DESIGN AND DEVELOPMENT OF THE ROUND BAR MOTORIZE JIG FOR THE ROTARY ABRASIVE WATER JET (RAWJ) PROCESS

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This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Process) (Hons.)

by

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DECLARATION

I hereby, declared this report entitled "Design and Development of The Round Bar Motorize Jig for The Rotary Abrasive Water Jet (RAWJ) Process" is the results of my own research except as cited in references.

Signature	:	……..
Author's Name	:	MOHAMMAD SHAH ALL-HAFIZ BIN MOHD SHAHRIM
Date	:	16 June 2017

APPROVAL

This report submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfillment of the requirements for the degree of Bachelor Manufacturing Engineering (Manufacturing Process) (Hons.).

……..

DR. MOHD SHAHIR BIN KASIM

(Principle Supervisor) - Signature & Stamp

ABSTRAK

Projek ini mencadangkan adalah untuk mereka-bentuk dan mencipta jig pemutar ke atas spesimen bulat untuk proses *Rotary Abrasive Waterjet* (RAWJ). Teknologi ini adalah salah satu teknologi hibrid yang dikaji dalam jangka tahun terdekat. RAWJ adalah berdasarkan pemesinan yang mengaplikasikan tembakan air sebagai medium pemotongan seperti pelarik konvensional yang memutarkan spesimen dengan menggunakan mekanisme bindu dan alat pemotongannya adalah perkakas pemotongan. Jig pemutar direka melalui perisian reka bentuk seperti *Solidwork* di mana reka bentuk konsep yang dipilih berdasarkan kaedah *Pugh* yang terdiri daripada konsep pemeriksaan dan pemarkahan. Kemudian, penciptaan dan pembuatan jig pemutar yang mempunyai dimensi kira-kira 510 x 340 x 150 mm melalui beberapa proses seperti proses pemotongan, proses kekemasan, proses penggerudian, proses pengaluran, proses pengisaran, proses berlubang alur, proses penyusuk dan proses poketan. Pembangunan jig pemutar yang mempunyai sedikit berbeza dari lain-lain jenis *abrasive waterjet turning* (AWJT) jig iaitu dengan penggantian bindu 3-rahang dengan mekanisme sesampai yang mempunyai ralat alir keluar paksi yang lebih rendah, ia juga direka untuk menjadi jig pemutar mudah alih dan panjang spesimen untuk proses mampu dilaraskan sehingga 200mm. Jig pemutar kemudian disahkan melalui beberapa standard dengan kategori yang berbeza iaitu Pertubuhan Standard Antarabangsa (ISO) standard 10816 untuk ujian pengukuran getaran, Institut Petroleum Amerika (API) standard yang mana API 617 (pemampat) dan API 612 (wap turbin) untuk sesampai alir keluar paksi apabila spesimen tidak diguna pakai dan ISO 7919 untuk fasa tergantung dan pemasangan stok ekor bagi spesimen apabila ia diguna pakai. Projek telah dijalankan untuk menentukan kebolehlaksanaan jig pemutar kepada proses penyusuk dan ujian telah dijalankan untuk dua putaran spesimen pada pepejal keluli lembut dengan diameter bersaiz 16mm. Hasil daripada permukaan pemotongan sepanjang 10 mm pada spesimen dengan tembakan tekanan air setinggi 380MPa diperhatikan dengan menggunakan mikroskop optik dan keputusan menunjukkan bahawa kerataan permukaan pemotongan bagi arah berlawanan jam dilihat lebih baik daripada aliran mengikut arah jam.

ABSTRACT

This project proposes is to design and develop the round bar motorize jig for the rotary abrasive water jet (RAWJ) process. This technology is one of the hybrid technologies that been studied throughout the years. RAWJ is based on machining which applied the abrasive waterjet as the cutting medium such as in the conventional lathe that turning the specimen with the chuck mechanism and cutting tool is the cutting medium. The motorize jig is designed through the Solid-Work design software where the final conceptual design is selected based of the Pugh method that consist of screening and scoring concept. Then, the development and fabrication of the motorize jig which have dimension approximately about 510 x 340 x 150 mm is undergo several processes such as cutting process, squaring process, drilling process, tapping process, milling process, slotting process, profiling process, pocketing process. The development of the motorize jig have slightly different with the other type of abrasive waterjet turning (AWJT) jig which the replacement of the 3-jaw chuck with the collet mechanism which have lower runout error, it is designed to be portable motorize jig and the length of the specimen to be process is adjustable up to 200mm. The developed motorize jig is then validate through several standard with different categories such are the International Standard Organization (ISO) 10816 standard for the vibration measurement test, the American Petroleum Institute (API) standard which are API 617 (compressors) and API 612 (steam turbines) for the collet runout of the unload specimen and the ISO 7919 for the overhang and tailstock installation for the loading specimen. Project has been conducted to determine the motorize jig feasibility upon the profiling process and the test were run for two different specimen rotation on the solid mild steel with 16mm in diameter. The result of the 10mm length of the specimen cutting surface with abrasive waterjet pressure at 380MPa is observed by using of the optical microscope and the results show that the waviness of the specimen cutting surface for the anti-clockwise flow direction seen more finer than the clockwise flow direction.

DEDICATION

To my beloved family,

Mr. Hendri Anto,

Ms. Yasmameri Binti Syarbaini,

Ms. Qistina Rachel Binti Ali

My Supervisor,

Dr. Mohd Shahir bin Kasim

My friends and technician especially to Mr. Mohd Hanafiah Bin Mohd Isa,
the CNC lab technician that involve in this study and project,
May Allah ease our journey and bless all of us. InshaaALLAH

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To my family, who raised and taught me that all the knowledge of life that we cannot get from school. To get the best knowledge that can teach us is by learning through our own mistake. All the mistakes that have been done by us can make us stronger and turn us to wise person. It not easy to learn something that new for us, learning can be hard sometimes but with hard and strong perseverance, nothing can stop us learns and gain experience. Last but not least, I would like to thank my friend and colleagues for their encouragement and moral support which lead to completion of my Final Year Project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

2D	2 Dimension
3D	3 Dimension
Al	Aluminum
ACC	Acceleration
API	American Petroleum Institute
AWJ	Abrasive Waterjet
AWJT	Abrasive Waterjet Turning
CAD	Computer Aided Design
CNC	Computer Numerical Control
DISP	Display
DOP	Depth of Penetration
FTK	Faculty of Technologies Engineering
ISO	International Standard Organization
Kg	Kilogram
LDPE	Polyethylene
mm	Milimeter
N	Newton
MAZ	Material Effected Zone
PSM	Final Year Project
RPM	Revolution Per Minute
RAWJ	Rotary Abrasive Waterjet
RSM	Response Surface Methodology
SOP	Standard operating procedure
UTeM	Universiti Teknikal Malaysia Melaka
VEL	Velocity

CHAPTER 1
INTRODUCTION

In this chapter, it starts with the general overview of Abrasive Water Jet (AWJ) operation. Then followed by a brief explanation and classification of the rotary abrasive waterjet (RAWJ) technique and the application of motorize jig in the AWJ machine are also described. This chapter ended up by determining the research objectives, scope of research work and finally the significance of the research conducted.

1.1 Background Study

In this 20's century, there are lots of processes that use advanced machining such as electrochemical process, hybrid electrochemical process, chemical process, and thermal process. The Abrasive Water Jet (AWJ) machine is one of advance machining process which currently high demand nowadays due to its accuracy.

Figure 1.1 shows that the AWJ is classified as non-traditional machining process which did not involve any direct contact between the tool and the work piece even though the water medium is actually make in contact with the specimen. AWJ also was selected because the characteristic features of this process have extremely low cutting forces and negligible thermal effects. Hence, AWJ is the most congruent for machining material hard to be machined and heat-sensitive.

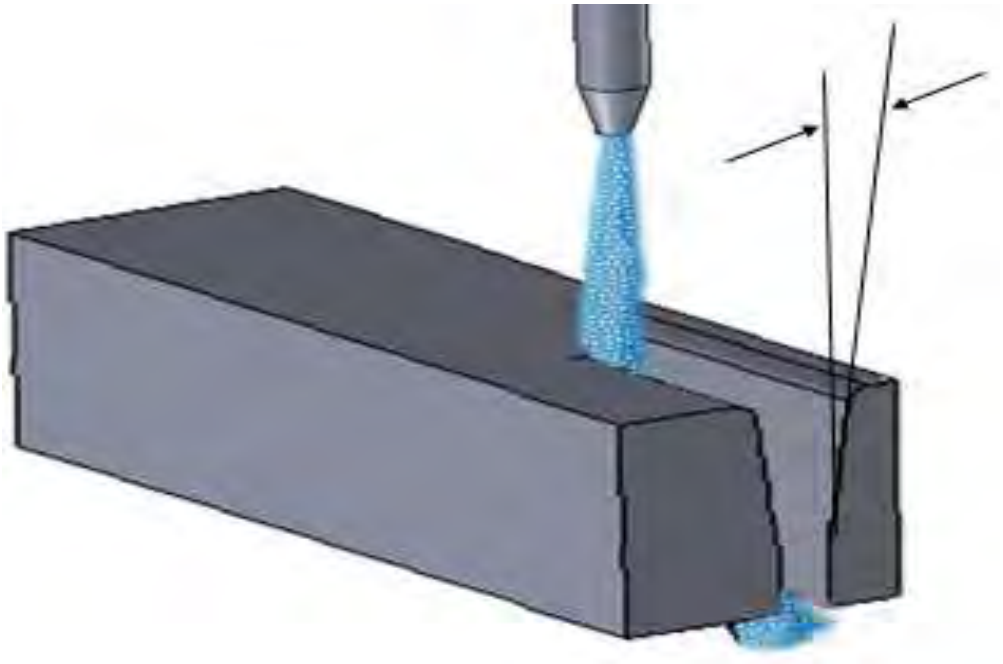

Figure 1.1 : Waterjet cutting process (Hassan, 2004)

By adding abrasives to the water jet during AWJ machining, it is able to cut harder material such as concrete, ceramics, glass, and tough composites can be cut (Hassan, 2004) without using any special fixtures or fixture modification. In AWJ the similar cutting tool can be used for turning, milling, drilling, and possibility contouring of virtually in any geometry by replacing an entire workshop of machine tools. So it is very suitable for use in this experiment.

AWJ machine is a process for cutting difficult material to machine and make cutting without reducing the properties of materials (Pang & Wang, 2009). The AWJ typically used in industry to cut ceramics, or hard material (Hassan, 2004). All the components of an AWJ machine are recyclable and environmentally friendly due to its composed water and some naturally occurring minerals were used to perform the process. Instead of that, AWJ does not even need cooling medium and did not require chemicals or synthetic oils for lubrication (Mark *et al.,* 2011).

AWJ process occurred by uses an abrasive to do the cutting path on the specimen using compress water and released through a nozzle. Because of the high velocity, the cutting process could be done quickly. This machine cuts almost all types of materials (conductive

and nonconductive). Where the traditional machine unable to perform effectively, especially for brittle and ductile materials. The non-traditional method has been introduced to conduct the cutting process in order to improve the productivity compared to the conventional machine method (Palleda, 2007).

Nowadays AWJ has been used in a wide variety of machining applications such as milling process which it used from the composite application towards to the aerospace alloys application, while for turning process, it still needs to be find its niche application. The utilization of the technology can be understood by the niche application such as the rotary AWJ where it applied in which several technologies were combined into one such as turning and the AWJ machining.

The combining is due to the AWJ application itself, which it is possibly can be applied with certain difficulty where it can cut into harder material, even though it has the limitation such as low material removal rates (MRR), very challenging to cut materials or lacking of efficiency cost. For the past decade, certain investigation work on rotary AWJ that study on the MRR, quality part e.g. finishing surface, geometrical accuracy or erosion mechanism exist at the jet specimen interface while reflect with the parameter influence such as the mesh size (abrasives), feed rate and rotational speed, and the jet impact angles on the machining process.

Even though the studied were comprehensive in their trial approach, the rotary AWJ fail to be present as the niche technology that acquire the necessary key enablers such as significantly higher productivity and MRR than the existing machining while considering particular specimen materials, cost reduction associated with consumables and tooling.

So, through the context, the paper presents the niche application for dressing or profiling the shaft geometrical shape through the use of the rotary AWJ. Dressing stated means to re-sharping or cleaning based on its initial contour while profiling is referring to the process that generated the shaft contour. From these statements, the rotary AWJ would open the new avenues for further research on design improvement of rotary AWJ jig thus enhances the performance while it operates.

1.2 Problem Statement

In recent years, AWJ technique was used in milling and specially turning operations. The turning operation were less applied due to its limitation. In turning operation, the process is more sensitive to materials properties unlike the AWJ which less sensitive to material properties and hence does not cause chatter and imposes minimal stresses on the specimen during the cutting process (Aswathy *et al.,* 2015).

Besides that, due to direct contact between the cutting tool and the specimen, this cause the rise of the specimen temperature, so the strength decreases while the ductility increases (Hassan, 2004). This phenomenal called as the material work hardening which change the material properties due to heat generated during the contact.

In other word, by transforming the AWJ application into the rotary AWJ, it can be greatly minimized the tool life usage, such as insert and the processing time where most of the AWJ perform with the CNC technology where with this advantage, it can greatly increase the productivity of the operation.

According to Eckart Uhlmann *et al.* (2012), the tool life time of at least 10 hours combined with a material removal rate of up to 0.8 cm^3/min and low process temperatures give this cutting technology a very high potential. This show that the abrasive waterjet turning to be a suitable cutting process for these challenging materials.

AWJ is also the environmental friendly machining process, since the machined debris are carried away by the water jet itself and are self- cleaning due to the penetration of the waterjet pressure into the specimen is directed to the machine tank.

Last but not least, the AWJ is the process that applies pressurized water used to perform the cutting process, so there are no heat affected zones presence and residual stresses during the surface generation process (Aswathy *et al.,* 2015).

In the RAWJ, it would traverse in axial and radial course with rotating specimen by the used of motorize jig to produce the required geometry. Motorize jig structure needs to be developed in order to perform the RAWJ. The motorize jig is design and develop would be the one that use to rotates the round bar specimen during the cutting process. The developed motorize jig is then studied and the performance is validate.

1.3 Objective

The objectives are as follows:

i. To design and develop the motorize jig to perform the rotary abrasive waterjet cutting process.
ii. To validate the motorize jig performance and compare it with the standards.

1.4 Scope and Key Assumption

The scope of the study as follows:

i. Design motorize jig for the rotary AWJ machining.
   To perform the method that use to finalize the best conceptual design of the motorize jig..
ii. Fabricate the motorize jig.
   The fabrication of the motorize jig may involve the other machining process to produce the final form of the motorize jig.
iii. Implement the designed motorize jig.
   The motorize jig is then implement to the abrasive water jet machine to validate its performance during the cutting process.

iv. Rectification of designing motorize jig.

If the performance of the motorize jig is not well functionally, some rectification and correction need to done, so that the performance of the motorize jig become better.

v. Validate the motorize jig performance.

The motorize jig need undergo the validation steps by used of several instrumentation. The result collected need to be compare with the traceability standard. So, the performances of the motorize jig can be justify through the appropriate standard.

1.5 Significance of Study

The significance of study is as follows:

i. AWJ machining already well known nowadays, but then RAWJ is still new for the hybrid technology. So, this research is design and developed the motorize jig to perform the RAWJ.

ii. Possible torque might happen during the process need to be justified. So that the jig's motor is the need to be justify. The information needs to be gathered in fabricating the motorize jig.

iii. The motorize jig fabricated need to be tested as well as when the AWJ notch the nozzle into the specimen whether the runout of the specimen is still under the standard range. Thus, the implementation of the fabricated motorize jig needs to be done, and information data gathered.

iv. All the information, data gathered needs to be used in modifying the motorize jig. So that the problem issues could be encountered. Then the rectification of the designing motorize jig can be done.

v. Reduce the issues happen could increase the performance of the motorize jig. So, the comparison between before and after rectification should be justified and why it could occur.

1.6 Summary

Before starting on designing and developing a motorize jig, the first step is to gather some data by doing some study and research for better understanding on the project. This was done by using resource through internet, journal, questionnaires, book, literature review and some of presents study cases that reflect and relevance to this project. This report consists of the basic understanding of the advantages of the AWJ, how the motorize jig would help to perform the rotary AWJ process.

All the gathered data from research will be covered in Introduction chapter and Literature Review chapter where in the introduction chapter is basically stated and discuss about the understanding of what actually this project all about, while for the Literature Review is more related to the previous research or studied data from another researcher and the scenario that could happen and need to be overcome during the machining.