FIBRE BASED NONWOVENS IN LIGHT WEIGHT CONSTRUCTION – A TRANSFERABLE CONCEPT FOR THE RECYCLING OF CARBON WASTE MATERIAL

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Abstract
Carbon fibre waste is a comparatively young and undeveloped kind of waste which will extensively grow over the next decades. In the future the application of CFRP structures will increase in the construction of vehicles, in particular in the section of e-mobility, based on the extreme lightweight construction potential in comparison to traditionally used materials like steel and aluminium. With the application of CFRP in different industrial branches the amount of the attacking fibre material waste will strongly increase in future as well. This fibre waste occurs on one hand as cutting scrap in the production process as well as on the other hand from recycled composite parts after pyrolysis or solvolysis (e.g. end-of-life-waste). Therefore, it is a necessity to bring these energy-intensely produced carbon fibres back to the cycle of material use.
Since 2005 the Saxon Textile Research Institute (STFI) works in the fields of recycling of carbon fibre waste and production of semi-finished textile products by use of recycled carbon fibres.

1. Introduction

Carbon fibre waste is a comparatively young and undeveloped kind of waste which will extensively grow over the next decades. In the future the application of carbon fibre reinforced plastics (CFRP) will increase in the construction of vehicles, in particular in the section of e-mobility, based on the extreme lightweight construction potential in comparison to traditionally used materials like steel and aluminium.

Analysts consider the CFRP market to be a solid market with great growth potential. Annual growth is estimated at a minimum of 12 %; in 2020 the global demand is expected to be at 100.000 t [1].

With the application of CFRP in different industrial branches the amount of the available fibre material waste will strongly increase in future as well. This fibre waste occurs on one hand as cutting scrap - so called “production waste” as well as “reclaimed fibres”. Therefore, it is a necessity to bring these energy-intensely produced carbon fibres back to the cycle of material use.

Having recycled carbon fibres of sufficient length available requires a completely new approach - it is a challenge and a chance for the nonwoven industry to join the CFRP boom. Carbon fibre based nonwovens, fibre bands and yarns can thus be used in areas of application, in which previously the prohibitive cost made their use difficult or impossible.

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2. First steps with primary fibres

Aim of the project work was the investigation of the processability of long carbon fibres. That's why a special carding device, a modified cross lapper and a stitch-bonding machine, type Maliwatt, were used. In a first step, it was tested whether long staple primary carbon fibres can generally be formed into a mat by the mechanical means of carding. Due to smaller amounts available recycled fibres at the beginning of the project in 2005, the used fibre material was produced by cutting raw material in form of rovings with a chopper. The material was characterized by a high carbon content and had a length of 50 mm and 100 mm. For the first time, it was possible to create a fibre web of primary carbon fibres using a carding process. Based on the results from these tests, the emerging real research goal was processing appropriately recycled carbon fibres.

3. Waste as a favoured raw material

Based on the gained experience, the existing line was successfully used to reproduce the results of the first stage with carbon fibres, which were resulting from recycled composite parts after pyrolysis (e.g. end-of-life-waste). Carbon fibres with a defined length between 30 and 100 mm represent the raw material of "reclaimed fibres".

The main focus of detailed project works in the last years was the development of a process which allows recycling of dry carbon waste in an industrial scale. STFI has succeeded with a modified tearing process to solve this task by defined material control and energy conditions. The advantages compared to the known milling process are less damage of the fibres and therefore possible maximum fibre length and also the cost-efficiency. Woven and web structures made from carbon filaments can be pre-cut and then processed in a preferably one-step recycling process. The fact, that the fibres are less damaged is reflected in mid-range fibre lengths of about 60 mm, which is still approx. 85 % of the pre-cut fibre length (fig.1).

Figure 1. Recycled carbon fibres after modified tearing process

4. Technology lab for further research

The tested recycling technology and the carefully adapted web laying technology have become the foundation of all processing tests in the STFI carbon nonwoven technology lab. For these tests, STFI has a full processing line for carded nonwovens with a working width of 1 m (fig. 2).

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Figure 2. STFI carbon nonwoven technology lab

This line is designed to process pure carbon fibres and/or blends with other fibres. The line also features inline needle-punching and stitch-bonding machinery (fig 3.).

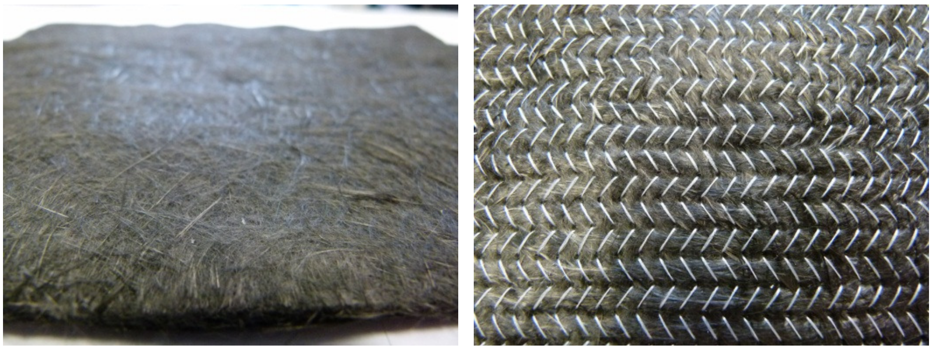

Figure 3. Nonwoven structures (left: needle-punched, right: stitch-bonded)

In 2016 the technology lab will be extended with an aerodynamic web laying in 1 m working width and a stand-alone line for production of fibre bands and yarns using recycled carbon fibres.

5. Outlook

The project work has shown that the web formation from 100 % primary carbon fibres and from 100 % recycled carbon fibres is possible via mechanical carding - a technology that will open up new potential for the industry. With their high formability and sufficient strength, these carbon fibre nonwovens are very suitable as semi-finished products for CFRP-structures. A carbon fibre nonwoven embedded in an epoxy resin matrix via High Pressure Resin Transfer Moulding, for example, at 24 % fibre volume generates tensile moduli of 16 GPa (machine direction) and 31 GPa (cross direction) as well as a tensile strength of 200 MPa (machine direction) and 500 MPa (cross direction).
Hybrid nonwovens with a carbon content of 40 % can reach tensile strengths up to 600 MPa and tensile moduli from about 40 GPa.
In future the main focus will be to optimize the production processes for nonwovens made from recycled carbon fibres and to get into the market with defined products made from nonwoven or a

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combination with other textile structures. Scope of work will be the increase of fibre volume contents in the processed CFRPs made of rCF nonwovens, higher tensile moduli and higher tensile strength.

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References

[1] T. Kraus, M. Kühnel: „Composites-Marktbericht 2015 - Marktentwicklungen, Trends, Ausblicke und Herausforderungen“, Publication of Industrievereinigung Verstärkte Kunststoffe and Carbon Composites e.V., September 2015,

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