LASER CUTTING OF WOODS

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) with Honours.

by

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ABSTRACT

This research is about Laser Cutting of Woods which is done to determine either wood can be cut by laser. Others, it is done to determine the optimum condition to cut the wood by using laser cutting machine and furthermore to investigate the dimension accuracy and surface roughness produce by various types of parameters which are cutting speed and laser power. To conduct this research mainly on performing the experiments, firstly the types of woods with suitable thickness are defined first before it is cut by laser. The selected woods are from Ramin and Kembang Semangkok and Nyatoh with 10 mm thickness. All these woods are cut into square shape with 30 mm x 30 mm dimension. There are 48 specimens that have been cut where 16 specimens from Ramin, 16 specimens from Kembang Semangkok and 16 specimens from Nyatoh before it is analyzed according to its dimension accuracy and surface roughness. Based on the analysis that have been conducted, the best dimension accuracy and surface roughness for all these types of woods are from the lowest parameters that have been used in this experiment which are 1400 W for laser power and 2100 mm/min for cutting speed. The best cutting parameter to cut Ramin, Kembang Semangkok and Nyatoh are by using 1400 W for the power and 2100 mm/min for the cutting speed. From this experiment also, it is concluded that dimension accuracy increased when cutting speed and laser power decreased while dimension accuracy will decreased when cutting speed and laser power increased while the smoother surface produced when the cutting speed decreased while rougher surface produced when cutting speed is increased.
ABSTRAK

Kajian ini memperihalkan pemotongan kayu menggunakan teknologi laser di mana ia dijalankan untuk mengenalpasti sama ada kayu boleh dipotong menggunakan laser ataupun tidak. Selain itu, kajian ini juga dijalankan untuk mengkaji parameter terbaik untuk memotong kayu menggunakan laser disamping menguji ketepatan pemotongan dan kerataan permukaan kayu dengan menggunakan pelbagai parameter yang akan dijelaskan kemudian di dalam hasil kajian ini. Pertama sekali, bagi melakukan ujian-ujian yang telah dinyatakan, Kayu Ramin, Kembang Semangkok dan Nyatoh dengan ketebalan 10 mm dan dipotong mengikut bentuk segiempat sama berukuran 30 mm x 30 mm telah digunakan sebagai sampel uji kaji. Semua jenis kayu ini telah dipotong kepada 48 sampel di mana 16 daripadanya adalah daripada jenis kayu Ramin, 16 daripada kayu Kembang Semangkok dan 16 daripada kayu Nyatoh sebelum diuji ketepatan dimensi dan kerataan permukaannya. Berdasarkan analisis yang telah dilakukan, didapati bahawa ketepatan dimensi dan kerataan permukaan terbaik untuk semua jenis kayu yang digunakan ini adalah dengan menggunakan parameter yang terendah bagi eksperimen ini iaitu dengan menggunakan kuasa sebanyak 1400 W dan kelajuan pemotongan sebanyak 2100 mm/min. Daripada eksperimen yang telah dijalankan ini juga boleh disimpulkan bahawa ketepatan dimensi meningkat sekiranya kuasa dan kelajuan pemotongan menurun dan kerataan permukaan terbaik dihasilkan apabila menggunakan kelajuan pemotongan yang rendah.
DEDICATION

For my supervisor, beloved parents, siblings and friends from UTeM, UKM and UPM.
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<td>Projek Sarjana Muda</td>
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<td>CW</td>
<td>Continuous Wave</td>
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<td>HAZ</td>
<td>Heat Affected Zone</td>
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<tr>
<td>TEM</td>
<td>Transverse Electromagnetic</td>
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<td>Nd:YAG</td>
<td>Neodymium Yttrium Aluminum Garnate</td>
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<td>HeNe</td>
<td>Helium Neon</td>
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<td>HeCd</td>
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<td>CO₂</td>
<td>Carbon Dioxide</td>
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<tr>
<td>TEA</td>
<td>Transverse Excitation Atmospheric</td>
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<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>Nm</td>
<td>Nano Meter</td>
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<td>μm</td>
<td>Micro Meter</td>
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<td>kW</td>
<td>Kilowatt</td>
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<td>MW</td>
<td>Megawatt</td>
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<td>mm</td>
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CHAPTER 1

INTRODUCTION

1.1 Background

A laser is not something weird to the modern society nowadays because of the technology has advanced at a rapid rate since the first operational laser was built in 1960. In the other hands, lasers have developed onto reliable, productive and widely used tools over the past two decades as stated by Finlayson, D. M. and Sinclair, B. D. (1999). Laser also has widely used in many industries such as manufacturing, medicine, military and also in research field. In manufacturing industries, it is used for heat treatment, measuring application, welding and also for cutting materials. Anonymous 8 (2008) stated that, laser machining is one of the processes that are classified under the non traditional methods of machining.

Silfvast, W. T. (2004) stated that laser is a specialized light source that produces a highly directional, high intensity beam that most often has a very pure frequency or wavelength. Others, a beam that produce from laser is a very narrow, beam of monocolored light which can be controlled over a wide range of temperatures, ranging from one that would feel slightly warm to the several times hotter than surfaces of the sun at the point of focus.

In the other hands, laser machining has unique characteristics which are a non contact machining which mean no contact between workpiece and the tool beside it has a flexible process which make laser machining possible to produce new material removal methods such as woods. Others, materials such as composite, ceramic or hardened materials can be machine by laser since it is difficult to process by mechanical material removal methods.
As addition, laser cutting works by directing the output of a high power laser by computer to the materials to be cut according to the shape that has been design in computer by using the suitable software. Then, the material that being cut will either burns, melts, vaporized away or blown away by a jet of gas that will leaving an edge of a good or high quality of surface finish.

In cutting application, lasers are widely used to cut aluminum, mild steel and the other metals that available including diamond. Unfortunately, laser cutting of non-metals especially woods has not widely used or been accepted by the modern industry or precisely to the wood industry as stated by Nukman, Y. et al. (2008) because lack of research or exposure to this method.

1.2 Problem Statements

Normally, in woodworking industries they used a saw or table saw and for complex part or design such as fillet, carpenters skills are needed. Furthermore, when this machine or a carpenter service used, the surface finish produced is not too good and may not in the needed tolerance or in the other words, the dimension produced is not too accurate. Besides, the production rate may become slower when producing the complex part involving the woods. Nowadays, woodworking industries has grown widely because it is used in producing furniture and also building construction. Because of this, the production rate must be speed up to fulfill the customers needed. Others, beside the slow production rate and low quality of surface finish, Norpoth, K. et al. (1989) stated that the worse thing is the workers that involve in this industries is highly expose to nose and nasal cavity cancer because of the wood dust. Others, Rapp, A. O. et al. (2004) stated that wood dust also caused different allergic reactions such as asthma or dermatitis. So, because of these problems, a study about ‘Laser Cutting of Woods’ have been conducted as solution of the matters arise since laser cutting produced high quality surface finish, good accuracy, can cut complex part and also automatically it increase the production rate.
1.3 Objectives

The aim of this project is to study the process of laser cutting on several types of woods. Others, this project are aim to:

(a) Establish the optimum condition for wood cutting by laser.
(b) Investigate the dimension accuracy of wood produce by laser cutting.
(c) Investigate the surface roughness of wood produce by laser cutting.

1.4 Scope of Study

The scopes of study in this project are:

(a) Investigate the effects to the woods when various speed and laser power are used.
(b) To compare the wood’s dimension accuracy and surface roughness by using various type of parameters.

All scopes of study will be experimentally conducted by using several machines. For cutting process purpose, LVD Helius 2513 Laser Cutting Machine that available in Makmal Fakulti Kejuruteraan Pembuatan (FKP), Universiti Teknikal Malaysia Melaka (UTeM) will be use. Others, for surface roughness examination, Surface Roughness Tester SJ-301 will be use and for dimensioning, vertical optical comparator will be use. Last but not least, the specimens that will be used are woods from Ramin, Kembang Semangkok and Nyatoh species.
CHAPTER 2
LITERATURE REVIEW

2.1 Introduction to Laser

The word laser is an abbreviation for light amplification by stimulated emission of radiation and is a device that emits light throughout a few processes which are stimulated emission where a natural effect that was deducted by considerations relating to thermodynamic equilibrium and optical feedback which present in most lasers that is provided by mirrors. In the other word, stimulated emission occurs in a laser that consists of a gain or amplifying medium and a set of mirrors to feed back into the amplifier to continued growth of the developing beam as seen in Figure 2.1. (Silfvast, W. T., 2004)

According to Silfvast W. T. (2004), there are two outputs that produced from laser. One is the continuous in time that is called as continuous wave (CW) and the other one is pulsed in time either as a single pulse or as a train of pulses.

When comparing laser properties to the other light sources, it can readily recognize that the value of various parameters for laser light either greatly exceed or much
more restrictive that the values for many common light sources. Light that emitted from a laser has certain characteristics which make it valuable in many applications. It is coherent which describes the property of waves that enables stationary interference as example temporally and spatially constant as stated by Anonymous 6 (2008). In the other hands, laser is a coherent source of radiation which means that the waves that are emanating from the laser have the same frequency and they are all in phase with each other as stated by Vijaya, M. S. and Rangarajan, G. (2004). Secondly, lasers have a narrower frequency distribution or much higher intensity or much shorter pulse duration that the common types of light sources. With these characteristics, lasers can be allowed to emit over a long distance such as to the moon or it can be focus tightly to a small spot.

Therefore, because of the laser characteristics, it is used for compact disc players, medical application such as a surgical knife or welding for detached retinas. Others, laser also been widely used in communication systems in radar and military targeting application as well as many areas. Other than its characteristics, the advantages of the laser machining also make it is widely used in many applications. This includes the higher productivity rate, the variability types of materials can be use, dimensional repeatability is high since laser beam does not wear, no need to clamp the workpiece since there is no torque involved, time efficiency and lastly the capable to produce a very narrow of heat affected zone (HAZ) as stated by Krar, S.F. et al. (1984).

Figure 2.2: Laser Cutting Operation on Sheet Metal (Anonymous 3, 2008)
2.2 History

In 1953, Charles Hard Townes took advantage of the stimulated emission process to construct the first microwave amplifier which is a device similar to principles of the laser, referred as a maser. This device produced a coherent beam of microwaves to be used for communications. This maser was produced with the inversion between two energy levels that produced gain at a wavelength of 1.25 cm in ammonia vapor. (Silfvast, W. T., 2004)

In 1957, Charles Hard Townes and Arthur Leonard Schawlow began a serious study about extending the maser concept to optical frequencies. They developed the concept of an optical amplifier surrounded by an optical mirror resonant cavity to allow for growth of the beam and a year later which is in 1958, they published their paper about this study and received a Nobel Prize for their work in this field. (Silfvast, W. T., 2004)

Later in 1960, the first working laser was produced in Hughes Research Laboratories in Malibu, California by Theodore Harold Maiman. The laser used ruby crystal as the amplifier and a flash lamp as the energy source. The optical cavity was formed by coating the flattened ends of the ruby rod with a high reflecting material and the helical flash lamp surrounded a rod-shaped ruby crystal. As result, an intense red beam was observed to emerge from end of the rod when the flash lamp was fired. (Silfvast, W. T., 2004)

A year after that, the Iranian physicist Ali Javan, William R. Bennet and Donald Herriot from Bell Laboratories produced the first laser gas using a mixture of helium and neon gases. At the same laboratories, L. F. Johnson and K. Nassau introduced the first neodymium laser which has become one of the most reliable lasers available and later in 1962, Robert N. Hall demonstrated the first semiconductor laser at General Electric Research Laboratories in Schenectady, New York. In 1963, the infrared carbon dioxide laser was discovered by C. Kumar N. Patel from Bell Laboratories in Murray Hill, New Jersey which is the one of the most powerful and efficient lasers available today. Then, in the same year, the first ion laser in mercury
vapor was discovered by E. Bell and a year later, the argon ion laser was discovered by W. Bridges. (Silfvast, W. T., 2004)

Anonymous 2 (2008) stated that since the existence of laser from the early period history, laser has been study widely to produced a variety of specialized and improved types of lasers, optimized for different application, reliability of lasers including the new wavelength bands, maximum charging, firing, power efficiency, output pulse duration, average output power and also the maximum of peak output power.

### 2.3 Types of Lasers

In this modern age, there are many types of lasers available and each of it has a particular use, depending on the job required. In this project, lasers that have been studied can be categorized in seven types which are atomic gas lasers, molecular gas lasers, x-ray plasma lasers, free electron lasers, organic dye lasers, solid state lasers and semiconductor diode lasers.

According to Silfvast, W. T. (2004), although there are a many types of lasers available, only some of them are frequently used in some applications. Different types of lasers are used for different applications and some of it didn’t work well. So, the study on this field is needed to increase the performance of lasers industries.

#### 2.3.1 Atomic Gas Lasers

Silfvast, W. T. (2004) defined that the atomic gas lasers was some of the earlier type of lasers discovered. The characteristic of this laser is it has a narrow discrete laser wavelength over a wide range of wavelength from 200 nm to 5 µm. This atomic gas lasers was produced by the two electrodes at opposite ends of the laser gain medium that are installed along cylindrical tube containing the atomic species in the form of low pressure gas of the order of 1/1000 to 1/100 of an atmosphere that is applied by