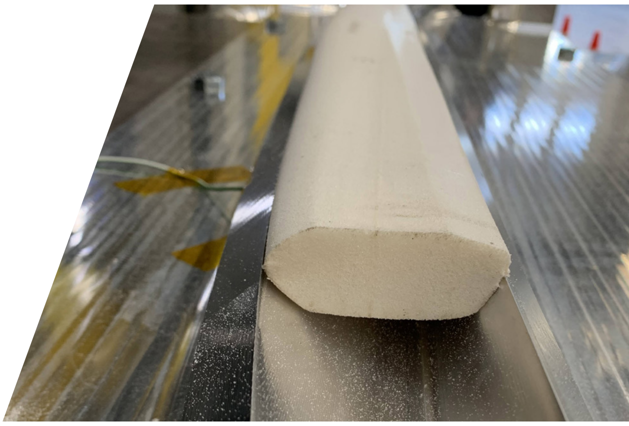
AMRC Composite Centre
Case Study

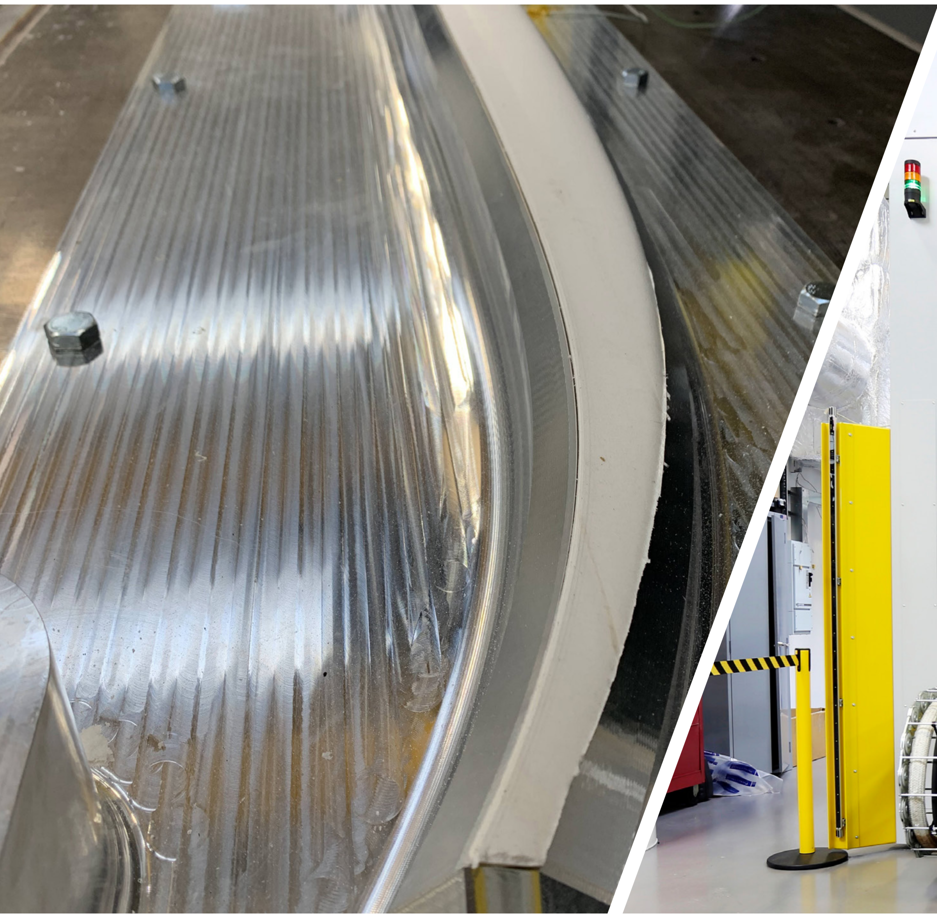
DigiProp: Propelling air travel to a sustainable destination

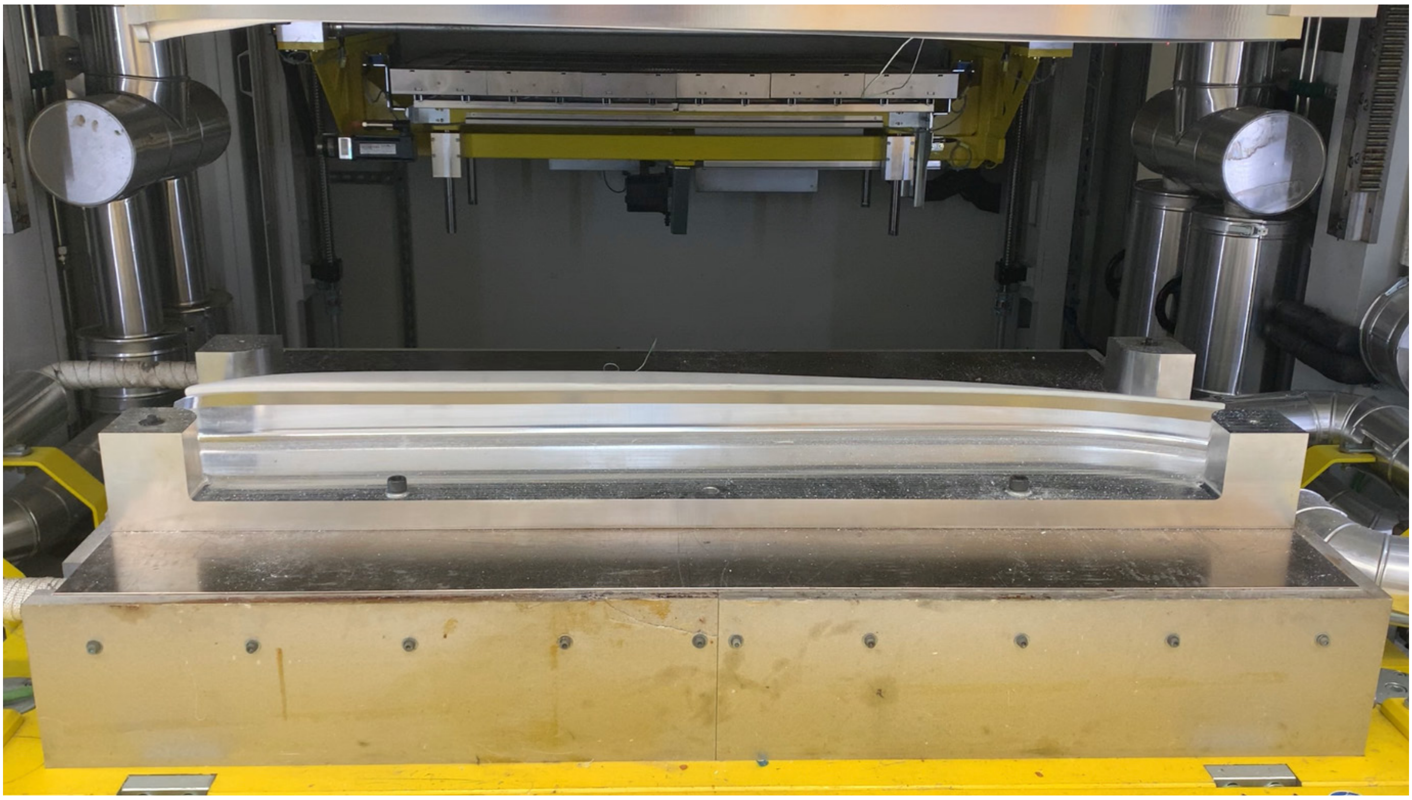
AMRC Technology Development: Foam Thermoforming

Challenge

Use a thermoforming process for foams to create shaped foam inserts for propeller blade manufacture to support Dowty Propellers' complex geometry manufacturing capabilities for its next generation composite propeller blades.







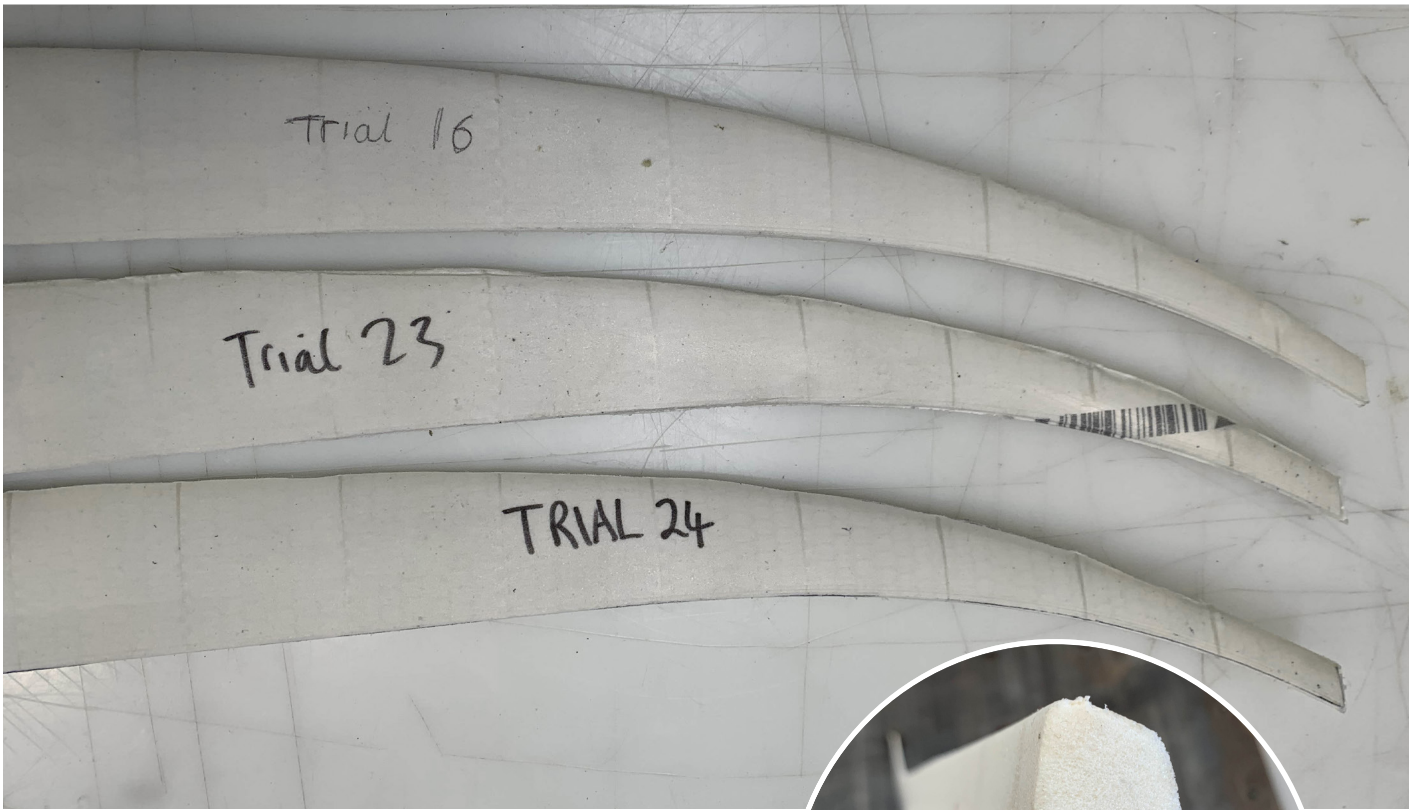
The Langzauner Heated Press was used with bespoke tooling to form the foam into shape.

Background

Demand for cleaner and cheaper air travel has never been greater with net zero and jet zero targets for 2050. To meet this demand, it is vital the UK maintains and extends its world-leading capability in sustainable aviation propulsion technologies. It is also key to achieving Europe's Flightpath 2050 vision for the European aviation community to lead the world in sustainable aviation products and services.

In 2017, a £20m four-year project was launched to develop lightweight propeller blades that will help the UK aviation sector reduce its carbon footprint and noise emissions at airports. Led by Dowty Propellers (part of GE Aviation Systems), it was supported by three High Value Manufacturing Catapult centres: the University of Sheffield AMRC, National Composites Centre and the Manufacturing Technology Centre. The project harnessed composite technologies with industrial digitalisation to cut production costs and increase performance of future propulsion systems to grow the UK's aerospace propeller manufacturing base within Europe's €200bn aviation sector.

The process was developed to form fine foam geometry without spring-back. The increase in foam density also makes the thin sections more robust.



The forming process was shown to be automatable and repeatable creating high quality, complex shaped parts from stock material.

Innovation

Dowty Propellers use foam structures in the manufacture of propeller blades. Currently the main methods to manufacture the foam parts are casting, which can result in an inconsistent foam structure and multiple defects; and machining, which can be difficult, expensive, time-consuming, and can result in fragile, thin sections.

The aim for the AMRC Composite Centre was to demonstrate the advantages of using thermoforming to create an automated and repeatable process to form complex geometry foam structures with large changes in thickness - moving thermoforming technology on from bending materials to fully shaping foam in an automated process. The benefits of this are threefold: it creates repeatable parts using an automated compression moulding process; foam is relatively cheap, keeping part costs down; and it creates the opportunity for innovative tooling.

Several key challenges were overcome as part of the AMRC's work in the DigiProp programme which could have prevented this technology from being applied as part of the manufacturing process, including expansion and securing of the foam.

Thermal expansion of the foam and the complex foam structure caused problems with the forming. As the foam cooled, the foam shrank away from the tool surface causing many defects. A two-step pressing process was developed to overcome these difficulties and part holding features were integrated into the tool design.

Initial trials were conducted at Dowty Propellers to understand the feasibility of forming the foam. Further trials were then conducted using a Resin Transfer Moulding tool and the Langzauner press at the AMRC to further check feasibility of the process. A material was selected and a tool was designed and manufactured at the AMRC to compress foam to different densification levels. This was subsequently tested at the AMRC's Advanced Structural Testing Centre to understand material properties.

The University Of Sheffield. /AMRC

Result

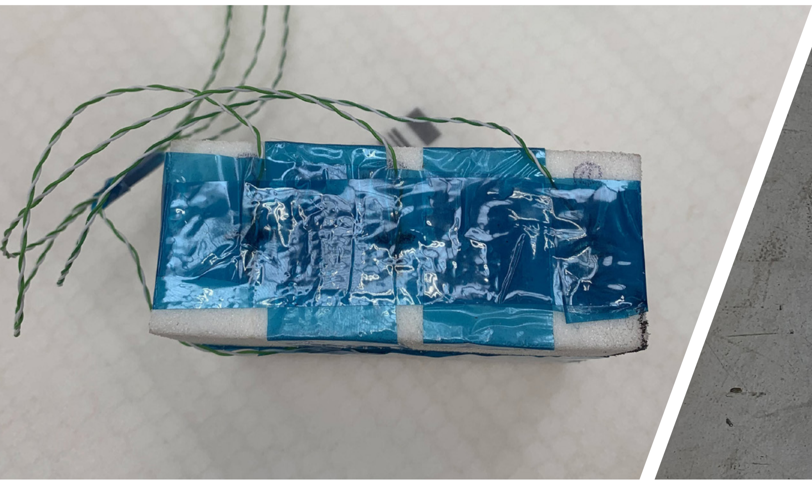
Thermoforming the foam creates repeatable parts using a compression moulding process, with low-cost, high-quality, off-the-shelf foam sheets helping to keep part costs down. The AMRC has shown the process can form complex 3D shapes with large changes in material thickness and the resulting components are of high quality and are more robust than machined foam parts due to the densification of the foam in thin areas.

The automated and repeatable foam component manufacture process developed has been proven on other foam materials to reduce costs and can:

- Use standard stock sheets;
- Be used for complex geometry propeller blade components;
- Be applied to other applications in automotive, rail and wind energy;
- Complement other manufacturing technologies at the AMRC including filament winding and braiding, offering a low-cost, repeatable method to produce complex shaped mandrels;
- Apply to any sandwich panel construction related to any of the applications mentioned above.

Impact

The process developed for the DigiProp programme has significant potential for wider applications across a range of sectors. These include: blades (shear webs and shells), nacelles, leading edges for wind energy; for decks, hull sides, superstructures, bulkheads, transoms and interiors for the marine sector; covers, tanks and containers, panelling, x-ray tables, sporting goods and furniture for industrial uses; truck body parts and floorsfor transportation; and bridge decking within the construction industry.



Heating trials and process monitoring were key to understanding the material behaviour.

The foam prior to trimming and the final pressing step.

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CATAPULT High Value Manufacturing