STUDY OF PLASMA CUTTING EFFICIENCY WITH DIFFERENT OPERATING PARAMETERS

By

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TABLE OF CONTENTS

CHAPTER 2 LITERATURE REVIEW

CHAPTER 4 RESULTS, ANALYSIS AND DISCUSSION

LIST OF FIGURES

LIST OF TABLES

LIST OF EQUATIONS

Equations No.

(1) $MRR = \frac{WRW}{T} \quad \frac{[g]}{[sec]}$

(2) $MRR = \frac{WRV}{T} \quad \frac{[mm3]}{[sec]}$

(3) $WRV = \frac{WRW}{\rho}$

(4) $MSD = \frac{(\quad)\ (\quad)\ \ldots\ (\quad)}{}$,QC = N

(5) S/N = 10Log10 ,QC = N

(6) $MSD = \frac{(\ )\ (\ )\ \ldots\ (\ )}{}$,QC = S

(7) S/N = -10Log10 ,QC =S

(8) MSD = $\frac{\overline{} \quad \overline{} \quad \ldots \quad \overline{}}{}$,QC = B

(9) S/N = -10Log1- ,QC = B

LIST OF SYMBOLS ABBREVIATIONS OR NOMENCLATURE

ANOVA	Analysis of Variance
DOE	Design of Experiment
OA	Orthogonal Array
g	gram
QC	Quality Characteristic
MSD	Mean Standard Deviation
CF	Correction Factors
S’	Factor sum of squares
P	Percentage
S/N	Single to Noise Ratio
ST	Total sum of square
SA	Sum of square of Factor A
PA	Percentage Deviation of Factor A
SB	Sum of square of Factor B

PB	Percentage Deviation of Factor B
SC	Sum of square of Factor C
PC	Percentage Deviation of Factor C
SD	Sum of square of Factor D
PD	Percentage Deviation of Factor D
T	Sum of all observations
$\sum Yi^2$	Sum of square Deviation

KAJIAN KECEKAPAN PEMOTONGAN ARCA PLASMA DENGAN FAKTOR-FAKTOR YANG BERBEZA

ABSTRAK

Plasma, fasa keempat bahan yang membezakan pepejal atau cecair atau gas dan hadir dalam bintang-bintang kombinasi reaktor-reaktor; sesuatu gas menjadi plasma apabila gas tersebut dipanaskan sehingga atom-atomnya kehilangan elektron-elektronnya, dan meninggalkan sekumpulan nuklei dan elektron-elektron bebas yang tinggi pegecasan elektriknya. Penggunaan mesin temaju seperti Mesin Pemotong Arka Plasma adalam amat jarang di dalam industry untuk kegunaan pemotongan bahan-bahan seperti Mild Steel, Copper Aloi dan Aluminum. Mesin Pemotong Arka Plasma model Selco Genesis 90 telah digunakan dalam kajian ini umtuk memotong Copper Aloi, Aluminium dan Mild Steel. Penggunaan kaedah Taguchi Design of Experiments bermula dari langkah perancangan sehingga ke peringkat penganalisaan dapatan kajian telah digunakan. Dalam kajian ini, Lay-out L-9(34) telah digunakan. Faktor-faktor yang diambil kira dalam kajian ini adalah tekanan udara [bar], aliran arus elektrik [A], halaju pemotongan [mm/min] dan jarak arka [mm]. Faktor-faktor ini digunakan untuk penganalisaan tentang pelarasan untuk mengoptimumkan pembolehubah Mesin Pemotongan Arka Plasma untuk mendapatkan kombinasi yang terbaik. Kesan faktor-faktor ini ke atas pancapaian Mesin Pemotongan Arka Plasma adalah Kadar Pembuangan Bahan (MRR) dan Kelicinan Permukaan (Ra). Ujian pengesahan perlulah dijalankan untuk mengesahkan nilai yang dianggarkan melalui perisian. Ujian pengesahan yang telah dijalankan menggunakan pelarasan yang diperolehi daripada perisian. Nilai optimum yang dijangkakan dan nilai sebenar yang diperolehi daripada ujian pengesahan yang dibenarkan mestilah di dalam ralat 10%.

ABSTRACT

Plasma, a fourth state of matter distinct from solid or liquid or gas and present in stars and fusion reactors; a gas becomes plasma when it is heated until atoms lose all their electrons, leaving a highly electrified collection of nuclei and free electrons. The usage of advanced machining, such as Plasma Arc Cutting machine to cut Mild Steel, Copper Alloy and Aluminium was very limited in the industry. Selco Genesis 90 Plasma Arc Cutting machine was used to cut Copper Alloy, Aluminium and Mild Steel in this study. The usage of Taguchi approach Design of Experiments from the designing steps until the analyzing phase from the experiment was used. In this study, Design of Experiment L-9 (34) layout is used. In this study, the parameters determined were the air pressure [bar], current flow rate [A], cutting speed [mm/min] and arc gap [mm]. These parameters used to analyze the setting required for optimizing the process variables for Plasma Arc Cutting machine to gain the best combination. The effect of these factors was the calculation of Material Removal Rate (MRR) and Surface Roughness (Ra). Confirmation test must be done to confirm the value estimated through the software. The confirmation run was done by using the setting gain from the software. The estimated optimum value and the actual value obtained from the confirmation test that is allowed are in range 10%.

CHAPTER 1

INTRODUCTION

1.1 Overview

The topic for the thesis writing is to study of the efficiency of plasma cutting with different operating parameters. The focus on this project is to obtain the best combination of those parameters in order to achieve optimum performance measures.

Nowadays, a lot of industries in the government sector and private sector are advances in the field of plasma cutting and have permitted the application of this technology in their company. The function of this plasma cutting is an arc cutting process that cuts metal by melting a localized area with the heat of a constricted arc. The various shapes of electric arc are emergent properties of nonlinear pattern of current and electric field. The arc occurs in the gas-filled space between two conductive electrodes and its results in a very high temperature, capable of melting or vaporizing virtually anything. The high temperature plasma arc cuts through a wide variety of metals at high speeds.

Advanced machining such as plasma arc cutting also grows fast in Malaysia. Currently it is used in the industry. So advanced material such as nickel alloy can be used as the work piece of this machine.

Plasma cutters are used in place of traditional sawing, drilling, machining, punching, and cutting. The high-temperature plasma arc cuts through a wide variety of metals at high speeds. Although plasma arc cutting can cut most metals at thicknesses of up to 4 to 6 inches, it provides the greatest economical advantages, speed, and quality on carbon steels under 1 inch thick, and on aluminum and stainless steels under 3 inches thick.

Plasma Arc cutting has been widely used in the industry but the fundamental of the usage is still limited. The feasibility and effectiveness of the usage need to be approving by using the Fractional Factorial from the Design of Experiment.

1.2 Problem Statement

Cutting process is the most important process to produce a product. It takes a lot of time to cut the material. So this study has been developed to find the solution about the problem of the cutting process, so the process will improve. Below is the problem of the cutting process:

i) Traditional way of cutting process takes a lot of time.

ii) What are the most factors that influence the cutting process?

iii) What are the optimum conditions to achieve optimum performances?

iv) The effective way to conduct the cutting process for Aluminium, Copper Alloy and Mild Steel.

1.3 Motivation

The focus on this research is to study, runs and to analyze plasma arc cutting efficiency based on several parameters. The machine used in this study is Selco Genesis 90. The new portable plasma cut generator in the genesis range by Selco features a modern innovative design. Exploiting the inverter resonant, this system is even more compact and lightweight and offers excellent quality.

The generator is the most powerful one in its weight category and is provided with ergonomic handle for easy transport. If used beyond the rated parameters a thermal device and mains voltage protection, protect the internal components from malfunctioning. Figure 1.1 below shows the Selco Genesis 90 Plasma Arc Cutter. Further information about this machine is discusses in part 3.3.1

Figure 1.1
Selco Genesis 90 Plasma Arc Cutter

Optimization of process parameters is the key step in Taguchi method to achieve high quality without increasing cost such as time and money. This is because optimization of process parameters can improve quality characteristic and the optimal process parameters obtained from the Taguchi method are insensitive to the variation of environmental conditions and other noise factors. C. Montgomery says basically, classical process parameter design is complex and not easy to use especially when a large number of experiments have to be carried out when the number of the process parameters increases. The Taguchi method uses a special design of orthogonal arrays to study the entire process parameter space with a small number of experiments only (Roy, 2001).

There are three categories of the quality characteristic in the analysis of the S/N ratio, i.e. the smaller is better, bigger is better and nominal is the best. The S/N ratio for each level of process parameters is computed based on the S/N analysis. Regardless of the category of the quality characteristic, a larger S/N ratio corresponds to a better quality