Cost Effective Manufacture of High Volume Composite Components for the Automotive Sector

Cameron Johnson
General Manager, Sigmatex Asia
Global Carbon Composite Solutions

- Leading converter of carbon fibre
- Global footprint
- Proprietary manufacturing equipment/processes
- Highest level of quality assurance
- Wide range of conversion technology
- Optimal fibre selection
- Dedicated in-house technical textile experts
- Extensive capacity with proven capability to deliver on large scale projects
- Investment orientated
Technical Solutions

sigma\textit{ST}

sigma\textit{MX}

sigma\textit{RF}

sigma\textit{IF}

sigma\textit{2D}

sigma\textit{3D}

sigma\textit{UD}

sigma\textit{PC}
Lightweighting Excellence Programme
Lightweighting Excellence Programme

Advanced composites for medium to high volume automotive applications

- Four-year programme to address the lack of capability to manufacture composite parts within Automotive sector in medium to high volumes
- Connect companies with expertise in design, processing and manufacturing to provide an integrated supply chain and commercially viable solution for automotive OEMs
Lightweighting Drivers

- Weight reductions can be achieved using carbon fibre reinforced composites for non-structural and structural components.
- Components to be designed for the material used.
- CFRC’s are viable light-weight alternative to metals but only account for 1-2% of overall weight of mass production car.
Bentley

- Bentley has offered as a use-case, the challenge of replacing a structural Door-Inner sub-assembly, currently made of numerous metallic parts, with a simplified carbon composite assembly.

- The Door-Inner assembly anchors the door’s anti-intrusion beams and mountings for numerous components such as electric window motors, window frame guides and exterior skin connection.

- Using composite materials, the LX consortium aims to produce a lightweight concept that reduces the number of parts used, while retaining strength, stiffness and crash integrity. This weight reduction could ultimately enable increased functionality that is sometimes prohibitive due to the weight of the existing metallic structures.
Emerald Automotive

- Emerald Automotive is developing a lightweight commercial vehicle that could utilise thermoplastic exterior body panels in the future.
- They are expected to achieve a high quality Class A surface finish that is lightweight, durable and dent resistant.
- When the LX consortium has proven rate, process, quality and price, component production numbers are anticipated to be in low to medium volumes.

**Component: Door skin for Emerald Development Programme**

- Material: sigma\textit{RF}
- Weight reduction: circa 50%.

Sigmatex have the ability to re-format 100% of all its production waste to produce a non-crimp fabric. sigma\textit{RF} is suitable for many applications which currently use virgin carbon fibre thermoset or thermoplastic materials and engineered plastics or metal, particularly in the automotive, sports, leisure and energy sectors.
Nissan believes that significant lightening of the weight of a passenger vehicle by replacing an existing metallic body structure with lightweight carbon composite is a future requirement.

The key challenges are producing a floor that is significantly lighter than the existing metallic part, at a price that is comparable with the existing metallic component it replaces, while maintaining consistent high quality, structural performance and just-in-time delivery to the production line.

**Component: Vehicle Floor Structure**

- **Material:** Sigma *UD* (random mat)
- **Weight reduction:** circa 58%
Use case: Composite Floor

Objectives:
• Demonstrate that partners of the programme are technically capable of designing and manufacturing a complex composite automotive part at production rates upward of £50k per year
• Establish a viable business case for the supply chain

Requirements:
• Innovative material development
• Component design & engineering
• Process design
• Prototyping
• Economic evaluation
Material Selection

Material selection is the highest proportion of the total cost
Compared to steel assembly where investment in tooling and equipment had the highest cost contribution

- High volume tailored NCF production
- Scrap Re-use in random fabric format

- Steel assembly has higher per part cost at volumes less than 15,000 parts per year
- Comparing total cost inc. materials CFRP assembly can’t compete with steel on cost at higher volumes because of high carbon fibre cost
- Capital investment in tooling required to produce the steel assembly is four times the cost of CFRP versions
Investment in Tooling & Equipment

Composite and steel parts cannot be easily compared since the investment required and therefore the underlying business case are vastly different.
Return on Investment

• The higher the suppliers margin, the better the business case for composites

• Composite parts are lightweight and integrate multiple functions show a better business case whereas black metal designs rarely show economic viability
Design & Engineering

Steel benchmark
• >35 separate steel stampings
• >30kg

Composites design
• Reduce part count
• Half the weight

Prototype & testing
• Assemble the composite part in the existing BIW
• Capable of in-body crash
**Design Approach**

1. Interrogate the steel structure within the BIW model to extract the performance requirements for the composite floor assembly.
2. Design the composite floor to have the same or better performance as the steel assembly when integrated into the existing BIW.
3. Produce prototypes from the equivalent prototype material for assembly and testing in the existing steel BIW.
Design Approach

- Black metal problem
  - Respect the existing package constraint

- Shape optimisation for composites producability
  - Improve drape
  - Reduce & re-use scrap
  - Improve matrix flow
# Process Design Options

<table>
<thead>
<tr>
<th>Fibre cutting</th>
<th>Lay-up</th>
<th>Pre-forming</th>
<th>Binder activation</th>
<th>Trimming</th>
<th>Preform transfer</th>
<th>Press closes</th>
<th>Injection</th>
<th>Compression</th>
<th>Curing</th>
<th>Trimming</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure RTM</td>
<td>Compression RTM</td>
<td>Wet Pressing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Spraying & preforming**
Prototype Manufacture
Technology Evaluation

Steel Benchmark
Benchmark to enable like-for-like comparison of steel & composite production scenarios and to value the LX technology

Initial concepts
Concept selection presented various options resulting in a single option selected for detailed design

LX Prototype with PIM
Composite prototype must respect existing package constraints resulting in added complexity & cost for composites preforming

Hypothetical Serial Production Concept
Serial production part should be designed for composites manufacture with appropriate package constraints
Steel benchmark
A benchmark steel part assembly was used to set the engineering and economic performance targets for the composite component development.

Composite prototype
The composite prototype was designed and produced to fit into an existing vehicle (black metal approach) and to demonstrate the crash performance within the vehicle body-in-white.

Serial production concept
The serial production concept was developed to show the economic viability of full-scale production with part and package designed specifically for composite materials (no black metal).

Significant achievements:
• Reduced 35 stampings to 6
• Weight saving – 18kg prototype, 15kg serial production
• 6% under price target set
Outcomes

Composite parts force a much closer relationship between the material supplier and the OEM
- Composite part cost is driven by materials cost & process reliability
- Whereas steel part cost is driven by investment in tooling

The composite supply chain will bear much more risk than the equivalent steel supply chain
- OEM in-house production and/or risk sharing partnerships will become the norm

Many unknowns in high volume composite part production but the risks can be measured and mitigated
- Selection of the right technology and partners
- Risk & reward sharing between the OEM and suppliers

Know-how intensive technology ensures that those willing to invest will maintain a competitive advantage well into the future
THANK YOU
Cameron Jonson
General Manager, Asia