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The Impact of Land Use Change on Improving Surface Runoff, Peak Flood Discharge, and Sedimentation in the Maros Watershed

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Abstract

This study focuses on the effects of the hard turning of SKD11 steel with nanofluid-based Minimum Quantity Lubrication (MQL) on machining efficiency, optimizing the surface roughness (R_a) and Material Removal Rate (MRR). For this purpose, a hybrid Response Surface Methodology (RSM) and Particle Swarm Optimization (PSO) approach are utilized for the SKD11 hard turning under Al_2O_3 nanofluid-MQL conditions. Initially, 27 experiments were conducted using a Box-Behnken design with Al_2O_3 concentration (0–3% wt), cutting speed (v) of 60–100 m/min, depth of cut (a_p) ranging from 0.2 to 0.6 mm, and feed rate (f) from 0.1 to 0.2 mm/rev, followed by four additional runs, totaling 31 experiments. The resulting RSM models for R_a and MRR achieved high accuracy with an R^2 value of 97.69%. The PSO optimization identified extreme solutions: A minimum R_a of 0.43 µm at 3.0% Al_2O_3, v of 95 m/min, a_p of 0.4 mm, f of 0.12 mm/rev, and a maximum MRR of 9000 mm^3/min at 1.5% Al_2O_3, v of 100 m/min, a_p of 0.6 mm, and f of 0.15 mm/rev. Additionally, a balanced multi-objective solution was obtained at 2.0% Al_2O_3: 98 m/min, 0.5 mm, and 0.14 mm/rev, yielding $R_a \approx 0.55$ µm and MRR ≈ 8400 mm^3/min. The proposed RSM-PSO hybrid approach effectively balances surface quality and productivity, outperforming traditional methods. The findings highlight the benefits of iterative refinement and provide practical parameter optimization for the sustainable machining of hardened steels.

Keywords:

Maros watershed conservation, surface runoff changes, peak flood discharge, sedimentation land use, flood risk mitigation