PRODUCT DEVELOPMENT FOR OUT-OF-AUTOCLAVE (OOA) MANUFACTURE OF AEROSPACE STRUCTURES

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Overview

- Why use the OOA process?
- Benchmarking of Existing Products
  - Matrices
  - Fabric styles
- Development of an OOA prepreg (M56)
  - Requirements
  - Processing
  - Performance
  - Demonstrator parts
- Next Generation Developments
- Summary
Why Out of Autoclave?

- Significant increase expected in composites used in aircraft manufacture over the coming years
  - Boeing 787
  - Airbus A350

- Autoclave capacity

- Ovens are lower capital investment

- The cost benefit to the customer?
  - Materials and processes are the same
  - Reduced tooling costs
  - Lower temperature cure

- Reliable inspection
  - Modern ultrasonic inspection methods can assure part quality
Acceptable Porosity Levels
- Secondary structure < 2%
- Primary structure - < 0.5 % ?

Cure –ply thickness
- Similar to Autoclave

Mechanical performance
- Same as equivalent autoclave prepregs

Processing
- Good tack / handling
- Similar lay-up / bagging to standard prepregs
- Must be capable for automated process (ATL/AFP)

Product format
- UD (134 – 268 gsm), woven (193PW-), RFI
M56 Product Development

- **Product**
  - Resin
  - Reinforcement

- **Process**
  - Bagging
  - Cure cycle

- **Performance**
**M56: Product Forms**

**UD carbon tape:**
- M56/35%/UD134/AS7-12K  M56/35%/UD268/IMA-12K
- M56/35%/UD268/AS7-12K  M56/35%/UD268/IM7-12K

Product forms can be tailored to suit ATL / AFP presentation

**Woven Fabric**
- M56/40%/280H5/AS4-3K
- M56/40%/193PW/AS4-3K

**Woven glass:**
- M56/37%/7581  (8 HS weave)
- M56/37%/120  (4 HS weave)

**Bronze mesh**
- M56/38%/BZ80  (80gsm Bronze mesh)
Fibre Volume Vs Product Type

Products optimised to achieve comparable fibre volume to autoclave cure
M56 Processing: Bagging

Optimum OOA bagging – surface breathing to remove air
**M56 Processing: Cure Cycles**

- **Sandwich structure**
  - Temperature: 110°C for 60 min at 1°C/min, then 180°C for 120 min at 1°C/min.
  - Vacuum: -0.95 bar.

- **Monolithic structure**
  - Temperature: 110°C for 60 min at 1°C/min, then 180°C for 120 min at 1°C/min.
  - Vacuum: -0.5 bar.

**Vacuum cycle adapted to part type**

*Lower temperature 6 hours at 135°C cycle possible*
M56 Processing: Typical OOA UD Laminate Quality

M56/35%/UD268/IMA-12K

Typical porosity < 0.3%
M56 - 80 Ply UD Laminate (20 mm Thickness)

Thick laminates possible with low porosity
**Mechanical Performance**

M56 mechanical data compared with 8552 autoclave prepreg UD prepreg, 35% resin content, 145 FAW IM7 fibre.

Large mechanical database developed. Compares well with 8552 but a little lower in compression.
Demonstrator Parts

- Challenges
  - Low porosity
  - Complex geometry
  - Thin skin over core
  - Surface finish
  - Automated processes
    - ATL
    - AFP

Trials have covered several critical processes
Demonstrator Parts - A320 Fillet Fairing

- Materials
  - M56/40%/280H5/AS4-3K
  - 30mm HRH10 core

- Feedback
  - Complex shape
  - Fully passed water leak test (3 ply skin)
  - Minimal spring back

Sealing of core with good finish particularly effective over complex shape.
Demonstrator parts – Surface finish

Materials: M56/40%/193PW/AS4-3K
HRH10 25 mm core

Excellent surface finish without need for surfacing films allowing direct painting
Automated processing

- M56 UD tapes have successfully been used in ATL and AFP trials with several component manufacturers.
- Fully impregnated material is essential for success in automated processes.
- Surface breathing results in low porosity parts.

268g FAW UD tapes successfully processed

Photo courtesy of GKN UK
Conclusions

- HexPly® M56 was specifically designed for out-of-autoclave processing
- Available with a variety of reinforcements
- Fully impregnated for ATL / AFP processing
- Handle as for ‘autoclave’ prepregs BUT cure under vacuum in an oven
- Suitable for aerospace quality sandwich panels and monolithic laminates
- Several demonstrator parts successfully manufactured
- M56 material in qualification
- Next generation products under development

OOA processing can produce high quality parts and is gaining acceptance in aerospace