CMM'S STYLI LENGTH EFFECT ON ERROR PROPAGATION

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

By

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BORANG PENGESAHAN STATUS LAPORAN PSM

TAJUK: **CMM's Styli Length Effect on Error Propagation**

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DECLARATION

I hereby, declared this reported entitled “CMM’s Styli Length Effect on Error Propagation” is the results of my own research expect as cited in references.

Signature : ………………………………………
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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) with Honours. The member of supervisory committee is as follow:

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Dr. Mohd Rizal B. Salleh

(Supervisor)

ABSTRACT

Coordinate Measuring Machine (CMM) are fast in operation and has high accuracy too. However, accuracy has their limitation. To get the accuracy of CMM, a method of correcting error in the coordinate measurement is proposed. This research describes an investigation of the CMM's styli length effect on error propagation. The result from the experiment will be shown that the shorter stylus used the better accuracy of measurement. The experiment will be done by comparing data from the lobbing model that had been given by supplier and pre-travel measurement from the experiment.

ABSTRAK

Mesin Pengukur Koordinat (MPK) boleh menyelesaikan pengukuran dalam masa yang singkat dan mempunyai ketepatan yang tinggi. Tetapi, ketepatan juga mempunyai hadnya sendiri. Bagi mendapatkan ketepatan, satu cara akan dicadangkan untuk mengatasi ralat yang berlaku. Kajian ini akan menganalisa tentang kesan panjang jejari MPK terhadap penyebaran ralat. Hasil daripada eksperimen yang akan dijalankan akan menunjukkan bahawa semakin pendek jejari MPK semakin tepat ukuran yang akan diambil. Kajian dijalankan dengan membezakan antara bacaan daripada ukuran sebenar artifak yang telah diberi oleh pembekal dan ukuran yang diambil daripada eksperimen yang yang dijalan.

DEDICATION

To my beloved parents, my lovely sisters, friends and colleagues, not forgeting UTeM's lecturers.

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Alhamdullilah, with the bless from Allah the Almighty, finally I have completed the final year project and research writing on time. Firstly, I would like to express my appreciation to my supervisor and co-supervisor, Dr. Mohd Rizal Salleh and Mr. Ammar Abd Rahman for thier guidance, advice and continuous encouragement in the process of completing my project successfully. Yours kindness in giving me continuous knowledge will be remembered always. I would also want to express my thankfulness to my beloved parent and my lovely siblings for thier never ending support, advice and encouragement since childhood until now. May your love and support will never be gone until the end of my life. For UTeM's lecturers who have taught me, thank you for giving me precious and valuable knowledge. For my friends and my classmates, thanks for your cooperation, support and help throughout these 4 years in UTeM. Thank you so much.

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LIST OF ABBREVIATION & NOMENCLATURE

ASME	American Standard Measuring Equipment
BS	British Standard
CMM	Coordinate Measuring Machine
CNC	Computer Numerical Control
DCC	Direct Computer Control
EWL	Effective Working Length
ISO	International Standard Organization
N	Newton (Force unit)
NC	Numerical Control
PH	Probe Head
PTV	Pre-Travel Variation
TP	Touch Probe

CHAPTER 1

INTRODUCTION

Coordinate measuring machines (CMMs) have become very widely used in recent years because of their ability to measure most or all of the individual geometrical features on complex engineering components. Compared with traditional methods, which normally employ a variety of separate instruments, CMMs are fast in operation and are adequately accurate for many applications. However, accuracy limitations often inhibit their use for high precision metrology. Accuracy is limited by such factors as straightness and orthogonality of the CMM movements (Renishaw, 2003).

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In many cases, the errors introduced by the probes are very significant and often exceed the errors from other sources. This report describes an investigation into the nature of probe errors, the factors that influence their performance and proposes a method to verifying the probe performance. Results from a number of probes used in different modes are presented (Renishaw, 2003).

Background of Study

International Standard ISO 10360-1 defines CMM as a measuring system with the means to move a probing system and capability to determine spatial coordinates on a work piece surface. Over the years standards and guidelines have been developed to harmonize the performance specifications of a CMM to enable a user to make meaningful performance comparisons when purchasing a machine and, once purchased, to provide a well-defined way in which the specified performance can be verified (Flack, 2001).

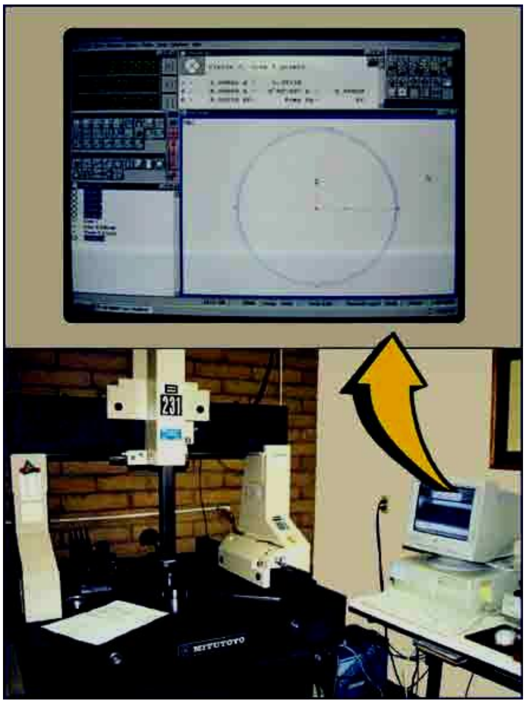

Figure 1.1: Coordinate Measuring Machine (Source: Renishaw, 2003).

CMM is essentially a very precise Cartesian robot equipped with a tactile probe, and used as a 3-D digitizer. The probe, under computer control, touches a sequence of points in the surface of a physical object to be measured, and the CMM produces a stream of x, y, z coordinates of the contact points. The coordinate stream is interpreted by algorithms that support applications such as reverse engineering, quality control, and process control. In quality and process control, the goal is to decide if a manufactured object meets its design specifications. This task is called dimensional inspection, and amounts to comparing the measurements obtained by a CMM with a solid model of the object (Spitz, 1999).

Friction due to the trigger touches the surface profile. The touch probe provides the connection between the probe head and the stylus and contains the necessary trigger capability to record a data point, or scan data when in contact with the artifact. The stylus length is measured from the centre of the ball to the point at which the stem will foul against the feature when measuring 'normal' to the part. Generally, the larger the ball diameter, the longer the stylus length and the greater the effective working length (EWL) (Renishaw, 2003).

There are so many kind of touch probe system used today, such as Two Piece System, Three Piece System - M8 Thread Mount, Three Piece System - TP20, Integral Kinematics Mount, Four Piece System- M8 Thread Mount, Stylus Change Module, and OPT6M Optical Trigger Probe. But for this study, the Three Piece System - M8 Thread Mount which is separate touch probe screws into the probe head via a M8 thread will be used. This style allows the use of M8 - 13mm diameter probe extensions between the probe and the head to reach into deep parts. With this system the touch probes can be easily exchanged if damaged or worn. The M8 thread mount is compatible with the standard TP2 and TP6 touch probes (Helmel, 2008).

Nevertheless, if this CMM's is precision dimension measuring equipment, it also has some dynamic measurement error. The dynamic measurement error happens when the measuring process needs short cycle's time. So the requirement for faster CMM operation is increased. Then, because of that, the CMM system had been influenced by the dynamic errors. The probe configuration, motion related factors, measured object, operating environment and mode of the operation are the factors that influencing the dynamic measurement errors (Johnson et.al, 1998).

It is well known that most touch trigger probes suffer from lobbing effects. These are propagation errors and normally depend upon a number of factors including probe orientation, stylus length, diameter, measuring speed, trigger force and etc. With most touch trigger probes, lobbing errors have much larger sizes than their repeatability uncertainty, resulting in difficulties in many applications (Johnson et.al, 1998).

In order to minimize the lobbing effects, careful consideration of probe selection, stylus configuration, data collecting procedure and measuring techniques is required. Current practices have relied largely on choosing probes of better performance, selecting stylus configurations of shorter length and higher stiffness, using smaller probing forces, and a careful sampling strategy (Johnson et.al, 1998).

1.2 Problem Statement

CMM are widely used throughout manufacturing industries, such as aerospace and automotive, to meet the increasing need for high quality standards and dimensional accuracy. However, in many applications, CMM measurement is not as efficient as it could be (Smith, 2002). So new measuring methodology and techniques needs to be developed that can be improve flexibility, reduce inspection time and achieve consistency.

Repeatability and reproducibility values for these probes are published in the manufacturers' catalogues and each new probe should have a certificate of performance provided with it. However, a customer may not be fully aware of how his mode of use affects the accuracy of measurements made with the probe (Aston et. al, 1997).

Usually the users are advised that when calibrating a stylus they should keep the stylus as short as possible to get the less error in measurement (Aston et. al, 1997). However, it is often necessary to use a stylus that is much longer than the ideal minimum or effective working length (EWL) , even though there will be a reduction in performance. So, how the CMM’s styli length effect on error propagation?

Objective of the study

To make sure this project is successfully achieved, certain objectives were outlined as follows:

- To identify the impact of styli length on the error distribution of CMM.
- To propose the appropriate methods or technique of measurement to minimize the measurement error.

Scope of the study

This study describes the CMM's styli length effects on propagation error. The investigation of the stylus length effect is find base on the experiment that will be done at Metrology Laboratory of Universiti Teknikal Malaysia Melaka (UTeM). The investigation are not covering the effect on stylus approach direction, probing force, diameter and measuring speed.

This study will focus on the CMM performance. The effect of styli length on the propagation error will be discussed in details later in this report. Where the longer of styli length used, the more the stylus bends or deflects, the lower the accuracy. Probing with the minimum stylus length for application is recommended and where possible the use of one piece styli is suggested. Probing with excessive styli or extension combinations should therefore be avoided to achieve measurement efficiency (Renishaw, 2003).

In contact measurement, CMM data collection starts at the stylus tip, the part of the measuring system that makes contact with the work piece. Most CMM users have a single sensor and stylus configuration, and although they might not realize it, in most cases this is limiting. Unless measuring a simple component, the stylus configuration needs to be changed to suit different measurement tasks. Traditionally this has been done manually, using a threaded connection. However, probe systems are now available with a repeatable stylus interchange, greatly increasing system flexibility by allowing quick changes to long or complex styli configurations, as well as different tips such as sphere, disc or cylinder (Smith, 2002).

In this study the TP2 touch probe will be used on the one artifact and same touch point to act as the independent variable during an experiment. TP2 is the traditional slim line switching probe for most applications. The error during the measurement taking technique must be reduced by finding the right way to get the high accuracy result. In order to find the best method or technique of measuring by using CMM, the scope of study must include the suggestion and improvement of measuring technique by using different and various measuring technique.

CHAPTER 2
LITERATURE REVIEW

2.1 Coordinate Measuring Machine (CMM)

A coordinate measuring machine (CMM) is a measuring system with the means to move a probing system and capability to determine spatial coordinates on a work piece surface. The Co-ordinate Measuring Machine has its origins in manually operated simple layout inspection equipment. With the development of numerical controlled (NC) machines in the 1950s for the production of complex components required in the United States aerospace programmed and the subsequent introduction of computer numerical control (CNC) machines in the 1970s, production techniques were often more accurate than inspection equipment in general use (Flack, 2001).

A major factor in the evolution of the CMM was the invention in 1972 of the touch trigger probe by David McMurtry of Rolls-Royce (Renishaw, 2003).The touch-trigger probe is a 3D sensor capable of rapid, accurate inspection with low trigger force. When incorporated with precision linear measuring systems developed for CNC machines plus cheap and powerful computer hardware and software, this paved the way for highly accurate, automated inspection centers. CMMs are widely used in manufacturing industries for accurate, fast and reliable dimensional measurement of components. They are generally expensive to buy and maintain but their results are crucial to the manufacturing process (Flack , 2001).

Two forms of CMMs are available; manual and Direct Computer Control (DCC). Manual CMMs are generally used for first-article inspection work. If the primary manufacturing environment is production orientated a DCC machine is the usual choice. DCC machines generally are the tools of choice for manufacturers who need to gather and analyze large amounts of data for maintaining control of the manufacturing process. The CMM is normally completely under DCC operation thereby eliminating any user influence on the quality of the recorded data (Flack , 2001).

2.1.1 How to Select CMM

The right chosen CMM will makes the measuring operations becomes more effective. Therefore, there are some criteria needs to be considered when choosing the right CMM.

i. The determination of minimum required measuring range

The first important selection criterion is the determination of the minimum required measuring range of the CMM. This range usually depends on the dimensions of the part to be measured, but is often more complex than that. For example, if the configuration of the part and the inspection routine require the use of probe extensions and fixtures, the actual minimum required measuring range could be considerably larger than work piece dimensions (Flack, 2001).

ii. Comparison with machine specification

However, in order to compare CMMs from different manufacturers, the comparison with machine specifications must be done first. Most CMM manufacturers already offer their specifications in a variety of formats to support their international customer base. In addition, if you're an international manufacturer, it may be prudent to request the CMM's specifications in the ISO 10360-2 format since it's becoming a world standard. This will allow you to not only compare between competitors, but to compare the new machine to your existing machines installed throughout the world (Flack, 2001).

iii. Specify the temperature range

The uncertainty of every CMM depends to a great extent on environmental conditions. Consequently, CMM manufacturers usually specify the temperature range, temperature