KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

QUALITY INVESTIGATION OF LINEAR LASER CUTTING

Thesis submitted in accordance with the requirements of the National Technical University College of Malaysia for the Degree of Bachelor of Manufacturing Engineering (Honors) (Manufacturing Process)

By

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ABSTRAK

Kualiti dalam pemotongan laser adalah satu daripada proses laser yg penting sebagai system laser untuk pembangunan bahagian pengawalan, diagnosis, pengaturan dan modelmenjadi keperluan untuk mecapai dan mengekalkan kualiti yang tinggi dalam proses pemotongan. Oleh itu kajian dalam kualiti dalam pemotongan laser pada garis lurus ini adalah untuk mencapai objektif yang perlu dicapai dalam kajian ini serta mencari tindakbalas parameter dalam pemotongan laser mengunakan kepingan besi. Di samping itu, eksperimen ini adalah untuk miningkatkan kualiti pada produk yg dihasilkan. Eksperimen ini adalah untuk mengenalpasti kaedah yg digunakan untuk membantu mengurangkan kos dan mengurangkan pembaziran bahan mentah. Kajian ini memfokuskan kepada beberapa parameter seperti tekanan gas, frekuensi dan putaran tugas. Ekperimen ini dijalankan dengan menggunakan Helius 2513 Laser Cutting, Roughness Tester SJ-301, CNC Roundness Tester dan software CADMAN.

ABSTRACT

The quality of laser cuts is one of utmost importance in laser processing as laser systems are becoming for developments in the area of monitoring, diagnosis, regulation and modeling becomes essential to achieve and maintain high-quality cutting process. Consequently, the present study examines the quality investigation in linear laser cutting experimentally to achieve the objectives that need to achieve in this research is to find the quality of finish product onto linear laser cutting by using several of parameters in metal plates. Besides that, this experimental work is to improve the quality of finish product. This experiment is also to identify the method that can help to decrease the cost and reduce the material waste. This study is focus on several parameters such as gas pressure, frequency and duty cycle. By using the Helius 2513 Laser Cutting, roughness tester, CNC Roundness tester and apply the CADMAN software, this experiment will do.

DEDICATION

For my mum and my siblings.

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CHAPTER 1
INTRODUCTION

1.1 Introduction to the project

In laser processing technology, laser cutting is probably the most widely used. There are still many problems that not well-lessened in laser cutting. One of the major problems is the quality of finish product. Many attempts in improving the laser cut quality that has been made. These include monitoring and controlling the laser output power, monitoring the laser material interaction and modeling of the laser cutting process (Bekir S.Y, 1995).

There are many quality aspects that need to consider in laser cutting. The quality of a cut is usually specified by geometrical parameters. These include the size and form tolerances of the part, the extent of dross or burr attachments, burnouts, the average roughness and the rectangularity of the cut edge.

The most significant input parameters of the laser cutting process, besides the relevant material properties of the work piece are includes the laser beam power, the laser beam diameter at the surface plane of the work piece, the thickness of the work piece and the cutting speed, etc.

There are many research and experimental work that have been done in process parameter of laser cutting. But the most effective parameter still cannot define. Consequently, experimental investigation of effective respond in laser cutting becomes essential for obtaining the actual controlable parameters.

For example, an experiment which conducted by B.S. Yilbas is to assess the cutting quality and validate the Kerf width predictions. It is found that increasing laser beam scanning speed reduces the Kerf width while Kerf width increases with increasing laser output power. The main effects of all the parameters employed have significant influence on the resulting cutting quality. First law efficiency increases with increasing laser scanning speed, which substantiates as the workpiece thickness is doubled (B.S.Yilbas, 2004).

1.2 Objective

The objectives that need to achieve in this research is to find the quality finish in linear laser cutting by using several of parameters on metal plates. Besides that, this experimental work is to improve the quality of finish product. This experiment is also to identify the method that can help to decrease the cost and reduce the material waste.

1.3 Scope of Project

Nowadays the laser technology is growing rapidly and extensively used for various applications such as cutting, drilling, surface treatment, ablation and so on. Lasers are widely used in industry as cutting tools due to ultra flexibility of the cutting condition, obtaining high quality end product, quick set up, non-mechanical contact between the work piece and the tool, and the small size of the heat affected zone. Nevertheless, one has to know in detail about the quality of finished product with various types of material and thickness in linear laser cutting. In this experiment the scope is in the laser cutting. This experiment is more on CO_2 laser cutting.

The aim of this project has to be mainly designed to get quality of finish product in linear laser cutting by adjust several parameter in order to produce the best quality in dimension and surface finish of final product. By doing this, the appropriate type of material and its thickness can be identified of certain set of cutting parameters in order to optimize the machine with excellent end result.

1.4 Problem Statement

Although many knew about the capability of laser machines, very few of them can figure out the facts of the process, parameters and quality of the end product. Therefore, by this experiment the quality in linear laser cutting are to be identified, so that in future the information from the experimental work can be further extended or to be used for analysis / modeling to validate the result.

CHAPTER 2
LITERATURE REVIEW

2.1 Background

The principle of the laser was first known in 1917, when physicist Albert Einstein described the theory of stimulated emission. However, it was not until the late 1940s that engineers began to utilize this principle for practical purposes. At the onset of the 1950's several different engineers were working towards the harnessing of energy using the principal of stimulated emission. Among them were Charles Townes at the University of Columbia, Joseph Weber at the University of Maryland and Alexander Prokhovoc and Nikolai G Basov at the Lebedev Laboratories in Moscow.

At this stage the engineers were working towards the creation of what was termed a MASER (Microwave Amplification by the Stimulated Emission of Radiation), a device that amplified microwaves as opposed to light and soon found use in microwave communication systems. Townes and the other engineers believed it to be possible create an optical maser, a device for creating powerful beams of light using higher frequency energy to stimulate what was to become termed the lasing medium. Despite the pioneering work of Townes and Prokhorov it was left to Theodore Maiman in 1960 it invent the first Laser using a lasing medium of ruby that was stimulated using high energy flashes of intense light. Both Townes and Prokhorov were later awarded the Nobel Science Prize in 1964 for their endeavours.

The Laser was a remarkable technical breakthrough, but in its early years it was something of a technology without a purpose. It was not powerful enough for use in the beam weapons envisioned by the military, and its usefulness for transmitting information through the atmosphere was severely hampered by its inability to penetrate clouds and rain. Almost immediately, though, some began to find uses for it.

Maiman and his colleagues developed some of the first Laser weapons sighting systems and other engineers developed powerful lasers for use in surgery and other areas where a moderately powerful, pinpoint source of heat was needed. Today, for example, Lasers are used in corrective eye surgery, providing a precise source of heat for cutting and cauterising tissue (http://encylopedia.labortalk.com/).

2.2 Definition of Laser

A **laser (light amplification by stimulated emission of radiation**) is a device which uses a quantum mechanical effect, stimulated emission, to generate a coherent beam of light from a lasing medium of controlled purity, size, and shape. The output of a laser may be a continuous, constant-amplitude output (known as *CW* or *continuous wave*), or pulsed, by using the techniques of Q-switching, modelocking, or gain-switching. In pulsed operation, an optical amplifier when *seeded* with light from another source.

The amplified signal can be very similar to the input signal in terms of wavelength, phase, and polarisation; this is particularly important in optical communications. The verb "to lase" means to give off coherent light or possibly to cut or otherwise treat with coherent light, and is a back-formation of the term laser (http://encylopedia.labortalk.com/).

2.3 Properties of Laser Light

2.3.1 Linewidth

Laser light is highly monochromatic, is has very narrow spectral width. The spectral width is not zero, but typically it is much less than the conventional light sources. The narrow spectral line width is one of the most important features in lasers. Early calculation indicated that the line width could be a small fraction of 1 Hz. Of course, most practical lasers have much greater line width. (Donald C.O, W. Rusell.C). Figure 2.1 is the Lorenziant and Gaussian laser line width.

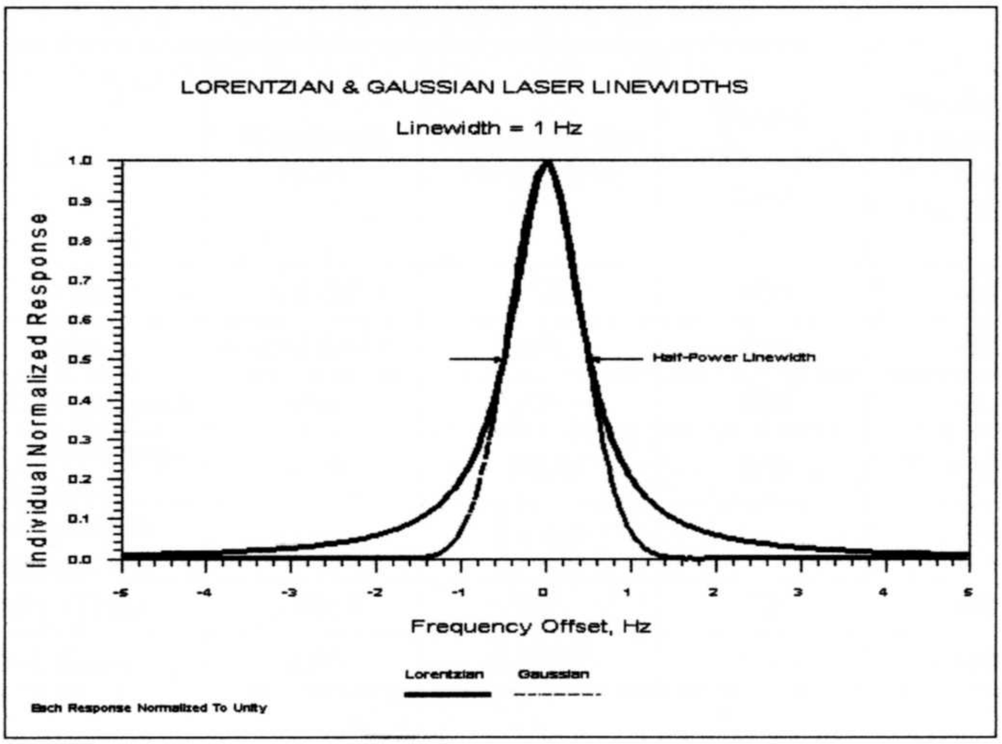

Figure 2.1: Lorentzian & Gaussian laser linewidth.

The light from a laser typically comes from one atomic transition with a single precise wavelength. So the laser light has a single spectral color and is almost the purest monochromatic light available.

That being said, however, the laser light is not exactly monochromatic. The spectral emission line from which it originates does have a finite width, if only from the Doppler effect of the moving atoms or molecules from which it comes.

Since the wavelength of the light is extremely small compared to the size of the laser cavities used, then within that tiny spectral bandwidth of the emission lines are many resonant modes of the laser cavity (http://hyperphysics.phy-astr.gsu.edu/).

Table 2.1: Showing the line width.

Laser	Wavelength (μm)	Fluorescent line width (MHz)	Typical cavity length (cm)	Number of modes under fluorescent line (c/2d)
He Ne	0.6328	1700	100	~10
Argon	0.4880,0.5145	3500	100	~20
CO_2 (low pressure)	10.6	60	100	~1
CO_2 (atmospheric pressure)	10.6	3000	100	~20
Ruby (Room Temperature)	0.6943	3×10^5	10	~200
Ruby (77 K)	0.6943	10^4	10	~6
Nd: Glass	1.06	6×10^6	10	~4000

2.3.2 Beam Divergence Angle

One of the important characteristics of laser radiation is the highly directional, collimated nature of the beam. The collimation is important because it means that the energy carried by the laser beam can easily be collected and focused to a small area.

2.4 Overview of Laser Material Processing

Material processing refers to a variety of industrial operations in the laser operates on the work piece to melt it or remove material from it (John F.R, Dar. F. F). The possible application in laser is include welding, hole drilling, cutting, trimming of electronics components and heat treating.

2.5 Laser Parameter

Laser can be characteristic by physical parameters such as the spatial and temporal properties of the output light, the active element producing the light, the pumping method and the resonator design. Also important are consideration such as size, weight, power required, efficiency, stability, and reliability (John F.R, Dar. F. F). The properties that determined the behavior of the light such as:

- Spatial and temporal coherence
- Operation in a continuous or pulse mode
- Spectral content
- State of polarization