Effect of Continuous Carbon Fiber Reinforcement on the Tensile Properties of Onyx Components Printed by Fused Deposition Modelling (FDM) Technology

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Abstract: Onyx is a type of Nylon that is infused with micro carbon fibers, providing it with superior strength properties compared to pure Nylon. The unique micro-carbon reinforcement of Onyx makes it stronger, and when continuous fiber reinforcement is added, it becomes both lightweight and durable. By using a Continuous Fiber Composite 3D Printer with Fused Deposition Modelling (FDM) technology, it is possible to create Onyx components with continuous strand fibers, resulting in an impressive level of strength. This combination of materials has the potential to be a suitable replacement for metal tooling in various industries such as aerospace, automotive, and wind energy. However, there is still incomplete understanding of how these composites behave under specific loading conditions. Therefore, this research utilizes FDM technology to produce components with varying proportions of continuous Carbon Fiber (CF) added to Onyx. The study employed FDM technology to manufacture samples made of Onyx, which is Nylon infused with 20% chopped carbon fiber. The Mark Two™ Continuous Fiber Composite 3D Printer was utilized to create tensile samples that followed the ASTM D638 standard. The samples were printed using concentric fill layers of fiber around the perimeter of the walls and solid infill to reinforce them against deformation. This fiber fill approach significantly enhances the strength of the walls, making them well-suited for automotive applications where deformation is a concern. The number of concentric fiber layers was modified to vary the quantity of fiber reinforcement, ranging from 16 to 24 layers in increments of 2. Three samples were printed for each set of layers, resulting in a total of fifteen samples with fiber reinforcement. Additionally, one set of three samples was printed using pure Onyx without any reinforcement for comparison purposes. The mechanical properties of each sample were experimentally tested using a universal tensile testing machine, and the fracture interfaces resulting from tensile testing were analysed using a scanning electron microscope (SEM) S-3000N Hitachi to explain the material's failure modes and reasons. The results showed that increasing the content of continuous fiber enhanced the tensile strength and modulus of elasticity of Onyx while reducing the percentage of elongation. SEM analysis revealed several defects in the printed samples, including openings, voids, and air gaps. Despite these defects, the use of Onyx reinforced with continuous fiber has significant potential in various applications such as aerospace, automotive, and wind energy. The findings of this study provide valuable insights into the behaviour of Onyx reinforced with continuous carbon fiber and can inform future research in the field of composite materials.