SAMPE UK and Ireland Chapter
Annual Seminar and Table Top Exhibition
23rd February 2017
Cranfield University
Maximising Composite Value by Innovation

The seminar comprised 8 varied presentations and was attended by over 80 delegates including 20 exhibitors. Thanks, are due to our three sponsors – Formaplex, Hexcel and Shape, also to Cranfield University for administrative support, and to Trevor Cook and David Carlton of SAMPE, for organisation.

Keynote Speaker Richard Thommeret in discussion with committee member Tim Wybrow

1.

Keynote Presentation. Solar Impulse – Wings of the Future. Richard Thommeret. Solvay.

- The concept of achieving around-the-world travel using no fuel and hence with no pollution was conceived in 2003. The aircraft must fly by day and by night. The two main challenges are the need for extremely lightweight structures and high energy efficiency sourced from solar power and stored in advanced batteries.
- Solvay has the necessary technologies and a mission for green solutions. The Solar impulse aircraft was a most challenging demonstrator for what can be used more widely on the ground

to save natural resources. The pilots Bertrand Piccard and Andre Borshberg spearheaded the project, described as "Achieving the Impossible."

- Examples of the technical challenges were described: at the outset 30kg of standard Li ion batteries were required to equal the energy from just 1kg of fuel, and every 8 kg of additional weight requires an extra $1m^2$ of solar panels. Breakthrough technologies are required. Solar Impulse 2 (Si2) has a 72m wingspan, over $200m^2$ surface area, 17,000 solar cells and a weight of only 2300kg.
- Test flights with prototype structures started in 2009 prior to the take-off of Si2 from Abu Dhabi in March 2015. The round voyage was 40,000km in 17 stages, 500+ flying hours, including 2 non-stop flights of 5 days / nights across the Pacific and 3 days / nights across the Atlantic, landing back in Abu Dhabi in July 2016. The mission was well achieved, and the technology required for the efficient use of renewable energy was clearly demonstrated.

2**. Out-of-Autoclave Processing of Advanced Thermoplastic Composites for Space Fuel Tanks and Launchers. Prof Conchur O Bradaigh. EireComposites / University of Edinburgh**

- Work is ESA-funded in collaboration with ICOMP (Irish Composites Centre, Limerick). Many space structures are too large for autoclaves hence the need for thermoplastics. Using ATP (automated tape layup) and advanced welding / joining processes, these have properties close to those from autoclave moulding.
- Work with two demonstrators was discussed: a cryogenic fuel tank and an inter-stage rocket launcher. CF/PEEK was layed-up using ATP with local laser heating just before compaction. Tensile properties were improved but voids and consistency were not quite as good as from autoclave. As expected, toughness from thermoplastic ATP was superior. Using a heated tool up to 280°C gave further increases in flexural strength / modulus and ILSS close to autoclave values.
- CF/PEEK composites were cryogenically cycled from -196°C to RT in 50 cycles. Thin parts are often crack-free but thicker parts can develop a crack, but only at the first cycle. It is expected that this can be designed out in the lay-up using QI as opposed to cross-ply reinforcement. The permeability of CF/PEEK is low enough for fuel tanks. For un-cycled material, the permeability at -196°C is an order of magnitude less than at RT. Cycled tanks will need polymer liners.
- The main challenges for the future are: cost effective bespoke TP tapes and, designed CF/PEEK crystallinity to optimise the toughness / strength ratio.

3. **Carbon Fibre Reinforced Plastics for High Performance Applications. Julian Lowe. Toho Tenax**

- TT is part of the Teijin Group with CF manufacture in Japan (mainly high and intermediate modulus fibres) and in Germany (mainly standard modulus 24k filament low cost fibre, also 3k for weaving). TT in Germany has 70 employees and 4000T/yr. production.
- TT is the largest producer of chopped CF with many different coatings including metal coatings. There is a large and growing production of thermoplastic materials, especially PEEK and PEKK (polyetherketonketone). PEKK has higher Tg (160°C cf 140°C) but lower melt temperature (minimum 305°C cf 343°C) and improved flow. A special CF size gives enhanced flexural properties, ahead of the competition. TP unidirectional tapes for ATP and FW processes are produced in widths from 0.25 to 12 inches. TP tapes are designed for hot stamping or continuous compression moulding. Carbon fibres are offered as continuous, chopped, stretch

broken, co-mingled and as fabrics. TP woven fabrics made by powder coating and sintering are available with PPS, PEI, PEEK, and other polymers.

- A large advantage of PEEK / PEKK over epoxy is the small loss in hot /wet compression strength and modulus, approx. 2% cf 10-30%, which is important for aerospace. Welding (by IR heating) offers weight saving (no rivets). Composites can be recycled by crushing to a powder, adding more PEEK if needed, and re-moulding.

4. Applications for Multi-Axial Reinforcements. Arthur Swarbrick. Hexcel

- FORMAX (Leicester), was acquired by Hexcel and as Hexcel Reinforcements UK has 150 personnel and processes 7000T pa E glass and 700T pa carbon fibre, also aramid fibres.
- A range of multi-axial fabrics in widths from 25 to 2500mm were described, sold under the "Hi Max" label. There is a heavy investment in in-process quality control and in the technical characterisation of the finished fabrics.
- The Carbon Analysis Line aims to improve fabric consistency and uniformity by continuously measuring the spread of the tows from spool throughout the process giving an on-going trace from 6mm to 14mm.
- Test methods for fabric stability, formability and permeability were described. Radial and X/Y flow are measured in a rapid test using silicone oil to simulate resin infusion. This enables customers to optimise the location of resin injection ports in the mould. The ultimate goal is to provide accurate processing simulation for the various fabrics in different moulding processes.

5. **A Platform for Novel Lightweight Automotive Composite Design. Antony Dodworth. Bright Lite Structures**

- It was described how design is paramount in achieving simplified structures with a lower number of sub-components and hence reduced assembly costs. Further cost reductions come from using affordable raw materials. The development of a 1-piece chassis for the Zenos car, to replace an original 5-piece assembly was described using discontinuous CF felt and a Huntsman PU core.

- Using similar technology, a single piece BMW bonnet was made weighing just 7.2Kg. Current development is with a 1-piece carbon fibre floor made from a flat sandwich stack of fibres which is sprayed using a multi-head applicator supplying 2 PU resins, epoxy, pigments, and mould release agent, before compression, and moulding as a single piece. The CF reinforcement comprises low cost recycled material with some NCF, with a polycarbonate core. The floor has very high crash resistance with a weight of only 6.2Kg. At a cost of €227, it is slightly cheaper than a 3-part structure in aluminium. The potential output is 3 floors per hour.

6**. Compression Moulding with PtFS for Automotive Applications.**
Alasdair Ryder. Surface Generation.

- SG is a member of the LX Programme (Lightweighting Excellence) with lead partner Sigmatex. A thin-skinned mould tool was described with SG's technology for controlling temperature in discrete individual zones with, in this case, 32 separate ports for entry of hot air. The required hot air flow is more complex for out-of-plane parts.
- Two work packages were described: a pedal arm and a low speed energy absorber (a corrugated tube). From a list of 5 candidate materials, short fibre moulding compound was selected initially to produce the pedal arm. With a 6-8 minute cycle time the aim is mass production with no loss in performance. The finished part gives a 70% mass reduction. The energy absorber is produced by stamp forming with a 50% mass reduction.

7. **Thermoplastic Preforms Manufactured by Automated Fibre Placement.**
Matta di Francesco. National Composites Centre

- One of NCC's main focus areas is on high rate automated processing using AFP and ATP. Moulding of thermoplastics with ATP is challenging. The work compared laminates made from commercially available CF/PEEK tapes with the in-situ production of the mix via fibre and polymer using AFP.
- AFP process is fast with less than 1 second contact time with melted polymer and 0.5 seconds for consolidation. For both AFP and ATP, the size of the laser heated area is critical in maximising mechanical performance and reducing voids. A maximum lay-up speed of 400mm/sec was achieved with ATP with a 40% reduction in ILSS at 800mm/sec whereas deposition of CF/PEEK via AFP was satisfactory at the higher speed. Work continues to optimise process speed and laminate properties via AFP.

8. **Forward Composites Activities with the Airship and UAV's.**
Paul Jackson. Forward Composites

- When Lola went in to administration 5 years ago, PJ (ex-commercial director) bought the company. With just 4 or 5 people in 2013, the company now employs 155 personnel. The markets are aerospace, automotive, motor sports and light-weighting generally.
- Forward Composites offer innovative engineered solutions with an emphasis on design, both design for manufacture and design for cost. They have advanced CAD and FEA facilities. R&D spend is high and focuses on new processes and cost reduction.
- UAV's were brought in from Lola and the order book is full. These are light weight low cost structures. Forward make the carriage module for the Airlander 10 programme. Although the airship crashed rather publicly the carriage, built for high impact resistance was easily re-built.
- Other diverse speciality projects were described: a composite car body for the NIO ep9, the fastest electric car to date, and a bespoke Nissan SUV with an all carbon fibre chassis and body as a "one-off" order for a Gulf State customer.

Prepared by Geoff Gould, SAMPE UK and Ireland Chapter

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