R&D of Advanced Composites and Their Manufacturing Methods

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Industry and Academia Working Together

www.sheffieldcomposites.co.uk

Coking Works in Sheffield: 1990 (after 200 years of mining)
Now: Advanced Manufacturing Park

AMRC 2013
The Hub: Composites At Sheffield
Over 70 academics, researchers and engineers working with around 90 industrial partners

Four major themes, more than 80 partners, more than 50 projects

- LEAD: Leading edge advanced design (high-E glass fibre, hybrid systems, nanotechnology)
- SMART (Self-amelioration, self-sensing, NDT and repair)
- MSM: Multi-scale modelling (Dynamic Ansys/LS Dyna + Molecular modelling)
- E-Friend (biopolymers and biocomposites, recycled systems)
New research concepts for cutting edge manufacturing

- Fundamental research concepts of direct relevance to the industry
- Novel technology realisation within 3-5 years
- Developing novel products, materials and manufacturing simultaneously
- Growing employment

World-class manufacturing facilities

University research centres

AMRC: 70 Industrial partners

IP versus risks, time, cost and regulations

Immediate filters:
- Aerospace: currently no loss allowed in structural properties, trade-offs subject to strict regulations
- Improvements to advanced materials should lead to incremental improvements in manufacturing methods
- A new technology needs to respond to a current problem
- Research impact ∝ return on investment
- Environmental concerns over reaching the EU and international targets (2020, 2050)

- £400M investment with £28 impact on industry
- 2010 Boeing International Supplier of the Year

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Female Radii

Pad up / Drop off

Collisions:
- Laminate thickness
- Head Geometry
- Ramp angle $\theta \geq 22^\circ$
- Staggered ply boundary

Chamfer

Focus: Core stiffened panel
- Geometry validation
- Core Crush Experiments

'Spar'

First Ply Adhesion

'Bridging'

'Add' edge quality

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**Spar**

- Overall Deposition rate > 0.5kg/hr
- Peak rate achieved > 1.2 Kg/hr
- Limiting factor - System Down time
- Production Capability 2.5kg/hr (< 10% downtime)

![Deposition rate graph](image1)

Cost Analysis

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Ply Cancellation/Preform</th>
<th>Consolidation/Curing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw's</td>
<td>Reduce Waste Krap</td>
<td>Equipment Depreciation Running Cost</td>
</tr>
<tr>
<td>Cost</td>
<td>Slitting Cost</td>
<td>Mechanical Properties</td>
</tr>
</tbody>
</table>

![Cost per 10 components graph](image2)

**LCA**

- Feasible alternative to Hand Layup
- Nearing manufacturing readiness
- Potential to reduce manufacturing cost
- Potential to reduce life cycle emissions
- Successful Use with Out of Autoclave materials

![LCA graph](image3)

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Impact

- Reduce system complexity
- Refine head geometry
- Shorten material feed distance
- Modify heating system

50% decrease in down time through new AFP head design

Lower scrap % due to the optimised AFP process

Cost-effective solution to hand lay-up

Inkjet Printed CFRPs

- Direct write technology (no masks needed)
- Additive technology
- Use droplets of ink emitted from a nozzle to create dot patterns on substrate
- Computer-aided which can pre-define patterns according to requirements
  - Rapid changing between patterns
- Non-contact deposition method (reduces/removes risk of contamination)
Inkjet printing can deposit highly controlled droplets onto substrate
- Minimum self-ameliorating agent usage
- Simplified manufacturing process

Interlaminar shear strength

Healing cycle:
- Heating to 177°C for 2 hours
- Surface ratio: 61%
- Volume fraction: 0.0247%

Interlaminar fracture toughness
Glass ceramic fibre composites

- Glass-ceramic systems are polycrystalline materials formed by controlled crystallisation of the parent glasses.
- Reduced Young's modulus obtained through nanoindentation for MAS was 139 GPa following crystallisation at 1140°C.


MAS Glass Ceramic Fabrication

a) Transfer of platinum crucible at 1600°C to drawing furnace at 1240°C

b) MAS fibre was up-drawn as the appropriate melt viscosity

c) The fibre diameter was controlled by the speed of drawing

LAS Glass Ceramic Fabrication

a) Rods up to 1.5m long with 5 mm diameter were produced by dipping a metal rod into molten glass

b) Glass rod was gripped by chuck before been drawn.

c) The glass rod softened and spun through the orifice.

d) The fibre diameter was successfully controlled.
Recycling theme: turning waste polymers into structures

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Case study: Recycled Composite Railway Sleepers

Recycled Polymer Blends Optimisation
- Optimised Blends used for Component Design
  - Component Optimised with Additives
  - Test Protocol on Optimised Components
  - Critical Tests in TP Passed by Component
  - Component Built into Track System
  - Product Delivery
- More than 30 product specific tests

10 - 300kN
Full size sleepers 250x130x2600mm
5 million cycles at 1.8 Hz (22 days)

Welcome to DFC 12 – SI 6 at Queens’ College, Cambridge
8-13 April 2013

Celebrating 85 years of Anthony Kelly
Focused on connecting SME’s into the country's advanced manufacturing supply chains, through which we supply the world…

**Festival Launch Night**
- Official Festival launch, Millennium Galleries

**Get up to Speed**
- Interactive Education event.
- Target audience – school children, students and parents
- Purpose – introduce the STEM subjects, and build confidence in the sector as an excellent place to work.

**Exhibition & Speakers**
- Exhibition focused on Manufacturing Supply Chain and Skills
- Presentations from the OEMS including Procurement Specialists
- Networking – Meet the OEMs from Aerospace, Nuclear, Medical and Renewables

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