Faculty of Manufacturing Engineering

MULTI OBJECTIVES OPTIMIZATION OF CUTTING PARAMETERS IN MACHINING CELLULOSE BASED HYBRID COMPOSITES

Zuraidah binti Zainudin

Master of Manufacturing Engineering
(Quality System Engineering)

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A thesis submitted
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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Manufacturing Engineering (Quality System Engineering).

Signature	:	…….....
Supervisor Name	:	Dr. Raja Izamshah bin Raja Abdullah
Date	:	26 June 2014

DECLARATION

I declare that this thesis entitled “Multi objectives optimization of cutting parameters in machining cellulose based hybrid composites” is the result of my own research except as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……

Name : Zuraidah binti Zainudin

Date : 26 June 2014

DEDICATION

To my children Irshaad, Humaira and Nabeeha, may this work becomes one of your inspirations in life. The time that we have sacrificed for my studies may not be pleasantly remembered but someday you will learn and understand that life is all about facing the challenges, learning and adapting. Please remember that it is not always about the end result, but the experience and knowledge we gain throughout the journey matters most.

ABSTRACT

Cellulose based hybrid (CBH) composites is gaining popularity in the growing green communities. People are progressively inventing greener and sustainable alternatives. With extensive studies and increasing number of applications for future advancement, the need for accurate and reliable guide in machining this type of composites has increased enormously. Smooth and defect free machined surface are always the ultimate objectives. The present work, deals with the study of machining parameters (i.e. spindle speed, feed rate and depth of cut) and its effects against machining performance (i.e. surface roughness, delamination and cutting forces) in due to establish an optimized setup of machining parameters in achieving multi objectives machining performance. CBH composites that is made in combination of jute (bast fiber) and glass fiber embedded in polyester resins were fabricated using Vacuum Infusion Process (VIP). Mechanical properties test demonstrates that jute-glass hybrid laminate has higher specific modulus as compared to glass and jute laminates alone. Through Response Surface Methodology (RSM), Box-Behnken Design (BBD) is chose as the design of experiment and subsequently 17 runs are devised. Next, mathematical model for each response is developed. Adequacy of models is analyzed statistically using analysis of variance (ANOVA) in determination of significant input variables and possible interactions. Various diagnostic plots are evaluated to check the model effectiveness. Multi objectives optimization is performed through numerical optimization and predicted results are validated. The agreement between experimental and selected solution are found to be strong in between 89% and 96%, thus validating the solution as optimal run condition. The findings suggest that feed rate is the main factor affecting surface roughness and delamination factor, whereas depth of cut, feed rate and followed by spindle speed are found to have significant effects on the cutting forces. Increase of feed rate and/ or depth of cut will increase the cutting forces. When this condition is coupled with low spindle speed, the cutting forces increase substantially. Similar to synthetic FRP, high cutting forces is proven to have proportional effects on the surface roughness and delamination. Therefore it is recommended to couple high spindle speed with low feed rate and depth of cut to minimize cutting forces and subsequently improving the machining surface quality.

ABSTRAK

Komposit hibrid berasaskan selulosa (CBH) semakin popular dan mendapat tempat di dalam komuniti yang mementingkan penyelesaian secara lestari. Dengan pertambahan dan kepelbagaian aplikasi serta kajian untuk kemajuan masa depan, keperluan untuk mempunyai panduan yang tepat dan boleh dipercayai dalam pemesinan komposit ini telah meningkat dengan mendadak. Objektif utama dalam pemesinan adalah menghasilkan permukaan yang licin dan tiada kecacatan atau kerosakan. Kajian ini dilakukan dengan mengkaji parameter pemesinan (iaitu kelajuan gelendong, kadar suapan dan kedalaman pemotongan) dan kesannya terhadap prestasi pemesinan (iaitu kekasaran permukaan, pemisahan lamina dan daya pemotongan) untuk menghasilkan kombinasi parameter pemesinan yang optima dalam mencapai prestasi pemesinan yang terbaik berdasarkan pelbagai objektif. Komposit CBH yang dihasilkan dengan kombinasi gentian jut dan gentian kaca digabungkan dengan resin polyester melalui Proses Infusi bervakum (VIP). Ujian mekanikal menunjukkan bahawa lamina hibrid jut -kaca mempunyai modulus spesifik yang tinggi berbanding dengan lamina kaca dan lamina jut semata-mata. Melalui Response Surface Methodology (RSM), reka bentuk eksperimen dipilih berasaskan Box-Behnken design (BBD) dan seterusnya 17 susunan pemotongan telah dirancang. Seterusnya, model matematik bagi setiap tindak balas dibangunkan. Kecukupan model dianalisis secara statistik menggunakan ANOVA dalam menentukan input pembolehubah (faktor) yang penting dan kemungkinan adanya interaksi di antara pembolehubah. Pelbagai plot diagnostik dinilai untuk memeriksa keberkesanan model. Pengoptimuman dengan pelbagai objektif dilakukan melalui pengoptimuman berangka dan keputusan yang dijangka akan disahkan. Keserasian antara keputusan eksperimen dan yang dijangkakan, adalah tinggi di antara 89 % dan 96 %, oleh itu penyelesaian yang dipilih adalah penyelesaian yang optima. Pemerhatian dan analisis melalui eksperimen mencadangkan bahawa kadar suapan merupakan faktor utama yang mempengaruhi kekasaran permukaan dan faktor pemisahan lamina, manakala kedalaman pemotongan, kadar suapan dan diikuti dengan kelajuan gelendong didapati mempunyai kesan yang penting pada daya memotong. Peningkatan kadar suapan dan / atau kedalaman pemotongan akan meningkatkan daya pemotongan. Apabila keadaan ini digandingkan dengan kelajuan gelendong yang rendah, daya pemotongan meningkat dengan ketara. Sama seperti sintetik FRP, daya pemotongan yang tinggi terbukti mempunyai kesan yang berkadar langsung dengan kekasaran permukaan dan pemisahan lamina. Oleh itu, adalah disyorkan untuk menggandingkan kelajuan gelendong yang tinggi dengan kadar suapan yang rendah dan juga kedalaman pemotongan yang rendah untuk mengurangkan daya pemotongan dan seterusnya meningkatkan kualiti permukaan yang dimesin.

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LIST OF SYMBOL

D	Cutting tool diameter (mm)
f	Feed per revolution (mm/rev)
Fd	Delamination factor
Fx	Cutting force in x-axis (feed force)
Fy	Cutting force in y-axis (normal force)
N	Spindle speed (rpm)
Ra	Surface roughness average
v	Cutting speed (m/min)
v_f	Feed rate (mm/min)

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LIST OF ABBREVIATIONS

AFP	Agence France-Presse
ANOVA	Analysis of Variance
ASTM	American Society for Testing Materials
BBD	Box-Behnken Design
CAGR	Compound Annual Growth Rate
CBH	Cellulose Based Hybrid
CCD	Central Composites Design
CFRP	Carbon Fiber Reinforced Plastics
DLC	Diamond like Coating
FAO	Food & Agricultural Organization
FRP	Fiber Reinforced Plastics
GFRP	Glass Fiber Reinforced Plastics
PCD	Polycrystalline Diamond
RSM	Response Surface Methodology
VIP	Vacuum Infusion Process