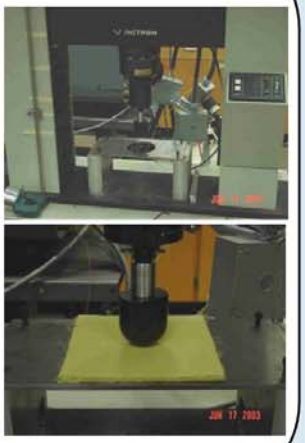
OBJECTIVES

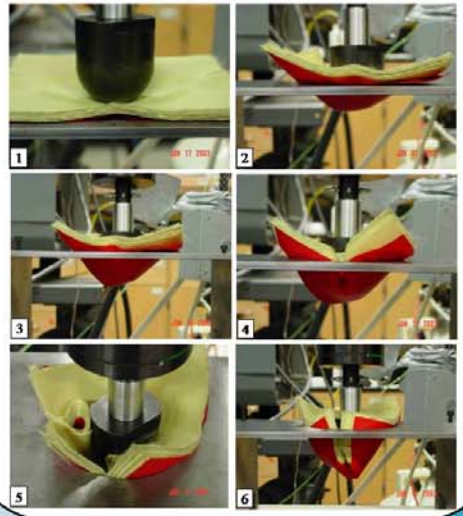
- To quantify the stiffness of ballistic materials
- Specifically, to determine the difference in flexibility of KEVLAR with and without shear thickening fluid
- The method used is presented in the paper "A new method for the measurement of the stiffness of ballistic fabrics", by M. Missihoun, G. Pageau and P. Vallee, Proceedings of 31st International SAMPE Technical Conference (1999)

METHOD

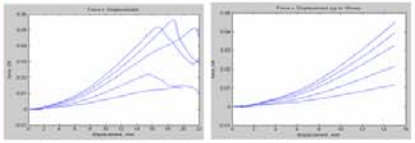
- The Instron is modified with a hemispherical plunger that pushes the sample through a circular hole
- Specimen size: 6 × 6 in.
- 1 layer of Ripstop nylon is laid in between the sample and the platform
- Crosshead speed: 15 mm/min
- The force required to "push" the sample is measured with a 100-N load cell
- Data acquisition rate: 10 pts/sec
- The data is recorded and displayed in a 'load vs. displacement' graph



SAMPLE RUN



DATA

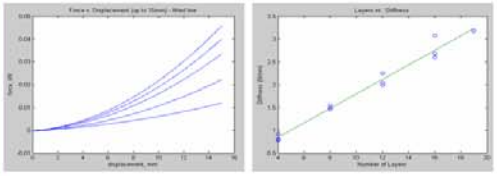


Test of 5 individual samples:

- one 4-layer sample
- one 8-layer sample
- one 12-layer sample
- two 16-layer samples

The stiffness of the material is defined in the method as the secant slope of the portion of the load vs. displacement curve between 0 and 15 mm or between 0 and the first peak load, which ever is shorter.

ANALYSIS



r^2 values of the fitted lines	
4 layers	0.9999990
8 layers	0.9999987
12 layers	0.9999993
16 layers	0.9999997
16 layers	0.9999996

Equation of the fitted line:

$y = 0.1590x + 0.2089$

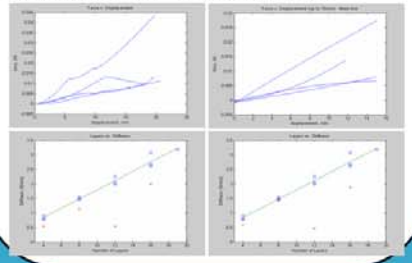
$r2$ for the fitted line is 0.98997

Equation for $r2$:

$$r^2 = 1 - \frac{\sum residuals^2}{\sum((y - \frac{\sum y}{n})^2)}$$

SAMPLE FABRICATION OF KEVLAR/STF COMPOSITES

- Ethanol is needed to lower the surface energy of the STF in order to enhance the STF's wettability
- Volume ratio of ethanol vs. STF is 6:1
- ~0.6 mL of STF per layer of Kevlar
- The composite is heated at 80° C to allow the ethanol to evaporate
- 4 samples: - One of each 4, 8, 12, and 16 layers samples



CONCLUSIONS

- A satisfactory model was created to predict the stiffness of neat Kevlar
- The results indicate that the stiffness of the Kevlar/STF composite lies below that of neat Kevlar
- More data points will be needed to create a model to predict the stiffness of the Kevlar/STF composite

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