Investigation on the effect of MQL aerosol temperature on machining steels with sesame oil

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Degree of Master of Engineering

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DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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Signature of the Supervisor: Date:

Name of the Supervisor : Prof H.K.G Punchihewa

Signature of the Supervisor: Date:

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ABSTRACT

In metal machining, heat generation leads to various challenges that cutting fluids help mitigate by dissipating heat in the machining area. Minimum quantity lubrication also known as MQL technique effectively addresses heat-related issues while reducing the machining cost. Effects of reducing the aerosol temperature in MQL is not completely addressed in literature, especially with vegetable-based oils. Sesame oil exhibits exceptional qualities among different types of vegetable oils, making it a prominent candidate for use in metalworking processes. In this study, multi-objective optimization for lathe turning of AISI D2 was conducted using the Taguchi and Grey relational analysis methods. This approach allows simultaneous optimization of multiple responses, such as tool nose wear, surface roughness, energy consumption, and material removal rate. Initially, a MQL application apparatus was designed and developed to deliver MQL aerosol of sesame oil below ambient temperatures. In the experimental investigation, we have successfully lowered the aerosol temperature from 27°C to 12°C, which is the cloud point temperature of the sesame oil. Trials were conducted with dry-cutting and flood cooling at 27°C to establish control parameters. The significant factors impacting tool nose wear were identified as the cutting fluid application method and cutting speed, with optimal outcomes observed at a MQL aerosol temperature of 17°C. On average, considering all cutting speeds the reduction of tool nose wear was approximately 45% compared to dry cutting. Feed played a pivotal role in surface roughness and energy consumption, with optimal surface roughness achieved at feed of 0.13 rev/min and least energy consumption at feed of 0.35 rev/min. It is noted that, in terms of material removal rate, the applying method of cutting fluid has not shown a significant impact on machining performance. Interestingly, from the grey relational analysis, the cutting fluid applying method was identified as the most significant factor in multi-objective optimization. Additionally, achieving optimum results with MQL at an aerosol temperature of 17°C is noteworthy, especially when other factors are at their minimum levels.

Keywords: Aerosol temperature, Grey relational analysis, MQL, Sesame oil, Taguchi method

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LIST OF ABBREVIATIONS

AISI	American Iron and Steel Institute
CF	Cutting Fluid
CVD	Chemical Vapour Deposition
EP	Extreme Pressure
GRA	Grey Relational Analysis
GRC	Grey Relational Coefficient
HPC	High Pressure Coolant
MRR	Material Removal Rate
MQL	Minimum Quantity Lubrication
NDM	Near Dry Machining
OA	Orthogonal Array
SAE	Society of Automotive Engineer
SLDMMI	Sri Lanka Die and Mould Manufacturing Industries
S/N	Signal-to-noise
SR	Surface Roughness
TNW	Tool Nose Wear