Carbon ThreeSixty

Aero-Cover Case Study:

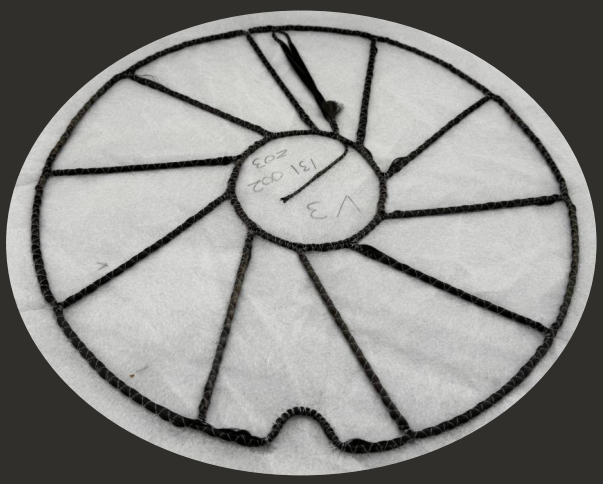
Carbon ThreeSixty is a leading innovator in composite technologies and manufacturing. Based in Chippenham, Wiltshire, UK, CTS recently relocated into a purpose designed 44,000 sq ft factory. Recent growth has lead to the staff count reaching 35 employees working across Automotive, Aerospace, Defence and Engineering sectors.

CTS is at the forefront of manufacturing, specialising in Resin Transfer Moulding (RTM), Compression Moulding, Filament winding and Tailored Fibre Placement (TFP)

Introduction:

Tailored Fibre Placement (TFP) is an innovative production method that enables Carbon ThreeSixty to optimise customer projects for both mass and stiffness through the automated placement of fibre at any desired orientation and location within a component. A perfect example of this is with our aerodynamic wheel covers.

Current aerodynamic wheel covers (Aero-Covers) are manufactured using traditional prepreg materials for their lightweight, mechanical, and aesthetic properties. Whilst prepreg fabrics are well suited for laminating large relatively flat surfaces, their use becomes increasingly time intensive and cost prohibitive as the requirements for localised reinforcement increases. Often the simplest method is to increase the total number of prepreg layers (plies) across the entire component to meet minimum stiffness and strength requirements. This can result in a component that is unnecessarily heavy and not fully optimised for its target application.



The Goal:

To increase the stiffness of the component whilst reducing mass and retaining the required strength.

Taking inspiration from nature, surfaces can be stiffened by introducing ribs and spars. Similar structures can be found in insect wings and leaves. Carbon ThreeSixty replicated this organic architecture by including precisely positioned “spokes” and “ribs” of raised unidirectional to the surface of the structure. This can only be repeatedly achieved by using processes such as TFP. The result is an optimised lightweight, stiff and strong component that requires less material than its predecessor.

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Prepreg Design:

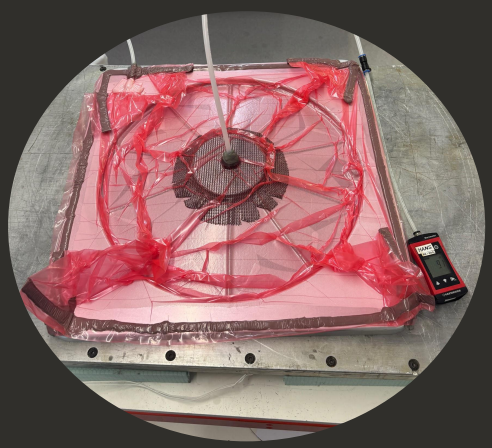
The prepreg design was 5 ply's. It featured a 90gsm spread tow surface layer and 4 200gsm 2x2 twill backing layers. Ply 3 and 4 were laid at +/-45° and all other ply's laid at 0,90°. This layup produced a relatively balanced layup that had consistent stiffness at all angles. The prepreg covers were cured under vacuum and at 120°C for 2 hours utilising a controlled and logged ramp rate.

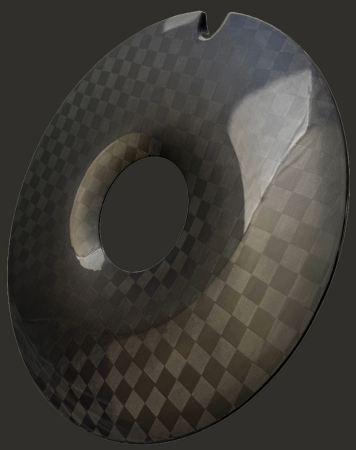
TFP Design:

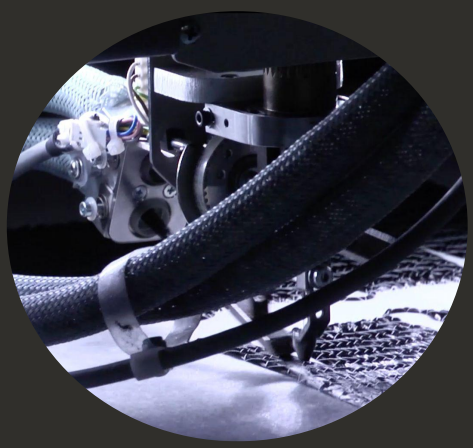
The final design of the TFP preform consisted of a 10 spoke pattern with additional supporting hoops on both the inner and outer diameter. Whilst the primary purpose of the TFP preform is to maintain the overall stiffness of the cover through the spokes, incorporating the hoops into the preform improved the edge quality of the final product by providing both localised reinforcement and improved consolidation of the laminate in the corner of the mould.

One other challenge faced with the use of textile fabrics is how their ability to drape and conform to complex geometries. In the case of the covers, the primary surface describes a negative curvature with a vertical drop from the inner diameter to the outer diameter. However, because of design freedoms allowed by the TFP process, there are multiple techniques and methods available to designers that can be applied to solve this challenge.

After several iterations, the optimal solution was found whereby the spoke arms remained straight but miss-aligned radially. This lengthens the spoke arms and gives the visual appearance that the inner hoop has been rotated by approximately 20 degrees. This apparent "twist" is exploited during the layup process by splitting supporting veil and untwisting the preform in the mould. The spoke arms drape across the surface of the Aero-Cover tooling and the extra length by untwisting eliminates any bridging of the spokes. Turning 2D design concepts into TFP preforms is achieved through a variety of in-house software tools.







Resin infusion was selected to manufacture the prototype covers. This manufacturing technique allowed for a low cost high quality part to be produced with a short lead time. Covers were manufactured with different quantities of plies along with the TFP structure so that their performance could be compared against the baseline prepreg cover.

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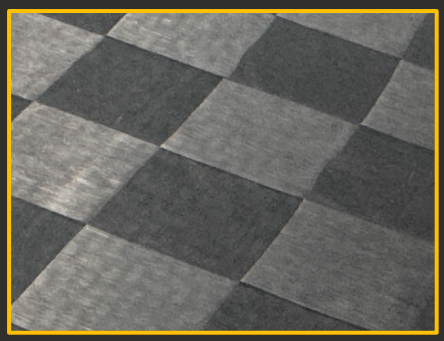
Different infusion strategies and consumables were tried to determine the optimum surface quality. Flow mesh with an integrated release fabric was used to encourage sufficient flow of resin and decrease infusion time. Carbon ThreeSixty has extensive experience in resin infusion and resin transfer moulding

A single peel ply layer was therefore used as a form of flow mesh. The peel ply firstly draped more effectively over the complex geometry of the cover but also produced a consistent surface finish on the back surface. This roughed surface could also then be used to bond the mount points to.



Conclusions:

The use of TFP optimised design has allowed for this particular product to have increased specific strength over traditional composite laminate design while still maintaining smooth surface finish.

The product produced is both lighter and stiffer than the original design while also having less steps in the layup process. This saves time over traditional prepreg layup techniques and therefore helps to reduce the cost of each aero cover. The reduction in cost is also further amplified by using dry fibres which are lower cost than prepreg.

This trial has demonstrated the viability of using TFP as a reinforcement structure to increase stiffness while not negatively affecting the mass.

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