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Sustainable Machining through Minimum Quantity Lubrication Using Green Cutting Fluids as an Alternative to Mineral Oils**Thenusa, S.^{1*}, Bavithira, T.²**¹*Department of Production Technology, University College of Jaffna,
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University of Vocational Technology, Jaffna, Sri Lanka***sthenusa@ucj.ac.lk***Abstract**

Machining operations have traditionally depended on conventional flood cooling with mineral-based emulsions to improve tool life and surface quality. However, these cutting fluids are costly to produce, difficult to dispose of, and pose considerable environmental and health hazards. Minimum Quantity Lubrication (MQL) has emerged as a cleaner alternative, significantly reducing fluid consumption while maintaining or enhancing machining performance. The use of green cutting fluids offers additional advantages by lowering environmental risks and providing economic benefits. Despite these potentials, only limited research has investigated the application of MQL with green cutting fluids for specific tool-workpiece combinations, particularly regarding surface roughness. This study evaluates the effect of MQL with green cutting fluids on the surface finish of machined components. Through literature review, three environmentally friendly oils sunflower oil, coconut oil, and waste cooking oil were identified for testing. Turning experiments were carried out on AISI D2 steel workpieces using carbide-coated tools under MQL with the selected oils. For comparison, additional trials were conducted under dry cutting, conventional flood cooling with emulsions, and MQL with emulsions. The results revealed that coconut oil and sunflower oil under MQL achieved superior surface finishes, surpassing conventional methods, while waste cooking oil performed poorly due to its degraded properties. These outcomes highlight the potential of green cutting fluids as sustainable substitutes for mineral-based emulsions in machining. Further studies with varied machining parameters and tool-workpiece combinations are recommended to strengthen and generalize these findings for broader industrial adoption.

Keywords: *Green cutting fluids, MQL, Surface roughness, Sustainable machining*