UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PORTABLE
COREXY CNC MACHINE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours.

by

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This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honors. The member of the supervisory is as follow:

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ABSTRAK

Portable CoreXY CNC Mesin direka dengan tujuan untuk meningkatkan produktiviti industri, mengurangkan kos dan menjimatkan masa. Projek ini adalah kombinasi rekaan elektronik dan mekanikal. Untuk bahagian elektronik, Arduino UNO dan CNC shield digunakan dalam projek ini. CNC shield harus memasang ke dalam Arduino UNO. Mesin CNC ini menerima perintah daripada komputer pengguna yang sudah memasang perisian Universal G-code Sender. Stepper motor dipandu oleh pemandu motor untuk berputar dengan kedudukan yang tepat. Untuk bahagian mekanikal, sistem kinematik diilhamkan oleh sistem mekanisme H-bot. Reka bentuk mekanikal tersebut menjadikan Mesin CNC lebih simetri dalam berat dan mudah alih. Mesin CNC yang mudah alih direka untuk membolehkan pengguna membawa ia ke kawasan yang mendalam untuk menjalankan tugas seperti menanda, ukiran atau memotong.

ABSTRACT

The Portable CoreXY CNC Machine is designed with the purposes to enhance the productivity of industry, reduce cost and saving time. The project is a combination of electronic and mechanical design. For the electronic part, an Arduino UNO board and a CNC shield are used in this project. The CNC shield is plugged into the Arduino microcontroller. The CNC machine receives command from user computer which already installs Universal G-code Sender software. The stepper motor is driven by a motor driver to move in accuracy positions and steps. For the mechanical part, the kinematic system is inspired by H-bot mechanism system. The mechanical design makes the CNC Machine more symmetry in weight and portable. The portable CNC Machine is designed to let the user carry for outstation for working such as marking, engraving or cutting.

DEDICATION

To my beloved parents, I acknowledge my sincere indebtedness and gratitude to them for their love, dream and sacrifice throughout my life. Their sacrifice had inspired me from the day I learned how to read and write until what I have become now. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to achieve my dreams.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

2D	-	Two-Dimensional
3D	-	Three-Dimensional
ABS	-	Acrylonitrile Butadiene Styrene
AC	-	Alternating Current
AWJ	-	Abrasive waterjet
AWIJs	-	Abrasive Water Injection Jets
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
CNC	-	Computer Numerical Control Machine
CO_2	-	Carbon dioxide
DC	-	Direct Current
EEPROM	-	Electrically Erasable Programmable Read-Only Memory
etc	-	et cetera
G-code	-	General code
GUI	-	Graphical User Interface
HEX	-	Hexadecimal form format
HIPS	-	High Impact Polystyrene
ICSP	-	In-Circuit Serial Programming
IDE	-	Integrated Development Environment

L-Cheapo	-	Low-Cost Hardware for Earth Applications and Physical Oceanography
Laser	-	Light Amplification by Stimulated Emission of Radiation
LED	-	Light - emitting diodes
M-code	-	Miscellaneous code
MXL	-	Miniature Extra Light
NEMA	-	National Electrical Manufacturer Association
Nd	-	Neodymium
RPM	-	Revolutions per minute
PC	-	Polycarbonate
PLA	-	Polylactic Acid
PSM	-	Projek Sarjana Muda
PVA	-	Polyvinyl Acetate
SD	-	Secure Digital
sldprt	-	SolidWorks Part format
STL	-	Stereolithography
SVG	-	Scalable Vector Graphics format.
UGS	-	Universal G-code Sender
UPH	-	Unit per hour
USB	-	Universal Serial Bus
WJ	-	Plain waterjet
YAG	-	Yttrium aluminium garnet

CHAPTER 1
INTRODUCTION

1.0 Introduction

In the world, all living creatures tend to stay in safe and comfortable habitats, humans are no exception. Humans always use the surrounding material to create something that makes life safer and easier since the era of the old ages, for example, primitive people will carve stones into a weapon for hunting. However, today the era which people live know as silicon era, the major improvement of making tools are far beyond imagination that one can be thought of during the era of the old, now tools are far more accurate, more efficient in times, less human error and faster unit per hour (UPH). Machines such as 3D Printer and Computer Numerical Control Machine (CNC) are one of the industrial machines out there that create and machine parts into the needs of an engineer. Nevertheless, the bulk sizes of those machines limit the potential of these technologies. A portable CNC machine is a help to solve the problem which can provide the service to any workplace.

1.1 Project's Background

Manufacturing plays a main role in support creativity and innovation for the civilization and progress of human society. Before the advent of the Industrial Revolution, the fabrication was done by using simple hand tool in homes or rural area. Start from the 18th century, the first steam engine was introduced to manufacturing field, some of the work human ancestors did had taken part by machines. Next was stimulated by electricity power, the assembly line has created made exist for mass production. The third revolution starts to apply computers in

assembly lines for automation purpose, which human began replaced by robots and machines. Today people are greeting Industry 4.0, in which automation will cooperate with computers turn into a developed way, with robotics connected remotely to computer systems implemented with machine learning algorithms that able learn and only require a little human's operation to control the robotics.

However, there are several challenges faced by manufacturers to achieve Industrial Revolution. The technology developmental level is uneven around the world, not all locations or workplaces provide internet access. In addition, most of the manufacturing machines are huge in size, heavy and whopping price. It becomes an excessive investment and unclear economic benefits. Today, a lot of industries still employ labours in manufacturing and assembly lines due to the tremendous expenses of high technology machine. These phenomena will no longer exist once the machine is being cheaper and portable. An affordable cost makes more organizations or government willing to do investment, research, and improvement in the industrial field. In this way, science and technology will go advanced by leaps and bounds.

A handy tool makes a handyman. To obtain and master a perfect tool is the key to create a high-quality product. Everything must start-up with a solid foundation including industry. Normally, the product begins with a design after meeting and discuss with clients. The first step in manufacture is labelling, measuring before cutting and welding. Next are assembly and mounting followed by prototype testing. Last, send the product to a factory for mass production. A good product design needs an experienced design engineer with his innovative, creative and professional knowledge. But without a complete and perfect industry base, the product is hard to build out and might only always jam in design state become a concept view or reference. Although it sounds disappointed and a little cruel, nevertheless, it is true. It is only when supported by a good manufacturing and production line, the innovative and creative can be just sustainable and able to keep going improve and enhance.

People always want to get the job done quickly so there has some buffer time for troubleshooting and improvement before a deadline. At the same time, it cannot have a mistake or careless. After a series of thinking, why not create a machine that can work faster by itself where complex model and equipment can be done without an extremely expensive cost and manpower. There is where the idea of creating a portable CNC machine that is affordable to any engineering team and industry. So that, a portable CNC Machine project has been set into motion.

CNC machines are automation electromechanical devices that perform tasks by computers run pre-set sequences of machine control commands. This is in contrast to a technician or worker manually operates machine tools by hand (Sutarman, et al., 2017). It is possible to instruct machines in producing parts by a direct insert CNC programming, for example, G-code and M-code. G-code basically is used to create motion while M-code is an auxiliary command used to control relay on breakout board. But there is another way of giving instruction to CNC machine which the design part in Computer Aided Design (CAD) software can convert automatically into CNC programming by the aided of Computer Aided Manufacturing (CAM) software (Valvo, et al., 2012). It is much easier and better than typing a complex machine code by your own self. To construct a complete CNC programming, it needs an educated programmer, and it takes too much time. Besides, the programming bug error or lack design in sequences must in consideration. So, it is highly recommended to use CAD software for a designing product since it dramatically reduces the error occurs in CNC programming. By the way, most CAD software is user-friendly and easy to learn.

There are many types of CNC machines out there, including CNC router machine, CNC plasma cutter machine, pick and place CNC machine, laser cutting CNC machine and so on. Different types of CNC machines equip different types of machine tools. Each machine has own properties and characteristic. In general, a CNC router machine used to engrave and cutting complex shapes from wood, metal or plastic (Patel & Patni, 2014). A plasma cutter is used to cut metal and wood in 2D shapes, and it consumes less power than CNC router machine. A laser cutter functions similar to a plasma cutter, it allows cutting wood, metal, and plastic.

This project would like to introduce a portable CNC Machine which is smaller, cheaper and portable, but it provides a highly efficient work same as other giant CNC machines. This machine is a versatile multi-purpose machine where the tooling holder can mount and change with several tools that are adjustable depending on the work type and environment. Its ability covers from labelling, marking until milling, drilling, engraving, cutting, and welding.

1.2 Problem Statement

In this era, technology is booming and flourishing, the level of requirement and demand are going to rise. Many customize parts request high precise in dimension, while manually fabricate by hand is lack of accuracy. It is impossible or hard to achieve by any ordinary man without the aid of a machine which provides efficient work.

Thus, create a custom part is too expensive and is a burden for a small engineering team. By the way, there is no factory willing to receive an order with just a single amount. It is hard to have an order from manufacturing industry just for a single custom part. They always have a scale in minimum quantity per order. Many people that are not related to fabrication field cannot create parts that are complex.

On the other hand, time consume in fabrication also need to consider since it will directly impact the manufacturing cost. Industries not only pay attention to their product quality, they also care about unit per hour rate because the market demand is large.

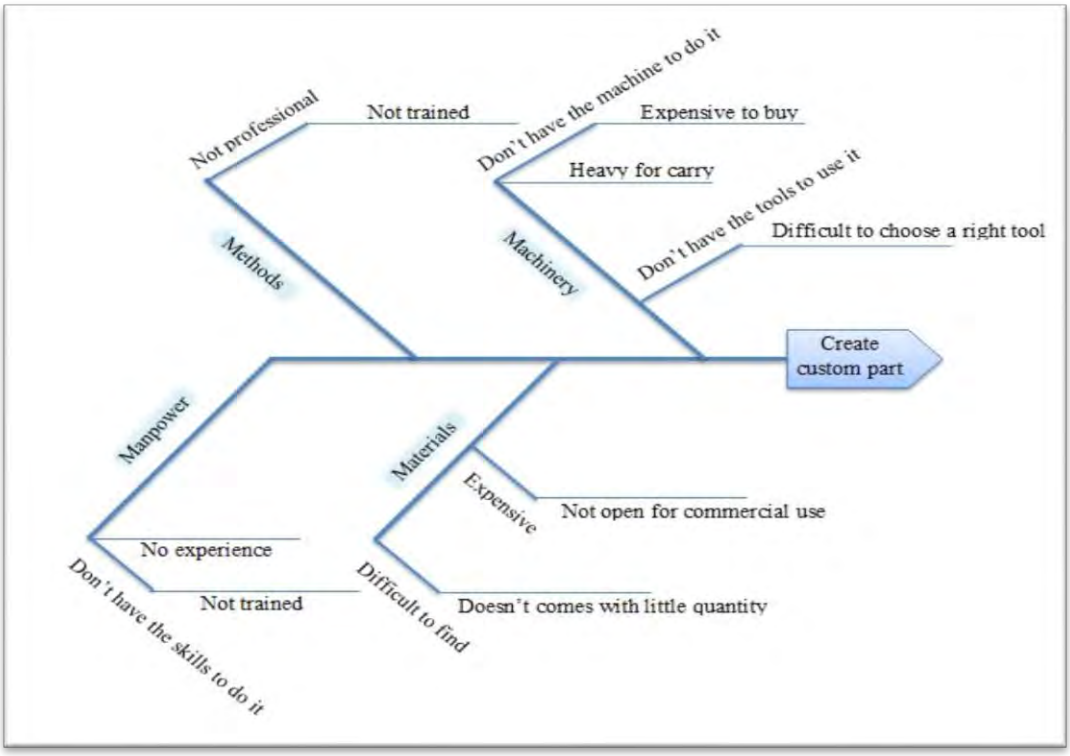

Figure 1.2a: Ishikawa diagram of problem statement

1.3 Project's Objective

- **To construct a simple mechanism**

A simple mechanism design uses less material cause the overall cost cheaper, affordable for anyone in such a way that if people can afford a smartphone. To break out that people mind set which they think to own a CNC machine is an impossible dream due to an expensive price, while the portable CNC machine will make the dream comes true.

- **To design a portable usage**

The portable CNC machine allows the user brings it to any working place because the size is smaller and special design for portable, for example, universities, office, workshop, and even outstation. This CNC machine can be a target for engineers, designers, researchers, lecturers or students and those who are interesting and want it as a hobby used.

- **An easy way to command the CNC machine**

A conventional CNC machine needs operate by a programmer which key in a series complex machine code to command the CNC machine. However, the portable CNC machine only requests the users direct upload their design to the machine by an aided of interface software. With this, the user does not need to employ an experienced programmer in operation. In addition, the typing error and bugging in programming is greatly reduced. It also works as automation, thus no workers are needed. All of this has indirect help the user reduce their product cost, and the user is no longer needed an order from the manufacturing industry.

- **To evaluate the efficiency outcomes**

The portable CNC machine allows the user to create whatever design they want on workshop piece. A task can do quickly and reduce error by the portable CNC machine. This is because no manpower is involved in the work. As the common-sense, a human might be tired and become careless after a long working period, but a machine would not distract from it. A comparison of the portable CNC machine's product will be doing with product of 3D printer and other conventional CNC machine. The speed execution, time consumer and accuracy will be judge for the quality of performance. To have a fair evaluation, a design with same dimension will used.

1.4 Scope

As the project to build a portable CNC machine, its major target is only focused on marking with a marker pen and engraving via laser beam or tooling bit. The power of laser beam will be used for engraving is around 1000mW, while the diameter for tooling bit is less than 6mm. The portable CNC machine has readily prepare an output signal for controlling the head tools.

It is possible using laser directly executes to the workpiece but the purpose of marking is tried to extract the layout design to the workpiece before real cutting. These marking can be a reference for engineers and still can change or edit since it is just in marking state. The design works normally do via CAD software such as AutoCAD, SolidWorks, Inkscape, etc. Usually there always has slightly different between ideally and practical based on uneven flat surface workpiece area, a limited corner workspace, and others. Marking can greatly reduce risk because it let engineers and operators checks and confirms again before execute.

By the way, the portable CNC machine has a limited working platform size with around 30cm width time 30cm height. The working platform can be increase by expand the structural base.

1.5 Organization

This project is focused on how to improve an industry fabrication. The first chapter has explained the problem which has faced in the most manufacturing field. Then introduce about the portable CNC machine and its characteristic. The second chapter is literature review which discusses tool application, control system, and hardware design. Next chapter is methodology, it describes procedure and progress of the project. In chapter four will shows the result and data analysis after testing. A response and opinion from industry also will list within this chapter. Last is a conclusion that will summarize the outcome of this project and suggest the next improvement of the portable CNC machine in the future.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter will discuss the application of CNC machine and other types of manufacturing machine. A comparison will do between the applications to show their properties. Besides that, the kinematics of several machines will also discuss in this chapter.

2.1 CNC Machine Head Tools

CNC machine is a subtractive way of manufacturing where the process starts with a bulk of workpiece, then cuts or mills it step by step using specialize machine tools (Hou, 2015). It is a contrast to a 3D printer where the process starts print from bottom layer by layer using hot end to melt the material. There is varies type of CNC cutting tools in the market with different properties, characteristics and also price (Spilling, 2014).

2.1.1 LASER

LASER is an initialism which stands for "light amplification by stimulated emission of radiation". Lasers work through a process of optical amplifiers which stimulating a lasing material by electrical discharges or lamps within a closed chamber. Two end sides of chamber consist of mirrors, one is totally reflects light internally until it gains a sufficient energy to