WEAR RATE REDUCTION MECHANISM OF MINIMUM QUANTITY LUBRICATION TO ENHANCE MACHINABILITY USING HYBRID NANO-COOLANT (TiO_2- Al_2O_3)

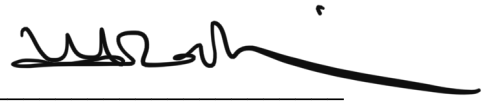
WAJIHA TASNIM URMI

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.



(Supervisor's Signature)

Full Name : TS. DR. MD MUSTAFIZUR RAHMAN

Position : PROFESSOR

Date : 20 May 2021

(Co-supervisor's Signature)

Full Name : DR. WAN AZMI BIN WAN HAMZAH

Position : ASSOCIATE PROFESSOR

Date : 20 May 2021

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

Wajiha Tasnim Urmi

(Student's Signature)

Full Name : WAJIHA TASNIM URMI

ID Number : MMA18006

Date : 20 May 2021

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ABSTRAK

Di dunia pembuatan yang maju, penggunaan aloi aluminium meningkat secara mendadak dalam pelbagai bidang kejuruteraan kerana sifat mekaniknya yang menarik. Pemesinan aloi aluminium mempunyai cabaran berlakunya keausan alat, kemerosotan permukaan membentuk pinggir terbina, lekatan kerana panas tinggi dan geseran di zon hubungan. Oleh itu, teknik penyejukan dan pelinciran yang betul dapat meningkatkan kecekapan pemesinan dengan meminimumkan keausan alat, geseran, kekasaran permukaan. Baru-baru ini, penyelidik memberi keutamaan pada teknik Minimum Quantity Lubrication (MQL) menggunakan cecair minimum berbanding dengan teknik penyejuk konvensional. Oleh itu, objektif kajian ini untuk mengkaji prestasi pemesinan dari segi mekanisme pemakaian alat termasuk kekasaran permukaan, kadar penyingkiran bahan dan untuk mengembangkan pengoptimuman multi-objektif penggilingan akhir aloi aluminium dengan keadaan MQL nanofluid banjir dan hibrid konvensional. Nanofluid hibrid TiO_2-Al_2O_3 disintesis untuk kepekatan isi padu dari 0.02 hingga 0.1% menggunakan kaedah sintesis dua langkah. Kestabilan nanofluid hibrid dinilai menggunakan ujian potensi zeta, analisis spektrum UV-Vis, foto pemendapan dan sifat termofizik diukur untuk julat suhu 30 hingga 80 ^oC. Untuk pemesinan reka bentuk komposit pusat metodologi permukaan tindak balas diikuti. Kajian ini menganggap kadar aliran minyak mineral komersial (ditambah 5% dengan air) sebagai 30 L / min untuk keadaan banjir dan kadar aliran HNF adalah 0.3 hingga 1.2 ml / min untuk keadaan HNF-MQL. Mekanisme pemakaian alat dipresentasikan menggunakan mikrograf SEM dengan analisis EDX serta interaksi pemakaian alat dengan kekasaran permukaan dan kadar penyingkiran bahan juga dianalisis. Kajian ini mendedahkan bahawa nanofluid hibrid TiO_2- Al_2O_3 mempunyai tempoh kestabilan lebih dari satu bulan yang menunjukkan nilai potensi zeta standard (lebih daripada 30 mV), nisbah serapan (lebih daripada 80%) tanpa sedimentasi yang jelas. Selain itu, HNF baru juga menunjukkan peningkatan ketara sifat termofisik dari segi kekonduksian terma (37.44%) dan kelikatan (101.22%). Sekiranya terdapat pemesinan, model matematik pesanan kedua dari alat termasuk kekasaran permukaan dan kadar penyingkiran bahan dikembangkan untuk kedua-dua keadaan penyejukan dengan ketepatan yang sangat baik. Lekapan, tanda lelasan, pinggir binaan, pecah tepi atau celah adalah kehausan kajian ini untuk kedua-dua keadaan. Prestasi pemesinan HNF-MQL dari segi faktor tindak balas yang dipertimbangkan menunjukkan peningkatan yang ketara berbanding dengan pemesinan banjir. Di antara semua faktor tindak balas, keausan alat (29%) dan kekasaran permukaan (30.13%) ketara diperbaiki untuk penggunaan HNF-MQL diikuti oleh kadar penyingkiran bahan (12.16%). Kadar penyingkiran bahan juga menunjukkan ketekalan untuk keadaan HNF-MQL. Selain itu, mekanisme keausan alat menunjukkan hubungan yang signifikan dengan kecekapan pemesinan, menunjukkan interaksi yang signifikan dengan kekasaran permukaan dan kadar penyingkiran bahan. Akhirnya, dari hasil pengoptimuman, keausan alat diperbaiki sebanyak 21.36% sementara kekasaran permukaan ditingkatkan sebanyak 80.90%. Oleh itu, hasil eksperimen menunjukkan kemungkinan penggunaan nanofluid hibrid dalam mesin sebagai penyejuk. Hasil kajian yang bermanfaat dari segi pencirian HNF dan ukuran prestasi pemesinan berbanding dengan pemesinan banjir menunjukkan bahawa penyelidik dan jurutera mengkaji dan menggunakan pelbagai jenis teknik MQL berasaskan HNF dalam industri pembuatan maju.

ABSTRACT

In the advanced manufacturing world, the applications of aluminium alloys are dramatically increasing in various engineering fields due to their exciting mechanical properties. The machining of aluminium alloy has the challenges of occurrences of tool wear, surface degradation forming built-up edge, adhesion due to high heat and friction at the contact zone. Hence, proper cooling and lubrication technique can improve machining efficiency by minimizing tool wear, friction, surface roughness. Recently, researchers have been giving priorities to the Minimum Quantity Lubrication (MQL) technique using minimum fluid compared to conventional coolant technique. Hence, the objective of this study to investigate machining performance in terms of the tool wear mechanism, including surface roughness, material removal rate and to develop multi-objective optimization of end milling of aluminium alloy with conventional flooded and hybrid nanofluid (HNF) MQL conditions. The TiO_2-Al_2O_3 hybrid nanofluid is synthesized for volume concentration from 0.02 to 0.1% using the two-step synthesis method. The stability of hybrid nanofluids is assessed using zeta potential test, UV- Vis spectral analysis, sedimentation photograph and the thermophysical properties are measured for the temperature range of 30 to 80 ^oC. For machining central composite design of response surface methodology is followed. The study considers the flow rate of commercial mineral oil (added 5 % with water) as 30 L/min for the flooded condition and the flow rate of HNF as 0.3 to 1.2 ml/min for the HNF-MQL condition. The mechanism of tool wear is presented using SEM micrographs with EDX analysis as well as the interaction of tool wear with surface roughness and material removal rate is also analysed. The study reveals that the TiO_2-Al_2O_3 hybrid nanofluid has a stability period of more than one month, showing standard zeta potential value (more than 30 mV), absorbance ratio (more than 80 %) with no apparent sedimentation. Besides, the new HNF also shows significant improvement of thermophysical properties in terms of thermal conductivity (37.44%) and viscosity (101.22 %). In the case of machining, second-order mathematical models of tool wear, including the surface roughness and material removal rate, are developed for both cooling conditions with excellent accuracy. Adhesion, abrasion marks, built-up edge, edge breakage or chipping are the significant wear of the study for both conditions. The performance of HNF-MQL machining in terms of considered response factors shows significant improvement compared to flood machining. Among all the response factors, tool wear (29 %) and surface roughness (30.13 %) noticeably improved for the application of HNF-MQL, followed by material removal rate (12.16 %). The material removal rate also shows consistency for the HNF-MQL condition. Besides, the tool wear mechanism shows a significant relationship with the efficiency of machining, revealing a significant interaction with surface roughness and material removal rate. Finally, from optimization results, tool wear is improved by 21.36 %, while the surface roughness is improved by 80.90%. Hence, experimental results revealed the prospective utilization of hybrid nanofluids in machining as coolant. Beneficial results of the study in HNF characterization terms and machining performance measures compared to flood machining suggest that researcher and engineers study and apply various types of HNF-based MQL technique in advanced manufacturing industries.

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