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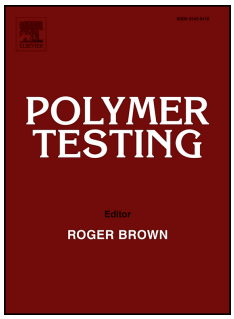

Exploration of specimens' geometry and tab configuration for tensile testing exploiting the potential of 3D printing freeform shape continuous carbon fibre-reinforced nylon matrix composites

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Test Method

Title: Exploration of specimens' geometry and tab configuration for tensile testing exploiting the potential of 3D printing freeform shape continuous carbon fibre-reinforced Nylon matrix composites.

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Abstract:

Now that the design freedom of printing of continuous fibre-reinforced polymers has become available, the recommendations on the specimens' geometry and tab configuration to experimentally determine the elastic properties of conventionally manufactured composites are reviewed. To explore this design freedom, tensile tests for five types of specimen geometry and tabs were investigated. Continuous carbon fibre-reinforced Nylon specimens were printed using a Mark Two commercial 3D printer. Dumbbell shape specimens according to ASTM D638-14 with proposed radius dimension, 76 mm, and with enlarged radius, 244 mm to reduce stress concentrations at the fillet and avoid crack initiation were tested. Rectangular specimens according to ASTM D3039/3039M-14 outperform other specimen geometries. The effectiveness of printed end tabs was investigated. Even although 3D printing offers facilities for printing end tabs, there is no convincing evidence that the performance of specimen gripping is better and the printing is more time consuming and expensive. Rectangular specimens with paper end tabs work best and that is why they were used in the further characterization. The effect of alternating Nylon layers was also investigated and shows drastic reduction in stiffness. In a next step, the tensile properties of a set of eight rectangular specimens with 0° unidirectional layup were characterized and compared with conventionally manufactured composites. The tensile properties for different fibre orientations were also determined. The effect of fibre location and microstructure was studied bringing important insights to the promising 3D printing but also revealing challenges to overcome (e.g. inhomogeneity in fibre distribution) to be able to fully explore the design freedom.

Keywords: 3D Printed Polymer-Matrix Composites, Tensile properties, Design of test specimens, Experimental investigation

1. Introduction – state-of-the-art

In today's technological evolution, 3D printing or Additive Manufacturing (AM) is considered to be one of the main contributors to what some claim will be the next industrial revolution [1]. According to ASTM F42 and ISO TC261, AM is the process of joining materials to make solid 3D objects in a layer by layer manner, starting from a 3D digital design (CAD). The AM community has at its disposal a broad panoply of 3D printing methods and materials with their own applications and individual challenges [2]. AM processes are categorised according to the type of material used, the deposition technique or the way the material is fused or solidified [3], [4]. The focus in the work leading to this publication is on the mechanical performance of 3D printed continuous carbon fibre-reinforced Nylon polymer parts. The extrusion and layer by layer deposition of a filament or so-called fused deposition modelling