A STUDY OF MECHANICAL PROPERTIES AND ENERGY ABSORPTION OF POWDER-IMPREGNATED CONTINUOUS FIBER THREMOPLASTIC MATRIX COMPOSITES

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OBJECTIVES

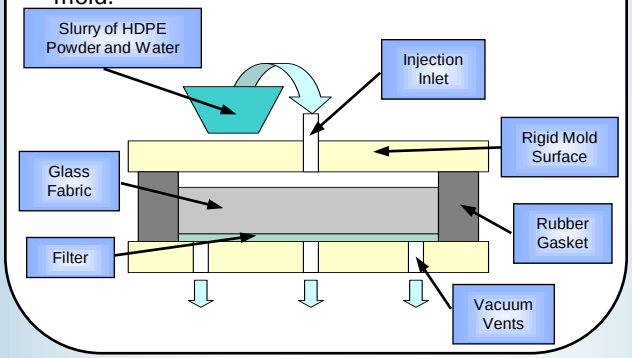
- Study mechanical properties and energy absorption characteristics of laminates made by powder-impregnation (PI) process with a baseline pre-preg.
  - Baseline made from 24 oz/yd^2 Polystrand (PS) E-glass/HDPE sheets (fiber weight is 17.1 oz/yd^2).
  - Results were normalized by composite density.

EXPERIMENTS

- Density and volume fraction measurements.
- Tension and compression tests.
  - Elastic modulus and stress at failure in compression.
- Energy absorption test.
  - Energy absorbed and deflection at max load.

PROCESS DESCRIPTION

- Fabric is impregnated with matrix powder material when a slurry is filtered through the thickness.
  - Slurry is drawn by vacuum through a rigid mold sealed with a gasket around the fiber bed.
- A filter prevents matrix powder from exiting the mold.



RESULTS

MICROSTRUCTURE CHARACTERIZATION

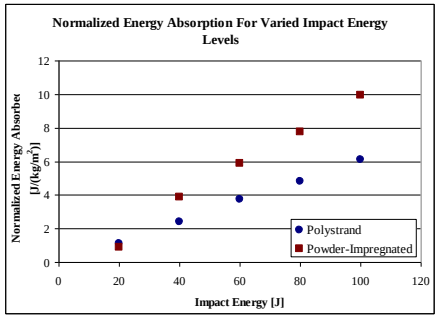
- Tension samples (1 layer of PI or 6 layers of PS)
  - Void fraction was 0.03 for PI and 0.01 for PS.
  - Glass fraction was 0.64 for PI and 0.45 for PS.
- Compression/Energy absorption (2 layers of PI or 12 layers of PS)
  - Void Fraction was 0.05 for PI and 0.01 for PS.
  - Glass fraction was 0.65 for PI and 0.45 for PS.

TENSION AND COMPRESSION

Material	Max Stress (Comp.) [MPa]	Elastic Modulus Raw [GPa]	Elastic Modulus Normalized [MPa/(kg/m^3)]
PI	**35.51 ± 10.16**	**14.15 ± 1.11**	**7.92**
PS	**143.34 ± 6.62**	**22.7 ± 2.38**	**13.73**

PI= Powder-Impregnated
PS= Polystrand

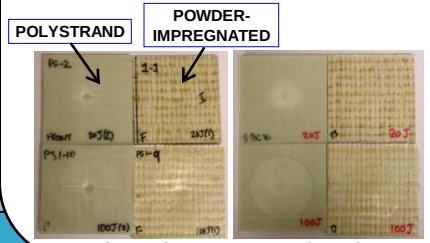
ENERGY ABSORPTION RESULTS



Energy absorption results are normalized by the aerial density of the plate.

DISCUSSION

- At low energy the Polystrand showed cracks in the matrix.
- Only at highest energy was there evidence of fracture in powder-impregnated panels.



DISCUSSION

- Theoretically the PI panels should have a higher modulus due to a much higher fiber content.
  - Higher void content in PI lowers the modulus.
  - Nuances of manufacturing process yield a variable void fraction throughout panel.
- PI has higher energy absorption.
  - PI Panel- Fiber-fiber interaction (friction) and large amounts of plastic deformation without brittle matrix failure causes higher absorption.
  - PS Panel- Brittle matrix failure.

CONCLUSIONS

- When designing for impact resistance one must choose the balance between mechanical properties and energy absorption.
  - Apparent that lower matrix fraction leads to more effective energy absorption.
- Easy to control matrix volume fraction with PI process.
  - Can extend this process to 3-D preforms.

ACKNOWLEDGEMENTS

This work is supported by the Office of Naval Research through the Advanced Materials Intelligent Processing Center.