Features

Page 8
Vacuum-Bag-Only Prepreg Processing of Honeycomb Structures: From Lab-Scale Experiments to an Aircraft Demonstrator

Page 23
Silk for Light-Weight Syntactic Foams and Tough Textile Composites

Page 44
Processing and Performance of Out-of-Autoclave Bismaleimide Composite Sandwich Structures

Join the Conversation
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Columns
2 President’s Message
5 Technical Director’s Corner
21 Japan Report
34 Perspectives
39 Europe Report
42 North America Report
58 China Report

Departments
6 Corporate Partners
20 SAMPE Brazil Congress 2016—Call for Papers
36 Technical Excellence Committee
38 SAMPE Europe Conference 16 Leige
40 Europe News
41 CAMX 2016, Anaheim, CA
56 Welcome SAMPE’s Newest Members
59 SAMPE China 2016
60 SAMPE Proceedings
62 Industry News
64 SAMPE Long Beach 2016
67 SAMPE Long Beach 2016 Show Floor
68 SAMPE Long Beach 2016 Exhibitors
69 SAMPE Long Beach 2016 Exhibitor Product and Services
93 SAMPE Seminar
94 Tobin Talks Washington
95 SAMPE Journal Editorial Calender
96 Advertiser’s Index
98 Resource Center
103 SAMPE Membership Information
104 SAMPE Foundation
105 SAMPE Books & CD’s Order Form
106 Corporate Partner Program—Become a Partner Today!
108 Industry Events Calender
108 SAMPE LinkedIn

About the Cover
High temperature PMI foam supplied by Evonik Foams for an Airbus A380 aft pressure bulkhead rib design (left) provides needed stiffness. The display of numerous Aluminum and composite honeycomb core materials (right) courtesy of Hexcel demonstrates wide variety of core types.
Vacuum-Bag-Only Prepreg Processing of Honeycomb Structures: From Lab-Scale Experiments to an Aircraft Demonstrator

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Abstract

An aircraft demonstrator was manufactured using out-of-autoclave prepreg and vacuum-bag-only processing techniques. The demonstrator featured flat, double-curvature, joggles, abrupt geometry changes, and honeycomb inserts. The scientific literature was used to assess and mitigate the processing risks for this demonstrator. Low through-thickness gas permeability and ply-bridging in small radii corners were thought to be the most significant risks. The through-thickness permeability of the target material was undetectable, therefore spiking was used to increase gas evacuation. Unfortunately, the available mould had small radii that could not be increased, as a result ply bridging was observed in these corners.

Miniature pressure sensors were successfully embedded in the demonstrator to monitor the honeycomb core pressure throughout the lay-up, including intermittent de-bulking, the pre-cure vacuum hold, and the elevated temperature cure. The sensors identified two insightful process phenomena: 1) gas evacuation increased with additional plies, and 2) non-uniform pressure response was observed in the part during cure. Visible part quality was acceptable, excluding small radii geometrical features. Internal part quality (voidage) was estimated using pulsed infrared thermography non-destructive-evaluation. While void contents are not exact, the thermography revealed local voidage can vary significantly over the part.

Processing and Performance of Out-of-Autoclave Bismaleimide Composite Sandwich Structures

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Abstract

Composite sandwich structures offer several advantages over conventional structural materials such as lightweight, high bending and torsional stiffness, superior thermal insulation and excellent acoustic damping. In the aerospace industry, sandwich composites are commonly manufactured using the autoclave process which is associated with high operating cost. Out-of-autoclave (OOA) manufacturing has been shown to be capable of producing low cost and high performance composites. Unlike the autoclave process, OOA processing avoids the issue of core-crushing due to high pressure. However, Bismaleimide (BMI) prepregs require high cure and post-cure temperatures which can lead to high internal core pressures, core-to-facesheet disbonding and voids. In the current work, OOA sandwich composite panels are manufactured using aluminum honeycomb core, BMI adhesive film and carbon/BMI prepregs. Two vacuum levels were used during OOA processing, full vacuum (100 kPa) and partial vacuum (80 kPa). Adhesive bond quality was evaluated using flatwise tensile and fracture toughness tests. Mechanical performance was evaluated using edgewise compression. It was observed that vacuum level variation during processing had no significant effect on mechanical properties of manufactured laminates. Tests are performed at room temperature and 177°C (350°F). All manufactured laminates exhibited room temperature flatwise tensile strengths comparable to those of aerospace grade epoxy adhesives. Sandwich mechanical properties reduced when test temperature was increased.
Silk for Light-Weight Syntactic Foams and Tough Textile Composites

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Abstract
Growing interest in bio-based materials has powered the recent industrial uptake of plant fibre reinforced plastics. In contrast, nature’s wonder-fibre silk has had no commercial applications and only limited scientific investigations as a composite reinforcement. In addressing the question ‘are silks suitable as polymer reinforcements?’, we explored two routes to silk composites: i) syntactic foams, where silk cocoons were employed as natural, macroballoon, particulate reinforcements in a bio-based polyurethane foam, and ii) laminate composites, where nonwoven mats and woven textiles of silk were fibre reinforcements in an epoxy matrix.

In the syntactic foams, cocoons were effective volume-occupying, structural fillers; the cocoons replaced 60–90 wt% (40–70 v%) of the polymer foam, and yet a marked increase in compressive properties was observed. Notably, the cocoon reinforced foams were useful hybrids between honeycomb structures (that are anisotropic, but difficult to form into complex shapes) and foams (easy to form, but are isotropic).

As a fibre reinforcement, silk was a superior alternative to flax, and a potential sustainable option against glass, in appropriate applications, viz. i) light-weight, impact-critical components, such as high-performance helmets and drones, and ii) light-weight, flexural stiffness- or strength-critical components, such as construction beams, automotive load-floors, and sporting equipment.
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