

Soft material drilling: A thermo-mechanical analysis of polyurethane foam for biomimetic bone scaffolds and optimization of process parameters using Taguchi method

Abstract

Drilling is a widely employed technique in machining processes, crucial for efficient material removal. However, when applied to living tissues, its invasiveness must be carefully considered. This study investigates drilling processes on polyurethane foam blocks mimicking human bone mechanical properties. Various drill bit types (118° twist, 135° twist, spherical, and conical), drilling speeds (1000–1600 rpm), and feed rates (20–80 mm/min) were examined to assess temperature elevation during drilling. The Taguchi method facilitated systematic experiment design and optimization. Signal-to-noise (S/N) ratio and analysis of variance (ANOVA) identified significant drilling parameters affecting temperature rise. Validation was conducted through confirmation testing. Results indicate that standard twist drill bits with smaller point angles, lower drilling speeds, and higher feed rates effectively minimize temperature elevation during drilling.

Keywords

Drilling optimization; Polyurethane foam; Synthetic bone; Taguchi method; Thermal effect