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Soy-based Composite Sandwich Structures Phase I and II

By

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The cost of producing hollow or sandwich composite parts can be competitive with conventional materials. The soy-based resin system can be used as the matrix to bind the reinforcement package. The interaction between fibers and atrix is important in designing damage-tolerant structures. Composite panels with soy husk foam will be manufactured and characterized. The fiber/matrix/core interface will be studied to examine the level of bonding.</td></tr>
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FINAL REPORT

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Polymer matrix composites using renewable resources are currently of great interest. A novel resin system based on soybean oil for pultrusion was synthesized at University of Missouri-Rolla. It is important to set up the process parameters properly in order to obtain high quality pultruded product using soy-based resin system. In Phase I of the project, a combination of experimental and numerical methods was used to investigate the effect of pultrusion process variables on the cure of composites. A mathematical model has been developed and implemented in the commercial ABAQUS finite element code to predict the degree of cure of soy-based composites. The kinetic parameters of the soy-based composites were obtained from differential scanning calorimeter (DSC). Glass fiber composite samples were manufactured using pultrusion machine. For experimental verification, an on-line monitoring system was used to measure the temperature profile and the degree of cure of the pultruded soy-based composites measured by DSC. The experimental findings are in good agreement with the finite element prediction. The developed process model can be used to establish optimal pultrusion parameters for soy-based composites. In Phase II of the project, the dynamic mechanical behavior of the soy based resin was investigated as a function of their stoichiometry and nature of the resin. The results indicate that soy resin is capable of damping the sound and vibration over a wide range of temperatures and frequencies.

PUBLICATIONS:

G. Liang, A. Garg, J. Zhu, K. Chandrashekhara, V. Flanigan and S. Kapila, "Cure Characterization of Pultruded Soy-based Composite," Proceedings of the SAMPE Conference, pp. 861-872, Long Beach, CA, May 11-15, 2003.

S. Ahamed, A. Garg, S. Sundararaman, K. Chandrashekhara, V. Flanigan and S. Kapila, "Dynamic Mechanical Characterization of Soy Based Epoxy Resin System," Proceedings of the SAMPE Conference, pp. 1-10, Long Beach, CA, May 16-20, 2004

Summary of Results:

PHASE I:

A DURAPUL 6000 LABSTAR pultrusion machine was used to pultrude glass/soy-based epoxy composites. The machine mainly consists of the following elements (1) Roving racks and cloth creels provide continuous fiber reinforcement. (2) Wet resin bath; (3) A series of preformer fixtures form the impregnated fiber package to shape before entering die and remove excess resin; (4) Heated die is made of chrome-plated steel and consists of multiple pieces depending on the cross section geometry of the product. Six electric resistance heater cartridges are in direct contact with the upper surface and bottom surface of die and hence three heating zones are formed to provide heat. (5) Puller system and cut-off saw; (6) Computer control interface.

Figure 1 shows the experimental centerline profiles for pure Epoxy, 30% AESO + 70% Epoxy and 30%MESO + 70% Epoxy at pulling speed of 12 in/min. It shows that the peak centerline temperature of pure epoxy is achieved later than 30% AESO and 30% MESO soy-based resin systems. The temperature of AESO and MESO reaches higher than pure epoxy after 2/3 of the die length for the higher heat of reaction of the two soy-based resin systems. This work shows that soy-based resin system can be pultruded at higher line speeds without compromising the degree of cure. Maximum productivity and optimum product quality for pultrusion can be easily achieved by numerical method. Serious consideration will be given in future work to optimize the parameters setting of the pultrusion process for different soy-resin formulations.

PHASE II:

The effects of the stoichiometry on the dynamic properties of soy based resin were investigated. The results show that the damping ability is enhanced through the introduction of AESO and MESO into the base EPON resin. Figure 2 shows the temperature dependence of the loss tangent for the soy resin prepared by varying the AESO concentration. It can be observed that the magnitude of loss tangent reduces as the concentration of AESO increases. Figure 3 shows the effect of cross-linking density of the loss tangent for AESO. The loss tangent decreased when the logarithmic cross-linking density of the polymers increased. The good damping in soy resin is attributed to the presence of long flexible polymer chains in the backbone. The increase in frequency of the loading displaced the loss tangent response to higher temperatures for all the concentrations. Therefore, soy resin is capable of damping the sound and vibration over a wide range of temperatures and frequencies.

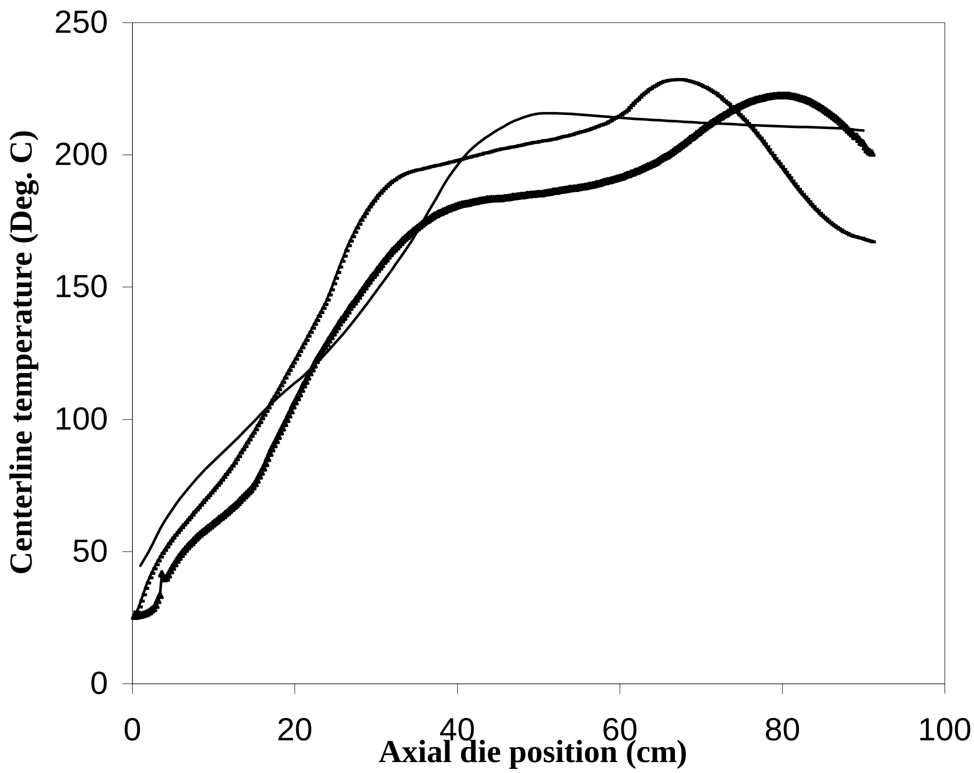

Figure 1. Centerline temperature with axial die position for different resin formulations

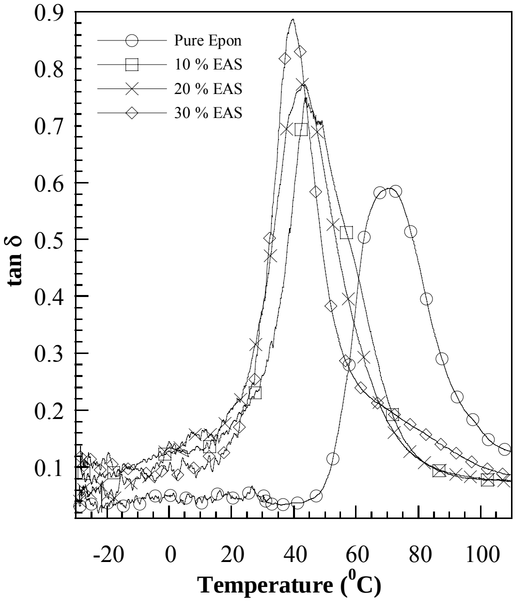

Figure 2 Loss tangent (tan δ) vs. temperature for various concentration of AESO/Pure Epon.

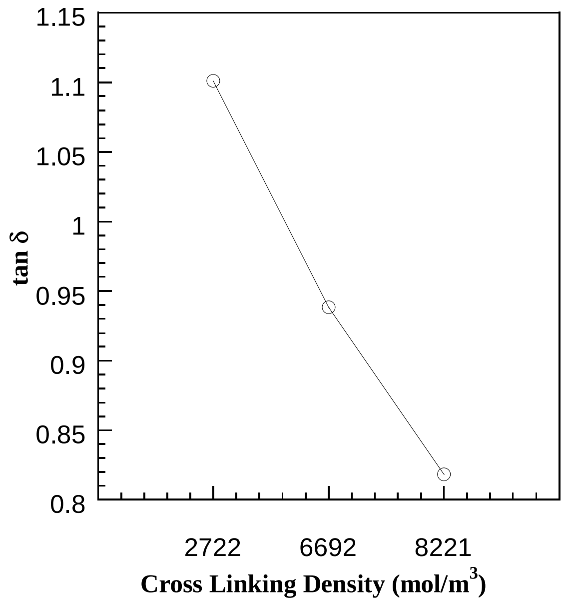

Figure 3 Relationship between loss factor (tanδ) and Logarithmic cross-linking density in AESO/Pure Epon.