EFFECT OF VEGETABLE AND MINERAL OIL-IN-WATER EMULSION CUTTING FLUIDS IN TURNING AISI 4340 STEEL WITH COATED CARBIDE TOOLS

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Field of Study: **Machining**

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ABSTRACT

Cutting fluids have been used extensively and play a significant role in machining processes. Cutting fluids affect the productivity of machining operations, tool life, quality of workpiece and prevent the cutting tool and machine from overheating as well. In general, a successful cutting fluid must not only improve the machining process performance, but also fulfill a number of requirements which are non-toxic, non-harmful to health for operators, not a fire hazard, not smoke or fog in use and cost less. One of the drawbacks of using conventional (mineral) oil based cutting fluids is the waste disposal after being used. Mineral oil has also poor biodegradability thus induces the potential for long term pollution of the environment. In this study, a comprehensive literature review of application of vegetable oil-based cutting fluids in machining different workpiece materials with different tool materials was done.

This study is divided into two main sections, the first section focused on the properties of palm kernel and cottonseed oils and formulation of oil-in-water emulsion cutting fluids using the two oils. The selection of cutting fluid additives (emulsifier, anticorrosive agent, antioxidant and biocide) for the formulation of oil-in-water emulsion using palm kernel and cottonseed oils are not dangerous or problematic to the environment or harmful to workers. The formulation of cutting fluid was based on Design of Experiment (DOE) of 2^4 full factorial designs and statistical analysis of the response value (pH) was employed using version 6 of DOE® software. The pH values of 10.46 and 10.98 were obtained for the palm kernel oil and cottonseed oil respectively, which are within the acceptable standard for cutting fluid for machining processes.

The second section considered the effect of the two formulated oil-in-water emulsion cutting fluids in turning AISI 4340 steel with coated carbide tools and compared with conventional (mineral) oil-based cutting fluid. Taguchi method with L_{27} (3^4) orthogonal

array for experimentation was adopted. Cutting speed, feed rate and depth of cut were output variables considered for experimentation. In addition to the cutting parameters, type of cutting fluid used was also considered as one of the critical input parameters while designing the experiment. Cutting force, surface roughness and tool wear are the output parameters obtained from the trials conducted as per L_{27} array experimentation and further analyzed. Minitab 14 statistical analysis software widely used in engineering application was used in the analysis of signal- to- noise (S/N) (dB) ratio and ANOVA for surface roughness, cutting force and tool wear. The ANOVA analysis shows that cutting speed (64.46%) and feed rate (32.19%) significantly affected surface roughness. Depth of cut (33.15%) and cutting fluid (51.12%) significantly affected cutting force and while cutting speed (85.36%) and feed rate (4.81%) significantly affected tool wear. The effect of cutting fluids on the type of chip formed was equally accounted for. Confirmation tests applied for Taguchi results and regression equations indicate reliable results.

ABSTRAK

Bendalir pemotong telah digunakan secara meluas dan memainkan peranan penting dalam proses pemesinan. Bendalir pemotong menjejaskan produktiviti operasi pemesinan, kehidupan alat, kualiti bahan kerja dan mencegah alat memotong dan mesin daripada terlalu panas juga. Secara umum, cecair pemotongan yang berjaya mesti bukan sahaja meningkatkan prestasi proses pemesinan, tetapi juga memenuhi beberapa keperluan yang bukan toksik, tidak berbahaya kepada kesihatan bagi pengendali, tidak bahaya kebakaran, bukan asap atau kabut dalam penggunaan dan mempunyai harga . Salah satu kelemahan menggunakan konvensional (mineral) berasaskan minyak memotong cecair adalah pelupusan sisa selepas digunakan. Minyak mineral telah juga biodegredasi miskin itu mendorong potensi untuk pencemaran jangka panjang alam sekitar. Dalam kajian ini, kajian literatur yang menyeluruh permohonan sayur-sayuran berasaskan minyak memotong cecair dalam bahan pemesinan bahan kerja yang berbeza dengan bahan-bahan alat yang berbeza telah dilaporkan. Pemboleh ubah biasa yang biasanya disiasat memotong berkuat kuasa, memakai alat, kehidupan alat, kekasaran permukaan dan morfologi cip.

Kajian ini dibahagikan kepada dua bahagian utama, bahagian pertama memberi tumpuan kepada sifat isirung sawit dan minyak cottonseed dan pembentukan emulsi minyak dalam air cecair pemotongan menggunakan dua minyak. Pemilihan memotong tambahan cecair (pengemulsi, agen anticorrosive, antioksidan dan biocide) untuk pembentukan emulsi minyak dalam air menggunakan isirong sawit dan minyak cottonseed tidak berbahaya atau bermasalah kepada alam sekitar atau berbahaya kepada pekerja. Pembentukan cecair pemotongan berdasarkan JAS 24 reka bentuk faktoran penuh dan analisis statistik nilai tindak balas (pH) telah digunakan menggunakan versi 6 perisian DOE ®. Nilai pH 10,46 dan 10,98 diperolehi untuk minyak isirong sawit dan

minyak cottonseed masing-masing, yang berada dalam standard yang diterima untuk proses pemesinan cecair pemotongan.

Bahagian kedua dianggap kesan dua dirumuskan emulsi minyak dalam air memotong cecair dalam beralih AISI 4340 keluli dengan alat karbida bersalut dan berbanding dengan (mineral) konvensional cecair pemotongan berasaskan minyak. Kaedah Taguchi dengan L27 (3^4) pelbagai ortogon untuk uji kaji telah diguna pakai. Kelajuan pemotongan, kadar suapan dan kedalaman pemotongan dianggap untuk percubaan. Dalam tambahan kepada parameter memotong, jenis memotong bendalir yang digunakan juga dianggap sebagai salah satu parameter input kritikal manakala mereka bentuk eksperimen. Kuasa memotong, kekasaran permukaan dan memakai alat parameter output yang diperolehi daripada ujian yang dijalankan sebagai satu L27 pelbagai eksperimen dan seterusnya dianalisis. Minitab 14 perisian analisis statistik yang digunakan secara meluas dalam aplikasi kejuruteraan telah digunakan dalam analisis isyarat kepada hingar (S / N) nisbah (dB) dan ANOVA bagi kekasaran permukaan, memotong kekerasan dan memakai alat. Analisis ANOVA menunjukkan bahawa kelajuan pemotongan (64.46%) dan kadar suapan (32.19%) dengan ketara mempengaruhi kekasaran permukaan. Cecair kedalaman pemotongan (33.15%) dan memotong (51.12%) dengan ketara menjejaskan daya pemotongan dan semasa memotong kelajuan (85.36%) dan kadar suapan (4.81%) dengan ketara menjejaskan memakai alat. Kesan pemotongan cecair kepada jenis cip yang terbentuk sama diambilkira. Ujian pengesahan yang digunakan untuk Taguchi keputusan dan persamaan regresi menunjukkan keputusan yang boleh dipercayai.

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I will bless the Lord at all times; His praise shall continually be in my mouth

(Psalms 34:1)

I am grateful to God almighty who kept me throughout this period of my studies. Your praise shall continually be in my mouth.

If I have seen further, it is by standing on ye shoulders of giant" Isaac Newton
(February 5th, 1676)

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AISI	America institute of steel and iron
ANOVA	Analysis of variance
DOE	Design of experiment
DSC	Differential scanning calorimetry
GC	Gas chromatography
S/N ratio	Signal-to-noise ratio
PKO	Palm kernel oil
CSO	Cottonseed oil
MO	Mineral oil
TGA	Thermo-gravimetric analysis

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