UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF MINI CNC MILLING MACHINE FOR SMALL SCALE PRODUCTION

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

by

MOHD. NAJIB BIN ZAMRI

B051010220

870706-23-5119

FACULTY OF MANUFACTURING ENGINEERING

2014

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Development of Mini CNC Milling Machine for Small Scale Production**

SESI PENGAJIAN: **2013/14 Semester 2**

Saya **MOHD. NAJIB BIN ZAMRI**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TIDAK TERHAD	

Disahkan oleh:

_________________________ _________________________

Alamat Tetap:

Kampung Parit Bakar,

Jalan Abdul Rahman,

Muar, Johor Darul Takzim

Tarikh:

Cop Rasmi:

Tarikh: _________________________

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled “Development of Mini CNC Milling Machine for Small Scale Production” is the results of my own research except as cited in references.

Signature	:	
Author’s Name	:	Mohd. Najib Bin Zamri
Date	:	

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process) (Hons.). The member of the supervisory is as follow:

……………………………….

(Project Supervisor)

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process) (Hons.). The members of the supervisory committee are as follow:

………………………………

(Principal Supervisor)

………………………………

(Co-Supervisor)

ABSTRACT

This thesis contains the report of how to build the mini CNC milling machine with the low cost compared to other machine that usually used in industry. This machine will be tested in term of accuracy and performance by doing some experiments. Most of the material that used to build this machine is Aluminum 6020 Alloy. Computer Numerical Control (CNC) machining is a process used in the manufacturing sector that involves the use of computers to control machine tools without direct human assistance. Tools that can be controlled in this manner include lathes, mills, routers, and grinders. CNC is a very broad term that encompasses a variety of types of machines all with different sizes, shapes, and functions. In modern CNC systems, mostly component design is highly automated using Computer Aided Design (CAM) programs but for this mini CNC milling machine, it is a simple and use basic CNC machine operation by usingMach3 software. There have some part that uses such as water cooled spindle with power 2.2 kilowatt, ball screw bearing, stepper motor, bearing, rail bearing, and some electronics parts. Some machining process are involves such as drilling, milling, cutting, facing, and others. This study focuses more on the how to build a mini CNC milling machine where this machine are very own, fully functional, easy to maintain and inexpensive. This machine also can cut, carves, engraves and drills any material depends on machine specifications that are build.

ABSTRAK

Tesis ini mengandungi laporan bagaimana untuk membina mesin kecil CNC dengan kos yang rendah berbanding dengan mesin CNC yang sediada yang biasanya digunakan dalam industri. Mesin ini akan diuji dari segi ketepatan dan prestasi dengan melakukan beberapa eksperimen. Kebanyakan bahan yang digunakan untuk membina mesin ini adalah Aluminium Alloy 6020 . Kawalan Berangka Komputer (CNC) pemesinan adalah satu proses yang digunakan dalam sektor pembuatan yang melibatkan penggunaan komputer untuk mengawal peralatan mesin tanpa bantuan manusia secara langsung . Alat-alat yang boleh dikawal dengan cara ini termasuk mesin larik, router, dan pengisar . CNC adalah satu istilah yang sangat luas yang merangkumi pelbagai jenis mesin dengan saiz yang berbeza , bentuk dan fungsi. Dalam sistem CNC moden, reka bentuk kebanyakannya automatik dengan menggunakan program Rekabentuk Berbantukan Komputer (CAM) tetapi untuk mesin CNC kecil ini , ia adalah satu asas mesin operasi CNC mudah digunakan oleh perisian Mach3 . Terdapat beberapa bahagian yang menggunakan seperti ‘spindle motor’ dengan kuasa 2.2 kilowatt , ‘ball crew bearing’, ‘stepper motor’ , ‘bearing’, ‘linear rail bearing, dan beberapa bahagian elektronik. Terdapat beberapa proses pemesinan yang terlibat seperti penggerudian ,memotong, dan lain-lain . Kajian ini lebih tertumpu kepada bagaimana untuk membina sebuah mesin CNC di mana mesin ini boleh berfungsi sepenuhnya , mudah untuk digunakan dan murah. Mesin ini juga boleh memotong dan mengukir pelbagai jenis bahan bergantung kepada spesifikasi mesin yang membina.

DEDICATION

To my beloved parents

ACKNOWLEDGEMENT

I would like to thank to my highest appreciation to my supportive academic supervisor, Mr.Hadzley Bin Abu Bakar. His supervision and support that gave me truly helps during the period of conducting my thesis. His never-ending supply of valuable advice and guidance has enlightens me and deeply engraved in my mind.

Next, I would like to dedicate my thankfulness to the helpful of Mr. Shahir Bin Kasim, as my second supervisor for his enthusiastic support and supervision of the thesis revision. I'm also happy to present my gratefully acknowledge to Machinery laboratory technicians, who has been so warmth and kind to provide sincere assistance and good cooperation during the training. I'm also would like to convey thanks to FKP lecturers for their assistance which really spend their time to teach me a lots of knowledge regarding to the design development.

Last but not least, I would like to state my appreciation to staff – Faculty of Manufacturing Engineering, FKP, my friends and colleagues for supporting me and administration department for their help in the project. Thank you.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Al	-	Aluminium
V	-	Cutting Speed
f	-	Feed Rate
t	-	Thickness
>	-	More than
σ	-	Stress
mm /rev	-	Millimeters per Revolution
Rpm	-	Revolution per Minute
z	-	Number of Teeth
f_t	-	Feed per Tooth
CAD	-	Computer-Aided Design
CAM	-	Computer-Aided Manufacturing
MDF	-	Medium-Density Fiberboard
+	-	Positive
-	-	Negative

CHAPTER 1
INTRODUCTION

1.1 Background

Machining is a chip removal process from raw material where the material is cut into a desired final shape and size by using a various processes with specific machine. Machining is used because it has a high accuracy. By machining, the time to produce a parts or product will decrease and production will rise higher. Machining has evolved over the past two centuries as technology has advanced in term of the precise which are traditional or conventional machining and non-traditional machine or advanced machining.

Traditional machining processes such as milling, turning, drilling, boring, sawing, tapping, broaching, and planning. In these traditional machining processes included milling, turning, lathes machines, drill presses or others are used a sharp cutting tool to remove material to achieve a desired final size and shape of the parts or products. For non-traditional machining processes, it is used chemical, thermal, or electrical processes to machine a workpiece such as electrical discharge, electrochemical machining, electron beam machining, and ultrasonic machining. These advanced machining includes a wide range of operation used for special purpose or special workpiece.

Now, a used machine is in automated form which is controlled by a computer program called Computer Numerical Control (CNC). CNC is a command-based coordinate to get a form for you automatically [(Kalpakjian 2006)].

In the 1940s, CNC machines were first built and were programmed by using paper tape with holes punched into it at specific points. After that, these early systems were changed with the augmentation of analogue and digital computers. To improve the productivity of the machine and the quality of the work, the range of CNC systems were be fitted to previously manually operate machine tools, and these systems provide a selection of features which can significantly.

Computer numerical control (CNC) machining is a process used in the manufacturing sector that involves the use of computers to control machine tools such as lathes, mills, turning, grinders, and others without direct human assistance. The use of a CNC machines are widely where that includes a variety of types of machines in different function, designs, and sizes. But the main point of a CNC is to simply understand that it is all about using a computer where the codes will control a machine that carves useful object from raw material to be a products or parts. For example, a CNC machine might begin with a solid block of Aluminum 6020 Alloy then the cutting tools from the machine will remove away the material to make a parts or products such as a gear shaft. In modern CNC systems, component design is highly automated using Computer Aided Design (CAD) and Computer-Aided Manufacturing (CAM) programs.

There are two types of CNC machines which are turning machine and milling machine. A turning machine is generally made up of a device that rotates a workpiece at high speed then the cutting tool will removes off the undesired material from the workpiece until achieves the desired form that needed. For a milling machine, various directions of rotating and cutting can be done by special tools. These special tool can moves in three directions axis which is x, y, and z-axis.

Mostly, all manufacturing industry uses CNC machine to produce a product in large quantities because it is no efficient or profitable to make everyday product by hand. By using CNC machine it is possible to produce hundreds or even thousands of the same products in a day. First, the design engineer will draw the product based on customer requirement using design software such as Computer Aided Design (CAD) and Computer-Aided Manufacturing (CAM) programs, than it is process by computer and manufactured using the CNC machine. In industry, CNC machine can be extremely large.

1.2 Objective

There are three main objectives by doing this project:

- Identify the parts of the CNC milling machine to build the mini milling CNC machine.
- To build mini CNC milling machine by assembled all the parts with some guided.
- Test the mini CNC milling machine which has been builds with some experiment.

1.3 Scope of Project

This project will be focus more on the how to build a mini CNC Milling machine where this machine are very own, fully functional, easy to maintain and inexpensive. It also can cuts, carves, engraves and drills any material depends on machine specifications that were building. On these project each parts that used to build the machine will assemble together to becomes a complete mini CNC milling machine. After that, this machine will tested with some experiment to look the machine accuracy and running condition. By refer to the result experiment, we will know either this mini CNC milling machine in a good condition or not. Some modification or adjustment will make if the machine has a problem.

CHAPTER 2
LITERATURE REVIEW

2.1 Machining

Machining is characterized by an operation of a cutting tool that engages a workpiece to remove a layer of material in the form of a chip [Shneider (2007)]. As the cutting tool engages the workpice, the material ahead of the tool is sheared and deformed under enormous pressure. The deformed material then seeks to relieve its stressed condition by separating and flowing into the air in the form of a chip. This operation involves large plastic deformations accompanied by elastic, thermal, and frictional effects in a region enclosed by the workpiece, the chip and the cutting tool [Childs (2000)].

Machining is usually divided into the following categories:

- Cutting which generally involves single-point or multipoint cutting tools, each with a clearly defined tool shape;
- Abrasive processes such as grinding;
- Advanced machining processes that utilize electrical, chemical, thermal, and hydrodynamic methods as well as lasers.

2.1.1 Elements of Machining

Figure 2.1 shows a schematic illustration to represent the nomenclature of the machining process. The undeformed chip thickness, t_1, is the value of the depth of cut while, t_2, is the thickness of the deformed chip after leaving the workpiece. The major deformation starts when the cutting tool, in a rake angle, α, shears the metal to form an angle of shear, Ø, at a specific cutting speed, *V*, and feed rate, *f*. The deformed chip is separated from the parent material by fracture to remove the excess stock of the parent material to create a finished workpiece of the required dimensions [Shneider (2007)].

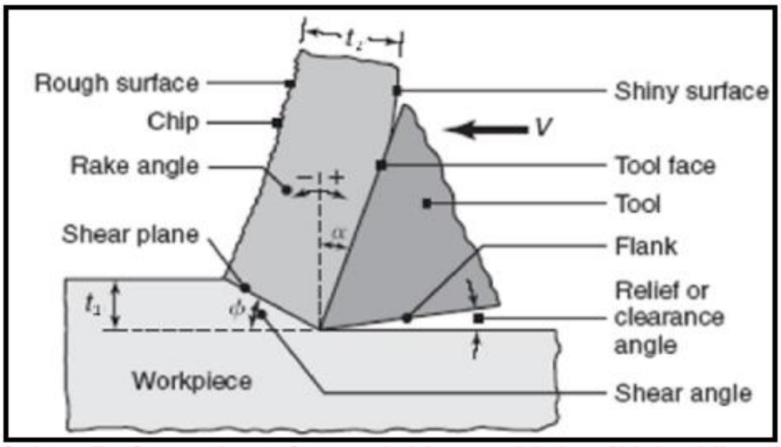
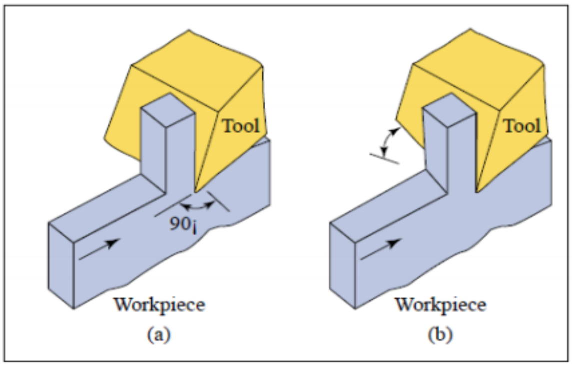


Figure 2.1: Deformation of material in machining [Kalpakjian (2000)].

2.1.2 Classical of Machining Process

The machining process can be distinguished as either an orthogonal or oblique machining [Kalpakjian (2001)]. Orthogonal cutting describes the process when the approach angle is 90º which is shown in Figure 2.2a oblique machining describes the process when the approach angle is not equal to 90º which is shown in Figure 2.2b. In orthogonal cutting, the cutting edge is a straight line extending perpendicular to the direction of motion as the work moves past it. Therefore, the forces generated are in the tangential and axial directions only. In oblique cutting, the forces generated include an additional radial force to the workpiece axial surface, which is dependent on the approach angle of the cutting tool [Trent (2000)].



(a) (b)

Figure 2.2: (a) Orthogonal cutting (b) Oblique cutting [Schneider (2000)]

2.1.3 Areas of Deformation

There are three areas of deformation that appear in the machining operation: the primary zone, the secondary zone and the tertiary zone, which is shown in Figure 2.3. The primary zone is the region in front of the tool tip on the free surface where the stresses and temperatures are generated to deform the workpiece material to produce the chips. A secondary zone occurs along the rake face of the cutting tool where the material experiences some additional shearing due to high friction at the tool-chip interface. Meanwhile the tertiary shear zone occurs under the leading edge of the cutting tool where the flank face rubs the deforming material [Kalpakjian (2001)].

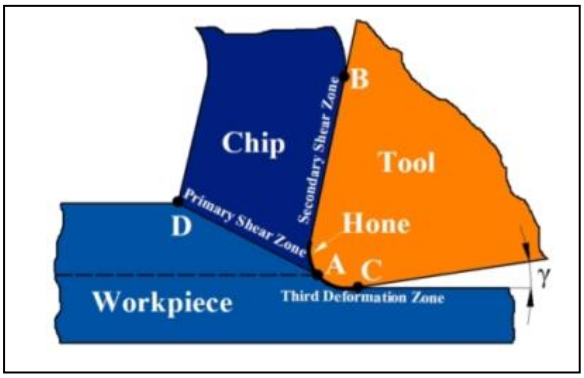


Figure 2.3: Deformation zones during machining [Kalpakjian (2001)]

2.1.4 Cutting Parameters

The most influential cutting parameters are cutting speed, feed rate and depth of cut. Cutting speed (*V*) is defined as the rate at which the surface of the workpiece is being passed by the cutting tool. Cutting speed is expressed in m/min by the formula

$$V = \frac{\pi d n}{1000} \tag{2.1}$$

where *d* is the diameter of the workpiece material and n is the spindle speed expressed in revolutions per minute (rev/min).

Feed Rate (*f*) is defined as the distance that the tool travels in an axial direction during each revolution of the workpiece material, which is normally expressed in millimeters per revolution (mm/rev). Generally feed is expressed in three ways such as feed per tooth, feed per revolution and feed per unit of time. In feed per tooth is the distance traveled by the workpiece between engagement by the two successive teeth, mm/tooth (f_t). For feed per revolution, it is a travel of workpiece during one revolution of milling cutter, mm/rev $f_{(rev).}$ And lastly, the feed per unit of time where the distance advances by the workpiece in unit time,(f_m). It also can be expressed as feed/minute or feed/sec. Above described three feed rates are mutually convertible.

$$F_m = n \text{ x } f_{rev} \tag{2.2}$$

where $n = rpm$ of cutter.

It can be extended further as

$$f_m = n \text{ x } f_{rev} = z \text{ x } n \text{ x } f_t \tag{2.3}$$

where z = Number of teeth in milling cutter.

2.1.5 Depth of Cut

Depth of cut in milling operation is the measure of penetration of cutter into the workpiece. It is thickness of the material removed in one pairs of cutter under process. One pairs of cutter means when cutter completes the milling operation from one end of the workpiece to another end. In other words, it is the perpendicular distance measured between the original and final surface of workpiece. Figure 2.4 shows the important parameters for the basic machining operation.

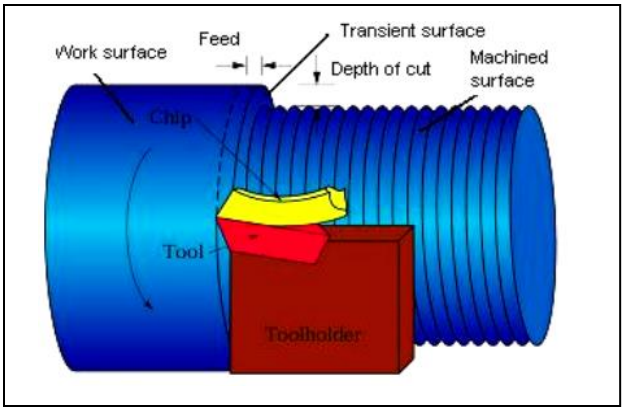


Figure 2.4: Basic machining operation and important parameters
[Kalpakjian (2001)].