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COMPARATIVE STUDY OF THE MECHANICAL PERFORMANCE OF VIRGIN AND RECYCLED CARBON FIBER REINFORCED THERMOSET MATRIX COMPOSITES

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ABSTRACT

The application of carbon fiber reinforced polymer (CFRP) materials have increased over the past few decades. These materials provide excellent mechanical performance and offer outstanding lightweight potential for state-of-the-art engineering concepts. Due to the global mitigation efforts on greenhouse gas (GHG) emission, there is an increasing demand for CFRP in several engineering sectors. Around 160 kilo tonnes [1,2] of CFRP was used by the aerospace, energy (wind turbines-WT), automotive, construction and sporting-goods industry in 2020. The success of the mitigation efforts is only achievable if the management of CFRP waste is considered.

However, the production of raw carbon fibers is energy- [3] and cost- intensive, while at the same time, waste rates of common manufacturing technologies are quite high and repair possibilities for damaged parts are still limited. Besides the environmental and economic factors, the high technical value of carbon fiber (CF) is driving the development of novel strategies for recycling. Implementation of a circular economy could eliminate waste, and reuse of resources could close the material chain. Regarding carbon fiber-containing waste materials Abdkader et al. [4] distinguished the following categories: dry textile scraps, impregnated prepreg scarps and cured, impregnated, and consolidated CFRP component. Latter applies to rejects from production and end-of-life (EoL) products.

The recycling of CFRP products generally include subsequent technological procedures. At first carbon fibers have to recovered from the polymer matrices. Thereafter the recovered fibers need to be formed into semi-finished products that could be processed further with conventional composite manufacturing technologies. The application of different thermoset and thermoplastic types of matrices make fiber recovery from EoL composite products a challenging task. Various kinds of fiber recovery processes exist, such as mechanical, thermal, chemical or hybrid recycling processes. High degree of control and optimized processing parameters are needed in order to preserve the properties of the CFs. Nowadays these methods are implemented on a laboratory or small production scale. Pyrolysis process is a widespread thermal fiber recovery process, it could be done batch-wise or continuously [5], which makes it suitable for larger scale recycling. Pimenta et. al. [6] provides a comprehensive review on fiber recovery processes performed by different companies. The recovered fibers could be repurposed in powderized, chopped fiber, nonwoven fabric or oriented yarn form. These could be applied as fillers, compounds, and reinforcement fabrics in recycled CFRP products, respectively. Apart from the different matrix materials the surface treatment of the CFs needs to be taken into consideration during the recycling process [7].

In our studies we aimed to compare the mechanical performance of recycled carbon fiber reinforced polymer composites (rCFRP) to virgin carbon fiber composites (vCFRP). Mechanical properties and microstructure have been investigated. For characterization of materials three-point bending, interlaminar shear and Charpy impact tests were carried out and scanning electron microscope (SEM)

images have been taken of the fracture surfaces. The virgin and the recycled carbon fibers were provided by two independent international carbon reinforcement manufacturers. The dependency of the mechanical properties from the fiber content was also investigated. Our results demonstrate that recycled CFRP specimens have comparable mechanical properties to original CFRP materials. These results enhance the potential usage of recycled carbon fibers in future structures.

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