INVESTIGATION OF TOOLTIP TEMPERATURE AND SURFACE ROUGHNESS IN TURNING OF AISI 1045 STEEL WITH COCONUT OIL-BASED HYBRID NANOFLUID UNDER MQL TECHNOLOGY

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Degree of Master of Engineering

Department of Mechanical Engineering

University of Moratuwa
Sri Lanka

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Dissertation submitted in partial fulfilment of the requirements for the Master of Engineering in Manufacturing Systems Engineering

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Declaration

I declare that this is my work, and this thesis 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.

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Name of the co-supervisor: Mr. R.K.P.S. Ranaweera

Dedication

To the most courageous individuals who guided me to great accomplishments: my beloved mother, *Nandanie Sumanarathna* and my wife, *Bimba Veenavi Yoshinika*

Acknowledgement

As a graduate student in the Faculty of Engineering at the University of Moratuwa, I had to complete a research project in partial fulfilment of the Manufacturing Systems Engineering Master of Engineering degree requirements. I chose " Investigation of tooltip temperature and surface roughness in turning of AISI 1045 steel with novel coconut oil-based hybrid nanofluid under MQL technology" as my topic. I am incredibly grateful to the University of Moratuwa for providing this opportunity. I would like to thank Dr G.I.P. Perera, Dr. H.K.G. Punchihewa, and Mr. R.K.P.S. Ranaweera for their guidance, constant supervision, and provision of project-related information and for their assistance in completing this research project. Their cooperation and encouragement motivated me to finish this project. In addition, I appreciate Mrs. M. Hennayake (QA manager @ CSCL) and Mr. M.M.L.C. Malmessa (DGM of technical @ CSCL) for their insightful comments and for giving extra support to complete my research. I would also like to express my sincere appreciation and gratitude to the University of Ruhuna for providing me with information, time, and engineering workshop facilities for the research. My gratitude and appreciation also goes to my project development colleagues and those who have voluntarily assisted me with their skills.

Abstract

Over the past few years, positive changes have occurred in the manufacturing industry and many other fields as a direct result of current breakthroughs in nanotechnology. The integration of nano-sized solid lubricants into aerosols, suspensions, and emulsions can lead to an enhancement of the end product's tribological and thermal properties. This is because of the constituent materials' unique chemical and physical properties. Therefore, this makes it possible for lubricants or coolants to perform their functions to attain a high level of productivity in machining processes.

This study aimed to investigate the effect on average surface roughness and tooltip temperature in turning AISI 1045 steel with novel coconut oil-based hybrid nanofluid under MQL technology. Al_2O_3 and TiO_2 were chosen as the two nanoparticles to use in the experiments after conducting a survey of the relevant research in the field. In order to reach this aim, Taguchi's L16 orthogonal array, which is comprised of four factors, was utilized. Concentrations of Al_2O_3, TiO_2, cutting speed, and air pressure are the four factors considered in this study. In this experimental design, the responses considered were average surface roughness and the temperature of the tooltip. Using the Minitab 17 software, the model fitting and optimization were carried out. The values that recorded as being optimal were,

- 0.75 wt. % of Al_2O_3,
- 0.00 wt. % of TiO_2,
- 2.5 bar of air pressure,
- 96 m/ min of cutting speed

As a direct consequence, it is clear that the developed MWFs show significantly higher performance than the other two techniques, dry cutting and coconut oil-based MQL cooling. The percentages show a 23.92 % and 37.97 % reduction in tooltip temperature compared to dry cutting conditions for MQL+ CC and Nano+ MQL+CC conditions, respectively. Also, the average surface roughness was reduced by 33.87 % and 94.85 % compared to dry cutting conditions for MQL+ CC and Nano+ MQL+CC conditions, respectively. For future work, we can use thermophysical and tribological factors rather than cost as a determining factor for better results.

Keywords: Minimum quantity lubrication/ nanoparticle/ machining/ surface roughness/ tooltip temperature

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List of abbreviations

Abbreviation	Description
AISI	American Iron and Steel Institute
Al_2O_3	Aluminium oxide
ANOVA	Analysis of variance
CC	Coconut Oil
CSCL	Ceylon Steel Corporation Limited
DOE	Design of Experiments
FOE, UOR	Faculty of Engineering, University of Ruhuna
FNG	Functionalized Nano Graphite
MCF	Metal Cutting Fluid
MOO	Multi-objective optimization
MQL	Minimum Quantity Lubrication
MWF	Metal Working Fluid
NBA	Nano Boric Acid
NDM	Near Dry Machining
NG	Nano Graphite
OA	Orthogonal Array
PGPR	Polyglycerol polyricinoleate
Ra	Average Surface Roughness
T_{tip}	Tool tip temperature
TiO_2	Titanium dioxide
VB	Flank wear

List of Appendices