



Article

Additively Manufactured Carbon Fibre PETG Composites: Effect of Print Parameters on Mechanical Properties

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Abstract: This study investigates the quasi-static and viscoelastic properties of additively manufactured (AM) PETG reinforced with short carbon fibres. Samples were manufactured using different parameters in terms of the infill pattern, porosity, and annealing condition. Tensile and compressive tests were conducted to determine quasi-static properties such as Young's modulus and toughness, and dynamic mechanical analysis was used under a frequency sweep of 1-100 Hz to describe the viscoelastic behaviour of the composites. The major impacts and responses between the print parameters were quantified using Analyses of Variance (ANOVAs), which revealed the major contributor to each mechanical property. Fractography on the tensile samples using scanning electron microscopy demonstrated fibre pull-out, indicating poor fibre-matrix bonding, but also revealed interfacial bonding between raster lines in the annealed samples. This had a prominent effect on the properties of latitudinal samples where the force applied was perpendicular to the raster lines. Generally, porosity appeared to have the greatest contribution to the variance in the mechanical properties, with the exception of the tensile modulus, where the infill pattern had a more substantial effect. Annealing caused a consistent increase in the tensile modulus of the tested samples, which can be used to support the design and optimisation of AM parts when they are used under specific leading conditions.

Keywords: additive manufacturing; viscoelastic characterisation; carbon fibres; quasi-static; tensile; compressive; composite material; dynamic mechanical analysis

1. Introduction

Additive manufacturing (AM) is a key process for the rapid prototyping and development of products in modern industry. It is a product development method that diverges from traditional means of manufacturing such as injection moulding and CNC milling, as it consists of the addition rather than the removal of material from a manufactured part, which reduces the amount of waste and the overall cost, as well as the time required to make customised products [1]. Fused deposition modelling (FDM) continues to be the most popular method for producing AM structures due to its relatively low hardware costs compared to those of other AM processes (e.g., stereolithography, selective laser sintering). as well as the cost and variety of feedstock, which are higher in various other thermoplastic polymers. The most commonly found thermoplastics for AM are polylactic acid (PLA), acrylonitrile butadiene styrene (ABS), and polyamide (PA/Nylon). The feedstock is extruded through a heated nozzle, and the molten polymer is deposited onto a heated bed, where the extruded material binds layer by layer to the previously deposited material via solidification. AM polymer structures typically have a lower strength and stiffness than their bulk polymer counterparts, as they have microstructural defects such as voids and porosity [2-4]. Additionally, poor parameter selection and hardware setup can lead to defects such as delamination of the printed layers [5,6].

Rapid prototyping remains limited in its applications due to restrictions in build size and material variety, as well as production time [7]; however, developments in material



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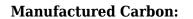
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Manufactured Carbon

Lingsheng Yao



Embracing the Song of Term: An Mental Symphony within Manufactured Carbon

In some sort of consumed by screens and the ceaseless chatter of immediate connection, the melodic beauty and psychological symphony produced by the published word often fade in to the background, eclipsed by the persistent sound and disruptions that permeate our lives. Nevertheless, situated within the pages of **Manufactured Carbon** a charming fictional treasure brimming with fresh emotions, lies an immersive symphony waiting to be embraced. Constructed by a wonderful composer of language, that captivating masterpiece conducts viewers on a mental trip, well unraveling the concealed songs and profound impact resonating within each cautiously crafted phrase. Within the depths of the poignant analysis, we will explore the book is key harmonies, analyze their enthralling publishing style, and submit ourselves to the profound resonance that echoes in the depths of readers souls.

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Table of Contents Manufactured Carbon

- 1. Understanding the eBook Manufactured Carbon
 - The Rise of Digital Reading Manufactured Carbon
 - Advantages of eBooks Over Traditional Books
- 2. Identifying Manufactured Carbon
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
- 3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Manufactured Carbon
 - User-Friendly Interface
- 4. Exploring eBook Recommendations from Manufactured Carbon

- Personalized Recommendations
- Manufactured Carbon User Reviews and Ratings
- Manufactured Carbon and Bestseller Lists
- 5. Accessing Manufactured Carbon Free and Paid eBooks
 - Manufactured Carbon Public Domain eBooks
 - Manufactured Carbon eBook Subscription Services
 - Manufactured Carbon Budget-Friendly Options
- 6. Navigating Manufactured Carbon eBook Formats
 - o ePub, PDF, MOBI, and More
 - Manufactured Carbon Compatibility with Devices
 - Manufactured Carbon Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Manufactured Carbon
 - Highlighting and Note-Taking Manufactured Carbon
 - Interactive Elements Manufactured Carbon
- 8. Staying Engaged with Manufactured Carbon
 - o Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Manufactured Carbon
- 9. Balancing eBooks and Physical Books Manufactured Carbon
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Manufactured Carbon
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Manufactured Carbon
 - Setting Reading Goals Manufactured Carbon
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Manufactured Carbon

- Fact-Checking eBook Content of Manufactured Carbon
- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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