REDUCTION OF BALLOON DEFECTS IN STRIPPING PROCESS USING DMAIC APPROACH: A CASE STUDY

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Manufacturing Management) (Hons.)

by

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Sesi Pengajian: **2016/2017 Semester 2**

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for the degree of Bachelor of Manufacturing Engineering (Manufacturing Management) (Hons). The member of the supervisory committee is as follow:

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(PM. IR. DR. PUVANASVARAN A/L A. PERUMAL)

ABSTRAK

"Six Sigma" adalah satu kaedah penambahbaikan kualiti yang berstruktur dan sistematik yang membolehkan kita untuk menyelesaikan masalah dan menjalankan analisis statistik mengenai masalah itu. Idea utama projek ini adalah untuk melaksanakan metodologi "Six Sigma" dalam proses pelucutan untuk menyelesaikan isu-isu kualiti dalam kajian proses kes pelucutan sebuah syarikat pembuatan belon. Syarikat itu telah menghadapi masalah ketidaksempurnaan produk serius sejak ia ditubuhkan. Terdapat banyak sebab mengapa isu ini masih berlaku. Pertama, syarikat itu tidak mempunyai kaedah yang betul untuk menangani ketidaksempurnaan tersebut. Kemudian, jurutera tidak menyedari bagaimana kesan buruk yang dibawa oleh ketidaksempurnaan kepada syarikat. Seterusnya, pengendali di proses pelucutan tidak mampu menangani ketidaksempurnaan tersebut. Selain itu, syarikat itu juga tidak mempunyai data untuk mengkaji ketidaksempurnaan itu. Ketidaksempurnaan utama dalam proses pelucutan adalah *Inverted Neck*. Oleh itu, dengan mengikuti metodologi "DMAIC", punca ketidaksempurnaan itu telah dikenal pasti dan penyelesaian untuk mengurangkan ketidaksempurnaan itu telah disediakan. Pelbagai alat statistik telah digunakan seperti *Analysis of Variance* (ANOVA), *Design of Experiment* (DOE), *Control chart* dan *Cause-and Effect Diagram*. Penggunaan ANOVA dan DOE telah menetapkan parameter penting dalam proses yang menyumbang kepada ketidaksempurnaan dan juga nilai-nilai optimum yang diperlukan untuk mengurangkan ketidaksempurnaan. Hasilnya, ketidaksempurnaan utama *Inverted Neck* itu adalah 9.37% pada mulanya telah dikurangkan kepada 3.57% selepas melaksanakan "Six Sigma" DMAIC. Anggaran RM21060 boleh dijimatkan setiap tahun selepas penambahbaikan. Objektif projek ini telah dicapai. Untuk pengoptimuman lanjut, syarikat itu perlu mengkaji semua parameter seperti suhu dan susu getah kompaun. Pengendalian latihan ketidaksempurnaan perlu diberikan untuk meningkatkan keberkesanan projek Six Sigma manakala DOE perlu terus digunakan untuk mencari penyelesaian terbaik.

ABSTRACT

Six Sigma is a well-structured and systematic quality improvement methodology that allowed us to break down the problem and carry out statistical analysis on that problem. The main idea of this project is to implement Six Sigma methodology in the stripping process to solve the quality issues in the stripping process of a case study balloon manufacturing company. The company has been facing a serious product defects problem since it was established. There are many reasons why this issue is still happening. Firstly, the company did not have a proper methodology to deal with defects. Then, the engineer did not realise the how severe is the impact brought by the defects to the company. Next, the operators at stripping process were not capable of dealing with the defects. Besides that, the company also did not have any data to study the defect. The major defect in stripping process was Inverted Neck. Hence, by following the DMAIC methodology, the root cause of the defect was identified and solution to reduce the defect was provided. Various statistical tools were used such as Analysis of Variance (ANOVA), Design of Experiment (DOE), control chart and Cause-and-Effect Diagram. Use of ANOVA and DOE has determined the significant parameter in stripping process that contributed to the defect as well as their optimum values needed to minimize the defect. As a result, the main defect Inverted Neck that was 9.37% at first has been reduced to 3.57% after implementing Six Sigma DMAIC. An estimation of RM21060 can be saved annually after the improvement. The objectives of this project have been achieved. For further optimization, the company should study all the parameters such as temperature and latex compound. Defect handling training should be given to improve the efficiency of Six Sigma project while DOE must continue to be used in order to find the best solution.

DEDICATION

This project is dedicated to my beloved parents,
who educated me, giving me mental and financial support,
that enabled me to complete this report successfully.
Thank You So Much.

ACKNOWLEDGEMENT

First of all, I would like to thank you my respected supervisor, PM Ir Dr. Puvanasvaran for all his great supervision, guidance, advice and constant encouragement throughout the project. This enabled me to complete the project successfully within the timeframe.

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LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	-	Analysis of Variance
CTQ	-	Critical to Quality
C&E	-	Cause and Effect
DMAIC	-	Define, Measure, Analyze, Improve, Control
DOE	-	Design of Experiment
FMEA	-	Failure Mode and Effect Analysis
FYP	-	Final Year Project
PDCA	-	Plan, Do, Check, Act
PPM	-	Parts per Million
SIPOC	-	Suppliers, Input, Process, Output, Customers
SOP	-	Standard Operating Procedure
SPC	-	Statistical Process Control
VOC	-	Voice of Customer
VSM	-	Value Stream Mapping
4Q	-	4 Quadrants
4W1H	-	What, Who, When, Where, How
8D	-	8 Disciplines
σ	-	Sigma

CHAPTER 1
INTRODUCTION

This report is about a project on improving quality in manufacturing industry. This chapter explained about the background of the project, problem statement, objectives, scope of the study and project significance.

1.1 Project Background

The term Lean Six Sigma is derived from the word ‘lean’ and ‘six sigma’. In simply, lean means creating more value for the customers with fewer resources whereas Six Sigma often referred as a number of 3.4 defects per million opportunities. The “sigma” in Six Sigma is a Greek symbol represented by "σ" measures this deviation. A company that starts measuring the mean number of defects in a process can then contemplate ways to reduce the number of defects and bring it as close to zero defects as possible (Romano *et al.*, 2002). Six Sigma is introduced by Engineer Bill Smith who worked in Motorola Company in 1986. Initially, Six Sigma was used to quantify the defects occurred during the manufacturing processes and then reduce the defects to a very low level. Motorola claimed to have saved several million dollars by applying this methodology.

Nowadays, business has become more and more competitive in latex industry. According to Rajan *et al.* (2006), manufacturers are facing very challenging tasks in producing high quality product with minimum cost possible to satisfy the customers. However, Ng *et al.* (2013) found that the production of these products usually comes in a lot of waste after the manufacturing process due to quality problems and indirectly will cause profit loss to the company. This is because there are too many variations in manufacturing a product. Jirasukprasert *et al.*, (2012) study points out that the reduction of common quality defects such as pin holes and stain in gloves are the most vital concern in latex gloves manufacturing industry. This is because the company waste its resources since those products are defective. At the same time, it also contributes to the customer dissatisfaction and loss of trust. As a result, this has driven the latex product industry to improve the quality of its product in order to sustain itself among the global competitive situation. In order to do so, the manufacturing company tried to adopt suitable quality improvement method which is Six Sigma methodology. Su and Chou (2008) claimed that Six Sigma is usually adopted in the manufacturing industry because it is a well-structured methodology that can help to company to overcome the problems through continuous project improvement.

Gijo *et al.* (2011) proven that the application of Six Sigma methodology had successfully decreased the defects in grinding process of an automotive company. The result of applying Six Sigma method had decreased the defects from 16.6% to 1.19%. Meanwhile, Hung and Sung (2011) also showed how a food company in Taiwan use adopted Six Sigma methodology to achieve a good quality level. The DMAIC methodology was used to reduce the defect rate of small custard buns by 70%.

The manufacturing process of latex balloon is called Latex Dipping Process. In its simplest form, latex dipping process is a process which a thin layer of latex polymer are formed by immersing a former into a latex compound, subsequently the former is then slowly withdrawn from the compound, leaving a uniform latex deposition upon the former (Blackley, 1997). Various steps are then taken to improve the quality of the product.

The importance of this study is to investigate the quality issues in Everts (M) Sdn. Bhd. then subsequently propose a possible solution to reduce or eliminate the most common defect. Everts (M) Sdn. Bhd. is established in 1924 in Germany, and in 1987 a second manufacturing plant was established in Melaka. Everts Sdn Bhd has become one of the largest balloon manufacturers in Malaysia. 99% of their product is exported to overseas. Product quality is very important to this company in order to create the best value to the customers. The largest challenge of this company is to maintain the quality while minimizing the resources at the same time. In order to achieve that, this project is focusing mainly on the Six Sigma DMAIC methodology, which is one of the most effective methodologies to identify and solve the current quality problem face by Everts Sdn Bhd.

1.2 Problem Statement

Stripping process is the last step of Latex Dipping process. It is a process where the latex balloons are removed mechanically from the former by aid of rollers and air pressure. However, many defective balloons can be found in this area, such as broken neck, burst, beading open, inverted neck and so on. The variability of parameters in that process is usually the main factor that causes the defects and usually results in a lot of waste. Some of the parameters are shown in the figure of basic setting guide of a roller below.

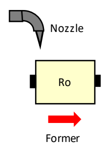
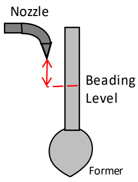
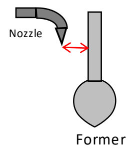
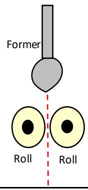
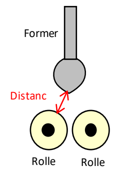
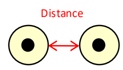
Category	A	B	C	D	E	F	G
	Nozzle Position in beginning	Distance Nozzle to Beading level	Nozzle in Running	Nozzle touching to former	Former align to center roller	Distance Former & Roller	Distance In Between Roller
Basic Setting Guide			Kindly state how many nozzle in running & closed.			See from front Side 	See from front side 
Notes	Nozzle must start at beginning	always 1cm	at least 2x nozzle run & side by side	DO NOT let nozzle touch the former	Must align at center	Always 1 ~ 2cm	Always touched - 0mm gap

Figure 1.1: Basic setting guide of roller. (Source: Everts Sdn Bhd)

However, there are few parameters that were not included in the basic setting guide which are the air pressure level from the nozzle and the speed or rollers. All the variations in these parameters has suspected to contribution of the formation of defective balloons. For example, high level of air pressure might lead to the defect burst, crack or broken neck. Big distance between rollers may cause double neck and so on.

There are more than 60 types of balloon defects can be found in Everts (M) Sdn. Bhd. Most of the common defect can be easily detected by visual checking in stripping process while some defects such as pin holes can only be detected by some tests. The Quality Control (QC) department use the method of quality tagging to list out the defects found in that particular basket of balloons during quality checking. Figure 1.2 shows the number of defect produced in production line from June 2016 to September 2016 whereas Figure 1.3 shows the Pareto chart of defects in each process.

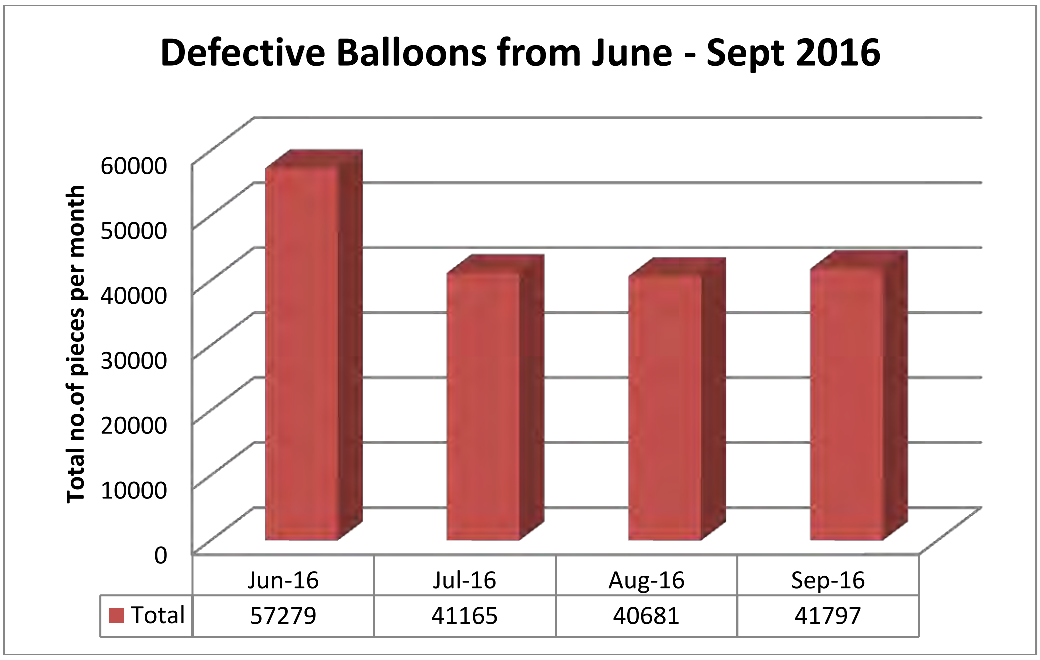


Figure 1.2: Number of pieces of defective balloons from July 2016 to September 2016

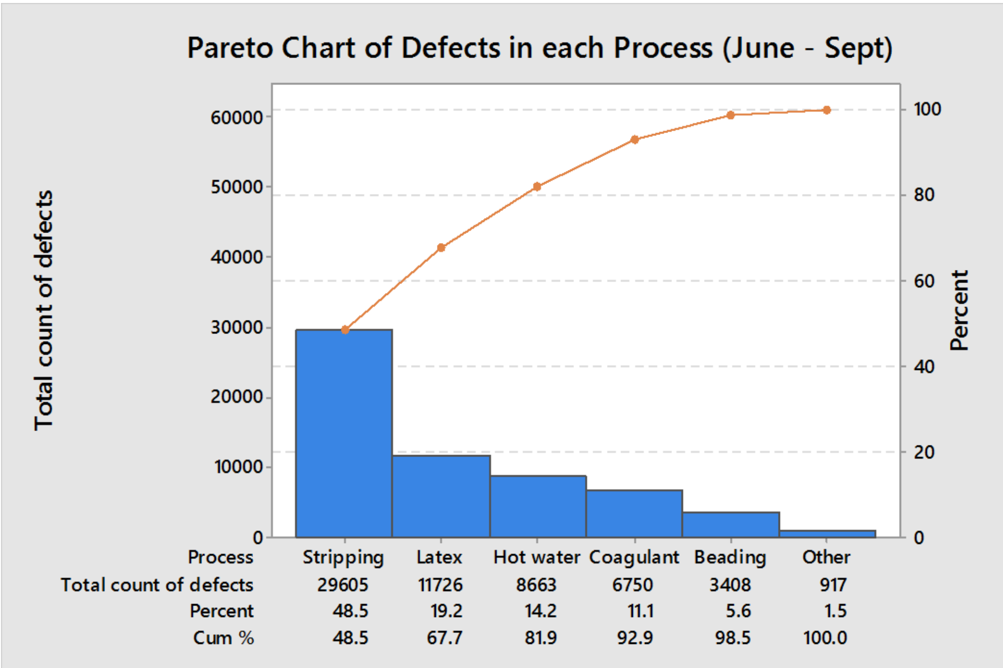


Figure 1.3: Pareto chart of defects in each process from June 2016 to September 2016

Basically, the class of defect is categorized into 3 classes in Table 1.1. The second quality balloons will be sent back to the re-screen area in production department for reworking. The workers are given 10 minutes to screen the balloons every time. However, due to the huge amount of defective balloons, the workers usually spend more than 10 minutes to pick out the scrap or reworking the balloons. The company also force to hire more workers to work at the screening area to ensure the product quality can achieve the acceptance level. More manpower in production department results in more cost and reworking time increases the production lead time and hence, brings negative impact to the productivity of the company. Meanwhile, company will waste resources to re-manufacture the product loss due to Class I defect also.

Table 1.1: Classes of Defect in Everts Sdn Bhd.

Class I – Critical Defective
• Fails to meet mandatory regulations • Affects the safety of consumer, like sharp edge/sharp point/poison/virus/bacterial source, etc or affects the overall function.
Class II - Major Defective
• Could be easily spotted by the consumer at the time of purchase. • Affecting appearance seriously. • Impairs the normal functioning of the product or is made with incorrect material of product make-up.
Class III – Minor Defective
• Affects the outer appearance of the product but is only noticeable to the consumer after a careful examination. • Is no likely to reduce materially the usability of the unit of product for its intended purpose. • Can be easily amended even by the consumer without using any special tools.

Currently, Everts does not have proper method to deal with the defects issues. They only use trial and error to fix the defect whereby this is very time consuming and can only solve the problem temporarily. Moreover, there is only one engineer in this company and the engineer is not aware of the impact of the defects caused. Other than that, the operators in production line are just normal foreign workers but not skilled workers. They are not educated or trained to deal with all these defects. Besides that, Everts does not have any data regarding of the variability of parameters in stripping process so they are not able to study this issue.

Therefore, Six Sigma methodology is selected to reduce the defects in stripping process because it is a well-structured methodology. It allows us to identify the root cause and solve the defects in five sequential steps. By implementing Six Sigma methodology in this project, we believe that the root causes of the problem can be determined and hence further action can be taken to reduce the defect in stripping process. This will results an increase in company productivity to a better level.

1.3 Objectives

The main aim of this project is to implement Six Sigma methodology in stripping process. The objectives of this project are

a) To review current quality problems in Everts company and past studies.
b) To apply DMAIC approach.
c) To propose a possible solution that addresses the most severe defect in stripping process.

1.4 Scope

This project will be conducted in Everts (M) Sdn. Bhd. This study is focusing on applying Lean Six Sigma methodology in stripping process. The theories that are not related to this methodology are not included. Other than that, there are 6 production lines in Everts. Since all the production line are doing the same process, therefore only one production line is chosen as study which is production chain 4 due to availability. The product to be chosen as sample study is balloon B70 only because these products have higher demand.

1.5 Project Significance

The result from this project has an impact on profitability of the company in terms of man-hour saving on rework and increased output. The output of this project also allows the company to understand the variation of parameter in stripping process. So, they able to identify which parameter will contribute more to the quality of balloons. Hence, the company able to train the operators that can get familiar with stripping process to ensure the good quality of balloons can be produced.

CHAPTER 2

LITERATURE REVIEW

This chapter will discuss about the past studies related to the project. The studies are review to support the statement of this project. The sources of the literature review are from many ways such as online journal, e-books, articles and books in UTeM library.

2.1 Quality Improvement Methodologies

Nowadays, many companies try to stay competitive by trying hard to improve their quality level in terms of products or services in order to satisfy the customers. In this modern age, there are many methodologies used by company for continuous improvement. Other than the famous Six Sigma methodology, there are other methodologies also widely used such as PDCA, 8D and 4Q.

2.1.1 Plan Do Check Act (PDCA)

In 1939, Walter Shewhart, the father of statistical quality control showed his Shewhart Cycle". In 1950, Deming modified the cycle and then JUSE modified the cycle again into PDCA cycle. PDCA cycle is focused more on preventing the error from repeating. PDCA also meant to improve the process or product continuously. The PDCA cycle categorized into two types of corrective action, which are temporary and permanent. According to Sokovic and Pavletic (2007), the temporary corrective action is aimed to tackle and fixing the problem to get results while the permanent corrective action is to investigate and eliminating root causes of the problem and sustains the improved process. Figure 2.1 below shows a PDCA cycle:

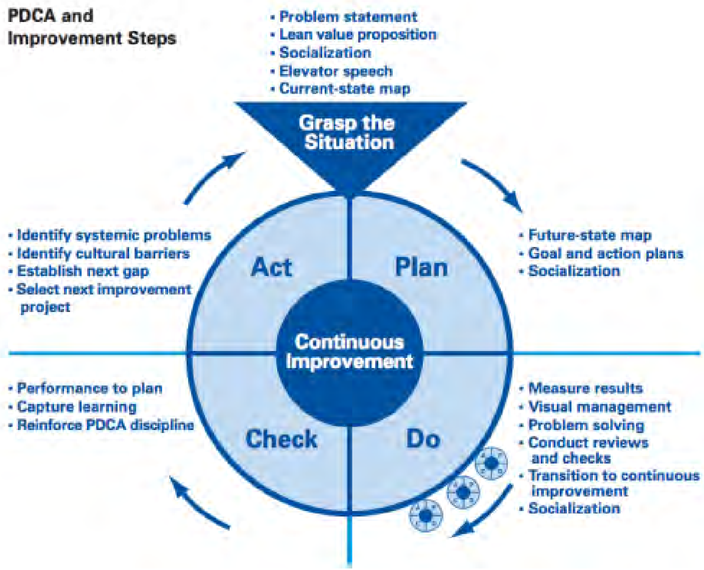


Figure 2.1: PDCA cycle (Graban, 2011)

2.1.2 8 Disciplines (8D)

The 8D process was standardized as "corrective action and disposition system for nonconforming material" during the World War 2. In middle of 1970's, this concept was adopted by the Ford Motor Company. After that, 8D has become a standard problem solving process in auto and other industries. This methodology is useful in improving product and process quality by indentifying, correcting and eliminating problems. According to Sahno and Shevtshenko (2014), the details of 8D were described as below:

- D0: Planning: The problem is planned to solve and determine the priorities.
- D1: Use a team: Form a team of professional people in product and process.
- D2: Define the problem: The problem must be specified by using the thinking of who, what, where, when, why, how and how many (5W2H).
- D3: Choose and verify interim containment plan: Define and implement containment actions to separate the problems from customers.
- D4: Identify the root cause: Determine all the potential causes that lead to the issue.
- D5: Choose Permanent Corrective Actions (PCAs): Choose the corrective action can overcome the root cause and resolve the issue.

- D6: Implement PCA: Implement the best corrective actions.
- D7: Prevent recurrence: Make sure the problems do not occur again by modifying the management and operation systems.
- D8: Congratulate team: Recognize all the efforts done by the team and thank them formally.

2.1.3 4 Quadrants (4Q)

4 quadrants, 4Q stands for: Measure, Analyse, Improve and Sustain. 4Q is a continuous improvement methodology that similar to Six Sigma DMAIC. Other than 4Q, there is a Define step which also known as pre 4Q. Table 2.1 shows the description of 4Q steps.

Table 2.1: Description of 4Q

Pre 4Q	Q1 Measure	Q2 Analyse	Q3 Improve	Q4 Sustain
• Draft the problem • Take immediate action • Identify project scope • Determine objectives • Create and enter project white sheet into SMT. • Project sponsor approval to proceed.	• Form a project team. • Construct SIPOC • Find VOC and translate to CTQ • Develop 'As-Is' process map • Develop data collection plan • Calculate baseline performance • Project sponsor approval to proceed.	• Analyse the variation and waste • Identify root causes • Construct Cause & Effect diagram • Select top 3-5 root causes and validate them • Project sponsor approval to proceed	• Brainstorm solutions • Select the best solution • Pilot test • Develop 'To-Be' process map • Implementation of solution • Project sponsor approval to proceed	• Select control techniques and standardize them • Develop control metrics • Monitor the progress • Validate the improvements • Recognize the team • Close project

2.1.4 Summary of the quality improvement methodologies

There are not many differences between the above methodologies. Each of them has they own structured and scientific steps to solve the issues. According to Sokovic and Pavletic (2007), PDCA is widely implemented in automobile industry. The most important