OPTIMIZATION OF PRINTING PARAMETERS THROUGH SHORT BEAM SHEAR TESTING USING RESPONSE SURFACE METHODOLOGY FOR ENHANCING STRUCTURAL INTEGRITY IN 3D-PRINTED PEEK

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Optimizing 3D printing parameters for polyether-ether-ketone (PEEK) is essential to produce mechanically robust prototypes. This study utilized fused deposition modeling to fabricate PEEK specimens and employed short beam shear (SBS) test to assess interlaminar shear strength (F_{SBS}). The SBS test provides a more precise evaluation of interlayer bonding compared to traditional three-point bending tests, which primarily focus on flexural strength and are less sensitive to interlaminar failures. Interlaminar shear failure is a critical state indicating poor interlayer adhesion, leading to compromise the structural integrity and mechanical performance in 3D-printed PEEK specimens. A face-centered central composite design with a significance level of p=0.05 was implemented using response surface methodology (RSM) to systematically measure the effects of printing temperature (370, 380, 390 °C), printing speed (20, 30, 40 mm/s), and layer height (0.10, 0.15, 0.20 mm) on F_{SBS}, and the interaction between these parameters. Specimens were printed following ASTM D2344 M-13 standards on a Prusa® MK3s+ 3D printer, modified to achieve extrusion temperatures above 350 °C. Analysis of Variance (ANOVA) revealed that both printing temperature (p=0.001) and layer height (p<0.001) significantly affected F_{SBS}, underscoring their critical roles in optimizing interlayer adhesion. Flexure stress-strain analysis indicated that specimens printed at 370 °C exhibited a stepwise behavior in the stress-strain curve, characteristic of interlaminar shear failure, suggesting that this temperature is insufficient for robust layers bonding. Additionally, specimens printed with a 0.20 mm layer height were prone to interlaminar shear failure, particularly at higher print speeds and temperatures below 390 °C, resulting in F_{SBS} values below 9 MPa. RSM optimization identified the ideal printing conditions as a temperature of 390 °C, a printing speed of 20 mm/s, and a layer height of 0.10 mm, which produced F_{SBS} values exceeding 12 MPa. The stress-strain curves under these conditions displayed abrupt tension failure, indicating excellent interlayer cohesion. This research highlights the importance of precise control over 3D printing conditions to fabricate high-performance, mechanically durable parts of PEEK.

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