SIX SIGMA FOR SCRAP COST REDUCTION IN REMANUFACTURING INDUSTRY

MISSJULIANA BINTI MAT KIAH

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Specially dedicated to:

My beloved husband and son,

Mohd Zulkarnain bin Ab. Razak and Aiman Danish bin Mohd Zulkarnain

for their love and support

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ABSTRACT

This project entails the adoption of Six Sigma Methodology in remanufacturing industry. The improvement project is carried out at a service and repair company for electronic product. Six Sigma is a set of quality management tools and strategies, including statistical methods used for process improvement by identifying and eliminating the causes of defects and reducing variability occurs in manufacturing and other businesses process. The Six Sigma DMAIC methodology consists of five phases which are Define (D), Measure (M), Analyse (A), Improve (I), and Control (C) respectively. This case study focuses on implementing Six Sigma methodologies into the motherboard repair process in to identify and minimize the variation exists in the process and subsequently reducing the associated scrap cost. As known, the original assembly process of motherboard is comparatively straightforward. However, the repair process of malfunction motherboard which requires troubleshooting of problem and replacement of electronic devices can be much more complicated and often end-up scrapping the whole set of motherboard itself. Realizing this great challenge, the DMAIC tools are mounted in this study to solve the underlying problem stated. The objective of the project is to reduce the overall scrap rate and to increase the sigma level of the motherboard repair process. The existing scrap rate is 45.89% and process sigma level is 1.84σ. It is proven that the method and tools chosen have successfully reduced the scrap rate to 18.60% and increased the process sigma level to 2.46σ in three months period after the improvement took place. This result indicates that Six Sigma methodology is also applicable in remanufacturing industry as good as in forward manufacturing industry.

ABSTRAK

Projek ini melibatkan penggunaan Metodologi *Six Sigma* dalam industri pembuatan semula. Projek perbaikan ini dijalankan di sebuah syarikat servis dan membaiki produk elektronik. *Six Sigma* adalah satu set alat pengurusan kualiti dan strategi, termasuk kaedah statistik yang digunakan untuk perbaikan proses dengan mengenal pasti dan menghapuskan punca-punca kecacatan dan mengurangkan kebolehubahan yang berlaku dalam industri pembuatan dan juga dalam sektor perniagaan yang lain. Metodologi *Six Sigma DMAIC* terdiri daripada lima fasa utama iaitu *Define (D), Measure (M), Analyse (A), Improve (I),* dan *Control (C).* Kajian kes ini memberi tumpuan kepada perlaksanaan metodologi *Six Sigma* dalam proses pembaikan *motherboard* untuk mengenal pasti dan mengurangkan variasi yang wujud dalam proses dan seterusnya mengurangkan kos sekerap. Seperti yang diketahui, proses pemasangan *motherboard* pada asasnya tidaklah begitu rumit. Walau bagaimanapun, proses pembaikan *motherboard* rosak yang memerlukan pengenalpastian jenis kerosakan dan penggantian alat-alat elektronik boleh menjadi lebih rumit dan sering berakhir dengan pelupusan keseluruhan *motherboard* itu sendiri. Menyedari cabaran yang besar ini, metodologi DMAIC telah digunakan dalam kajian ini untuk menyelesaikan masalah yang dinyatakan. Objektif projek ini adalah untuk mengurangkan kadar sekerap secara keseluruhan dan meningkatkan tahap sigma proses pembaikan motherboard. Kadar sekerap yang sedia ada ialah 45.89% dan tahap sigma proses adalah 1.84σ. Terbukti bahawa kaedah dan metodologi yang dipilih telah berjaya mengurangkan kadar sekerap kepada 18.60% dan meningkatkan tahap sigma proses kepada 2.46σ dalam tempoh tiga bulan selepas aktiviti perbaikan berlaku. Keputusan ini menunjukkan bahawa metodologi *Six Sigma* juga boleh diaplikasikan dalam industri pembuatan semula sebagaimana aplikasinya yang meluas dalam industri pembuatan biasa.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter explains on the introduction of developing Six Sigma (6σ) to reduce the scrap cost in motherboard repair process in remanufacturing industry. In general, all companies concern about the process performance for example quality, efficiency, productivity, and capability to meet customer's requirement. This chapter provides an introduction, problem statement, objectives, scope, flow of the report, and also conclusion for this chapter.

One of the most innovative developments that emerged out of the total quality movement is the Six Sigma concept introduced by Motorola in the mid-1980s. Six Sigma consists of five phases to complete the methodology and this study conducts all the phases for improvement based on quality aspect and yield performance. The purpose of Six Sigma is to improve the performance of processes to the point where the defect rate is 3.4 per million or less.

So, this project focuses on reducing the scrap cost in motherboard repair process through the adoption of Six Sigma methodology in remanufacturing industry. Next, the definition of terms used, background of case study, problem statement, objectives and scope are defined.

1.2 Definition of Terms Used

To further understand this topic, each terms used in this project title is briefly explained as below;

i) **Six Sigma –** A set of strategies, techniques, and tools used for process improvement. It was developed by Motorola in 1981, and became famous when Jack Welch; the chairman and CEO of General Electric between 1981 and 2001 made it central to his successful business strategy at General Electric in 1995. Today, it is adopted in many industrial sectors with phenomenal outcomes as a result of its adoption.

ii) **Sigma** – The Greek letter used to describe the standard deviation of a data distribution. The standard deviation is defined as a measure of the amount of variation or dispersion from the average of the observations of a data distribution.

iii) **DMAIC** – The strategic approach for reducing variation and achieving improvement used in Six Sigma. DMAIC is an acronym for Define, Measure, Analyse, Improve, and Control phases of Six Sigma methodology.

iv) **Critical to Quality (CTQ)** – The characteristic of a process or product that has a direct impact on the customers' perception towards quality.

v) **Defect** – Failure to meet a customer-defined requirement. Defining what constitutes a defect for a particular process or product is the first step in quantifying the number of defects, leading to calculation of a sigma level, which is the number of defects out of one million opportunities.

vi) **Defects per million opportunities (DPMO)** – The number of defects out of one million opportunities for defects.

vii) **Scrap costs** – A manufacturing reality impacting organizations across all industries and product lines. Scrap cost are caused by many things. It may be generated, regardless how severe it is when the wrong parts are ordered, when engineering changes are not effectively communicated, when designs are not properly executed on the manufacturing line, or when the process is out of control. No matter why scrap occurs, its impact on an organization is always the same, where it wasted time and money.

viii) **Motherboard** – A printed circuit board containing the principal components of a computer or other devices, with connectors for other circuit boards to be slotted into. Sometimes, it is alternatively known as the main board, logic board, or system board.

ix) **Remanufacturing –** The series of business activities required to retrieve a used product from a customer, either to dispose or repair and reuse it.

1.3 Background of Research

In today's highly competitive electronics industry, a company must be able to adapt to its customers' ever changing needs and improve the quality of its products and services in order to survive (Abdollah, 2011). As customer demands higher quality, more reliable process at higher yield and quality levels becomes much more critical.

Besides that, day by day competitiveness is growing and in consequence, organizations are increasingly becoming 'process-centred' and process improvement efforts are crucial to increase efficiency, standardize practices, and reduce variance. Every business is required to optimize its processes in order to increase the efficiency and productivity of operations to maximize the profit.

In order to make process optimization a reality, Six Sigma (6σ) philosophy is developed into the process to achieve 3.4 defects per million opportunities (DPMO). Six Sigma's framework known as DMAIC (define-measure-analyse-improve-control) is employed to assist in improving the process yield and thus reduce the scrap rate associated to it.

Montgomery in his seventh edition Statistical Quality Control: A Modern Introduction has listed the following tools used in DMAIC approach;

- Project charter – Define phase
- Process maps & flow charts – Define & measure phases
- Cause-and-effect analysis – Measure phase

- Process capability analysis – Measure phase
- Hypothesis tests, confidence intervals – Analyse phase
- Regression analysis, other multivariate methods – Analyse phase
- Gauge R&R – Measure phase
- Failure mode & effects analysis – Analyse phase
- Designed experiments – Analyse & improve phases
- SPC and process control plans – Measure, analyse & control phases

This case study is conducted at a service and repair company for electronic product located at Senai Industrial Park III, Johor, Malaysia. The company's nature of business is sub-contracting the repairing and testing of in-warranty (IW) and out-of-warranty (OW) electronic products from many well-known giant original equipment manufacturer (EOM) companies like Western Digital (WD), Hewlett-Packard (HP), Sony and many more. The company is specialized in troubleshooting and repairing of many types of electronic products like hard disc drive (HDD), LCD panel, motherboard, server and etc.

Previously, this company was operated in Chai Chee, Singapore since 1989 until the top management had decided to close the plant and transfer it to Malaysia. It was transferred to Senai Industrial Park III in June 2011. Initially, the processes, equipment, tooling, testers, and materials were successfully transferred to the new plant in Malaysia, except the specialists which many of the employees have decided to take retrenchment package and leave the company.

1.4 Problem Statement

It is known that troubleshooting of electronic products especially the motherboard that is mounted with hundreds of small but complicated components on it requires high-skilled technical personnel to identify one or more problematic components that has led to malfunction of the product. Once the troubleshooting team able to identify the problem, repair team consisting of high-skilled repair technicians needs to do the repairing jobs like component change, component re-soldering, BIOS upgrade, open trace closure and etc.

During the motherboard rework process, QA inspection has found numbers of un-repairable defects on the PCBA area such as lifted pad which is the first top defect, board delaminating, burnt board, warped, and so on due to many weaknesses occurred in the process. These un-repairable defects have caused the PCBA to be scrapped.

In average, 45.89% of the received motherboards for repair are scrapped due to un-repairable defects encountered during the repair process. The high scrap rate in the motherboard repair process has caused the company to loss its profits approximately up to USD32, 400.00 per month. Besides that, it also creates much intangible loss to the company where customer trust to the company's capability is put in doubt and company image is greatly tarnished.

Therefore, in order to overcome the challenge, the management decides to adopt and apply the Six Sigma methodology in the motherboard repair process with an objective to reduce the high scrap cost associated with high defect percentage

occurred in the repair process. By reducing the scrap rate of motherboard repair process, the organization expects to gain back customer trust on their capability in repairing and servicing customer products. This is to ensure continuous business and profit coming into the company.

The management has a great confidence that the stated problem can be solved by employing the Six Sigma methodology in the process by reviewing the overall repair process, assessing the possible actions to take, implanting the appropriate actions and monitor the process after improvement took place through its DMAIC (Define-Measure-Analyse-Improve-Control) approach. Six Sigma methodology is a helpful approach that can be used to solve the existing problem regarding the quality. Starting from the Define phase until the final Control phase, the entire problem can be virtualized especially the root causes, wastes, and potential failures.

However, even though Six Sigma is proven to be a useful tool to solve any quality issues in many forward manufacturing companies, but so far hardly any research ever done to prove that it also works well in remanufacturing industry.

1.5 Research Objectives

The core objective of this research is to reduce the overall scrap rate for motherboard repair process and to increase the current process sigma level through the deployment of Six Sigma methodology in remanufacturing industry.

In order to achieve the main objective, three specific objectives of this case study are set as below;

- To analyse the current-state of motherboard repair process performance
- To establish the significant causes of highest defects in motherboard repair process, and
- To solve the significant causes of highest defects in motherboard repair process.

1.6 Scope of Research

The focus of the research is to improve the quality and reduce the defect in order to bring down the overall scrap rate and increase the sigma level of motherboard repair process. Since there are too many aspects that need to be improved, this case study is precisely focus on;

i. Ball Grid Array (BGA) component rework process only.
ii. The research is focused on reducing the lifted pad issue which give the highest number of defect.
iii. Minitab software as a tool employed to do the data analysis for the entire improvement project.
iv. DMAIC approach as a methodology to improve the repair process within the research period of 8 months.
v. Data to trace the main defect are limited to three months data only and data collected for after improvement of repair process are also limited to three months data only.

1.7 Significance of Findings

The purpose of this study is to reduce the number of scrapped motherboard so that the scrap cost can be reduced and give a great contribution for cost saving. Financial controls play important role in business management. This is because, as competition between competitors becomes tighten time to time, cost has become a major concern by the management to review. Analysis of current process and tracing the potential failures exist in the process can lead to solving the problem from its root.

The result of this project is very important as a proof that Six Sigma is not only applicable to forward manufacturing, but also to other business segments like remanufacturing industry as long as we are dealing with processes and its efficiency and productivity.

1.8 Organization of Thesis

This thesis is classified into five chapters which are introduction, literature review, methodology, results and discussion, and conclusion and future recommendation.

Chapter 1: Introduction

Chapter 1 is an introduction to the research which explains the background of case study, problem statement, research objectives, scope of the case study, significance of findings, organization of thesis, and conclusion. Furthermore, problem statement also explicates the high scrap issue facing by the company before Six Sigma is developed into the repair process.

Chapter 2: Literature Review

The literature review of the research is discussed in the second chapter. It contains several related issues found in the journals, books, internet, and also actual situation in the repair process at the company. Definitions, principles, and approaches are used in conducting the research. Broad areas are discussed beginning from the meaning of quality, Total Quality Management (TQM), Six Sigma understanding, and DMAIC (Define-Measure-Analyse-Improve-Control) approach that is used to improve the overall quality of motherboard repair process.

Besides that, Design of Experiment (DOE), Gauge Repeatability and Reproducibility (GR&R), and Statistical Process Control (SPC) are covered in this chapter as they are very useful for data analysis and are widely used to help in making the right decision for process improvement. The purpose of review is to study on how those tools are used in other areas and businesses and what results it gives. Besides that, this chapter also briefly discusses about the implementation of Six Sigma in various industries.

Chapter 3: Methodology

The methodology of the research is discussed in the third chapter. Concept and problem solving tools used during the research process are described in this chapter. Case study, data collection method, conceptual framework, process flow, charts, and diagrams are used to explain the problem for better understanding of issue.

Chapter 4: Data Analysis and Problem Identification

Chapter 4 describes the data collection, analysis of data, and problem identification. This chapter discusses in details about one out of four implementation stages in DMAIC approach which is identification stage consisting of three DMAIC phases which are define, measure, and analyse phase that are used to improve the quality of the reworked motherboard.

Chapter 5: Improvement and Countermeasure Improvement

This chapter continues the next three stages of Six Sigma DMAIC approach which are categorization, optimization, and standardization stage. Categorization stage consists of analyse phase, optimization consists of improve phase, and standardization stage consists of control phase and horizontal implementation or *'yoko-tenkai'* of action to other areas. This chapter discusses about the proposed solution and recommendation of improvement. Furthermore, the results of the experiment are evaluated and analysed using related Six Sigma tools.

Chapter 6: Conclusion and Future Recommendation

This is the last chapter that concludes and summarizes the whole research on the benefits and advantages grabbed as the result for implementing Six Sigma including reduction of scrap cost, increasing of rework process yield, and also on the future plan for research. The organization of thesis is summarized in Figure 1.1.

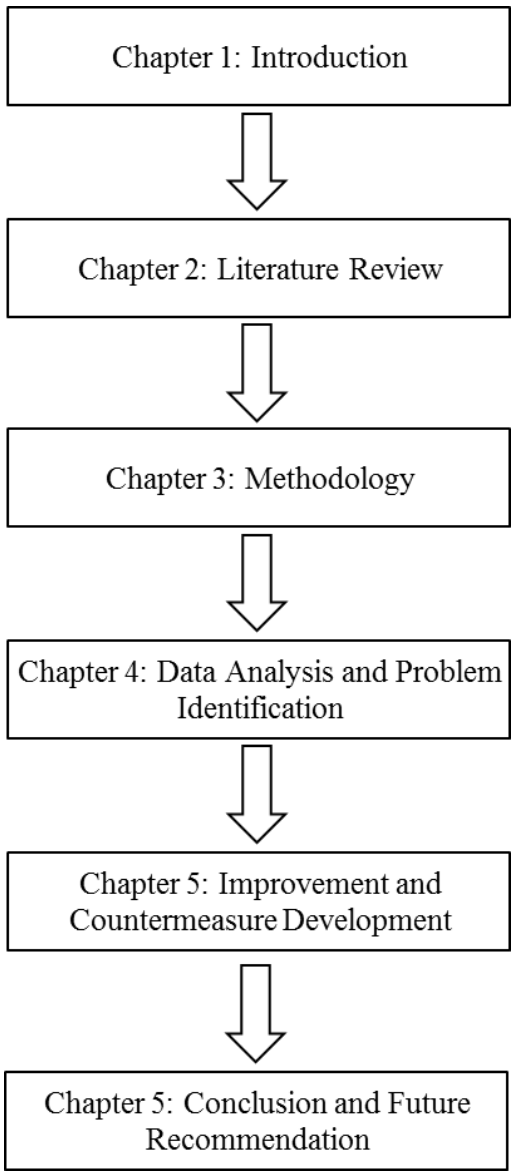

Figure 1.1: Organization of thesis

1.9 Conclusion

This chapter explains a general introduction about the entire research. It begins with the introduction of the project, then followed by the background of research, problem statement, research objectives, scope of research, significance of findings, organization of thesis, and ended with the conclusion. This chapter also presents the importance of quality not only in manufacturing industry, but also in remanufacturing sector and other types of business. However, executing continuous quality improvement only is not enough to compete in this highly competitive world. Therefore, culture change is needed in the organization to build the quality along the whole process in order to succeed in this challenging market. Six Sigma methodology is the quality improvement tool consists the both elements as mentioned above and is applied during this project. The next chapter focuses on literature review related to the case study.

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