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Prototype of an epoxy wind blade reinforced by FLOWER flax preforms

University of Cambridge

European Regional Development Fund

Partners

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Content

- Objectives:

Rotor blades are constructed with non-recyclable composites – 2.5 Mtonnes annually – that are landfilled at scale at their 15-25 year end-of-life. Europe alone will decommission 25ktonnes of blades a year by 2025, pushing the European wind energy agency, WindEurope, to call for a ban on landfilling of decommissioned wind blades by 2025 (WindEurope, 2020). Wind energy firms are also aiming for carbon neutrality by 2030, and zero-waste wind turbines by 2040. Plant fibre composites may have some role to play in sustainability of the wind-energy sector – at the very least, they offer incineration for energy recovery, and sequester 1.5kg of CO2eq in every kg of plant fibre used.

This study aims to replace short glass/polyamide (30% fibre content) in 1m-long blades with a flax biocomposite, produced with a new non-crimp biaxial reinforcement developed as part of the FLOWER project by industry partners. Flax fibres have low density, impressive specific properties, and can be produced into a plethora of composite reinforcement forms like no other natural fibre (Bourmaud et al., 2018; Pil et al., 2016). The blades are for a 1kW horizontal axis upwind micro wind turbine system (Figure 1, left).

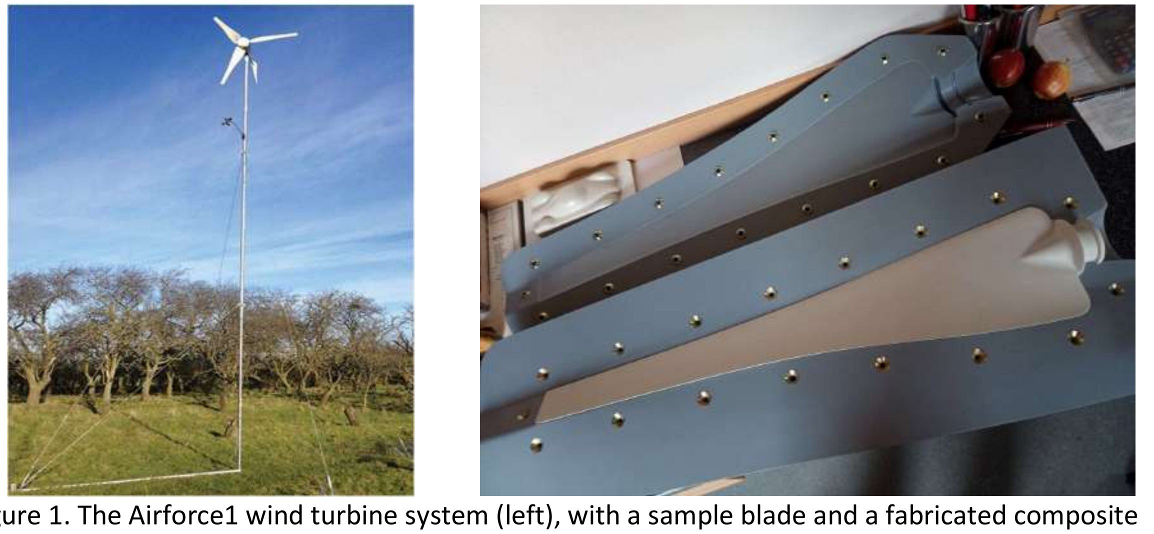

Figure 1. The Airforce1 wind turbine system (left), with a sample blade and a fabricated composite mould tool for the blade (right).

- Materials:

Flax NCFs are provided by Teillage Vandecandelaère; this was a BX TV 312 biaxial stitched non-crimped fabric, with a 312 gsm areal density.

Infugreen 810 epoxy resin with standard hardener SD 8824 (Sicomin Epoxy Systems, France) was used. Blade fabrication took place within 30 minutes of resin mixing, and was carried out by hand lay-up under ambient conditions (ca 15 °C), at which resin visocosity is estimated to be around 400 mPa.s.

A GC50 epoxy-compatible polyester clear gelcoat, with MEKP catalyst was used (Easycomposites, UK).

- Methods and Results:

A fibreglass-vinylester composite mould tool was first fabricated for the turbine blade using the conventional blade as a pattern (Figure 1, right). The tool allows fabrication with thermoset systems with exotherms up to 120°C. It is a two-part tool allowing the blade to be made into two separate parts, which were then bonded together with the same resin used for impregnating the reinforcement.

Preliminary mould experiments were carried out on a similar mould tool surface to test how the flax-epoxy materials work together, any damage they might cause to the mould (due to exothermic reaction during resin cross-linking) and to test ease of de-moulding. These trials were successful and led to very well-impregnated motorcycle mud-guard parts with a glossy surface (Figure 2).

Figure 2. A preliminary successful trial hand lay-up trial on the mould tool surface.

For blade fabrication, the BX TV 312 fabric was laid up at ±45° in relation to the blade length/axis (Figure 3). The root junction detail of the blade required chopping up some fibres into short fibres and mixing with the resin to fill the mould. One each half of the mould tool, one layer of the BX TV 312 fabric was laid up, with 2 additional layers placed along the central spine of the blade near the root and extending ca 100mm along the blade length (Figure 3).

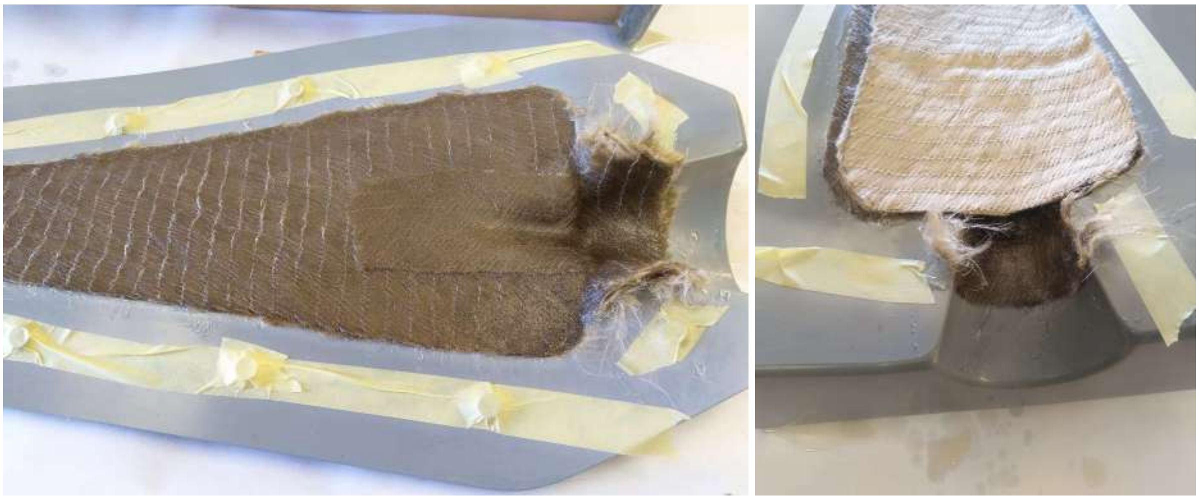

Figure 3. Images of blade fabrication

The two halves of the blades, once fully impregnated and saturated were left to cure under ambient conditions for 24 hours (Figure 4).

Figure 4. Images of blade fabrication

Once the two halves had fully-cured, the surface was sanded to ensure the two halves fit near-perfectly. Thereafter, with the same epoxy resin as a bonding agent, the two halves for consolidated together. The resulting blade edges were trimmed as necessary to produce the final prototype flax-epoxy composite blade (Figure 5), which is ca significantly lighter than the solid, injection moulded short glass/nylon conventional blade.

Figure 5. The flax-epoxy composite prototype blade, sitting in relation to the conventional glass/nylon blade.

Conclusion

A prototype 1m-long blade with a flax-epoxy biocomposite has been fabricated, deploying a new non-crimp biaxial reinforcement developed as part of the FLOWER project by industry partners. A full set of 3 blades are now being produced.

➢ <u>Acknowledgements:</u>

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