Printing the Future of Flight: Additive Manufacturing of Carbon Fiber/Carbon Nanotube Hybrid Reinforced Polyetheretherketone (PEEK) Composites Using Selective Laser Sintering

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Reducing carbon emissions in modern engineering has a critical tradeoff: materials must be lightweight to improve energy efficiency, yet strong enough to maintain structural integrity. Polyetheretherketone (PEEK) balances this tradeoff, but current processing methods are wasteful and inefficient. 3D printing, specifically Selective Laser Sintering (SLS), offers low material waste and high geometrical design freedom, yet its adoption is limited by weak mechanical performance caused by internal porosity and anisotropy. This study aimed to develop high-strength, lightweight SLS printed hybrid PEEK composite reinforced with carbon fiber (CF) and carbon nanotubes (CNT). A novel liquid-assisted ball milling process was developed to achieve uniform dispersion and reduce agglomeration. The effects of reinforcement ratio and printing parameters on mechanical performance and internal structure were evaluated. Under optimal composition, consisting of 10 wt% CF and 0.5 wt% CNT, the material achieved the highest performance, with an ultimate tensile strength of 107 MPa and flexural strength of 131 MPa, alongside over 80% improvement in modulus compared to unreinforced counterparts, indicating hybrid multiscale reinforcement enhanced mechanical strength. Microstructural analysis through Scanning Electron Microscopy (SEM) and X-ray Computed micro-Tomography (μCT) further revealed low internal porosity and stronger interlayer fusion in this group. Overall, the hybrid PEEK composite achieved superior performance compared to conventional SLS materials. By combining materials science, nanotechnology, and 3D printing, this study pushes 3D-printed materials beyond current limits and lays the foundation for applications across the medical, defense, and next-generation aerospace industries.

Awards Won:

Third Award of $1,200