UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MEASUREMENT UNCERTAINTY EVALUATION COMPUTATION USING MATLAB

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

by

LEOW SHELL FANG

FACULTY OF MANUFACTURING ENGINEERING
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I hereby declare that this report entitled **"**Measurement Uncertainty Evaluation Computation using Matlab**"** is the result of my own research except as cited in the references.

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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 members of the supervisory committee are as follow:

Dr. Mohd Rizal bin Salleh

(PSM Supervisor)

ABSTRACT

The purpose of this project is to develop a program by using MATLAB in uncertainty of measurement. Error and uncertainty happens in every measurement no matter how carefully a result of measurement is taken. It is impossible to eliminate the errors occurred in a particular measurement. What can be done is to minimize the error when a reading is taken during the measurement. Uncertainty plays an important role in measurement as it will affect the quality of a particular measurement. First of all, the measurement of gauge block is taken. Temperature and humidity of the environment also being recorded. There are the factors to affect the uncertainty in measurement. Error calculation and uncertainty calculation are being carried out. Matlab program has been developed based on the data obtained. It is an ambitious program which contains hundreds of commands to do mathematics. M-file is being used in order to key in the coding and the program is executed in the command window. Discussion has been done on the parameters of uncertainty in measurement. Conclusion is included in the report in the final part.

ABSTRAK

Tujuan projek ini dijalankan adalah untuk menghasilkan satu program dengan menggunakan MATLAB tentang ketidakpastian dalam pengukuran. Keralatan dan ketidakpastian berlaku dalam semua pengukuran tidak kira berapa perhatian diambil semasa pengukuran dijalankan. Tidak kemungkinan untuk menghapuskan keralatan dalam sesuatu pengukuran. Apa yang boleh dilakukan ialah mengurangkan keralatan ketika mengambil bacaan. Ketidakpastian dalam pengukuran memainkan peranan yang penting kerana ia akan mempengaruhi kualiti sesuatu pengukuran. Pada mulanya, pengukuran gauge block diambil. Suhu and kelembapan persekitaran juga dicatatkan. Mereka merupakan factor yang mempengaruhi ketidakpastian dalam sesuatu pengiraan. Pengiraan bagi ralat dan ketidakpastian juga dijalankan. Matlab program dilakukan berdasarkan maklumat yang dicatatkan. Ia merupakan satu program yang mengandungi banyak command untuk menjalankan pengiraan matematik. Perbincangan dilakukan tentang parameter yang mempengaruhi ketidakpastian dalam pengukuran. Kesimpulan juga dimasukkan dalam projek ini.

DEDICATION

For my beloved family

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Next, I would like to deliver special thanks to my lovely family. Without my family support, I could not complete the project on time. They really help me a lot when I am facing difficulty in the project. Their advices may not useful in my project but they have give to me the strength to continue and complete the task successfully.

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LIST OF ABBREVIATIONS

BMP	-	Bitmap
CMM	-	Coordinate Measuring Machine
GIF	-	Graphics Interchange Format
GUM	-	Guide to the Expression of Uncertainty in Measurement
ISO	-	International Organization for Standardization
JPEG	-	Joint Photographic Experts Group
MATLAB	-	Matrix Laboratory
n	-	Sample size
NPL	-	National Physical Laboratory
RH	-	Relative humidity
SD	-	Standard deviation
SEM	-	Standard error of the mean
SI	-	International System
U	-	Expanded uncertainty
QC	-	Quality Control
QA	-	Quality Assurance

CHAPTER 1

INTRODUCTION

This chapter focuses on the introduction about the topic of the project, its problem statement, objectives to be achieved and also the scope of study. The project title also had been briefly explained.

1.1 Introduction

Even the most carefully designed and executed experiments instruments which are performed in temperature and humidity controlled environments, yield values that are influenced by various sources of error. A key responsibility of an experimenter is to attempt to identify sources of error that may affect the measurement process and then quantify the likely extent of those errors. Random errors cause measured values to lie above and below the true value. Due to the scatter created by the values, it is usually easy to recognize. So long as only random errors exist, the best estimate of the true value, which is often taken to be the mean of many measured values, tends towards the true value as the number of repeat measurements increases. Another type of error is that which causes the measured values to be consistently above or consistently below the true value, this is termed a systematic error. (Les Kirkup, 2007).

According to International Organization for Standardization (ISO), uncertainty in measurement is defined as the parameter which associated with a result of a measurement that characterizes the dispersion of the values that could be reasonably attributed to the measured value (Kallner, 2006). In other words, uncertainty of measurement is the doubt which exists in the result of any measurement. Uncertainty is a quantification of the doubt about the measurement result. It is different with error whereas error means the difference between the measured value and the 'true value' of the thing being measured. Uncertainty measurement is significant when we hope to make good quality measurements and to understand the results. Besides that, it also plays an important role in calibration, test and tolerance.

To encourage uniformity in the way uncertainty in measurement is expressed, ISO prepared and published the document 'Guide to the Expression of Uncertainty in Measurement' (GUM) in 1993. The work, which culminated in GUM, was begun in the late 1970's and drew together experts in metrology from around the world. As a starting point, an ISO working group was given the following terms of reference. Though the terms of reference appear to focus upon services and facilities provided to the scientific, engineering and other communities by standards and calibration laboratories, GUM also anticipates the general rules it conveys to be applicable to a broad range of measurements carried out in science and engineering. A broad aim of the GUM document is to encourage those involved with measurement to supply full details on how uncertainties are calculated, permitting the comparison of values obtained through measurement by workers around the world. (Les Kirkup, 2007).

No measurement can perfectly determine the value of the quantity being measured (the measurand). Imprecision arising from flaws in the construction of the instrument, from operator error, from incorrect specification of environmental conditions or from failure to identify all factors determining the measurement output can lead the measurement to deviate from the measured value (Leon Jay Gleser, 1998). Any error whose value we do not know is also a source of uncertainty. Therefore, one must have detailed knowledge about the procedure of measurement to allow identification and quantification of all reasonable sources. All of these uncertainty factors must be evaluated and brought into the uncertainty budget (Kallner, 2006).

There are two types of estimation of the uncertainty in measurement, that are Type A and Type B. For Type A, the estimation is based on the standard deviations derived from repeated measurements. As a result, the standard deviation and the standard uncertainty will have the same size. Sometimes in complex measurement procedures, it is not able to estimate the variation from repeated experiments. Hence, the professional experience, information in the literature or specifications from a manufacturer will usually allow the demarcation of an interval within which a result can reasonably be expected (Kallner, 2006). This is what had been done in the Type B evaluation of uncertainty.

1.2 Problem Statement

All the measurement data is issue to uncertainty and a measured value is only comprehensive if it is accompanied by a suitable statement of the associated uncertainty. Therefore, understanding and evaluating uncertainty is important to make good quality measurement. It is because the measurement data will maintain the quality control when the production is carried out. Besides that, it also will undertake the research and development. The data obtained is also very useful in calibrate the instruments. The error and uncertainty in measurement will affect the quality of a particular measurement, so it is a must to identify the parameters of them. There are such as temperature, instrument, human factor and so on. As a result, it is a need to establish a computer program in order to analysis the uncertainty of the measurement.

1.3 Aim & Objectives

The aim of this project is to reduce the errors and uncertainty of measurements which occur when the measurement data is being taken. As the uncertainty of measurement will affect the quality of a particular measurement, so it is a must to minimize it so that the quality control of measurement can be maintained. The objectives including:

- Identify the parameters of error and uncertainty
- Establish a computing program for uncertainty analysis
- Analyze the impact of parameters on the error and uncertainty of gauge block measurement procedure

1.4 Scope of Study

The scope of the study is included the error analysis of the measurement taken in the metrology laboratory. The measurement is being done on the master piece by using the micrometer. The master piece can be gage block with known actual value. The sizes of gauge block used are 5mm, 10mm and 20mm. The readings have to be as much as possible so that the average value is more accurate and precise; hence 100 readings are taken. The parameters of error will be identified. Then the uncertainty analysis will be done according to the measurements taken in the lab. After that, the factors of uncertainty will be recognized. When all the parameters are known, the computing program will then be created. Finally, analysis on the impact of parameters on errors and uncertainty is done. Conclusion has been done after the analysis.

CHAPTER 2

LITERATURE REVIEW

The content of this chapter will generally focus on literature review related to the error and uncertainty. The difference between error and uncertainty is stated; the details explanation also included. In this chapter, the information about uncertainty is being focused. There are such as the categories of uncertainty, component of uncertainty, the sources of uncertainty and the effect of uncertainty. This chapter also consists of the equations used in calculating uncertainty.

2.1 Introduction

No measurement can perfectly verify the value of the quantity being measured. A measurement, together with current knowledge, can allow one to eliminate certain values as implausible, but there will be uncertainty about which of the remaining values is the correct one (Leon Jay Gleser, 1998). For measurements which are repeatable, together with outcomes whose deviations from the measurand appear random with mean zero, the quantification of the uncertainty for a single measurement has been some multiple of the standard deviation of the standard deviation of the distribution of errors. Error analysis is required for any results involve in a measurement process. Error analysis means analyze the uncertainties in the measurements taken during the experiment. Random error and systematic error are the types of errors need to be encountered in the measurement.

2.1.1 Error

Error is the difference or discrepancy between the result of the measurement and the actual value of the measurement; in other words, it can be said that it is a mistake. By the way, error also can be explained as the difference between the measured value and the 'true value' of a particular thing being measured. However, the magnitude of this error will never be known exactly.

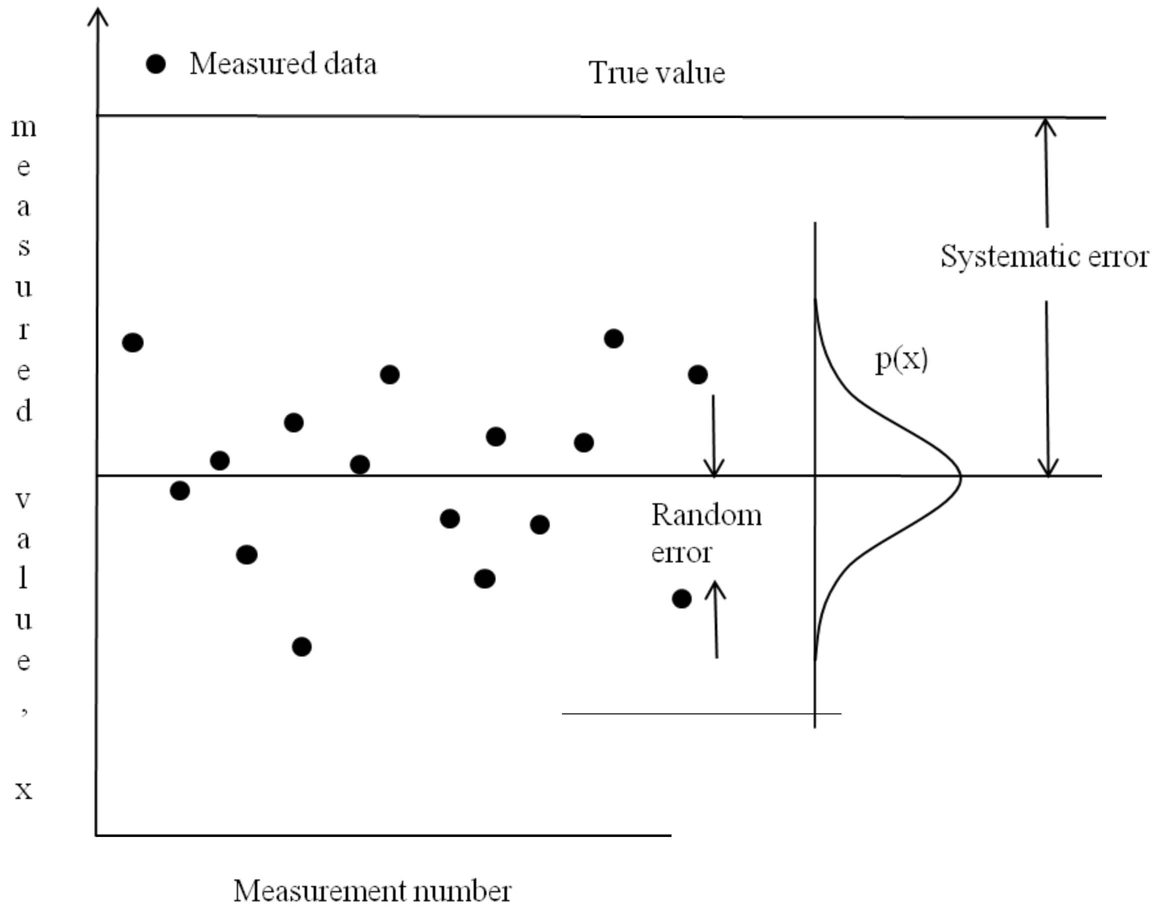

Figure 2.1: Distribution of errors upon repeated measurements

2.1.2 Types of Error

There is no measurement or test is perfect and the imperfections give rise to error of measurement in the result (Leon Jay Gleser, 1998). Error of measurement may have two components. There are random component and systematic component. It can be said that uncertainty arises from random effects and also from imperfect correction for systematic effects (Clarke et al., 2008). These errors may affect a measurement result.

2.1.2.1 Random Error

Random error is the difference between a measurement and the mean that would result from an infinite number of measurements of the same measurand done under repeatability situations. Random error is caused by uncontrollable circumstances in the experiment (Clarke et al., 2008). There are such as humidity, short-term fluctuations in temperature, and air-pressure or variability in the performance of the measure. The important thing about random error is that it does not have any consistent effects across the entire sample (Trochim, 2006). In other words, it pushes observed scores up or down randomly. Random error will add the variability to the data but does not affect the average performance for the group. As a result, random error is sometimes considered noise. This type of error is random and impossible to eliminate completely (Clarke et al, 2008). What can be done is minimize the effects of random error in the experiments by taking careful measurements or improving the experimental techniques (Clarke et al., 2008). Besides, the number of observations can be increased and statistical analysis may be applied in order to reduce the uncertainty due to the effect of random error.

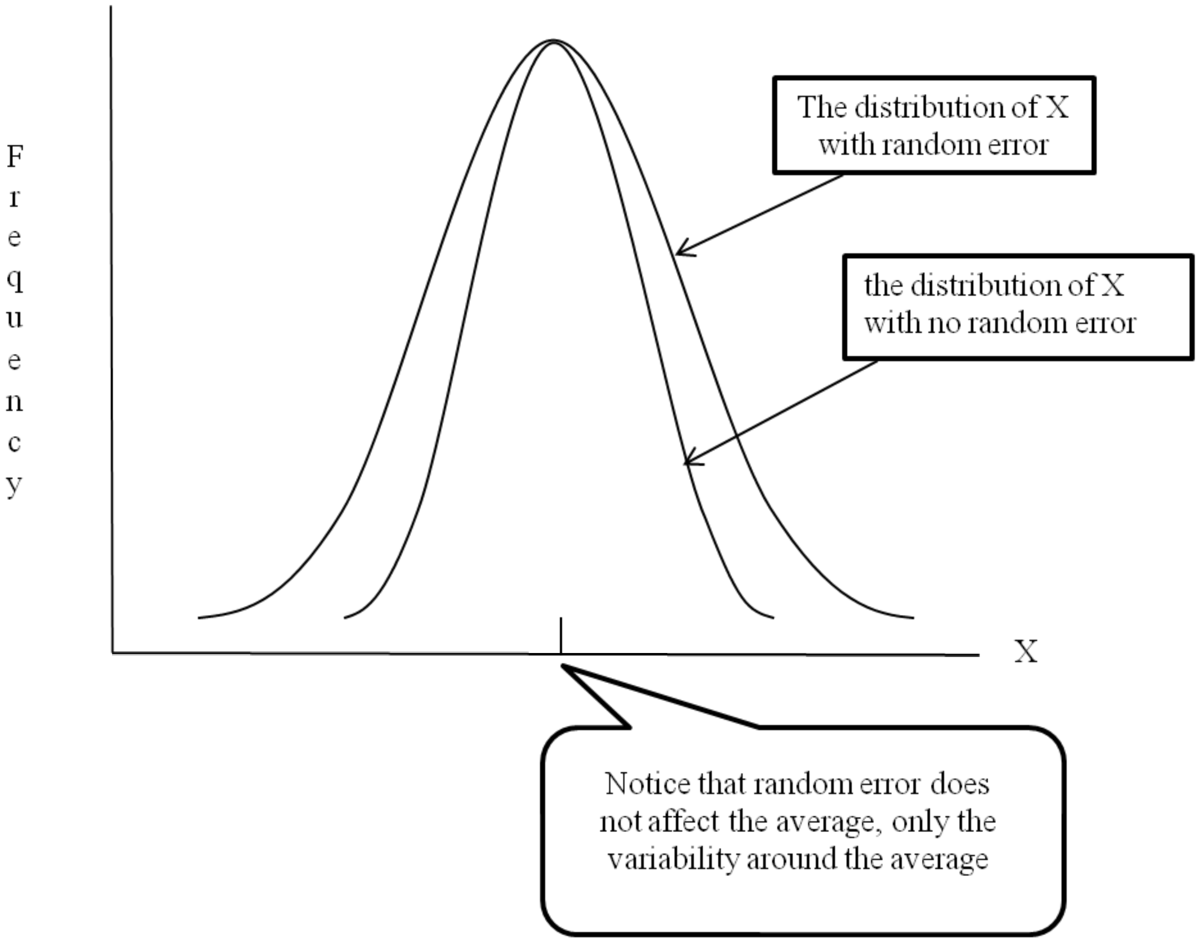

Figure 2.2: Random Error

2.1.2.2 Systematic Error

The systematic error is the difference between the mean that would result from an infinite number of measurements of the same measurand carried out under repeatability conditions and the accepted true value of the measurand. Systematic error is caused by faulty experimental methods, uncalibrated equipment, or some other variable that consistently contaminates the measurements (Clarke et al., 2008). These effects are such as offset of a measuring instrument, drift in its characteristics between calibrations, personal bias in reading an analogue scale or the uncertainty of the value of a reference standard. Therefore, systematic error is sometimes considered to be bias in a measurement. Systematic error will always change the