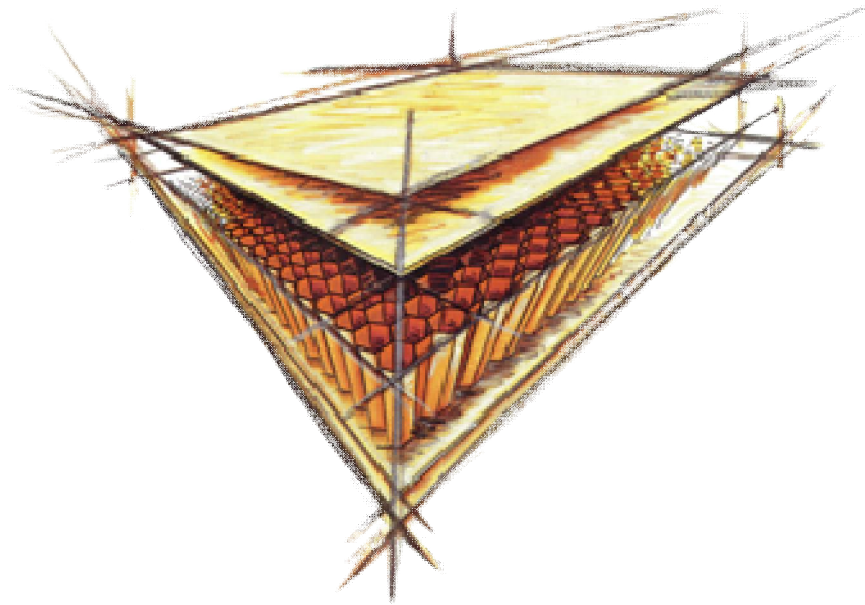


EC-HLM Honeycomb liquid molding



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Dr. rer. nat., Dipl. Chem. Jürgen Walter



Content

- Process description
- Areas of applications
- Mechanical properties compared to prepreg technology
- Which possibilities can we offer?
- The advantages for our customer
- Conclusion



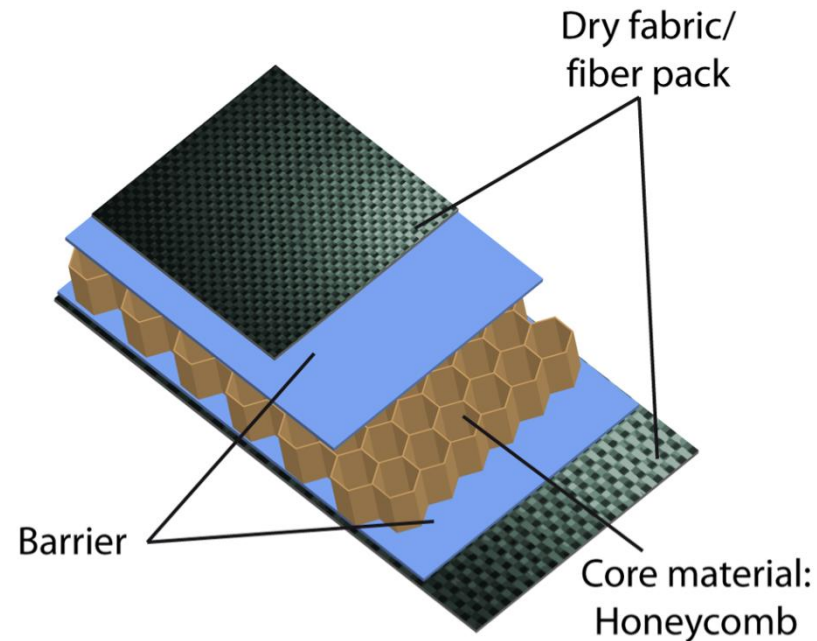
Honeycomb liquid molding: An overview

- 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

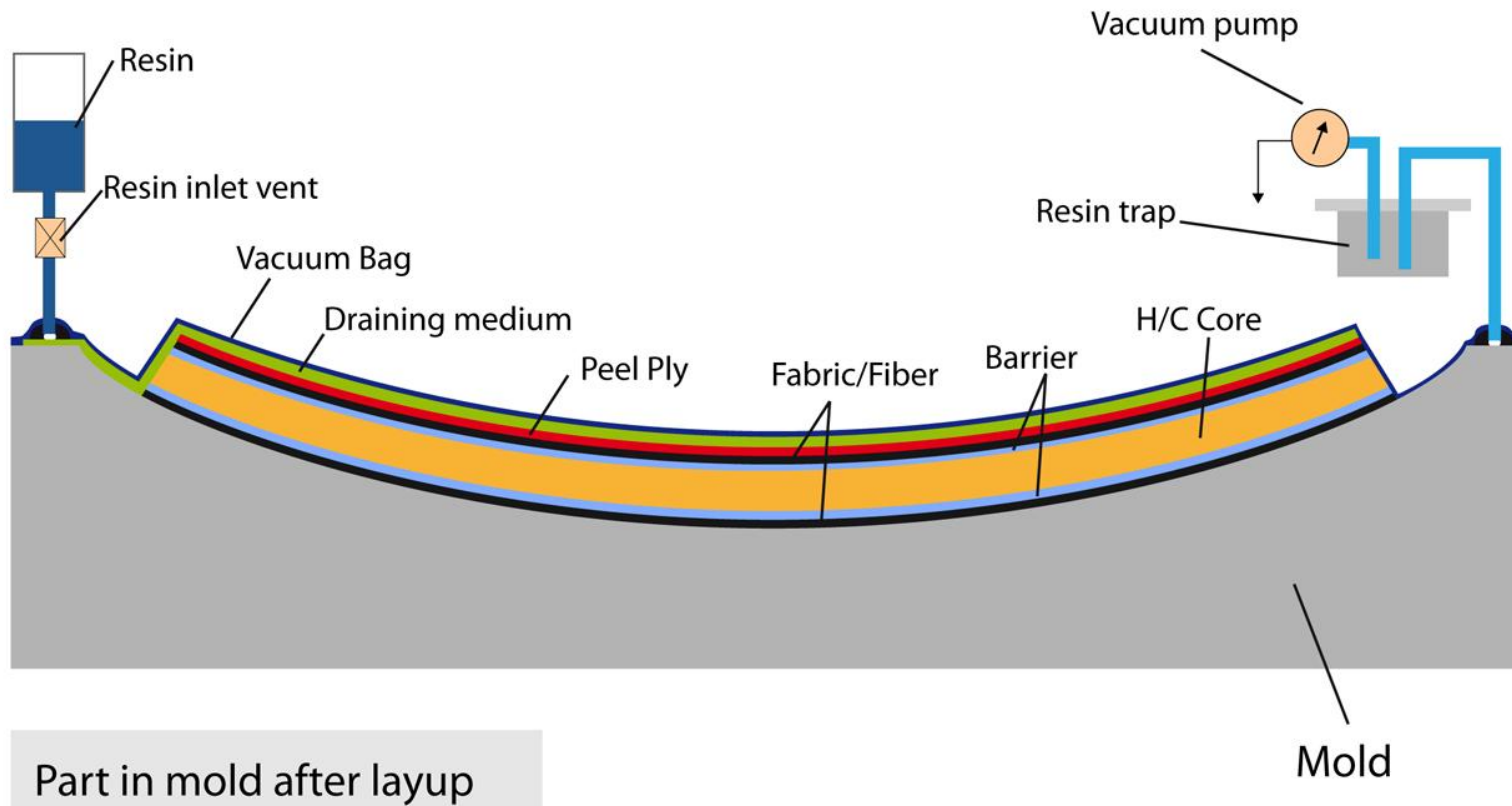
Lay-up: A barrier layer and dry fabric are laid up in an integrated process.



Detail of Part during layup

Advantages: Cost reduction (No costly prepreg needed, easy dry lay-up)

EC-HLM process. How is it done?



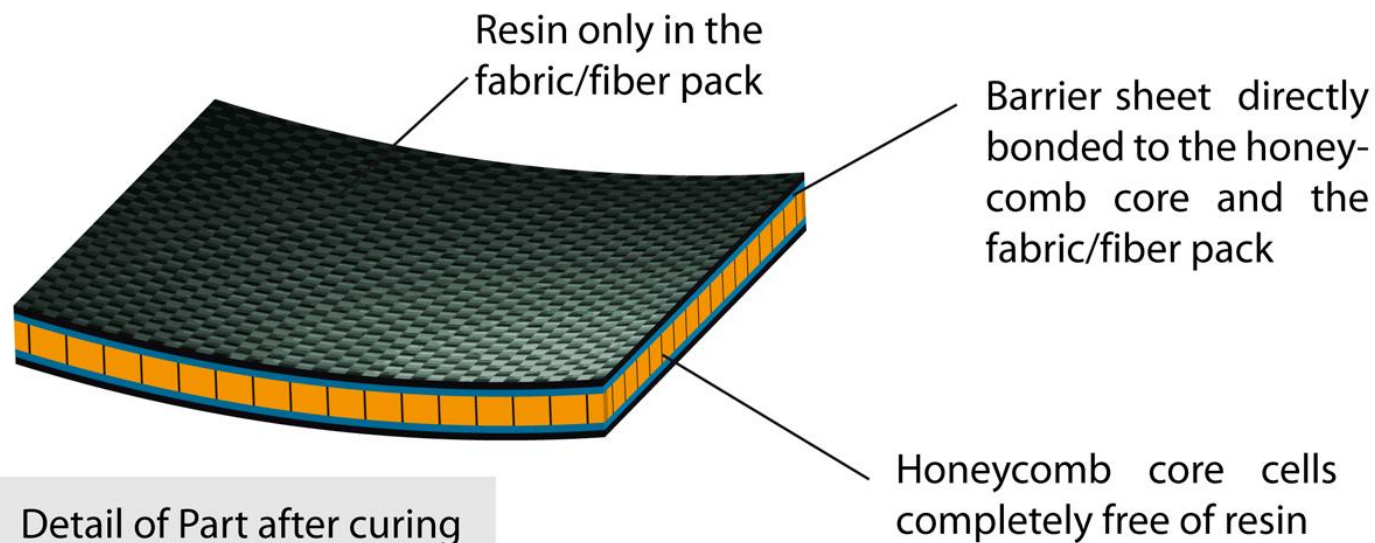
Draining medium facilitates resin flow

Peel-ply assures a uniform surface, apt for decoration or further bonding

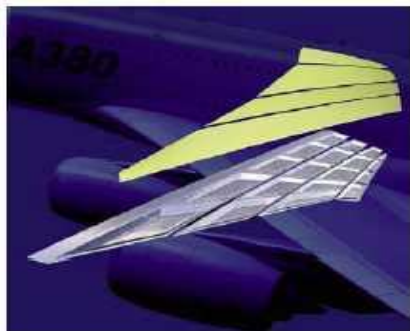
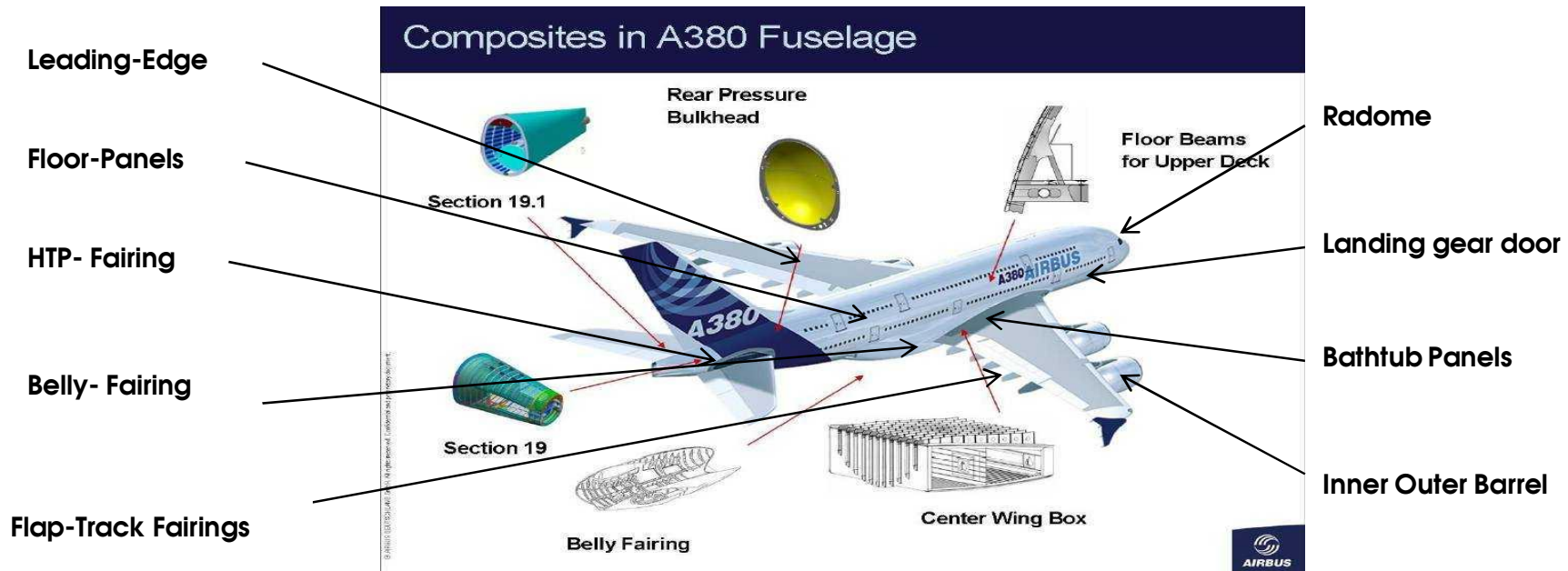
EC-HLM process: The part

Integrated Infusion process:

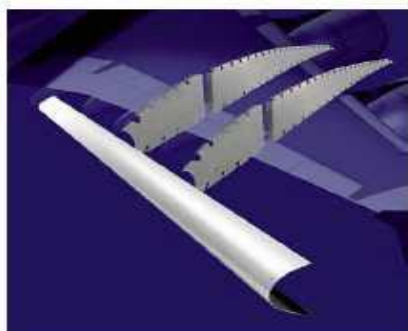
- a) pre-curing of the barrier-core-bonding
- b) resin infusion & final cure



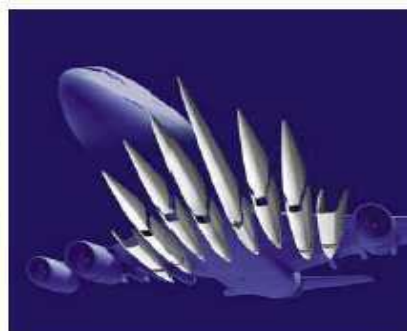
EC-HLM: Sample Products I



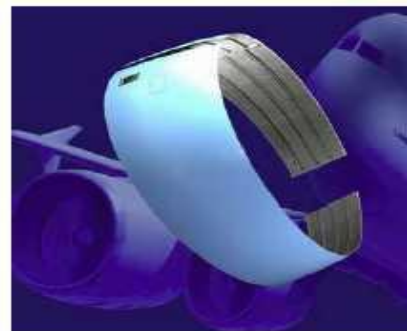
BATHTUB PANELS



FLAP RIBS+LEADING EDGE



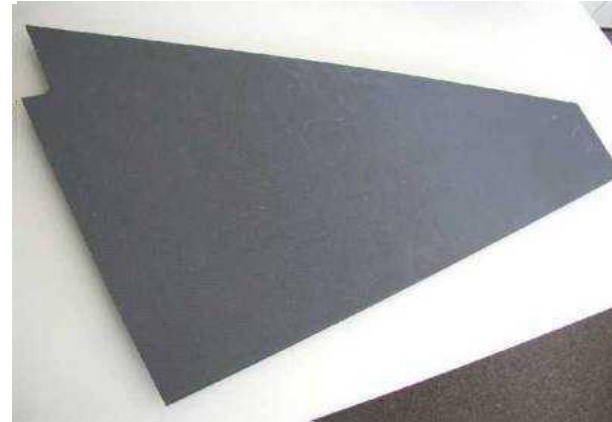
FLAP TRACK FAIRINGS



INNER OUTER BARREL

EC-HLM: Sample Products II

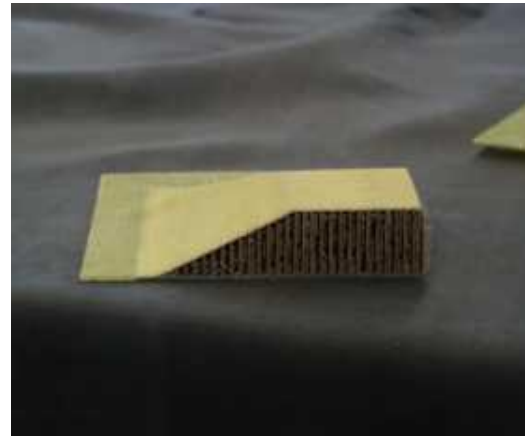
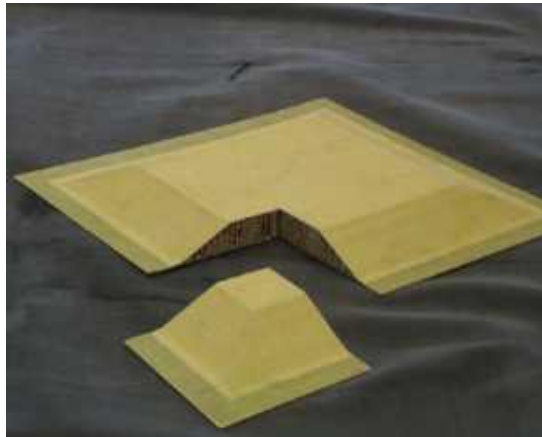
Structural part: KEVLAR® honeycomb 3.2-40 with Carbon fabric G926 (6 layers on each side) infused with RTM6 (structural epoxy resin)



EC-HLM: Sample Products III

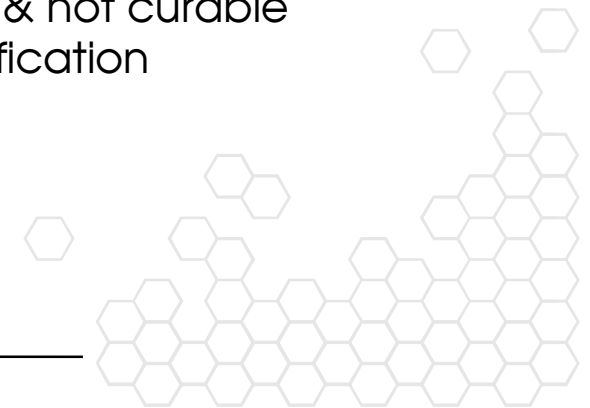
New Development:

Resin Infusion with honeycomb for aircraft interior parts

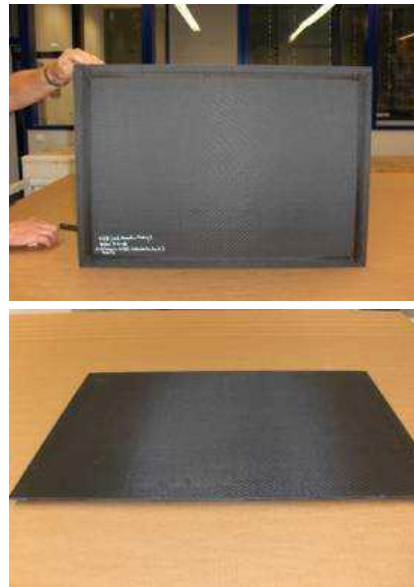
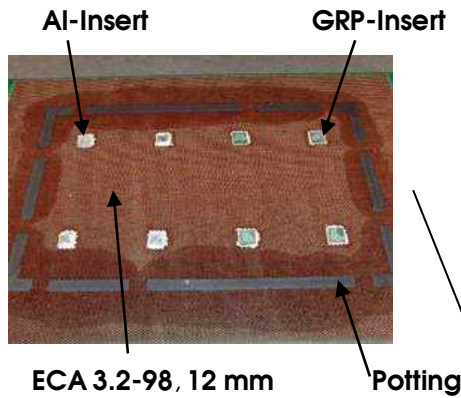


Current results:

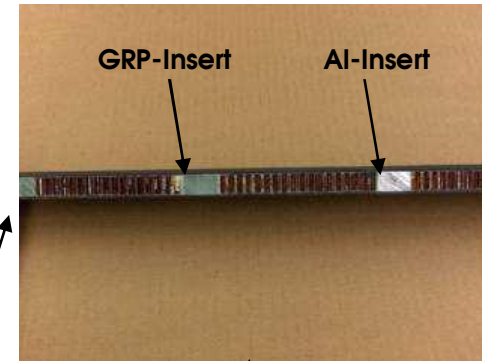
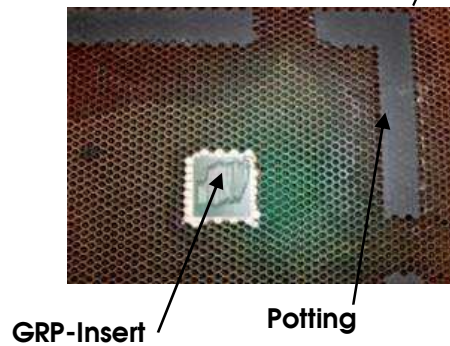
- New resin EC-RI-FST without any flame retardant fillers, cold & hot curable
- FAR 25853: flammability and smoke density within the specification
- Flat wise tensile: core failure
- Tg: adjustable between 120 – 200° C
- Very good resin flow behavior
- Viscosity adjustable within the range of 30-1500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



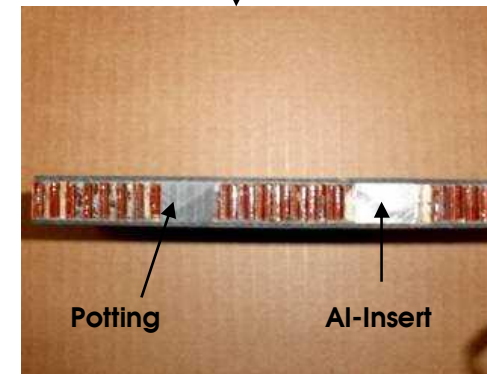
EC-HLM: The integration of fasteners and pottings



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

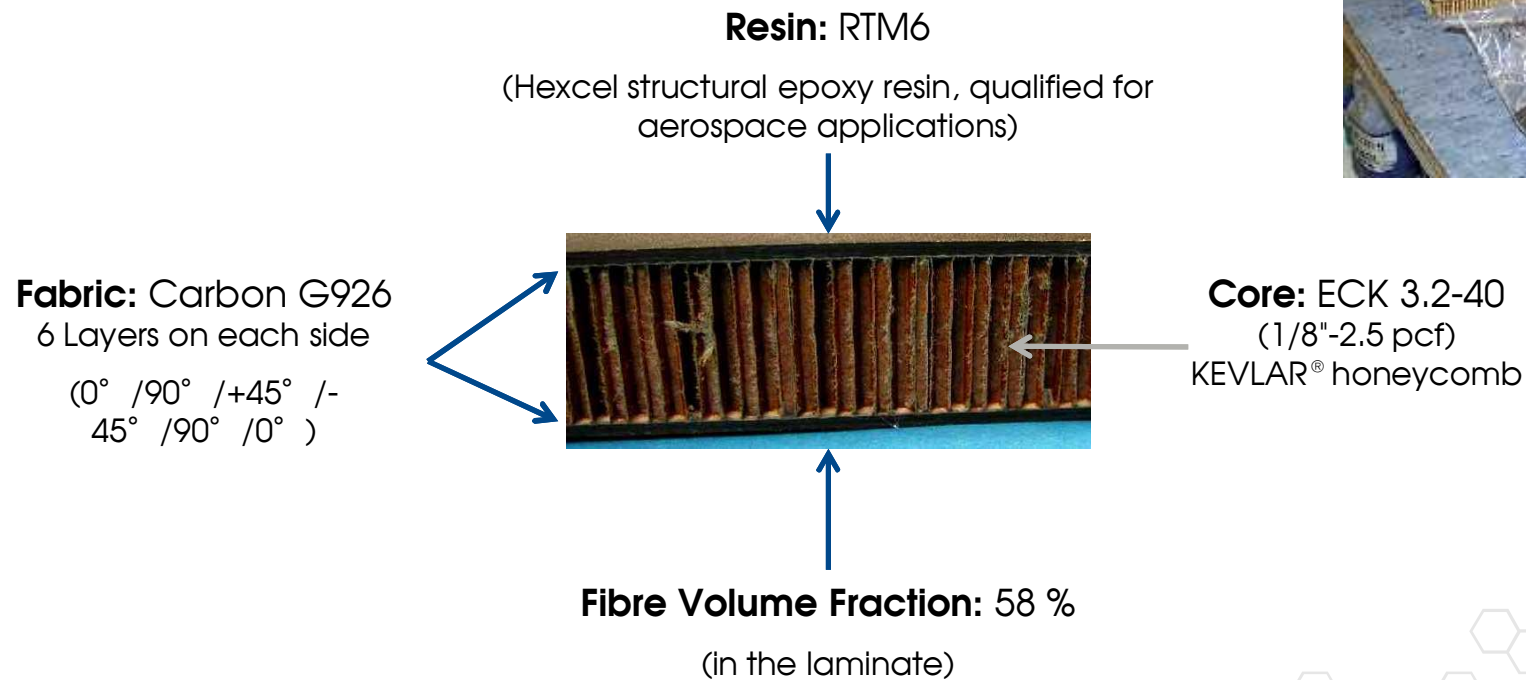
- Mechanical and adhesive properties
 - 3- & 4- point bending
 - Flat-wise tensile (20° & 80° C)
- Non Destructive Testing
- Watertightness
- Further testing







EC-HLM: Mechanical properties

Mechanical Testing

Test samples have been cut from two panels sized 1000 x 1200 mm



EC-HLM: Mechanical properties

Mechanical Test	Test results (average values)	Honeycomb behavior
4-Point-Bending (5 samples per panel and direction) 	Panel 1 in W: 3202 N in L: 4930 N Panel 2 in W: 3238 N in L: 4739 N	Core failure
3-Point-Bending (5 samples per panel and direction) 	Panel 1 in W: 3657 N in L: 5198 N Panel 2 in W: 3509 N in L: 5181 N	Core failure
Flat wise tensile (22° C / 75% RH) (6 samples per panel) 	Panel 1 4,35 N/mm ² Panel 2 4,26 N/mm ²	Several samples with core failure, others with values close to core failure
Flat wise tensile (80° C) (2 samples per panel) 	Panel 1 3,47 N/mm ² Panel 2 3,38 N/mm ²	Core failure

EC-HLM: Mechanical properties

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)

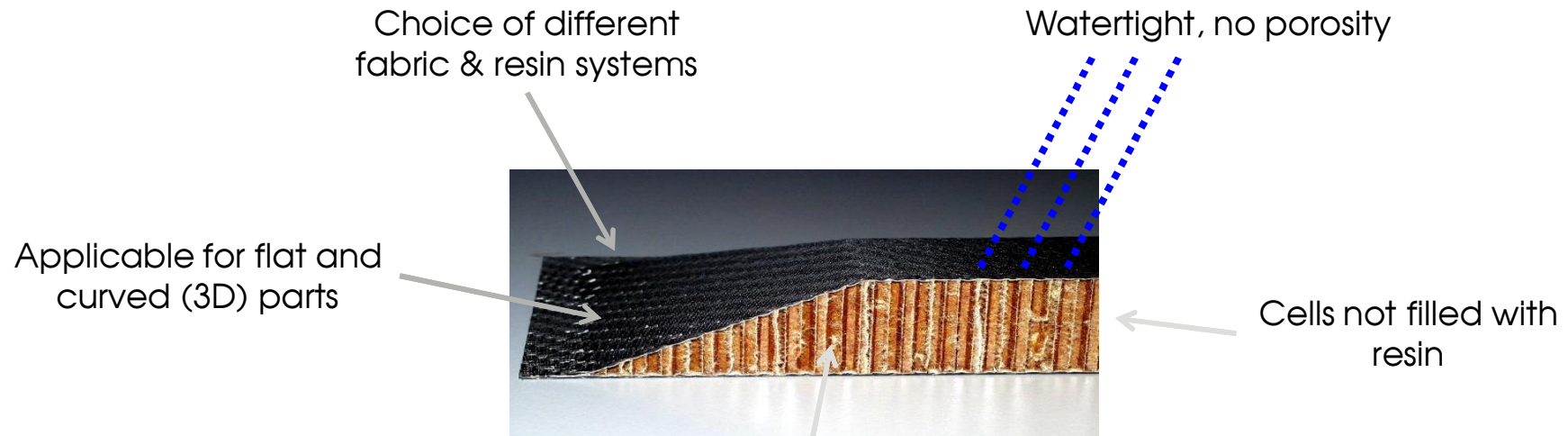
6 panels tested

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



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

Requirements	EC-HLM
Mechanical properties	✓ Similar to autoclaved prepreg parts
Weight	✓ Lightweight yet resistant honeycomb core ✓ High fiber volume fraction ✓ No water ingress (sealed core)
Geometry	✓ Not restricted to autoclave dimensions ✓ processing of curved and flat parts

EC-HLM: Areas of application

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.



EC-HLM: The advantages for our customer

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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