

DESIGN AND DEVELOPMENT OF LASER CNC
MACHINE STRUCTURE

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BORANG PENGESAHAN STATUS TESIS

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MACHINE STRUCTURE

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DESIGN AND DEVELOPMENT OF LASER CNC MACHINE STRUCTURE

MOHAMMAD SYAZWAN BIN FAUZI

Report submitted in partial fulfillment of the requirements for the award of
Diploma of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the Diploma of Mechanical Engineering.

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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DEDICATION

*I specially dedicate to my beloved parents, my siblings,
My supervisor and those who have guided
And motivated me for this project*

ACKNOWLEDGEMENT

In the name of Allah S.W.T the most gracious and merciful, first and foremost, after a year of struggle and hard work, with His will, this thesis is completed. Thanks to Allah for giving me the strength to complete this project and the strength to keep on living. I would like to convey heartiest appreciation to my supervisor, Sir Fadhlur Rahman bin Mohd Romlay for his consistency, advising and giving ideas throughout this thesis. I appreciate his consistent support from the first day I start doing the thesis.

To my parents, thank you for all the support and sacrifice that both of you gave me. Your sacrifice is too great to be measured and it will be never forgotten. Thanks also given to my brothers and sister.

Last but not least, to all people that did not involve directly nor directly in succeeded the thesis, especially to all my beloved friend, that is cannot find appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Hopefully, they will continue to support me and thanks for making this possible to happen.

ABSTRACT

Computer Numerical Control (CNC) machines are used in a variety of ways in supporting the development of new products and processes and can provide an excellent means to expose students to standardized control procedures as well as offer opportunities to effectively supplement the teaching of control systems and instrumentation. Using Mach3 for software control and stepper motors for power transmission, a relative low cost but effective CNC Laser machine was developed by Western Carolina University (WCU) and Asheville-Buncombe Technical Community College through a joint partnership. This paper will present a logical approach to developing such a system and describe how applications have been integrated into curricula at both the two-year and university level programs through Project Based Learning (PBL). Educational merit and approaches will be described relative to respective educational levels.

ABSTRAK

Komputer Kawalan Berangka (KKB) digunakan dalam pelbagai cara dalam menyokong pembangunan produk baru dan proses malahan boleh memberikan cara terbaik untuk mendedahkan pelajar kepada prosedur kawalan yang seragam serta peluang tawaran yang berkesan menambah pengajaran sistem kawalan dan peralatan. Menggunakan Mach3 untuk perisian kawalan dan motor bagi penghantaran kuasa, kos yang relatif rendah tetapi berkesan mesin KKB laser telah dibangunkan oleh Universiti Western Carolina (WCU) dan Asheville-Buncombe Kolej Komuniti Teknikal melalui perkongsian bersama. Kertas kerja ini akan membentangkan satu pendekatan yang logik untuk membangunkan sistem tersebut dan huraikan bagaimana permohonan telah disepadukan dalam kurikulum di kedua-dua program peringkat dua tahun dan universiti melalui Pembelajaran Berasaskan Projek (PBP). Merit pendidikan dan pendekatan akan diterangkan relatif kepada tahap pendidikan masing-masing.

TABLE OF CONTENT

		PAGE
SUPERVISOR'S DECLARATION		ii
STUDENT'S DECLARATION		iii
DEDICATION		iv
ACKNOWLEDGEMENT		v
ABSTRACT		vi
ABSTRAK		vii
TABLE CONTENT		viii
LIST OF TABLE		xi
LIST OF FIGURE		xii
CHAPTER 1	INTRODUCTION	
1.1	Project Synopsis	1
1.2	Project background	2
1.3	Problem Statement	2
1.4	Objectives	3
1.5	Project Scopes	3
1.6	Project Schedule	3
CHAPTER 2	LITERATURE RIVIEW	
2.1	Introduction	4
2.2	Laser	5
2.2.1	Working Principle	5
2.2.2	Laser History	8

2.3	Laser Cutting CNC Machine	9
2.4	Aluminium	9
2.5	Laser Cutting Process	10
2.5.1	Power and Intensity	11
2.5.2	Cutting Speed	12
2.5.3	Focal Length	13
2.5.4	Cutting performances	14
2.6	Common Fabrication Method	16
2.6.1	Welding	16
2.6.2	Milling	17
2.6.3	Drilling	18
2.6.4	Cutting	19
2.6.5	Bending	20

CHAPTER 3 METHODOLOGY

3.1	Introduction	21
3.2	Flow Chart	22
3.3	Design of Experiment	23
3.3.1	Procedure	23
3.4	Fabrication Process	28
3.5	Summary	30
3.6	Summary	28

CHAPTER 4 RESULT AND DISCUSSION

4.1	Introduction	31
4.2	Final Product	32
4.2.1	Overview of Product	32

4.3	Analysis	33
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CHAPTER 5 CONCLUSION

5.1	Introduction	35
5.2	Problem Faced During The Project	36
5.3	Recommendation	36
5.4	Conclusion	37

REFERENCE	38
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APPENDICES

A1	Gantt chart	39
A2	Frame structure	40
A3	Additional part	41

LIST OF TABLE

TABLE NO.	TITLE	PAGE
Table 1	Cutting Speed Value Different	12
Table 2	Listed Component needed	25
Table 3	Listed Aluminium Profile Size 40 X 80	26
Table 4	Listed Aluminium Profile Size 40 X 40	27
Table 5	Listed Gussets Needed	27

LIST OF FIGURE

FIGURE NO.	TITLE	PAGE
1	Schematic of laser cutting process	2
2	Formation of spontaneous emission	5
3	Formation of stimulated emission	6
4	A three level laser energy diagram	7
5	Focal length diagram	13
6	Diagram for kerf width	15
7	MIG Welding	16
8	Milling machine	17
9	Drilling machine	18
10	Cutting tool	19
11	Bending tool	20
12	Flow chart for producing laser CNC machine	22
13	Sketch of laser CNC machine	23
14	Side view of laser CNC machine drawing	24
15	Top view of laser CNC machine drawing	24
16	Main frame of the structure	28
17	Addition part of the structure	29
18	Whole Structure	29
19	CNC laser machine structure	32
20	CNC laser machine structure	32
21	CNC laser machine structure	32
22	CNC laser machine structure	32

23	Beam deflection theory	33
24	Beam Simply Supported at Ends – Concentrated load P at the center	33
25	To find the angle of deflection	34
26	To find the maximum bending of the rod	34
27	To find the maximum load the structure can afford	34

CHAPTER 1

INTRODUCTION

1.1 Project Synopsis

These project titles are design and development of laser CNC machine. Nowadays, laser has been used widely in industry. All people know laser and what are the functions of the laser but they didn't know what the actual meaning of laser. For the information, "laser" is a short form for the Light Amplification by Stimulated Emission of Radiation. This device which is laser functioning by emits the light that carries electromagnetic radiation through the optical amplification based on stimulated emission of radiation [1]. In the engineering field, the laser process is used widely. For example, laser cutting which is the cutting process used laser as the cutting tool.

Besides, laser cutting process becomes one of the most important applications based on laser in engineering and manufacturing industry. Normally, laser cutting is used in manufacturing of sheet metal cutting. Figure 1 below shows the schematics of the laser cutting process. Further information, the sheet metal like aluminum is most widely established in engineering application because of the great and unique characteristics.

1.2 Project Background

From the introduction above, we can determine that the laser cutting process become most useful manufacturing process in industries. Advanced machining in laser process will be characterized by the advance machining purpose like the ability of this machine to cut any materials given. [A.K Pandey, 2011]. However, there are several parameters we should optimize to make it result achieved. In this project, by used the Laser CNC Machine, perform the cutting process on the aluminum thin plates and finally explore the suitable operating parameters in order to get the higher cutting performance.

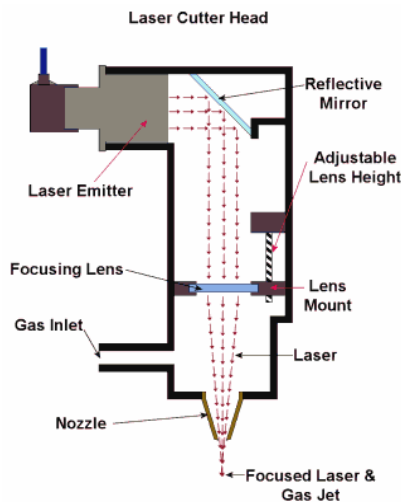


Figure 1 : Schematic of laser cutting process

1.3 Problem Statement

Know all people know the capability of laser cutting CNC Machine which is can cut various types of materials. By the way, there are many precautions and parameters that should observe and identify. The experimental materials uses which are aluminum possessing great properties like light weight, high strength and higher resistance. [A.Riveiro, 2010]. So, by using the laser cutter CNC Machine perform the cutting on aluminum thin plate.

1.4 Objectives

The objectives of this project to design and develop of Laser CNC Machine. Then, the laser CNC Machine performance can be determined by the cutting performance. Besides that, the second objective is to fabricate the strong CNC machine frame structure.

1.5 Project Scopes

In this project scopes, there is divided into three sections. First is the Laser CNC Machine structure. This machine operates in 2-axis which is in x-axis and y-axis. Besides, the machine uses ball-screw and linear guide concept. Next, the software that suitable and capable for this machine is CAD&CAM. Last but not list, which is the important ones is the cutting process. From this cutting process, a conclusion can be made about the cutting performance and cut quality. However, from this laser cutting process, there are several operating parameters that should find in order to get the great cutting performances.

1.6 Project Schedule

Gantt chart illustrates the start and end date of the terminal element and summary of a project. With Gantt chart, it helps us to guide the work process during this project. So, we can run the project smoothly and finish it on time. Refer to the appendix A1 to see the Gantt chart.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Literature review is an important aspect which is needed to be focused in a thesis. Therefore, on this chapter are focusing on the fundamental of laser, history of laser and the working principle of laser. Besides, this chapter also shows the view of the main point which is the Laser CNC Machine and the operating parameters to make the cutting performances better. The literature in this chapter will be helpful for further study in this research.

2.2 LASER

2.2.1 Working principle

Laser is the acronym of Light Amplification by Stimulated Emission of Radiation. Laser is light of special properties, light is electromagnetic (EM) wave in visible range. Lasers, broadly speaking, are devices that generate or amplify light, just as transistors generate and amplify electronic signals at audio, radio or microwave frequencies [1]. The principles of laser are divided into three division or section. First section is the formation of spontaneous and stimulated emission. This formation is formed at initial stage of formation principles of laser. Based on quantum mechanics, the electron can have only certain value of energy or energy level. In this cases, we consider two energy levels which is ground and excited states that electron can occupy.

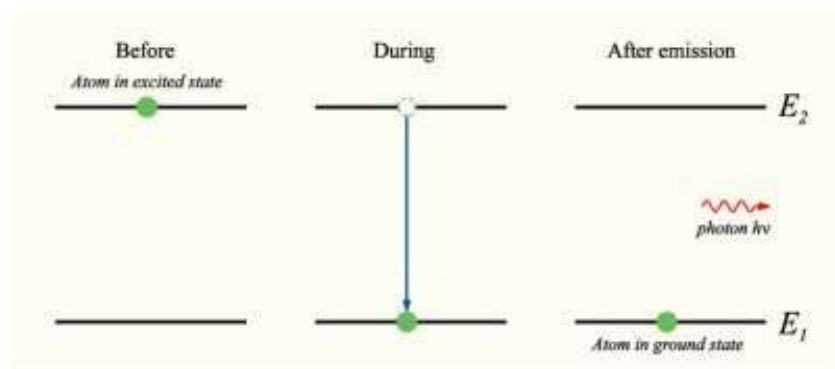


Figure 2 : Formation of spontaneous emission

From the Figure 2 above, there are two level energy which ground states relate with E_1 and another state which is excited state relate with E_2 . At the beginning, the atom is in excited state. After the spontaneous decay, the electron in excited state with energy E_2 went to ground state with energy E_1 . From the formation above, we can see that the release differences in energy between two states as photon. From overall of the formation above, that process is called spontaneous emission. The phase and direction of the photons move are completely randomly due to uncertainty principle in this spontaneous emission. Below shows the equation relate with this emission.

$$E_2 - E_1 = h\omega \quad (1)$$

E_2 : Energy at excited state

E_1 : Energy at ground state

h : Plank constant

ω : Angular frequency

Based on equation 1, a photon with frequency will be absorbed by electron which at ground state. Next, the electron will back again to the excited state and will remain for a while and finally return back to lower state which is ground state. By the way, the formation of absorption and spontaneous emission not give amplification of light. The best way to make it useful is by formation of photon absorbed and emitted simultaneously.

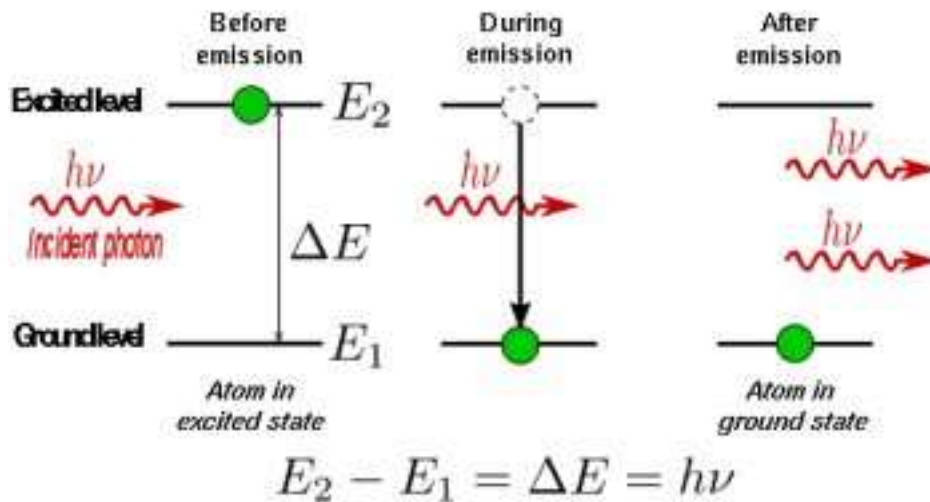


Figure 3 : Formation of stimulated emission

The formation of second photon which is same in frequency and the same phase with first photon that influenced by electric field of photon in excited state is needed to make this atom will decay again into ground state. This process will called stimulated emission as you can see in Figure 3 above.

After the stimulated emission occurred, this process will go to the next section which is population inversion of the gain medium. At this section, higher energy state will have more population than lower energy state. By this kind of formation, it will results the light increase in intensity called population inversion. By the way, this formation can't be achieved by two states because electron will reach equilibrium position with exciting process of spontaneous and stimulate emission [2].

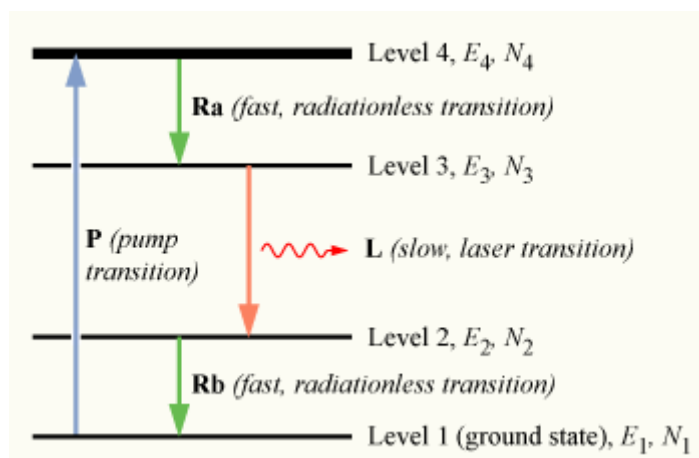


Figure 4 : A three level laser energy diagram

The, to achieve non-equilibrium conditions, we must go the method of an indirect method of populating the excited state must be used. To understand how this is done, we may use a slightly more realistic model, that of a three-level laser as you can see in Figure 4 above. At this condition, the group of N can exist in three types of energy level like the Figure 4 above.

The final section of working principle of laser is optical resonator. This section is major component of laser which surrounding the gain medium. This optical resonator is an arrangement of mirrors that contribute the standing wave cavity for light waves [3]. By the way, even population inversion have ability signal due to stimulated emission, but overall single gain is very small and not contribute overall output. The presence of the optical resonator is to make the positive feedback mechanism [2].

2.2.2 Laser history

History of the formation of laser, even 100 years ago starting from new reveal of laser, laser become one of the most powerful engineering devices nowadays. For the information, in 1905, Max Planck gives the new information or theory about the relationship between the energy and frequency of radiation. His theory becomes a starting point the laser discovered and will encourage coming up physicists to find the new useful theory.

In 1905, a famous physicist, Albert Einstein released his research about the photoelectric effect which proposed the light deliver in energy. Based on physic context, Albert Einstein says that discrete quantum particles that now we called as a photon. After two years, Albert Einstein become innovative by possible the process of laser that mentioned earlier which is stimulated emission.

2.3 LASER CUTTING CNC MACHINE

For the information, advanced machining is adopted rapidly in materials focus area and manufacturing disciplines. In this project, laser cutting CNC machine considered as the advanced machining system to their precision work or operate effectively. This kind of advance machining not only high speed operation, it also easily to control due to advancement in laser technology and computational powers. [B.K Yilbas, 2011]. For any types of laser cutting CNC machine, the axis of motion are typically X and Y axis. For the machine operate included with Z axis motion, the cutting head may be controlled. Laser cutting machines are distinct from traditional mechanical cutters. The laser cutter never makes physical contact with material. Eventually, there is less probability for the material damaged and the surface finish of material cuts is high performance.

2.4 ALUMINUM

For the introduction, Aluminum is an abundant metallic chemical element which is widely used worldwide for a wide range of products. Based on the periodic table, the aluminum element has an atomic number of 13, and it is identified with the symbol Al. It is classified in the poor metals, sharing the property of extreme malleability with metals like tin and lead. The international standard spelling is *aluminum*. In context engineering world, aluminum and its alloys are among the most versatile engineering and construction materials because of their unique characteristics. They have become the world's second most used metal after steel. Annual primary production of aluminum in 2006 was around 34 million tonnes and recycled production around 16 million tonnes. The total of some 50 million tonnes compares with 17 million tonnes of copper, 8 million tonnes of lead and 0.4 million tonnes of tin [4].

Aluminums alloys are typical engineering material used widely in heavy industry like automotive, aerospace and shipbuilding. [A.Riveiro, 2010]. This material is characterized by their light weight, high strength and high resistance corrosion. [A.Stournaras, 2009]. However, the strength of this material becomes a challenge to the laser cutting to perform good quality on this kind of material. There are several parameter that should be includes due to cut the high reflectivity and thermal conductivity material like aluminum. By the way, this material mostly used in different forms and shapes of the plate, but difficult to cut precisely in complex shapes. Laser cutting that use Laser Beam Machining (LBM) as the operating catalyst are capable to cut aluminum which exhibit high degree of hardness and brittleness. Besides, this material has strong, hard and lightweight which is widely used in aircraft construction. [A.K Pandey, 2011].

2.5 LASER CUTTING PROCESS

Laser cutting is the process used laser as a mainly agents cut the material on specific or certain values of parameters given. This process becomes significant in industry due to material uses for automotive, aerospace and manufacturing field that need the high quality product from the cutting material. In order to get the best cut quality and high efficiency in cutting performances, laser processing parameters that contribute the cut quality are literature below:

1. Power and intensity
2. Cutting speed
3. Focal length

2.5.1 Power and intensity

Lasers are usually described in terms of power, e.g. 1,000 watts or 6kW. Laser power is the total energy emitted in the form of laser light per second. The intensity of a laser beam is equal to its power divided by the area over which the power is concentrated. The high intensity causes the material to heat up rapidly so that little time is available for heat to dissipate into the surrounding material. This produces high cutting rates and an excellent quality of cut. Equation 2 below shows how to find intensity. . For example, focusing a 50W laser beam over a diameter of 6mm will result in a power density of approximately .1.8W per mm².

$$intensity = \frac{power}{area} \quad \left(\frac{w}{mm^2}\right) \quad (2)$$

By the way, the laser intensity also can determine the thickness that should be cut. Higher laser intensities can be formed by increasing the laser power and other parameter shorter focal length. If we want to cut the higher thickness materials, the intensity must be higher. However, focusing the beam on to a smaller spot also reduces the depth of focus and is therefore unsuitable for cutting thick materials. High intensity can be achieved both in pulsed and continuous beams. Accordingly, either the peak pulse power in pulsed cutting or the average power in continuous cutting determines the penetration.

2.5.2 Cutting speed

Next parameter which is cutting speed plays an important role in laser cutting process. The speed of the cutting can give the great significant change even changes in speed values are small. Based on the done experiment, N.Naprstkosa said, the parameters recommended by the machine manufacture does not give a full performance [N.Naprstkosa, 2012]. As you can see below, the Table 1 shows the reaction mechanism between manufacturer parameters and optimizing parameters.

Table 1: Cutting speed value different

Cutting speed (ms^{-1})						
Thickness (mm)	1	2	3	4	5	6
Manufacturer parameters	6500	5500	3500	3000	2100	1900
Optimizing parameters	8500	8000	6000	4400	3800	2750

2.5.3 Focal length

Focal length also give the significant effect when has the change of values of focal length. By the way, the focal length is the distance between the centers of concave or convex lens to the point where the parallel rays of the light meets. As you can see Figure 5 below show the mechanism of focal length occurs at concave and convex lenses.

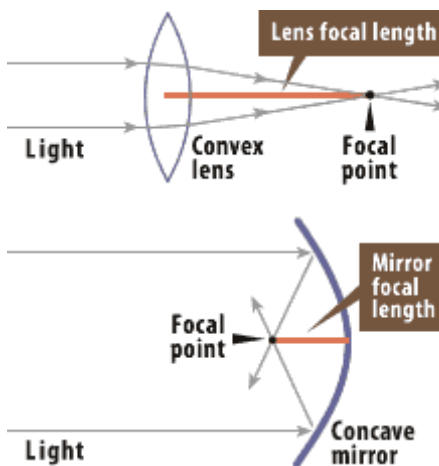


Figure 5 : Focal length diagram

However, in order to get the good performances on cutting process, the suitable focal length should take a serious action. How to choose the right lens focal length for cutting process? By the way the first consideration to take an action when choose lens focal length for cutting process is the depth of focus requirement of material to cut. Then, two factors more must be consider due to more accurate machining which is the thickness of the material want to cut and the distance between lens and material.

The optimal cutting will be occurred at focus point. The depth of focus will function as a guide to see how far from the focus point that can perform the cutting process. As a summary for this focal length issue, the focal length of the lens especially in cutting applications must include the depth of focus based on the material thickness and any vertical height which the distance from the lens to the material that we want to cut. Below show the useful equation to calculate the depth of field or depth of focus:

$$d.o.f = 2.5 \times \lambda \times \left(\frac{f}{d}\right)^2 \quad (3)$$

$$d.o.f = 0.027 \times \left(\frac{f}{d}\right)^2 \quad (4)$$

From the Equation 3 and 4 above, we can assume that when the focal length increase, the depth of focus is automatically increases. For equation 4, that equation is for co2 laser due to their wavelength values about 10 μ m. As the information, the capital “f” will represent the focal length values and capital “d” will represent the beam diameter.

2.5.4 Cutting performances

The cut quality can be geometrically characterized by the mean width of the cut opening which is kerf width, the cutting edge surface roughness and size of heat-affected zone. By the way, both operating parameters which are laser power and cutting speed plays an important role that effect on the quality characteristic especially on the kerf width, heat-affected zone and surface roughness that what mentioned earlier. Figure 6 below show the formation of kerf width and heat-affected zone.

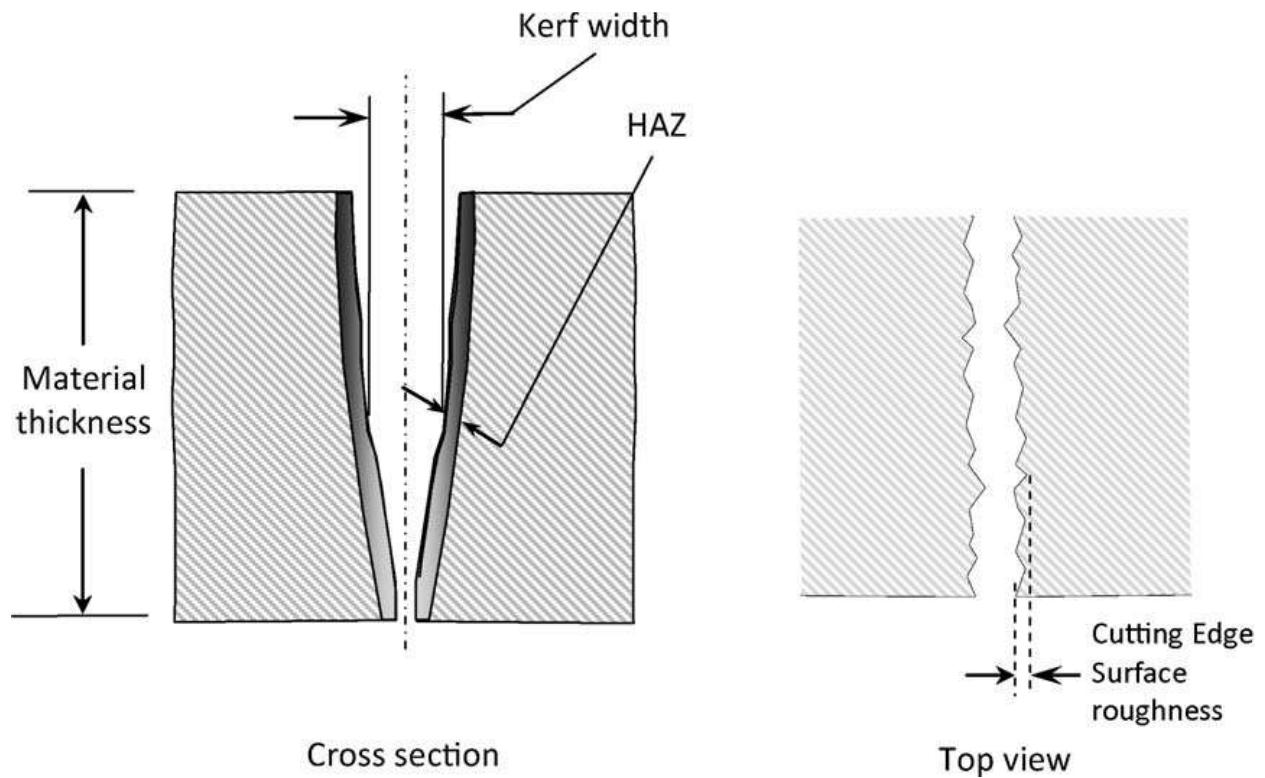


Figure 6 : Diagram for kerf width, heat-affected zone and surface roughness

The combination of operating parameter by combining cutting speed with laser power will be result the formation of kerf width and heat-affected zone. The lower the laser power and the higher the cutting speed will be positively result due to lower kerf width and heat-affected zone. For the surface roughness, the laser power and cutting speed also become the influencing parameters due to laser cutting. Lower the value of frequency will result the decreasing of the laser spot overlaps and finally increasing the undulations and ripples at the cutting edge.

2.6 COMMON FABRICATION METHOD

Before start to fabricate the structure, some researches are made to gain some knowledge about the methods needed during the fabrication.

2.6.1 Welding



Figure 7: MIG Welding

Source (<http://www.markthewelder.co.uk/id26.html>)

MIG welding is a welding process in which an electrical arc forms between a consumable wire electrode and the work-piece metal, which heats the work-piece metal, causing them to melt, and join. Along with the wire electrode, a shielding gas feed through the welding gun, which shields the process form contaminants in the air. The process can be semi-automatic or automatic. A constant voltage and power source is most commonly used with GMAW.

2.6.2 Milling

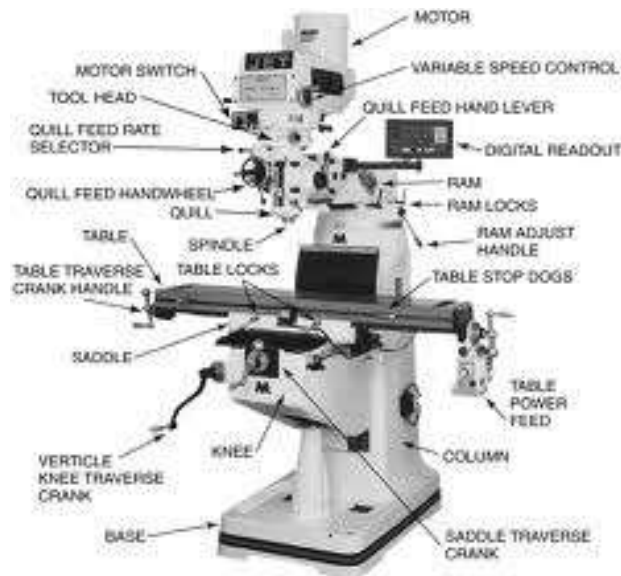


Figure 8: Milling machine

Source (<http://www.custompartnet.com/wu/milling>)

Milling is the most common form of machining, a material removal process, which can create a variety of features on a part by cutting away the unwanted material, work-piece, fixture, and cutter. The work-piece is a piece of pre-shaped material that is secured to the fixture, which itself attached to a platform inside the milling machine. The cutter is a cutting tool with sharp teeth that is also secured in the milling machine and rotates at high speeds. By feeding the work-piece into the rotating cutter, material is cut away from this work-piece in the form of small chips to create the desired shape.

2.6.3 Drilling



Figure 9: Drilling machine

Drilling is a cutting process that uses a drill bit to cut or enlarge a hole of circular cross-section in solid materials. The drill bit is a rotary cutting tool, often multipoint. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work-piece, cutting off chips from what will become the hole being drilled. Exceptionally, specially-shaped bits can cut holes of non-circular cross-section; a square cross-section is possible.

2.6.4 Cutting



Figure 10: Cutting tool

Source (<http://en.wikipedia.org/wiki/Cutting>)

Cutting is the separation of a physical object, or a portion of a physical object, into two or more portions, through the application of an acutely directed force. Implements commonly used for cutting are the knife and saw, or in medicine and science the scalpel and microtome. However, any sufficiently sharp object is capable of cutting if it has a hardness sufficiently larger than the object being cut, and if it is applied with sufficient force.

2.6.5 Bending



Figure 11: Bending tool

Source (http://www.efunda.com/processes/metal_processing/bending.cfm)

Bending is a process by which metal can be deformed by plastically deforming the material and changing its shape. The material is stressed beyond the yield strength but below the ultimate tensile strength. The surface area of the material does not change much. Bending usually refers to deformation about one axis.

Bending is a flexible process by which many different shapes can be produced. Standard die sets are used to produce a wide variety of shapes. The material is placed on the die, and positioned in place with stops and/or gages. It is held in place with hold-downs. The upper part of the press, the ram with the appropriately shaped punch descends and forms the v-shaped bend.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Chapter 3 will discuss about process and methodology for this research. Methodology is very important for doing analysis. Every process that will be discusses has their own importance according to the research. Start from find the article, journal, thesis, and books, the idea of thesis or another research which is related or same with this research will be use. The idea from that literature review will be compare to make the best conclusion for the research get the successfully result. The report writing process will be guided by the UMP final year project report writing. This process also included the presentation slide marking for the final presentation of the project. The project ended after the submission of the report.

3.2 FLOW CHART

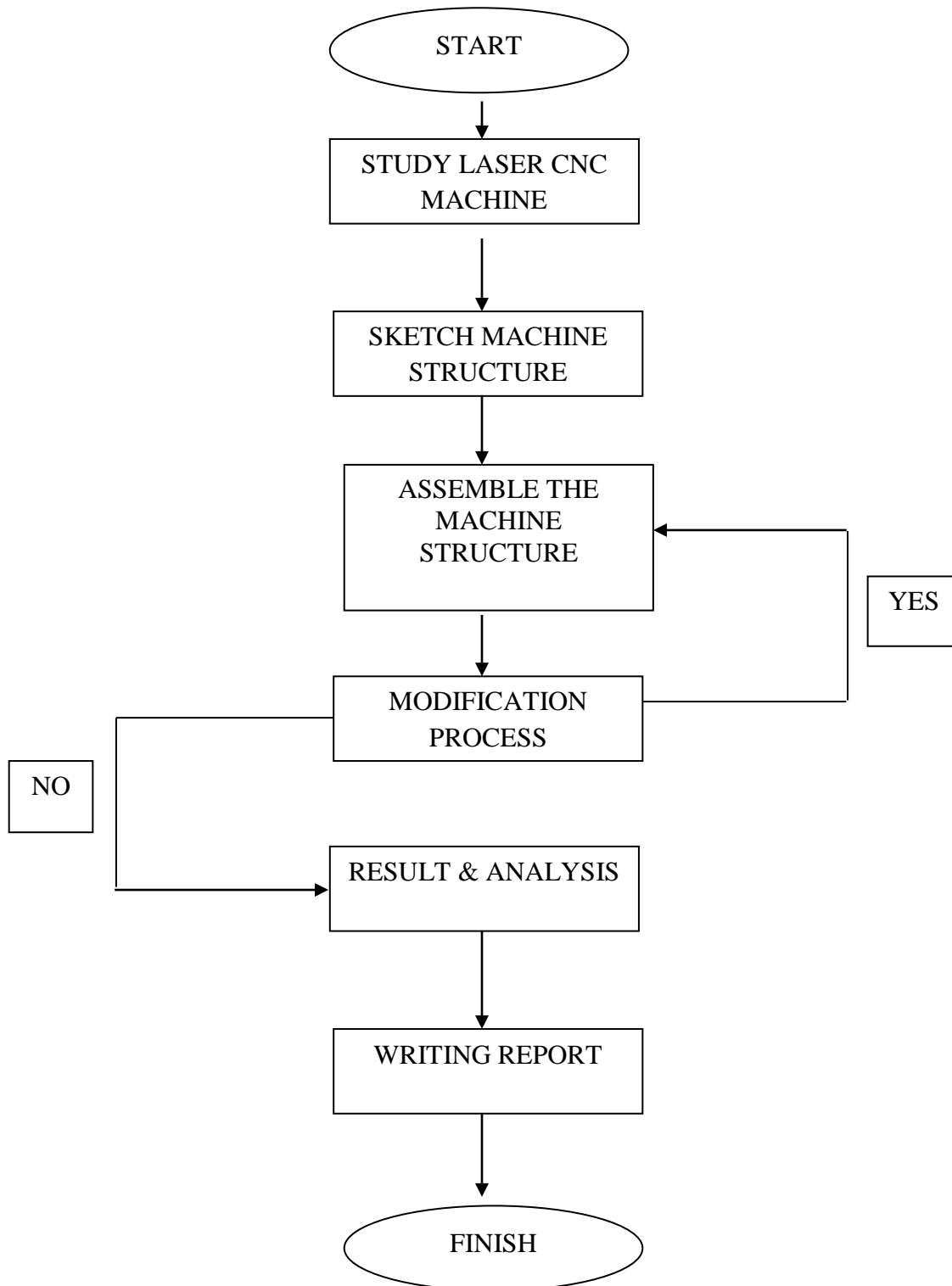


Figure 12: Flow chart for producing laser CNC machine

3.3 DESIGN OF EXPERIMENT

3.3.1 Procedure

For the producing the laser CNC machine, there are a few steps to take an action smoothly. The step of formation of this machine is established below:-

1. First, study about the structure of laser CNC machine.
2. After sketch the desired design of laser CNC machine, assume suitable dimensions for all parts that want to produce in order of formation laser CNC machine structure. Figure 8 show the sketch of the CNC machine structure.
3. Then, by using the Auto Cad and Solid works software, draw the proper design of desired laser CNC machine include the dimensions. For the information, the SI unit for dimensions is in mm. Figure 9 and 10 below shows the drawing of laser CNC machine.

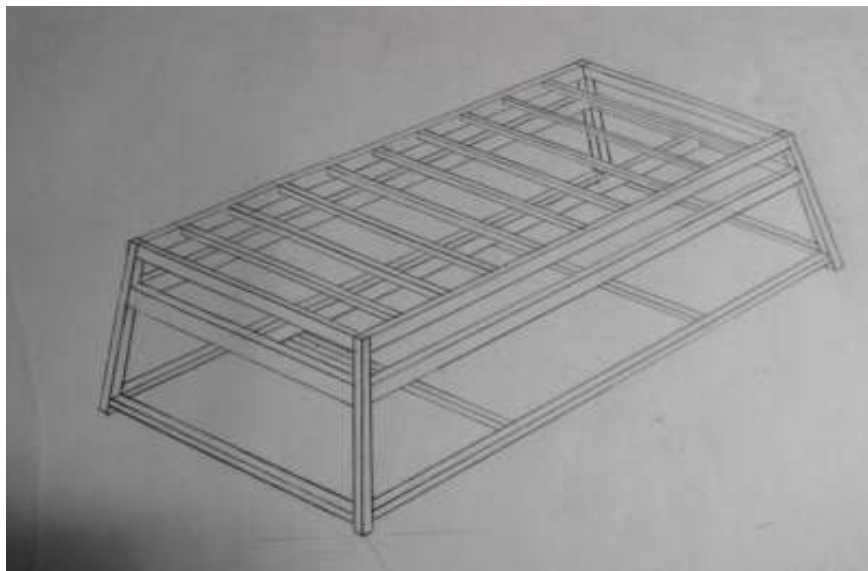


Figure 13 : Sketch of laser CNC machine

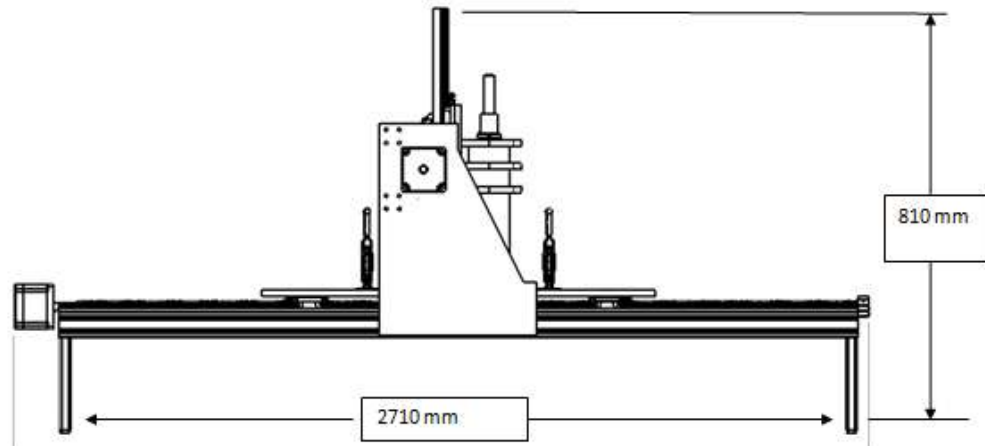


Figure 14 : Side view of laser CNC machine drawing

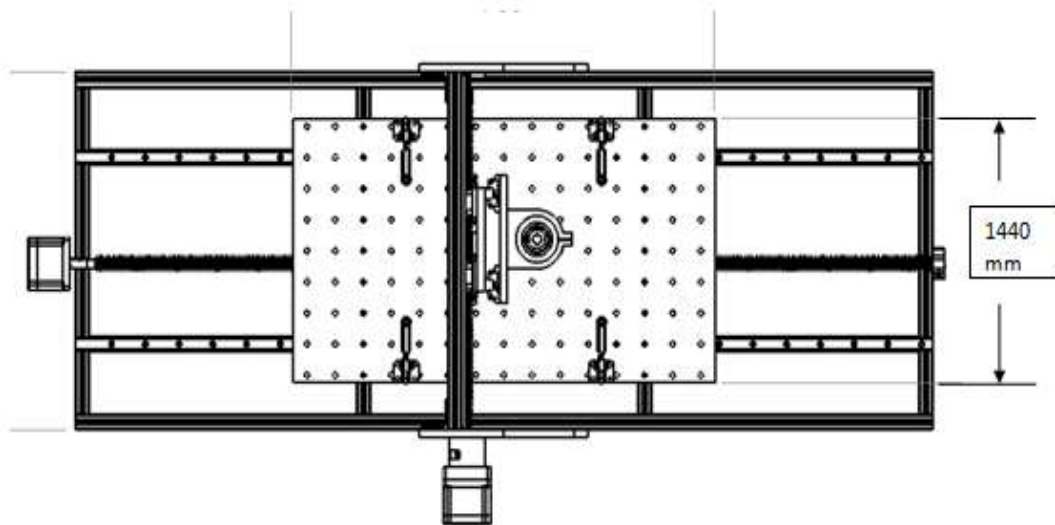


Figure 15 : Top view of laser CNC machine drawing

4. Next, list the components that want to use for all part of the machine. From the Table 2 below, show the listed components.

Table 2 : Listed component needed

No	Description	Quantity
1	Ball screw system, FEM-E-S Size : 40x10R	1
2	Ball screw shaft Size : 40x10R Length: 3268 mm	1
3	Ball runner block Size : 30	6
4	Ball guide rail Size : 30 Length : 3268 mm	2
5	Ball screw shaft Size : 32x10R Length : 1708 mm	1
6	Ball screw system, FEM-E-S 32x10R	1
7	Ball runner block Size : 25	4
8	Ball guide rail Size : 25 Length : 1708 mm	2
9	Ball screw system, FEM-E-C Size : 16x10R	1
10	Ball screw shaft Size : 16x10R Length : 412 mm	1
11	Ball runner block Size : 20	4
12	Ball guide rail Size : 20 Length : 412 mm	2

5. For the information, the material used for the frame or body of this machine is aluminum profile. Table below show the complete one the listed of aluminum profile that had been order to supplier included with specific dimension. For the joint process of aluminum profile, the gusset is suitable to use. From Table 3,4 and 5 below also the size and quantities of aluminum profile and gussets.

Table 3 : Listed aluminum profile size 40x80

Length (mm)	No of unit needed	Based on 5000 mm		Based on 6000 mm	
		Use	Less	Use	Less
2710	5	2710 (1)	2290	5420 (2)	580
		2710 (1)	2290	5420 (2)	580
		2710 (1)	2290	2710 (1)	3290
		2710 (1)	2290		
		2710 (1)	2290		
1220	4	4880 (4)	120	4880 (4)	1120
1440	2	2880 (2)	2120	2880 (2)	3120
440	2	880 (2)	4120	880 (2)	5120

Table 4 : Listed aluminum profile size 40x40

Length (mm)	No of unit needed	Based on 5000 mm		Based on 6000 mm	
		Use	Less	Use	Less
2710	2	2710 (1) 2710 (1)	2290 2290	5420 (2)	580
1220	14	4880 (4) 4880 (4) 4880 (4) 2440 (2)	120 120 120 2560	4880 (4) 4880 (4) 4880 (4) 2440 (2)	1120 1120 1120 3560
810	4	3240 (4)	1760	3240 (4)	2760
490	2	980 (2)	4020	980 (2)	5020
200	4	800 (4)	4200	800 (4)	5200

Table 5 : Listed gussets needed

Size	No of unit
40x80	12
40x40	44

6. These are all the components we need to fabricate this laser CNC machine.
7. After that we fabricate the CNC structure based on the design we had make.

3.4 Fabrication Process

There are some steps to fabricate the structure and some process needed which are:-

1. Firstly, gathered all the components and materials in a place.
2. Start with assemble the bottom part of the structure which is the main part of the structure.
3. Assemble until the whole main body is produced. The main frame is the Figure 11 below.



Figure 16: Main frame of the structure.

4. Then add some aluminum profile on the top of the structure to improve the strength of the structure and increase the maximum load the structure can afford. Figure 12 below show the addition part of the structure.



Figure 17: Addition part of the structure.

5. Then build up the support for the ball rail in x and y axis. Figure 13 below show the structure.



Figure 18 : Whole Structure.

3.5 SUMMARY

This chapter present on how the project is being conducted. The structure is being made some modification to improve the stiffness of the structure. Some improvement made to increase the maximum load can be handles by the structure.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

In this chapter will discuss detail about the main function of the structure and the strength of the structure. This section will also discuss on the produce and variables affecting the stiffness of the structure. The focus of this chapter is based on the product of this project. Once the target of this chapter is met, then only the whole project process and outcome can be concluded in the next chapter.

4.2 FINAL PRODUCT

4.2.1 Overview of structure

These are the figures of CNC laser machine structure.



Figure 19



Figure 20



Figure 21



Figure 22

4.3 ANALYSIS

Some analysis has been made to ensure the structure is stiff enough to afford load. Because of the aluminum profile used are quite long, an analysis of beam deflection is made. This analysis is made to calculate the maximum load the structure can afford before it is bending.

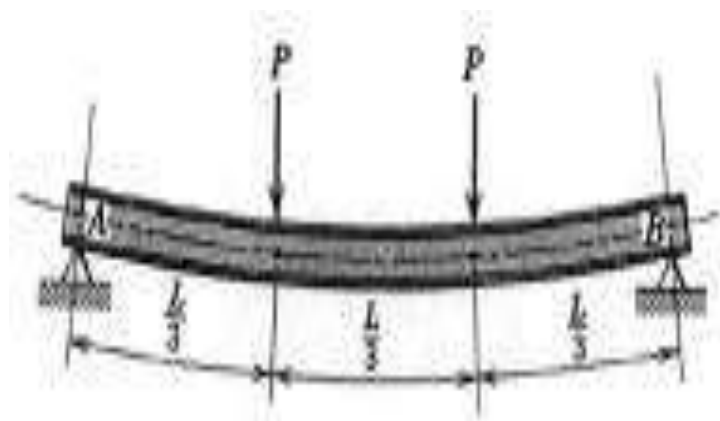


Figure 23 : Beam deflection theory

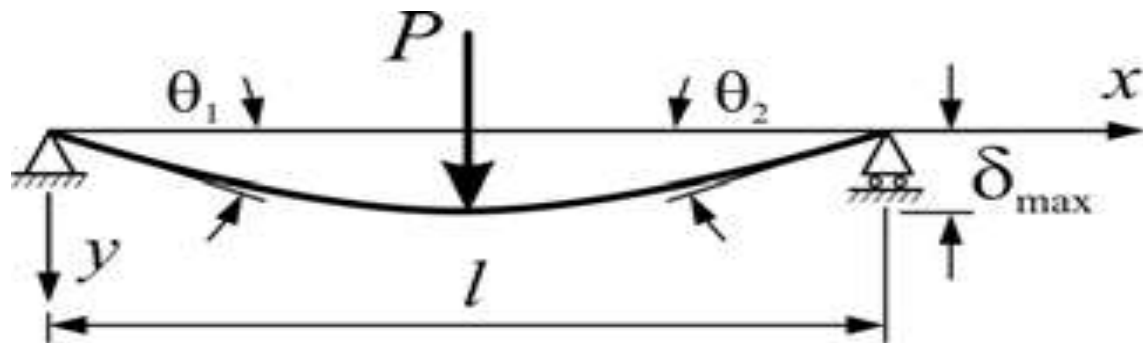


Figure 24 : Beam Simply Supported at Ends – Concentrated load P at the center

These are some equation to calculate the maximum load can be handle.

$$\theta_1 = \theta_2 = \frac{Pl^2}{16EI}$$

Figure 25 : To find the angle of deflection.

$$y = \frac{Px}{12EI} \left(\frac{3l^2}{4} - x^2 \right) \text{ for } 0 < x < \frac{l}{2}$$

Figure 26 : To find the maximum bending of the rod.

$$\delta_{\max} = \frac{Pl^3}{48EI}$$

Figure 27 : To find the maximum load the structure can afford.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

In this chapter, the overall process of design and fabrication will be summarized. Furthermore, the recommendation for further design and development of laser CNC machine structure will be included in this chapter.

5.2 PROBLEM FACED DURING THE PROJECT

During the design and fabrication process of design and development of plasma CNC machine structure project, some problems had been faced. The first was obtaining the knowledge of who to create the new design and fabricate with manually. This knowledge is not through in one lecture but also with the chief engineer students. Therefore, internet and books from the library was the side source of information. The next problem faced was obtaining the material for fabrication. Most of the needed material was not available immediately because it needs to be order first. The hardest thing to get is the half-round nut and bolts because it needed to be order and the materials arrive in quite long time. For the supporter, galvanize iron is used for plate support and motor holder because galvanize iron is hard and strong material. The problem is to cut the galvanize iron into the desire shape. Because of the iron is too hard, so it is quite hard to shape it. For guide rail stainless steel is used because it can prevent from rusting. After supervisors agrees and satisfy with the materials information, fabrication is proceeds when all the needed materials are available.

5.3 RECOMMENDATION

There are some recommendation related to this project are material purchasing and receiving should be on schedule. This will help to complete fabrication process on schedule. Besides that, the material availability at mechanical laboratory must consider before decide the specification of design. The availability of material should be provided by laboratory instructor to reduce the time of searching for the correct material which delays the process.

Besides that, the structure of the bottom part should be made some addition to improve the stability of the structure. Some supporter plate should be added to increase the strength of the structure.

5.4 CONCLUSION

The project objective has been achieved. The final design of laser CNC machine refer to current machine but development has been done to make more better to the current machine by add some addition parts into the structure. Solid works software is used to draw the best design. This laser frame structure assemble is successfully fabricated within 14 weeks.

Moreover, the fabrication which involved in cutting, welding, grinding, bending, milling, and drilling needs great technique to make it perfect. Throughout the fabrication, the skills of handling these fabrication processes were improved. Furthermore, problems facing during the fabrication process are resolved with the solution at which critical thinking and problem solving skills were improved.

Therefore, this project is successfully developing the frame structure compare to the basic structure. The laser CNC machine structure is completely done.

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APPENDIX A1

Gantt chart

Shows the details project activities in order to complete this project.

PROJECT ACTIVITIES		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14
LITERATURE REVIEW	PLANNING														
	ACTUAL														
REVERSE ENGINEERING	PLANNING														
	ACTUAL														
DESIGN & PLANNING	PLANNING														
	ACTUAL														
PREPARE MATERIAL & TOOL	PLANNING														
	ACTUAL														
FABRICATION	PLANNING														
	ACTUAL														
SYSTEM INTEGRATION	PLANNING														
	ACTUAL														
MODIFICATION	PLANNING														
	ACTUAL														
FINAL REPORT	PLANNING														
	ACTUAL														

APPENDIX A2

The frame structure



APPENDIX A3

The additional part to the structure

