Development of Liquid Resin Infusion Processing for High Temperature Structural Composites

Francis Arthur
Technology Development Engineer
Cobham Advanced Composites
Cobham Plc.
Global Composites Capability

- Part of the Cobham Plc Group which is a global Aerospace and Defence business with an annual revenue of approximately £2Bn and has a worldwide presence including US, Europe and Australia.
- Composites sits within the Cobham Aerospace and Surveillance Division
- Composite manufacturing Sites are situated in both the UK and the US

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<th>Composite Technologies</th>
<th>Composite Products</th>
<th>Sensor Systems</th>
<th>Life Support</th>
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Composites Knowledge Base
Materials Selection, Design, Qualification, Manufacture, Testing & Support
Cobham Composite Technologies
Capabilities overview

Radomes
- Rotary wing Radomes
- SATCOM and SAR Radomes
- Fast Jet Radomes
- Embedded Antennas
- Train SATCOM Radomes
- Naval Radomes

Structures
- In-Flight Refuelling Systems
- Aircraft Engine Structures
- Space Products
- Structures for UAVs

Development Programmes
- TSB
- FP7
- AMSCI
Development of Liquid Resin Infusion Processing for High Temperature Structural Components

**LIRIC**
Collaborative Research project between Cobham and Sigmatex and funded through AMSCI as part of the Composites Innovation Cluster
With a Primes and Supplier Vision:

Developing the UK Composites Supply Chain:

• The Composites Innovation Cluster is financed by £22million in total, of which over £11 million is awarded by the UK Government Advanced Manufacturing Supply Chain Initiative (AMSCI), and the rest matched from private partners.

• The CiC Programme is led by Cytec Industrial Materials (Heanor, UK), partnered by Axillium and Composites UK in response to the demand signals of all UK industry sectors.

• The aim is to support the delivery of a nationally connected network of composite knowledge and technology providers to address the market failures facing composites for high value manufacturing applications in the UK.

• Under the leadership of the partners, the collaborative cluster programme will be delivered by materials specialists, manufacturing & process businesses, and tooling & systems providers, all working with academic support from experts in the field.
The Composites Innovation Cluster

Partners across 4 Themes with Key Sector Sponsors

Knowledge
Analysis of future trends and demands • Preparing for growth through training and skills development • Data for Materials Engineering and manufacture
Read more

Materials
Natural fibres and Biocomposites • Design, Manufacturing and testing for new materials
Read more

Process
Design for 3D Materials • Design for manufacture • Thermoplastic composite technology
Read more

Automation
High volume manufacturing • High value manufacturing • Production engineering and testing
Read more

Composites Skills Alliance

BENTLEY

BAE SYSTEMS

JAGUAR

LAND ROVER

COMPOSITES INNOVATION CLUSTER
Liquid Resin Infusion for High Temperature structural components

Definition of LRI

- RTM: Resin Transfer Moulding
- VIP: vacuum infusion process
- DRDF: double RIFT diaphragm forming
- Quickstep: use of liquids for enhanced heat transfer in infusion
- RFI: resin film infusion
- VARTM: vacuum assisted resin transfer moulding
- SCRIMP: Seeman Composites Resin Infusion Molding Process
- RIFT: Resin infusion under flexible tooling
- VAIM: vacuum-assisted injection moulding
- VAP: vacuum assisted processing
- VARI: vacuum assisted resin injection system
- VARIM: vacuum assisted resin injection moulding
- VIM: vacuum infusion moulding
- VIMP: vacuum infusion moulding process
- VM/RTM Light: a hybrid RIFT/RTM
- LRI: Liquid Resin infusion
Infusion of a fibre preform with liquid resin under atmospheric pressure on single sided tooling
Liquid Resin Infusion
Applications

LRI used widely with ambient temperature cure resins. Advantages include:

1. Very large single piece structures
2. Low weight & high performance
3. Affordable manufacturing process
**Advantages**

- **Affordable method of composites manufacture:**
  - Reduced tooling costs in comparison to RTM manufacture
  - Reduced materials cost and labour in comparison to prepreg manufacture
- Tends to be an out of autoclave manufacturing process (reduced cost, remove bottleneck)
- Greater choice due to separate Resin and Reinforcement
- Manufacture of single piece complex geometries including 3D woven preforms
- Manufacture of large scale structures

**Disadvantages**

- Can be difficult to infuse complex geometries (dry patches)
- Only one tool surface (if using vacuum bag)
- Requirement for low viscosity resins means reduced thermal and mechanical performance
- Laminate thickness can be difficult to control (dependent on flow history)
Liquid Resin Infusion
Rarely used with Elevated temperature components

- LRI is rarely used with elevated temperature infusion and cure resin systems such as those required for the manufacture of structural aerospace components.

- The development of low labour, out of autoclave and affordable composite processing such as Liquid Resin Infusion are an important development for the UK to remain competitive in the global composites market.

- The current project will further develop LRI for low to medium volume (10’s – 100’s pa) manufacture of composite components with temperature performance in excess of Epoxies.
AMSCI LiRIC

To develop and validate liquid resin infusion technology for high temperature structural aerospace components

**Phase 1**
- Material Screening & process development
- Sub Element design and manufacture
- 3D Weaving design and Development

**Phase 2**
- Self Heated tooling design and manufacture
- Demonstrator design and manufacture
- Production process analysis including certification and route to market
Shortlist of candidate resins including:

- Epoxy
- Benzoxazine
- Cyanate Ester
- BMI
A flat panel of each of the candidate resin systems was successfully infused and oven cured using a centre point infusion strategy.
Work was conducted in collaboration with catapult centres around the UK
Laminates were subjected to C-scan imaging, microscopy and fibre volume fraction testing to demonstrate good consolidation.

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<tr>
<th>Panel</th>
<th>Average Void Content</th>
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<tbody>
<tr>
<td>Epoxy</td>
<td>0.9%</td>
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<tr>
<td>Cyanate Ester</td>
<td>0.4%</td>
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<tr>
<td>Benzoxazine</td>
<td>0.3%</td>
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<tr>
<td>BMI</td>
<td>0.4%</td>
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LIRIC
Laminate properties

*Following free standing post cure
ETW – 90°C
ETD – 120°C
*Following free standing post cure
LIRIC Project
Future work

• Manufacture of 3D woven T-section elements tufted to an NCF skin

• Development and manufacture of demonstrator component including the following features:
  – Double curvature skin
  – Variable thickness skin
  – Integrated T-stringers
  – Omega stiffeners
Conclusions

- Affordable methods of OoA composite manufacture are important for the long term competitiveness of the UK composites industry.

- Cobham shall expand the number of applications for this technology though the development of the LRI process to be suitable for low to medium volume manufacture of high temperature composite components.
Thank you

Any questions?