UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MACH 3 CNC MACHINE SOFTWARE FAMILIARISATION AND MACHINING

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

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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 committee is as follow:

……

(ENGR. DR. MOHAMAD BIN MINHAT)

ABSTRAK

Projek ini dijalankan berdasarkan aplikasi dan keperluan industri. Mach 3 adalah salah satu pakej kawalan yang mengawal sistem pemesinan CNC. Sebagai perisian "sumber terbuka", Mach 3 dengan pantas menjadi salah satu teknologi terbaik berasaskan PC telah berkembang di pasaran yang dibina dengan kos rendah. Disebabkan kebolehpercayaan dan kos rendah, kini ia digunakan secara global. Membiasakan diri dengan perisian sehingga pemesinan adalah menjadi isu utama yang akan dibincangkan, sejajar dengan objektif projek ini. Tambahan pula, kajian ini menunjukkan secara tidak langsung dapat menghasilkan reka bentuk produk dengan menjana kod program dan simulasi. Hasil diperolehi selepas proses pemesinan dengan menggunakan 3-paksi Sherline CNC Milling. Kekuatan dalam projek ini menunjukkan bagaimana untuk menggunakan dan menyesuaikan dengan perisian melalui membiasakan diri.

ABSTRACT

This project is carried out based on the industrial application and requirement. Mach 3 is one of the controller packages, which control CNC machining systems. As a "open source" software, Mach 3 has quickly turned into one of the best PC's-based technology evolved in the market with low-cost constructed. Due to its reliability and low-price, nowadays it's being used globally. On the other hand, familiarisation with the software until machining will be the main issue that will be discussed, in line with the objective of this project. In addition, familiarisations using the software indirectly produce the design part by generating the coding and simulation. The result is obtained after the machining process by using the 3-axis Sherline CNC Milling machine via the software. Strength in this project shows how to use and adapted the software through familiarise.

DEDICATION

My beloved parents and family members
Who has always been there for me, understanding and always prays for me,

My friends and all faculty members
Who have supported and guidance to me.

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Praised to Allah SWT, with His grace I am able to complete 'Projek Sarjana Muda'. My appreciation also greatly indebted to Engr. Dr. Mohamad bin Minhat, my most respective PSM supervisor. With his kindness, guidance, understanding, willingness to spend time, and continuous support along the completion of this project.

Not to be forgotten to all lecturers who has taught me for the whole semester in Degree of Manufacturing Process. I also would like to take this opportunity to thank to Faculty of Manufacturing Engineering (UTeM) for providing all the facilities needed during the project.

Last but not least, my greatest appreciation also extends to my beloved parents and family members for being so supportive and understanding in completing this project. And lastly, I would like to dedicate thanks to all my fellow friends and for those who offered valuable advice that made this project successful. Thank you for the support and willingness to be part of this project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

2D	-	Two-Dimensional
3D	-	Three-Dimensional
BMP	-	Bitmap
CAD	-	Computer-Aided Design
CAD/CAM	-	Computer-Aided Design/Computer-Aided Manufacturing
CAPP	-	Computer-Aided Process Planning
CAM	-	Computer-Aided Manufacturing
CATIA	-	Computer Aided Three-dimensional Interactive Application
CNC	-	Computer Numerical Control
CPU		Control Processing Unit
DIY	-	Do-It-Yourself
DXF	-	Drawing Exchange Format
EMC	-	Enhanced Machine Controller
HPGL	-	Hewlett-Packard Graphics Language
JPG/JPEG	-	Joint Photographic Expert Group
MB		Megabytes
mm		millimetres
NC	-	Numerical Control
PSM I	-	Projek Sarjana Muda I
PSM II	-	Projek Sarjana Muda II
RAM		Random Access Memory
TPG		Toolpath Generating

CHAPTER 1
INTRODUCTION

This chapter explains the introduction of the project which is conducted in accordance with the needs of industry and consumerism. In this chapter, an overview of Mach3, problem statement, objectives, and scopes of work is discussed. The structure of the report is also included that explain about an overall chapter of the project.

1.1 Overview

These days, Computer Numerical Controller (CNC) machine have dozens of business and widely used in the industrial field as a modern machineries. Most CNC machines are now programmed using Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) software. In CNC fields, phrase "open source software" show a great number of choices. An internet search, the key word of open source will show thousands of definitions. Generally, open source refers to a software license in which the source code available to the public for any purpose with or without existent copyright restrictions.

In this project, Mach3 is used as the example of CNC open source software available nowadays. Mach3 is a computer-aided manufacturing (CAM) application and one of the software programs that controls CNC machining systems. Mach series is one of the best available PC-based software has evolved in the market and it is designed to be used on the windows operating system.

In the beginning, this software is developed for the home hobbyist, but has quickly turned into one of the most multipurpose control packages for industrial use as well and capable of running many different kinds of CNC machinery. Mach3 is not only recognized as being extremely affordable to the hobbyist and industry alike, it has continued to pioneer with new features and industry-leading development. According to ArtSoft Corporation, more than 10,000 users of Mach3 grateful to the creators for simplicity, ease of use, excellent technical features, and professional support.

Since it is the most popular controller software, the software is available with an optional CAM and milling add-on packages. Although the software runs on a PC-controller operating system, it can operate up to six axes at the same time and has considerable built-in functionality. These allow users to modify the design and undergo of the application to suit the needs.

As a end-users who wish to use open source software with the new technology development, the familiarisation on the Mach3 CNC software will be the main objective of this project. The project begins with information seeking, familiarise the function and designing the part by using CATIA. Later, the project will be continued with generating NC code for part programming using Mach3, and finally is to machine the part using CNC machine provided.

1.2 Problem Statement

In the era of modernization, the use of CNC controller software in the industry was growing rapidly. Mach3 is one of the updated technologies adopted by the CNC machining industries. Mach3 is an "open source" software and freely to be downloaded and to be used. If it is downloaded as a free user, the software can support up to 1000 lines of G-code only in which this code will give many benefits to the user, small hobbyist or industries. Since this software is quite new, the skillful person is less. The

purpose of this project is to expose the student on the software based on industrial requirement by familiarises. The familiarisation until machining will be the main issue that will be discussed. In this project, student can undergo the application through familiarise and at the same time, give experience by doing the machining via the software.

1.3 Objectives

The ultimate goal of this project is to familiarise the Mach3 CNC machine software. The specific objectives that need to be achieved until the machining operation consist of:

- Enable to apply the method of CNC programming,
- To generate NC code for part programming, and
- To produce the part by machining using Sherline 3-Axis CNC Milling Machine via Mach3 CNC software.

1.4 Scope of Work

One of the first and most important steps in a project is to flesh out a scope which identifies and describes all work necessary to produce the final part. The project emphasized on Mach3 CNC machine familiarisation software and machining with using 3-axis Sherline Milling machine. All of the planning steps involved are listed in methodology. The discussion on this project are analysed based on the result obtained.

1.5 Structure of Dissertation

This report consists of five chapters which is covered on Projek Sarjana Muda I (PSM I) and Projek Sarjana Muda II (PSM II). The dissertation is structured into three chapters during the PSM I and two chapters of PSM II. The first chapter is an outline of the overview project, problem statement, objectives, scope of work and the structure of the report. Chapter 2 comprises information on the literature review of Mach3 software and CNC machining. This chapter discusses the integration of CAx chain, CNC control software available in the market, and overview of Mach3 software. In a literature review, the data in this section mainly from several sources include journals, internet websites and books.

Next, chapter three explains the project methodology during undergoing the study, the action plan, and process flow of the project to complete this project. The methodology is performed to ensure this project is successfully completed on the specified time. Meanwhile, PSM II is continuity of PSM I which covered chapter four and five. The PSM II is more to the experimentation to produce the final product. In chapter 4, all of the results obtained were presented and discussed in this section. Finally, the Chapter 5 is regarding to the conclusion whether the project is successful or not based on the objectives and added with future suggestion in order to improve this project.

CHAPTER 2
LITERATURE REVIEW

This chapter explains the literature review of the integration of CAx chain, CNC controller software evolved in the market, CNC machine and others. In CAx chain, the integrated is constructed consist of development of CAD, CAM, CAPP and CNC technologies. Besides that, the theory of CNC machines is also explained and illustrated in this chapter. In addition, the review is based on the searching information from other sources which is comprised into three main sources such as internet websites, book, and journal or article. Suitability is required to make sure information obtained is adaptable and beneficial for the further step.

2.1 Overview

The technologies are diverse. For the last 50 years, manufacturing industries have been looking for more efficient processes for manufacturing products with CNC machines (Nassehi et. al, 2006). This project is carried out based on the industrial requirement. In this study, Mach3 is a CAM application and used as one of the CNC software available in the market today that control CNC machining system. Figure 2.1 shows the flow which involves in CNC software. The flow consists of primarily three parts. In addition, the integration of CAx chain is describes in the next section (refer section 2.2) which consist of: (1) development of CAD technology, (2) development of CAM technology, (3) Computer-Aided Process Planning (CAPP) and CAD/CAM integration, and (4) CNC.

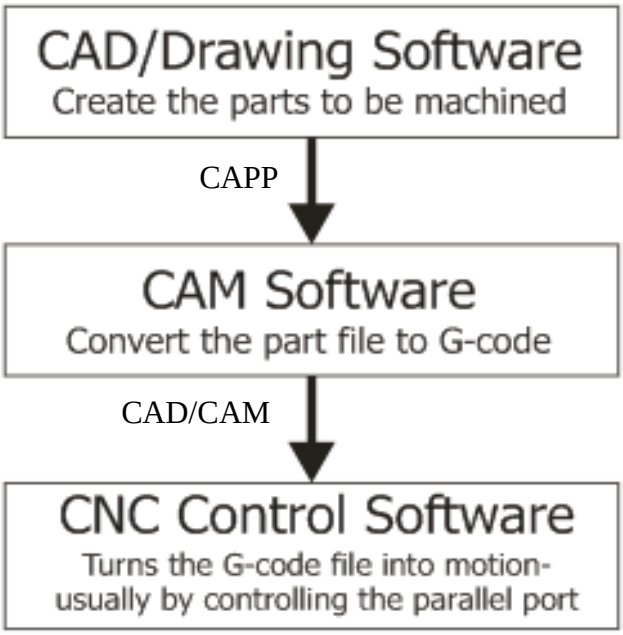

Figure 2.1: Primarily flow process involved in CNC
(Source: http://www.probotix.com/cnc_software/)

2.2 Integration of CAx Chain

Computers have been greatly involved in product development throughout the product lifecycle, from design, analysis, to manufacturing. In the early 1960s, Ivan Sutherland developed the sketchpad system (Sutherland, 1963 as cited in Saaski et. al, 2005), a milestone of research achievement in computer graphics. The evolution of computer graphics has since resulted in the development of CAD (Saaski et. al, 2005). CAD technology has evolved dramatically since it was born. In the early, CAD systems were essentially for two-dimensional (2D) drawing and drafting.

Then, in the early 1970s, CAD systems were little more than drafting software used to create 2D drawings similar to hand-drafted drawings. CAD was often referred to as Computer Aided Drafting at that time. The geometry available to the user was limited to simple geometry, like lines, circular arcs and ellipse arcs. Advances in programming and computer hardware, notably solid modelling in the 1970s, have allowed more versatile

CAD applications in design activities. As the geometric modelling, technology has progressed from simple 2D drawing, to three-dimensional (3D) drawing (Hou, 2008).

At the same time, development saw CAM more closely connected to CNC systems. Numerical Control (NC) machines were first introduced in the early 1950s. Development of CAM technology was inspired by NC machines. In industry, CAD techniques are extensively used to design products, and CAM techniques are used to manufacture the products. NC machine tools were developed to manufacture complex shapes. NC programs are lengthy and must specify each single movement of the machine tool. NC programs are difficult to create or edit by hand. Figure 2.2 shows an example of NC part programs for a drilling operation. Simple NC programs, like point-to-point processes, can be created manually, usually with the aid of a calculator. However, for more complex programs, it is very time consuming and subject to human errors to manually generate NC programs from drawings. CAM systems were developed to use computers to prepare and generate part programs for NC machines (Hou, 2008)

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N0010 G40 G17 G90 G70
N0020 G91 G28 Z0.0
N0030 T01 M06
N0040 G00 G90 X4.2445 Y-9.8098 S500 M03
N0050 G43 Z5.9207 H00 M08
N0060 G81 Z5.7644 R5.9207 F10.
N0070 G80
N0080 M09
N0090 G00 Z8.
N0100 X3.6 Y-9.2
N0110 M02
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Figure 2.2: NC programs for a drilling operation (Hou, 2008)

The bridge between CAD and CAM is processed planning. Process planning is the process of determining detailed operation instructions to transform an engineering design to a final part (Chang et. al, 1998 as cited in Hou, 2008). In the past, process plans were often generated by human process planners who had plenty of manufacturing domain knowledge and worthy experience. In the recent decades, computer technologies have stimulated the advance toward CAPP (Zhao et. al, 1999). CAPP has evolved to simplify and improve process planning and use product information on and manufacturing resources more effectively. The goal of CAPP is to generate a sequenced set of instructions used to manufacture the specified part, which then can be applied to downstream applications, like CAM (Hou, 2008).

Computers were introduced into manufacturing to compute and control the cutter motions of machine tools. This required a new way of understanding and extracting the shape information of a part design from engineering drawings. Such a task was not possible until special languages were developed to translate the shape information from the drawing into computer-controlled machine tools (Mortensen, 1985 as cited in Saaski et. al, 2005). Current NC programming is based on ISO 6983 (ISO 6983 1982), called G-code where the cutter motion is mainly specified in terms of position and the feed rate of axes (Saaski et. al, 2005).

Later on, CAD/CAM technologies have continued to evolve. The benefits of integrated CAD/CAM systems include decreased time to market, lower development and design cost and the ability to rapidly translate ideas into models (Chang et al, 1998 as cited in Hou, 2008). Current major commercial CAD/CAM systems such as Unigraphics, Pro/E, and CATIA have many specialized modules packed together and running on their own proprietary databases (Hou, 2008).

With the continuing demand for ease of use and productivity improvement, greater automation is being embedded into all aspects of CAM products, from the user interface to post processors. Machining intelligence built into a CAM system makes the system produce more consistent NC code in less time. CNC are at the heart of modern machine

tools and traditionally programmed in a primitive vendor-specific language, G-code. G-code is a common name for the programming language for a NC machine tool (Minhat, 2009). In the development of NC to CNC, most CNC machines were programmed using the G-code language, which designed to sequentially document and pass instructions to the controls of single machine tools (Lee et. al, 2006). CNC technology has the following advantages over NC technology: program can be entered in the machine and stored in memory, and easier to edit, so the programming of parts and design time are reduced. It is widely used through the world because of its accuracy, reliability, repeatability and productivity. There is also greater flexibility in dealing with complex parts assisted by three-dimensional (3D) geometric models. Figure 2.3 shows the flow process from CAD tools until the product is fabricated.

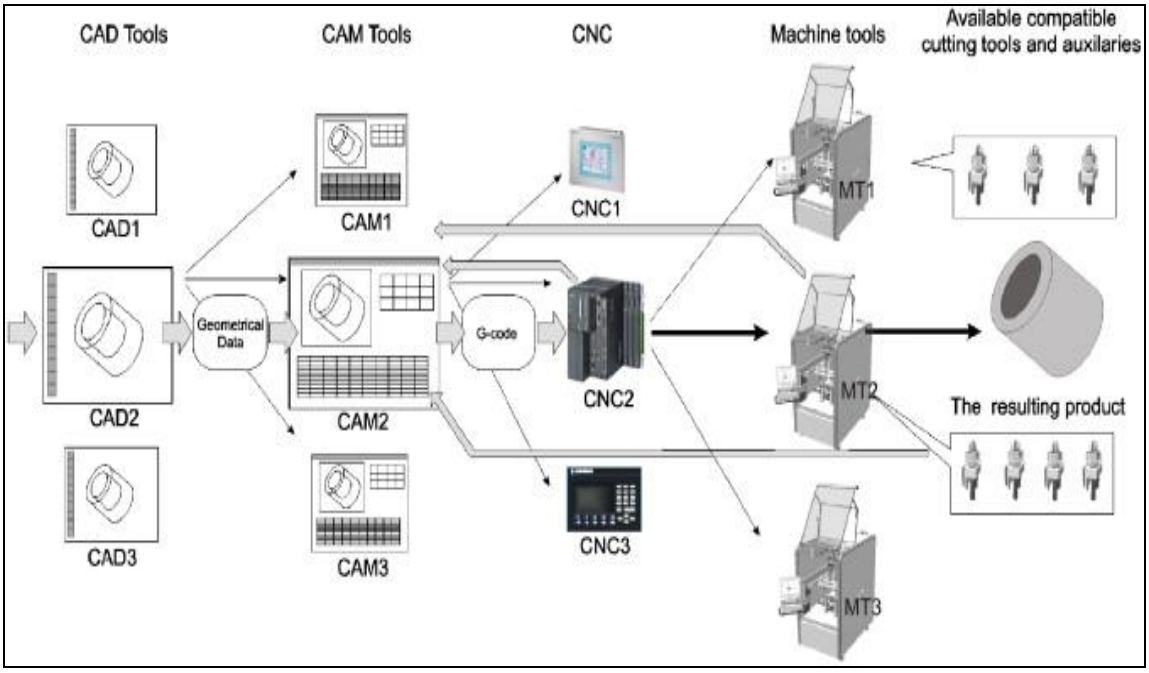

Figure 2.3: A typical CAx chain (Minhat et. al, 2009)

2.3 Industrial CNC Machine Controller Software

There are several controller packages available to the user. Some are stand alone software that supports a wide range of hardware choices. Others are specific to work exclusively with a specific hardware controller, which would be considered a proprietary-based system and should be avoided if possible. Some are free whereas others almost require a second mortgage. As a user, to find a controller package that is capable of interfacing and controlling hardware that is commonly available, as well as works with various peripheral devices. An internet search with the key words "CNC controller software" will show a great number of choices (Alan, 2011).

However, for low cost, home and small business CNCs require at least one software package to operate. This is the basic package which allows the user to open a graphics file and command the system to machine the part. There is several basic interface software available for Do-It-Yourself (DIY) CNC, which lower cost units are constructed. Mach3, Enhanced Machine Controller (EMC), BobCAD CNC, and Desk CNC are an example of CNC control software that available with lower cost units are constructed (William et. al, 2009).

2.3.1 Mach3

Mach3 is a CNC software system that works with a full PC 6-axis CNC controller. Mach3 can import Drawing Exchange Format (DXF), Bitmap (BMP), Joint Photographic Expert Group (JPG/JPEG), and Hewlett-Packard Graphics Language (HPGL) files to create an image that can be machined with the CNC. This program which was created by Art Soft was designed for small businesses and hobbyist. Mach3 uses three external software packages: LazyCam, Wizards, and VB scribe. LazyCam that allows the user to import different file types to the CNC controller and transfers them into G-code files. Wizards are mini programs that allow the user to write their own G-code easily. It has many capabilities such as gear cutting, holes, slots, text and