NOVEL PERSPECTIVES IN USE OF RECYCLED CARBON FIBRES – HEATING, SHIELDING AND MAINTENANCE

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ABSTRACT

The demand for carbon fibres is driven by the trends of electro mobility, energy efficiency (lightweight construction) and high-performance materials. The global demand for carbon fibres in 2017 was about 74,000 t/a. By 2022, the demand will increase by around 11 % annually to 120,000 t/a. Around 35 % of carbon fibres are processed in Europe. During carbon fibre processing (i.e. for reinforced plastics) around 40 % of carbon fibres are wasted. The unused potential by fibre wasting in component manufacturing in 2022 in Europe is hence approx. 336 million €/a (at a virgin c-fibre price of 20 €/kg).
A common approach to recycle carbon fibres to a new product is to produce staple fibre nonwovens. The strength of such nonwoven structures are descent but still worse than those of virgin carbon fibre surfaces such as wovens. In this paper, an overview about different approaches in given in which the electrical conductivity of the carbon fibres is used to create electrical functionalised materials in terms of heating, maintainence and electromagnetic shielding.

Key Words: RECYCLED CARBON FIBRE, ELECTRICAL FUNCTIONISATION, HEATING, EMI-SHIELDING, MAINTENANCE

1. INTRODUCTION

A common approach to recycle carbon fibres (rCF) to a new product is to produce staple fibre nonwovens by the carding-, airlay- or wetlay-process. Those nonwovens have decent mechanical properties in terms of modulus and strength but the properties are still worse than the capabilities of virgin fibre textile fabrics such as woven fabrics. An approach at the ITA which has already been investigated at ITA and is still under investigation within the scope of multiple projects is to combine the decent mechanical properties with electrical functionalisation capabilities. For this purpose, the electrical conductivity of the fibres is used.

In a finalised project (PolyTube), three approaches of functionalisation have been investigated by using recycled carbon fibre (rCF) nonwovens in glass fibre reinforced plastic (GFRP) tubes. Those are heating, leakage detection and electrostatic (EX) protection. The final results are discussed in chapter 2. A further approach for the electrical functionalisation, shielding of electromagnetic waves, will be introduced in chapter 3.

2. HEATING, LEAKAGE DETECTION AND EX-PROTECTION

In a finalised project (PolyTube), three approaches of functionalisation have been investigated by using carbon fibre nonwovens in glass fibre reinforced plastic (GFRP) tubes. Those are heating, leakage detection and electrostatic (EX) protection. As approach, the rCF nonwovens were added to the common GFRP tube as an additional layer in between of the layers of glass. For EX protection, the rCF nonwovens were added to the inner side of the tube. To ensure a safe electrical contact, different principles of contacting have been investigated.

Figure 1 shows a rCFRP sample plate with 210 mm x 250 mm effective size, operated at different voltages. It is shown, that a maximal heat dissipation of around 1500 W/m² is possible. However, values around 820 W/m² are more advantageous as the resin in the rCFRP starts to degrade at high temperatures. The needed heating capability for industrial tubes is around 200 W/m².

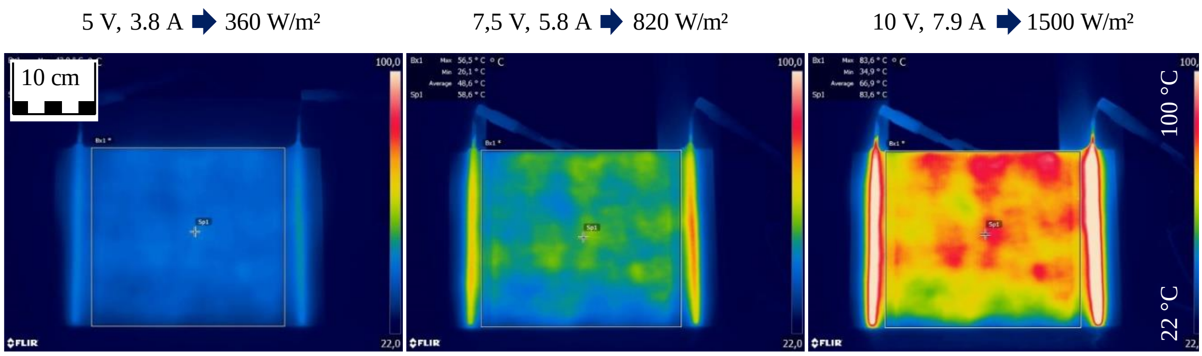

Figure 1. Sample plates of reinforced plastics from recycled carbon fibres as heating unit

In the second approach, an additional fluid-absorbent layer has been added to the rCFRP-structure of the tube, as shown in figure 2. In case cracks within the tubes wall, the transported fluid is leaking into the absorbent layer. By use of the electrical conductivity, the two rCFRP layers can be used to generate a capacitor whose capacity changes by change of the dielectricity of the intermediate layer.

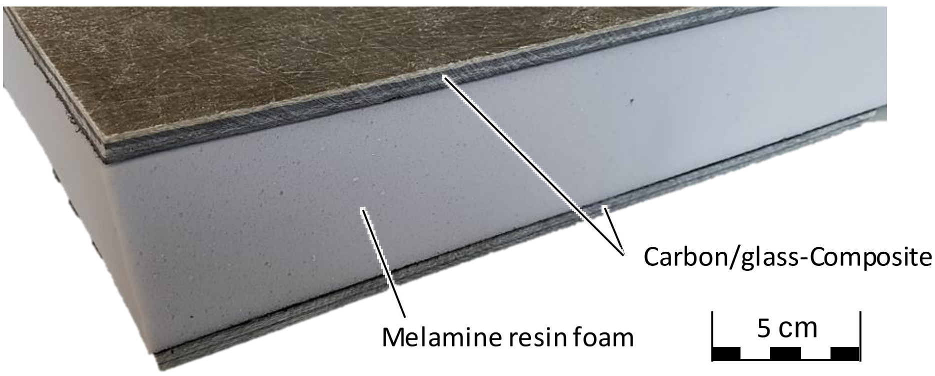

Figure 2. Maintenance observation by measurement of electrical capacity

By use of the capacitor-concept, leaking fluids can be detected. Depending on accessability of the tube (e. g. ground tubes), the capacitor has to be split in differen sub-capacitors to detect the exact position of the leakage. If the fluid is an electrical conducting, a further localisation of the leakage position can be done via the measurement of the electrical resistance.

For EX-protection, a minimum electrical surface resistance of 10^{-6} ohms are needed. The surface resistance of the produced tubes are around 10^{-2}. Accordingly the rCF-nonwovens are capable to provide proper EX-protection

2. ELECTROMAGNETIC (EMI) SHIELDING

A new approach to use the electrical conductivity is to provide an electromagnetic shielding. This approach is being investigated from the beginning of 2019 in the IGF project "EMSHIELD". The aim is to substitute common electromagnetic shielding materials by recycled fibre nonwovens, as shown in figure 3.

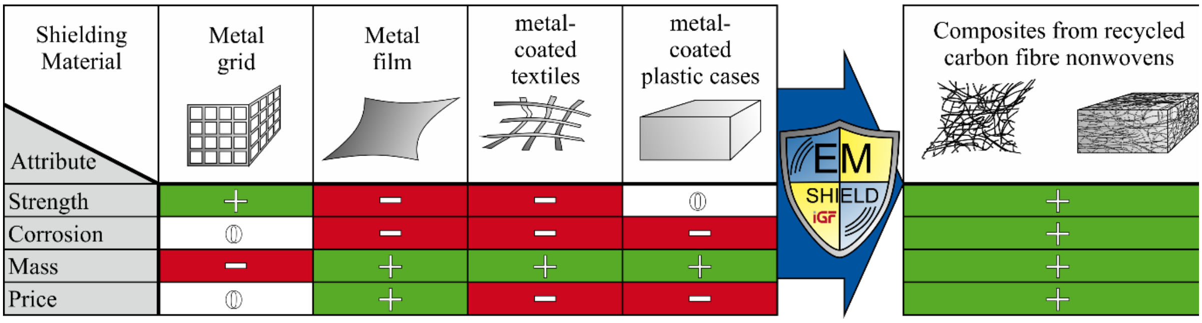

Figure 3. Substitution of common electromagnetic shielding materials by recycled carbon fibres

To maximise shielding, reflection and absorption as required, different single- and multi-layer sandwich-structures will be examined. By the use of layers with different electromagnetic behavior, the electromagnetic reflection and shielding can be optimised by intermediate reflection and absorption, as shown in figure 4.

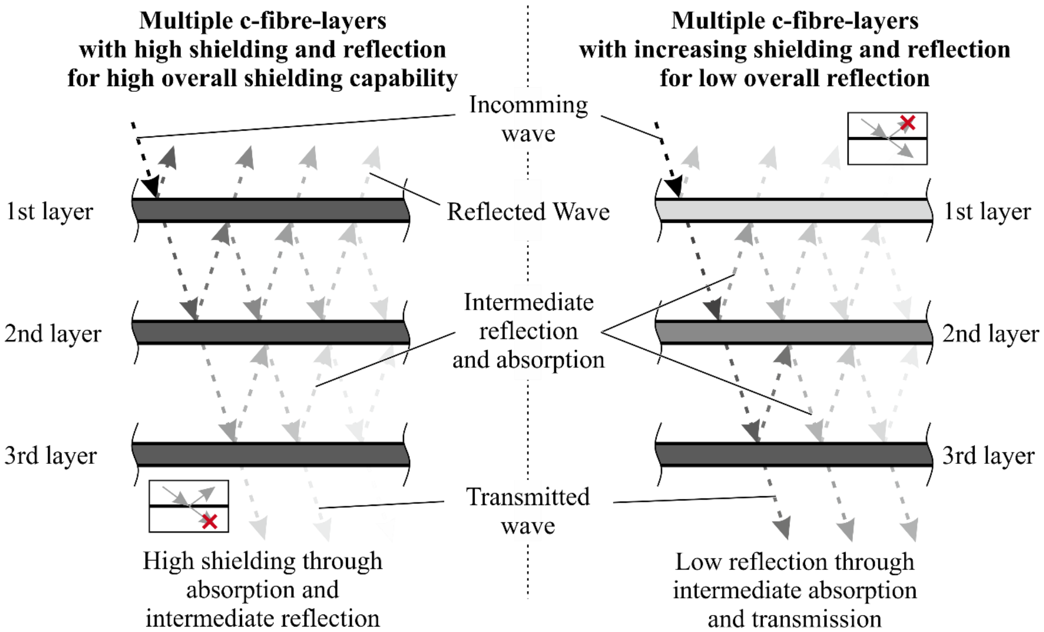

Figure 4. Optimisation of electromagnetic shielding, reflection and absorption by use of sandwich structures

Within the project EMSHIELD, a physical model and a design catalogue will be developed until the end of 2020. The project is carried out by Institut für Textiltechnik der RWTH Aachen, Aachen, Institut für Hochfrequenztechnik des KIT, Karlsruhe and Institut für Textiltechnik Augsburg gGmbH, Augsburg.

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