SPC CHARTING PROCEDURE FOR MONITORING OF SMALL AND LARGE SHIFTS IN PROCESS MEAN

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SPC CHARTING PROCEDURE
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IBRAHIM MASOOD

This project report submitted in partial fulfillment of requirement for
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November 2004

"I herby declare that this Postgraduate Project report is the result of my own work and the idea except for the works that I had cited clearly stated the resources."

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In the name of Allah the Most Gracious and the Most Merciful

SPECIALLY TO MY LOVELY FAMILY,

AMINAH, ZAITON, SITI FATIMAH AND SITI SAFURA

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Yours sincerely,

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ABSTRACT

The research objectives are to study the effectiveness of traditional control charts that are *Shewhart*, *Two-Sided Cusum* and *EWMA* in monitoring small and large process mean shifts and to propose an improved statistical process control charting procedures that effective for monitoring all process mean shifts. Process mean shift can be described as unstable patterns such as shift pattern itself and trend pattern. Average run length (*ARL*), *Type I Error* and *Type II Error* are used as the performance measures. The charting procedures were coded in MATLAB program and extensive simulation experiments were conducted. Design of Experiment (DOE) methods were applied in selecting the suitable design parameters of control charts before conducting the detail *ARL* simulations. The *ARL* simulation identifies each control chart monitoring advantages and disadvantages. In general, *Two-Sided Cusum* and *EWMA* were confirmed effective for detecting small process shifts, while *Shewhart* only effective for large process shifts. Specifically, *Two-Sided Cusum* with (k, h) = (0.5, 4.77) and (0.75, 3.34) were identified produced small *Type I error*, so effective for monitoring small process mean shift, more effective than *EWMA* and close to *Nelson's Run Rules* performance for 0.75σ to 2.5σ shift range. The findings were validated using a few real process data. The concurrent application of *Shewhart*, *Two-Sided Cusum* with (k, h) = (0.5, 4.77) and (0.75, 3.34) were proposed as an improved charting scheme. It is observed more effective than the *Combined Shewhart-Cusum* which was recommended by Lucas (1982). However, *Nelson's Run Rules* is not recommended because it provides large *Type I error* even so effective for monitoring process shift. The findings were confirmed and detailed the individual *Nelson Run Rules* performances stated by Nelson (1985), except rules for detecting stratification. Finding on different rules gave different 'rate of false signal' (*RFS*), contradicted with result based on Monte Carlo method (Nelson, 1985) but confirmed the result from Trietsch (1997). Findings on *EWMA* were confirmed Montgomery (1996) which stated that small constant (λ) more sensitive for identifying small shifts while large λ better for identifying large shifts.

ABSTRAK

Objektif penyelidikan ini adalah mengkaji keberkesanan carta kawalan tradisional iaitu *Shewhart*, *Cusum Dua-Belah* dan *EWMA* bagi mengawal anjakan purata proses yang kecil dan besar serta mencadangkan peningkatan tatacara carta kawalan proses statistik yang berkesan bagi keseluruhan anjakan purata proses. Anjakan purata proses boleh dinyatakan sebagai corak-corak tidak stabil seperti corak anjakan dan mendaki. Purata Panjang Larian (*ARL*), *Ralat Jenis I* dan *Ralat Jenis II* digunakan sebagai penilai keupayaan. Tatacara kawalan dikodkan di dalam program MATLAB dan simulasi ujikaji yang terperinci dijalankan. Ujikaji Rekabentuk (DOE) diapplikasikan di dalam memilih parameter-parameter carta kawalan yang bersesuaian sebelum menjalankan simulasi *ARL*. Simulasi *ARL* mengenalpasti kelebihan dan kelemahan setiap carta kawalan proses. Umumnya, *Cusum Dua-Belah* dan *EWMA* dikenalpasti berkesan bagi mengesan anjakan proses yang kecil sementara *Shewhart* hanya berkesan bagi anjakan proses yang besar. Secara terperinci, *Cusum Dua-Belah* dengan (k, h) = (0.5, 4.77) dan (0.75, 3.34) dikenalpasti mengeluarkan *Ralat Jenis I* yang kecil, sangat berkesan bagi mengawal anjakan proses yang kecil, lebih baik berbanding *EWMA* dan hampir menyamai keupayaan *Undang Larian Nelson* bagi julat anjakan 0.75σ sehingga 2.5σ. Pemerhatian tersebut telah disahkan menggunakan beberapa data proses yang sebenar. Penggunakan serentak carta kawalan *Shewhart*, *Cusum Dua-Belah* dengan (k,h) = (0.5,4.77) dan (0.75,3.34) dicadangkan sebagai peningkatan skim kawalan. Ia lebih berkesan berbanding *Gabungan Shewhart-Cusum* yang disyorkan oleh Lucas (1982). Biarpun begitu, *Undang Larian Nelson* tidak disyorkan kerana memberikan *Ralat Jenis I* yang besar, walaupun sangat berkesan bagi mengawal anjakan proses. Penemuan tersebut mengesahkan dan memperincikan keupayaan *Undang Larian Nelson* yang dinyatakan oleh Nelson (1985), kecuali bagi mengesan percampuran. Undang berbeza memberikan 'kadar kesilapan isyarat' (*RFS*) berbeza, bercanggah dengan kaedah Monte Carlo (Nelson, 1985) tetapi mengesahkan keputusan Trietsch (1997). Penemuan ke atas *EWMA* mengesahkan pernyataan Montgomery (1996) yang menyifatkan bahawa pemalar (λ) yang kecil lebih sensitif bagi mengenalpasti anjakan proses yang kecil sementara λ yang besar lebih sensitif bagi anjakan besar.

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CHAPTER I

INTRODUCTION

1.1 Introduction

Quality can be defined as *the totality of features and characteristics of a product or service that bears on its ability to satisfy stated or implied needs* (ASQ). The simple term means an ability of manufacturer or organization to satisfy or exceed the consumer wants through products and/or services. As technology keep on growing in various fields especially in mechanical, electronic and chemical base, various kinds of product for consumer can be produced. In many developed and developing countries where the economy are stable, people have an ability to pay for quality products even the price is high. However, in recent miniaturization technology growth where production toward finer size components, people need also become diversify and complex. Today, customers are sensitive about quality of product or services that they paid. Therefore, in order to keep in pace with customer interest, manufacturer have to ensure any products that are being produced will meet a certain quality level. This can be achieved with the good functionality, stable mating components, consistent sizes and high durability.

Products of high quality and competitive price cannot be manufactured without supporting with technology tools either in product development activities and production run. The implementation of concurrent engineering in product development activities, statistical quality engineering tools and computer aided tools until production stage will help to maintain quality in long term production run. An organization can maintain their products and/or services quality by implementing the 'Statistical Quality Engineering' (SQE) tools. SQE tools can be classified into eight main elements that are quality function deployment (QFD), design of experiment (DOE), statistical process control (SPC), acceptance sampling, process capability

(Cp), failure mode and effect analysis (FMEA), gauge repeatability and reproducibility (GR&R) and six sigma.

In continuous production activity, usually seven basic SPC tools such as flow chart, check sheet, scatter plot, control chart, histogram, Pareto analysis and Ishikawa fish bone chart are applied concurrently. Control charts are classified to the variable and attribute control charts. Control chart for variables consists of several types such as *Shewhart X-bar,R* and *X-bar,S*, Cumulative sum (*Cusum*), exponentially weighted moving average (*EWMA*), individual moving range and others. The diagram of SQE tools classification from Adnan (2002) is modified by adding the types of variable control charts that involved in this project. Figure 1.1 illustrates this classification.

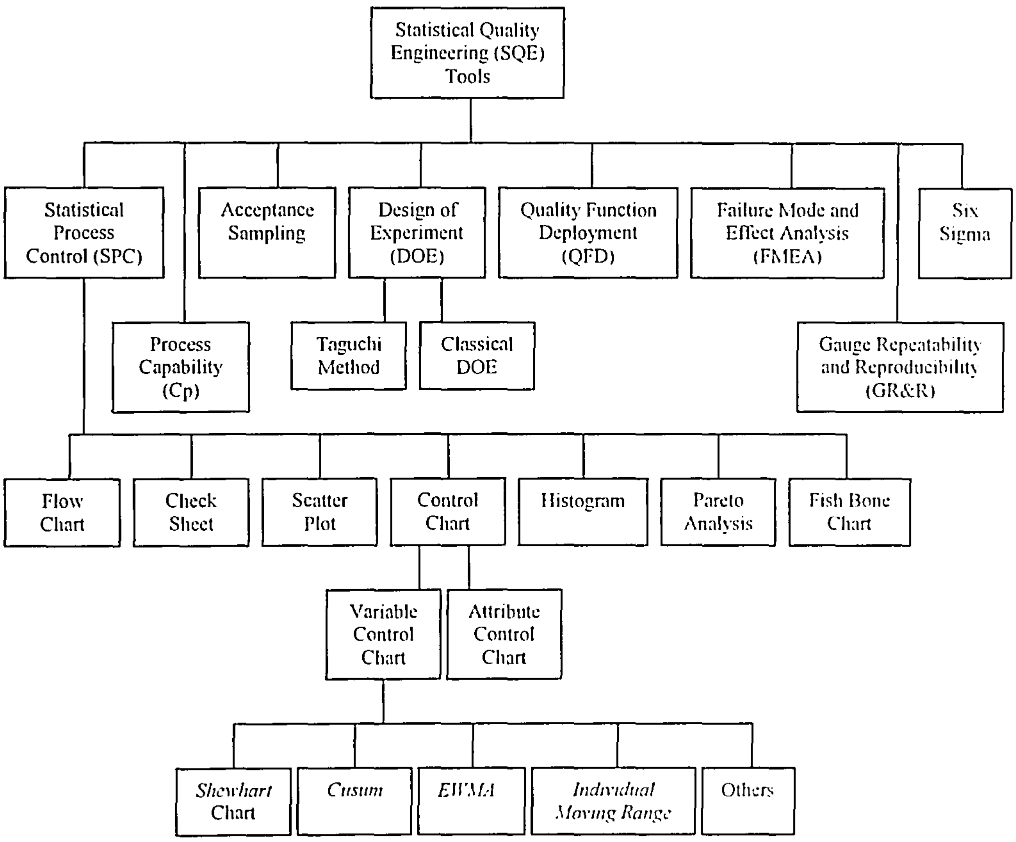

Figure 1.1: Statistical Quality Engineering (SQE) tools classification (Adnan, 2002)

Control charts function as the statistical method to monitor and control the process variable or attribute within the computed or historical control limits. Control limits are usually computed based on drawing specification, machine capability or historical process mean and standard deviation. Most production practicers will use the tightened control limits which is 1.33 times smaller than the specification limits. For stable process, a centerline between these two control limits need to be maintained continuously. Basically, control charts acts to monitor a process by signals any plotted data that is out from the control limits.

1.2 Statement of the Problem

In conducting a continuous quality improvement, control chart for variable is one of the SPC tools that useful to monitor and signal any unstable process. In achieving high quality products, application of effective charting scheme is a critical aspect. The traditional control charts such as 'cumulative sum' (*Cusum*) and 'exponentially weighted moving average' (*EWMA*) are known only effective for identifying small shifts, while *Shewhart X-bar* is only effective for identifying large process mean shifts. However, actual process mean variation is normally unpredictable either it will deform to small or large shifts when process become unstable. Therefore, an improved control charting scheme that effective for monitoring both small and large process mean shifts need to be investigated.

1.3 Objectives

The specific objectives of this research are:

(i) To study the effectiveness of *Shewhart*, *Two-Sided Cusum* and *EWMA* control charts for monitoring small and large shifts in process mean within $\pm 3\sigma$ control limits.

(ii) To propose an improved Statistical Process Control charting scheme for effective monitoring of both small and large shifts on process mean.