INVESTIGATION OF LASER CUTTING PARAMETERS ON SURFACE QUALITY OF STAINLESS STEEL

AZMAN BIN ANUAR

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Universiti Teknologi Malaysia

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To my beloved family father and mother , my wife - Norhasniza , my kids - Muhammad Aqil Farihin and Nur Damia Harisa, and my siblings. Thank for all your support .

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ABSTRACT

In this thesis, the optimal CO_2 laser cutting parameters on stainless steel AISI 304 with 2 mm in thickness were studied. The cut quality to achieve a uniform kerf with minimum kerf width for circular cuts of stainless steel sheets depends on appropriate selection of process parameters was investigated. The cutting parameters considered include laser output power level, cutting speed, cutting gas pressure, and focus length. The effect of the cutting parameters on the cut quality was further investigated by monitoring the kerf width, roundness, and diameter accuracy. The experiments were conducted by using the nitrogen gas assisted laser cutting, and the factorial analysis is employed to formulate an empirical formula for optimum.

ABSTRAK

Dalam tesis ini, mengkaji *CO2 laser cutting* parameter optimum pada *stainless steel AISI 304* dengan ketebalan 2 mm. Untuk permotongan yang berkualiti mencapai garitan seragam dengan *kerf width* bagi kepingan *stainless steel* yang tepat bergantung pada parameter proses. Parameter pemotongan dianggap meliputi tahap keluaran kuasa laser, kelajuan potong, pemotongan tekanan gas, dan panjang fokus. Pengaruh parameter pemotongan terhadap kualiti pemotongan itu berdasarkan penyelidikan lebih lanjut oleh pemantauan *kerf width*, kebulatan, dan diameter. Ekseperimen ini dijalankan dengan menggunakan laser cutting gas nitrogen dibantu dan dianalisa dengan faktoran untuk merumuskan *empirical formula* menjadi optimum.

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LIST OF SYMBOLS AND ABBREVIATIONS

λ	-	wavelength
K	-	beam quality factor
M^2	-	times diffraction limit factor
D	-	beam diameter at the optic
d_f	-	focused beam diameter
z	-	depth of focus
f	-	focus length
F	-	focus length diveded by the beam diameter at the optic
d_o	-	beam waist diameter
ψ	-	angle between the plane of polarization and cutting direction
P		plane of polarization
cw		continuous wave laser power
BPP		Beam Parameter Product
CO_2		carbon dioxide
DPSSLs		diode pumped solid state lasers
HAZ		heat affected zone
LPSSLs		Lamp Pumped Solid State Lasers
Nd: YAG		Neodymium –Yttrium Aluminium Garnet
TEM_{00}		lowest order beam mode/ diffraction limit
Yb: YAG		Ytterbium: Yttrium Aluminium Garnet

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CHAPTER 1

INTRODUCTION

1.1 Overview

Laser cutting is a two-dimensional machining process in which material removal is obtained by focusing a highly intense laser beam on the workpiece. Laser cutting finds wide application in industry. This is mainly due to the ability of lasers to produce high quality cuts at reasonable production rates.[1]).

The production of lasers and laser systems for material processing has grown continuously over the last few years because of its economic benefits, such as high quality, high productivity, saving of the pre- and post-processing of the material, and minimum waste of base material. The industrial applications of material processing with laser machining systems are mainly laser cutting (39%), laser welding (20%), laser labelling (16%), laser micromachining (8%), and laser drilling (4%) [2].

Industrial applied materials, which can be machined by a laser beam, include steel, alloyed steel, aluminium, copper, ceramics, composite material, plastic, glass, and wood. The CO_2 laser and Nd:YAG laser (solid state laser) are the main lasers used for industrial cutting applications. The CO_2 laser is the most commonly used, especially for cutting of thick sections, because of its better beam quality compared

with the Nd:YAG laser of a similar power level and the CO_2 lasers are also available in higher output powers than the Nd:YAG lasers.[3]

Stainless steel is used extensively in a number of everyday applications in the home, industry, hospitals, food processing, farming, aerospace, construction, chemical, electronics, and energy industries; the austenitic grade of stainless steel is the most used by far. Cutting of stainless steel sheets is one of the primary requirements in the fabrication of most of the components. Laser cutting offers several advantages over conventional cutting methods such as plasma cutting.[3]

In the experimental part of this study, the cutting experiments covered cutting of austenitic stainless steel (grades AISI 304) of sheet thickness of 2.0 mm using the CO_2 laser cutting. The cut qualities were analyzed by measuring the kerf width, roundness and diameter.

The laser cutting parameters will be used for these experiments are power and cutting speed, pressure and focus length Because the previous researchers, prove this parameter affect to cutting quality of laser cutting.

1.2 Problem statement

Laser cutting finds wide application in industry. This is mainly due to the ability of lasers to produce high quality cuts at reasonable production rates. However, there are some problems with the process that require immediate attention, because no standard laser cutting setting parameters to archive the good cutting quality on stainless steel.

This material are common used in industry, home, hospitals, food processing, farming, aerospace, construction, chemical, electronics, and energy industries but

difficult to setting the parameter with good cutting quality by CO_2 Laser Cutting Machine.

1.3 Objective

To investigate the effect of independent factor such as machine power, cutting speed, pressure and focus length on cutting quality of stainless steel sheet with 2mm thickness using CO_2 laser cutting.

1.4 Scope

a) These experiments are conducted by using of machine CO_2 laser cutting model Trumatic L2530 plus 2.0 kw.
b) The investigated material is 2 mm thickness of stainless steel 304 sheet.
c) The laser cutting parameters will be used for these experiments are machine power, cutting speed, pressure and focus length.
d) The responses to be study are kerf width, roundness error and diameter accuracy.