CASE STUDY

From hemp to composite material

FUSE™-Tape, a product in the "Natural Fibers In USE" (FUSE) brand of SachsenLeinen GmbH, is a sustainable alternative for conventional Unidirectional (UD)-Tapes as it is based on natural fibres. The idea of this innovation was born in the expert panel Sachsen-Leinen e.V. With the goal to substitute conventional fibres used in composite materials, SachsenLeinen GmbH developed a technique that creates fibre-tapes made out of hemp. This resource has the potential to reduce CO2-emissions and the accumulation of non-recyclable fibre waste. Hemp has a lower density than comparable materials while providing ideal technical performance. SachsenLeinen GmbH is located in Markkleeberg in the south of Leipzig and works together with regional farmers (field in Mausitz, Zwenkau), to keep a shorter value chain and thus to shorten transportation. Additionally, this cooperation with regional farmers facilitated the cultivation of a type of hemp that is suitable for their process and reactivated the hemp fields and its uses in Saxony, Germany. The whole supply chain is transparent to ensure quality and sustainability.

Figure 1. Hemp-based UD tape product from FUSE Composites (Source: https://en.fuse-composite.com/).

KEY WORDS

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COUNTRY

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AUTHORS

Raphael Tremmel,
Laura García

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The FUSE™ UD tape can be used for technically demanding composite products and passes the needed endurance tests for extension and flexure. This analysis was performed with a composite of 50 % FUSE™ UD tape and 50 % thermoset resin. The tested properties can be provided with product weights of 100 to 250 g/m2 which offers various possibilities for composite elements. A comparison with other natural fibre tapes shows that with its available length of up to 500 m per roll and direct surface formation it is more efficient in application than other products, based on natural fibres, on the market. The current available width is up to 20 cm, with a future prospect of up to 50 cm. The production process allows the use of various natural fibres besides hemp, for instance flax, sheep wool or pineapple, and also combinations of different fibres. The product has a technology readiness level (TRL) of 6 still in the development phase, although FUSE™ already offers an efficient alternative for mineral based fibre and has proved its performance as reinforcement material in ski and snowboards.

The production costs are very low and consist of sourcing and storage, running costs, marketing and low personnel expenses because of economical campaign production. Revenue comes from direct marketing of the UD tape, development services for specific client requirements and licensing. So far, the natural fibre supply chain consists of only few suppliers, but prospective the sourcing needs to be diversified. For the FUSE™ production, it is very important to ensure homogenous and reliable feedstock quality. Current plans pursue a regional supply chain from crop to refinement in the south of Leipzig. The future prospect is to obtain resources mainly from central Germany to support the regional development of the bioeconomy. A parallel increase in production will enable the company to accept larger orders, for example from the automobile industry. Other potential applications are in interior designs, packaging, and sporting equipment. Design based on natural fibre are functional and resource efficient while being durable and recyclable.

Packaging made with FUSE™ is lightweight, durable and safe during handling. A composition of sporting equipment with natural origin addresses the connection to nature and creates a more appealing product. Another possible application is the use of natural UD tape in wind turbines where huge amounts of fibre are needed. While conventional glass fibre cannot be properly recycled, rotor blades made with hemp as the fibre composite can be put in thermal recycling. Clipping accumulating in the production of the rotor blades can even be composted.

Figure 2. Potential uses of FUSE™ UD Tape product (Source: https://en.fuse-composite.com/).

In the development of the FUSE™ UD tape several challenges arose. As the existing supply chain of natural fibres was concentrating on the textile industry, it was necessary to establish direct distributions from farmers to the production plant. To compete with conventional fibres, the hemp tape needed to be at least as homogeneous and resilient as their precursor. This could be achieved with close cooperation with applied research, namely the Fraunhofer Pilot Plant Center for Polymer Synthesis and Processing (PAZ) in Schkopau, Saxony-Anhalt, leading to an innovative production process. The process consists of first arranging the fibres in a unidirectional manner, starting on the harvest. The harvest machinery, which is not available in many EU countries, and rounds several European areas in the harvesting season (Late July – Late August) to carry out the harvest, is already designed to cut the long stems of the hemp plant in two to three sections and place them in the field in a unidirectional manner.

This is important to also facilitate the retting process, which builds up the fibre development in the plant, and consists in leaving the cut hemp stems in the field to receive rain, sun and, more importantly, to be enhanced by the soil microorganisms. This allows the cellular tissues and pectins surrounding bast-fibre bundles to rot, facilitating the separation of the fibre from the stem. During this process, another machine is utilised to turn the sub-partitioned sections of the plant along their longitudinal axes every now and then. After the stems are retted and dried, they are taken to the plant, where a mechanical process takes place to assure finalize the separation of the fibre from the stems and assure a similar thickness among fibres. This is then followed by the weaving of the fibres with polymers for the construction of the composite UD tapes.

By concentrating on the production of a UD tape for fibre composites instead of more complex textiles, several steps could be eliminated to make the process more efficient and the product more homogeneous. Due to small output and well-established synthetic competition, the production needed scaling through campaign production and, cooperative marketing and development.

Photo 3: Harvesting process (Source: Laura García).

Motivation for development

A wide range of products depends on reinforcement with synthetic fibres. As we face a changing climate because of the use of fossil resources and an alerting accumulation of non-recyclable waste, there is a need to substitute unsustainable materials like glass and carbon fibre. Many sectors are already trying to achieve that goal and most of the times the obvious solution is to use natural feedstock as alternative. The challenge of natural material is to achieve the necessary properties needed to compete with conventional products. For companies to accept the more sustainable alternative, it needs to be reliable and homogeneous for industrial production. In the case of FUSE, they created an efficient substitute that meets the technical requirements. Additionally, because there is no need for energy demanding artificial fabrication of synthetic fibres and transportation from oversea production is replaced with local cultivation and efficient refinement, it is less energy consuming. Broad implementation of FUSE UD tape could lead to drastic decrease of CO_2-emissions by the production of composite materials. To use natural materials in composites even removes carbon from the carbon-cycle.

Value added remains in a regional supply chain, while establishing a strong cooperation with the agriculture cooperative, given that the plant is very weather resistance, with low care needs that reduces the cost of production. When licensing the technological process from FUSE, it is easy to use and to manage for the other potential users, allowing a production of simplified steps towards a highly applicable and diversifiable product of tested quality.

Economic-, energy- and environmental perspectives

As FUSE™ UD tape is made from regional, natural resources it has lower production costs, but also lower environmental costs than conventional UD tapes. The innovative production process reduced the number of production steps. Thus, the shorter supply and production chain leads to more efficiency and the current campaign production reduces labour costs. The regional production and feedstock supply reduce the environmental impact of transportation, and it supports the local economy, so there is a social benefit as well.

The environment benefits from the decrease in mineral fibre, too. The negative effects of glass fibre or carbon fibre, that cannot be properly recycled, on humans and the natural system are decreased. While the production of natural fibres is mostly based on the cultivation process and the energy need of further processing is relatively small, synthetic fibres origin from fossil resources and are about ten times more energy demanding. Hence, production of natural fibre composites produces less carbon emissions. Additionally, because of the natural origin, the fibre is biodegradable. A composite made of this fibre has similar properties, depends on the used binding material. As natural fibres are less dense compared to synthetic fibres, composites can be more lightweight, which is advantageous for the automotive sector and for transportation.

The setup of a regional supply structure with cultivation, refinement and production strengthens the local economy, attracts new producers and promotes the development of new innovative approaches. FUSE™ acts as provider of the fibre but also as partner in the innovation process of possible natural fibre-based products that have individual requirements.

Knowledge transfer potential to other regions

As it is increasingly important to find alternatives for fossil resources, the implementation of natural feedstock in industrial systems is crucial. Because there is a high demand for composite materials based on fibre, the pioneer technology of FUSE™ has the potential to reduce the use of non-renewable resources in several sectors. If the structural demands for the composite use are met, the fibre-base can always be from a natural origin.

One possible limitation of natural grown materials is the prioritized use of arable land for food production. Agricultural used land is decreasing constantly due to unsustainable management. A potential risk of scaling up the use of hemp for material production at industrial scale is to potentially put food systems under pressure. A possible solution is the secondary use of crops. For example, the straw of hemp or flax, grown mostly for linseed oil, can be used as source for natural fibres, as these plants are already grown in huge amounts and the residue is accumulating as a waste product.

Other aspects to consider for practitioners are the "try and error" nature of this practice and technological process. Although, the technological process can be calibrated and specifications can be made, this is not the same with the hemp plantation, when applied in other regions where it has not been widely produced, such as is the case in Sachsen in the last decades. Trying different hemp varieties and testing their productivity in the given environment is to be expected.

Summary

This case study presented the innovative process designed by the start-up FUSE™ Composites from Leipzig, for the utilization of hemp to produce composite unidirectional (UD)-Tapes for their utilization in diverse other sectors, such as the sports, automotive, housing, among others. In the case study, the process, technologies utilized, cooperation models between the farmers and processing company, as well as the advantages and disadvantages of this innovation have been detailed. In summary, the production of a hemp-based UD tape allows to substitute conventional fibres made of glass and therefore contributes to a more sustainable product that has demand in diverse end-product sectors, such as the sport, furniture, housing, among others.

ABOUT BRANCHES

BRANCHES is a H2020 "Coordination Support Action" project, that brings together 12 partners from 5 different countries. The overall objective of **BRANCHES** is to foster knowledge transfer and innovation in rural areas (agriculture and forestry), enhancing the viability and competitiveness of biomass supply chains and promoting innovative technologies, rural bioeconomy solutions and sustainable agricultural and forest management.

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