CYCOM® X5320

Innovative Approach to Out-of-Autoclave Processing

September 9, 2008
**Innovative Approach to Out-of-Autoclave Processing**

**Abstract**
The original document contains color images.

**Security Classification**
- Unclassified

**DISTRIBUTION/AVAILABILITY STATEMENT**
Approved for public release, distribution unlimited
Agenda

– Introduction
– Problem Statement
– Cycom X5320
– Potential Value Proposition
– Solicit input on the interest for Out-of Autoclave
Introduction-Cycom X5320 prepreg

CEM is experienced and capable with OOA

- Material Science – through chemistry and understanding
  - Balanced cure cycles to customer requirements
  - Reduce porosity; control viscosity
  - Tack life and total out-time
  - Maximize mechanical properties that drive key design elements

- Technical Service Support – Global tech support of material selection, lay-up, tooling, and assembly

- Application Engineering – PRIM, Automation (AFP, ATL) - BMI & toughened epoxy
Problem Statement

- Progress technology/capability from secondary to primary structure
- Provide material system capable of prototype or production needs

<table>
<thead>
<tr>
<th>Gaps Today</th>
<th>Specific Limitation</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical performance</td>
<td>secondary structure</td>
<td>primary</td>
</tr>
<tr>
<td>Porosity</td>
<td>&lt;4%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Tack/Handling</td>
<td>&lt;10 days</td>
<td>30 days</td>
</tr>
<tr>
<td>Component size</td>
<td>geometry and dimension limited</td>
<td>unlimited</td>
</tr>
<tr>
<td>Versatility</td>
<td>lengthy low temp cure</td>
<td>&lt;12hr initial</td>
</tr>
<tr>
<td></td>
<td>varying properties w/cure</td>
<td>consistent</td>
</tr>
<tr>
<td></td>
<td>poor green strength</td>
<td>excellent</td>
</tr>
</tbody>
</table>
Attacking problem through material science

- Fundamental material science approach
- 977-3 technology
- Critical in-depth understanding of key OOA characteristics of flow, gel, impregnation, resin advancement
- Versatile, robust manufacturing cure cycle options – providing necessary green strength
- Supported by in-application engineering

X5320 - primary structure performance with OOA benefits

- Potentially unlimited component size
- <1% porosity
- Hot/Wet strength
- Continuous flow processing
- Expanded supply base to Tier 1
- Highly versatile/flexible system
- Prototype to production

977-3 Toughening Technology

Current OOA Materials
- Limited component size
- Continuous flow processing
- Expanded supply base – mostly Tier 2 or 3
- Traditional secondary structure applications

Autoclave Materials
- Primary structure capable
- Toughened material systems
- Batch processing
- Autoclave size limited

Eliminated Porosity

Total Component Cost

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Cycom X5320 Introduction

**Breakthrough OOA material** – addresses primary structure needs

- Legacy military fighter epoxy autoclave mechanical properties with OOA processing
- Large, primary structure component processing
  - Porosity
  - Hot/Wet
- Tailorable handling properties to meet hand-layup and automation part manufacturing
- Prototype parts to high-rate production capable
- Flexible cure cycles providing robust degree of cure with final resin cross-linking

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>X5320</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autoclave</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OOA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large scale components</td>
<td>☒</td>
<td>☑</td>
</tr>
<tr>
<td>Primary structure</td>
<td>☑</td>
<td>☒</td>
</tr>
<tr>
<td>Continuous flow process</td>
<td>☒</td>
<td>☑</td>
</tr>
<tr>
<td>Hot/Wet strength</td>
<td>☑</td>
<td>☒</td>
</tr>
<tr>
<td>Eliminates porosity</td>
<td>☑</td>
<td>☒</td>
</tr>
<tr>
<td>Automation</td>
<td>☑</td>
<td>☒</td>
</tr>
</tbody>
</table>

**Flow Characteristics - Viscosity**

**Flexible Cure Cycles**
- Initial Cure in Oven
  - 200°F/8hrs or, 225°F/4hrs or, 250°F/2hrs
- Freestanding Post-Cure 350°F for 2 hrs
- 1-5°F/min

**X5320 Degree of Cure**

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## Properties of X5320

**limited and preliminary data collection**

<table>
<thead>
<tr>
<th>Properties</th>
<th>977-3 IM fiber</th>
<th>X5320 IM fiber</th>
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</thead>
<tbody>
<tr>
<td>OHC (220F/Wet) [0/90]3s; ASTM D6484; qty=8</td>
<td>39.3 ksi</td>
<td>42.3 ksi</td>
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<tr>
<td>Tg (Wet) DMA Storage Mod; [0]10</td>
<td>303°F</td>
<td>310°F</td>
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<tr>
<td>OHT (-65F/Dry) [+,-,-,90]3s; ASTM D5766; qty=8</td>
<td>65.4 ksi</td>
<td>75.1 ksi</td>
</tr>
<tr>
<td>CAI [+,0,-,90]4s; SRM02R94; qty=8</td>
<td>25.2 ksi</td>
<td>29.6 ksi</td>
</tr>
<tr>
<td>Solvent Resistant</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>Initial Cure Temp</td>
<td>355F (autoclave)</td>
<td>200F/16 hours (VBO)</td>
</tr>
</tbody>
</table>
Product Portfolio

Unidirectional Tape
- X5320 T40-800B 145 gsm/33% resin content, 49” width
- X5320 T40-800B 290gsm/33% resin content, 49” width

Fabric
- X5320 WT650-35 3K-8HS 48" width, 36% resin content

Non-Carbon Forms
- X5320 4581Q-9837 38” DP 35% resin content
- X5320 108 50” width, 50% resin content
- X5320 60001 50” width Peel Ply
## Ancillary products

<table>
<thead>
<tr>
<th>Material</th>
<th>Recommended</th>
<th>Target Properties</th>
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<tbody>
<tr>
<td>Film Adhesive</td>
<td>FM300-2K or FM209M</td>
<td>FWT (220F/Wet) Equivalent to FM300 (-65F:800psi, RT:700psi, 250f:500psi)</td>
</tr>
<tr>
<td>Foaming Adhesive</td>
<td>FM490A</td>
<td>Similar to FM404A. Passes expansion requirement at 200F of 200%.</td>
</tr>
<tr>
<td>Peel Ply</td>
<td>X5320 Peel Ply</td>
<td>Compatible with resin and removes cleanly from part</td>
</tr>
<tr>
<td>Syntactic Core</td>
<td>FM381</td>
<td>Density:40 pcf, FWT similar to FM381</td>
</tr>
<tr>
<td>Surfacing Film</td>
<td>SM 905M</td>
<td>Clean surface; no surface porosity</td>
</tr>
</tbody>
</table>
Out-of-Autoclave Value Proposition

Performance

– Address **porosity** and **mechanical performance** which have historically limited Out-of-Autoclave materials to secondary structures

– **Geometrically limited** due to part quality of autoclave processing (resin rich, thin out, etc)

– **Unitized structure design**

– Ability to support rapid, small volume **aircraft demonstrations** & insertion into **production rates**

Cost

– **Alternative tooling** design concepts

– **Part count reduction** addressing legacy black aluminum designs

– **Supply-base capability & expansion**

– **Lower capital costs** for further composite application adoption

– **Qualification** serves demonstration articles and production
Discussions/Feedback

– Material characteristics
– Material product forms
– Industry Material Specifications – interest, approaches
– Processing constraints, desires
– Database considerations
– Tooling approaches, concerns
– Equipment requirements – ovens, vacuum sources, other heat sources
– Challenging part features for producibility evaluation/scale
– Applications and related constraints/issues
– Variability, robustness
– Further interest?

Please complete the questionnaire provided... your input is essential!