SAMPE UK and Ireland Chapter
Annual Seminar and SME Table Top Exhibtion

Challenges for High Volume Composites Manufacturing

International Digital Laboratory, WMG, University of Warwick
Thursday 26th February 2015

This year's seminar was a "sell-out" with 100 delegates, 20 exhibitors and 8 presentations. Thanks are due to the event's sponsors: WMG for offering the event's location, to CYTEC for sponsoring lunch and refreshments.

1 Keynote Presentation:
Advanced Composites in High Volume Automotive Applications.
Dave Roche, PENSO.

- Engineering Consultancy, who are very active in introducing composites into automotive with some aerospace interests. They have 250 staff, a low volume vehicle production output (<600) and a capability up to 50,000 composite parts per annum (ppa). The company is expanding over several sites.
- Composites in auto market is driven by emissions reduction, hence weight saving requirement. Additional reduction in emissions is 100g CO_2 / km by 2020. Compared with steel, CFRP gives 60% wt saving, and "new" CFRP targets 70% wt reduction (joint work with CYTEC).
- Future car bodies will use a combination of technologies: steel, Al, FRP.
- Hot compression moulding was highlighted as a 4 minutes takt time can be achieved. For CFRP volume production, the target is one part per 80 seconds with thermoplastics are favoured over thermosets. Quality control emphasises SPC (statistical process control) and pre-dominant destructive testing is diminished in favour of NDT.

2. ***Opportunities to Achieve High Productivity / Low Cost Parts Production.***
Matthew Frost, Coriolis Composites.

- Based in Lorient, France with 100 employees, CC manufactures robotic Automated Fibre Placement machinery (AFP). Uses 6.3mm width tapes or tows with 8 feed supply on 5-axis machine. Lay-up on the tool 1m/s; feed and cut up to 0.3m/s.
- Alternative feedstocks: low tack prepreg, dry fibre with binder, thermoplastic prepreg.
- Process is multi-stage with sophisticated engineering:
  (i) creel with climate control storage,
  (ii) fibre feed with minimum tension and twist-avoidance ,
  (iii) fibre delivery to tool,
  (iv) heating is via lamps or laser.
- AFP is more precise than ATP (automated tape lay-up), greater design opportunities, more complex parts, lower scrap. Example: A350 flap – scrap rate 3%-5% AFP cf. 50% hand layup.
- A compaction roller is used to minimise voids which can be an issue with both AFP and ATP (little time for resin flow in layup) and optimised fibre storage also assists. AFP particularly suitable for aerospace structures, as the robot can be too slow for some high volume automotive parts.

3. **Capabilities of Automated Chopped Fibre Technology (DCFP).**
Lee Harper, University of Nottingham.

- DFC (Directed Fibre Compounding) is designed for fast processing. Twenty years ago production volume was typically <5000 ppa, now >350,000 ppa – BMWi3 vehicle alone stands at 30,000 ppa.
- Composites formerly based mainly on prepreg with takt time >40 minutes (complete cycle time). Now, newer processes eg. RTM, HP-RTM (high pressure) and SMC are increasingly used with much shorter takt times. HP-RTM and SMC are the only processes to offer <5min cycle time. SMC is well-established using glass fibre with 50,000 ppa routine in automotive parts.
- DFC takes fibre directly from the bobbin at 12kg/hr for 12K carbon tow and achieves 55% Vf, and variable fibre lengths 6mm-90mm. Studies were explained on factors affecting optimum fibre flow and the related effect on composite tensile strength and modulus. The target is 45% Vf +/- 5% with uniform mould coverage. Typically there is a little increased “fibre-swirling” as the distance across the mould which the charge travels also increases.
- Processing variables
  (v) tow size: 3K better than 12K and much better than 24K,
  (vi) moulding pressure: 85 Bar better than 20 Bar,
  (vii) fibre length: 15mm better than 50mm
- Hybrid structures comprising a combination of fabric (NCF) and DFC with resin are being evaluated. These give higher tensile properties from the fabric combined with higher damage tolerance / decreased notch sensitivity from the discontinuous fibres. Some evidence of a plane of weakness at the DFC/NCF interface is being investigated.
- In summary a useful process technique for improving composite properties around cut-outs by reducing and re-distributing stress concentrations.

4. ***3D LightTrans – The 3D Woven Thermoplastic Project – EU Framework 7.***
Lee Bateup, Bentley Motors

- The aim is to produce highly specific "bespoke" composite structures for the automotive applications, cost effective in the use of advanced materials. There are 18 European partners.
- The use of advanced composites in cars is not new. Lee highlighted the example of the Bentley Azure which when modified from solid-top to open-top lost nothing significant in compression strength but suffered a large drop in torsional stiffness. A CFRP cross brace was the only feasible option and is in service. In total today approx 3000 -5000 cars pa of various types use composites.
- Bentley's high end cars are subject to the same legislation as all manufacturers to reduce weight. Lightweight 3D structures are the focus.
- The available cost-performance spectrum was explained with the scope to achieve satisfactory c-p by:
  (i) increasing the performance of glass mat thermoplastics on the one side or
  (ii) reducing the cost of CF/epoxy on the other side of the spectrum. For this reason co-mingled yarns were used (CF/GF) with thermoplastic resins, and quasi-isotropy achieved with 3D woven fabrics or 2.5D multi-layered fabrics.
- Erudite modelling of fibre architecture and fabric drapability is an important aspect of the project. Enhanced drapability is followed by thermal fixing of reinforcements incorporating embedded thermoplastic yarns in the fabrics.
- Results are in progress, but to date show:
  (i) improved impact compared UD, and as expected
  (ii) similar properties from 3D and 2.5D fibre fabrics.

  A complex tailgate component has been selected as demonstrator with necessary design change from metal. Looks good, and in test now for bending strength / modulus, slamming loads and environmental testing. Work continues.

5. ***Overview of Composite Research Activities in WMG.***
Richard Dashwood, CEO of WMG.

- Founded by Professor Lord Bhattacharyya in 1980, chairman of WMG. It is the national CATAPULT centre for High Value Manufacturing (NB: NCC is the CATAPULT centre exclusively for composites). WMG has a core team of 22 academics and engineers but has 800 people in total from universities and industry combined, and is co-located with JLR, TATA Motors, Ford, Aston Martin, Penso and others.
- High volume, low cycle time applications is the main focus, mainly for automotive. WMG is well-stocked with many advanced process technologies for materials and manufacture, with expertise in nanocomposites, 3D printing and energy innovation. Latest acquisition is a 1700 tonnes press now integrated with a resin injection process with highly instrumented mould for which work includes high volume suspension structures for City Cars.

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6. ***The Progression of Composites from Niche to Normal Automotive Applications.***
Tim Wybrow, CYTEC Industrial Materials.

- CYTEC is in different businesses but focus is on aerospace (50%) and on "serial" automotive applications.
- Materials include: toughened thermosets, infusion resins, engineered thermoplastics, carbon fibres, textile preforms, structural adhesives, and composites.
- As in the Bentley presentation, Tim explained that composites in the auto market is not a new concept eg. Lotus Elite (1958-63) and SMC used in non-structural body panels for Chrysler Corvette in the 1960's/1970's. First structural use of composites is in F1 with the McLaren MP4/1C monocoque in 1980.
- Composite chassis and other structural components grew from small use in the Alfa Romeo 4C to the current BMW i3 targeted for mass production at 25,000 to 30,000 ppa (using HP-RTM), and globally upwards to >100,000 ppa with the impact of emissions legislation.
- CYTEC develop products to meet this mass auto challenge. Example, a rapid cure prepreg (aimed at RTM) at 5min/150ºC (or 3min/150ºC), with an out life of 2 days and Tg 145ºC. Cured composite has Tg 140ºC with no post cure. Most competitors' RTM resins have Tg <120ºC or require post cure.
- Case studies were described:
  (i) automation by robot, involving DDF (Double Diaphragm Forming) with optimisation of textile preforms, dry fabrics and thermoplastics
  (ii) Chevrolet battery box – the design moved necessarily from "black metal"; hand lay-up retained because volume does not justify automation; bespoke preforms inserted in the tool; rapid RTM.
- Other automotive innovations listed: recycled fibres, bio-derived composites, repair and overhaul of composites, 3D printing (a complete car has been 3D printed in 3 days!).
- The solution to high volume affordable automotive applications is: dedicated design, and the correct combination of processes and materials.

7. ***Recent Advances in Thermoplastic RTM/Surface RTM and FiberForm Technology.***
Philipp Zimmermann, Krauss Maffei.

- Manufacturers of machinery for RTM, extrusion, presses, other bespoke machines and combination of machines.
  Different RTM processes were described:
  (i) Compression RTM ("standard")
  (ii) HP-RTM (high pressure)
  (iii) S-RTM (Surface)
  (iv) T-RTM (thermoplastic)
- Typical applications of automotive HP-RTM include: roof, bonnet, side frame, seat structures. KM has a project with BMW in which release agent is added through a special mixing head directly to the resin.
- S-RTM enables in-mould coating with "Colour Print Technology." The mould is opened a little, colour print polyurethane is added, and then moulding continues. This enables direct in-mould painting without surface preparation/ cleaning.
- T-RTM injects PA6 nylon, via the monomer caprolactam, directly into the mould using KM's injection moulding machinery. Fibre wetting is good at 100ºC. Cycle time is <55 seconds. This "FiberForm" technology is in joint project with BMW and VW, and door impact beams are being made for Audi.

8. ***Advances in High Volume Composites Manufacture.***
Michael Emonts. Aachen Centre for Integrated Lightweight Production (AZL)

- AZL, founded in 2012 - European centre for production technology, allied to RWTH Aachen University. AZL - expert consultants in production technologies, textile structures, plastics and composites. Have processes for large structures including aero and wind energy. AZL have currently 54 partners including, BASF, Gurit, Tencate, Toyota, DuPont, Siemens.
- If customers need assistance, AZL can carry out trials at the customer's location or at AZL base. The single point of contact is Michael Emonts CEO.
- Latest acquisition is an 1800 tonnes press. Current novel project involves the joining of thermoplastics to thermosets in one combined integrated process involving RTM (t/set) combined with injection moulding (t/pl) and precise directed laser technology to expose fibre ends from the resin.

Overall this seminar was a huge success with a sell-out audience enjoying detailed information on a rich variety of cutting edge technologies for high volume composite manufacture.

Thanks are due to Dhiren Modi of WMG, David Carlton and Trevor Cook of the SUKIC Committee for organising the event.

The table-top exhibitors were:

Bindatex	Imetrium
CIMCOMP	JR Technologies
Composites in Manufacturing	M Wright and Son
Creative Composites	Mettler Toledo
DolphiTech AS	NCEFF, Manchester
ESI	Net Composites
Exova	Pinette Emidecau Industries
Formax	Surface Generation
Gearing Scientific	Synthesites
IChrome	Tencate