KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

Universal Measuring Machine: A Study On Potential Error and Common Error In Calibration Process (Dial Indicator)

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

By

Marwan Bin Mat Salleh

Faculty of Manufacturing Engineering

May 2006

KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA

BORANG PENGESAHAN STATUS TESIS*

JUDUL: UNIVERSAL MEASURING MACHINE: A STUDY ON POTENTIAL ERROR AND COMMON ERROR IN CALIBRATION PROCESS (DIAL INDICATOR)

SESI PENGAJIAN : 2002 / 2006

Saya MARWAN BIN MAT SALLEH No. K/P 821001-09-5135 No. Matrix B050210036

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	

Disahkan oleh:

(MARWAN BIN MAT SALLEH)

(CIK ZUHRIAH BT. EBRAHIM)

Alamat Tetap:
PT 2708, TAMAN RANTAU BARU
MUKIM GUAL NERING, 17200
RANTAU PANJANG, KELANTAN.

Cop Rasmi:
ZUHRIAH BTE EBRAHIM
Pensyarah
Fakulti Kejuruteraan Pembuatan
Kolej Universiti Teknikal Kebangsaan Malaysia
Karung Berkunci 1200
75450 Ayer Keroh, Melaka.

Tarikh: 22 MAY 2006

Tarikh: 05 JUN 2006.

* 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 "Universal Measuring Machine: A Study On Potential Error And Common Error In Calibration Process (Dial Indicator)" is the results of my own research except as cited in the reference.

Signature	:	.....
Author's Name	:	MARWAN BIN MAT SALLEH
Date	:	22 MAY 2006

DEDICATION

For my beloved mom, my elder brother and my younger brother.

Especially for my special girlfriend.

Special thanks for my supervisor.

ACKNOWLEDGEMENTS

In the Name of Allah, The Most Gracious, The Most Merciful

The completion of this thesis would not have been possible without the help and contributions of many people.

Firstly I am grateful due to my supervisor Miss Zuhriah Bt. Ebrahim guidance me along for providing help completing this project. Mr. Hasan for giving permission to use the UMM machine for this study.

Thanks are to due two technicians Mr. Jaafar Lajis and Mr. Hairmi Othman for give me full training on handling Universal Measuring Machine (UMM). All there given, I also thank for suggestions are highly appreciated.

I also acknowledgement the invaluable contributions for my friends (Adib, Florence, and Mohd. Azhar) and technicians (Mr. Sahar and Mr. Hairul) for their willing to spend their time being a non-experienced person in this study.

Finally, but not least, I would like to dedicate my special acknowledgement to my beloved mom, Hamidah, who has been and still is giving constant support and encouragement during the my study, spiritually and materially, particularly when the going got tough.

A special mention is due to my elder brother Mokhtar, my younger brother Marzuki and who has been supportive in my academic purist. Especial thankful for my special girlfriend Wan Salmiah for give me full support and have been a source of inspiration and have made life more interesting and colorful.

ABSTRACT

Calibration is one part in metrology process. This part is very important because in measurement process that assign values to the property of an instrument relative to reference standards. In this study, have been used UMM machine to determine common errors and potential errors. UMM machine is the high precision machine and the accuracy up to $\pm$ 0.00001 mm. This machine can calibrate several equipment such as dial indictor, micrometer, gauge block, snap gauge and ring gauge. Generally, the aims of this study are to identify potential errors and common errors, to eliminated or reduce the errors and to determine the optimum time for calibration by using dial indicator. Experimentation is used in order to identify the potential errors and common errors. In this experiment, have divided for two group; experienced group and non-experienced group. The results are generally to compare between this two groups.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

CW	-	Clockwise
CCW	-	Counter Clockwise
FKP	-	"Falkuti Kejuruteraan Pembuatan" / Department of Manufacturing Engineering
KUTKM	-	"Kolej Universiti Teknikal Kebangsaan Malaysia" / Malaysian National Technical University College
N	-	No. of Frequency
SOP	-	Standard Operation Procedure
SPSS	-	Statistical Package for Social Science
UMM	-	Universal Measuring Machine
min	-	minute
mm	-	millimeter
μm	-	micrometer
σ	-	Standard Deviation

CHAPTER 1
INTRODUCTION

1.1 OVERVIEW

In this study will be discuss and discover about common error and potential error in calibration process using Universal Measuring Machine (UMM). Will be use dial indicator for the equipment to detect which error at this equipment always happen. On this study, will be specific on to identify the potential errors and common errors that might occur the calibration process.

According to Berthouex and Brown (2002), they say the calibrations standards are measured under the same conditions are those that subsequently will be used to test the unknown specimens. Next from the Kalpakjian and Schmid (2001), they mentions that a calibration is defined as a adjusting or setting an instrument to give readings that are accurate within a references standards. Calibration of dial indicator for the equipments to search the errors when the human using this equipment using UMM machine for the method to determine the errors at this equipments.

According to Bucher (2004), he says when using the UMM machine, will be consider about the traceability. Traceability is very important because it is a property of the result of a measurement and all of the comparisons must have stated uncertainties. Traceability applies to the measured value and its uncertainty, as a single entity.

1.2 SOURCES OF ERRORS

According to Bolton (1996), errors can be classified as being either random or systematic errors. Random errors are ones, which can vary in a random manner between successive readings of the same quality. Systematic errors are errors, which do not vary from one reading to another. In this study, human errors are classified under random errors. However, human errors can be divided into two; potential errors and common errors.

1.3 DEFINITION OF POTENTIAL ERRORS

A potential error is a latent error that is capable to be occurred. In this study, the potential errors have been determined an errors that was done by either experienced person or non-experienced person while handling the UMM machine.

1.4 DEFINITION OF COMMON ERRORS

A common error is a typical error that normally is done by anybody. In this study, the common errors have been determined an errors that was done by either experienced person or non-experienced person while handling the UMM machine.

1.5 DIAL INDICATOR

According to Kalpakjian and Schmid (2001), they mention that dial indicators are simple mechanical devices that convert linear displacements of a pointer to the amount of rotation of an indicator on a circular dial (Fig. 1.1). The indicator is set to zero at a certain reference surface, and the instrument or the surface to be measured (either external or internal) is brought into contact with the pointer. The movement of the

indicator is read directly on the circular dial (either plus or minus) to accuracies as high as 1μm (40 μin.).

Base on the statements, they says against a dial indicators of several designs are available for use as portable or benchtop units. The basic design consists of a rack-and-pinion and a gear-train mechanism that, together, convert linear motion to rotary motion, with large amplifications. These instruments are also used for multiple-dimension gaging of parts (Fig. 1.1c).

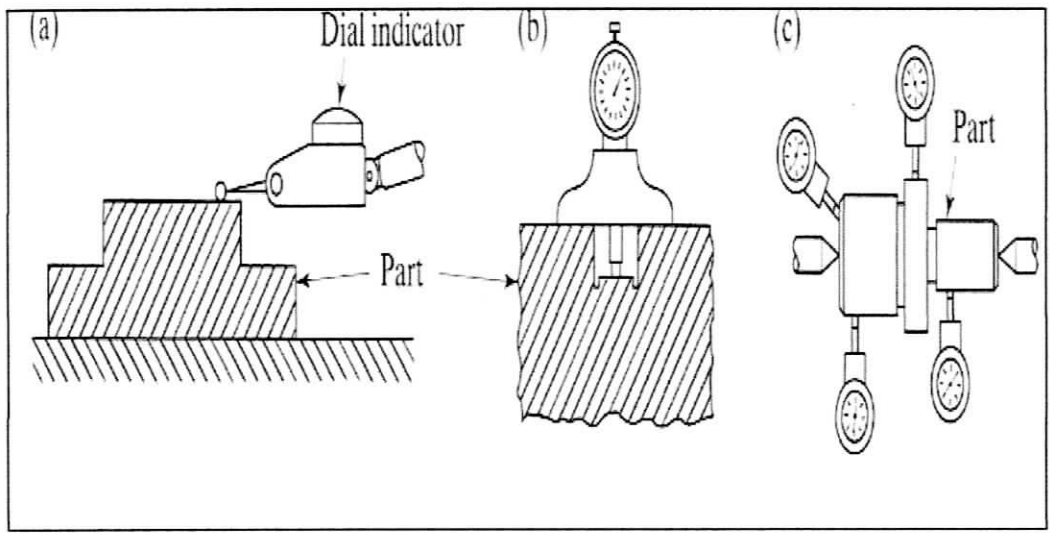

Figure 1.1: Three Uses for Dial Indicators; (a) Roundness Measurement, (b) Depth Measurement, and (c) Multiple-Dimension Gaging of A Part (Kalpakjian and Schmid, 2001)

1.6 THE UNIVERSAL MEASURING MACHINE (UMM)

As generally, the Universal Measuring Machine (UMM) is machine to calibrate and measured several equipment such as micrometer, dial indicator, ring gauge, block gauge, snap gauge, plug gauge, bores, threads and etc. For the operation on UMM machine, they will be control using by the software and for the setup the equipment must be manually setup. In this UMM machine, the objectives calibration are to determine and confirm equipment are good condition and still can be reusable.

1.7 BACKGROUND PROBLEMS

In 2004, "Kolej Universiti Teknikal Kebangsaan Malaysia" (KUTKM) purchased a Universal Measuring Machine (UMM) for calibration purposes. This machine can calibrate several equipments such as micrometer, dial indicator, plug gauge, block gauge, ring gauge and etc. This machine requires high skill person to handle the calibration process.

Currently, there are only two (2) persons who have been well trained for this machine. However, errors are never expected. Therefore, it is important to identify a potential errors and common errors that might occur during the calibration processes by using UMM machine. The problems are:

i. How effective the manual that has been used as a guide to operators especially the new operator.
ii. What are the optimums taken times for calibrating the dial indicator between experience and non-experience operator. The taken time of each operator will determine that errors might occurred if it could not achieve the optimum time.

1.8 OBJECTIVES OF STUDY

The objectives of this study are:

i. To identify the potential errors and common errors that might occur the calibration process by using Universal Measuring Machine (UMM).
ii. To reduce or elimination the potential errors and common errors in the calibration process.
iii. To determine an optimum taken time for calibrating dial indicator. This will be used as a benchmark for each human operator in order to reduce or eliminate human errors.

1.9 SCOPE OF STUDY

The scope of this study is to identifying the potential errors and common errors while calibrating dial indicator by using UMM machine. Only four (4) experience operators and four (4) non-experience operators have been involved in this study according to availability.

1.10 THE EXPECTED OUTCOMES

The results of this study can be used for:

i. Increasing the efficiency of the calibration process for dial indicator.
ii. Optimizing the time taken that will be improved time by time.
iii. Enhancing the skill of operators.

CHAPTER 2
LITERATURE REVIEW

2.1 DEFINITIONS

The basic words of common, potential and error are using to define the meaning of potential errors and common errors. Therefore, these errors are determined accordingly.

2.1.1 Common

According to Oxford University (2004), they mention that common have several meaning such as ordinary, average, normal, conventional, typical, unexceptional, plain, commonplace, run-of-the-mill, simple, habitual, widespread, general, universal, popular, accepted, prevalent, prevailing, shared, public, communal, collective, vulgar, coarse, rude, uncouth, unrefined and boorish.

2.1.2 Potential

According to Katman (1996), he mentions the meaning of potential is the possible as apposed to actual, capable of becoming or latent. He says these words are occasionally used in error.

According to Oxford University (2004), a meaning of the potential is budding, embryonic, developing, promising, prospective, likely, possible, and probable.

2.1.3 Error

According to Oxford University (2004), they mention that error have many meaning such as mistake, inaccuracy, miscalculation, blunder, fault, oversight, misprint, erratum, misinterpretation, misreading, fallacy, wrongness, misconduct, misbehavior, lawlessness, criminality, delinquency, sinfulness and evil.

2.2 ERRORS IN MEASUREMENT

This study will focus how to determine the errors have been occurred in measurement for calibration. There are three elements in measurement;

i. Measurement Method.
ii. Measurement System.
iii. Measurement Capability.

Errors do interfere into the measurement elements.

2.2.1 Measurement Method

According to Bucher (2004), measurement is accomplished by employing one or more well-defined measurement method in an effort to obtain quantifiable information about an object or phenomena. These measurements method exhibit certain fundamental characteristics, which allow them to be used to categorize different types of measurements. Usually a particular situation or application will obviate the appropriate measurement method needed to achieve the desired measurement data. Experience tells us which specific measurement method will typically yield the best results for a particular situation or application. Factors such as phenomena stability, resolution requirements, environmental influences, timing restrains, and so on must be considered in order to determine the optimum measurement method.

As he say, understanding the mechanics and theory behind measurement method is helpful not only for determining the best method for a particular situation or application but also for understanding their limitations and the measurement data they produce.

A measurement method is important because these measurement show convinced fundamental characteristics. In measurement method, they will be allow to the categorize different types of measurements. When using the UMM machine, will be consider about factors to determine the optimum measurement method such as phenomena stability, resolution requirements, environmental influences, timing restrains, and etc. In UMM machine, will be not only understanding about machine and theory but must be consider about understanding their limitations and the measurement data they produce for the optimum the measurement method.

2.2.2 Measurement System

According to Bucher (2004), he mentions that, measurements system is the means by which measurement data are obtained. A measurement system in an ensemble comprised of various elements including measurement personnel, calibration standards, measurement devices, measurement fixtures, measurement environment and measurement methodology and so on. They are used to obtain quantifiable, attributable data related to an object or phenomena. Will be visualizing a measurement system as a process of interactive, interrelated activities by which various objects or phenomena are related to measurement data.

As refer to him, he says a measurement system are created and used based on needs for specific measurement data. The makeup of a measurement system is determined by an application or particular situation. The adequacy of a measurement system depends on the accuracy and reliability requirements of the measurement data.

Next, he says against the less stringent requirements demand less of a measurement system in terms of sophistication, variability, repeatability, and so on. How measurement data will be used will drive the selection, composition and sophistication of a measurement system in order to meet measurement objectives.

Measurement system most explains about as a process of interactive, interrelated activities by which various objects or phenomena are related to measurement data. In this cases, when using dial indicator will be consider the accuracy and reliability of this equipments of the measurement data. The error can be detected when equipment they used is not accurate.

2.2.3 Measurement Capability

Based on Bucher (2004), he mentions that, a measurement system embodies a variety of measurement capability inherent in their design for their intended purpose(s). Measurement capability are basically attributes of a measurements system that determine the extent to which measurements may be made within some qualifying restrains such as measurement range, ambient conditions, required input amplitude, and so on. Measurement system capability should be congruent with the requirements of the measurement application it is intended for. Determining whether a measurement system has the required capability to meet a measurement application is not always readily apparent and must often be established through user-assessment activities. It is ultimately the responsibility of the measurement system user to ascertain whether a measurement system is capable of meeting the requirements of a particular measurement application. Intentional/unintentional use of a measurement system in terms of operation beyond its established capability normally results in measurement data with unknown uncertainties at best or totally erroneous measurement data in worst-case scenarios.

Next, he mention that a measurement system's capability are often characterized in terms of bias, linearity, repeatability, reproducibility, and stability. VIM (International Vocabulary of Basic and General Terms of Metrology) defines bias (of a measuring instrument) as "systematic error of the indication of a measurement instrument" noting

that bias is normally established by averaging the error of indication over an appropriate number of repeated measurements. These measurements are assumed to be of the same measured using the same measurement system. Bias is frequently referred to as systematic offset. Some possible causes for bias are:

i. Measurement system needs calibration or has been improperly calibrated
ii. Measurement system is defective, worn, contaminated
iii. Measurement system is inadequate or inappropriate for the measurement application
iv. Environmental conditions are excessive
v. Compensation not applied
vi. Operator error
vii. Computational error

Than, he says again, a measurements system must have consider all factors such as linearity, repeatability, reproducibility, and stability. In this cases, when using same methods and same procedures, will be consider a bias to as systematic error. Bias can be from the temperature of the calibration room, skill of the operator error, and etc.

From the point of view, him says that, VIM defines a linear scale as, "scale in which each spacing is related to the corresponding scale interval by a coefficient of proportionality that is a constant throughout the scale." VIM subsequently notes that a nonlinear scale coefficient of proportionality is non-constant such as in the case of a logarithmic scale or square-law scale. Relating this definition in terms of bias, linearity can be through of as the proportional difference in bias throughout a scale or range. This bias can be constant (linear) or nonconstant (nonlinear). Some possible causes for linearity errors are:

i. Measurement system needs calibration or is improperly calibrated.
ii. Measurement system is defective, worn, or contaminated.
iii. Measurement system environment is excessive and/or unstable.
iv. Measurement system is inadequately maintained.

Linear scale such as a calibration possible causes for linearity error because in measurements, will be consider the calibration because before start the measurements, must do the calibration to determine this equipments is in good conditions or not.

He says again, the continuing with VIM definitions; repeatability (of results of measurements) is defined as, "ability of a measuring instrument to provide closely similar indications for repeated applications for the same measurand under the same conditions of measurement." The same condition of measurement assumes:

i. The same operator makes the measurements.
ii. The same measurement procedure is used.
iii. The same measurement equipment is used.
iv. The same measurement standard used.
v. It's the same location.
vi. Environmental conditions are the same.
vii. Measurements are performed over a short period of time.

2.2.4 Random Errors

Random errors are basically errors from the environment and current situations such as temperature would affect the result when do the measurement. This error also gives the reading for each other in random method from the consecutive analysis of the value of the same feature and would be seems to have a random statistics to the experiment results.

According to Bolton (1996), he mention they have some explanation about random error such as:

a) *Operating Errors*:

These can result from a variety of causes, e.g. errors in reading the position of a pointer on a scale due to the scale and pointer not being in the same plane, the reading obtained then depending on the angle at which the pointer is viewed against the scale (the so-called parallax error).

Also there are errors due to the uncertainty that exists in estimating readings between scale markings on an instrument's display.

b) *Environmental Errors*:

These are errors, which can arise as a result of environmental effects, such as a change in temperature or electromagnetic interference.

c) *Stochastic Errors*:

These result from stochastic processes such as noise. A stochastic process is one, which results in random signals.

2.2.5 Systematic Errors

Systematic errors remains do not vary from one value to another. In this errors will be consider about the factor that contributes to chop up this error is not affected by the environment or current situation as random errors. Systematic errors a consistent bias from the true value and bias can be removed by calibration and careful checks on experimental methods and equipment.

According to Bolton (1996), he says they have some explanation about random error such as:

a) *Construction Errors*:

These occur in the manufacture of an instrument and arise from such causes as tolerances on the dimensions of components and on the values of electrical components used.

b) *Ageing Errors*:

These are errors resulting from the instruments getting older, e.g. components deteriorating and their values charging, a build-up of deposits on surfaces affecting contact resistances and insulation.