IMPLEMENTATION OF STATISTICAL PROCESS CONTROL IN SMALL AND MEDIUM ENTERPRISE INDUSTRY

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SUPERVISOR DECLARATION

"We hereby declare that we have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering"

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STUDENT DECLARATION

I hereby declare that this thesis entitled *"Implementation of Statistical Process Control in Small and Medium Enterprise Industry"* is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To

My near and dear ones,

Abd. Halim B. Din

Siti Rokiah Bt. Ramli

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ABSTRACT

This project has undertaken analysis and report on the Statistical Process Control (SPC) in Chaudry Textiles (Malaysia) Sdn Bhd, a manufacturing company. The objectives of this project are to implement SPC technique in printing process, to analyzed data of printed fabric and give some recommendations from the study of SPC. By using SPC tools specially the $\bar{x}$ and R chart and process capability study which is the C_p and C_{pk} indices in this particular study, variation due to assignable causes in the process has been identified where the 4M; Men, Machines, Methods, and Materials, causes become the main source of variation. The C_p index show how well the process spread is compared to the specification spread and the C_{pk} index shows whether the process is producing reject or not. Analysis has showed that the printing process for the production of cotton fabric is in-control. The C_p index value is 1.51 which is more than 1.00, the pattern on the control chart showing the unnatural process where many points in a row fell below the centerline. The C_{pk} index value is 1.19 and showing the process is in control but the printing process is not consistent. Prevention action and countermeasure are proposed in order to get the process back on its target based on the effect of the 4M.

ABSTRAK

Laporan projek ini adalah mengenai analisi kualiti ke atas pencetakan fabrik menggunakan Kaedah Proses Kritikal (SPC) di Chaudry Textiles (Malaysia) Sdn Bhd, sebuah syarikat pembuatan. Objektif bagi projek ini adalah untuk melaksanakan teknik SPC dalam proses pencetakan, menganalisis data bagi fabrik yang telah dicetak dan memberi sedikit cadangan daripada pembelajaran SPC. Dengan menggunakan kaedah SPC terutamanya carta $\bar{x}$ dan R serta kajian proses kapabiliti iaitu indek C_p dan C_{pk}, variasi yang berlaku di dalam proses pencetakan fabrik yang disebabkan oleh '*assignable-cause'* telah dikenal pasti dimana elemen 4M; Manusia, Mesin, Bahan (material) dan Metodologi adalah faktor utama yang menyumbang ke arah kewujudan variasi. Indek C_p menunjukkan bagaimana bagusnya proses penyebaran berbanding dengan spesifikasi penyebaran manakala indek C_{pk} pula menunjukkan samaada proses itu gagal atau tidak. Analisis menunjukkan proses pencetakan bagi penghasilan fabrik kapas masih berada di dalam kawalan. Nilai indek C_p bagi proses pencetakan adalah 1.51 iaitu lebih daripada 1.00, keadaan ini dikenalpasti sebagai paten tidak natural dimana terdapat banyak titik plot masih berada di bawah garisan tengah. Nilai indek C_{pk} pula adalah 1.19, ini menunjukkan proses pencetakan berada di dalam kawalan tetapi proses pencetakan tidak konsisten. Berdasarkan faktor-faktor 4M, suatu langkah pencegahan dan pembetulan dirangka bagi mengembalikan nilai purata proses kepada menjadi hampir sama atau sama dengan nilai purata spesifikasi dan beberapa kaedah penyelesaian telah diusulkan.

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LIST OF SYMBOLS

C_p	Capability index
C_{pk}	Capability index
6σ	6-sigma
USL	Upper specification limit
LSL	Lower specification limit
C_{pu}	Single sided process spread capability index
C_{pl}	Single sided process spread capability index
μ	Process mean
σ^2	Process variance
$\bar{x}_i$	Average of i^{th} subgroup
$\bar{\bar{x}}$	Average of the subgroup averages
$\sigma_{\bar{x}}$	Population standard deviation for the subgroup averages
$\bar{R}$	Average of the ranges
R_i	Individual range value for the sample
A_2	Approximation factor used to calculate control limits
m	Number of subgroups
σ_R	Population standard deviation of the subgroup ranges
D_4	Approximation factor used to calculate range chart
D_3	Approximation factor used to calculate range chart
d_2	Approximation factor for calculating within subgroup
T	Tolerance

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF RESEARCH

Statistical Process Control (SPC) procedures can help you monitor process behavior. The most successful SPC tool is the control chart. SPC originally developed by Walter Shewhart in the early 1920s. Statistical Process Control quality control refers to using statistical techniques for measuring and improving the quality of processes and includes SPC in addition to other techniques, such as sampling plans, experimental design, variation reduction, process capability analysis, and process improvement plans [1].

The SPC consists of selecting quality characteristics in the process, collecting data from the process output and calculating process capability indices. The C_p should be at least 1.33 in order for the process to be considered capable. C_{pk} indicates whether it is capable and how well-centered the process is. If the process is not capable, the improvement steps or make an enhancement to the process must be taken by the company. SPC is used to monitor the consistency of processes used to manufacture a product as designed. It aims to get and keep processes under control. SPC can ensure that the product is being manufactured as designed and intended [1].

SPC can be applied whenever work is being done. Initially, it was applied to just production processes, but is has evolved to the point where it is applied to any work situation where data can be gathered. As companies work toward quality goal, SPC is used in more diverse situations. SPC involves the use of statistical signals to identify the source of variation,to improve performance and to miantain control of processes at higher quality levels. The statistical concepts that are applied in SPC are very basic and can be learned by everyone in company [2].

In this case study, Chaudry Textiles (Malaysia) Sdn Bhd had been chosen as a small and medium industry to collaborate in this research which is situated in Pengkalan Chepa, Kelantan. Chaudry Textiles (Malaysia) is actually a manufacturer

and marketer of cotton fabric production. The company had produced many products such as cotton, polycotton, polyrayon, polyester staple fibre mixed, unbleached 100% cotton plain weave, unbleached poly cotton plain and unbleached twill polyester.

1.2 PROBLEM STATEMENT

The printing process has been selected. There are four steps that involved in the printing process. First step the fabric or cotton is taken up by machine and then the fabric goes through the dryer and curing oven. After that the fabric is ready to be printed. Lastly the printed fabric is displayed to the operator and ready to be delivered to the next process. The printing process has been selected because this is critical process, means there are problems occurred when fabric being printed. In this case, the main problem is the printing machine.

SPC tools will be used in this study to solve the problems in printing process. This project is to study the implementation of SPC in Small and Medium Enterprise (SME) industry. SPC will increase the product quality and hence reduce the total work need to be done. In this project, SPC tools which is Average and Range ($\bar{x}$ and R) chart will be needed and will be used to solving this study. Process Capability also will be needed in this study.

1.3 OBJECTIVE

The objective of this study are:

i. To implement the SPC technique in the printing process.

ii. To analyze the observed data of printed fabric.

iii. To propose some improvement recommendation from the study of SPC.

1.4 PROJECT SCOPES

This project focuses on SPC and Process Capability Analysis that had been applied in small and medium industry in the organization which includes:

1. Select Critical Parameters – Time taken, color contrast and printing speed.
2. Data Collection – Data of printed fabric.
3. Study on Process Capability.
4. Data Evaluation – Using MINITAB and manual calculation.

Manufacturer : Chaudry Textiles (Malaysia) Sdn Bhd.
Boundaries : SPC includes those tools used during production to eliminate unexpected causes of variation.
Population : The study subject is production in Printing process.
Time period : One month data, taken from the production in printing process.

1.5 THESIS DISPOSITION

In Chapter 1, it elaborates about the introduction to this study briefly. In this chapter contain the problem statement, the objectives of study, scopes of study, and the initial explaination to the problem to study; printing process.

All of information that related to the title will be conducted in Chapter 2. Literature review will explain deeply through the definitions, example or previous research that had been done. The information can get through the internet, books, and journal.

Chapter 3 is the methodology. It is discuss about the methodology of my project. Starating with literature review, literature review contains of explanation on

definition of SPC. Follow by product selection, determination of quality characteristic, determination of inspection sampling size, control charts, and process capability. Finally is conclusions.

In Chapter 4, all of results and discussions are described. The result will be interpreted by calculation and several formulas are given, and using MINITAB software to analyze the data and then do a comparison with the manual calculations. Then, the result will be analyzed and write the discussion to discuss the result

The last chapter for this research is Chapter 5. This chapter consists of conclusion and future works in connection with this research. Other than that, several recommendations are list in order as the guide to overcome these problems.

CHAPTER 2

LITERATURE REVIEW

2.1 RELATED ARTICLES

Based on four summarized articles in table 2.1, the article with title process capability indices overview and extension is related in this case study. The objective of the article is to analyze the process capability indices that are C_p and C_{pk}. The method that used in this article is capability analysis, operating characteristic function, statistical process control, process performance, specification limits, and target value. From the result of the distributions of capability indices, the product improvement can be continuously monitored. In this article, statistical process control (SPC) and control chart is used to monitor the products quality. For the conclusion, capability indices help to prevent conformance products to be produced which do not meet the specification requirements and help continuously monitor product improvement.

Table 2.1: Summarized of the articles

Article/Author	Year of published	Description of the article

Article- Assessing the process capability index for non-normal processes [9]. **Author-** **S.E.Ahmed**	2004	**Objective-** To propose shrinkage estimation strategies for estimating the population capability indexes. **Method-** Capability index, Non-normal populations, Restricted parameter spaces, Stein-type estimation, Asymptotic risk analysis **Result-** If the scale distance between the actual value of the true parameter and the guessed value is large, the behavior of the both shrinkage estimators is the same, which supports the validity of our asymptotic theory as well. **Conclusion-** Stein- type shrinkage estimator (SE) and positive-part shrinkage estimator (PSE) are the best method and should be used as a tool for developing the positive part shrinkage estimator.
Article- C_{pk} index estimation using fuzzy numbers [13]. **Author-** **Hong Tau Lee**	**2001**	**Objective-** To propose a method to calculate the C_{pk} index when precise quality cannot be identified and must referred to the decision-makers subjective evaluation of the quality of product. **Method-** Fuzzy theory is applied to construct the PCI. Fuzzy set theory, as developed by Zadeh and the concept and arrangement of fuzzy numbers presented by Dubois and Prade are applied to improve the presentation of the fuzzily defined system. **Result-** Although, the calculation is a little tedious,

		however, with a formula it can be easily calculated by a computer. The larger value of $U_{T(G)}$ indicates that the mean of quality measurement of the sample is closer to the target of specification and the quality of the sample is more coincident and stable. **Conclusion**- The exposition approach proposed in this journal is generic enough to be applicable to the fuzzy number with other types of membership functions.
Article- Process capability indices overview and extensions [10]. Author- **Zachary G.Stoumbos**	**2001**	**Objective**- To analyze the process capability indices. **Method**- Capability analysis, Operating characteristic function, Statistical process control, Process performance, Specification limits,Target value. **Result**- Products improvement can be continuously monitored in the distributions of capability indices. **Conclusion**- Capability indices help to prevent conformance products to be produce.

Article- Process capability indices and product reliability [12]. **Author- Bharatwaj Ramakrishnan, Peter Sandborn and Michael Pecht**	2001	**Objective-** To discuss the relationships between process capability indices and product reliability. **Method-** Process capability indices C_p and $C_{pk.}$ **Result-** C_p does not take the process mean into account and does not reflect the non-conformance rejects, or reliability. **Conclusion-** There are many product characteristics, which contribute to product quality or reliability. By obtaining a higher C_{pk} for that process can improve the quality and reliability.

2.2 IMPLEMENTING STATISTICAL PROCESS CONTROL (SPC)

In most situations, a Statistical Quality Control (SQC) analysis would be done first by identifying the quality of the characteristics are critical quality control (CTQ) and determining how those characteristics can be controlled. Data that observed must be gathered and analyze, this is SPC were begin. SPC bring a lot of benefits to the manufacturing process, the tools of SPC helped guide the decision-making process [3]. From here, a SPC tools can be placed on the process to help determine where the true source of the problem is located. The tools of SPC has helped whether the special-cause is present implying that action needs to be taken either eliminate that cause. SPC helps define the capability of the stable process to judge whether the process run at acceptable level if no special-cause variation is found. There are steps in briefing of existing SPC in manufacturing process [2]:

1. The first step in SPC is diagramming and analyzing the process to decide where control chart can be applied.

2. Decrease the variability in the target process.
3. The next step involving statistically testing the gauge using capability study. This must be done before measurement is taken for control charting. The variations that show up the control charts must be reflect the process variation that need to be reduced.
4. Make a sampling plan. Determine the size of sample and when the sample is to be taken.
5. Find the out-of-control situation that caused by common-cause and special-cause, evaluates what happened at that specific tome to cause it, and the work to prevent the cause. This procedure continues until the control chart indicates that there are no more special-cause variation problems. Then, the process running as well as it possibly can without process modifications and it is did to be in statistical control.
6. The sixth step is to put the operator in-charged. This step occurred at the same time with step 5 because the operator should be doing the control charting and attaining statistical control with the help of process team.
7. At this step, determine how capable the process is according to product specifications and customer expectations.
8. Then improve the process. Most of the process problems are handle at this stage. Processes changes can be analyzed by apply it to control chart either singly or in variable studies for signs of process improvement. To search improvement, designed experiments can be use. When improvements are found, management must follow and see the suitable changes are incorporated in the process without blacklisting.
9. The ninth step calls for a switch to pre-control, a monitoring technique that compares a measurement with target and warming measurements, when the process is in control and capable.
10. Quality improvement is continuous process. There are two things should be done at this step; first, continue to look for ways in term to improve the process and second, return to step 1 if there are critical measurement.

Historically, many companies did not begin using SPC until they were forced. Either they could the competitive position diminishing or they were obliged to meet

customer's requirement that contracts would not be awarded until their workforce was trained in SPC. Workers must understand the important of SPC for their own good to prevent losses becoming routine. The management also must have good interpretation on SPC where when workers suggestion is made based on SPC analysis.

2.3 THE BASIC TOOLS FOR SPC

There are seven tools of SPC, there are [7]:

i. Flow Chart
ii. Pareto Chart
iii. Check Sheet
iv. Cause-and-effect diagram
v. Histogram
vi. Control chart, and
vii. Scatter plot

For the purpose of this study, Control Chart is chosen to be implemented as a SPC tool. Control chart is broken-line graph illustrates how a process or a point in process behaves over time. Samples are periodically taken, checked or measured and the results plotted in the chart. This chart can show how the specific measurement changes, how the variation in measurement changes or how the proportion of defective pieces changes over time. Control chart are used to find sources of special cause variation, to measure the problem of causes and to maintain control the process that is operating effectively [4].

2.4 SPC TECHNIQUES

Techniques in SPC include use of [7]:

i. Process control chart to achieve and maintain statistical control in the process.