AN ANALYSIS ON REDUCING DEFECT RATE IN MOULDING PROCESS OF PHONE CASING

NORLIZA ZAFIRA BINTI RAZALI

PC10034

BACHELOR OF INDUSTRIAL TECHNOLOGY MANAGEMENT WITH HONORS

UNIVERSITI MALAYSIA PAHANG

AN ANALYSIS ON REDUCING DEFECT RATE IN MOULDING PROCESS OF PHONE CASING

NORLIZA ZAFIRA BINTI RAZALI

Thesis submitted in fulfillment of the requirements for the award of Degree of Industrial Technology Management with Honors

Faculty of Technology

UNIVERSITI MALAYSIA PAHANG

December 2013

APPROVAL DOCUMENT

UNIVERSITI MALAYSIA PAHANG

CENTER FOR GRADUATE STUDIES

We certify that the thesis entitled "An Analysis on Reducing Defect Rate in Moulding Process of Phone Casing" is written by Norliza Zafira Binti Razali. We have examined the final copy of this thesis and in our opinion; it is fully adequate in terms of scope and quality for the award in Degree of Industrial Technology Management with Honors. We herewith recommend that it be accepted in fulfillment of the requirements for the Degree of Industrial Technology Management with Honors.

Name of External Examiner Signature

Institution:

Name of Internal Examiner Signature

Institution:

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Industrial Technology Management in Universiti Malaysia Pahang.

Signature

Name of supervisor: Dr. Fatimah Binti Mahmud

Position: Supervisor

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. This thesis has not been accepted for any degree and is not concurrently submitted for award of degree.

Signature

Name: NORLIZA ZAFIRA BINTI RAZALI

ID Number: PC 10034

DEDICATION

This dissertation is dedicated to my parents, Razali Bin Atan and Fautiha Bt Kastamam. They give a lot of support to me while I do my research. They give an encouragement and unconditional all this time. They provided me strengths and determination to move through the final stages of this process. They are the reasons why I keep going until I done this research. Besides that, this dissertation is also dedicated to my friends and classmates. They are so kind and adorable. They often shared what they have done and never hesitated to help me in my research. They always guide me on how to do a better analysis. They are too awesome. Special appreciation to my lecturer who is understanding and always give an untiring device to me in order for me to complete my research. Thank you.

ACKNOWLEDGEMENTS

Alhamdulillah, I have done my research. First of all, I would like to express my grateful to Allah S.W.T for HIS love, help and support during my research. Thanks Allah for always being by my side. I also want to thank a lot to my supervisor, Dr Fatimah Mahmud for always giving me an untiring advice and always guide me to do better in my research. She always had been supportive and generous to me. Her helps always make my day easier in order to complete my research.

I also want to thank to all who have contributed to my graduate studies during past four years. They have been my classmates and friends. Thanks for being my map during my data collection. They are so awesome. Since we have been together for 4 years, there are too many memories we had together. Thanks for helping me to grow further and influence my research in order to finish my research and also for the idea and information give along done this project.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I cannot find any appropriate words that could properly describe my appreciation for their love, support and faith in my ability to attain my goals.

ABSTRACT

The occurrence of plastic moulding defect products is not a foreign problem. These defect problems always occur and it can affect the company's image and also involved the customer dissatisfaction. Some factors that are man, machine, mould, method and material has been identified and these factors influenced most in defect rate of the phone casing. The aim of this research is to analyze the factors that lead to the defect rate in moulding process and at the same time some improvement plan can be recommended. A quantitative data are collected through the site visit of one of the plastic company. The results of this research show that the company is facing a big problem with short mould, silver streak and moisture, black dot and contamination, and scratches. Several improvement plans were recommended to reduce these types of defect such as continually monitored using the Statistical Process Control (SPC) Tools such as Pareto diagram and Cause-and-Effect diagram.

ABSTRAK

Kejadian produk kecacatan pengacuan plastik bukan masalah asing. Masalah-masalah kecacatan ini sentiasa berlaku dan ia boleh menjejaskan imej syarikat dan juga melibatkan rasa tidak puas hati pelanggan. Beberapa faktor iaitu manusia, mesin, acuan, kaedah dan bahan telah dikenal pasti dan faktor-faktor ini sangat mempengaruhi kadar kecacatan selongsong telefon. Tujuan kajian ini adalah untuk menganalisis faktor-faktor yang membawa kepada kadar kecacatan dalam proses pembentukan dan pada masa yang sama beberapa pelan peningkatan boleh disyorkan. Data kuantitatif dikumpul melalui lawatan tapak bagi salah satu syarikat plastik. Keputusan kajian ini menunjukkan bahawa syarikat itu sedang menghadapi masalah besar dengan acuan pendek, coretan perak dan kelembapan, dot hitam dan pencemaran, dan calar. Beberapa rancangan penambahbaikan telah dicadangkan untuk mengurangkan jenis kecacatan dan terus dipantau menggunakan Alat Kawalan Proses Statistik (KPS) seperti rajah Pareto dan rajah Punca-dan-Kesan.

TABLE OF CONTENT

CHAPTER 4 DATA ANALYSIS

LIST OF TABLE

LIST OF FIGURES

LIST OF ABBREVIATION

CAD	Computer Aided Design
DOE	Design of Experiment
LCL	Lower Control Limit
QMS	Quality Management System
SPC	Statistical Process Control
TQM	Total Quality Management
UCL	Upper Control Limit

CHAPTER 1

INTRODUCTION

1.1 Introduction

Quality plays an important role in maintaining the successful product development. According to Hairulliza et al (2011) quality can be defined as accomplishing specification or customer demand or requirement, without defect. Well-developed quality system mainly focused on technical problem such as equipment reliability, inspection, detects measurement and process control will strengthen the market position of the industry. The change to a customer-driven organization has created the fundamental shift in manufacturing practices, changes that are often apparent in areas such as product design, human resources management and supplier relations.

Quality control in industries normally based on conformance. Specifically conformance to specifications. A broad work has been done in the last three decades to determine the quality problems which are general to all industries and to discover a general solution to this problem. Industrial organization practices various quality control techniques to improve the quality of the process by reducing its variability. A range of techniques are acquirable to verify product or process quality.

Continual quality improvement as an imperative for the survival of a company requires the establishment of a process measuring system. Measurement data have to be arranged, processed and analyzed using adequate methods and techniques to determine the possibilities for improving process effectiveness and efficiency.

This study illustrates the prominence of the application of Statistical Process Control (SPC) in monitoring the quality in the plastic moulding outfit. It depicts the SPC Tools such as Cause and Effect Diagram, Process Flow Diagram, Scatter Diagram, Pareto Diagram, Controls Charts and Histogram and the implementation of these tools can monitor towards product quality.

Since quality improvement is a never-ending process, the effort to diminish both the variability of a process and the production of nonconforming items should be continued. The company might need to train their employees or engineer on the usage of these tools on new technology, improving the quality of material or updating their machines. The option of the manufacturing process, training and supervision of the workforce, type of process control, test and inspection activities that are employed and the motivation of workforce to achieve quality are the influential factors encouragement towards better level of quality of conformance.

1.2 Problem Background

The invention of an injection moulding machine was introduced by John Wesley who was the injected hot celluloid into a mould and resulted in billiard balls which were used as a replacement for ivory. The ivory is based on the pressure die casting technique for metals. The injection moulding process that forms plastic material into useful parts or components commonly found in multitude of consumer goods. The material of molten plastic is injected into a mold cavity at high speed. Rapid cooling then solidifies the plastic, causing the material to hold the needed shape. (Woll, 1997)

Bharti et. al. (2010) said that injection moulding has been a challenging process for many manufacturers and researchers in order to produce products that meet the customer requirements at the lowest cost. Complexity and parameter manipulation may contribute to serious quality problem and high manufacturing costs. One of the major goals in injection moulding is the advancement of quality of moulded parts besides the decreasing of cycle time and smaller production cost. Factors that affect the quality of a moulded part can be sorted into four groups that are part design, mould design, machine performance and processing condition. Common quality problems that often happen from an injection moulding process includes voids, surface blemish, short-shot, flash, jetting, flow marks, weld lines, burns and war page (Jafri and Teng, 2000).

Wilkinson (2010) recommend that parts made from partially crystalline engineering polymers should be if possible not be completed by hot runner injection moulding if an ideal surface finish is essential. It is desirable to make use of a secondary runner, which thermally separates the nozzle from moulded part, and lowering the potential of surface defects. The cold slug coming from the injection should be seized by a unique tool opposite the sprue so that it cannot get into moulded part.

1.3 Problem Statement

Phone has become necessities to people nowadays. People often use it for communicate to each other. These telecommunication devices contribute a lot to their users as it provides a variety of application needed. A variety of colours, size, brand and technology applied in phone make the customer become a quality conscious. In order to ensure that the product is worth to have, customer will choose a product that satisfies them most.

For maintaining the customer loyalty and satisfaction, company have to maintain their quality of product too. Manufacturing of phone should aware about the product produce. In injection moulding of phone casing, several defects often occur. For example, short mould, scratches, moisture and shrinkage. These types of defect will affect most on quality of product.

As the defects will decrease the quality of product, the customer satisfaction will also decrease. This will affect most on company image and lead to loss in profit. The company should find some solution to overcome this problem. If not, the company is at risk and lost the customer loyalty. To improve the quality of product, the whole organization should work together and help each other to reduce defect rate.

According to Leachman (2011), there are many factors that may lead or contribute to the injection moulding problems which may result in defection and affect the quality. Variation is a common problem in quality control. Common causes of variation are inherent in the process and can be thought of as the natural rhythm of the process. Common causes are stated by a stable, repeat the pattern of variation. Real quality improvement requires a continual focus on reducing common cause variation.

Surface defects may be caused by many factors such as (Wilkinson, 2010) compounding, injection moulding conditions, the design of the hot runner system and mould design. While war page is greatly affected by wall thickness and mould surface temperature. These defects can be identified by using SPC tools and the solution of defect rate reduction can be identified.

SPC monitors the process to reduce but not to eliminate the need for inspection for each output. One objective of using SPC is to use a process control system that will concentrate on defect prevention rather than defect in order to have a quality guarantee on the output without having to use a 100 percent inspection.

In this study, the SPC Tools are applied and identify how these tools monitored the process and help in quality improvement. As a result, it may lead to problem solving. SPC tools can help. Thus, it can detect the variations and identify the causes. Since the problem is identified, problem solving can be done. Quality improvement requires a continual focus on reducing common cause variation, so reducing these cause is possible only after the process has been brought into control.

As the major defect is identified through Pareto diagram and causes of each defects are determine by Cause-and-Effect diagram and intensive literature, improvement plan will be recommended to the company to reduce their defect rate. Figure 1.1 shows the summary of the problem statement.

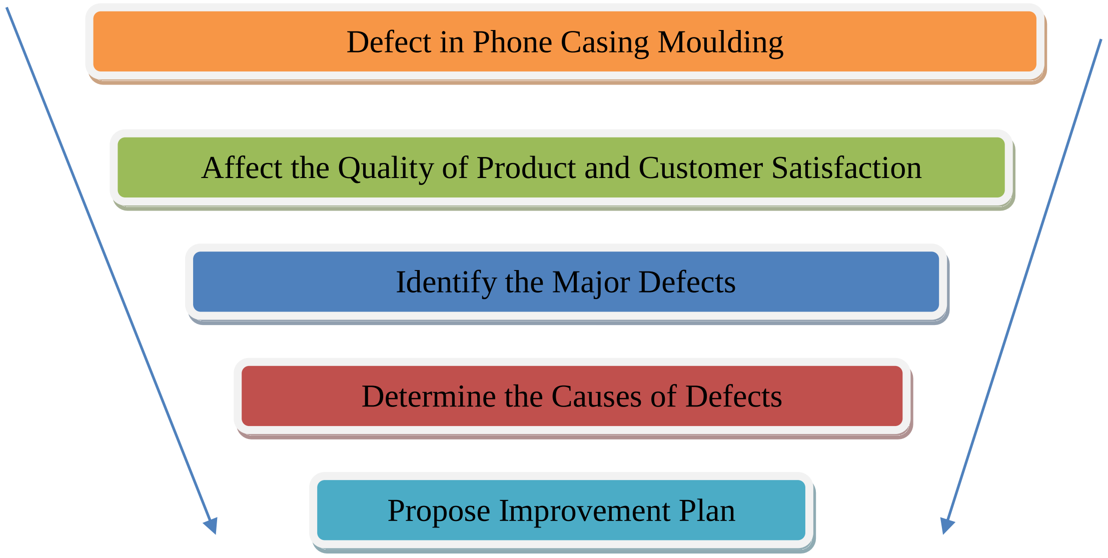

Figure 1.1: Framework of Problem Statement

1.4 Objectives of the Study

There are three specific objectives intends to be identified and pursued in this research.

1. To identify types of defect in phone casing moulding operation.
2. To investigate the causes of each types of defect.
3. To recommend the improvement plan to reduce defect rate.

1.5 Research Question

These research questions are designed to help in pursuing the objective of this research.

1. What are the types of defect in phone casing moulding operation?
2. What are the causes of each types of defect?
3. How to reduce the defect rate in moulding operation?

1.6 Scope of Study

For the purpose of data collection, this study focuses on production line which includes the machine and the operators. The study was carried out to identify the defect rate and causes that lead to the defect occurrences. This problem is done through the qualitative data collected at the company. To carry on this study, one of the plastic companies will be chosen. The data collection focus on the defects produced in the production line.

1.7 Significant of study

This study will be useful to the plastic industry. Otherwise, it also gives some benefits to the product quality and the organization. They can implement the method and identify the defects rate and increase the customer satisfaction by producing high quality of product. This study also useful and contribute to the quality improvement of the product.

This study can improve the quality of product. The application of SPC tools can help to monitor the process and can detects the defects. Once the defects are identified, the solution of the problem can be executed. Besides that, these seven tools also able to decrease the product waste.

Furthermore, this study can increase the company's profit through quality improvement adoption. Nowadays, customer very conscious about quality of product. They can determine which product has a higher and lower quality. They will loyal to the company that provide the best quality of product. For them, it does not a matter if the product is expensive but worth to be bought.

This study also will maintain the customer loyalty. When customer satisfied with the service provided or quality of product, the positive comment will attract them to stay and enjoy the benefits they gained and may attract others deal with that company.

1.8 Operational Definition

An operational definition specify the variable, term or object in terms of the particular process or set of verification tests used to determine its appearance and quantity. In this research, there are some operational definitions used.

1. Plastic Injection Moulding

Injection moulding is a technique of forming a plastic product from powdered thermoplastics by feeding the material through the machine component to a heated chamber in order to make it soft and force the material into the mould by the use of the screw. The main concept of plastic moulding is placing a polymer in a molten state into the mould cavity. So that the polymer can take the required shape with the help of varying temperature and pressures. (Peter Thyregod, 2011)

2. Product defects

Any characteristics of a product which delay its usability for which it was designed and manufactured. Some product may be defective during the production process. Some of defect products in plastic industry are, surface defects, war page, sink marks and voids.

3. Plastic industry

It manufactures polymer materials and has services in plastics. Plastic industry is an industry that produces the plastic products.

4. Production line

A set of in order operations established in a factory whereby materials are put through a refining process to produce an end-product.

5. Quality improvement

Consists of organized and nonstop actions that lead to measureable improvement in product process.

6. Statistical Process Control

A data-driven methodology for quality analysis and improvement. It contains a variety of tools such as Cause and Effect Diagram, Process Flow Diagram, Scatter Diagram, Pareto Diagram, Controls Charts and Histogram (Olugbenga O. Akinbiola, 2003).

7. Computer Aided Design (CAD)

Computer Aided Design is the utilization of the computers to interactively design products and organize an engineering documentation. (Heizer, J. and Render, B. 2011). CAD software permits designers to use three-dimensional drawings to reduce time and money by decrease the development cycles for virtually all products.

1.9 Expected Result

There are some expected result that are expected to be gain at the end of the research.

1. The defect that will affect most on the product is identified.
2. The factors that lead to the defect are determined.
3. The solution to overcome the defect problem can be identified.
4. The improvement plan will help the company to improve their product quality and production.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter describes the process of plastic moulding injection will be studied and several factors that can lead to defect product will be listed out. Various type of defect type and process control tool will be discussed too. This chapter will focus more on theory and research that have been conducted before.

The purpose of information technology and internet services in quality control is among current development in industries (Besterfield, 2004). Real time quality control would be a supportive way for companies facing issues around low of quality awareness, passive response, machine problems, unreliable incoming material quality, and tight customer schedule (Chung et al., 2007). Engineers use quality control to analyze the ultimate limits of different manufacturing processes.

The ability to meet the customer requirements is very important, not only between two separate organizations but within the same organization. For industrial and commercial organizations, which are practical only if they give satisfaction to the consumer, competitiveness in quality is not only essential to profitability but also vital to business survival (Oakland, 2003).

A process is the makeover of a set of inputs, in the figure of products, information, services or generally, results. The output of the process is that which is transferred to somewhere or to customer. Clearly, to make an output which meets the demand of the customer, it is important to define, monitor and control the input process, at every supplier customer edge there resides a makeover process and every single mission throughout an organization must be viewed as a process.

According to Bharti et.al (2011) injection moulding has been a challenging process for many manufacturers and researchers to produce products meeting requirements at the lowest cost. Determine the optimal process parameter settings critically affect productivity and quality of production in the plastic injection moulding industries.

This chapter will also discuss the tools used to analyze the data. The tools will facilitate the data analysis and help in finding the needed information in this study. It also will give the accurate data that will help the researcher to get a better result and conclusion.

2.2 PLASTIC MOULDING PROCESS

Plastic injection moulding was covered by John Wesley. He has injected hot celluloid into a mold which causes the billiard balls which were used as a substitute for ivory. The key concept of plastic moulding is inserted of a polymer in a molten state into the mold cavity. The polymer can take the required forms with the assist of varying temperature and pressure (Samson Teklehaimanot, 2011). Figure 2.1 shows the plastic injection moulding machine that used to produce the phone casing. The injection moulding process phases start with the feeding of a polymer through a hopper to barrel. Then heated to the specific temperature to make it flow and make it molten plastic. This molten plastic then was melted and injected under high pressure into the mold.

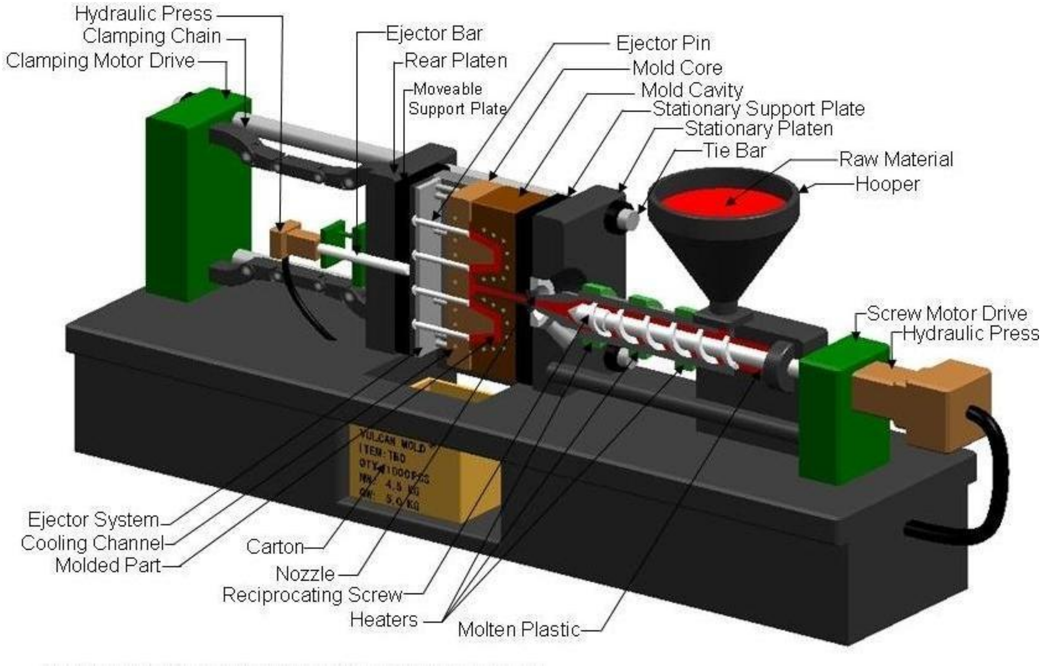

Figure 2.1: Plastic Injection Moulding Machine

This machine lets the material to be combined before injection which colored plastic or recycled plastic could be inserted into the virgin material and mixed carefully before being injected (Noordin, 2009). The main units of a typical injection moulding machine are the clamping unit, the plasticizing unit and the drive unit.

The clamping unit holds the mold. It is capable of close, clamp and opens the mold. Its major components are the fixed and moving plates, the tie bars and the mechanism for opening, closing and clamping. The injection unit or plasticizing melts the plastic and injects it into the mold. The drive unit will be used supply power to the plasticizing unit and clamping unit.

There are a few stages in the plastic injection moulding process; clamping, cooling and ejection. Raw materials such as nylon, polypropylene and polystyrene are poured into the hopper and falls onto the rear flights of the screw which transmits material to the front cylinder. It is plasticized to a fluid with the assist of external heaters on the barrel through passes along the cylinder. Some material may flee through the nozzle but the back pressure is usually enough to push the screw back in the cylinder and to supply a reservoir of fluid plastic in the front of the cylinder for injection.

The mold closed and the cylinder moves forward unit carriage until the nozzle is in contact with the entrance of the mold. The screw is moved frontward by the hydraulic cylinder at the rear of the machine and the injection takes a turn. After a short period, the screw rotates, generating some force in the barrel and offers it back against low pressure in the hydraulic cylinder, until the limit switch works, stopping the rotation. The mold is open, the article is ejected and the mold closed again and ready for the next cycle (Reliance Industries Limited Group, 2000). The overall cycle of injection moulding was illustrated in Figure 2.2. Subsection 2.21 till 2.2.3 describes in details about each stages involved in plastic injection moulding process.

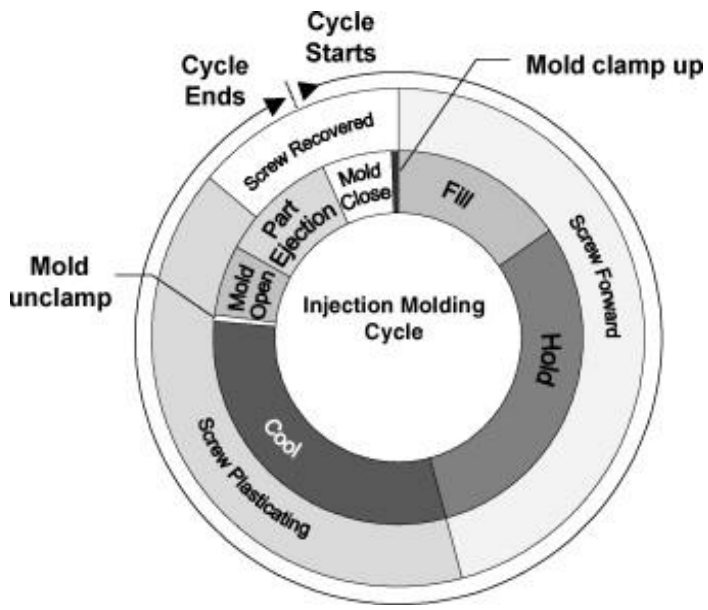

Figure 2.2: Injection Moulding Cycle

2.2.1 Clamping

Proceeding to the injection of the material into the mold, the two halves of the mold will first be firmly closed by the clamping unit (Noordin, 2009). Each half of the mold is attached to the injection moulding machine and one half is allowed to glide. The hydraulically powered clamping unit forces the mold halves together and exerts sufficient force to keep the mold securely closed while the material is injected.

2.2.2 Cooling

The molten plastic that is in the mold starts to cool as soon as it makes contact with the interior mold surfaces. As the plastic cools, it will harden in the form of the desired part. However, during cooling some shrinkage of the part may happen.

The packing of material in the injection phase allows additional material to flow into the mold and decrease the amount of visible shrinkage. However, the mold cannot be opened until the set cooling time has elapsed. The cooling period can be calculated from a few thermodynamic properties of the plastic and the maximum wall thickness of the part.

2.2.3 Ejection

After sufficient time has passed, the parts that have been cooled will be ejected from the mold by the ejection system. When the mold is opened, a mechanism is used to push the part out of the mold. Pressure must be applied to emit the part because during cooling the part shrinks and adheres to the mold. Once the part is emitted, the mold will be clamped shut for the next shot to be injected.

2.3 MOULDING DEFECTS

Injection moulding is a technology with possible production problems. It may be caused by defects in the molds or more often by part processing. According to the R. Wilkinson, these are the common defects that always happen in these industries. Partially crystalline engineering thermoplastics such as POM (acetal), PA (nylon), PBT and PET (polyesters) are used mainly because of their outstanding mechanical, thermal excellent and electric properties. Further benefits over amorphous materials include their chemical resistance and low tendency towards stress cracking.

Table 2.1: Common defects in plastic injection moulding

Defects	Description	Causes	Researcher
Warping	Molded parts do not match specification drawing / distorted part	Short cooling. The materials are too hot. Lack of cooling around the tool. Water temperature is incorrect.	Sinha and Bohn, 1991; Bociaga et al.,2010; Wilkinson, 2010; Wang et al., 2013.
Sink marks	Localized depression	Low pressure or holding time. Short cooling time. Too high gate temperature.	Wilkinson, 2010; Susanwari and Sirovetnukul, 2013; Wang et al, 2013.
Stringing	Long, thin threads emerge from the machine or hot runner nozzle	Nozzle aperture too large Poor thermal isolation at the nozzle point. Nozzle temperature is too high. Insufficient screw retraction.	Nazri, 2009; Wilkinson, 2010.
Weld Lines	Discolored line where two flow fronts meet	Too low mold/ material temperatures set.	Jafry and Teng, 2001; Noakes et al., 2002.
Short Shot	Incomplete molded part	Insufficient material. Polymer melts cannot fill the entire cavity	Susanwari and Sirovetnukul, 2013.

2.4 STATISTICAL PROCESS CONTROL (SPC) TOOLS

Statistical Process Control Tools are broadly used to monitor and advance manufacturing processes and service operations (Woodall, 2000). Realizing the variation in value of a quality characteristic is a main importance in SPC.

SPC is a scientific, data-driven methodology quality analysis and improvement (Akinbiola, 2003). It is a method used to identify whether a process is in statistical control or not. In industry, the Shewhart chart is the most frequently applied statistical quality control techniques for studying the variation in output from a manufacturing process.

Common causes are problem existed in the manufacturing system as a whole. The process is said to be in statistical control when the special causes have been identified and removed. Montgomery (1997) stated that Shewhart charts can be used to monitor the process for the occurrence of future special cause and d to measure and reduce the effects of common causes.

According to Leavengood and Reeb (1999), SPC assists manufacturers increase their competitiveness and profitability as it monitors the process and help in maintaining high quality. SPC in understanding, modeling and reducing variability over time remains very important (Woodall, 2000). There needs to be a quicker transition, however, from the classical methods to some of the newer approaches when appropriate.

The subsection 2.4.1 till 2.4.7 describes more on these seven tools; histograms, Pareto diagram, Cause-and-Effect diagram, flowchart, Scatter diagram, control chart, and check sheet.

2.4.1 Histograms

Histograms are visual tools to determine distributions (Leavengood and Reeb, 1999). A histogram is a bar graph that shows how frequently data fall within specific cells, that is ranges of value. From histogram, where the process is centered and the amount of spread about the center can be calculated. It is a helpful snapshot of the process but it does not let us assess the process over time or identify whether the process is stable or not.

2.4.2 Pareto Diagram

Pareto Diagram is a graph that ranks data classifications in descending order from left to right. In this case, the data classifications are types of field failures. Other possible data classifications are problems, causes and types of nonconformities. The Pareto diagram has the advantage of providing a visual impact of those vital few characteristics that need attention (Besterfield, 2009).

It is a formal technique for finding the changes that will give the biggest benefits. Is also often misquoted as the 80/20 rule that are 80% of the total effect will come from only 20% of the components.

Pareto chart is a very useful tool whenever one needs to separate the important from trivial Goetsch. It is simply a frequency distribution of attribute data arranged by Montgomery (Hikmat and Mukattash, 2010).

2.4.3 Cause and Effect Diagram

Cause and Effect Diagram are charted as a medium to identify potential causes for quality problem (Bagchi, 1997). It is a tool that helps determine, sort and display possible potential factors of a specific problem or quality characteristic. It shows the relationship between a given outcome and all the factors that influence the outcome.

The causes can be related to the 4M. Those are machine, manpower, method and materials. Each of these potential causes can have similar bones that address specific issues that relate to each cause. For example, a problem that caused by manpower or worker which it should be due to the lack of training and poor supervision. The other causes are management, environment and environment

2.4.4 Flowchart

It is a schematic diagram that represents the flow of the product or service as it moves through the various processing stations or operations. The diagram makes it simple to show the entire system, identify possible trouble marks and locate control activities. Flow diagrams that are constructed by a team are better because it is rare for one individual to understand the entire process (Sharat et al, 2006)

2.4.5 Scatter Diagram

The scatter diagram is the simplest of the seven tools and one of the most useful. It is used to determine the relationship between two characteristics. The greater the degree of correlation, the more linear is the inspections in the diagram; the lower correlation exists between the variables. When all the potted points fall on a straight line, it is a perfect correlation (Sharat et al, 2006)

2.4.6 Control Charts

Variable control chart is designed to control product characteristics and process parameters which are measured in continuous scale. Examples of product characteristics are length, weight and diameter. Examples of process parameters are temperature, pressure, and PH value. The primary variable control chart used are the X-bar and R-bar chart and moving range chart, the other two, that rarely used charts include X-bar and s-chart and median chart (Hikmat and Mukattash, 2010).

Attribute control charts are designed to control the process. A measurement used are in terms of good or bad, accept or reject, or pass or fail criteria. The distinction between nonconforming or defective unit and nonconformities or defects is very important in attribute control chart. This is because it will determine the selection on the type of attribute control chart used.

2.4.7 Check Sheet

The main purpose of check sheet is to ensure that the data collected is carefully and accurately by operating personnel. Data should be collected in such manner that it can be quickly and easily used and analyzed (Hikmat and Mukattash, 2010).

2.5 CONCLUSION

From this chapter, the process of injection moulding is identified. This process is divided into 3 stages which are clamping, cooling and ejection. The injection moulding cycle is describe where the cycle of this process starts and cycle ends. Besides that, common defect rate in moulding injection is determined. Defects such as warping sink marks, stringing, weld lines, short mould, scratches, silver streak and contamination always occur as the process of moulding is running. Most of these defects are causes by improper parameter setting. In order to identify problem faced by company, SPC tools is used. Those seven tools; histograms, Pareto diagram, cause and effect diagram, flowchart, Scatter diagram, control charts and check sheet. Each of these tools is described in this chapter. Chapter 3 will discuss the method used in data collection.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter represents the research methodology used to investigate the factors of defection and the solution to solve the problem. In this chapter, detail about an instrument or method used to conduct the research on the reduce defect rate in plastic moulding industries will be discussed. Methodology or research design is a blueprint, plan, framework or as a guideline. A method such as data collection technique can be used in conducting research methodology. This chapter consists of three parts which are information about participants, data collection techniques and data analysis. The flow chart of this research can be seen through the Gantt chart provided in Appendix A and Appendix B.

3.2 PARTICIPANTS

This research will focus on plastic industry. Since this research is about defect parts and quality, participants that are involved in this research are the department manager, quality control personnel and the operator. The quality personnel that monitoring the process can help the author to determine the quality of product as well. The author also able determines the process of a product well through the operator. Besides that, he can identify whether the defect product is caused by man or not.

3.3 DATA COLLECTION TECHNIQUES

In order to collect the research data, the face to face interview with selected respondent were employed. The company background and the target of the study in the company have been identified. The factors that influence the rejection also can be determined through the interview with respective person in production department. The data collection technique includes two parts, interviewing and observation.

Figure 3.1 show the steps taken in data collection. These steps have to be followed in order to ensure the research flow will run smoothly.

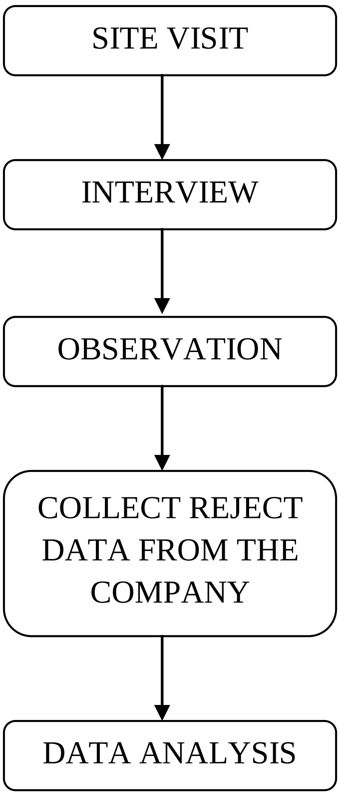

Figure 3.1: The flow of data collection

3.3.1 Interviewing

An interview is a verbal conversation between two or more people where the interviewer asks questions to collect facts or statements from the interviewee. Through interviews, the interviewer can pursue in-depth information around the topic. The interviewer also can give direct feedback to the respondent, give clarifications and help reduce any misconceptions or apprehensions over confidentiality that the respondent may have in answering the interviewer's questions.

For this research, a site visit to the company is necessary to conduct a face to face interview related to the defect rate in quality of product with manager in the production department. The type of defects that affect most in product quality and the factors that may cause the defects also can be determined through the interview with the manager. After all the data are collected, analyzing process to reduce the defection rate can be proceeding.

That is very important to ensure that the interviewee does not hold any preconceived notions regarding the objective of the study. Interviewees range from quite informal and completely open-ended with very formal with the questions predetermined and asked in a standard manner. There are a few factors that need to be concerned while doing the interview which is listening and questioning.

The questions that will be asked in the interview will be more on quality of product and the process flow of production. Through these interview, the information obtain will focus more on defective part. The questions asked are focused on the factors of defective and the solution on solving it. The process flow is important as it can affect the quality of the product. Steps that are not followed can contribute to the defective part. In this interview, the information whether the company already done some solution to solve the defect problem or not is acknowledge.

However, there are two skills that need to adopt by interviewer while conducting the interview session. They are listening and questioning. Listening is an important skill for the interviewer. There are two levels of listening (Seidman, 1991). First, the interviewer need to listen to what the interviewee is saying which the content of the reply as constructed from the words used. The interviewer needs to concentrate to ensure that the information is understood. They need to evaluate whether the answer is on the right track or not and is as detailed and complete as expected.

Second level is the interviewer listens to the unstated message which what is not clearly be delivered but is being contradicted by non-verbal messages. Participants have different roles and the answer was provided by the interviewee. The information given is the raw data so the interviewer must listen very carefully.

The explanation given by the interviewee need to be listened well by the author which includes the process flow, the defect part and the factors that lead to the defect part should be known well. These explanations will be the data for this research.

In addition, the questioning skills also a crucial part in interview method. Well-designed questions allow the interviewer to manage the direction of the interview. There are two types of questions that can be asked during the interview that are open questions and close questions.

According to Delahaye and Smith (1998), there are two aspects to the open question which is open or open-ended questions that allow the interviewee a wide choice of possible answers and open question that are arranged in stem-plus-query design. Stem-plus-query design allows the interview to focus on the topic.

Closed questions are used to identify explicit facts. These questions need a very short interviewee response, stem-plus-query is inappropriate for the closed questions. The question asked should be focusing more on quality.

The sample of semi-structured interview protocol can be seen in Appendix C.

3.3.2 Observation

Observation is used to collect data according to the number of occurrences in a specific period of time or duration of a very specific behavior or event. Employee can be observed in their natural work environment and their activities and behaviors or other points of interest recorded. The researcher can play one of two roles while collecting observational data that are nonparticipant observer or participant observer.

In this research, observation is needed as the author needs to observe the operator doing their work. The way operator works can contribute to defect product. The author also needs to observe the process of product making.

The author collects the data without becoming an integral part of the organizational system. The researcher might be in a production line and observe how operator done their work. This observation might help the author to summarize how employee behavior and how it can affects the product quality. The observer must be present in the workplace for an extended period of time to make observational studies time-consuming.

3.4 TYPES OF DATA RESOURCES

Primary data and secondary data were used in this research and both are complement each other's.

Primary data are a data that are gained for the specific research problem at hand, using procedures that fit the research problem best (Joop, 2005). An often method of data collection used is interview which interviewee is able to talk about their experiences, views and so on.

A structured interview is conducted when it is known at the outset what information is needed. The interviewer has a list of standardized questions which are carefully ordered and worded in a detailed interview schedule and each research subject is asking exactly the same questions, in exactly the same order (Minichiello et al, 1990).

In this research, semi-structured interview was conducted in plastic company to obtain the information about process involved and defect types in injection moulding. This method is more appropriate as it remain focused on a given issue. It is even more direct and provides detailed information on defect.

The secondary data for this research is gained through the readings from academic materials, online articles and journals. Secondary data is information collected for purposes other than the completion of a research study (Steppingstones, 2004). These data also used to obtain initial insight into the research problem.

Secondary data can be obtained from two different research standards that are quantitative and qualitative data. Quantitative includes census, social security and etc. Whereas for qualitative data, it involves interviews, focus group transcripts and observation.

Due to lack of research study of reducing the defection rate in plastic industry, it’s harder to find the data through online browsing. Related articles with a quality defect in plastic moulding industry are the main reference of source hunting. Otherwise, online journal and articles are important and through the reference book, the researcher can seek related information about this research.

A reject data from the company is the main data needed. As the data show the important information that is the defection rate which is the main data for these researches. From the data, researcher can detect the defect that has the highest rate.

3.5 DATA ANALYSIS

All the data obtained from the research will be analyses using Minitab software. Through the software, the factors that influence most of product quality can be identified by using Pareto Diagram or Cause and Effect Diagram. Besides that, it also can describe an unsatisfactory condition or phenomenon and help to examine why that problem arise.

Pareto diagrams are used to determine the most important problem as it ranks the data classification from left to right in descending order. It is a powerful improvement tool as it is applicable to problem identification and measurement of progress. So, in this research, the defect type with the highest rate will determine through the Pareto diagram.

Cause and Effect diagram represent a relationship between an effect and its causes. Kaoru Ishikawa was developed this diagram in 1943. Sometimes it was referred as Ishikawa diagram. This diagram is used to investigate either a bad effect or good effect and to take an action to correct it or learn causes responsible. For this research, the effect is the quality characteristics that need an improvement. The causes of the defect will be determined through Ishikawa diagram.

The control chart is often used of the SPC tools since it shows the process behavior graphically and it is used to monitor and control processes within the specified control limits. When the factors of each defects are identified, the problem solving have to be done.

3.6 CONCLUSION

As a conclusion, this research will use a few methods for purpose of data collection. For data collection, author already done a site visit to one plastic company in Johor Bahru. A semi-structured interview has been conducted with the operation manager of the company. Observation also has been done. Since the data collected is not enough, a single case study is applied. Needed information is gathered to fulfill the requirement of data analysis. Chapter 4 will discussed about the data analysis from the company and thus it answered the entire research question.

CHAPTER 4

DATA ANALYSIS

4.1 INTRODUCTION

This chapter is discussed about the analysis of data in defect rate from one company that using the moulding process. This company produces a few types of plastic product but in this research, only one type of product which is phone casing will be discussed. The data collected from the company is confidential and the name of the company should not be mentioned. This data focused on defect rate in moulding process of phone casing.

The data collected already show the defects that affect most on the product. The data in analysis used to determine the highest defect rate among four defects detected. The types of defects stated in the data are short mould, scratches, silver streak and moisture, and black dot and contamination. These defects which if not prevented will cause loss to the company.

The data is also used to find the causes or factors that contribute to the defects in moulding operation. These causes can be identified through the analysis in Ishikawa diagram and also through an intensive literature. Since the company does not cooperate well during the data collection, this chapter will be discussed through literature review which the information gathered from journal, previous research, book, article and etc.

Through the data collected, the improvement plan can be recommended to the company. This problem should be prevented or at least the company needs to do something to decrease their defects product as it can affect their image and profit well. The improvement plan also will be proposed by conducting the intensive literature from previous research.

Table 4.1 shows the exploration of objectives which each objective is answered by each exploration and action taken. Each of the objectives is explored and thus will help the author analyze the data effectively.

Table 4.1: Objective Exploration and Action

No	Objectives	Research Exploration	Analysis
1	To identify types of defect in phone casing moulding operation.	- 4 types of defect - Discuss overall defect - Discuss monthly defect	Pareto Diagram
2	To investigate the causes of each types of defect.	- Causes for each defect	Cause-and-Effect Diagram
3	To recommend the improvement plan to reduce the defect rate	- Proposed improvement plan	Intensive literature

4.2 FINDINGS

4.2.1 Overall Data for 6 Months (January - June)

Table 4.2 shows the overall data of defect rate in moulding process of phone casing from January to June. There are four types of defect that gives the high impact in quality of phone casing; short mould, scratches, silver streak and moisture, and black dot and contamination.

Roughly, the numbers of phone casing defects are not less than 1400 units per months. From Table 4.1, there are 2659 units of phone casing defect in January while in February, the number defect decrease to 1443 units. However, in March and April, the defects drastically increase to 2803 units and 3834 units respectively and later decreasing to 2294 units in May. But the defects increase again in June, with number of defect is 2420 units. Total reject in April are the highest among these 6 month as the number of defect in short mould hit more than 2000 units. Based on findings tabulated in Table 4.2, the defect phone casing for each month are not uniform as it keep decrease and increase unevenly.

Table 4.2: Data of overall defects rate from January to June

Defects	January	February	March	April	May	June
Short mould	1169	675	843	2085	542	1364
Scratches	14	136	747	195	183	253
Silver Streak & Moisture	893	391	708	965	959	446
Black Dot & Contamination	583	241	505	589	610	357
% Reject	0.23%	0.10%	0.15%	0.26%	0.24%	0.21%
Target Reject	3%	3%	3%	3%	3%	3%
Total Output	1210607	1567965	1817287	1445848	1107110	1126745
Total Reject	2659	1443	2803	3834	2294	2420

The percentage of defect part also not uniform as the percentage of defect part in January is 0.23% while in February the percentage decrease to 0.10% and increase to 0.15% in March. In April, the percentage increase to 0.26%, decrease to 0.24% in May and 0.21% in June. The percentage of defect part depends on the total output. Table 4.1 show that the total output for each month is not same. The company produces their product based on customer demand. This statement can be proved by this formula.

The company has stated that their target for defect is < 3% for each month. As the reject are ≥ 3%, production should come out with action plan for improvement and supervisor must control reject part at the production line. Table 4.1 show that the percentage of defects does not exceed their target. The companies also have their improvement plans that are:

a) Technician should clear of all good part from machine before any adjustment on parameter. They must clear part before restart production.
b) Recycle material should proper mixing before suction to hopper dryer. Prevent inconsistent material changing due to runner stuck.
c) Technician must be clear all the existing part when machine alarm.

The company also gives the responsibility to the production supervisors to monitor part reject at the production line and study how to control reject part as well.

From Figure 4.1, the defects part becomes worse in April. In April, the defects amount increase drastically which may lead to loss. In conclusion, the trend of defects is not uniform and the analysis for defects needs to be conducted in order to identify the problem faced by the company.

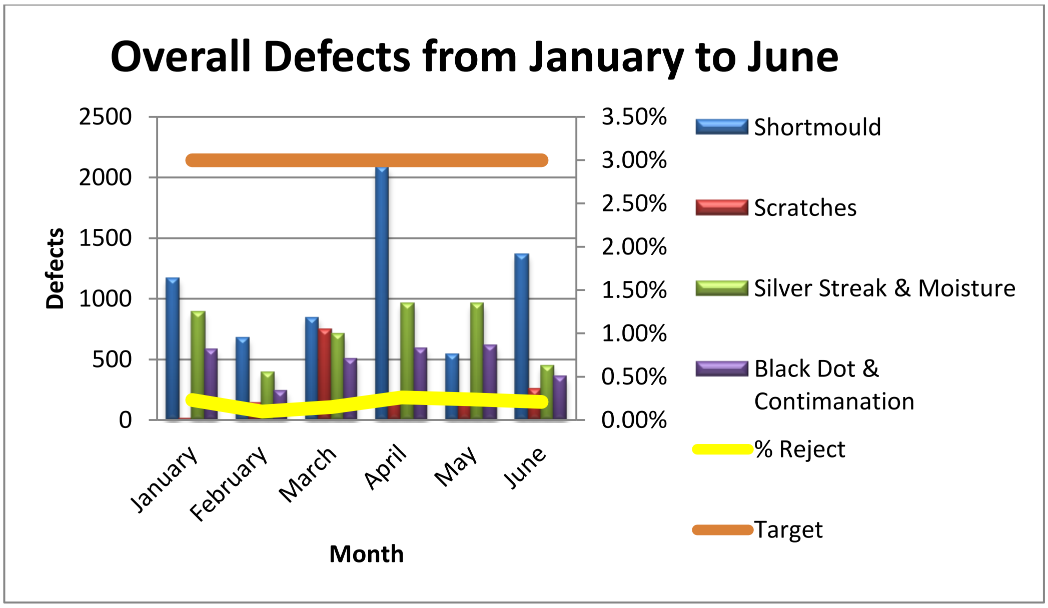

Figure 4.1: Defect Rate of Phone Casing from January to June

4.2.2 Defect Analysis from January to June

In this analysis, the defects are analyzed and the highest defect within this 6 month can be identified. This analysis is using Pareto diagram which is powerful tool in problem identification and progress measurement.

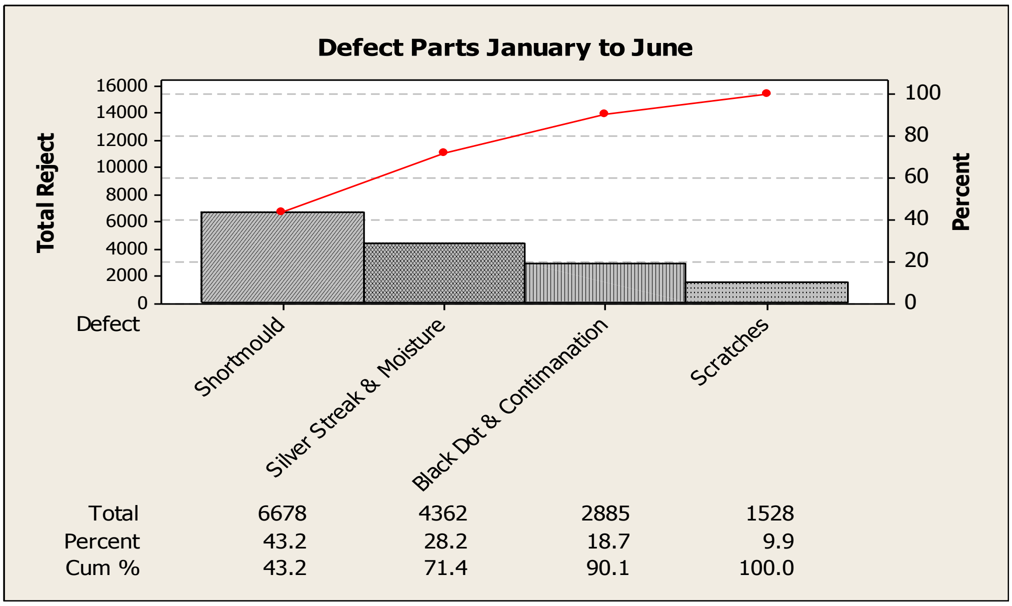

Figure 4.2: Pareto Diagram of Defects from January to June

Figure 4.2 shows the defects rate from January to June. The types of defects with their amount and the defects which have the highest can be seen in this Pareto Diagram. The defects have been ranked from the highest to the lowest. Total defect part for 6 month is 15 453 units.

Pareto diagram reveals that short mould is the major defect in moulding operation of phone casing. Within 6 month, 6678 units of phone casing were rejected due to short mould defect. It has the highest amount among other defects. The percentage of short mould defects is 43.2% and the cumulative percentage is also 43.2% of the total defects in phone casing.

The second rank in this diagram is silver streak and moisture with 4362 units. The percentage of from overall defects is 28.2% while the cumulative frequency is

71.4%. This defect is quite high in number which also led to major defects in moulding process of phone casing.

Black dot and contamination are the third rank in Pareto diagram. The amount of this defect is 2885 units and the percentage of defect is 18.7% from total defects. This defect phone casing has cumulative percentage of 90.1 %.

The last ranked in Pareto diagram is scratches which is 1528 units. The percentage from total defects is 9.9% and it cumulative frequency is 100.0%. This defect has the lowest amount but still the amount is over 1000 units per 6 month. And these defects can be increase and decrease anytime as long as this problem not prevented or monitored.

4.2.3 Defect Analysis in Month

This section discussed in details about number of occurrences and the types of defect involved for every months, starting from January till June. The trend of defects of every month can be studied and any problem from production also can be identified. The defects trend may be different for each month.

4.2.3.1 Defect Analysis in January

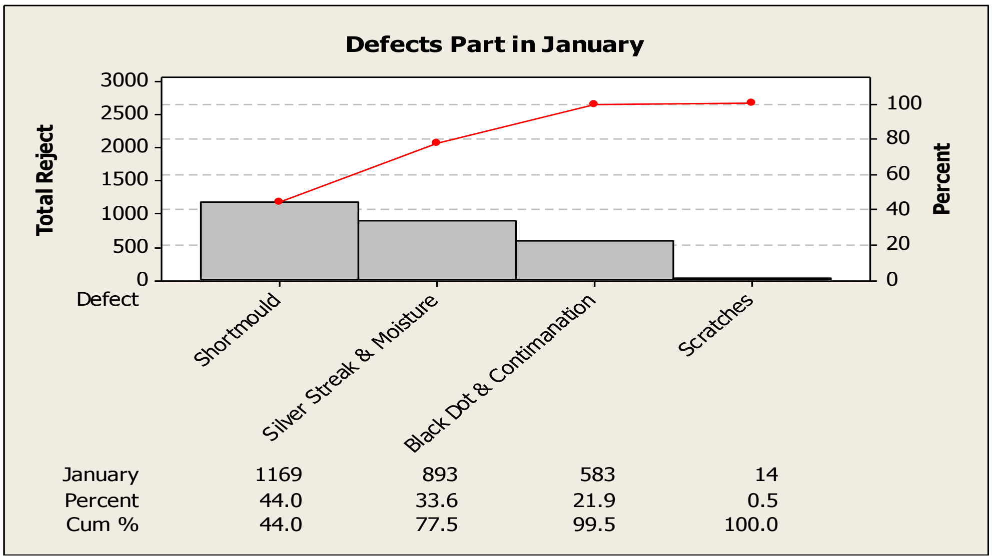

Figure 4.3: Pareto Diagram of Defects in January

From Figure 3, the defects have ranked from highest to lowest amount in January. There are four types of defects to be discussed in this analysis which are short mould, silver streak and moisture, black dot and contamination, and scratches.

The production has 1169 units of short mould defect phone casing which is in first ranked. The percentage of this defect is 44.0% from total defects and has 44.0% cumulative percentage. The second ranked is silver streak and moisture which is 893 units. Its percentage is 33.6% from total defects. This defect cumulative percentage is 77.5%. Black dot and contamination is third ranked by 583 units. The percentage is 21.9% from total defects and 99.5% for cumulative percentage. In this month, defects by scratches are the lowest which is 14 units only. It is 0.5% from total defects and 100.0% for cumulative percentage.

For the conclusion, short mould are the highest defect part produced while silver streak and moisture are second highest, black dot and contamination are third highest, and scratches are the lowest in January.

4.2.3.2 Defect Analysis in February

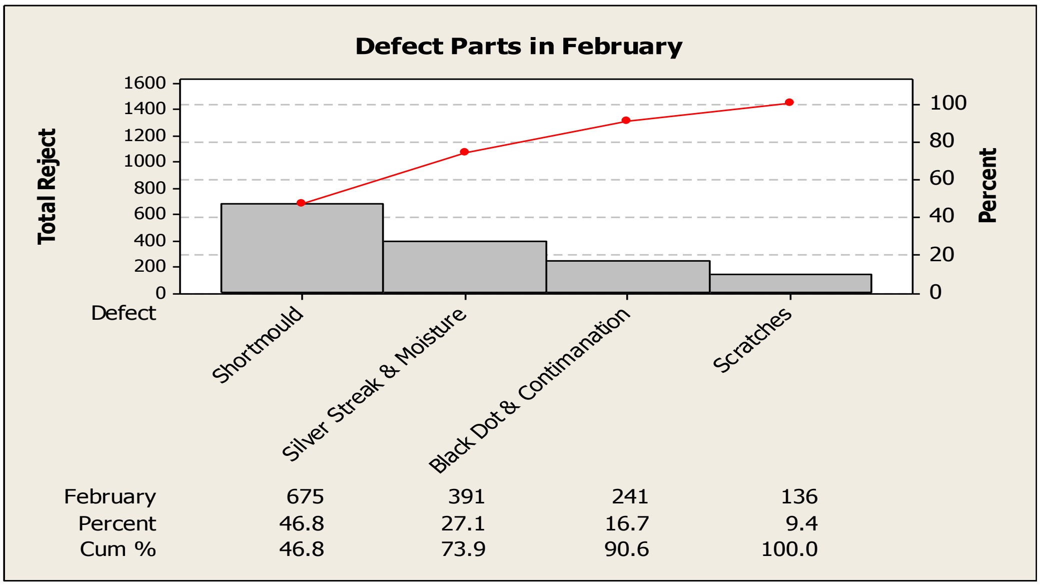

Figure 4.4: Pareto Diagram of Defects in February

Figure 4 shows the Pareto diagram of defect part in February. Again, short mould becomes the highest defect types occur with the amount of 675 units of phone casing rejected.

In February, 675 units of short mould defect has been produced by production. The percentage is 46.8 % from total defects while the cumulative percentage is 46.8% too. Silver streak and moisture defect that been produced are 391 units and it percentage is 27.1% from total defects. The cumulative percentage is 73.9%. The third ranked, black dot and contamination defects are 241 units in February and it covers about 16.7% from total defects. It cumulative percentage is 90.6%. Lastly, the lowest defect rate according to the Figure 4.4, scratches is produced by 136 units. The percentage of this defects is 9.4% from total defects and it cumulative defects is 100.0%.

For the conclusion, short mould still in the first ranked, while silver streak and moisture is second ranked and black dot and contamination is third ranked. Scratches defects are in the lowest ranked in the Pareto diagram in February

4.2.3.3 Defect Analysis for March

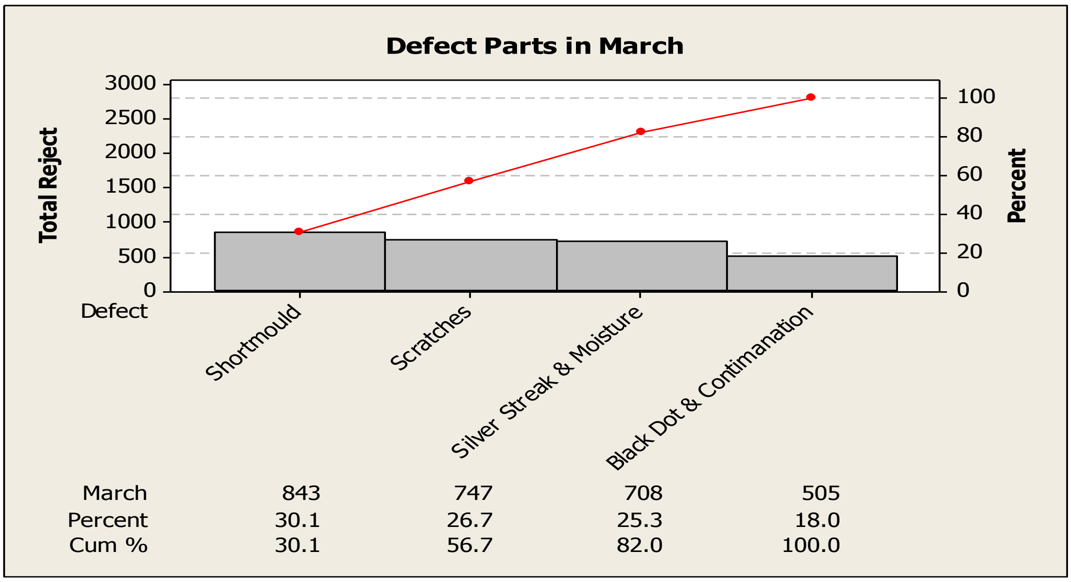

Figure 4.5: Defect Analysis for March

Figure 5 shows the Pareto diagram for defect analysis in March. For this month, short mould defects increasing to 843 units and still the first ranked in March. It occupies 30.1% from total defects and its cumulative percentage is also 30.1%. Scratches defects are ranked in second which 747 units have been produced and its cover 26.7% from total defects. Their cumulative defect is 56.7%. Besides that, a silver streak and moisture defect produced is 708 units. The percentage for this defect is 25.3% and its cumulative percentage is 82.0%. And the lowest ranked in Pareto diagram for March, black dot and contamination is produced by 505 units and its percentage is 18.0% from the total defects. Its cumulative percentage is 100.0%.

The conclusion is short mould is first ranked followed by scratches in second ranked. Silver streak and moisture is in third ranked while black dot and contamination is in the last ranked. The Pareto diagram for this month is different as the types of defects ranked are different from previous two month diagram.

4.2.3.4 Defect Analysis in April

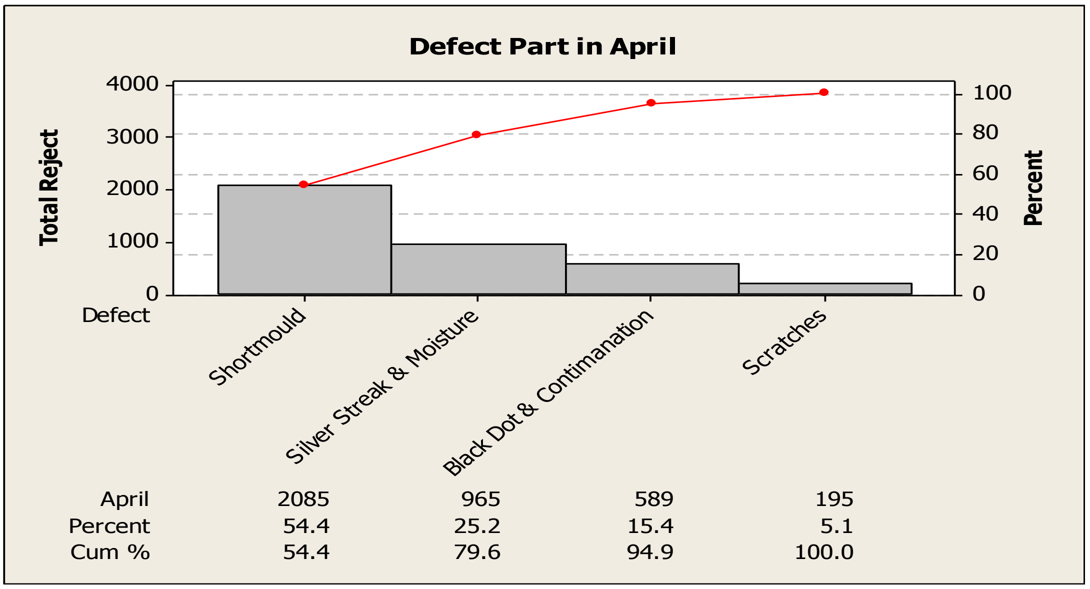

Figure 4.6 : Defect Analysis in April

Figure 4.6 shows the defect analysis in April. The data has been ranked from the highest to the lowest amount. In April, short mould defect for phone casing is the highest which is 2085 units. It covers 54.4% from the total defects. This defect covers more than half from the total defects for this month. Silver streak and moisture defects which ranked second in this Pareto diagram, was produced by 965 units. The percentage of this defect is 25.2% from total defects and its cumulative percentage is 79.6%. The third ranked, black dot and contamination is 589 units produced in April. Its percentage is 15.4% from total defects. This defect has cumulative percentage that is 94.9%. Scratches defect is 195 units in total which is the lowest ranked in Pareto diagram. It covers only 5.1% from total defects and its cumulative percentage is 100.0%.

The conclusion is short mould defect is produced by the largest amount which cover over than 50% from the total defects and directly ranked first in Pareto diagram. Silver streak and moisture, black dot and contamination, and scratches are ranked second, third and fourth respectively.

4.2.3.5 Defect Analysis in May

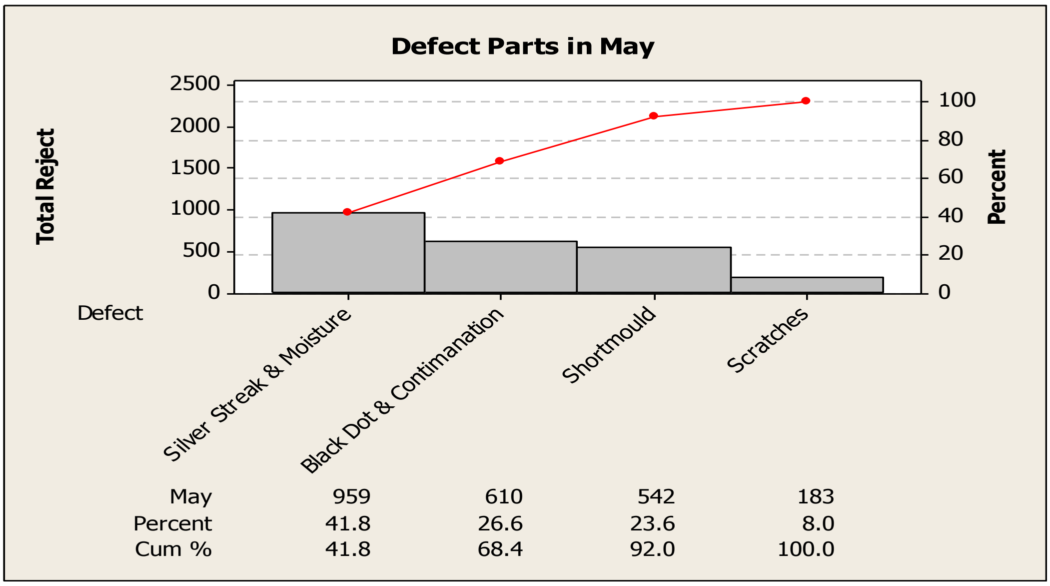

Figure 4.7 : Defect Analysis in May

Figure 4.7 shows the defect analysis in May. For this month, silver streak and moisture has ranked first in Pareto diagram which mean this defects has the highest amount than other defects. The production has produced 959 units of this defects which cover 41.8% from the total defects. Black dot and contamination which has second ranked is produced by 610 units. Its percentage is 26.6% from total defects and its cumulative percentage is 68.4%. A short mould defect for this month is 542 units. This defect percentage is 23.6% and its cumulative percentage is 92.0%. Scratches are lowest among these four defects for this month. It has been produced as much as 183 units and cover 8.0% from total defects. This defect has cumulative percentage for 100.0%.

The conclusion from this Pareto diagram is the defects trend for this month is different from previous 4 months which silver streak and moisture defects was ranked in first, totally make it as a highest defects in this months. Black dot and contamination, short mould and scratches are ranked second, third and fourth respectively.

4.2.3.6 Defect Analysis in June

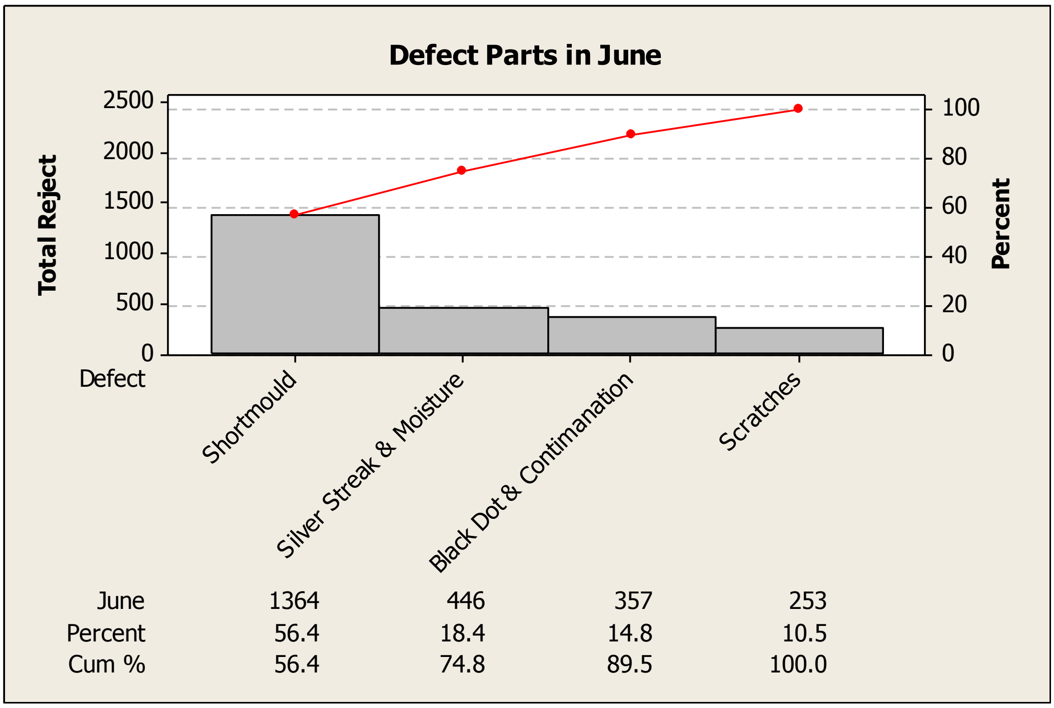

Figure 4.8: Defect Analysis for June

Figure 4.8 shows the defect analysis in June. In June, short mould defects are 1364 units and it is the highest defects among these four defects. It covers more than half which is 56.4% from total defects. While silver streak and moisture defects is in second ranked which 446 units was produced in this month. The percentage is 18.4% from the total defects. Its cumulative percentage is 74.8%. The third ranked, black dot and contamination was produced by 357 units and it covers 14.8% from total defects. This defect has cumulative percentage for 89.5%. And lastly, scratches are produced by 253 units in this month. The percentage of this defect is 10.5% from total defects and its cumulative percentage is 100.0%.

From this Pareto diagram, conclusion can be made. Short mould defects have been ranked first with total amount more than 1000 units produced. Silver streak and moisture, black dot and contamination, and scratches are ranked second, third and fourth respectively.

4.2.4 Defects Analysis from January to June 2013

This analysis explained more on the each type of defects produced for each of 6 months. It also described the trend of each defects in moulding process of phone casing. Besides that, this analysis will conclude all the data analysis that has been discussed before.

Table 4.3: Data of Defect Rate from January to June

Defects	January	February	March	April	May	June	Total Reject
Short mould	1169	675	843	2085	542	1364	6678
Silver Streak & Moisture	893	391	708	965	959	446	4362
Black Dot & Contamination	583	241	505	589	610	357	2885
Scratches	14	136	747	195	183	253	1528
Total Reject							15453

From Table 4.3, the trend of short mould defect can be determined. In January, production produced 1169 units of short mould and it decrease to 675 units in February. The defect increase to 843 units in March and in April, short mould defects become worse which it increase abruptly to 2083 units. The defects decrease to 542 units in May and increase again by 1364 in June. This makes the total short mould defect within 6 month to 6678 units.

The trend for scratches defects also not uniform. It keeps increase and decrease unevenly. From January to March, the defects increased by 14 units, 136 units and 747 units respectively. The defects then decreased to 195 units in April and also decrease in May by 183 units. Unfortunately, the defects increase to 253 units in June. The total scratches defect from January to June is 1528 units.

Black dot and contamination has total defects by 2885 units from January to June. In January, this defect was produced by 583 units and decrease to 241 units in February. And for the following month, the defects become increased for three months which is March, April and May by 505 units, 589 units and 610 units respectively.

Black dot and contamination defects decrease in June which is from 610 units to 357 units.

Lastly, silver streak and moisture defects were produced by 893 units in January and decrease to 391 units in February. The defect increased again in March and April which is 708 units and 965 units respectively. In May, the defects were slightly decreased from 965 units to 959 units and decrease abruptly to 446 units in June. This makes the total of this defect to 4362 units for 6 month.

As the conclusion, the defect is not uniform which it increase and decrease unevenly for each month and this problem should be monitored or prevented. Pareto diagram for each month except May shows that short mould defects are the highest in number among other defects. Even short mould defects amount that was produced in different number for each month but it still ranked in first and this identified that short mould is the major defect and some improvement plan have to be done. The trend for short mould defect within 6 month is not uniform as it can exceed 2000 units and can be low than 600 units. It happens also for silver streak and moisture, black dot and contamination, and scratches. These problems also need to improve effectively and efficiently.

Besides that, the improvement plan made by the company did not work well as the defect's trend did not change even after they applied their plan. Based on the information, the failure of their improvement may due to man factor which the technician did not apply well the plan. The technician did not follow the instruction of the improvement plan which causes the trend to change unevenly. From this analysis, the defect that keeps increase and decrease unevenly is a proved that the improvement plan done by the company needs to improved. Through Figure 3 to Figure 8, the data can be analyzed by going through each month. In May, the scratches defects has ranked first as it was produced by 959 units which is highest than other defects. The company has decreased the short mould defect on that month which turns to 542 units and ranked in third. This prove that the improvement plan by the company do not effective on another defects. It can reduce the current defects but at the same time, another defects increased.

4.3 Application of Causes and Effect Diagram in Defect Analysis

This section describes the use of Cause-and-Effect Diagram to investigate the causes of each types of defect. The causes were broken down into the major causes of work method, material, mould, machine and men. Then, each of major cause is further subdivided into numerous causes.

4.3.1 Cause and Effect Diagram for Short Mould Defect

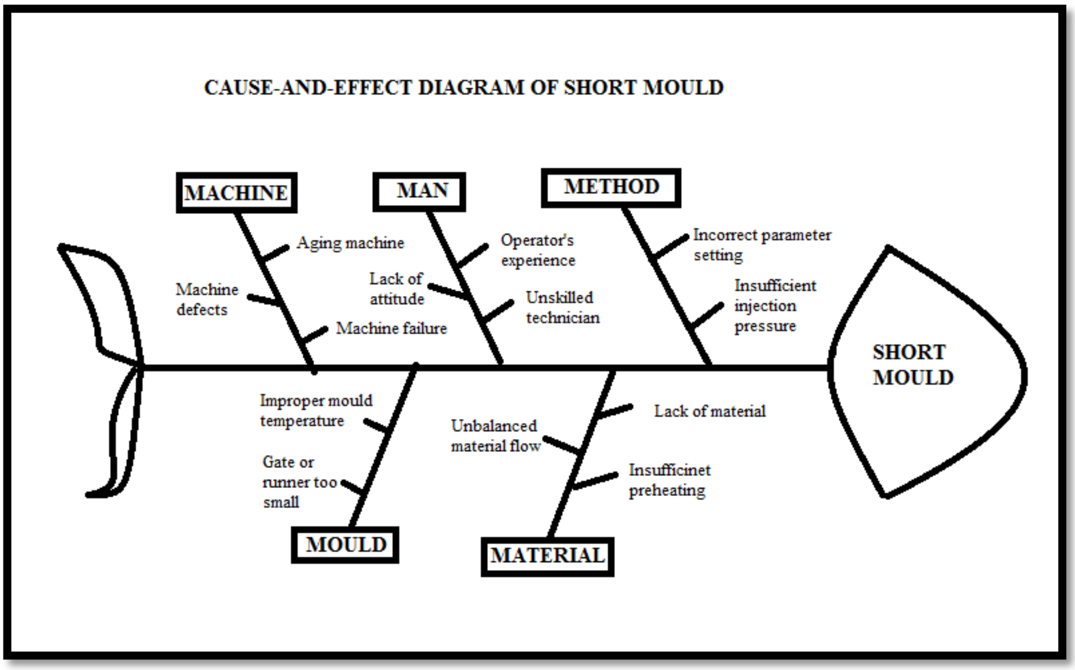

Figure 4.9: Cause-and-Effect Diagram of Short Mould Defect

Figure 4.9 shows the causes of short mould defects. Short mould defects are moulded part which is incomplete due to insufficient material injected to the mould. There five main factors in identifying this defect causes which are machine, man, mould, material and method. These main factors will be discussed broadly by going through each of the factors.

According to Alireza and Mohammad (2011), one of the factors that can contribute a lot to short mould defects is method. Machine parameters and process condition can affect most on the moulded polymers even though moulding process seems simple. Surface roughness, decrease in dimensional precision, unacceptable wastes and also increasing in lead time and cost desirable were all causes by incorrect parameters input.

Low injection pressure, shot size and inadequate back pressure are some of the major machine parameter which is improper parameter setting and will result in short mould. This improper parameter setting was identified as the root cause of short mould defect (Shajan et al, 2012).

Besides that, injection pressure should be set just high enough to avoid other defects such as voids, sink marks and control shrinkage. Insufficient injection pressure is also one of the improper parameter setting in this process. The pressure, friction and additional heaters which surround the reciprocating screw melted the material. As the pressure is high, it allows the material to be packed and forcedly held in the mould. So, if the injection pressure low, the molten plastic will not be pushed into the mould cavity soon enough to fill before it has begun to cool down and result in non-fill. Besides that, lower temperature because the plastic granules stuck at the nozzle and make hindrance to the flow of molten plastic resin. In addition, if the temperature of barrel is too low, the resin does not stay molten long enough to allow full mould filling before the material solidifies which result in incomplete part.

Shot is the amount of material that is injected into the moulding machine. Shot size should represent up to approximately 80% of the capacity of the barrel which a mould required 4-ounce shot should be run in a machine that has a 5-ounce capacity. This is fairly general statement because depending on the heat sensitivity of the material, the ration can be as small as 20%. However, as the ratio drops, the time of residence in the barrel increases and so does for the material to degrade. The back pressure control is used to impact a resistance to the molten material as it is transferred from the rear of the barrel to the front of the barrel. This resistance results in frictional heat which helps plasticize the resin and also results in an increase of the mixing of the resin to better homogenize it. If the back pressure is inadequate the additional heating is not achieved and the resin is not hot enough to stay molten long enough to fill the mould.

Second main factors that will discuss are mould. Defect rate due to short mould is high. One of the causes is the mould temperature is too cold. (Shajan et al, 2012). This defect often occurs during machine start up and at situations where frequent power failures occur. In addition, gate or runner too small also can lead to this defect. When gates or runner too small, it will cause them to begin solidification too early and the material cannot fill the mould before it becomes too stiff to flow. This will result in short mould.

According to Sookand Yusof (2009), material is one of the factors that turn the product into short mould defect. Unbalanced material flow causes the short mould defects of the product. Resin manufacturers usually supply formulation in a variety of flow rates. Thin-walled parts may require an easy flow material while thick-walled parts may be able to use a material that is stiffer. There is some trade-off in physical properties when a fast flowing material is used so it is always best to use the stiffest grade possible. However, a material that is too stiff may not flow fast enough to enter the cavity at the proper speed to maintain desired flow and may solidify before filling is complete.

The other cause is machine. Aging machine often make a problem reported by Susanwari and Sirovetnukul (2013). When the machine is too old, some of their parts did not work well. And this aging machine will lead to machine defect which result defects product to be produced. Instead of low mould temperature, machine that always start up also intend to produce short mould defect product.

The last main factors that lead to defects are man. This factor involved the managers, supervisors, line leaders, quality controller and also operators as they can also lead to not only short mould defect but also other defects too. These employees, who have an attitude problem, may affect their work performance and productivity at once (Ann et al, 2011). A technician who should know how to monitor the machine and acknowledge avoiding the defects but unskilled technician will just make the condition worse as they did not know how to fix a problem.

It is always possible that the machine operator, or some other person, is the source of a short mould condition. If an operator is causing late or early gate openings or closings, the cycle will be inconsistent. When this happens, the barrel heating system tries to compensate for heat losses erratically and there eventually will be cold spots in the barrel. These cause localized under heating of the resin and result in improper flow of the material in the mould. The material begins to solidify before filling is completed.

4.3.2 Cause-and-Effect Diagram for Silver Streak and Moisture Defects

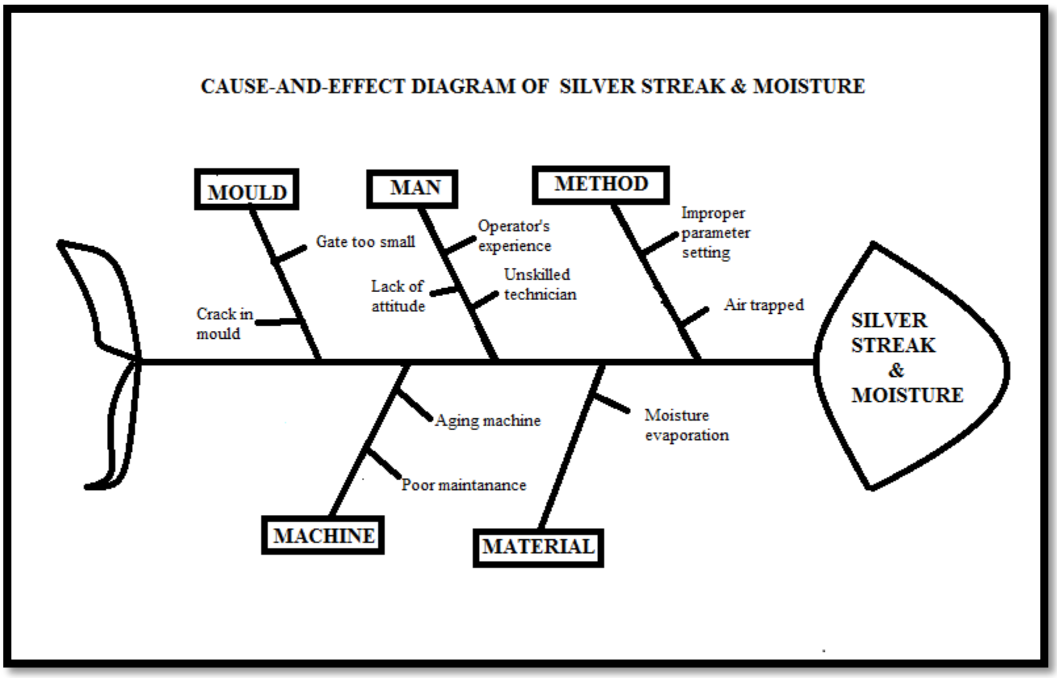

Figure 4.10: Cause-and-Effect Diagram of Silver Streak& Moisture

Figure 4.10 shows the cause and effect diagram of silver streak and moisture. Silver streak and moisture is the splash appearance of moisture, air or charred plastic particle on the surface of a moulded part which are fanned out in a direction emanating from the gate location (Silver streak, retrieved on November 2013). There are four main factors that lead to this defect. Mostly, plastic will absorb a lot of water. Traces of surface splash will be produced as the residual humidity turned into steam during injection moulding process if the process could not be fully drying before process.

In method factor, improper parameter setting contributes to silver streak and moisture defect. According to Rajalingan et al (2012) improper parameters setting in this defect are

1. Injection pressure too high
2. Injection speed to fast
3. Melt temperature too high
4. Nozzle temperature too high

The injection pressure and melt temperature that too high can affect the product surface. Excessive turbulence in the flow path may cause the pockets of air that travel along the liner of the injection barrel. These pockets of air signal the heater bands to increase temperature in small localized areas. When this occurs, degraded material can form and travel into the mould.

Melt temperature that is too high will produce water vapour while melting. Water vapours that trapped and blended into the melt material and if air do not escape during the injection process, it could splash on the surface of the moulded part. The same situation occur when the nozzle temperature too high. Because improper temperature setting may degrade polymer molecules and it will begin to char (Silver streak, retrieved from November 2013).

The nozzle being the final transfer point between the heating barrel and the mould is a critical area which must be scrutinized whenever silver streaking and moisture problems occur. The molten become degraded and charred when the nozzle temperature too high and enters the mould to be forced to the surface as defects. It also creates overheating through convection.

Besides that, the other main factor that will discuss is material. When moulding with two materials, as the operator switch from one material to another, the residual particles left in the barrel could be charred if the second material is being moulded at a higher temperature. In addition, contaminated, rejected parts and regrind will recontaminate virgin material in the next batch of moulded parts (Injection Moulding Troubleshoot, 2009). Furthermore, if drooling is drastic, drying the pallet will be necessary, since the cause is moisture in most of the time (Injection Moulding, retrieved on November 2013).

Gates that are too small will cause restrictions to the flow of molten plastic and may cause the material to overheat and degrade. The degraded material may then enter the cavity of the mould and be forced to the surface of the moulded part in the form of silver streak and moisture. Furthermore, if a mould base develops a crack, it is possible for cooling water to enter mould and get into the plastic melt stream. When that occurs, the water is converted to steam due to the intense heat of the plastic. The steam then gets trapped in the plastic and is carried into the surface of the moulded part, appearing as a streak.

It is possible that the machine operator is the cause of delayed or inconsistent cycles. This results in excessive residence time of the material in the injection barrel. If such a condition exists, heat sensitive materials will degrade, resulting in silver streak and moisture.

4.3.3 Cause-and-Effect Diagram for Black Dot and Contamination

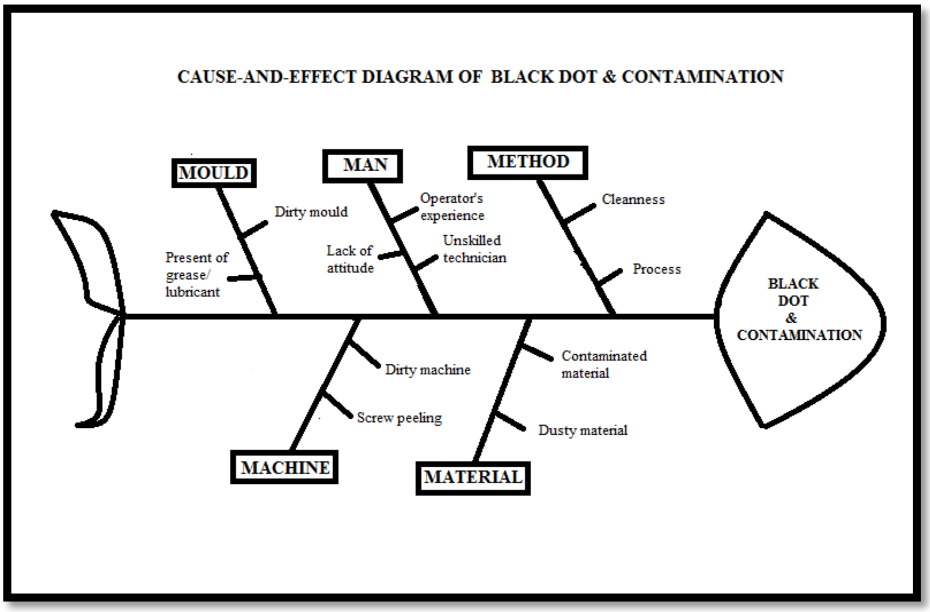

Figure 4.11: Cause-and-Effect Diagrams for Black Dot & Contamination

Figure 4.11 shows the cause and effect diagram for black dot and contamination defects in phone cover. Black dot and contamination is an imperfection in a moulded part caused by the presence of a foreign object or material that is not part of the moulding material (Wilkinson et al, 2007).

According to Shajan et al (2012) the injection screw becomes carbonized as time proceeds. It is due to overheating of material in the barrel. The overheated material will stick on the screw and will be released slowly during injection process and caused for the black dot on the surface of the cover.

Due to the dirty machine, lot of scrap material will accumulate on the barrel and hydraulic unit area. This condition will lead to a situation where the foreign material or scrap material will mix with original material and leads to black dot. If a machine had operated the last batch with black colour material, the brighter colour product might be contaminated with black dot leading to waste in time and resources (Suwannassari and Sirovetnukul, 2013).

It is quite common for most moulders to allow small oil leaks to become big ones before they consider fixing them. If this happens the oil can find its way into some unbelievable places, such as the feed throat of the injection barrel during material changes. Also, when equipment is greased, it is usually overdone and grease drips end up on mould surfaces and machine areas, finding its way into the plastic material.

Moulds with cams, slides, lifters and other mechanical actions need periodic lubrication. Unfortunately, there is a tendency to overdo this and the lubricant finds its way into the cavity of the mould to be moulded into the finished part. Also, some materials may require the use of mould release agent. This is another item that is often overused and can be the source of contamination.

4.3.4 Cause-and-Effect Diagram for Scratches

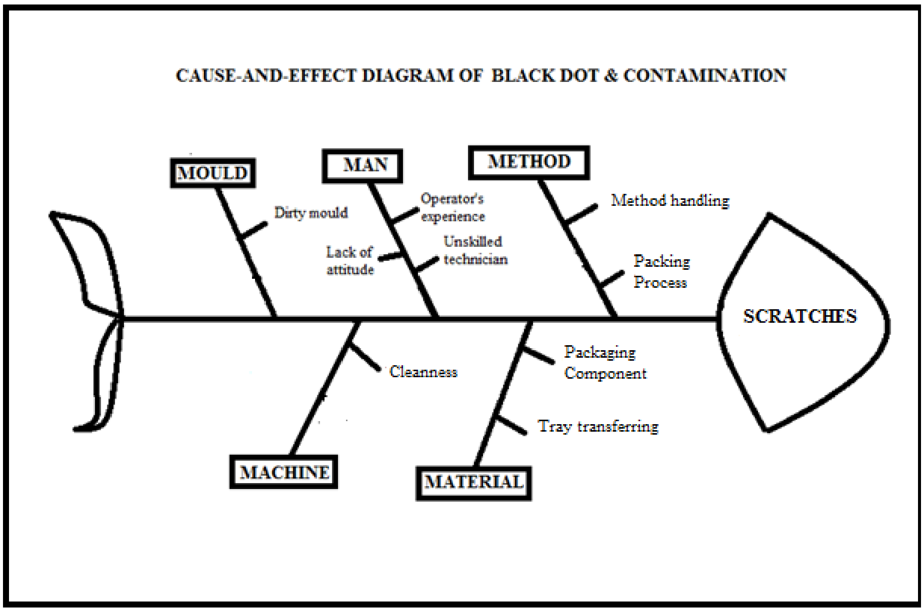

Figure 4.12: Cause-and-Effect Diagrams for Scratches

Figure 4.12 shows the cause-and-effect diagram for scratches of phone casing. Scratches are a surface damage under scratch condition (Susanwari and Sirovetnukul, 2013). They also stated that one of the effects of wrong selection criteria can lead to scratches.

According to Rohani and Teng (2001), main factor that lead to this defect is method. Improper method handlings and packing process cause the phone casing surface scratches. Dirty mould also can lead to scratches defects. Material that stick to mould and not removed, tend to make the product defect when process occurred. Besides that, in material factor, packaging component and tray transferring also can cause defect phone casing. As the packaging component is not suitable and the tray transferring is not proper, phone casing might scratches.

Furthermore, in handling product, manpower should know how to handle it properly. Operator should pay full attention and committed with their duty as they can avoid this silly mistakes.

4.4 PROPOSAL OF IMPROVEMENT PLAN

The causes of the defects are identified. Improvement plan for defects is needed as it can help in reducing the defects rate. Some of the improvement plan in reducing these defects has been studied by previous researcher. This improvement plan can be implemented in the company and they need to monitor this process regularly to ensure that this improvement plan is suitable and help them reduced the defect rate of their product. Table 4.4 shows the improvement plan that can be practice by the company.

Mohd, et al (2001) has stated that their action plan for black dot and scratches has reduced the monthly defect which 4% to 3.51% from total defects in May. They also stated that the related areas for improvement can be classified into material, machine, work method and environment. These researchers who are doing a research on improving quality with basic statistical process control (SPC) tools mentioned that in order to reduce black dot defects, operator must handled properly from any dirt. They also need to pay full attention and have a good attitude towards their duty. The cleanness need to maintain which machine, mould and hopper must be clean all the time. The connector between machine and hopper must be clean to avoid the contamination and the work procedure must be followed properly.

While Shajan, et al (2012) which stated that screw and barrel peeling are the major causes of black dot, this defect can be reduced using the proper cleaning agent to clean the barrel and the machine must be covered with a plastic sheet to make sure that no dirt or dust affect the machine. They also recommend the technique in purging the screw and barrel of the injection moulding machine. The injection unit need to be retracting first. The barrel empty is run using the maximum back pressure. Wiped the hopper and feed the throat. The required amount of cleaning agent is feed into the hopper. About one to two barrel capacities of cleaning agent is required for purging a typical injection moulding machine. The back pressure is increased to the maximum level with completely forwarded screw. The screw speed is increased to the maximum safe level after cleaning agent begins to come from puzzle. The back pressure is dropped once the nozzle is cleaned. The screw is retracted and performs short, high-velocity injection shots. This procedure need to be repeated as long as the contaminants are still visible.

Table 4.4: Improvement Plan

Defect	**Description**	**Root Cause**	**Action**
Short mould	Incomplete moulded part	➢ Incorrect parameter setting (Low injection pressure, low mould temperature, inadequate back pressure) ➢ Insufficient material injected	➢ Set up the parameter setting properly ➢ Increase the amount of material injected to fulfil the desired part
Silver streak and moisture	Splash appearance of moisture	➢ Incorrect parameter setting (Injection pressure too high, injection speed to fast, melt temperature too high, nozzle temperature too high) ➢ Gate too small	➢ Set up the parameter setting properly ➢ Using the most suitable gate size ➢ Proper drying of material
Black dot and contamination	The presence of a foreign material that is not part of the moulding material	➢ Dirty machine ➢ Screw peeling	➢ Clean the mould regularly ➢ Using proper cleaning agent to clean the barrel
Scratches	Surface damage under scratch condition	➢ Dirty mould ➢ Improper method handling and packaging process	➢ The awareness about the condition packaging ➢ Clean the machine regularly

While for short mould defects, these researcher recommend to increase the injection speed which the rate at which the material entering into the mould cavity increases and reduces short moulding. Mould temperature also needs to increase as short mould defects can occur if the mould is too cold. Usually the mould would initially cold during machine start up. Hence, the mould temperature must be increased before the production started. Besides that, injection pressure needs to be increased as the material can be forced to enter every part of the mould cavity. By increasing the material temperature by increased the barrel temperature can avoid the granules stuck at the nozzle which will make a hindrance to the flow of molten plastic resin. In addition, shot size must be increased to avoid short mould defect.

Furthermore, the amount of material being fed to the mould must be increased. This is usually done by adjusting the return stroke of the injection screw so that more material is transferred from the hopper system with each rotation of the screw. The operators need to be instructed on the importance of maintaining good moulding practices. Ensure to include relief operators and material handlers. Potential problems of not running consistent cycles should be informed.

The barrel temperature is decreased which allowed the plastic to stay molten without degrading and charring for reducing the silver streak and moisture defects. The molecules all bond together as designed and splaying is eliminated. While in the nozzle problem, inspect the nozzle and take appropriate action. Nozzle temperature is checked either it is at the proper temperature. This can be done by reducing the nozzle temperature in 10 degree (F) increments until the material flows with the consistency of warm honey. This will be the right temperature for the material being used. The injection speed is reduced which will allow molten material to be properly mixed and plasticized without air being introduced.

As for gates problem, examine the gate and if possible, perform a computer simulation to determine the optimum size and shape for the specific part. Too large gate can have other undesirable defects. On marginal designs, trial and error may be the final solution to finding the proper size and shape. Cracks that lead to silver streak and moisture defects also can reduce. The crack is inspected and the mould is replaced or repaired. If the crack is small it might be possible to weld it for repair. However, it is not advisable to run mould that has been cracked and welded due to the tempering effect that takes place during welding. If this is not possible a new mould may be required.

For excessive moisture, the proper drying of the material is ensured. One of the items most frequently overlooked is condition of the desiccant material in the drying unit. This procedure need to be regenerated regularly. The setting of drying condition and any blockage of the air flow on the unit is checked regularly. If there is any blockage, dry air is not being swept over the material being dried and moisture is not being picked up.

As for scratches, the operator need to aware about the condition packaging and follow the work instruction. They also need to have a good attitude and pay full attention towards their work instead of having a skill or knowledge on negating. In material factor, packaging component need to be properly and must have correct design or requirement. The machine must be clean and the packing process must be correct. The work instruction and method of handling part need to be followed properly (Mohd, et al. 2001).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

In this chapter, the conclusion of findings and some recommendation or suggestion related to this research is done. Since the data resulted is gathered and being analyze in previous chapter and some discussion then come out with the overall conclusion and recommendation that suitable for the selected company to be implemented in future.

5.2 CONCLUSION OF FINDINGS

A few of the Statistical Process Control (SPC) tools had been used in this research. Pareto diagram and Cause-and-Effect diagram has a big role in this study which Pareto diagram found the trend of the defects which are ranked from highest to lowest. Since the defect trend is identified, Cause-and-Effect diagram is used to find the causes of the defects. There are five types of main factors that have been discussed that are man, method, machine, mould and material. These five main factors are helped a lot in this research as the problem is determined and analyze.

The overall defect rate from January to June has been discussed in Chapter 4. In this graph, some information is gained. The company has target for each month which is 3% but the defects rate for each month never exceed that target. Roughly, the overall defect trend can be determined through this analysis. The total defects for each month keep increase and decrease unevenly and among this 6 month, April has the highest total amount of defects.

Phone casing produced by this company has defect problems. Through the Pareto diagram, the defect trend for six month is identified. Short mould defect is ranked first while silver streak and moisture in second ranked. Third ranked is black dot and contamination and fourth rank which is lowest defect rate is scratches. Pareto diagram help the company to identify which problem should have more attention.

From each month analysis, the defects problem faced by this company can be detected. Pareto diagram shows the trend for each month and mainly short mould is ranked in first except in May. This shows that the main defects problem is short mould. The amount of this defect also is higher than other defects which may lead to loss and waste. In May, a silver streak and moisture defect is ranked first while short mould is ranked third. The company should think wisely about the improvement plan to improve their product as these defects will affect their image too.

Cause-and-Effect diagram determined the causes of each defects to occur. In this analysis, the five main factors which are man, method, material, mould and machine contribute a lot to the occurrence of this defect. The unskilled technician and operator's bad attitude towards their duty will only cause the production to have a problem that is not only involved in quality but also the production itself.

This company should aware about the parameter settings. The injection pressure, mould temperature, and injection speed that are set in improper setting will cause defects to occur. This parameter occupies a lot in all defects problem. In short mould, the injection pressure need to be set properly it can cause the product to incomplete. The flow of the material should be balanced to ensure that short mould will not occur due to these causes. Mould temperature also needs to set up properly which it may cause the silver streak and moisture defects.

In addition, the machine cleanness should always be monitored. As the machine is dirty, the product produces will end up with defects. Black dot and contamination is one of these results. The screw and barrel cleaning also lead to these defects. Aging machine which causes the machine fail in operation will disturb the process and lead to defect occur. Machine that always start up also cause the defect to occur.

As the causes have been detected, some improvement plan can be done. Through the research from previous study, improvement plan is necessary and it work which the defects are reduced while they implemented the plan well. The company also have their own improvement plan but their plan did not result better. The defects keep changing unevenly and sometimes it become worse. This plan include all the main factors as these main factors which contribute a lot to the defects problem can help in reducing defect rate if these factor defects is improved well.

The conclusion is the defect problems that occur in this company is detected which one is the highest and need an improvement quickly as this problem become worse from time to time. Instead of focus on defect problems, the other defects should also give an attention as it can cause the product to be rejected and waste occur.

5.3 RECOMMENDATION

After analysing the data and doing some research in this problem, some recommendation can be made. This recommendation can be implemented also or the company can use it as a lesson learned in improving their product defects.

Company should be more disciplined and all operators must go through some simple training especially on how to handle parts to avoid defect caused by human handling. New operator must be trained to handle part properly. Work instruction sheets can be used as a guide for the proper work method.

Machine must have a daily check sheet and machine operator must check the machine condition for every shift to confirm that the machines are in a good condition. The machine's pressure, temperature, and speed must be accurate to avoid defects to occur. Mould must always in be in a good condition and free from any dirt or dust that also may cause the occurrence of defects.

The material should be fed enough to avoid short mould. Ensure the flow of the material is smooth and balanced and there is no blockage which may cause defects. The regularly machine checked is important to ensure the machine is ready to start the process. The operator should check the air trapped in the machine well. The proper drying of material is needed.

Besides that, the management should also involve in improving the quality of the product. Standard operating procedure (SOP) should be applied in working environment as it can help a lot for operators to understand well the procedure of using a machine and some silly mistakes can be prevented. Machine setup procedure contributes need the regularly check up so that it can be better to reduce the defects.

Therefore, the quality tools and regularly monitoring the process is very important to ensure the product produced did not end up with defect. As if there is a defect, it should be prevented early before the defects become worse.

5.4 CONCLUSION

The research has achieved its stated objectives; however, much further research needs to be carried out. Hopefully, this present work will contribute to the enrichment of knowledge related to injection moulding defect and benefits to the industry to continuously improve their product quality using quality improvement tools.

REFERENCE

Akbarzadeh, A., Sadeghi, M. (2011). Parameter Study in Plastic Injection Moulding Process Using Statistical Methods and IWO Algorithm. *International Journal of Modeling and Optimization*. 1(2).

Akinbiola, O.O. (2003). *Quality Data Analysis and Statistical Process Control (SPC) For AMG Engineering and Inc.*

Alexander, K.O. (2005). *Evaluation of a Short-Run Injection Moulding Process with Somos Nanoform 15120 Tooling*.

Bagchi, T. (1997). Total Quality Management: Tools and Accessories. *IE (1) Journal.*

Bharti, P. K., Khan, M. I, and Singh, H. 2011. Six Sigma Approach for Quality Management in Plastic Injection Moulding Process: A Case Study and Review. *International Journal of Applied Engineering Research.* **6**(3): 303-314.

Besterfiled.D.H. 2009. *Quality Control.* Eighth Edition. New Jersey: Pearson Education.

Bochiaga, E., Jaruga. T., Lubazyka, K., Gnatowski, A. 2010. Warpage of Injection Moulded Parts as the Result of Mould Temperature Different. *International Scientific Journal. 44*(1): 28-34.

Chan, T. S., Sha'ri, M.Y. (2009). Quality Improvement Using Taguchi Method In A Manufacturing Company. *Jurnal Mekanikal.* (28): 44-56.

Chen, W.C., Fu, G.L., Tai, P.H., Deng, W.J. (2008). Process Parameter Optimization for MIMO Plastic Injection Moulding via Soft Computing.

Dow Chemical Company ("Dow"). 2009. *Injection Moulding Processing Guide.* (online) http://msdssearch.dow.com/PublishedLiteratureDOWCOM/dh_0234/0901b8038023408c.pdf?filepath=infuse/pdfs/noreg/788-09201.pdf&fromPage=GetDoc. March 2009.

Gebus, S. (2000). Process Control Tool for a Production Line at Nokia.

Hairulliza, M.J., Ruzakkiah, J., Genesan, D. (2011). Quality Control Implementation in Manufacturing Companies: Motivating Factors and Challenges.

Hikmat, R. and Mukattash. A. 2010. Statistical Process Control Tool. *Journal of Mechanical and Industrial Engineering.*4(6).693-700.

Injection Moulding Troubleshoot. (2009). Retrieved from http://www.kenplas.com/service/imtroubleshooting.aspx#Splay Marks, Silver Streaks . 10 October 2013.

Injection Moulding. Retrieved from http://www.ril.com/downloads/pdf/injection%20moulding.pdf . 15 October 2013.

Jafri, M.R., Teng, C.K. (2000). Statistical Process Control (SPC) Applied in Plastic Injection Moulded Lenses.

Kuriakose, S., George, S.K., Mathew, D.V. (2012). Study of Moulding Defects in Automobile Relay Cover. *International Journal of Engineering and Innovative Technology.* 2(6).

Leachman, R.C. (2011). Statistical Process Control.

Leavengood, S., and Reeb. J. 1999.How and why SPC works?.*Performance Excellence in the Wood Industries.*

Lenz, J. Enneti, R.K., Park, S.J., Atre, S.V. (2013). Powder Injection Moulding Process Design for UAV Engine Component using Nanoscale Silicon Nitride Powder. *Ceramics International.* 40: 893-900.

Montgomery, D.C. 2005. *Introduction to Statistical Quality Control.*5^{th} ed. John Wiley, New York.

Nazri, N. (2009). Sink Mark Defect on Injection Moulding Using Different Raw Material.

Noakes, C.J., Gaskell, P.H., Thompson, H.M., Ikin, J.B. (2002). Streak Line Defect Minimization in Multi-Layer Slide Coating System. *Institution of Chemical Engineer.*

Noodin, M.H. 2009.*Sink Marks Defect On Injection Moulding Using Different Raw Materials.*

Oakland, J.S. 2003.*Statistical Process Control.*5^{th} ed. Burlington. British Library Cataloguing.**9**(1): 31-48.

Ozcelik, B., Ozbay, A., Demirbas, E. (2010). Influence of Injection Parameters and Mold Material on Mechanical Properties of ABS in Plastic Moulding Injection. *Internal Communication in Heat and Mass Transfer.* 37: 1359-1365.

Rajalingan, S., Bono, A., Jumat, S. (2012). Identifying The Critical Moulding Machine Parameters, Affecting Injection Moulding Process by Basic Statistical Process Control Tools. *International Journal of Engineering and Physical Science.* (6).

Reliance Industries Limited. 2000. *Injection Moulding.* (online). http://www.ril.com/downloads/pdf/injectionmoulding.pdf. 5 May 2013.

Sinha, A.K. Bohn, P.D. (1991). Defects and Distortion in Heat-treated Part. *ASM Handbook.* 4 : 601-619.

Sharat, M.A.E, Rashed, H.I, Khabeery, M.M.E. (2006). Statistical Process Control Charts Applied to Steelmaking Quality Improvement. *Quality Technology and Quantitative Management.* 3(4): 473-491.

Susanwari, S. Sirovetnukul, R. (2013). The Defect Reduction in Injection Moulding by Fuzzy Logic based Machine Selection System. *World Academy of Science, Engineering and Technology.* (74)

Wang, X., Zhao, G. (2013). Research on The Reduction of Sink Mark and Warpage of The Molded Part in Rapid Heat Cycle Moulding Process. *Material and Design.* 47 : 779-792.

Wilkinson, R., Poppe, E.A., Schimer, K. (2010). Engineering Polymer : The 'Top Ten' Injection Moulding Problem.

Woodall, H.V. (2000). Controversies and Contradictors in Statistical Process Control. *Journal of Quality Technology Session.*

APPENDIX A

FYP 1 GANNT CHART

			SEMESTER I															
			FEB				MARCH				APRIL				MAY			
NO	RESEARCH ACTIVITY		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	Identifying topic of research	Estimate																
		Actual																
2	Preparation of finding journal	Estimate																
		Actual																
3	Introduction	Estimate																
		Actual																
4	Problem background	Estimate																
		Actual																
5	Research objective	Estimate																
		Actual																
6	Significance of study	Estimate																
		Actual																
7	Operational definition	Estimate																
		Actual																
8	Expected result	Estimate																
		Actual																
9	Literature review	Estimate																
		Actual																
10	Ability of construct a suitable research methodology	Estimate																
		Actual																
11	Check report	Estimate																
		Actual																
12	Submit report	Estimate																
		Actual																
13	Presentation	Estimate																
		Actual																

APPENDIX B

FYP 2 Ghant Chart

MONTH		August				September				October				November				December			
WEEK / ACTIVITY		1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Approach Company	Estimate																				
	Actual																				
Visit Company and receive responses	Estimate																				
	Actual																				
Data Entry and Analyzing Data	Estimate																				
	Actual																				
Write the Report Chapter Four: Results and Findings	Estimate																				
	Actual																				
Write Report Chapter Five: Conclusion and recommendation	Estimate																				
	Actual																				
Compile and Submit Report	Estimate																				
	Actual																				
Presentation FYP 2	Estimate																				
	Actual																				

APPENDIX C

INTERVIEW PROTOCOL

These questions are designed and will be asked during the interview with the respondent from the company. Research objective have been applied in designing these question.

Respondent Name:

Position in Company:

STAGE	NEEDED INFORMATION	INTERVIEW QUESTIONS
Introduction	- Respondent background - Experience - Responsibility - Product background	• How long have you work in this company? • What is your responsibility in your company? • What are the product produce by your company?
Objective 1 To Identify Types Of Defect In Phone Casing Moulding Operation.	- Types of defect that occur in production - Type of defect that affect most of the product - Types of defect that need a serious precaution	• What types of common defect that often occur in production? • What types of defect that has the highest amount for past 6 month? • Did the company aware about this problem?
Objective 2 To Investigate The Causes Of Each Types Of Defect	- The cause of defects to occur - Who responsible for it? - Explain on how the defect can occur - Quality of product issue in the company - Material used is relevant or not	• What are the causes of these defects to occur? • How your operators or staff attitude while they are on duty? • What material used to produce this product? • Did the supervisor monitor the operator's work performance? • What are the causes of defect that affect most on product? Is it the machine problem or any other reason behind this defect

		problem to occur?
Objective 3 To Recommend Improvement Plan For Reducing The Defect Rate	- Action taken by the company - Effective or not the improvement plan done by the company	• Is there any improvement plan done by the company? • Is the defect rate decreased after applied the improvement plan? • How your company manages this problem as the improvement plan did not work well? • Is there any method used to maintain your product quality?
Conclusion	- To conclude all the needed information from the company	• Can you conclude about this defect problem? • What is your opinion on your quality of product? • Is there any complain from your customer about your quality of product? • If there any complaint, how do you manage it?