MODELLING OF RECYCLED CARBON FIBRE-REINFORCED 3D-PRINTED THERMOPLASTIC COMPOSITES

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Due to the global mitigation efforts on greenhouse gas (GHG) emissions, there is an increasing demand for carbon fibre-reinforced polymers (CFRP) in several engineering sectors. They provide excellent mechanical performance, multifunctionality and offer outstanding lightweight potential for state-of-the-art engineering concepts. Approximately 160 kilotons [1, 2] of CFRP was used by the aerospace, energy (wind), automotive, construction and sporting goods industries 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 fibres is energy- [3] and cost-intensive. At the same time, the waste rates of standard 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 fibre (CF) drives the development of novel strategies for recycling. Implementing a circular economy could eliminate waste, and the reuse of resources could close the material supply chain. Regarding CFRP waste materials, Abdkader et al. [4] distinguished the following categories: dry textile scraps, impregnated prepreg scarps and cured, impregnated, and consolidated CFRP components. Latter applies to rejects from production and end-of-life (EoL) products.

The recycling of CFRP products generally includes subsequent technological procedures. At first, carbon fibres must be separated from the embedding polymer matrix materials. Thereafter the recovered fibres need to be repurposed into semi-finished products that could be processed further with conventional composite manufacturing technologies. Applying different thermoset and thermoplastic matrices makes fibre recovery from EoL composite products challenging. Reclamation processes are currently attracting most of the scientific interest in the composite recycling field [1-6]. Existing fibre recovery technologies are classified into mechanical, thermal, chemical or hybrid recycling processes. A high degree of control and optimised processing parameters are essential to preserve the properties of the CFs. Pyrolysis is a widespread thermal fibre recovery process and is potentially suitable for larger-scale recycling [7].

Regardless of the reclamation technique, the length of recycled carbon fibres (rCF) is usually reduced as brittle fibres lose their continuity during processing. Moreover, the architecture and organisation of the fibre are lost. It is possible to repurpose discontinuous fibres as fillers, compounds, or reinforcements in recycled CFRP products. Additionally, at the interface: the sizing material is usually removed, the fibre topology is altered by char formation or residue, and the fibre-matrix adhesion properties are compromised [8]. To promote the usage of recycled CFs, it is vital to develop computationally efficient and industrially applicable material models to predict their behavior.

The following work proposes a framework for modelling the mechanical response of rCF-reinforced

3D-printed thermoplastic composites on the macroscale. The mechanical parameters are identified by uniaxial tensile, compression and in-plane shear experimental curves. The effect of fibre content, fibre length, fibre orientation, porosity and fracture morphologies were analysed.

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