UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEPTH OF CUT ANALYSIS USING PLASMA CUTTER FOR HYBRID MACHINE INNOVATION

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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TAJUK: **Depth Of Cut Analysis Using Plasma Cutter For Hybrid Machine Innovation**

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Engineering) (Hons.). The member of the supervisory is as follow:

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ABSTRAK

Pada zaman moden sekarang, terdapat perningkatan penyelidikan dalam pemesinan dan penerokaan dalam inovasi teknologi. Salah satu kejayaan penyelidikan adalah mesin hibrid iaitu di mana gabungan dua atau lebih proses dalam sebuah mesin. Peningkatan persaingan dalam industri untuk mencapai kejituan yang tinggi selain kepercayaan dalam permesinan, mesin konvensional menjadi nadi dalam pelbagai industri. Proses konvensional yang selalu diketengahkan adalah Pemotongan Secara Plasma Udara. Kadar kejituan produk akhir dan kebolehan untuk memotong pelbagai bahan yang keras dan dapat membentuk rekabentuk yang komplek untuk memenuhi permintaan pasaran. Berdasarkan kajian terdahulu dalam tesis ini telah menganalisis rangka kerja untuk memaksimumkan keputusan, kaedah separa *two factorial* telah digunakan untuk tujuan tersebut. Siri *orthogonal* yang sesuai telah diputuskan berdasarkan bilangan parameter dan terdapat peringkat yang melaksanakan bilangan ujian yang minimum. Bahan kerja *Ameriacan Iron and Steel Institute* (AISI) D2 iaitu besi bahan kerja digunakan untuk tujuan ujikaji. Nilai yang terbaik diputuskan dengan menggunakan plot perkadaran yang utama dan jadual analisis perbezaan (ANOVA). Persamaan regrasi untuk kedalaman potongan telah dihasilkan melalui perisian Design Expert 7.0. Ujikaji pengesahan untuk kedalaman potongan telah dijalankan dan keputusan ujikaji yang diberikan untuk mengesahkan keberkesanan perdekatan ini dengan kedalaman pemotongan sebanyak 4.625mm dengan ralat yang diterima adalah dibawah 10%. Persamaan antara model berangka peringkat pertama yang dihasilkan dalam projek dengan keputusan ujikaji ini untuk Jarak pemotongan menggunakan pemotongan secara Plasma adalah 96.7 % dan persamaan ini dapat digunapakai dalam menjimatkan kos dan masa proses pemotongan.

ABSTRACT

Within modern age, there is huge investigation in machining and exploration in innovation of technology. On the list of successful project is hybrid machine within the combination of two or more process in single machine. The increasing of competition in industry and on order to achieve high precision and reliability, today the nontraditional machining are become lifeline of almost any industry. The most essential nontraditional machining approaches are Air Plasma Machining. Its finishing, high precision, the capability to cut variety hard materials and to create complex design raises the need in industry. Throughout thesis literature review has been analyzed in framework to parametric optimization of Air Plasma Cutting Machine. In order to achieve target and optimum results, two level factorial method utilized. The suitable orthogonal array has been decided according to number of parameter and there levels to execute minimum testing. The work pieces of American Iron and Steel Institute (AISI) D2 tool steel materials were used for experiment purpose. The best possible value has been decided with by using major influence plot and ANOVA table. The Regression equation for distance of cut has been developed with the help of Design Expert 7.0 Software. Verification experiments have done to verify the value predicted throughout software. The verification for Distance of cut run has been carried and experimental results are provided to confirm the effectiveness of this approach, the DOC value was 4.625mm. Error within 10 % was allowed, where the similarity between model and experimental result is 96.7%, the conclusion that, this model can used for reduce the process time and cost

DEDICATION

For my beloved mother, lecture, friend and also to everyone who were with me all the time

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Alhamdulillah and grateful to ALLAH S.W.T for giving me the strength, patience and perseverance in completing the Final Year Project

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CHAPTER 1
INTRODUCTION

1.1 Introduction

Topic of this thesis writing is analysis of the surface integrity by using a plasma cutting for the hybrid machine technique. The focus of this project is keen to obtain an optimum condition (setting) and also to obtain maximum Distance Of Cut (DOC).

The result of the electrical arcs when air plasma is heating air to a high temperature to ionize its atoms (the result is due to an unequal number of electron to protons to an equal temperature an electrically is charged) and allowing it to conduct electricity. The light will be produced by a fluorescent lamp when you are reading by lights where you see plasma in action and containing of low pressure mercury within the shinning tube of the lamp. A across electrodes with a high voltage that is ionized at the ends of the tube conducts an electric current which result the plasma to radiate which in turn causes the phosphor coating on the inner surface of the tube to glow (Miller, 2013) .

Oxy-acetylene cutting repeatedly is the process of selecting fast cutting over steel plate in many years. The using of the plasma cutting has an attractive much full over, for the some good reasons to perhaps a most vital for many years. Electrical conductive that is

an electrical metal such as stainless steel, aluminum; copper, brass etc will be cut by plasma cutter.

The cutting that is hotter and tighter than an oxy-acetylene flame is ensured by the plasma jet which gave kerfs width smaller with a cleaner cut. Compare with oxy-acetylene the plasma cutting mainly suitable for cutting a sheet metal and meanwhile a task the oxy-acetylene cutting torch is not mostly well-suited for since it leaves a lot of slag on the edges. Moreover the particularly tight focus of the plasma arc tends to reduce heat distortion in the cut parts.

For reaching high quality, in term of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase of the product performance with reduced environmental impact are the challenges that mostly focused with. End milling is the ability to control the process for a better quality of the final product that is very commonly used and very high importance for machining process in machining industry.

Hardened steels are substantial in reducing machining costs and lead times compared to more traditional machine route which benefits in the manufacture of components (Koshy, 2002). AISI D tool steel group is extensively used in making molds and dies, but the machine ability of this group is very poor indeed.

1.2 Process Description

Plasma cutting is the process used to cut steel and other metals (or sometimes other materials) by using a plasma torch. In this process an inert gas (in some units, compressed air) is blown at high speed out of a nozzle and at the same time an electrical arc is formed through that gas from the nozzle to the surface that has being cut and turning some of that gas to plasma. Plasma is used for welding and other applications

due to it is sufficient hot to melt the metal that has being cut and also fast to blow molten away from the cut (Sacks, 2005).

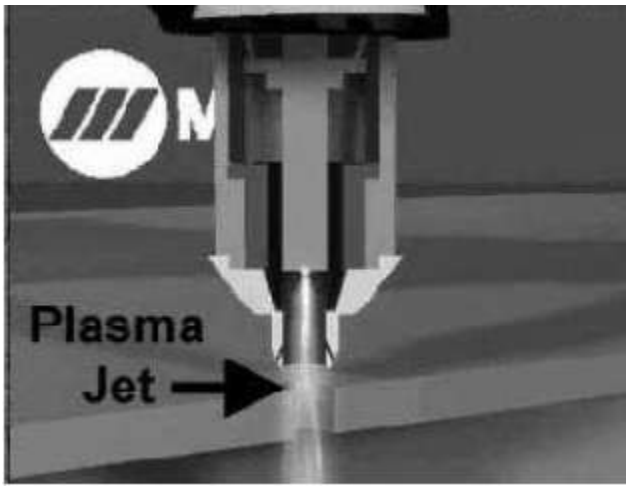

Figure 1.1- Plasma Jet

Space or area surrounding the circumference of the electrode that air plasma has between the inside circumference of the torch tip or nozzle is the chamber where the air heated and ionized and heating that cause air greatly expand in volume and pressure. With a very high speed of temperatures; up to 16,000 degrees C and 6000 m/s air exits from the constricting orifice of the torch nozzle or tip. The intensity and velocity of the plasma are determined by a several variables including the type of gas, its pressure & volume, the flow pattern, the amount of electric current, the size and shape of the constricting tip or nozzle orifice, and the tip to work distance.

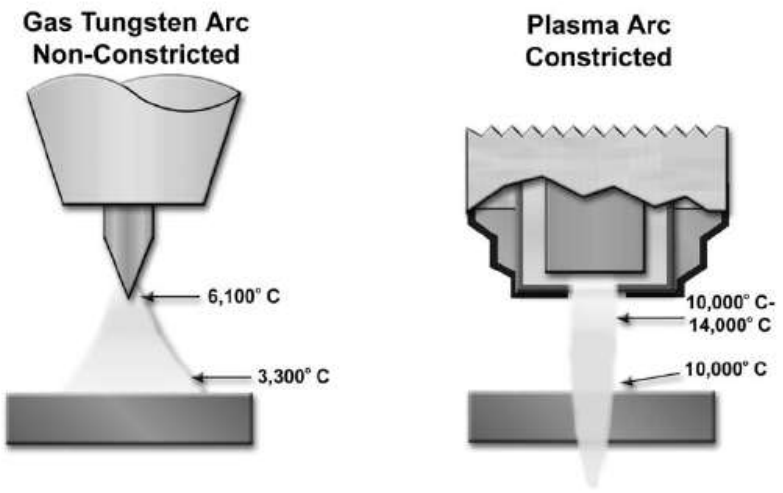

Figure 1.2 - TIG and Plasma Arcs

High temperature, constricted, high velocity jet of ionized gas exiting from the constricting orifice of the torch tip to melt a much localized area and remove the molten material from the metal being cut by the force of the plasma jet are where the APC process is used. This process is happened when the force of the arc pushes the molten metal through the work piece and severs with APC the material gave an extremely clean and accurate cuts are possible due to tightly focused heat energy that has a very little warping, even when cutting thin gauge sheet metal thickness.

1.3 Problem Statements

Conventional materials exhibit in a very excellent technical properties. But however the constraints such as a high cost of both raw materials and processing limit their use. Alternatively the advanced machining such as Air Plasma Cutting is normally used. Material such as Stainless steel, Soft Steel and Aluminum can be used as the work piece in this type of cutting.

To form a jet for welding, spraying of molten metal and cutting of hard rock or hard metal a torch is required in temperatures as high as 30000°C this is achieved by injecting

air tangentially into an electric arc formed between electrodes in a chamber and this is resulting vortex of hot gases emerges at very high speed through a hole in the negative electrode.

Compare to Oxy-Fuel torch or abrasive saws that are using low or no heat affected zone air plasma cuts ferrous and non-ferrous metal much faster. A clean cut with little or no dross means less time and money is required to finish the work piece. Parts are virtually weld-ready.

By using air plasma less preparation of work is required due it is hot enough to burn through most surface coatings such as paint and rust and still provides an excellent cutting results and minimal heat input and distortion of the metal as there is with jigsaws or cutting shears. Applications such as ventilation ductwork (HVAC), tanks or vessels, plasma cutting offers considerable advantage since there is no fixturing required are being used to handle difficult shape.

In order to obtain the best factors combination (Distance of Cut) an experiment and using full factorial methods of the processing is needed to prove feasibility and effectiveness.

The two distinct speeds can be characterized for plasma cutting. At feed rate above, the plasma jet does not cut through metal plate and another one at speeds below, the molten metal from the kerf sticks to the bottom of the plate, forming the so-called dross and how to properly select a plasma cutting system. Currents, metal thicknesses and nozzle orifice diameters can be cut by Plasma with AISI D2.

1.4 Objectives

The objectives of this experiment are:

1. Design and fabricate a set of jig to guide the Plasma Air Cutter at the HAZ2 CNC Milling Machine.
2. To study about the influence of Plasma Air Cutting Parameters on Distance of Cut at Tool steel (AISI D2).
3. To design a series of experiment using the help of Design of Experiments (DOE) layout in order to study about Plasma Arc Cutting (PAC).
4. To study about the best combination of solution for maximizing the Distance Of Cut with full factorial method.

1.5 Scope of project

The scope of this project is to:

a) The design of Jig to guide the plasma cutter will perform using Solidwork 2012 software and no performance analysis will generate.
b) The fabricating of jigs design using CO2 Laser cutter machine for each part and use TiG welding machine for assembly section.
c) This project focuses on the optimization of cutting parameters of Plasma Air Cutting (PAC).
d) The material used as workpiece was Tool Steel of specification ASTM A681 D2 UNS T30402
e) Design of Experiments (DOE) layout will be used for testing and analyzing with Full Factorial Method.
f) The self-fabricate machine Haz2 mini CNC Hybrid Machine will used to perform the machining operation.

CHAPTER 2
LITERATUREREVIEW

2.1 Introduction

This part describes the principle of milling process. Air plasma the parameters by referring the journal beside, cutting tools and workpiece. This chapter also include about basic introduction about solid work, laser cutting machine and several part about the jig design.

2.2 AISI D12 Carbon Steel

American Iron and Steel Institute (AISI) D2 is a high-carbon, high-chromium tool steel alloyed with molybdenum and vanadium. It characterized by high resistance, compressive strength, firm hardening properties, high hardening stability, and good resistance to tempering-back. Refer table 2.1 for the details of the material.

Table 2. 1 Element in AISI D 12

Typical analysis	C	Si	Mn	Cr	Mo	V
	1.55	0.3	0.4	11.8	0.8	0.8
Standard Specification	AISI D2, W-Nr 1.2379					
Delivery condition	Soft annealed to approx. 210 HB					
Color code	Yellow/ white					

2.2.1 Application of AISI D2

AISI D2 is recommended for tool with high wear resistance and moderate toughness (shock-resistance) beside than that, it supply different finishes, which include hot-rolled, pre-machined, and fine machined condition. Refer table 2.2 for the properties of AISI D2.

Table 2. 2 Properties table of AISI D2

Temperature	20 ˚C	200 ˚C	400 ˚C
Density Kg/m³	7.700	7.650	7.600
Coefficient of thermal expansion -low temperature tempering per ˚C from 20 ˚C - high temperature tempering per ˚C from 20 ˚C	 - -	 12.3 x 10 11.2 x 10	 - 12 x 10
Thermal Conductivity W/m ˚C	20.0	21.0	23.0
Modulus of elasticity Mpa	210 000	200 000	180 000
Specific Heat J/kg ˚C	460	-	-

2.3 Milling Machine

Milling Machine is mechanism used to process, to produce the finish product and the chips from raw material. This Milling machines can be represented in two basic forms which are vertical and horizontal. Positioning of the cutting tool spindle is the basic form and meanwhile drill press is where work material static on the table and the cutting tool is moved vertically to machine the material otherwise milling machine which includes the movement of the work material against the spinning cutter .The movement of the cutting tool and work piece are accurately controlled to below than 0.025 mm, usually by means of precision instrument or analogous technology. Milling machines can be mechanically automated and may be manually operated, or digitally automated via computer numerical control (CNC). unnecessary number of processes, some complex, keyway cutting and such as slot, drilling, planning, rebating, die sinking, and routing can be performed by the Milling machine. Coolant is frequently pumped to the cutting site to lubricate and to cool the machining process. Techniques to categorize milling machines are dependent on which conditions are focuses:

Table 2. 3 CNC machine criteria

Criterion	Example classification scheme	Comments
Control	Mechanically ; Manual; Digitally automated via NC/CNC; automated via cams.	In the CNC age, a very basic difference is manual versus CNC. Among manual machines, a worthwhile distinction is non-DRO-equipped versus DRO-equipped
Control (specifically among CNC machines)	Number of axes (e.g., 3-axis, 4-axis, or more); Within this scheme, also: Full-auto tool changing Versus semi-auto or manual tool changing Pallet-changing versus non-pallet-changing	