PERFORMANCE OF RBD PALM OIL BASED DIELECTRIC FLUID ON SUSTAINABLE ELECTRICAL DISCHARGE MACHINING (EDM) PROCESS OF TITANIUM ALLOYS

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This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

In electrical discharge machining (EDM), the material removal is accomplished through a continuous discharge that occurs between the electrode and the workpiece in the presence of a dielectric fluid. Appropriate selection of dielectric medium is an important consideration due to the function of dielectric medium which greatly influences the performance of this process. Low machining efficiency and poor surface finish caused by using a conventional dielectric fluid that pollutes the environment and cause health problems in EDM processes have been issues that must be dealt well. The preliminary study aims to investigate the performance of biodegradable oil-based dielectric fluid compared to conventional dielectric fluid for titanium alloys (Ti-6Al-4V) with copper (Cu) electrode using a sustainable EDM. To achieve high EDM performance for this research, the main parameter of peak current (I_p); 6, 9 and 12A and pulse duration (t_{on}); 50, 100 and 150µs were selected. Refine, bleach, and deodorized (RBD) palm oil, modified RBD palm oil, and kerosene were used as dielectrics. The influence on the machinabilities of the material removal rate (MRR), electrode wear rate (EWR), and sparking characteristic were experimentally investigated. Some aspects of surface integrity, such as surface roughness (R_a), recast layer (R_L) and microhardness (MH) were also evaluated. The result shows that RBD palm oil has higher MRR, EWR, R_a and MH but lower R_L compared to modified RBD palm oil and kerosene in term of machinability and surface integrity. This is due to the density, viscosity and flash point of the dielectric fluid that play a vital role in the determination of the desired outcome in the EDM process. The highest improvement of MRR is 567.43% when RBD palm oil is compared to kerosene at I_p=12A and t_{on}=150µs. Overall, all dielectric fluids have almost similar trend. However, RBD palm oil based dielectric fluid is the best option for EDM machining of Ti-6Al-4V.

ABSTRAK

Di dalam penggunaan mesin discaj elektrik (EDM), bahan dinyah melalui discaj elektrik secara berturut-turut antara elektrod dan bahan kerja dengan kehadiran cecair dielektrik. Pemilihan medium dielektrik adalah penting kerana medium dielektrik mempengaruhi prestasi proses ini. Kecekapan pemesinan yang rendah dan kemasan permukaan yang lemah disebabkan oleh penggunaan cecair dielektrik konvensional yang mencemarkan alam sekitar serta menyebabkan masalah kesihatan dalam proses EDM adalah isu yang harus ditangani dengan baik. Kajian awal ini bertujuan untuk mengkaji prestasi cecair dielektrik berasaskan minyak mudah terbakar dengan cecair dielektrik konvensional bagi aloi titanium (Ti-6Al-4V) dan elektrod tembaga dengan menggunakan EDM mampan. Untuk mencapai prestasi EDM yang tinggi bagi penyelidikan ini, parameter utama seperti arus puncak, I_p; 6, 9 dan 12A dan tempoh denyutan, t_{on}; 50, 100 dan 150µs telah dipilih. RBD minyak sawit, pengubahsuaian RBD minyak sawit dan minyak tanah digunakan sebagai dielektrik. Kesan daripada parameter terhadap kebolehmesinan melalui kadar pembuangan bahan (MRR), kadar kehausan elektrod (EWR) dan ciri percikan api dikaji secara eksperimen. Beberapa aspek integrity permukaan seperti kekasaran permukaan (R_a), lapisan putih (R_L) dan kekerasan mikro (MH) juga dinilai. Keputusan menunjukkan bahawa RBD minyak sawit mempunyai MRR, EWR, R_a dan MH yang lebih tinggi tetapi R_L yang lebih rendah berbanding pengubahsuaian RBD minyak sawit dan minyak tanah dari segi kebolehmesinan dan integriti permukaan. Hal ini disebabkan oleh ketumpatan, kelikatan dan takat kilat cecair dielektrik yang memainkan peranan penting dalam penentuan hasil yang dikehendaki dalam proses EDM. Peningkatan tertinggi MRR ialah 567.43% apabila RBD minyak sawit dibandingkan dengan minyak tanah pada I_p=12A dan t_{on}=150µs. Secara keseluruhan, semua cecair dielektrik mempunyai trend yang hampir serupa. Walau bagaimanapun, cecair dielektrik berasaskan RBD minyak sawit adalah pilihan terbaik untuk pemesinan EDM bagi Ti-6Al-4V.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	-	Percentage
µm	-	Micro metre
µs	-	Micro second
A	-	Ampere
Al	-	Aluminium
AML	-	Advanced Machining Laboratory
ASTM	-	American standard for testing and material
C	-	Carbon
C_3H_8O	-	Propanol
CH_4O	-	Methanol
cm^3	-	Cubic centimetre
cP	-	Centipoise
cSt	-	Centistoke
Cu	-	Copper
EDM	-	Electro discharge machining
EN ISO	-	European standard
ERBDPO	-	Esterified RBD palm oil
EWR	-	Electrode wear rate
F	-	Load in kgf
Fe	-	Iron
FFA	-	Free fatty acid
g	-	Gram
G	-	Giga
H	-	Hydrogen
H_2O	-	Water
H_2SO_4	-	Sulphuric acid
HAZ	-	Heat affected zone
HCL	-	Hydrochloric acid
HRC	-	Rockwell hardness unit

HV	-	Vickers hardness unit
HV	-	Vickers hardness
I_p	-	Peak current
J	-	Joule
kg	-	Kilo gram
KOH	-	Potassium hydroxide
kV	-	Kilo volt
M	-	Mega
m	-	Metre
MH	-	Micro-hardness
min	-	Minutes
ml	-	Mililitre
mm	-	Milimetre
MRR	-	Material removal rate
m_w	-	Mass loss of workpiece
N	-	Nitrogen
N	-	Newton
N	-	Number of alkali concentration
NaOH	-	Sodium hydroxide
NCL	-	Nitric acid
O	-	Oxygen
^oC	-	Degree celcius
OM	-	Optical microscope
Pa	-	Pascal
R_a	-	Surface roughness
RBD	-	Refined, bleach and deodorized
RBDPOME	-	RBD palm oil methy ester
R_L	-	Recast layer
rpm	-	Revolution per minute
s	-	second
SA	-	Surface area
SEM	-	Scanning electron microscopy
SI	-	Surface integrity
SiC	-	Silica carbide
Ti	-	Titanium
Ti-6Al-4V	-	Titanium alooys

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