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by

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MACHINABILITY OF ALUMINIUM METAL MATRIX COMPOSITE REINFORCED WITH ALUMINA USING ELECTRO-DISCHARGE MACHINING

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A Thesis
Submitted to the Postgraduate Studies Programme
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DECLARATION OF THESIS

Title of thesis

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I **ALEXIS MOUANGUE NANIMINA**

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This work is dedicated to my family and my beloved parents.

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In the name of Almighty God, the most Gracious and most Compassionate

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Alexis Mouangue Nanimina

Abstract

Aluminium metal matrix composites (AMMCs) are making inroads in various engineering applications (aviation, marine, automotive parts as diesel engine pistons, cylinder, and brake components) requiring higher strength and stiffness than those offered by conventional aluminium alloys. Traditional machining of AMMCs however is difficult due to hard reinforcement in the AMMC material which tends to wrap around the cutting tool-bit leading to tool breakage. Electro-discharge machining (EDM) has been successfully applied on standard aluminium alloys such as Al 6061 but yet to be tested on 30% Al_2O_3 reinforced AMMC. In this study, a specific machining performance on 30% Al_2O_3 reinforced AMMC is assessed in comparison with Al 6061. The characteristics analyzed are surface roughness (Ra), material removal rate (MRR), tool wear ratio (TWR), overcut (OC) and surface morphology. Process parameters used, are peak current, ON-time (pulse duration) and OFF-time (pause duration), were varied in this research to determine the machinability of AMMC reinforced by 30% Al_2O_3 by using EDM. The research methodology adopted was using design of experiment (DOE) and results from the experiment were analyzed and interpreted. The response surface methodology (RSM) was used to predict the machining performance and empirical mathematical models for Ra, MRR and TWR using Design Expert software. Results showed that peak current, ON-time and OFF-time have influenced on the EDM performance. Machinability of electro-discharge machining of 30% Al_2O_3 reinforced AMMC composite using electrolytic copper electrode has been proven feasible at certain parameters setting. Nevertheless, EDM machining performance of Al 6061 is better than that of AMMC. For machining at a specific material removal rate, minimal surface roughness, and low overcut can be obtained at low peak current or short ON-time and longer OFF-time however tool wear ratio remains high. Appropriate setting of EDM parameters that results in optimum machining performance have been identified in this research.

Keywords: EDM, ON-time, Aluminium metal matrix composite, MRR, TWR.

Abstrak

Komposit logam aluminium (AMMC) telah mendapat tempat dalam pelbagai aplikasi kejuruteraan (aviasi, marin, komponen automotif seperti piston dan silinder enjin diesel) yang memerlukan kekuatan yang lebih tinggi daripada yang dimiliki aluminium konvensional. Namun, pemesinan AMMC secara konvensional menghadapi masalah kerana rungkaian keras dalam AMMC cenderung untuk melilit bit pemotong yang membawa kepada kerosakan peralatan. Pemesinan Nyahcas Elektro (EDM) telah berjaya dilaksanakan ke atas aluminium standard seperti Al 6061, tetapi masih belum diuji kepada AMMC. Dalam kajian ini, ciri-ciri prestasi khusus pemesinan AMMC bertetulangkan 30% Al_2O_3 dinilai dengan membandingkannya dengan ciri-ciri prestasi pemesinan Al 6061. Ciri-ciri yang dianalisis adalah kekasaran permukaan (Ra), kadar penyahan bahan (MRR), nisbah penyusutan peralatan (TWR), terlebihpotongan (OC) dan morfologi permukaan. Parameter proses yang digunakan adalah arus puncak, tempoh pulsa dan jeda (masa-ON dan masa-OFF), diubah dalam kajian ini untuk menentukan kebolehmesinan AMMC bertetulangkan 30% Al_2O_3 menggunakan EDM. Metodologi penyelidikan yang digunakan adalah dengan menggunakan rekabentuk ujikaji (DOE) dan hasil dari ujikaji dianalisis dan diinterpretasikan. Metodologi permukaan respon (RSM) digunakan untuk meramal prestasi pemesinan dan model matematik empirik untuk Ra, MRR dan TWR menggunakan perisian Design Expert. Keputusan ujikaji menunjukkan bahawa arus puncak, masa-ON dan masa-OFF mempengaruhi kebolehmesinan AMMC bertetulangkan 30% Al_2O_3 menggunakan EDM. Walau bagaimanapun, prestasi pemesinan EDM Al 6061 adalah lebih baik daripada prestasi pemesinan AMMC. Untuk memesin pada MRR tertentu, kekasaran permukaan minima dan terlebihpotongan yang rendah boleh dicapai pada arus puncak yang rendah atau masa-ON yang pendek dan masa-OFF yang panjang dengan TWR yang masih tinggi. Parameter EDM yang optimum untuk pemesinan AMMC juga telah dikenalpasti dalam kajian ini.

Kata Kunci: EDM, Masa-ON, komposit matriks logam aluminium, MRR, TWR.

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PREFACE

This thesis is based on the work carried out at Mechanical Engineering Department, Universiti Teknologi PETRONAS during the period January 2008–June 2010 under the supervision of Dr Ahmad Majdi Abdul-Rani and Co-supersized by Assoc. Prof. Dr Faiz Ahmad and Mr Azman Zainuddin. This thesis is written based on results obtained during a two and half year project regarding machinability of aluminium matrix composite reinforced with alumina using electro-discharge machine. The project was funded by Universiti Teknologi PETRONAS. The project addresses the challenges in machining composite materials using a non-conventional process.

Alexis Mouangue Nanimina