UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PERFORMANCE OF SELF-FABRICATED CNC MACHINE WHEN MACHINING INDUSTRIAL PRODUCT

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 TALMIZI BIN MAT DAUD

B051010119

880429-03-5707

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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)

ABSTRAK

Tesis ini mengandungi laporan mengenai prestasi pemesinan mesin CNC yang dihasilkan sendiri apabila digunakan untuk proses pemesinan. Tujuan kertas kerja ini adalah untuk mengkaji kecekapan mesin baru dan kekasaran permukaan yang hadir pada bahan Aluminium Alloy LM6 apabila dimesin dalam keadaan tanpa cecair penyejuk dan untuk menentukan ciri-ciri mata alat tungsten karbida semasa pemesinan. Prestasi Pemesinan ditentukan mengikut kehausan mata alat dan kekemasan permukaan yang diperolehi. Semasa ujian, kelajuan pemotongan akan digunakan dalam pelbagai kelajuan pemotongan 7000 rpm sehingga 10000 rpm dengan kadar suapan dan kedalaman pemotongan adalah, 90 mm / min dan 0.5 mm. Masa pemotongan dianggap dalam ujian pemesinan ini untuk mengenalpasti jangka hayat alat. Daripada ini, parameter pemotongan yang sesuai untuk setiap alat pemotong akan dikenalpasti bergantung kepada kekasaran permukaan dan penggunaan alat. Prestasi integriti permukaan untuk aloi aluminium adalah berdasarkan pengukuran oleh penguji kekasaran permukaan dan profil permukaan menggunaan alatan Mikroskop optik . Dari gambar ini dan data yang terhasil, dijangkakan kekasaran permukaan dan memotong alat akan terjejas oleh parameter pemesinan. Data dianalisis menggunakan satu reka bentuk cara berdasarkan graf dan pemerhatian. Berdasarkan kepada kekasaran permukaan bahagian dimesin dan alat nilai memakai alat pemotong. Mesin buatan sendiri mampu untuk melakukan pemesinan aloi aluminium LM6. Pemotongan parameter terbaik yang diperolehi daripada eksperimen yang memotong kelajuan 8000 rpm, kadar suapan 90 mm / min dan dalam pemotongan 0.5 mm menggunakan alat pemotong tungsten karbida.

ABSTRACT

This thesis contain the report of machining performance of Self-fabricated CNC machine when apply to machining process. The aim of this paperwork is to study the machinability of new machine and present surface roughness of Aluminum LM6 Alloy material in dry milling and to determine the tool wear characteristics of tungsten carbide cutting tool during machining. Machining performance is determined according to tool wear and surface finish that obtained. During testing, cutting speeds will be used in range of 7000 rpm until 10000 rpm with feed rate and depth of cut is 90 mm/min and 0.5 mm, respectively. The cutting time is considered in this machining test to identify the tool life. From that, the appropriate cutting parameters for each cutting tool will be identify depending on surface roughness and tool wear. The performance of surface integrity for aluminum alloy is measure by surface roughness tester and surface profile and tool wear by Optical Microscope. From this photograph and data, the expected outcome of surface roughness and cutting tool will be affected by machining parameters. The resulted data is analyzed using one way design based on graph and observation. Based on the surface roughness of machined part and tool wear value of cutting tools, self-fabricated CNC machine are capable to perform machining of aluminum LM6 alloy. The best cutting parameters obtained from the experiment are cutting speed 8000 rpm, feed rate 90 mm/min and radial depth of cut 0.5 mm using tungsten carbide cutting tool.

DEDICATION

To my beloved parents and siblings

ACKNOWLEDGMENT

Bismillahirrahmannirrahim,

Alhamdulillah, thanks to ALLAH S.W.T for giving me strength and good health during completing this final project. First and foremost, I would like to express my highest appreciation to my supportive supervisor, Engr. Dr Hadzley B. Abu Bakar that had provided guidance and good advises to me throughout this project. His supervision and support that gave me truly helps during the period of conducting my thesis. My gratitude also goes to the technicians in Faculty of Manufacturing Engineering (UTeM) for helping me in this project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

Al	-	Aluminium
Al2O3	-	Aluminium Oxide
BUE	-	Built-up edge
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
c-BN	-	Cubic Boron Nitride
CNC	-	Computer Numerical Controlled
HSS	-	High Speed Steel
MMC	-	Metal Matrix Composite
MRR	-	Material removal rate
NC	-	Numerical Control
Ra	-	Arithmetic mean value
Rq	-	Root- mean squire average
Si	-	Silicon
Si3N4	-	Silicon Nitride
TiC	-	Titanium Carbide
TiN	-	Titanium Nitride
WC	-	Tungsten carbide
>	-	More than
μm	-	Micrometer

CHAPTER 1
INTRODUCTION

This chapter provides the backgrounds of the project which focuses on the evolution of Computer Numerical Controlled (CNC) machine. It is also included on determining the general properties and application of Aluminium LM6 alloy. Test is performed using self-fabricated CNC machine based on machinability of material product in different cutting speed machining process towards to surface finish and tool wear. In this chapter, objectives and scope of the studies and a description of the problems encountered included.

1.1 Background

Nowadays, new industrial requirements such as high production rates, low production costs, high precision and good quality of part are increasingly demanded. Most of such requirements, including tolerances of finished products, dimensional accuracy and production rate can be met with better machine tools such as Computer Numerical Controlled (CNC) machine. CNC machine has been development significantly to meet the higher requirements in various manufacturing technologies, especially for the precision metal performance in job application. This improvement gives the effect of different machining parameters such as spindle speed, feed, and depth of cut in machining operation.

After computers were introduced for control of machine tools has made, many industry are using multi-axis Computer Numerical Controlled (CNC) machine tools

as a process for most of machining applications. Production industries required the high precision and speed machining which is to meet the requirement in the accuracy of the machined part shapes. Multi axis machining like CNC machine is best application to maintained high degree of accuracy positioning and capable to be fast in feed rate. This requirements is important in order to reduces the production cost with the reduces of cycle time for machining and to provide the product that can satisfy the customer's need in term of quality machining.

However, the high precision of CNC machines is very expensive, complicated, and typically only found in large manufacturing companies that can afford it. This professional CNC machine can cost millions of dollars. In present, there are custom made machine which is only cost around 7000 dollars or higher (H.D Patrick et. al, 2009). This custom made CNC machine is more inexpensive and capable to perform the same process in order for higher production rate and to meet the requirements of customer's need. Figure 1.1 below is the one example of custom made that typically used in small industries such as at the workshop to make structural part and for handyman in making new design of complex shape. With the innovation of this CNC machine, it can be implement in the education for training the student about the basic principle of CNC machine.

Figure 1.1: Example of custom made CNC machine.
(Source: http://kurnia-alrizq.blogspot.com)

One of the materials that are used in industry is aluminum alloy. The important factors in selecting aluminum (AL) because of their high strength to weight ratio, high thermal and electrical conductivity, resistance to corrosion by many chemicals, reflectivity, appearance, and ease of formability and the important thing is in term of of machinability. [Kapalkjian and Schmid (2006)]. One of the examples of aluminum alloy in industry is aluminum LM6. LM6 is a high purity alloy that usually used as raw materials for casting. This high purity give aluminum an advantage for the complex shape with large surface area which it can filled the thinner and intricate sections in mold casting. Besides that, Al LM6 alloy is medium in strength but has an excellent ductility. It also tends to suffers a rapid loss of properties at elevated service temperatures. Application of LM6 in industry includes electrical, marine, intricate shaped castings, and buildings cladding panels.

In machining operation, their efficiency depends on characteristics such as dimensional tolerances, surface finish of product, production rate, and cost considerations. In presents, many types of milling machines are varied from simple to the versatile machines that are used for general purpose machining in job shops and tool and die work to highly specialized machines for mass production. Most of the previous researches on aluminum LM6 are focusing on milling using of professional CNC machine. Since millings are among the most versatile and useful tools and also capable to produce various profiles and curved surfaces, the study of aluminum milling is important to determine the right cutting tool and cutting parameter for this new machine.

These projects are important for several advantages of using custom made machines to produce small sized objects. With a smaller machine size, space is saved. The energy required to operate the machine is reduced as well. The fabrication of this machine required less material and components, hence bringing down the cost greatly. The weight of moving component also comes down so that during operation, the vibration and noise, as well as pollution to the environment, are markedly reduced. As the machine becomes denser and lighter, it becomes more portable. The layout of the manufacturing plant can be more flexible. The productivity and manufacturing speed also increases due to possible faster operation.

1.2 Problem Statement

In the CNC machining operation, there are a few conditions of part need to be considered after machining. Surface roughness and the tool wear rate of cutting tool is the important thing when machining metal product. Cutting speed, feed rate or depth of cut is the main factor affecting the tool life and surface roughness of product. Therefore, it is necessary to define this suitable variable in machining in order to get good surface finish. The used of CNC machine have much benefits in application in local industry, but most of the machine is very expensive. Custom made CNC machine are capable to do the same process as existing CNC machine. This custom made machine usually used for machining soft material such as wood and plastics as shown in Figure 1.2 below.

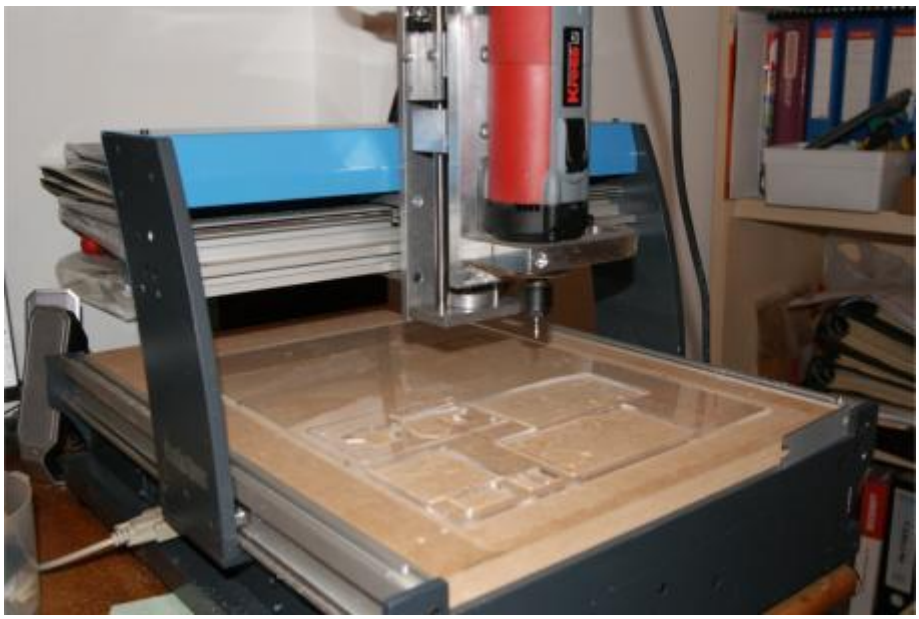

Figure 1.1: Application of custom made CNC machine.
(Source: http://www.mycockpit.org)

For new machine, experiment of effects main effects of machining parameters is important to get guidelines when operate this machine. Zhang et al (2007) revealed that the cutting speed was a significant factor affecting surface roughness of machining material and tool life of the cutting tool. By conduct an experiment on machining testing, the performance of self-fabricated CNC machine can be measured based of machinability of material product. Database are analyze based on cutting

speed, feed rate and depth of cut while machining process towards surface roughness and tool wear.

1.3 Objective

The purposes of this project are:

1. To compare the effect of different cutting speed when machining LM6 Aluminum Alloy using self fabricated CNC machine
2. To analyze the effects of cutting speed on surface roughness and tool wear when machining using self-fabricated CNC machine

1.4 Scope

This project will cover the study of custom made CNC machine that newly fabricated. The project consists of the study of raw material Aluminum LM6 Alloys that will be machining using tungsten carbide cutting tool. During this machining process, the machining parameters are set to three different values with the variable cutting speed and constant federate and depth of cut. Test that is conducted in this experiment are surface roughness, tool wear and surface profile related with various cutting speed. There are no studies related to the vibration of machine during machining the material.

1.5 Report Outlines

The first chapter of this project is discussed about introduction of the CNC machine with the material of Aluminum alloy. In this chapter, the purpose of CNC milling process and objective about the investigation of performance and machinability of aluminum LM6 alloy using tungsten carbide cutting tool for certain parameters are

included as well. The scope of this project is to analyze surface roughness and tool wear using self-fabricated CNC machine.

Chapter 2 presents the previous studies that will focus on key point that related to the CNC milling and several parameters that effect in dry machining. The characteristic of material and cutting tool are also explained here. The literature review can be approximately close to the objective of this project also. From this chapter, the author will get more knowledge on the results of the previous researches and can predict the result for the project.

Chapter 3 present the synopsis of the method and procedure of the specimen material and experimental work when machining used of self-fabricated CNC machine. The performance of this machine is measured in terms of tool wear and surface roughness of aluminum LM6 alloy with tungsten carbide cutting tool

Chapter 4 discussed about the resulted and outcomes of experimental work. Used surface roughness tester to measure the surface roughness and optical microscope to measure the tool wear during machining. Graph and observation of figure was developed to understand the performance of self-fabricated CNC machine.

Chapter 5 presents summarize of resulted data based on objective of this studies. This chapter are discussed on the conclusions of the project and recommendations for future work studies. This chapter also will summarize both the results based on objectives of the project. The reviews of finding and limitation in this project also considered as well.

CHAPTER 2

LITERATURE REVIEW

This chapter describes the basic concept of Computer Numerical Control (CNC) machine and the important parameters by referring from the books and previous study. Besides that, type of cutting tool and workpiece used in this project is explained further on this chapter based on response variable and summary of journals.

2.1 CNC Machine

Machining a part needs passed certain steps before actual process machining is takes place. Figure 2.1 show that the workflow of machining stages that typically characterized. The process of machining is started from design on CAD/CAD system through to the actual machining (Papiernik, 2006).

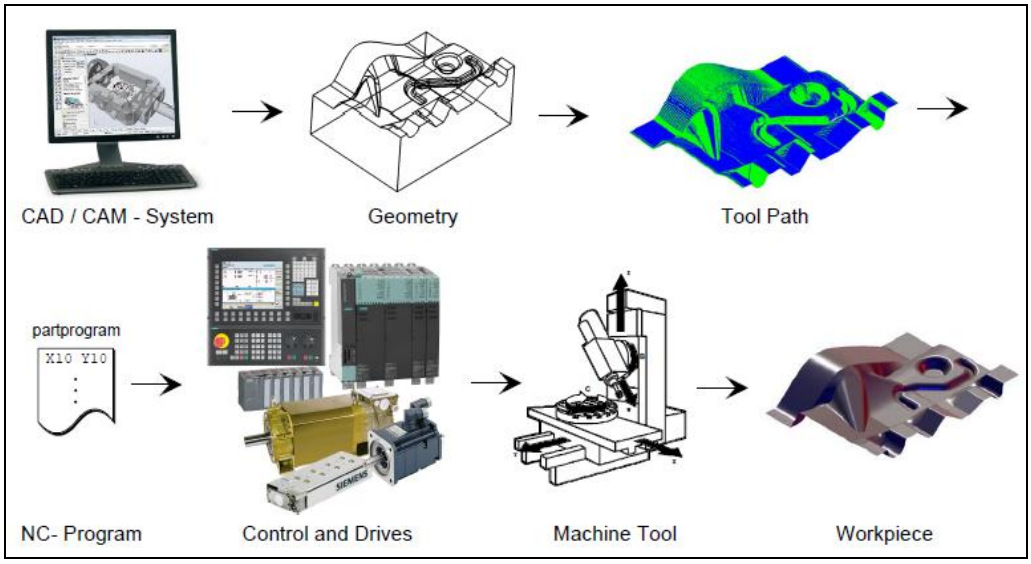

Figure 2.1: Workflow of CNC machining process [W. Papiernik(2006)].

From CAD data system, the information generated at this stage and the geometrical of the workpiece or part are analyze before machining process. As a second step, the Computer Aided Manufacturing (CAM) system converts the geometric data into a tool path trajectory in the form of a machine to understand code that know as a part program. After that, the control and drives unit, the brain of the CNC machine tool, will analyzes the program code and designs proper time optimal trajectories based on position, acceleration, velocity and jerk trajectories for the machine axes. This is performed when actuators received the signals from code program and described the geometry of the workpiece. Based on the contours machining process is takes place and machined directly toward the part program (Papiernik, 2006).

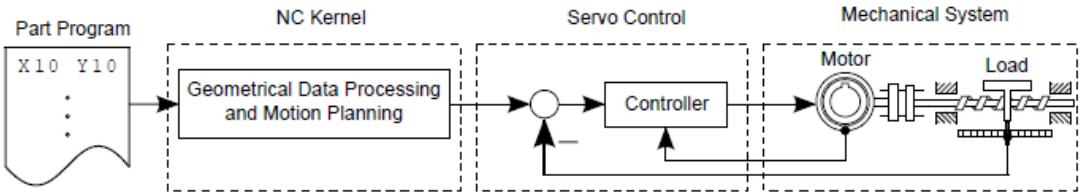

Figure 2.2: Principle control structure diagram of CNC machine tool [W.Papiernik(2006)].

Figure 2.2 shows a basic principle of control structure and drives unit of CNC machine tool. The structure is divided into three main parts which is NC kernel for data processing and motion planning, servo control to control the motion of machine and the mechanical system to transfer the energy for example stepper motor.

2.1.1 Numerical Control Kernel

Numerical control kernel is the unit responsible for the motion planning in the control unit geometrical data processing. NC kernel accept an input the required contour defined by the part program in the form of helical, linear, circular, spline or polynomial blocks and has access to machine data such as the maximal axis velocity, acceleration and jerk. The outputs of the NC kernel are a time optimal trajectories serving as reference set points for the servo controllers. Figure 2.3 shows that the flow steps of the basic functional blocks incorporated in the NC kernel (Papiernik, 2006).

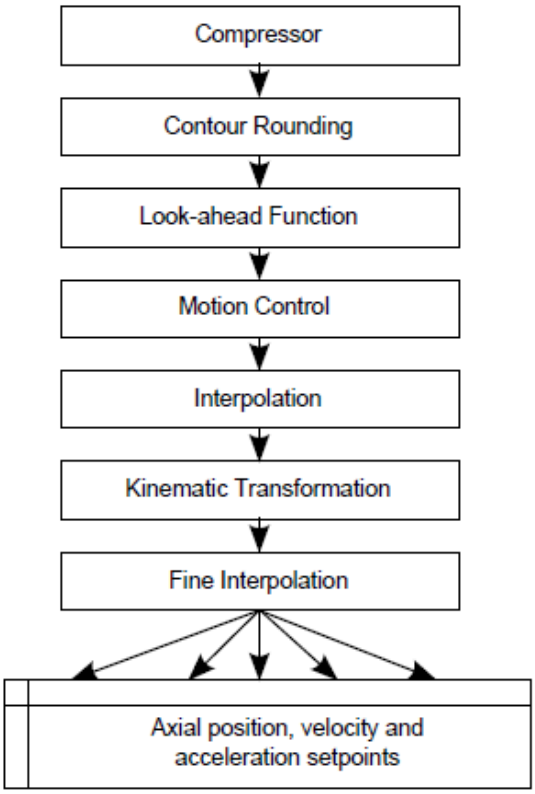

Figure 2.3: Overview of flow in numerical control kernel [W. Papiernik(1996)]

2.1.2 Servo Control

The principle of CNC Machine tools machine generally controlled using independent joint control schemes (Siciliano and Khatib, 2008). In independent join control, each axis in the machine tool controlled independently and modeled as a Single-Input Single-Output (SISO) system. During the motion are treated as disturbance inputs, coupling are effects among the axes during the varying configuration. The controllers in use to control each axis are servo controllers (Koren, 1997). Servo control is a preferred as a controller in open loop controller because of reduces the sensitivity to changes in load, reduce the steady state errors and system parameters. With using servo motor it also provided better handling of disturbances and the need to improve transient response times.