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Article

Experimental Evaluation of the Lubrication Performance of Garlic Oil Based MQL in Machining of EN24 Steel

Mohammad Arif Parray [1)]*, Suhail Shahzad[2)], M. Jebran Khan[1)], Fatima Farooq Bisati[2)], Asif Manzoor[2)] and Qurat ul Ain[2)]

[1)] Department of Mechanical Engineering, Islamic University of Science and Technology Awantipora, Kashmir
[2)] Department of Mechanical Engineering, SSM College of Engineering, Parihaspora Pattan Kashmir

*Corresponding author: Mohammad Arif Parray (arifengg7@gmail.com)

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Abstract

This study explores the remarkable potential of garlic oil as a green, high-performance lubricant in machining, aiming to elevate wear resistance, reduce cutting temperatures, and improve surface finishes, all in contrast to conventional dry cutting methods. Through Scanning Electron Microscopy (SEM), intricate wear patterns on tungsten carbide (WC) tool inserts were meticulously analyzed, while Energy Dispersive X-ray Spectroscopy (EDS) unveiled the adhesive behavior influenced by the garlic oil-based lubrication. Surface roughness, following the turning operation, was elegantly measured using stylus profilometry. The results reveal that garlic oil-based Minimum Quantity Lubrication (MQL) achieved a 43.8% reduction in flank wear, a 69.3% decrease in cutting temperatures, and an impressive 79.3% improvement in surface finish. These findings illuminate garlic oil's ability to maintain cooler cutting zones, significantly extending tool life while preserving the precision of machined parts. This research underscores the promise of garlic oil as a natural, eco-friendly lubricant, paving the way for sustainable machining practices that not only protect the environment but also ensure unparalleled performance in the processing of EN24 steel.

Keywords

cutting fluids, MQL, garlic oil, sustainable machining

1 Introduction

In the realm of modern manufacturing, the pursuit of sustainable and eco-friendly practices has taken center stage. The continuous evolution of materials and processes demands innovative lubrication techniques to ensure the longevity and efficiency of machining operations. The choice of cutting fluids plays a pivotal role in achieving these goals. While traditional flood cooling methods have long been employed to enhance tool life and reduce wear in machining processes, their association with environmental hazards, high consumption, and escalating costs have raised questions about their sustainability. This has sparked a quest for alternative lubrication solutions that not only meet the performance criteria of cutting fluids but also align with the principles of sustainability [1-5].

MQL is a promising approach that stands at the crossroads of sustainability and efficiency in metalworking processes. MQL, characterized by the application of a minimal amount of lubricant directly to the cutting zone, seeks to address the environmental and economic concerns associated with traditional flood cooling. This method not only reduces fluid consumption but also provides an opportunity to explore unconventional, environmentally friendly lubricants, including vegetable oils and their derivatives [6-10].

This research embarks on a journey to investigate the viability of garlic oil as a sustainable MQL lubricant in the machining of EN24 steel, a material widely used in the automotive and aerospace industries. Garlic, a culinary and medicinal herb, has found its way into various applications beyond the kitchen, owing to its unique properties, including antimicrobial, antioxidant, and anti-inflammatory characteristics. The notion of utilizing garlic oil as a machining lubricant is rooted in the desire to harness its inherent tribological benefits while reducing the environmental impact associated with machining operations [11]. This innovative approach seeks to contribute to the growing body of research dedicated to sustainable manufacturing practices. EN24 steel, a high-strength, low-alloy, and heat-treatable material, is widely used in the manufacturing of various components across industries, from automotive to aerospace [12]. The machining of EN24 steel, however, poses significant challenges due to its high hardness and abrasiveness. Traditional cutting fluids,