The Future of Composites Manufacturing: An Automation Case Study of an Automotive Battery Box
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Airborne Group

High-tech SME

Facilities in The Netherlands and the UK

25-year legacy in design and manufacturing of Advanced Composites: Aerospace, Marine, Renewables, Industrial and Oil & Gas

Supplying automated and digital manufacturing systems, to radically industrialise composite manufacturing

Vision: Digital, on-demand manufacturing platform
Your Industrialisation Partner

Automate

Evaluate

System Integration

Automation Systems

Digital Solutions

Automated Programming

Process Engineering

Advanced Analytics

Digital Integration

Automated Kitting

Automated Preforming

Automated Honeycomb Potting

Automated Edge Sealing

Automated Laminating

System Integration

Design and Manufacturing services
Airborne can support in product development to ensure materials and designs are optimised for automation.

Airborne can provide industrialisation system engineering and manufacture composite prototypes.

Airborne has a flexible business model including equipment-as-a-service to provide customers flexibility, less operational responsibility and less up-front investment.

Airborne can provide production capacity by running the automated production systems for the customer during ramp up.
What does automotive electrification mean for composites?
Trend: Electrification

Electric Vehicle (EV) fleet worldwide (2020): 10.5 mio

Global EV forecast, CAGR 29%, over the next 10 years

Total EV sales growth from 2.5 mio in 2020 to 31.1 mio by 2030

Source: Deloitte analysis
Growth factors

**Policy and Regulation:**
- Fuel economy and emission targets
- City access restrictions

**Consumer Sentiment:**
- Accessible infrastructure
- Improved vehicle range

**OEM strategy:**
- Availability of models
- Affordability
Battery boxes

A multitude of requirements in combination with cost & weight targets!

Composite material can meet them all in theory

Airborne design and manufacturing processes can ensure this in practice

- Crash worthiness
- EMI shielding
- Leak proof
- Temperature/fire resistance
- Rupture containment
- Volatile organic compound (VOC) emission

- High performance material
- Design to eliminate holes
- Pass burn though testing
- Addition of shielding layers
- Pass burn though testing
- High performance material

Composite Material
Example Battery Box construction

There are many solutions and configurations. Not all use composites but example shown uses SMC “lid”, metallic frame, and a glass reinforced thermoplastic lower protection cover.

Airborne Development Challenge:

- Example vehicle volume 100k units per annum
- Requires 2 min TAKT time
- How to process composites from lowest cost form at this rate?
Case Study 1: Affordable Rate-Capable Composite Structures (ARCS) Thermoset Part
Project Overview

• Project aim is to develop an automated production line for the manufacture of the lid of a battery box for an electric vehicle from NCF and Epoxy using liquid compression moulding, with 2 minute TAKT time.

• Partners include:
  • Cranfield University – Preforming concept development
  • AMRC – General support & tooling
  • GKN Automotive – Press, infusion and cure process
  • Sigmatex (project lead) – NCF machine development

• Use case provider 1: Nissan
• Use case provider 2: Jaguar LandRover

Part funded with UK public money by Innovate UK through Advanced Propulsion Centre
Conceptual Plan of Process

Operational Digital Twin Architecture
Power and Control System Architecture

- 2D ply cut and layup system: Prototype being fabricated, demonstrator system overview started
- Landing stage & tension frame: Demonstrator design started
- Preforming cell: Prototype fabricated. Demonstrator design started
- Preform cell lower tool shuttle: Prototype fabricated, demonstrator design started

Demonstrator version to be developed at Airborne
- Pick & place 3D preform movement: Initial trials in progress

Conceptual only – key processes to be demonstrated manually
- Patch detail applicator
- demould
- Resin applicator
- Linear track or gantry or forming press shuttle
System Level Design

- System level design using
  - PFMEA
  - Value stream mapping
  - System architecture design
System Level Design

- Layup table with cutter gantry
- Lay up drawers for laying up NCF tapes
- Preforming Cell
- 3D Preform movement end effector system
- Landing stage for movement of tension frames
- Tension frame in preforming position
- Tension frame in buffer position
Automated Process Development – 3D forming machine concept

- Lower tool / platen shuttle
- Preforming tool - heated
- Tension frame prototype
- Landing stage / layup area prototype
- Actuator banks
Development of 3D forming press

- First we developed a small scale prototype cell, based on a concept of a self-reacting frame.
- Trials run offline to develop a suitable process using cost effective materials e.g MDF frames
- Process development included use of tension frame to hold material during pressing
- Development of machine including pneumatics and control systems
- Material pressed between male and female form
- Material patterns developed to manage drape; shear; wrinkling; overlaps and necessary final part thickness/material orientation requirements.
ARCS Conclusion

Project still has 9 months to run until completion. Targets:

- Airborne 3D forming press at full scale to be completed
- Installation of automated process showing cutting $\rightarrow$ pick & place preforming $\rightarrow$ pressing to 3D $\rightarrow$ transport to injection/pressing process at Tier 1.
- Run at rate demonstration with 2 min TAKT
- Commercial demonstrator component to be made
- Basic digital twin of process to be developed.

With thanks to APC; Innovate UK; Sigmatex; Nissan; JLR; GKN Wheels & Structures; Cranfield University; AMRC Sheffield;
Case Study 2: Processing Thermoplastic Tapes at high rate
Example Battery Box construction

There are many solutions and configurations. Not all use composites but example shown uses SMC “lid”, metallic frame, and a glass reinforced thermoplastic lower protection cover.

- Typical construction for this component is glass/polypropylene sandwich using UD tapes for skins, and core from Direct LFT
Forming Process (for this example component)

UD Tape Supply

Multi-Tape Preforming Line

Combine with D-LFT & Press Consolidation

Trimming, finishing, inspection

Airborne Product

Airborne System Integration Capability
Building blocks

• Tape feed / shapes
  • Cutting table -> all shapes possible
  • Tape feeder  -> simpler
  • Multi-tape tape feeder -> high output
  • Laminate cutting / trimming can be integrated

• Quality control
  • Visual cameras for defects, laminate quality
  • Gap measurement
  • Thickness and geometry measurement
  • Welding quality measurement

• Offloading
  • By robot, integrated with downstream process
  • Shutter table
  • Conveyor belt
Multi-tape Automated Preforming

- Based on Airborne’s Automated Preforming technology:
  - Cut plies to length/shape
  - Pick & Weld: pick & place with spotwelding to create a tailored blank
- Multi-tape feed
- 0/90 laminates, 1500x2000mm
- Spot-welded stacks
- Offloading to downstream process
- Output: 200,000 laminates / year
- Option for 2 material type feeding
- Advantages:
  - Fast: full layer is handled per cycle
  - Flexible: can do any shape or layup or material
  - Scalable: functionalities can be added, modules can be multiplied
  - Multi-axials can be integrated
Automated Preforming system

Suitable for Thermosets or Thermoplastic materials:

- Robotic cell to manufacture tailored blanks
- Airborne ‘Pick & Weld’ technology
  - Spot welding
- Dry fibre, impregnated thermoset or thermoplastic composite
- Integrated with ply cutter or stand-alone

- No programming required – in the software
- Fast, robust and flexible
- Output: ~ 20,000 – 200,000 parts/year
Kitting + Preforming

2.2 Material Feed

2.3 Ply Handling system

2.4 Buffer station

2.5 Preforming

2.6 Software and Control System

Footprint 75 m²
(max. l 14 m, w 9 m, h 3.5 m)
Automated Preforming
by Pick & Weld

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