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A new generation of sustainable bidirectional fabrics

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Blackfabric developed a bidirectional fabric made of 100%-recycled carbon fibres from pyrolysis recycling processes combined with thermoplastic fibres in a commingled yarn, resulting in a thermoplastic prepreg ready to be directly thermoformed.

Due to the impressive growth of carbon fibre consumption in recent years, the leftovers and waste dumped in landfills significantly increased as most of the composite materials consumed are not recycled.

Environmental legislation is increasingly restrictive to regulate this waste, and therefore recycling has become a fundamental and very important issue in all sectors, in terms of limiting the use of finite resources and managing waste disposal. As a result of all these needs, the Blackfabric project emerged to provide more sustainable, recyclable and high value-added solutions in the world of fibre-reinforced materials.

Achieving a next level of mechanical properties using recycled CF

Blackfabric was born from the connection between two Spanish companies from the textile sector, both with more than 20 years of experience in the technical fabrics sector. Marina Textil is a well-known company in the field of technical fabrics for personal protective equipment, with a production capability of 3.5M metres of fabric and a sales force in more than 50 countries around the world. Texfire is a textile engineering company that develops customized textile solutions for high-temperature applications. Taking advantage of their knowledge in the design and production of technical fabrics, Marina Textil and Texfire joined forces to launch a new line of advanced fabrics for the world of composites, betting on change for a more sustainable world.

Blackfabric offers a wide selection of fabrics. Its manufacturing plant can weave all types of reinforcing fibres and yarns, producing final fabrics up to two metres wide. An in-house bonding plant allows them to apply polymers on the surface of fabrics to produce fibre-reinforced thermoplastic prepregs. The company focuses mainly on thermoplastic polymers due to their sustainable advantages, improved manufacturing processes, time savings and all the added value provided by thermoplastic matrices (Figure 1).

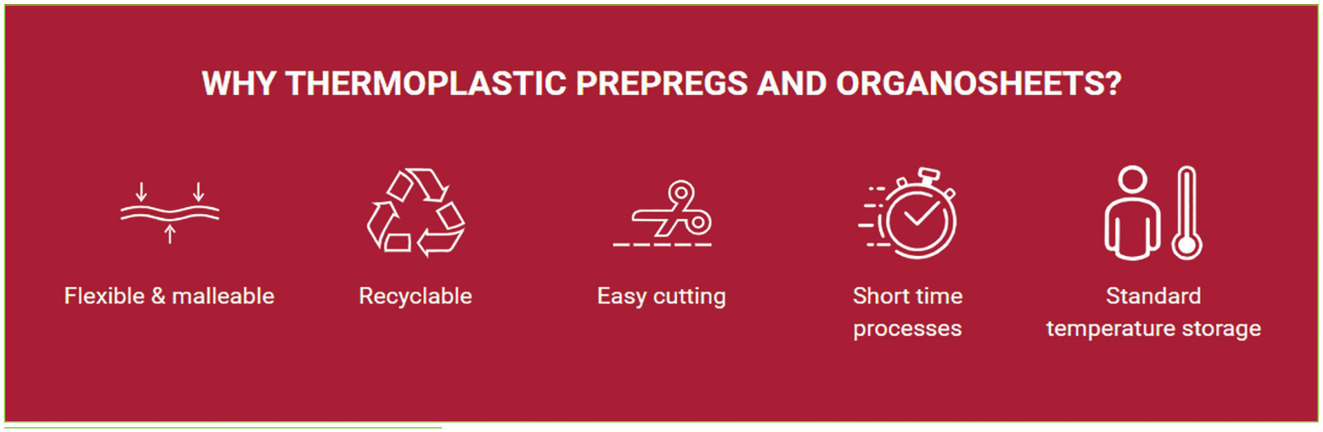

Fig. 1: Advantages of thermoplastic materials

Fig. 2: 2 Bidirectional tape weaving with natural fibres

Blackfabric's production plant is also equipped with a special loom designed to weave flat wide tapes up to 20 mm wide. This enabled them to design a new collection of bidirectional fabrics produced with tapes impregnated with thermoplastic polymers, also considered to be thermoplastic prepregs ready to be directly thermoformed.

Focusing their efforts on natural fibres, they developed a bidirectional spread tow fabric that has the yellow-beige colour characteristic of linen fibres as well as the technical appearance that wide tapes provide to the final product (Figure 2).

This fabric is revolutionizing many sectors, and surely will be used in many applications in the next generations.

Taking a step forward in sustainable solutions

Capitalizing on the knowledge in weaving technologies and subsequent processes, Blackfabric has been able to take a step forward in sustainable solutions, developing the first high-drapability fabric made with 100%-recycled carbon fibres.

Tab.1: Comparison of mechanical properties

Fabric	Virgin CF/thermoplastic (general average)	Blackfabric bidirectional fabric Recycled CF/PA6	Non-oriented recycled CF/epoxy resin
Fibre volume fraction (%)	41%	39%	25%
Tensile strength (MPa)	700	345	100
Tensile modulus (GPa)	50	31	12
Flexural strength (MPa)	470	310	-
Flexural modulus (GPa)	48	27	-

In this process, discontinuous carbon fibres from pyrolysis recycling processes are oriented together with thermoplastic fibres in a commingled yarn. The composition and properties of the ideal hybrid thread were defined to achieve a yarn suitable for weaving that incorporates the right percentage of matrix, resulting in a thermoplastic prepreg ready to be directly consolidated without any additional process.

However, the company had to develop the whole weaving process, adapting the machinery and looms, designing a special area protected from the fibrils and dust released by recycled fibres, and adapting the entire production process to the yarn properties.

The resulting bidirectional fabric (Figure 3) looks similar to a conventional "wool fabric", is very flexible and mouldable and adapts well to any geometry. It is easy to cut, manipulate and mould. The fabric can be formed easily with conventional thermoforming or stamping processes, avoiding additional impregnation processes (infusion or injection), reducing processing times and notably reducing production costs.

In addition, the fabric retains all the advantages of thermoplastic matrices: easy to store and transport at room temperature, no expiration date, reducing leftovers, with short processing times and the ability to melt every time the polymer's melting temperature is exceeded, so that parts can be repaired and recycled at the end of their useful life.
Visually, the taffeta weave forms patterns with perpendicular threads oriented in the 0 and 90° directions so that the alignment of the fibres is visible, something unheard of with the recycled carbon fibre composites known today, where the fibres are randomly distributed without any orientation or order.

This thermoplastic prepreg made with recycled fibres can be used in many

Fig. 3: Blackfabric's bidirectional fabric, made of 100% recycled fibres and a thermoplastic polymer

sectors and all applications that do not require high mechanical properties, such as decorative elements, aesthetic parts, body interiors, home accessories, as well as more functional applications in the world of sports goods and automotive parts where you can opt for a more sustainable solution, upcycling and giving new life to recycled carbon fibres.

Upcycling to create value

This material is ideal for aesthetic parts, to reflect a company's ecological values, to involve the customer and to make him feel part of a more responsible and sustainable production. The rustic but technical aspect of the fabric reflects the values of sustainability but at the same time can provide the high-quality finish needed to gain the trust of the market and turn it around, starting to bet on recycled fibre materials.

Blackfabric has managed to provide an innovative solution to the recycled fibres sector, improving mechanical properties, facilitating handling and use and significantly improving aesthetics. The main objective of this development is to motivate all manufacturers of aesthetic parts to opt for this new fabric combining recycled raw materials with thermoplastic matrices, which will allow products to be recycled at the end of their useful life.

Finding a new commercial use for recycled carbon fibres, Blackfabric contributes to a common good. Upcycling current waste into new products, revaluing it and re-introducing it in the value chain, fostering the circular economy and enhancing recycling significantly improve the company's ecological footprint. Giving more added value to recycled carbon fibres through mechanical and aesthetical improvements and making the material usable in multiple applications can clearly reduce the consumption of raw materials such as virgin carbon, and therefore contribute to all the savings involved.

Fig. 4: Aesthetic part made of recycled carbon fibre

A real virtuous circle

It is difficult to quantify the environmental impact at this early stage of the project, but it is clear that the use of recycled fibres significantly reduces it. Studies show that the production of recycled fibres can reduce the global warming potential by up to 75% and requires 60% less energy than the production of virgin carbon fibre, considerably reducing the carbon footprint of the final product.

In addition, the introduction of recycled carbon fibres into the value chain exponentially reduces the use of virgin raw materials and the waste generated. All this entails major energy and CO_2 savings, while adding value to waste, turning it into a raw material for new products that will enter the value chain, thus closing the loop.

Blackfabric strongly focuses on the development of recycled carbon fibre fabrics, and is committed to these sustainable solutions for the common good.

They believe that these are the fabrics of the future and that this type of technological research advances will motivate a gradual change to improved methodologies, reduced consumption and design with product circularity in mind, thus facilitating recyclability.

The future is upon us, this is why it is essential to start using these types of solutions, and try to start curbing the frenetic environmental impact of the recent years. □

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