Experimental and multi-scale numerical investigation of the mechanical responses for recycled chopped strand woven reinforced thermoplastic composites

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Abstract

The use of fiber-reinforced thermoplastic composites has increased drastically in the automotive and aerospace industries due to their lightweight, high specific mechanical properties, and better recyclability as compared to conventional thermosetting resins. However, the development of recycled thermoplastic composites has been limited by the lack of understanding of their long-term behavior. It is difficult to estimate their lifespan because of their heterogeneous mesostructure, but also because their durability is inextricably linked to the parameters used during the fiber recovery stage and the subsequent processing parameters used during composite manufacturing. In this context, the present research aims at investigating the microstructure – property relationship for recycled thermoplastic composites. The latter is processed by compression of chopped woven glass fiber reinforced thermoplastic composites (GF/PA66). An innovative numerical approach is proposed to link the local microstructure of the composite to the mechanical behavior of the recycled material. It exploits the experimental results of the material microstructure obtained through optical microscopy and X-ray micro-computed tomography (mCT). The mixed experimental-numerical strategy is applied to mimic the tensile behavior, based on a micromechanical approach coupling mean and full field analysis. The region of interest is reconstructed from detailed 3D images using a modified random sequential adsorption (MRSA) algorithm, while other regions are modeled as homogenized macro-scale continua. Furthermore, the abilities of the proposed modelling strategy are demonstrated in viscoplastic regime, which is induced by the polymer matrix. Finally, a comparison between the recycled and non-recycled composite materials has been performed. The originality of the present research resides in the capability of the multi-scale FE analysis to capture the induced process-microstructural effects of the recycled thermoplastic composites.

Keywords: *Recycled composite materials, Multiscale viscoplastic modeling, Microstructure characterization, Mechanical testing, Laminate.*

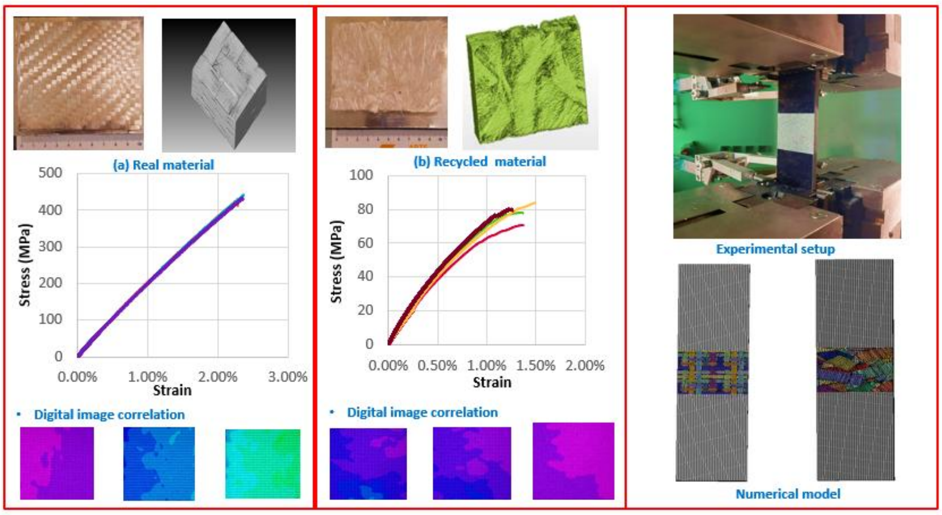

Fig.1: Numerical and experimental framework for multi-scale characterization of tensile simulation of recycled thermoplastic composite material.