KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALASIA

Performance Test Methodology for 3-Axis Machining Center

Thesis submitted in accordance with the requirements of the Kolej Universiti Teknikal Kebangsaan Malaysia for the Degree of Bachelor of Manufacturing Engineering (Honours) (Manufacturing Process)

By

Habibah Binti Jamaludin

Faculty of Manufacturing Engineering

June 2006

KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

BORANG PENGESAHAN STATUS TESIS*

JUDUL: PERFORMANCE TEST METHODOLOGY FOR 3-AXIS MACHINING CENTER

SESI PENGAJIAN : 2002/2006

Saya HABIBAH BINTI JAMALUDIN

mengaku membenarkan tesis (PSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Kolej Universiti Teknikal Kebangsaan Malaysia (KUTKM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Kolej Universiti Teknikal Kebangsaan Malaysia.
2. Perpustakaan Kolej Universiti Teknikal Kebangsaan Malaysia dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

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

(TANDATANGAN PENULIS)

Alamat Tetap:
Lot 1506.Jalan Haji Salleh, Kampung Bunohan,16210 Tumpat, Kelantan Darul Naim.

Tarikh: 25/5/06

Disahkan oleh:

(TANDATANGAN PENYELIA)

Cop Rasmi:

HASSAN BIN ATTAN
Lab Manager
Faculty Of Manufacturing Engineering
Kolej Universiti Teknikal Kebangsaan Malaysia
Karung Berkunci 1200, Ayer Keroh
Melaka.

Tarikh: 25/05/06

* Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).
** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declare this thesis entitled "Performance Test Methodology for 3-Axis Machining Center" is the results of my own research except as cited in the reference.

Signature	:	
Author's Name	:	Habibah Binti Jamaludin
Date	:	25 May 2006

APPROVAL

This thesis summitted to the senate of KUTKM and has been accepted as fulfilment of the requirement for the degree of Bachelor of Engineering (Honours) Manufacturing (Process). The members of the supervisory committee are as follows:

.....

Main supervisor

Faculty of Manufacturing Engineering

ABSTRACT

Nowadays, manufacturing industries are facing problems in determining or verifying the machine tool accuracy. In the manufacturing sector, the accuracy of parts is very important because from the finish part we can evaluate the accuracy of the machine that produces the particular part. One method that can be recommended is by specifying the machine tool accuracy by conducting performance test to the machine that is likely to be used. The performance test conducted should be based on certain standards to ensure the validity of the results. The performance test conducted uses a certain standard for machining center test which is International Standard Organization (ISO) 10791-2:2001: Test Conditions for Machining Center 'Geometric that is a test for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis)'. By referring to the standard, the accuracy of the machine can be determined by specifying the value of tolerance from the finish part produced. The standard test piece was machined by using a 3 axis machining center which specifies the eight critical parameter that includes in the standard which is straightness, parallelism, angularity, perpendicularity, circularity, concentricity, position, and cylindricity. In this project, a 3-axis vertical machining center is used to conduct the performance test. The standard test piece machined will be measured by using suitable metrology equipment at KUTKM laboratory to determine the tolerances of the eights critical parameter are within ISO tolerance. The machine can be classified as operating in the acceptable working conditions if the tolerance results are within the tolerances in the ISO 10791-2:2001.

ABSTRAK

Pada masa kini, industri pembuatan berhadapan dengan masalah dalam menentukan ketepatan sesuatu mesin. Didalam sektor pembuatan, ketepatan sesuatu produk adalah amat penting kerana dengan melihat kepada penyudahan permukaan sesuatu produk secara tak langsung akan turut dinilai juga bahawa mesin yg digunakan itu dapat menghasilkan sesuatu produk seperti yang diharapkan. Salah satu ujikaji yang dapat dipraktikkan dalam menentukan ketepatan sesuatu mesin tersebut adalah dengan menjalankan ujian keupayaan keatas mesin tersebut. Ujian yang dijalankan haruslah berpandukan kepada standard yang tertentu bagi memastikan kesahihan keputusan yang diterima nanti. Di dalam ujian ini ianya menggunakan standard yang tertentu untuk machining center iaitu International Standard Organization (ISO) 10791-2:2001: Test Conditions for Machining Center 'Geometric that is a test for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis)'. Dengan berpandukan kepada standard tersebut, ketepatan sesuatu mesin akan dapat ditentukan dengan terhasilnya nilai toleran daripada produk tersebut. Pemesinan bahan kerja ini adalah dengan menggunakan '3-axis machining center' dengan menentukan lapan parameter kritikal yang terkandung didalam standard iaitu 'straightness', 'parallelism', 'angularity', 'perpendicularity', 'circularity', 'concentricity', 'position', and 'cylindricity'. Di dalam projek ini, sebuah mesin '3-axis vertical machining center' digunakan untuk menjayakan ujian. Selepas pemesinan produk tersebut, perkara yang akan dijalankan seterusnya ialah kerja pengukuran pada produk tersebut dengan menggunakan peralatan yang sesuai di makmal KUTKM bagi menentukan toleran yang terhasil samada ianya berada didalam zon toleran ISO standard. Mesin yang dikaji itu akan dapat diklasifikasikan sebagai diterima didalam kerja pemesinan sekiranya toleran yang terhasil daripada produk tersebut berada didalam julat toleran ISO 10791-2:2001.

ACKNOWLEDGEMENTS

Assalamualaikum Warahmatullahitaala Wabarakatuh…

I would like to thank Allah SWT with this blessing that give me the chance to complete my thesis on the topic 'Performance Test Methodology for 3-Axis Machining Center'. I would like everyone who helped me to make the completion of this work possible. First, I would like to thank my supervisor Mr.Hassan B. Attan who have supported and guided me in the completion of this thesis. I would also like to thank KUTKM technical support staff especially Mr.Sahar and Mr.Jaafar helps me most in the experiment conducted at the CNC machine and CMM machine that is used in this project. Finally yet importantly, my deepest gratitude goes to my family, especially to my parents who supports me in the successful of this project. Without their sacrifice and support, it would not have been possible for me to complete my thesis.

TABLE OF CONTENT

LISTS OF FIGURE

LISTS OF TABLE

SIGN AND SYMBOLS

CNC	Computer Numerical Controlled
CMM	Coordinate Measuring Machine
Π	Pi (3.141592654)
V	Cutting Speed
D	Diameter of Cutter
N	Spindle Speed
F	Feed
KUTKM	Kolej Universiti Teknikal Kebangsaan Malaysia
μm	Micro meter

CHAPTER 1.0
INTRODUCTION

1.1 PROBLEM STATEMENT

Most manufacturing companies nowadays invested lots of money in order to buy the expensive machine tools that will help them to improve the quality and delivery time of the products that they produced. With all the high investment, users expect that the machine tools they purchased can fulfill all their requirements and needs which is to have the performance in machine accuracy. The users demanded that the machines they purchased need to have high flexibility, good running power, speed, accuracy and is capable of holding tight tolerance. The users expect that the machine will perform based on the standard specification in machining.

It is assumed by buying the expensive machine can help their company to produce the high quality of product in the short time to market. This is not true because not all machine ordered can achieve their desired accuracy so, the one method that companies can imply is to ascertain the exact machine capability and performance by conducting an acceptance test which can be called as a 'Performance Test Methodology' for each of the machines they purchased. The performance test used a methodology by machining the standard test piece and then from the finish part it can be evaluated from the measurement result compared to the standard. From the result, we can know either the machine that been tested has the capability or the desired accuracy.

The outcome from the test specifically outlines the methodology of testing, the equipment, the critical parameters to be machined, test results, and the result analysis compared to the standard. The results of the performance tests are used for machine acceptance, predictive maintenance, error compensation and to evaluate the capability of a machine to manufacture parts by specifying the tolerance (Y.Tina Lee, 2001). The project also aim to educate the industrialists and machine users on the necessity of conducting their own machine performance test to ensure they get good return in terms of machine performance from the investment in machine tools. This project outlined the methodology of conducting the performance test is according to the specified ISO (International Standard Organization) standard procedures.

1.2 OBJECTIVE

Objective of the Performance Test Methodology for 3-Axis Machining Center can be state broadly:

i. To recommend the appropriate methodology of conducting a performance test on the machine.
ii. To identify the standards to be used as reference and ensuring validity.
iii. To produce a Standard Operating Procedure in conducting performance test for machine tools.

1.3 SCOPE OF PROJECT

The overall scope of performance test methodology for 3-axis machining center can be list as below:

i. This performance test is conducted fully based on the ISO (International Standard Organization) to ensure its validity. To find the appropriate standard to be used.

ii. With reference to the standard available, we will create the drawing in the CAD software based on the ISO standard. To produce detail drawing of the product by using CAD software.

iii. After complete the drawing, specimen will be machined by using the machine tools is CNC (Control Numerical Controlled) for each of the critical parameter as already design in the drawing. Machining the test specimen.

iv. In this performance test, the measurement process is conducted by using a suitable metrology equipment to ensure the validity of the finish part is base on the standard. Conduct the measurement process by using the suitable metrology equipment.

v. The measurement value will be compare with the standard. Conduct the data analysis.

CHAPTER 2.0
LITERATURE REVIEW

2.1 MANUFACTURING ENGINEERING

2.1.1 Overview of Manufacturing Engineering

Manufacturing, in its broadest sense can be defined as the process of the converting the raw materials into finally be produced as a products. It encompasses like as below:

1. The design of the product
2. The selection of raw materials
3. The sequence of processes through which the product will be manufactured

The word of manufacturing is derived from the Latin *manu factus*, meaning is made by hand. The word manufacture first appeared in1567, and the word manufacturing appeared in 1683. In the modern sense, manufacturing involves making products from raw materials by means of various processes, machinery and the sequence operations, through a well be organized the plan for each activity required. The word *product* means, something that is produced, and the words product and production first appeared sometime during the 15^{th} century.

The word production is often used interchangeably with the word manufacturing. The manufacturing engineering is the term used widely in the United State to define this are of industrial activity, the equivalent term in other countries is production engineering. The manufacturing is generally a complex activity involving a wide variety of resources and activities, such as the following below (Kalpakjian, S. and Schmid, S.R, 2001):

- Product design
- Machinery and tooling
- Process planning
- Materials
- Purchasing
- Manufacturing
- Production tool
- Support services
- Marketing
- Sales
- Shipping
- Customer service

The manufacturing activities also must be responsive to the several demands and trends show as below (Kalpakjian, S. and Schmid, S.R, 2001):

1. A product that wants to produce must fully meet the design requirements, product specifications and the standards.
2. A product must be manufactured by the most environmentally friendly and economical methods.

3. The quality must be built into the product at each stage, from the design to assembly, rather than tested in after the product is made. Furthermore, the level of quality should be in range appropriate to the products user.
4. A manufacturing organization must constantly strive for higher levels of quality and productivity (defined as the optimum use of all its resources: materials, machines, energy, capital, labor and technology).

2.1.2 Design for Manufacture and Assembly

The design and manufacturing are two major components in the engineering aspect of production (Cheng Ho, 1997). The design process for a product first requires a clear understanding of the functions and the performance expected of the product. A product design that cannot realize through manufacturing processes is not a good design. On the other hand, manufacturing processes cannot be effective without a thoughtful design and planning. The manufacturing company will not achieve the quality products if the machine that been use in manufacturing is not running the process of high accuracy. In the design for manufacture and assembly, the very important factor is to specify dimensional tolerance and surface finish with the process selected.

2.1.3 Selecting Manufacturing Processes

In manufacturing processes, there are many processes used to produce parts and shapes. Below shows the categories of processing method for material:

1. Casting: Expendable mold and permanent mold.
2. Forming and shaping: Rolling, forging, extrusion, drawing, sheet forming, powder metallurgy and molding.
3. Machining: Turning, boring, drilling, milling, planning, shaping, broaching, and grinding, ultrasonic machining, chemical,

electrical and electrochemical machining and high-energy beam machining.

4. Joining: Welding, brazing, soldering, diffusion bonding, adhesive bonding and mechanical joining.
5. Finishing: Honing, lapping, polishing, burnishing, deburring, surface treating, coating and plating.

2.1.3.1 Machining process

The machining process is one of the most very important of the basic manufacturing processes. Almost every manufactured product contains components that require machining, often to get the high accuracy and precision. We can define the machining process as the manufacturing process designed to remove unwanted material, usually in the form of chips, from a workpiece. Machining is used to produce the desired product by removing material to size and finish as specified to in the design requirement.

The machining processes are performed on wide variety of machine tools and majority application of the machining is done to a metal workpiece. The process can also be combined into multiple capability machines known as machining center. The machining center is capable of performing the machining processes normally performed on a milling machine, drilling machine and boring machine and it is numerically controlled.

2.2 MACHINE TOOL CONTROL

2.2.1 Introduction

The machine tools are the machinery used to process metals and nonmetallic materials to get desired shapes or properties in manufacturing industries. Therefore, they constitute the core of manufacturing systems. A modern form of machine tools was first introduced during the industrial revolution in the 18^{th} century with the birth of steam engines. Those steam engine powered machine tools opened the era the automation along with the use of jigs and fixtures. Particularly, the continual development of new tool materials since the early 20^{th} century has been the major driving force in advancing the technology of machine tools (Yung C. Shin, 1994). More rigid and higher speed machine tools have been required to use fully the capability of new tool materials. It is not uncommon to see machining operations of cast iron with cutting speeds exceeding 3000 fpm in the automotive industry today.

The machine tools are generally powered driven metal cutting or forming machines used to shape metals by:

- The removal of chips
- Pressing, drawing or shearing
- Controlled electrical machining processes

Any machine tool generally has the capability of:

- Holding and supporting the workpieces
- Holding and supporting a cutting tool
- Imparting a suitable movement (rotating or reciprocating) to the cutting tool or the work (Kalpakjian, S. and Schmid, S.R, 2001)