UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

MULTI OBJECTIVE PERFORMANCES OPTIMIZATION OF HYBRID ROTARY ULTRASONIC ASSISTED MICRO DRILLING ON CHEMICALLY STRENGTHENED GLASS

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MUHAMAD FIRDAUZ BIN ABD. RASID

A thesis submitted
in fulfillment of the requirements for the degree of Master of Science
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2021

DECLARATION

I declare that this thesis entitled “Multi Objective Performances Optimization of Hybrid Rotary Ultrasonic Assisted Micro Drilling on Chemically Strengthened Glass” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

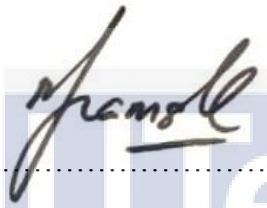
Signature : ……

Name : Muhamad Firdauz Bin Abd. Rasid

Date : 30/08/2021

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 Science in Manufacturing Engineering.

Signature : 

Supervisor Name : Associate Professor Dr. Raja Izamshah Bin Raja Abdullah

Date : 30/08/2021

DEDICATION

My beloved father, mother, family, supervisor, and supportive friends accompany me along the problematic pathway in my university life.

ABSTRACT

The usage of chemically treated strengthened glass has become a revolutionary and steadily increased for the past decade, predominantly by the electronic devices industry. Chemically treated strengthened glass offered a great strength as a result of a post-production chemical process by means of an ion-exchange process that improved scratching, impact and bending strength, as well as increased temperature stability which makes it as a preferred material for electronic panel display devices application such as mobile phone and tablet PCs screen, camera lens, optical component and many more. In such aforementioned applications, micro holes drilling is required to serve for particular purposes such as camera lenses, speakers and proximity sensors. However, due to the inherent properties of chemical treated toughened glass, stronger under compressive stress and weak under tension, it is a challenge for the subsequent secondary manufacturing process such as hole drilling. Conventional drilling process towards this glass tends to generate high tensile stress that consequently affects the hole performances and accuracy. This study proposed a significant advancement in improving the hole drilling quality using a hybrid machining technique. The hybrid technique combines two of established machining processes into a new combined setup known as Rotary Ultrasonic Assisted Drilling (RUAD). In order to obtain desired drilling quality specifications, namely, hole quality (burr area), and drilling thrust force, the ultrasonic machining and amplitude function performances are investigated. The Burr shape characterization and quantification are processed using the JAVA digital image processing software ImageJ, which is captured using the optical microscope (EMZ-13T Meiji Techno). Meanwhile, the thrust force measurement will be obtaining using kistler dynamometer (9257 B) The machine parameter, namely cutting speed in the range of 1000-3500 rpm, feed rate (0.5-1 mm/min), ultrasonic frequency ranging between 20 and 27 kHz, and amplitude (1-3 µm), were used. The aluminium oxide (Al2O3) slurry was applied within the machining ultrasonic environment. The 5% of concentration slurry circulated inside a designated slurry pool. The electroplated diamond tool was used to perform the drilling process. The experimental run based on the statistical Taguchi matrix was executed, comprising a different machining parameter. The further investigation proceeded by using statistical Response Surface Methodology for finding the best set of optimal machining parameter and satisfactory validation index. Based on the compromises decision between the responses on cutting speed and feed rate, the optimized parameter of drilling CSG glass was selected is 6511 rpm and 0.50 mm/min under RUAD condition of 27 kHz (ultrasonic frequency) and 1 µm (amplitude), with with the highest desirability index with 97.5%. The responses which are the burr area accuracy entry and exit with the machining trust force having relative percentage error with1.03%, 0.99%, and 0.37% respectively compared to prediction model values. Besides, the analytical results demonstrated that, the presence of the intermittent ultrasonic vibration amplitude was able to minimize the chipping area and enhance the hole quality with acceptable tolerance value.

PENGOPTIMUMAN PRESTASI PELBAGAI OBJEKTIF BAGI PENGGERUDIAN MIKRO HIBRID TERBANTU ULTRASONIK UNTUK KACA YANG DIPERKUAT SECARA KIMIA

ABSTRAK

Penggunaan kaca diperkuat kimia telah menjadi revolusi dan terus meningkat untuk dekad yang lalu terutamanya oleh industri alat elektronik. Gelas diperkuat secara kimia menawarkan kekuatan hebat hasil daripada proses kimia pasca pengeluaran dengan cara proses pertukaran ion yang meningkatkan daya tahan calar, kesan dan kekuatan lenturan, serta peningkatan kestabilan suhu yang menjadikannya sebagai bahan pilihan untuk aplikasi elektronik peranti paparan panel seperti skrin telefon mudah alih dan tablet PC, lensa kamera, komponen optik, dan sebagainya. Dalam aplikasi seperti tersebut, penggerudian lubang mikro diperlukan untuk tujuan tertentu seperti lensa kamera, pembesar suara dan sensor jarak. Walau bagaimanapun, disebabkan sifat-sifat yang wujud dari kaca yang dirawat kimia di mana tegasan mampatan yang kuat dan lemah di bawah ketegangan menjadikannya sebagai cabaran untuk proses seterusnya iaitu penggerudian lubang. Proses penggerudian konvensional pada kaca akan cenderung menghasilkan tekanan tegangan tinggi yang seterusnya memberi kesan kepada prestasi lubang dan ketepatannya. Kajian ini mencadangkan signifikasi kemajuan dalam meningkatkan kualiti gerudi lubang menggunakan teknik mesin hibrid. Teknik hibrid menggabungkan dua proses pemesinan yang digabungkan ke dalam satu proses dikenali sebagai Rotary Assisted Drilling (RUAD). Untuk mendapatkan spesifikasi kualiti penggerudian yang diinginkan, iaitu, kualiti lubang (luas serpihan) dan daya tujahan penggerudian, prestasi pemesinan ultrasonik dan fungsi amplitud diselidiki. Pencirian dan pengukuran bentuk serpihan diproses dengan menggunakan perisian pemprosesan gambar digital JAVA ImageJ, yang ditangkap menggunakan mikroskop optik (EMZ-13T Meiji Techno). Sementara itu, pengukuran daya tujah akan dilakukan dengan menggunakan dynamometer kistler (9257 B) Parameter mesin, iaitu kecepatan pemotongan dalam julat 1000-3500 rpm, kadar suapan (0,5-1 mm/min), frekuensi ultrasonik antara 20 dan 27 kHz, dan amplitud (1-3 µm), digunakan-pakai. Buburan aluminium oksida (Al2O3) diterapkan dalam lingkungan ultrasonik semasa pemesinan. 5% kepekatan buburan beredar di dalam kolam buburan yang dicipta. Alat berlian adur digunakan untuk melakukan proses penggerudian. Jalanan eksperimen berdasarkan matriks Taguchi statistik digunakan dimana yang terdiri dari parameter pemesinan yang berbeza.Penyiasatan kemudian diteruskan dengan menggunakan statistik Surface Respon Metodologi untuk mencari set terbaik parameter pemesinan optimum dan indeks pengesahan yang memuaskan.Berdasarkan keputusan kompromi antara tindak balas mengenai kecepatan pemotongan dan kadar suapan, parameter optimum penggerudian kaca CSG yang dipilih adalah 6511 rpm dan 0,50 mm/min di bawah kondisi RUAD 27 kHz (frekuensi ultrasonik) dan 1 µm (amplitud), dengan dengan indeks keinginan tertinggi iaitu 97.5%. Respon ketepatan kemasukan dan luar kawasan serpihan dengan kekuatan kepercayaan pemesinan, mempunyai ralat peratusan relatif masing-masing dengan 1.03%, 0.99%, dan 0.37% berbanding dengan nilai model ramalan. Selain itu, hasil analisa menunjukkan bahawa, kehadiran amplitud getaran ultrasonik dapat meminimumkan kawasan celah dan meningkatkan kualiti lubang dengan nilai toleransi yang dapat diterima..

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Muhamad Firdauz Bin Abd. Rasid,

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AP	-	Adeq Precision
ANOVA	-	Analysis of Variance
CCD		Central Composite Design
CNC	-	Computer Numerical Control
CSG	-	Chemically Strengthened Glass
DOE	-	Design of Experiment
ECM	-	Electrochemical Machining
EDM	-	Electrical Discharge Machining
FCCD	-	Face-centered Central Composite Design
GFRP	-	Glass Fibre Reinforced Plastics
HFRP	-	Hybrid Carbon/ Glass Fibre Reinforced Polymer
ISE	-	Indentation Size Effect
MUSD	-	Micro Ultrasonic Drilling
RUAD	-	Rotary Ultrasonic Assisted Micro Drilling
RSM	-	Response Surface Methodology
RUM	-	Rotary Ultrasonic Machining
USM	-	Ultrasonic Machining
USMM	-	Ultrasonic Micro Machining
VAD	-	Vibration-Assisted Drilling