



UKLA Metalworking Fluid Product Stewardship Group

TOPIC REVIEW 5: New Lubricant and Cooling Techniques

Introduction: Exposure to metalworking fluids (MWF) is linked to an increased risk of occupational respiratory and skin diseases among machinists. This review focuses on new lubrication and cooling techniques that aim to reduce the use of mineral oil-based MWFs. Lubricant technology is evolving to minimise tool and workpiece damage from friction, pitting, and wear, and to reduce energy costs and improve productivity. This review considers whether the development of ‘sustainable’ MWFs and the use of novel lubricant additives pose health risks for machinists.

Research Methods: The review synthesises evidence from published research on plant-oil-based lubricants, dry machining, low-temperature machining, Minimum Quantity Lubrication (MQL), and nanoparticle-enhanced lubricants. It covers research published between 2005 and 2024 on the performance, sustainability, and health risks associated with new lubricant technologies.

Main Findings: Modern mineral oil-based MWFs, including water-mix MWFs, pose a lower risk to machinists' health, provided their quality is maintained during use. However, their environmental disposal is more costly. Alternative plant oil-based WFs are claimed to reduce occupational health risks, but published evidence supporting this is limited. Despite environmental pressures on the use of mineral oil-based lubricants, obstacles to the widespread adoption of ‘sustainable’ lubricants include their higher cost and limited evidence of reliable long-term performance. This review identifies knowledge gaps regarding the safety of sustainable MWFs and novel lubricant additives.

Discussion and Analysis: The review concludes that alternative lubricant technologies can improve machining outcomes and reduce environmental impacts. Inhalation of aerosolised plant oils during machining may raise concerns, as edible oils can contain residual allergens and their use also places pressure on food resources. Plant oils may also have lower volatility, which could reduce mist formation, though this is not supported by published evidence. Nanomaterial additives used as novel lubricants include reactive metals and multiwalled carbon nanotubes. Experimental studies have demonstrated their toxicity, so minimising occupational exposure is advised. Minimal quantity lubrication has been developed to reduce the volume of mineral oil used, but this method produces very small droplets at higher mass concentrations than conventional flood cooling methods. Dry machining methods also release small particles that can enter the lungs. Cryo-machining has been developed to replace the use of lubricants but presents risks such as leakage of asphyxiant gases, injuries, and burns.

Conclusion and Knowledge Gaps: A better understanding of the health risks associated with new lubricant methods, particularly chemically reactive nanoparticle additives, is needed. Industry guidance on the safe management of these methods is lacking. Research into the use of nanomaterial lubricants has increased in recent years. However, few of these studies have considered the potential for exposure and health risks from particles sufficiently small to enter the lungs and blood circulation.