Affordable Composites

WDSF

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Presented by

Alison Starr Executive Director National Composites Centre
What is a Composite?

The ultimate ‘designer material’!
Human Use of Composites

The ancient Sumerians made composites
  Mud – the matrix
  Straw - the reinforce

The classic composite

The English Long Bow

Soft sapwood in tension and denser heartwood in compression

2 materials working together
Today’s Applications

- **Aerospace** – making Wings, spoilers, fairings, engine blades
- **Marine** – for Boat structures, canoes, paddles
- **Renewable Energy Generation** – especially for Wind turbine blades
- **High end - Sporting Goods** – in Golf club shafts, tennis rackets, cycle frames
- **To the new and emerging areas such as**
- **Automotive** – using it in Brake discs, body panels, leaf springs
- **Medical** – for Wheelchairs, leg braces, prosthetic devices.
- **Civil Engineering** – for Bridge reinforcements, cladding, wall panels

It is interesting to note that the amount of composites used in construction differs depending on where you live in the world - the far east are significant users in building cladding; the Dutch for composite based bridges over canals – while the UK who invented the materials lags far behind in this area.

And has anyone seen the roof of the new Apple building? The building known as the Theatre has a carbon fiber roof, which Apple is saying is the largest freestanding carbon fiber roof ever made. The circular roof weighs 80 tons and is slightly above 43 metres in diameter. It is made up of 44 identical radial panels, each 21 metres long and 3.3 metres wide.
Composites Global Opportunity

<table>
<thead>
<tr>
<th>Sector</th>
<th>2013</th>
<th>2020</th>
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<tbody>
<tr>
<td>AEROSPACE</td>
<td>$10.6bn</td>
<td>$20bn</td>
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<tr>
<td>DEFENCE</td>
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<td>AUTOMOTIVE</td>
<td>$9.6bn</td>
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<td>RAIL</td>
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<tr>
<td>CONSTRUCTION</td>
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<td>$14.1bn</td>
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<td>MARINE</td>
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<td>$18.2bn</td>
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<tr>
<td>WIND ENERGY</td>
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Traditional Aerospace Manufacturing

Material / tool preparation  Manual lay-up  Curing

While improvement have been made over these traditional methods like automated cutting and lazer guided layup the 8 hour cure cycle is a big challenge for the industry.
Automated Fibre Placement

- Automated Fibre Placement now normal for large, primary structures for aerospace parts, and has been one of the main enablers of the significant shift to composites on aircraft such as A350 and the Boeing 787.

- With AFP, robots can manufacture large complex geometry parts of high quality and performance by laying down multiple narrow strips of carbon fibre straight onto a mould surface which allows for a very high degree of tailoring of the material to the loads and shape requirements, giving highly optimised, light weight structures, with significantly reduced production times and costs achieved.

- However, this is a slow and costly process, with very poor asset utilisation. The economics have been made to work for large aircraft which require slower build rates and highly performance driven, but the process is inappropriate for high rate lower cost manufacture needs of short range aircraft fleets.

Automated lay-up
It’s all in the Head!

While the robots are very useful and we need to be able to control them, get them to collaborate, much of the power is in the design of the head and tools the robots use.

The heads show here enable, tape laying, curing as the tape is laid and a prototype for lifting complex and delicate fabric pieces automatically into a complex tool. The design of the head is an area expertise for the NCC, we are now designing heads that are multi function so the head does not have to be changed to achieve the different aspects of a task.
One of the issues for Composites has been the delamination, or the pulling apart, of the layers under some conditions leading to failure. New stitching and pinning techniques – known as Z pinning and tufting are now being developed – these hold the layers together and stop the delamination from occurring. The work we have done at the NCC has led to patents in this area.
Remember this and the 8 hours?

This head is an early stage proof of concept demonstration that is capability of picking up fabric shapes that are complex, delicate and that need to be laid up into tools. This is an essential part of the process of part manufacture for dry fibre infused composite processes.

These systems do not require the hours of curing time in an auto clave that pre-impregnated fabrics currently used in aerospace and can facilitate the rates of production required by the automotive sector. Change 8 hours into a few minutes for the curing cycle

For an average car the current steel body costs around $1000 (£800); an Aluminium one comes in around $2000 (£1500) and a composites could be acceptable at $3.8K (£3k) because of the other merits the material brings... but not there yet
Preforming

Collaborating robot system making, kitting, pre-form [ressing, trimming assembleyng and sewing together as the first stage of the process
Curing in a Press

A new generation ‘up-stroke’ press with rapid closing 3600 tonne closing force
- 3600 x 2400 mm platen
- Maximum closing speed 1000 mm/s
- Active parallelism control
- Shut height range of press platens: 400 -2400mm

The Press can be used with multiple manufacturing methods: HP-RTM, compression moulding, SMC, etc.

Using this press, & Krause Maffei three pot high pressure injection system the NCC has already successfully demonstrated high rate production with a cycle time better than 5 minutes per part.
New Doors

New doors can save over £5 million a year on the central line alone with 2 second quicker closer time, that leads to:

- Energy savings of £100,000 a year;
- Passenger journey time savings £4.7m a year (530k passenger hrs).
- Reduction in track wear, saving £400,000 a year
The Power of Design and Simulation

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The Power of Simulation

Similarly simulation of the liquid composite moulding process allows the designer to optimise the different elements of the process; such as the location of injection and vent points, and the injection strategies use through the selection of pressure and volumetric rate of resin infusion.

In addition we can use these techniques to minimizing cycle time in a manufacturing process. Information can also be used to direct the tool manufacture to provide a right-first-time tool without a need for rework to achieve the desired geometry.

Multi-physics simulation can help to define new manufacturing processes such as induction welding of thermoplastics, including a demonstration of the process ahead of production of any tooling.

For automated processes such as AFP (automated fibre placement), to develop a fibre deposition strategy.
The Power of Simulation

By applying advanced design and simulation CAE tools we can make best use of the directional properties of composite materials to maximise stiffness, minimise stress/strain and reduce mass through multi-parameter optimisation techniques. These methods can be used to minimise the cost of manufacture and consider lifecycle costing early in the design process.

We can also understand the effect of defects and variability through manufacturing processes early in the conceptual and detailed design workflow and build in appropriate margins of safety to reduce the need for costly physical prototyping and testing.
Dymag BOXSTROM Wheel

Detailed knowledge of how composite materials behave under extreme loading and harsh conditions has enabled an enhanced structural design to rapidly mature. The design iteration is actually exceeding the original load requirements and is doing so at a lower mass than previous wheels and as an added bonus only takes half the time to manufacture compared to the previous designs.

The Dymag BOXSTROM™ Carbon Hybrid Wheel offers many technical advantages:
- Typically 40% lighter than standard cast aluminium wheels
- Typically 25% lighter than equivalent OEM forged aluminium wheels, tested to the same OEM standards
- 30% to 40% lower moment of inertia than aluminium cast and forged wheels
The National Composites Centre and the High Value Manufacturing Catapult

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Market failure: Bridging the Valley of Death

Technology Readiness Scale developed by NASA.
Technology Readiness Level 1-3 is the stage from idea to interesting prototype. This often takes place in a research institution, university or laboratory.
TRL 4-6 is the translational space which moves the prototype to proof of commercial viability.
TRL 7-9 is where private investment turns the proven concept into industrial scale manufacturing activity.
The translational activity is the risky, expensive stage, often involving significant investments without any guarantee of success. It is estimated that 80% of innovations fail in this so-called Valley of Death.
Other countries recognise this market failure and have put in place support mechanisms.
The NCC a member of the UKs High Value Manufacturing catapult fit in the translational space.
What Do Catapults Do

Drive growth of manufacturing
Help companies of all sizes incubate and develop new technologies to commercial reality
- Collaborations
- Network of technology and innovation
- Focus on strengths and market potential is significant

Take the risk out of innovation
Give business open access to:
- World class open sourced equipment
- The UK’s best relevant research knowledge
- At elbow support from engineers, scientists, technicians
- An environment of collaboration and open innovation:
  Cross sector
  Cross technology
  Whole supply chain
  Even among direct competitors
The NCC Provides

- design and simulation
- prototype manufacture
- process optimisation
- testing and inspection
- manufacturing & test equipment
- industry training & skills needs

✔ Open Access
✔ Confidentiality
✔ Cross Sector
✔ Collaboration

Multiple Sector Engagement; Multiple size Company Engagement

~200 Engineers and Technicians
Who are the HVM Catapults

- The National Composites - Composites
- The Advance metals research centre – Metals machining
- The Nuclear Metals research centre – Large metal structures
- The Advanced forming research centre – Metals forming
- Warwick Manufacturing group – Batteries and automotive design
- Centre for process innovation – Support to the process industry sector
- The Manufacturing Technology Centre – Manufacturing technologies inc. Additive