From Recycled Glass Fibres to Unidirectional Composites: Influence of Staple Fibre Yarn Architecture on Laminate Properties

Miriam Preinfalck*[1], Sophie Dushaj[1], Julian Kupski[1], Stephan Baz†[1], and Götz Gresser[1]

[1]German Institutes of Textile and Fiber Research Denkendorf – Germany

Abstract

The growing volume of wind turbine blade waste requires recycling routes that preserve the value of glass fibres and enable their reuse in structural applications. A key challenge is to design recycled glass staple fibre yarns that are robust enough for textile processing while maintaining a fibre architecture suitable for high laminate performance.
In a recent study, recovered non-crimp fabric production waste was mechanically opened and carded, then processed into > 98 % glass staple fibre wrapped yarns. Five variants were developed to investigate the influence of foreign fibre content in the yarn core, wrapping density, single- versus cross-wrapped yarn architecture and a false-twist-assisted wrapped yarn configuration. The yarns were characterised by fibre length distribution, linear density and tensile testing and their processability was evaluated during weaving. The resulting unidirectional woven fabrics were infused with epoxy resin via vacuum infusion, reflecting a process widely used in wind turbine blade production. The laminates were assessed by tensile testing, fibre volume fraction and cross-sectional microscopy and compared with a reference laminate reinforced with continuous virgin glass fibre rovings.

The results confirm a fundamental trade-off between yarn strength, textile processability and composite performance. Removing foreign fibres from the yarn core increased specific yarn strength by 40 % and laminate tensile strength by 9 %. A cross-wrapped architecture improved specific yarn strength by 174 % and enabled stable weaving, while laminate tensile strength changed only marginally. In contrast, the coupled false-twist/wrapping configuration achieved the highest yarn strength (+298 %) and break-free weaving, but reduced laminate tensile strength by 36 %. Increasing the wrapping density provided no mechanical or processing benefit.
The best overall compromise was achieved by preserving fibre alignment and maximising the load-bearing glass fibre content through a glass fibre core with minimal foreign fibre contamination, while limiting yarn stabilisation to the level required for textile processing. The study demonstrates the route from blade waste to yarn, textile reinforcement and load-bearing composite and provides design guidelines for high-value blade-to-blade recycling. Detailed material parameters as well as an outlook to other reinforcement fibres will be presented on the poster.

*Corresponding author: miriam.preinfalck@ditf.de
†Speaker

Keywords: wind turbine blades, glass fibre recycling, staple fibre yarn, yarn architecture, hollow spindle wrap spinning, fibre reinforced composites, GFRP