UNIVERSITI TEKNIKAL MALAYSIA MELAKA

CMM'S STYLUS APPROACH DIRECTION EFFECT ON ERROR PROPAGATION

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

NOOR DIANA BINTI MOHD DIAH

FACULTY OF MANUFACTURING ENGINEERING

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTeM)

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SESI PENGAJIAN: 2008/2009

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Alamat Tetap:
NO 39 JLN KEMAJUAN 11,
TAMAN UNIVERSITI,
81300 SKUDAI,JOHOR.

Tarikh: 11 MEI 2009

Cop Rasmi: DR. MOHD RIZAL BIN SALLEH
Dekan
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka

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Author's Name	:	NOOR DIANA BINTI MOHD DIAH
Date	:	13/05/09

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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ABSTRACT

Coordinates Measuring Machines (CMM) are referred to as those machine that gives physical representations of a three dimensional rectilinear Cartesian coordinate system. As one of the most powerful metrological instruments, CMM are widely used in most manufacturing plants, large and small.

There are many types of probe commercially available. Touch trigger probes are by far the most commonly used due to their simplicity. It is well known that most touch trigger probes suffer from lobing effects, for example pre-travel variation in different probing direction. These are largely systematic error and normally depend upon a number of factors including probe orientation, stylus length, diameter, measuring speed, trigger force and approach direction.

The purpose of this project is to presenting about a CMM performance evaluation in a different of stylus approach direction. It is because, in different approach direction of touch trigger on the calibrated instrument, it will produce error propagation. At here, this study will investigate in what direction will give the large of propagation error.

ABSTRAK

Coordinate Measuring Machine (CMM) merujuk kepada sebuah mesin yang memberikan gambaran fizikal sesuatu 3D pada sistem kordinate Cartesian. CMM juga merupakan alat metrologi yang sangat jitu dan penggunaannya sangat meluas di dalam sector pembuatan tidak mengira besar atau kecil. Alat yang menyumbang kepada nadi CMM adalah sejenis sesentuh dengan bebola delima (touch trigger probe with ruby ball) yang digunakan untuk menyentuh permukaan benda kerja dan memberikan kesan kepada setiap bacaan yang diambil.

Seperti yang kita tahu, kebanyakan alat sesentuh ini boleh memberikan kesan kepada perlandasan sesntuh ke atas permukaan benda kerja seperti kepelbagaian dalam arah sentuhan yang berlainan. Ralat sistematik yang besar ini dan biasanya bergantung kepada beberapa faktor termasuk susunan "probe", panjang sesentuh, lilitan bebola delima, kelajuan semasa mengukur, daya tindakbalas dan arah yang berdekatan.Oleh yang demikian, kajian ini bertujuan untuk mengenalpasti kebolehan CMM dalam memberi dan mengenalpasti pengukuran melalui sesntuh yang dating dari arah yang berdekatam. Ini kerana, setiap arah yang menghampiri permukaan benda kerja boleh menyebabkan kepada penyebaran ralat dan kajian ini juga bertujuan untuk megenalpasti arah yang mana boleh memberikan penyebaran ralat yang besar.

DEDICATION

To my beloved father, Mohd Diah bin Mohd Noh and mother,
Chekta binti Ahmad for all that you have given to me.
For my supervisor and all my fellow friends whom never gave up
supporting and encouraging me.

Thank you very much

ACKNOWLEDGEMENT

I am thankful to Allah S.W.T for the bless me along the way I have been through, for enabling me to undertake the Bachelor of manufacturing Engineering and for granting me the strength and wisdom to face and overcome challenges and obstacle during accomplish this research.

I appreciate all those around me who had to put up with temporarily neglect while I focused on the demands of accomplish this research. I also thank to my supervisor, Dr. Mohd Rizal Bin Salleh for continuing to be source of inspiration for my intellectual pursuit. Several individuals participated directly in putting together this work. Last but not least, I would like to thank all those who had contributed to my final year project, directly or indirectly.

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CHAPTER 1

INTRODUCTION

This chapter generally describes the general idea of this study, the problem statement, the objectives and the scope of this study.

1.1 Overview

A coordinates measuring machine (CMM) is a device for dimensional measuring. It is a machine that is used to move a measuring probe to obtain the coordinates of points on an object surface. These machines are used to measure dimension of target object. Often these parts have tolerances as small as 0.0001" [Lester *et al.*, 1994]. The machine uses an X-Y-Z grid to determine its position of worktable. The probe is used to touch different spot on the part being measured. The machine then uses the X, Y, and Z coordinates of each point to determine size and position. A coordinates measuring machine is also a devices used in manufacturing and assembly process to test a part or assembly against the design intent. By precisely recording the X, Y, and Z coordinates of the target, point are generated which can be analyzed via regression algorithm for the construction of features.

These parts are collected by using probe that is positioned manually by an operator or automatically via direct computer. Coordinates measuring machine are widely use to obtain three dimensional metrological shape information on a work piece and to evaluate it. Manufacturers needs an instrument provided them with precise and highly accurate data and enables to shorten cycle time and reduce measurement error.

The performance of coordinates measuring machine depends upon various factor either in external or internal. It can be recognized that coordinates measuring machine hardware, part form error, sampling strategy, algorithm selection can all influence coordinate measuring machine measurement. Its not only because of its function in the coordinates measuring machine, but also it produce larger errors than other part of machine such in styli's approach direction which meet on error propagation [Shen *et al.*, 1997]. Geometric calibration of CMMs is typically performed in the sequential manner. Each of the components to be calibrated is assessed, more or less, independently and serially in sequence.

Quality indication of the calibration measurement can be known in fragments as the estimation residual on each of the calculation steps. However, the overall indication is not. Building a set of the linear equations the parametric errors can be estimated by one step calculation. Former studies adopting this approach focus on realization of the self calibration method by the linear equation including unknown parameter for the standard to be referred to through the calibration. Although, there are many types of probe commercial available, touch trigger probes are by far the most commonly used due to their simplicity. It is well known that most touch trigger probes suffer from lobing effect such as pre-travel variation in different probing direction

1.2 Problem Statement

Many measurement results, such as the length of a gauge blocks or the diameter of the circle can be expressed as single number. When a probing point is recorded, a particular error vector is precipitated out of the cloud. This error vector is different between the coordinates the CMM records at a measurement point and the true coordinated in a perfect coordinated in a perfect coordinates system. If the same point measurement is repeated, a slightly different X, Y, Z coordinates will usually recorded. Therefore, a different error vector will be precipitated from the cloud. The size and shape of the uncertainty could involves in time as the CMM responds to such changes as the thermal environment, structural distortion due to part loading and damage to machine structure. In addition, the uncertainty not only depends on quasi-static error, but may also depend on many measurement specific (user selectable) factors such as the probe approach direction, approach velocity and probing force.

There are certain of factor that faced to error propagation in coordinate measuring machine by using approach direction of stylus. Firstly, by the touch trigger probe itself. This is because by the structure of stylus that carried on 3 supports. Level action causes 2 of the support become fulcrum and as the CMM moves the third support is lifted, so the electrical conductivity is interrupted and causes the error of propagation on the direction that stylus approach. This statement also supported by Shen et.al, (1997) which is an error propagation occur in stylus approach direction mainly caused by bending deflection of the stylus shaft, account for the majority of touch trigger probe. The impact of this stylus approach direction will due to dynamic error. According to Cauchick, P.A. and King, T.G. (1998), when a probe makes a contact with the measured surface, it will give an impact to the dynamic error. One of it is motion related factor including surface approach angle, probe latitude, probe longitude, approach speed and also approach direction. Other than that, Pre-travel error highly repeatable BUT adversely influence by force variation encountered in different probe approach direction. Dobozs (2004) also stated the most significant source of error comes from the direction-dependent pre-travel variation.

1.3 Objective

The objectives of this study are as follow:

- Investigating the parameters that influence the CMM's styli approach direction.
- Identifying the impact of approach direction on the error distribution of CMM.
- Proposing the appropriate method of technique for measurement of direction to minimizing the measurement error.

1.2 Scope Of The Research

The scope of the research is on the styli approach direction of CMM, where the studies are concentrated on the propagation error on probe approach direction to measurement artifacts. Then, this study also concentrated what is the best technique to minimizing the error occurs and the influence parameters. As a summary, This PSM 1 (Projek Sarjana Muda 1) includes Chapter 1, Chapter 2 and Chapter 3. Chapter 1 will briefly explain about the problem statements, objectives and scope of the study. Meanwhile, in Chapter 2 is the literature reviews of CMMs, which are presented a fact that support a finding for this study. And chapter 3, describe the research methodology on how the experiment will be conducted to collect and analyze the data.

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CHAPTER 2

LITERATURE REVIEW

Chapter 2 generally explain about the literature review including TP2 probe, the dynamic errors that influenced by the CMM styli's approach direction and the finding from the expert about the styli's approach direction that meet with error propagation.

2.1 Overview

Since most coordinate measuring machines are fitted with touch trigger probes, and because one of the largest sources of measurement error in coordinate measuring machine system is the touch trigger probe itself, it is very important to know the characteristic of the probe dynamic errors.

So that the dynamic performance of touch trigger probes may be improved. J.A Bosch (1995) briefly described the dynamic measurement error is generated by the machine. When a probe makes a contact with the measured surface, the impact force is influence by several factor including probe approach direction, probe acceleration, probe speed, probe acceleration, and approach distance.

2.2 Coordinate Measuring Machine

2.2.1 Types of CMM

According to John A. Bosch (1995) there are five types of coordinate measuring machine; which is moving bridge, fixed bridge, cantilever, horizontal arm and gantry. Below was briefly explaining the types of the CMMs with it advantages and disadvantages.

i. *Moving Bridge*

The moving bridge CMM as shown in Figure 2.2.1 is the most widely use configuration as the workhorse of the CMM. The stationary table is provided to support the work piece to be measured. With this design, the phenomenon of yawing can occur for example the two column or legs move at different paces causing the bridge to twist. This affects the accuracy of parts measured at different locations on the CMM table. The advantage of the moving bridge configuration over the cantilever is that the bending effect of the second horizontal axis can be greatly reduced by having two supporting columns. It also has higher natural frequencies than those of a cantilever machine.

Figure 2.2.1: CMMs Moving Bridge Types [J.A Bosch, 1995]

ii. Fixed Bridge

In the fixed bridge configuration as shown Figure 2.2.2, the bridge is rigidly attached to the machine bed. Upon the table which the work piece is mounted provides one axis of motion. This design eliminates the phenomenon of walking and provides high rigidity. Therefore, some of the most accurate CMMs use this design. On the other hand, the operating speed is reduced since it is necessary to move the heavy table with the part on it. This reduces the throughput of the machine. Also, part weight limitation is a disadvantage. The main advantage with the fixed bridge is its rigid structure. As the table is driven centrally and the feedback element is also located in the center, the Abbe offset error is considerably reduced for the table motion. The need to have extended guide ways to support the movement of a long table is a disadvantage of the fixed bridge configuration.

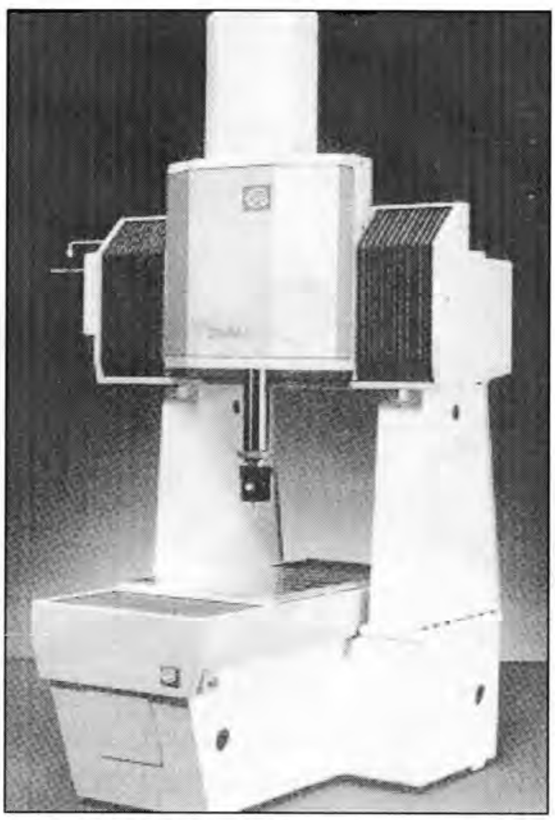

Figure 2.2.2: CMMs Fixed Bridge Types [J.A Bosch, 1995].