EC-HLM Honeycomb liquid molding

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• Process description
• Areas of applications
• Mechanical properties compared to prepreg technology
• Which possibilities can we offer?
• The advantages for our customer
• Conclusion
Honeycomb liquid molding: An overview

- It is a resin infusion process combined with a honeycomb core.
- A honeycomb sandwich structure can be produced with resin infused adjacent fabrics without filling the cells by infusion.
- The honeycomb is water tight sealed and remains stable in weight.
- The adjacent fabric bonded to the honeycomb adds to the mechanical stability of the composite.
- It is a low cost process avoiding autoclave technology and prepregs.
Honeycomb liquid moulding: The sketch

Lay-up: A barrier layer and dry fabric are laid up in an integrated process.

Advantages: Cost reduction (No costly prepreg needed, easy dry lay-up)
Draining medium facilitates resin flow
Peel-ply assures a uniform surface, apt for decoration or further bonding
Integrated Infusion process:

a) pre-curing of the barrier-core-bonding
b) resin infusion & final cure

Detail of Part after curing
EC-HLM: Sample Products I

Composites in A380 Fuselage

- Leading-Edge
- Floor-Panels
- HTP- Fairing
- Belly- Fairing
- Flap-Track Fairings
- Radome
- Landing gear door
- Bathtub Panels
- Inner Outer Barrel

BATHTUB PANELS  FLAP RIBS+LEADING EDGE  FLAP TRACK FAIRINGS  INNER OUTER BARREL
EC-HLM: Sample Products II

**Structural part:** KEVLAR® honeycomb 3.2-40 with Carbon fabric G926 (6 layers on each side) infused with RTM6 (structural epoxy resin)
New Development:
Resin Infusion with honeycomb for aircraft interior parts

Current results:

• New resin EC-RI-FST without any flame retardant fillers, cold & hot curable
• FAR 25853: flammability and smoke density within the specification
• Flat wise tensile: core failure
• Tg: adjustable between 120 – 200° C
• Very good resin flow behavior
• Viscosity adjustable within the range of 30-1500 mPas
• Infusion at room temperature
EC-HLM: The integration of fasteners and potting

Panel with inserts + potting after infusion with RTM6. 6 layers carbon fabric on each side.

Cut panel with inserts and potting after infusion with RTM6.
EC-HLM: Mechanical properties

Laboratory Testing

• Mechanical and adhesive properties
  o 3- & 4- point bending
  o Flat-wise tensile (20° & 80° C)

• Non Destructive Testing

• Watertightness

• Further testing
Mechanical Testing
Test samples have been cut from two panels sized 1000 x 1200 mm

**Resin:** RTM6
(Hexcel structural epoxy resin, qualified for aerospace applications)

**Core:** ECK 3.2-40
(1/8”-2.5 pcf)
KEVLAR® honeycomb

**Fabric:** Carbon G926
6 Layers on each side
(0° /90° /+45° /-45° /90° /0°)

**Fibre Volume Fraction:** 58 %
(in the laminate)
## Mechanical Properties

<table>
<thead>
<tr>
<th>Mechanical Test</th>
<th>Test results (average values)</th>
<th>Honeycomb behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4-Point-Bending</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5 samples per panel and direction)</td>
<td>Panel 1: W: 3202 N, L: 4930 N</td>
<td>Core failure</td>
</tr>
<tr>
<td></td>
<td>Panel 2: W: 3238 N, L: 4739 N</td>
<td></td>
</tr>
<tr>
<td><strong>3-Point-Bending</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5 samples per panel and direction)</td>
<td>Panel 1: W: 3657 N, L: 5198 N</td>
<td>Core failure</td>
</tr>
<tr>
<td></td>
<td>Panel 2: W: 3509 N, L: 5181 N</td>
<td></td>
</tr>
<tr>
<td><strong>Flat wise tensile</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(22° C / 75% RH)</td>
<td>Panel 1: 4.35 N/mm²</td>
<td>Several samples with core failure, others with values close to core failure</td>
</tr>
<tr>
<td>(6 samples per panel)</td>
<td>Panel 2: 4.26 N/mm²</td>
<td></td>
</tr>
<tr>
<td><strong>Flat wise tensile</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(80° C)</td>
<td>Panel 1: 3.47 N/mm²</td>
<td>Core failure</td>
</tr>
<tr>
<td>(2 samples per panel)</td>
<td>Panel 2: 3.38 N/mm²</td>
<td></td>
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</tbody>
</table>
Non-destructive Testing (NDT)

- Ultrasonic and X-Ray tests have been conducted confirm to Airbus standards.
- Results: No porosity, no delaminated areas!
- Infrared camera has been used to detect pores and water penetrated into honeycombs. No such pores could be detected after 24h immersion in hot water.
- A 2000 hour climate chamber test is currently in process and will be finished end of January 2009.
EC-HLM: Mechanical properties

Watertightness test according to AITM 2.0037

Immersion:
75°C, 200 mm depth
Time: 1 min required (but also 24h conducted)
6 panels tested

Results: None of the panels showed air bubbles during immersion
=> watertightness according to Airbus requirements
Tests: air bubbles, weight increase, infrared camera
EC-HLM: The possibilities and advantages

Choice of different fabric & resin systems

Watertight, no porosity

Applicable for flat and curved (3D) parts

Cells not filled with resin

Out-of-autoclave process:
- Cost-reduction
- Fewer dimensional restrictions
- High fiber volume fraction

Choice of core material: NOMEX®, KEVLAR®, aluminum honeycomb

Physical Properties:
- Excellent mechanical properties
- Weight reduction possible
## EC-HLM: Areas of application

### Structural aerospace parts

<table>
<thead>
<tr>
<th>Requirements</th>
<th>EC-HLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical properties</td>
<td>✓ Similar to autoclaved prepreg parts</td>
</tr>
<tr>
<td>Weight</td>
<td>✓ Lightweight yet resistant honeycomb core</td>
</tr>
<tr>
<td></td>
<td>✓ High fiber volume fraction</td>
</tr>
<tr>
<td></td>
<td>✓ No water ingress (sealed core)</td>
</tr>
<tr>
<td>Geometry</td>
<td>✓ Not restricted to autoclave dimensions</td>
</tr>
<tr>
<td></td>
<td>✓ Processing of curved and flat parts</td>
</tr>
</tbody>
</table>
Aerospace interior applications

Preliminary testing showed, that RI can respond to the basic requirements of interior parts regarding:

- FST compliance
- Surface apt for decoration
- Weight
- Costs

EURO-COMPOSITES® conducted tests on several resin systems and found a resin well suited to respond to FST requirements and to the needs of the infusion process. The certification of this resin is pending.
EURO-COMPOSITES® EC-HLM process with honeycomb is well suited for:

- "Out-of-autoclave" process with honeycomb structures: EC-HLM can help to reduce costs
- No expensive prepreg is needed!
- You can choose from carbon, KEVLAR®, NOMEX®, or glass based composite layers. Wide range of honeycomb types can be produced with KEVLAR®, NOMEX®, aluminum or glass.
- Water tightness & weight: Less porosity and better sealing of the honeycomb core compared to prepreg techniques. Weight reduction is possible.
- Sealed honeycomb core prevents water ingress during service life.
- Competitive price by the use of dry fabrics and avoidance of autoclave processing.
Thank you very much for your attention

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