The University Of Sheffield.

Composites At Sheffield.

Composite Systems Innovation Centre

Advanced Manufacturing Research Centre with Boeing

R&D of Advanced Composites and Their Manufacturing Methods

Prof. Alma Hodzic, AMRC, The University of Sheffield
a.hodzic@sheffield.ac.uk

Industry and Academia Working Together

www.sheffieldcomposites.co.uk

CATAPULT High Value Manufacturing

EUROPEAN UNION Investing in Your Future
European Regional Development Fund 2007-13

Coking Works in Sheffield: 1990 (after 200 years of mining)

Now: Advanced Manufacturing Park

AMRC 2013

The University Of Sheffield.

Composites At Sheffield.

Composite Systems Innovation Centre

Advanced Manufacturing Research Centre

BOEING

The Hub: Composites At Sheffield

Over 70 academics, researchers and engineers working with around 90 industrial partners

EUROPEAN UNION
Investing in Your Future
European Regional Development Fund 2007-13

www.sheffieldcomposites.co.uk

The University Of Sheffield.

Composites At Sheffield.

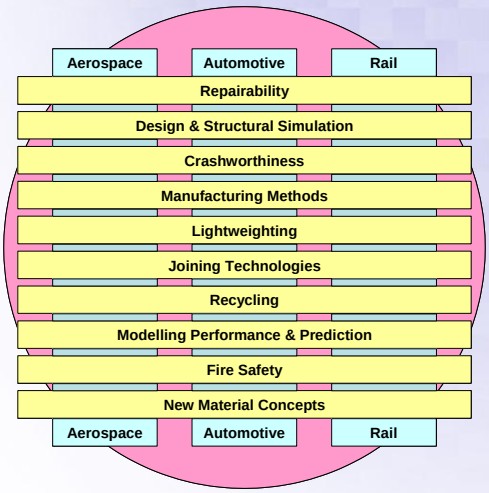
Composite Systems Innovation Centre

Advanced Manufacturing Research Centre

BOEING

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)

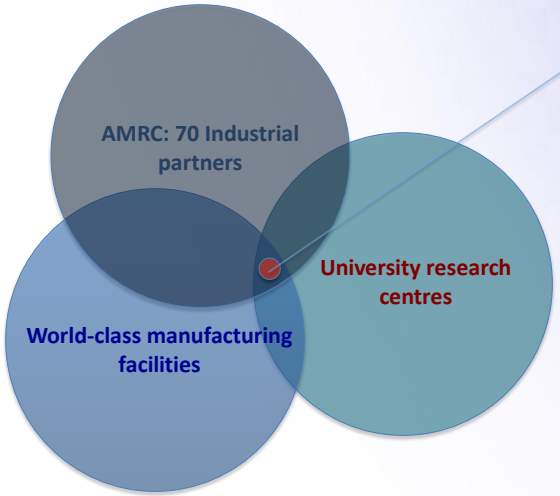


www.sheffieldcomposites.co.uk

© 2012 The University Of Sheffield

The University Of Sheffield. Composites At Sheffield. Composite Systems Innovation Centre. Advanced Manufacturing Research Centre. BOEING

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

www.sheffieldcomposites.co.uk

The University Of Sheffield. Composites At Sheffield. Composite Systems Innovation Centre. Advanced Manufacturing Research Centre. BOEING

IP versus risks, time, cost and regulations

- £400M investment with £2B impact on industry
- 2010 Boeing International Supplier of the Year

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)

www.sheffieldcomposites.co.uk

The University Of Sheffield.

Composites At Sheffield.

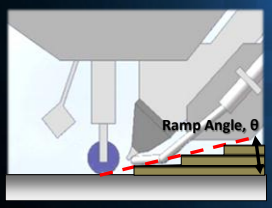
Composite Systems Innovation Centre

Advanced Manufacturing Research Centre

BOEING

Female Radii

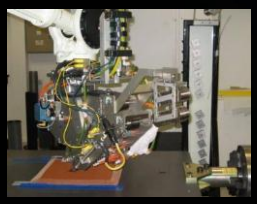
Pad up / Drop off



Collisions:

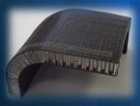
- Laminate thickness
- Head Geometry
- Ramp angle θ ≥ =22°
- Staggered ply boundary

Chamfer



Focus: Core stiffened panel

- Geometry validation
- Core Crush Experiments



6 months

4y integrated wing project

www.sheffieldcomposites.co.uk

The University Of Sheffield.

Composites At Sheffield.

Composite Systems Innovation Centre

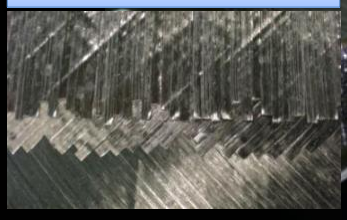
Advanced Manufacturing Research Centre

BOEING

Spar

First Ply Adhesion

'Add' edge quality



Bridging

www.sheffieldcomposites.co.uk

© 2013 The University Of Sheffield

The University Of Sheffield.

Composites At Sheffield.

Composite Systems Innovation Centre

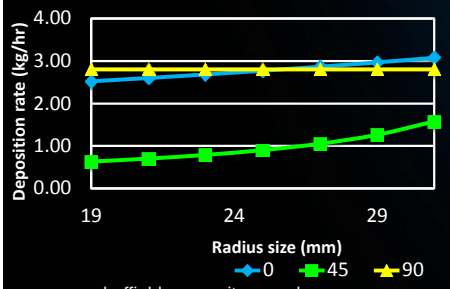
Advanced Manufacturing Research Centre

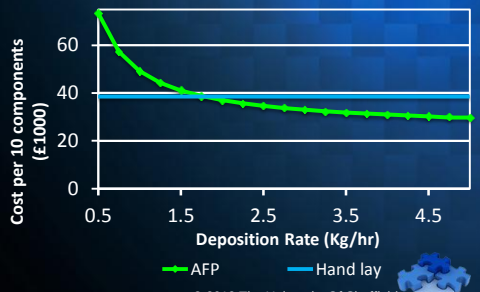
BOEING

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)

Cost Analysis	Raw Material	Ply Collation / Preform	Consolidation / curing
Pro's	Reduce Waste / Scrap	Faster Rate Higher accuracy Reduced labour	Equipment Cost Running cost
Con's	Slitting Cost	Equipment Depreciation Running Cost	Mechanical Properties





www.sheffieldcomposites.co.uk

The University Of Sheffield.

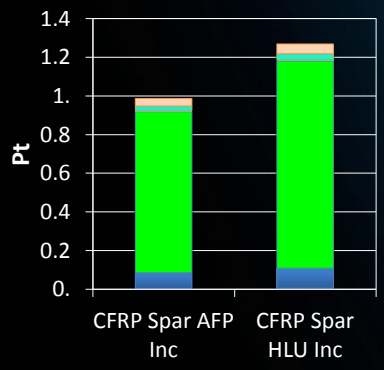
Composites At Sheffield.

Composite Systems Innovation Centre

Advanced Manufacturing Research Centre

BOEING

LCA



- Fossil fuels
- Minerals
- Land use
- Ecotoxicity
- Ozone layer
- Radiation
- Climate change
- Respiratory inorganics

- 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

www.sheffieldcomposites.co.uk

© 2013 The University Of Sheffield

The University Of Sheffield.

Composites At Sheffield.

Composite Systems Innovation Centre

Advanced Manufacturing Research Centre

BOEING

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

www.sheffieldcomposites.co.uk

The University Of Sheffield.

Composites At Sheffield.

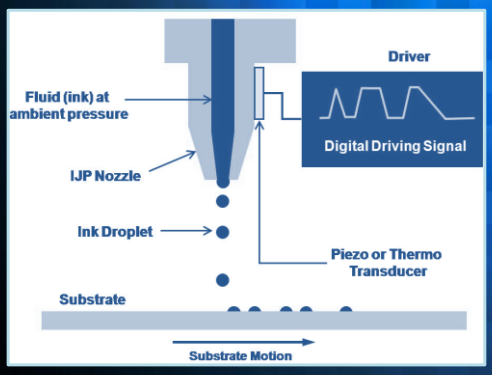
Composite Systems Innovation Centre

Advanced Manufacturing Research Centre

BOEING

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)



www.sheffieldcomposites.co.uk

© 2012 The University Of Sheffield

The University Of Sheffield.

Composites At Sheffield.

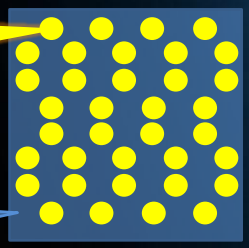
Composite Systems Innovation Centre

Advanced Manufacturing Research Centre

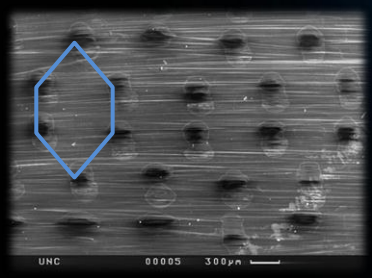
BOEING

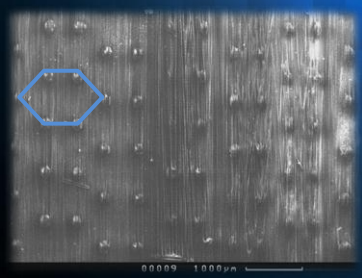
Thermoplastic additive

Composite ply



- Inkjet printing can deposit highly controlled droplets onto substrate
- Minimum self-ameliorating agent usage
- Simplified manufacturing process





www.sheffieldcomposites.co.uk

The University Of Sheffield.

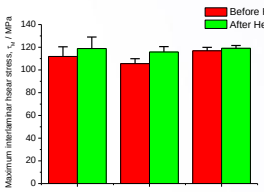
Composites At Sheffield.

Composite Systems Innovation Centre

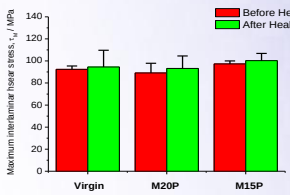
Advanced Manufacturing Research Centre

BOEING

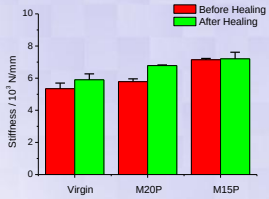
Interlaminar shear strength



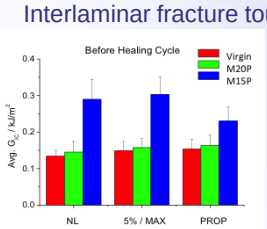
Undamaged

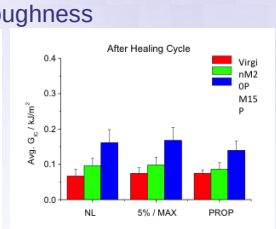


Damaged



Interlaminar fracture toughness





Healing cycle:
Heating to 177°C for 2 hours

Surface ratio: 61%

Volume fraction: 0.0247%

www.sheffieldcomposites.co.uk

The University Of Sheffield.

Composites At Sheffield.

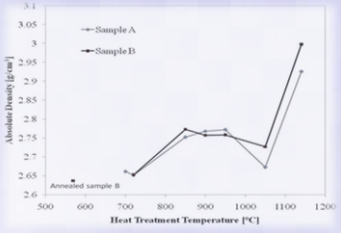
Composite Systems Innovation Centre

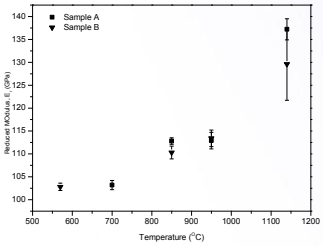
Advanced Manufacturing Research Centre

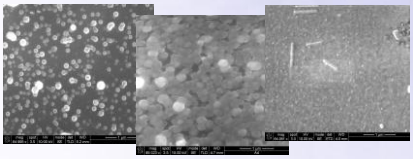
BOEING

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 139GPa following crystallisation at 1140°C.







Shamsudin, Z., Hodzic, A., Soutis, C., Hand, R. J., Hayes, S. A., Bond, I. P.. *J. Mater. Sci.* **46(17),** pp. 5822-5829(2011)

www.sheffieldcomposites.co.uk

ALSTOM

The University Of Sheffield.

Composites At Sheffield.

Composite Systems Innovation Centre

Advanced Manufacturing Research Centre

BOEING

MAS Glass Ceramic Fabrication

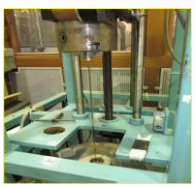
a) Transfer of platinum crucible at 1600° C to drawing furnace at 1240°C

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.

ALSTOM

The University Of Sheffield.

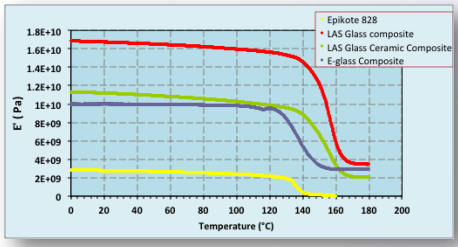
Composites At Sheffield.

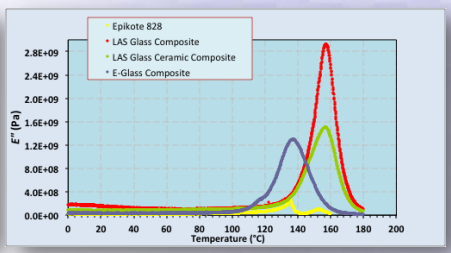
Composite Systems Innovation Centre

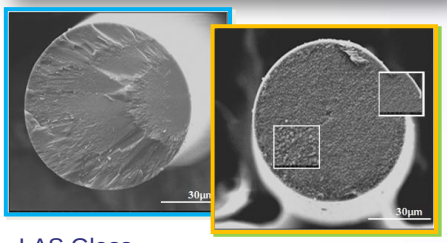
Advanced Manufacturing Research Centre

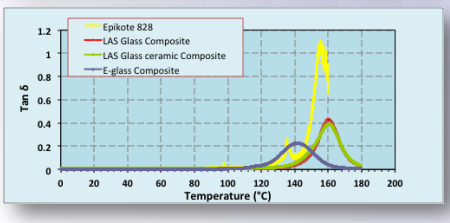
BOEING

DMTA









LAS Glass

LAS GC

www.sheffieldcomposites.co.uk

ALSTOM

The University Of Sheffield.

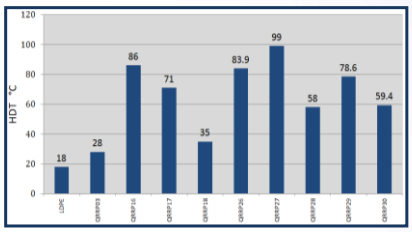
Composites At Sheffield.

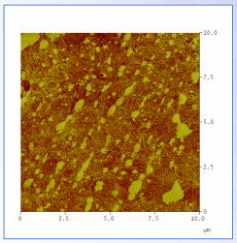
Composite Systems Innovation Centre

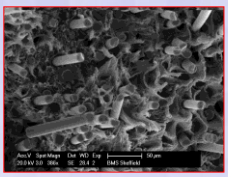
Advanced Manufacturing Research Centre

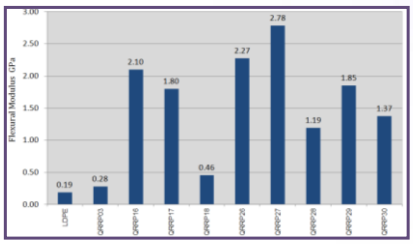
BOEING

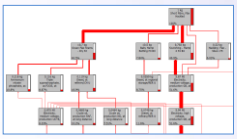
Recycling theme: turning waste polymers into structures

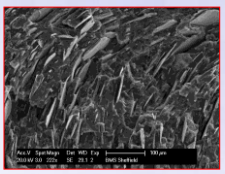












QATAR SCIENCE & TECHNOLOGY PARK

Member of Qatar Foundation

QATAR UNIVERSITY

www.sheffieldcomposites.co.uk

The University Of Sheffield.

Composites At Sheffield.

Composite Systems Innovation Centre

Advanced Manufacturing Research Centre

BOEING

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

⬇

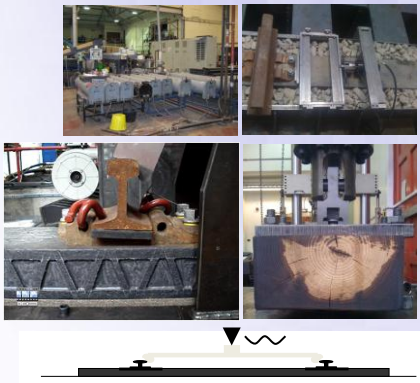
Component Built into Track System

⬇

Product Delivery

⬇

More than 30 product specific tests



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

iplas Technology Strategy Board Driving Innovation

Network Rail

www.sheffieldcomposites.co.uk

The University Of Sheffield.

Composites At Sheffield.

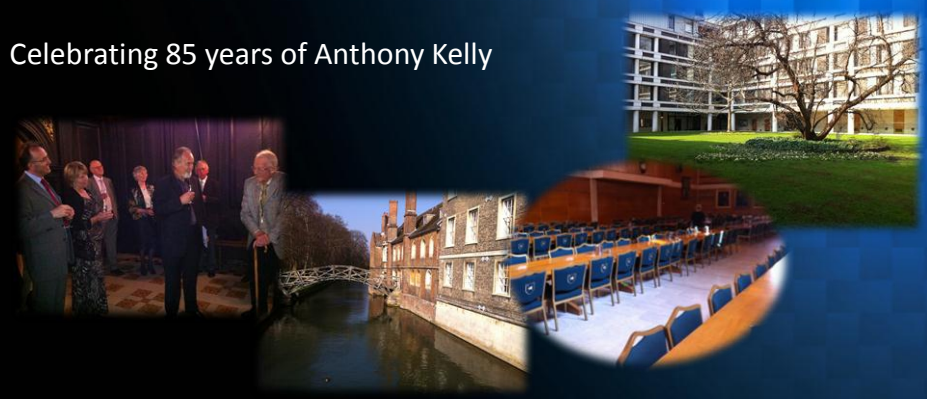
Composite Systems Innovation Centre

Advanced Manufacturing Research Centre

BOEING

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

Celebrating 85 years of Anthony Kelly



www.sheffieldcomposites.co.uk

Global Manufacturing Festival: Sheffield

17th-19th April 2013 **AMRC - Advanced Manufacturing Park**

Focused on connecting SME's into the country's advanced manufacturing supply chains, through which we supply the world…

17th April

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.

18th April

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

globalmanufacturingfestival.com
@GMFSheffield