NATIONAL TECHNICAL UNIVERSITY COLLEGE OF MALAYSIA

Study of Laser Cutting Machine & Its Application in Malaysian Industries

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

By

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Faculty of Manufacturing Engineering

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ABSTRACT

This project represents a highly simplified introduction to laser processing and a basic description of the major laser types in manufacturing industry. The project also covered machine classification, its advantages and disadvantages, laser applications, and also the statistic of usage of the laser cutting machine used in the Malaysian industries. This approach starts by considering only the laser cutting process that can occur when a laser beam strikes a surface. Both theory and practical give the answers that the beam is either reflected or absorbed on any material. In order to get the laser performance, a case study had been arranged in the machine shop of Manufacturing Faculty in the Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM). The result showed, the laser cutting perform the cutting accordingly to drawing given without any obstacle. Diameter of nozzle plays the main role when a small diameter in drawing is required. By the way, this project was better in search and investigation by visit to several industries in Malaysia. The searching was more industries which apply this technology in their site.

ABSTRAK

Projek ini dihasilkan untuk mempermudahkan pengenalan mengenai pemprosesan laser dan memberi gambaran asas jenis-jenis laser yang terdapat dalam industri pembuatan. Projek ini juga merangkumi klasifikasi mesin, kebaikan dan keburukannya, kegunaan laser dan juga statistik dalam penggunaan pemotongan mesin laser yang digunakan dalam industri di Malaysia. Secara pengenalan, proses pemotongan laser terhasil apabila terdapat perlanggaran elektron-elektron pada permukaan cermin pemantul di dalam mesin laser. Penggabungan antara teori dan praktikal memberi jawapan di mana kesemua elektron akan terpesong atau terserap pada semua jenis permukaan bahan. Dalam perlaksanaan untuk mendapatkan keberkesanan system laser, satu penyelidikan telah dijalankan di dalam bengkel Fakulti Pembuatan, Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM). Sebagai hasil, pemotongan laser ini dapat dijalankan berdasarkan lukisan yang diberikan tanpa menimbulkan sebarang masalah. Selain daripada itu, diameter nozzle memainkan peranan dalam menghasilkan pelbagai diameter samada kecil atau besar. Akan tetapi, untuk menghasilkan projek ini yang lebih berjaya, analisis dan pengkajian lanjut dilaksanakan dengan mengadakan lawatan ke beberapa buah industri yang terdapat di Malaysia. Pengkajian ini bertumpu kepada keberkesanan mesin laser ini dalam industri di Malaysia.

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DEDICATION

To my beloved father; Haron b Hj Jaus and beloved mother; Mazlina Tan Abdullah

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First of all, I would like to thanks to Allah for His bless and let my Final Year Project (PSM) successfully done. Then, I would like to appreciate my parents for their encouragement in my life besides full support in my project.

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SIGN AND SYMBOLS

KUTKM	-	Kolej Universiti Teknikal Kebangsaan Malaysia
UPM	-	Universiti Putra Malaysia
UKM	-	Universiti Teknologi Malaysia
LASER	-	**L**ight **A**mplification by the **S**timulated **E**mission of **R**adiation
CO2	-	Carbon Dioxide
mm	-	Millimeters
EDM	-	Electrical-Discharge Machining
ECM	-	Electrochemical Machining
CNC	-	Computer Numerical Control
Nd:YAG	-	Neodymium–Doped Yttrium–Aluminum–Garnet

CHAPTER 1
INTRODUCTION

Generally, in principle a laser transforms some external form of energy (an electrical discharge or radiation of a flash lamp or a laser diode) into light of a single wavelength (photons). This can be achieved in several ways for example the active laser medium can be a gas enclosed in a cavity or a solid crystal. The active photons accelerate the intensity of the beam of light and it will cross the partial mirror.

Lasers are devices that convert electrical or light energy into a light wave that propagates in principle in a certain direction and shows a small cross section perpendicular to the latter direction, a so-called 'beam of light' based on Schuöcker D. (2001) [1]. In addition to that, the latter beam or laser beam is the general case of a light wave, whereas limiting cases are spherical light waves which originating from point sources, and plane waves, generated by infinitely large sources. The last two cases applying to natural light whereby beams generated by artificial sources which called as lasers.

Lasers are an exciting enabling technology that still regularly catches public attention. From laser surgery to weapons applications, the laser has always fascinated technical people since its emergence from the Science labs in the early 1960's. According to Schuöcker D. (2001) [1], in the case of high power lasers with their application in material processing, the active medium can practically be an ionized gas (Gas laser) or an insulating or semi conducting crystal (Solid state laser).

Certainly, the laser has now become a common place tool for many engineers, and the highly specialized, highly dynamic nature of the processes by

which lasers assist in the manufacturing process are now much better understood by specialists in the field. This project represents a basic knowledge to laser processing and its application in the manufacturing industry besides the main characteristic that the industries can get from the technology of the laser cutting machine. Furthermore, sharing of knowledge and information by person in-charge in selected industries was assisting this project to study the product (job).

1.1 FOUNDATION OF THE LASER THEORY

The laser is a device that sustains steady state oscillations with a well-defined frequency in the optical range. In electrical engineering such devices are well known and their operation depends on the properties of amplifiers with frequency-dependent feedback as in the Figure 1.1 whereby it can call as closed-loop system. For this closed-loop system, the benefit is can know the errors that occur in the system and to maintain the system, so that it will in the range of requirement.

Based on Stenholm S. (1984) [2], the gain must be present to overcome the unavoidable losses in any physical system and the frequency selectivity is used to fix the oscillation frequency within the frequency range where the amplifier works, the gain bandwidth.

By refer to the feedback loop in Figure 1.1, assumed that the output Y is depend on the input X through

$$Y = A(X) \tag{1.1}$$

and the feedback signal is taken to be

$$X_m = FY \tag{1.2}$$

which usually is linear but on the frequency of the signal. With the feedback connected, the system satisfies the equation of

$$\mathbf{Y' = A\,(\,X + FY\,)} \qquad (1.3)$$

So, to get the equation of (1.3), the full equation is as below

$$\begin{aligned} Y' &= Y + X_m A \\ &= A\,(X) + FYA \qquad \text{;take the equation of (1.1) and (1.2)} \\ &= A\,(\,X + FY\,) \end{aligned}$$

Take note; Y is output (laser beam)
X is input (generate of laser beam)
A is adjustable parameter
F is feedback from output

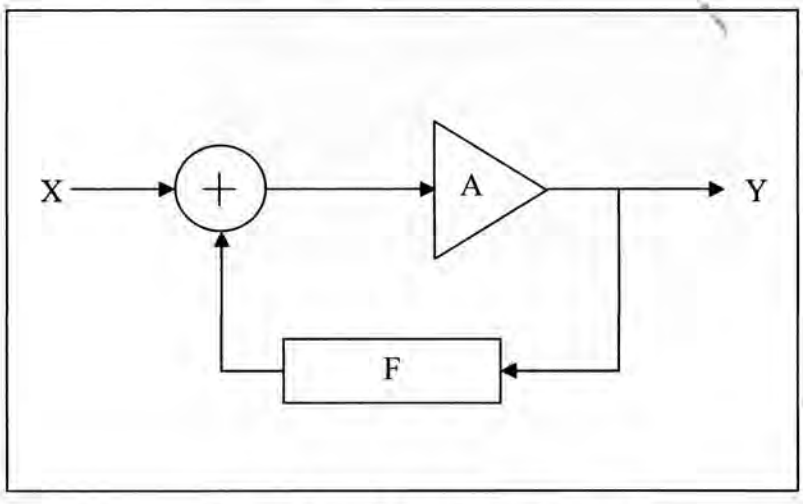

Figure 1.1: A closed-loop system

The atomic medium in the laser amplifies over a range of frequencies most of which are lost through the diffraction losses and leakage through the mirrors. The maser and the laser are hence self-sustained oscillators based on the quantum mechanical processes in atomic systems.

According to Stenholm S. (1984) [2], the name quantum electronics seems appropriately chosen for such investigations, even one is mainly interested in investigating the atomic properties, namely in laser spectroscopy, where interested in the nonlinear response of the medium in addition to the linear absorption.

1.2 THEORETICAL OF LASER

An important development in laser technology is based-gas laser in which the population is produced not by an electrical discharge but rather by expansion through a nozzle as in Figure 1.2.

Figure 1.2: The concept of laser cutting machine

The gas is heated to high temperature and pressure and allowed to expand through supersonic nozzle. Heating may be obtained by several methods such as by use of a shock tube or a plasma arc. The optical cavity is perpendicular to the flow. The gas flows past the optical cavity and is exhausted by a pump. As the gas passes through the region of the optical cavity, the pressure and temperature have cooled considerably because of expansion. The design of the nozzle is important for producing the desired conditions.

In the other hand, inside the laser resonator, the laser medium is placed between at least two mirrors. The laser light reflects back and forth between the mirrors, undergoing amplification each time it passes through the resonator. The output coupler is a partially translucent, partially reflective mirror, which allows a portion of the laser beam to exit out of the resonator. That portion is used for material processing such as laser cutting, laser welding or laser surface treatment. The other portion is reflected back into the resonator to continue the laser process.

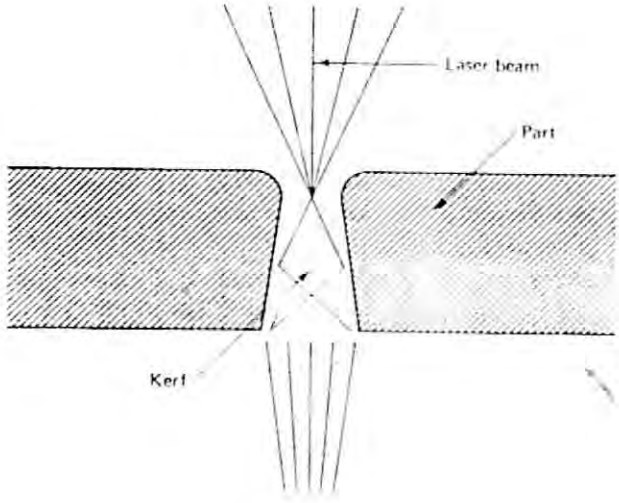

Figure 1.3: Kerfs produced by laser cutting

Furthermore, according to Luxon J.T. and Parker D.E (1976) mentioned that straight-sided kerfs can be achieved when cutting relatively thick materials as a result of a light-guiding effect due to multiple reflections from the sides of the kerfs as illustrated in Figure 1.3.

1.3 PRINCIPLE OF LASER CUTTING MACHINE

Figure 1.4 shows the required components in order to produce laser in the laser cutting machine. With this component, a laser cutting can be performed based on the requirement (drawing). There are some descriptions for each component as follows;

a) Laser source
   i) Mention on optical path and mirrors which this laser source will produce laser beam to nozzle by traveling using the mirrors.
b) Cutting gas
   i) For gas, usually used premix gas (40% He + 55% N2 + 5% CO2) to assist the laser cutting to perform it jobs.
c) Cutting head
   i) By combining laser source and cutting gas, the mixture will be shot on the material by using nozzle (cutting head).
d) Plate, profile, tube
   i) Certain surface to be cut depends on the thickness and material

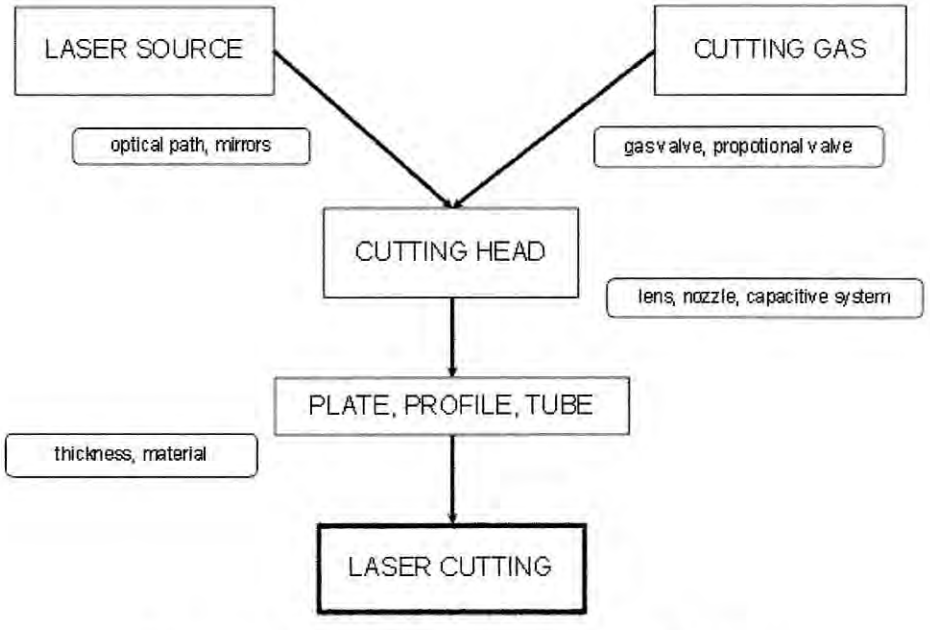

Figure 1.4: Required components to produce laser

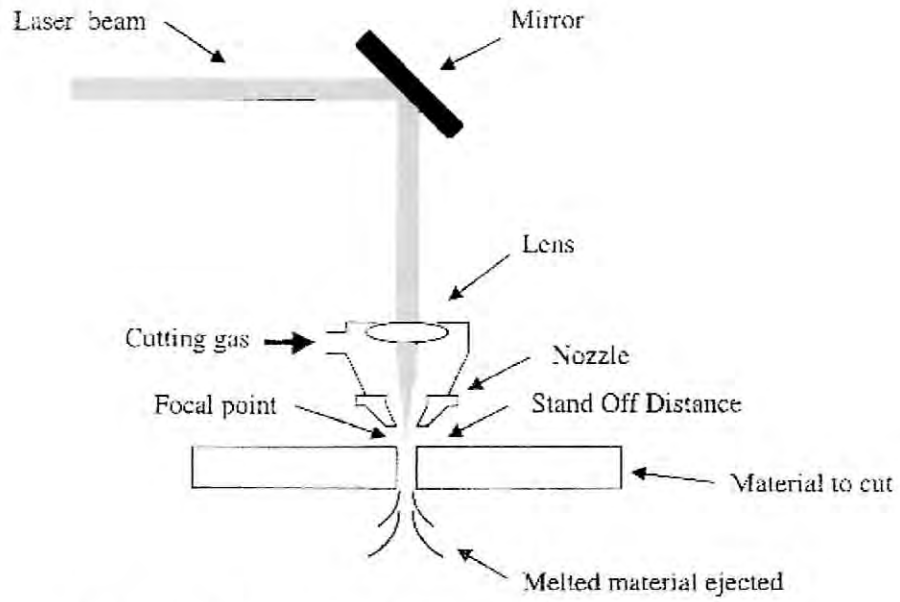

Figure 1.5: Principle of laser cutting deflected by mirror

The laser cutting (beam) is deflected through the bridge by using mirror as in Figure 1.5. At the end of point, laser cutting will melt the area to be cut and produce the required product.

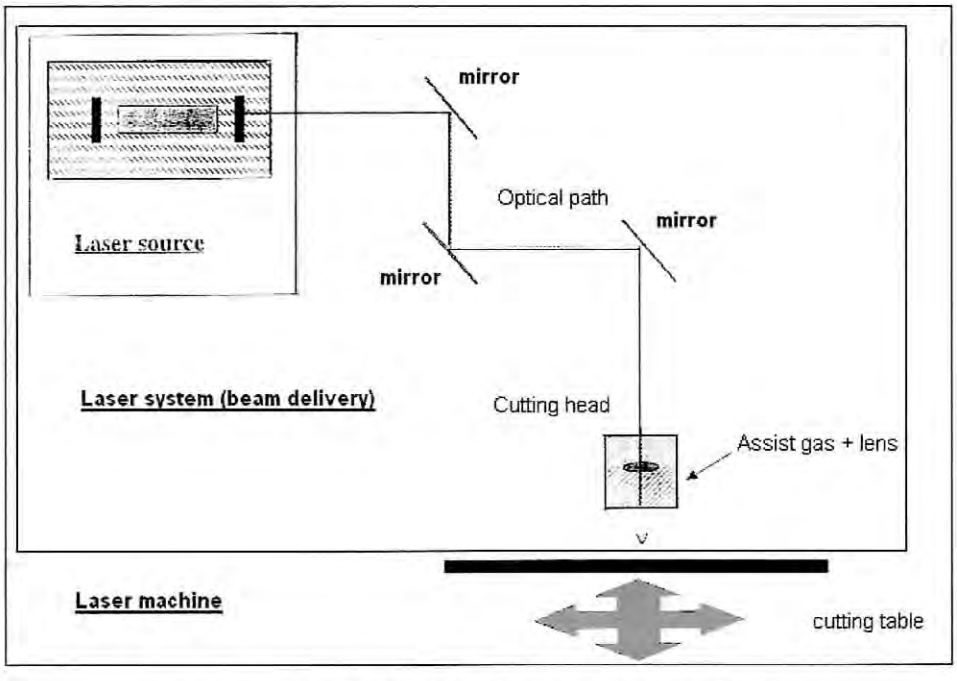

Figure 1.6: Principle of laser cutting machine