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

Steve Mortimer, Matthew J. Smith
Hexcel
Duxford, Cambridgeshire, UK

Elizabeth Olk
Hexcel
Dublin, California, USA

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

OOA Development – Product Requirements

- **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/AS7-12K

M56/35%/UD268/IMA-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:

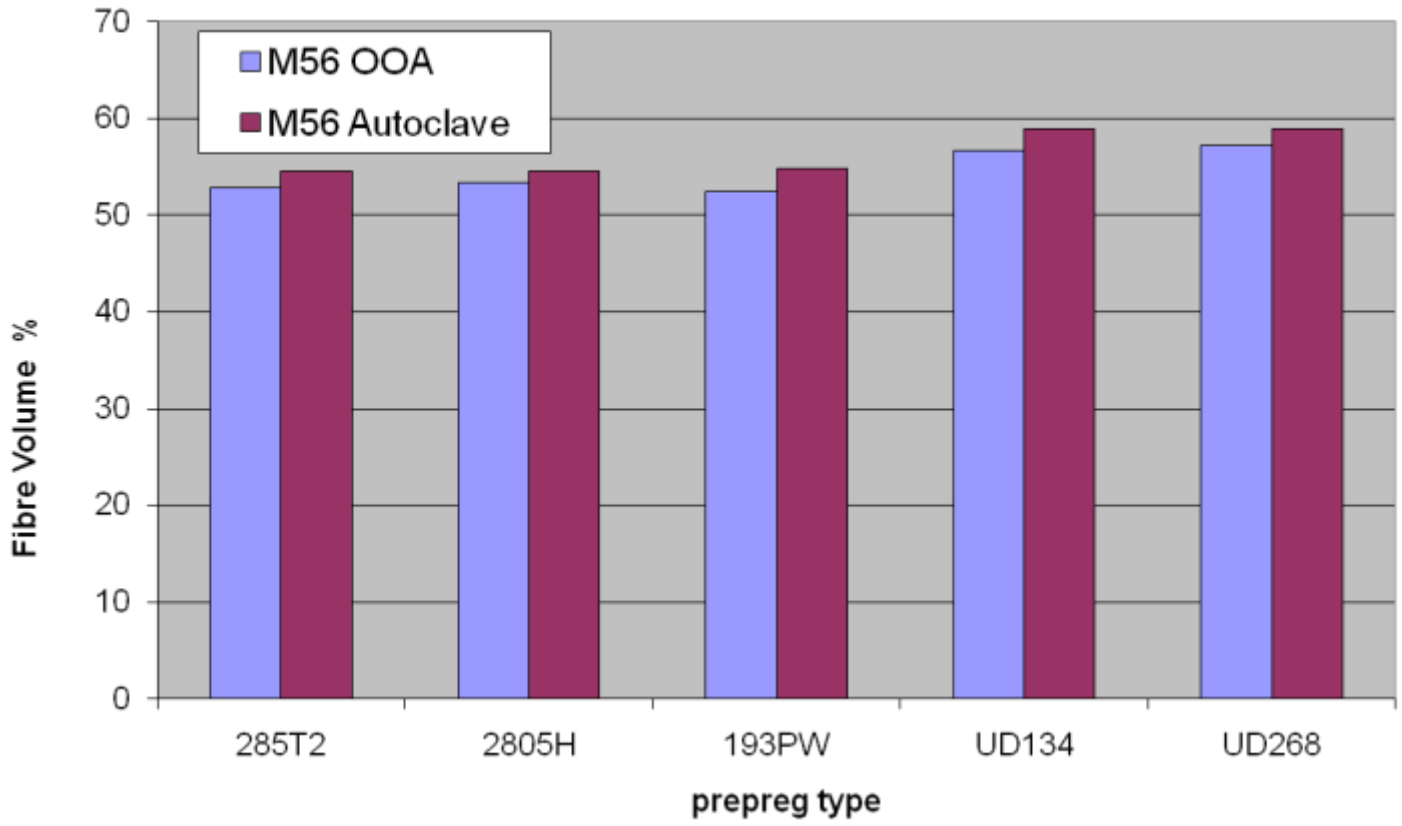
M56/37%/7581 (8 HS weave)

M56/37%/120 (4 HS weave)

Bronze mesh

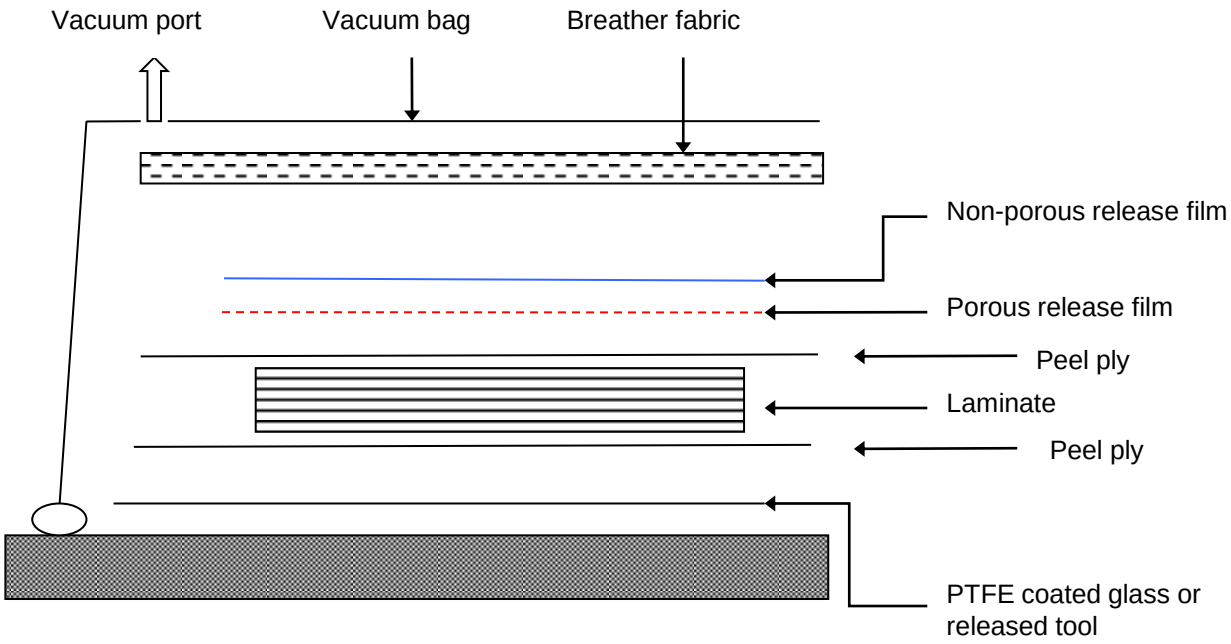
- M56/38%/BZ80 (80gsm Bronze mesh)

Fibre Volume Vs Product Type



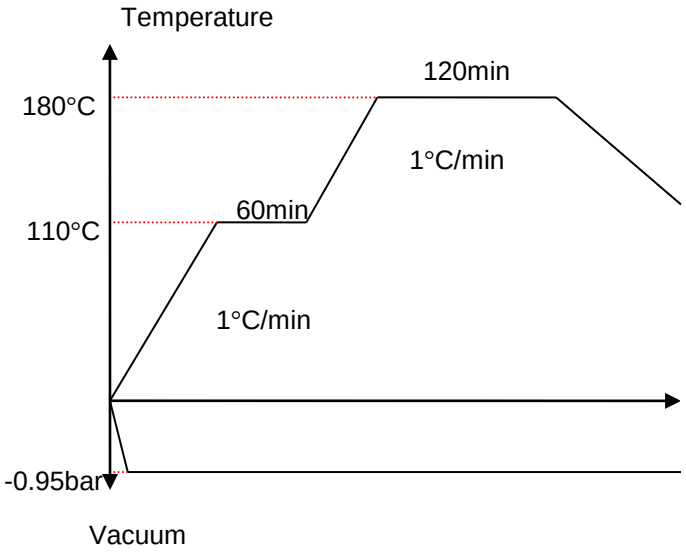
Products optimised to achieve comparable fibre volume to autoclave cure

M56 Processing: Bagging

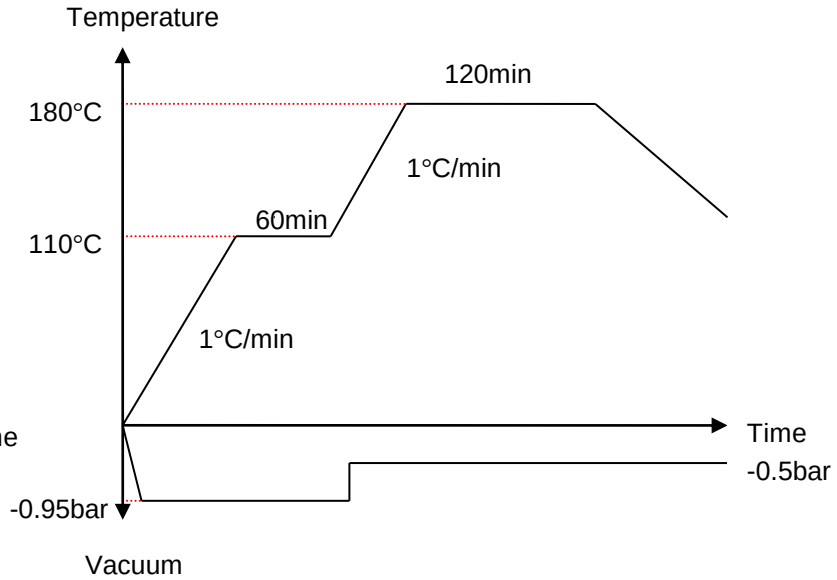


Optimum OOA bagging – surface breathing to remove air

M56 Processing: Cure Cycles



Sandwich structure

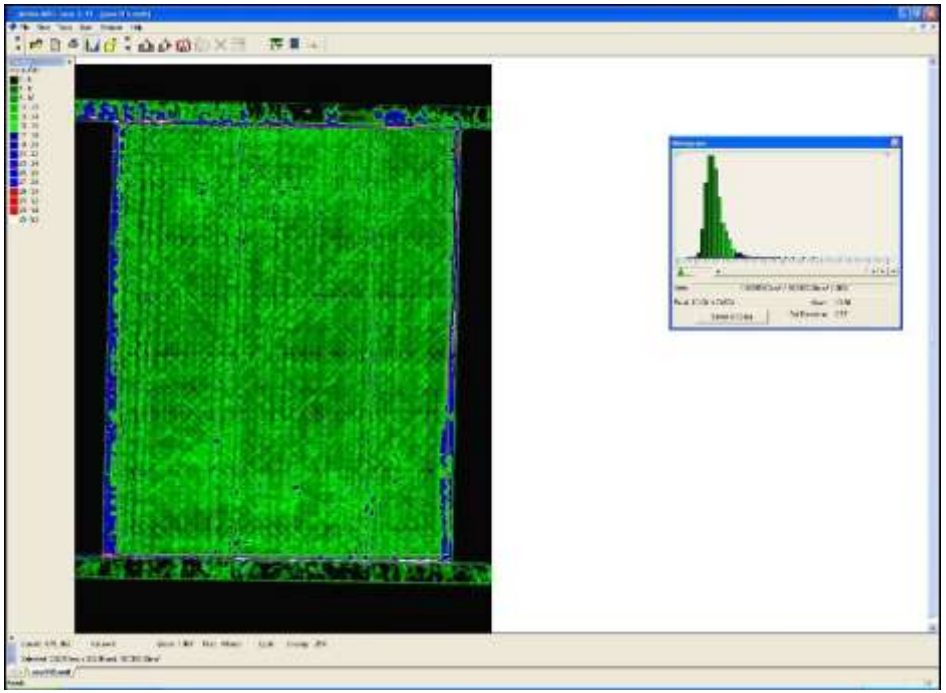


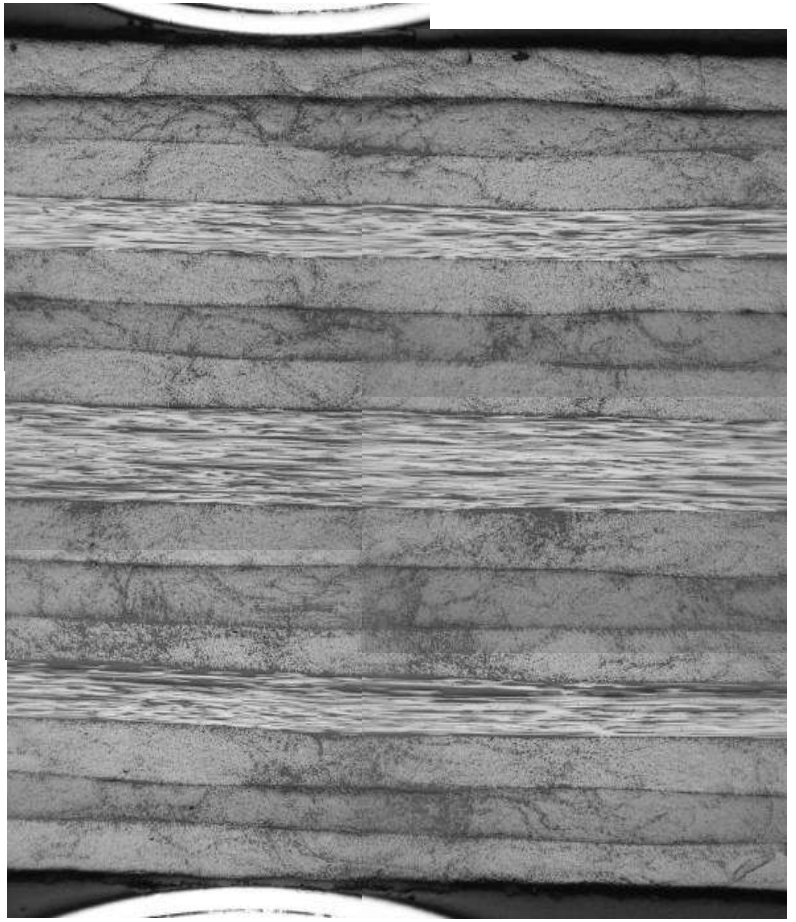
Monolithic structure

Vacuum cycle adapted to part type
Lower temperature 6 hours at 135°C cycle possible

M56 Processing: Typical OOA UD Laminate Quality

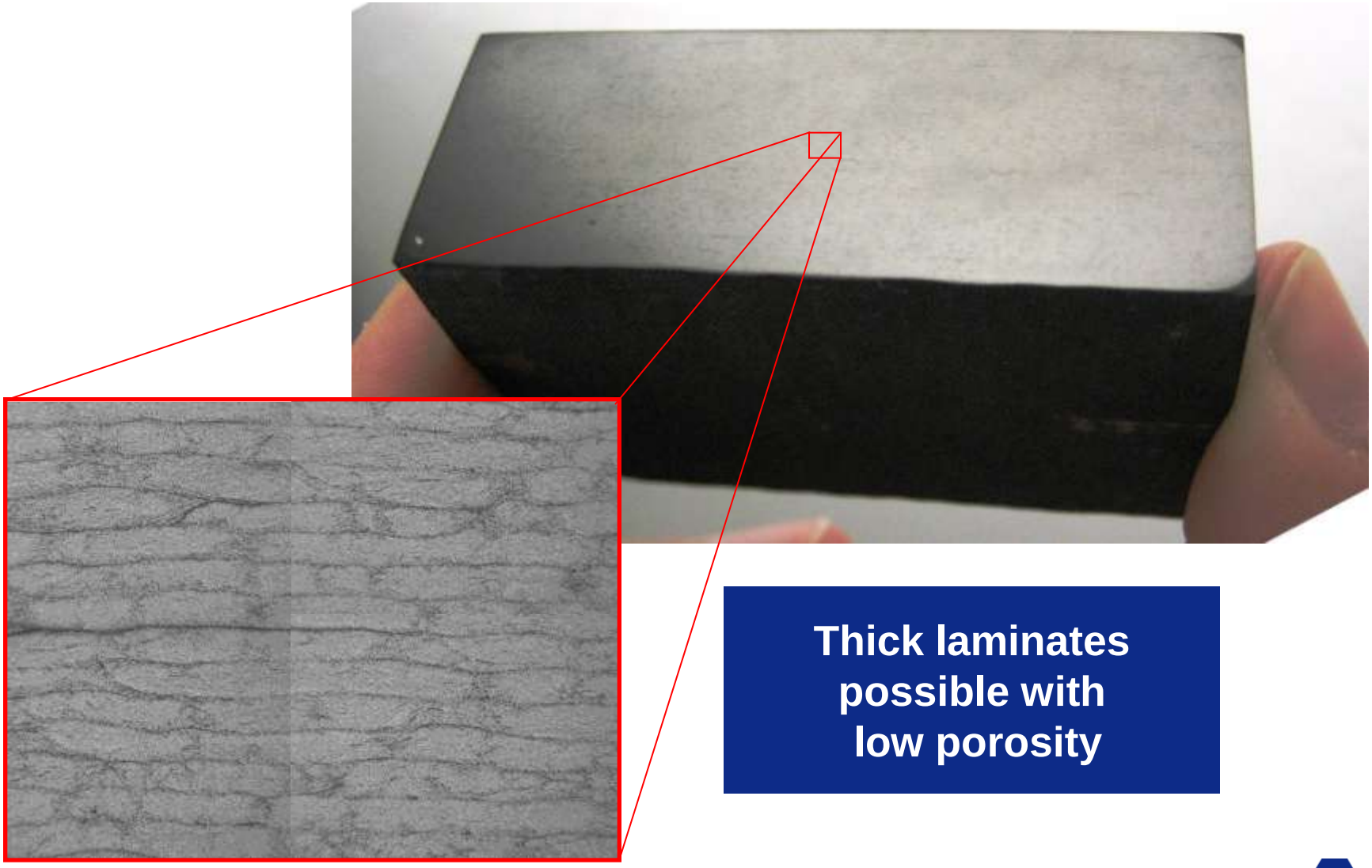
M56/35%/UD268/IMA-12K





Typical porosity < 0.3%

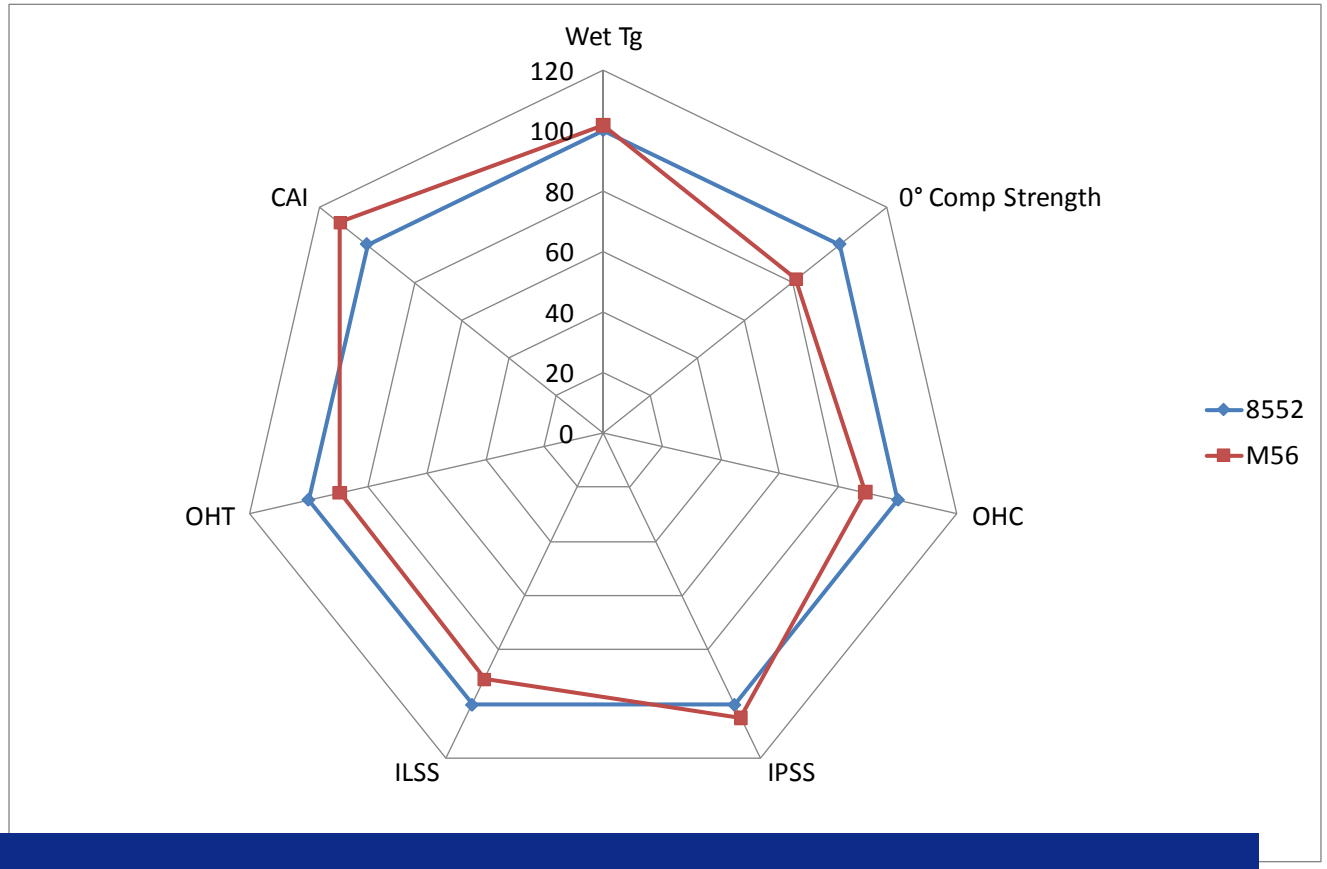
M56 - 80 Ply UD Laminate (20 mm Thickness)



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.

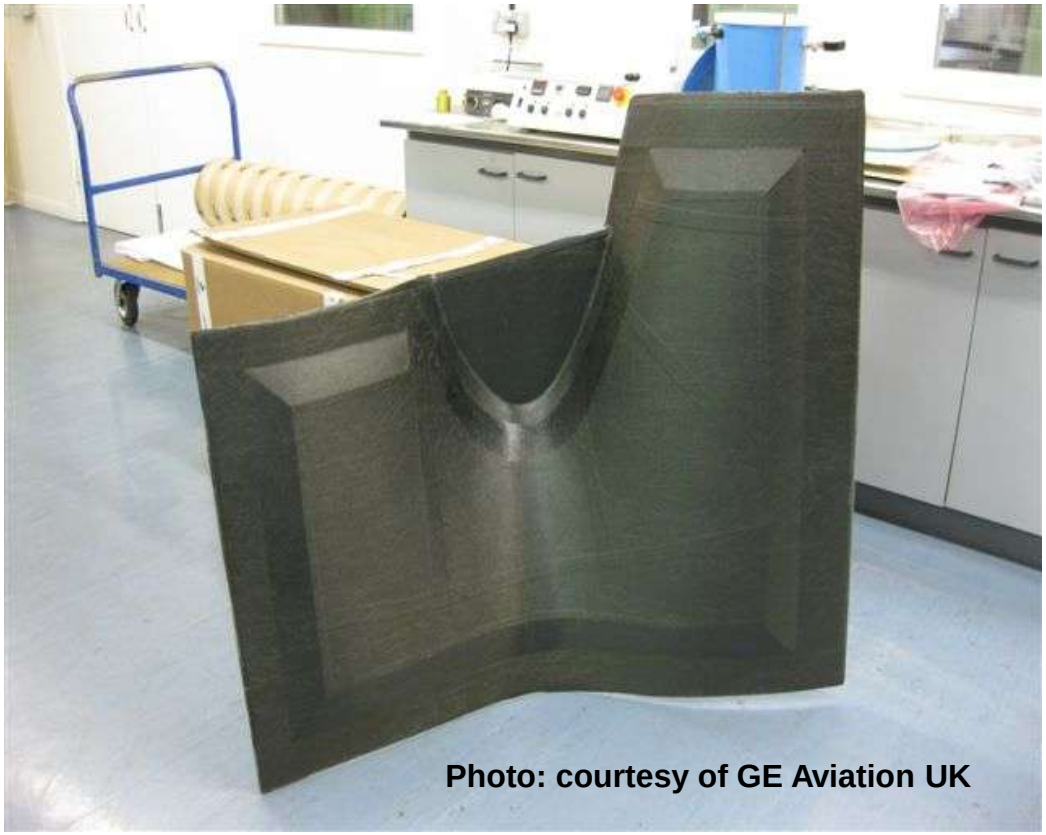
Demonstrator Parts

- **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



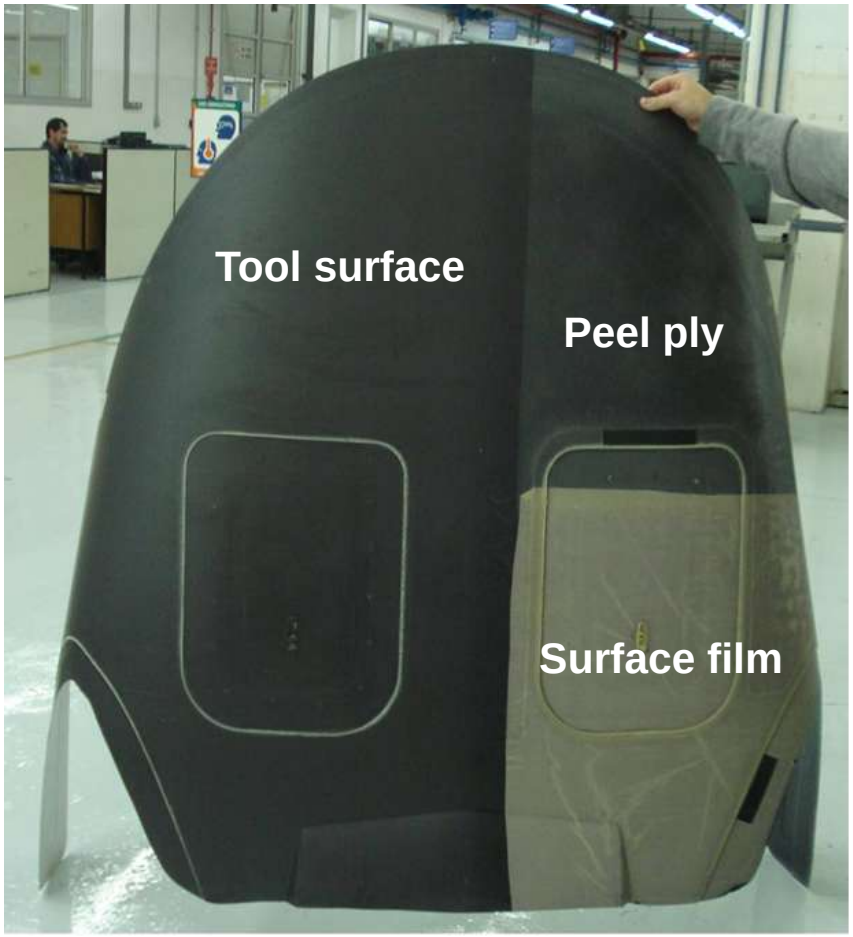
Sealing of core with good finish particularly effective over complex shape.

HEXCEL

Demonstrator parts – Surface finish

Materials: M56/40%/193PW/AS4-3K

HRH10 25 mm core

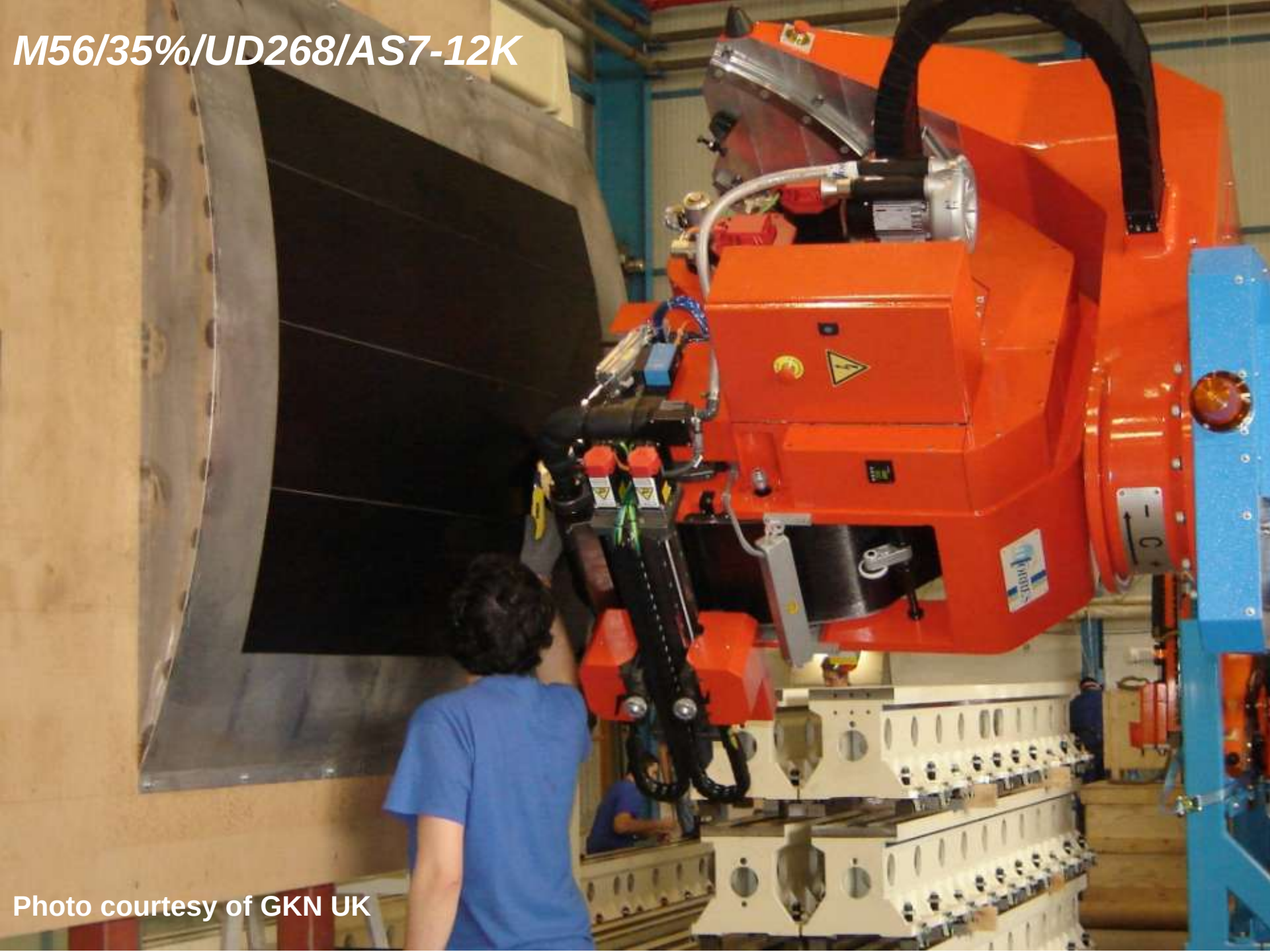


Excellent surface finish without need for surfacing films allowing direct painting

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


M56/35%/UD268/AS7-12K
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