APPLICATION OF 7QC TOOLS TO ANALYZE DEFECT REDUCTION AT A REMANUFACTURING COMPANY

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BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY (PROCESS AND TECHNOLOGY) WITH HONOURS

2022

Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Manufacturing Engineering Technology (Process And Technology) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this Choose an item. entitled “Application Of 7QC Tools to Analyze Defect Reduction at A Remanufacturing Company” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Ainur Natasha Binti Azmi

Date : 26/1/2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology (Process And Technology) with Honours.

Signature :

Supervisor Name : Ts.Dr.Mohd Soufhwee Bin Abd Rahman

Date : 27/JAN/2023

DEDICATION

Especially glad and thankful to Allah swt for his compassion and love. I would like to express my greatest appreciation and gratitude to everyone who has provided me with support, encouragement, and advice, especially my parents and family. Ts.Dr. Mohd Soufhwee Bin Abd Rahman, who provided moral support, adequate guidance, and served as an inspiration in completing the project. Not forgetting the classmates and friends from Universiti Teknologi Malaysia Melaka (UTeM) who assisted both directly and indirectly in the preparation of this report. Thank you to the team at Motor And Technology Sdn.Bhd. (MTI) who assisted and provided information, advice, and helpful guidance.

ABSTRACT

Quality has an important role in the business process across the entire organization. A lot of literature has been published on the effective application of 7QC tools concept in productivity,quality improvement and defect rejection. The 7Quality Control (QC) tools are simple statistical tools used for problem solving. However, In this work, a case study to resolve current situation in remanufacturing industry using 7QC tools was necessary apply into it. Most of the company doesn`t applied appropriate technique to solve the problem which gives an optimum result to the company. In this study, author an investigate of dimension out defect of connecting rod and data has been collected from inspection data. The application of 7QC tools which are flow chart, check sheet, pareto chart, cause, and effect diagram, scatter diagram and control chart with PDCA method (Plan, do, check, Action) have been developed and implemented in remanufacturing company. I investigate and analysis techniques used using the combination of 7QC tools with PDCA to resolve the problem of connecting rod defect. This cycle is used in different cases for continuous improvement or any change. It used also for quality problem solving, and this is what we will address in this research. PDCA cycle is an iterative four steps managing technique, The Plan phase consisted of investigating problem which using flowchart. The Do phase consisted of process analysis using check sheet, pareto diagram and cause and effect diagram. The result evaluation was verified in Scatter diagram and control chart in Check phase. The final phase act where decision making was made either the process can be remanufactured or rejected by Cpk value. From the method merged of 7QC tools with PDCA, it indicates a decision making where Cpk used as indicator either the process can proceed to remanufactured in the next process or rejected. Cpk value illustrate the process is capable where $Cpk > 1$, and vice versa. Hence, the outcome of this research, The significant QC tool has been studied and suggested in a remanufacturing process. The validation of QC tool has been establish and 6 tools of 7QC have been applied in the case study. The author offers significant tools with the PDCA concept and Cpk has been proposed as an indicator of decision making in the remanufacturing process and the process showing that the process was capable.

ABSTRAK

Kualiti mempunyai peranan penting dalam proses perniagaan di seluruh organisasi. Banyak literatur telah diterbitkan mengenai aplikasi berkesan konsep alat 7QC dalam produktiviti, peningkatan kualiti dan penolakan kecacatan. Alat 7Quality Control (QC) ialah alat statistik mudah yang digunakan untuk menyelesaikan masalah. Walau bagaimanapun, Dalam kerja ini, kajian kes untuk menyelesaikan situasi semasa dalam industri pembuatan semula menggunakan alat 7QC adalah perlu digunakan ke dalamnya. Kebanyakan syarikat tidak menggunakan teknik yang sesuai untuk menyelesaikan masalah yang memberikan hasil yang optimum kepada syarikat. Dalam kajian ini, penulis menyiasat kecacatan dimensi keluar rod penyambung dan data telah dikumpul daripada data pemeriksaan. Aplikasi alat 7QC iaitu carta alir, helaian semak, carta pareto, rajah sebab dan kesan, rajah serakan dan carta kawalan dengan kaedah PDCA (Rancang, lakukan, semak, Tindakan) telah dibangunkan dan dilaksanakan dalam syarikat pembuatan semula. Saya menyiasat dan menganalisis teknik yang digunakan menggunakan gabungan alat 7QC dengan PDCA untuk menyelesaikan masalah kecacatan rod penyambung. Kitaran ini digunakan dalam kes yang berbeza untuk penambahbaikan berterusan atau sebarang perubahan. Ia juga digunakan untuk penyelesaian masalah yang berkualiti, dan inilah yang akan kami tangani dalam penyelidikan ini. Kitaran PDCA ialah teknik pengurusan empat langkah berulang, Fasa Rancangan terdiri daripada menyiasat masalah yang menggunakan carta alir. Fasa Do terdiri daripada analisis proses menggunakan helaian semak, rajah pareto dan rajah sebab dan akibat. Penilaian keputusan telah disahkan dalam gambar rajah Scatter dan carta kawalan dalam fasa Semak. Tindakan fasa terakhir di mana keputusan dibuat sama ada proses boleh dibuat semula atau ditolak oleh nilai Cpk. Daripada kaedah penggabungan alat 7QC dengan PDCA, ia menunjukkan pembuatan keputusan di mana Cpk digunakan sebagai penunjuk sama ada proses itu boleh diteruskan untuk pembuatan semula dalam proses seterusnya atau ditolak. Nilai Cpk menggambarkan proses itu mampu di mana $Cpk > 1$, dan sebaliknya. Oleh itu, hasil penyelidikan ini, Alat QC yang penting telah dikaji dan dicadangkan dalam proses pembuatan semula. Pengesahan alat QC telah diwujudkan dan 6 alat 7QC telah digunakan dalam kajian kes. Penulis menawarkan alat penting dengan konsep PDCA dan Cpk telah dicadangkan sebagai penunjuk membuat keputusan dalam proses pembuatan semula dan proses yang menunjukkan bahawa proses itu boleh diteruskan.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First and foremost, I would like to thank and praise Allah the Almighty, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to the Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform and financial assistance.

My utmost appreciation goes to my main supervisor, Ts.Dr.Mohd Soufhwee Bin Abd Rahman for all his support, advice and inspiration. His constant patience for guiding and providing priceless insights will forever be remembered.

Last Lastly, from the bottom of my heart, I would like to thank my beloved parents Azmi Bin Khamis and Zainah Binti Mansoor for their support and who have become the pillar of power in all my efforts. My everlasting gratitude to all my brothers and sister for their courage and understanding. Ultimately, thank you to all the individuals who have given me the encouragement, guidance, and motivation to continue my studies.

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LIST OF SYMBOLS AND ABBREVIATIONS

QC	-	Quality Control
SOP	-	Standard Operating Procedure
PDCA	-	Plan, Do, Check, Action
CPK	-	Process Capability Index
DIR		Drop Impact Resistance
KBS	-	Knowledge-Based System
L6s	-	Lean Six Sigma
IMD	-	In-Mould Decorating
DMAIC	-	Define, Measure, Analyze, Improve, And Control

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CHAPTER 1

INTRODUCTION

1.1 Background

The Massachusetts Institute of Technology initiated research on the recycling of waste materials in the late 1970s. In the 1980s, the United States proposed "remanufacturing" to refer to the renovation or regeneration of waste items (Xu, 2013). In 1861, the first known instance of remanufacturing occurred during the conversion of a steam frigate into an ironclad vessel. During World War II, however, the United States and the United Kingdom were able to implement remanufacturing on a wider scale. At the time, none of these countries had started automobile revolution and all of their factories were making war supplies. Then, remanufacturing was frequently employed to keep obsolete automobiles functioning (Steinhilper and Brent, 2008).

Remanufacturing is typically more labor-intensive than repairing or reconditioning. As a result, its outputs are generally of higher quality and performance. Since the process involves more work, the quality and performance of remanufactured products are higher than those of repaired or reconditioned products. When a product is made, all of its parts are checked, and product that can't be repaired are replaced with new ones. This means that the product might not be the same anymore. But in remanufacturing, the products are reconditioned, they keep their original product with new quality. Remanufacturing is the process of taking things apart, cleaning, fixing, or replacing parts, and then putting them back together in good shape. It is a process that repeats itself by making products that look and work just as well as the originals.

The PDCA cycle, also called the Deming cycle or Shewhart cycle (Jagtap and Teli, 2015), is a lean manufacturing system developed in 1930, the PDCA cycle became a widespread framework for constant improvements in manufacturing, management, and other areas. (Juran, 1973). However, In the 1950s, William Edward Deming created this widely-used strategy. PDCA was originally used to control product quality. It quickly became a method for improving organisational processes. Nowadays, PDCA is a logic programme that improves activities through a continuous improvement strategy.

Quality plays crucial part in operations of the entire industry in order to be efficient and productive. Hence, improving the quality and productivity of a product or process is essential for any company to succeed in a competitive market. This study evaluate the application of quality control tools in the remanufacturing industrial of engine component as well as minimizing defects by determining the highest rejection parameter occurs and systematically resolving the issue.

According to the American Society for Quality (2016), quality control comprises the processes and procedures that are utilised to monitor and fulfil quality requirements. Aside from that, in today's difficult world, every organisation should use the right tools to improve productivity. Customers also benefit directly from these problem-solving tools because they make it easier to make high-quality products with fewer flaws, which saves money and time. 7QC tools for quality control have helped people realise that they can help develop and solve operational problems quickly.

1.2 Problem Statement

In today's highly competitive global economy, it can be challenging for manufacturers to maintain a competitive edge. Numerous companies are looking for innovative methods to enhance the quality and productivity of their supplies. Enhancing productivity is always the primary issue in company because it has a direct effect on profitability. Specifically, Motor Teknologi & Industri Sdn Bhd (MTI) was implement a 7QC tools, but it not quite organize and having high rejection or waste in the production processing line. The company is having problems with the dimensions out of an engine part which is connecting rod. Besides, this remanufacturing company want to enhance solutions for solving quality problem in the remanufacturing company's process by utilisiing 7QC tools with a PDCA approach.

1.3 Research Objective

The purpose of this research is to improve manufacturing processes by using the 7 quality control tools in order to reach the highest quality and solve the problem of improving manufacturing performance. Specifically, the objectives are as follows:

a) To study the significant of 7QC tools in a remanufacturing process.

b) To recommended the significant tools in remanufacturing process based on PDCA approach.

c) To validate the recommended tools based on Cpk index for decision making in remanufacturing process.

1.4 Scope of Research

The scope of this research is to applied the 7QC tool in the remanufacturing company and solving the defect issue of the engine part. The project scopes are mainly focused on tools and techniques of 7QC tools and PDCA approach as a improvement. Then, standardizing of 7QC tools in remanufacturing company where applying a properly step on technique used and evaluate which tools are contribute among all the 7QC tools. Futhermore, suitable quality tools used to decide which tools are affected by the most defect rejection that occurs in remanufacturing companies. This case study will investigated in remanufacturing company. The Cpk value as a decision making to know the acceptance condition either the process is capable continue to the next process of remanufacturing or rejected.

1.5 Summary

In this chapter, summary of the entire research project is discussed, with an emphasis placed on the problem statement, research objective, and the scope. The defective in the remanufacturing industry serves as the basis for the investigation into the problem statement. In addition, the solution to the problem statement is included into the development of three of the objectives. Based on the literature review and other online resources, the researchers expect that 7QC tools are very useful and have an impact on quality activities. The use of 7QC tools can implement the concept and approach to tackling quality issues in the remanufacturing industry.

Based on this project, data is collected in a remanufacturing company as proof of data collection. Hence, the tools are usually used as individuals, so the combination of 7QC tools through PDCA are developed to enhance the inspection process in remanufacturing or to standardized the inspection process of remanufacturing process.As a result, not all of the 7QC tools are implemented completely. Relevant tools are used for this project and the cpk value is used to know the process capability.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter elaborates on 7QC definitions, concepts, utilization, as well as an understanding of the existing research on this theme. The goal of this section is to ensure that this research is still relevant and to evaluate what authorised researchers have published on a subject. Moreover, this section contains information on quality control tools used to reduce defects in manufacturing companies. Besides, this chapter indicates the gaps between previous studies and what could be investigated further. Hence, it also highlights and contains all of the history, information, concepts, ideas, and approaches for developing and solving operational problems efficiently using quality control tools.

2.2 Quality Control

Quality refers to providing value for the customer, or, in other words, supplying product or service conditions that meet the customer’s expectations. According to Raut and Verma, (2017), quality also considers the minimization of waste that a product may contribute to the environment or human society while allowing the manufacturing company to keep customer loyalty and controls to help standardize both production and quality-related issues. Testing units and ensuring they meet the criteria for the final product is what quality control is all about. The inspection will determine whether any corrective actions in the manufacturing process are necessary. Industries with strong quality control are better equipped to meet their customers' demands for high-quality products.

2.3 History of Quality

Following the entry of the United States into World War II, a law was established to assist in the conversion of the civilian sector to military manufacturing. Quality became a crucial element of the entire war and a significant safety concern during this time. Walter A. Shewhart, the organization's first honorary member, successfully integrated the fields of statistics, engineering, and economics, and was later dubbed the "Father of Modern Quality Control" (Jadhav et al., 2014) .The control chart is the most well-known of these, a basic but highly useful tool that Shewhart called it "the development of a scientific basis for controlling the economy." His main work, Economic Control of Quality of Manufactured Products, was published in 1931 and is widely thought to be the best book on quality control methods (Shewart,1931).

2.4 Quality Gurus

Quality gurus are people who specialise in this field and know how to use their skills and experience to modify what needs to be improved. They are people who bring new ideas to the organisation, change it to fit the time in which they live, or even lead it to move forward. Quality can be defined in the field of administration as the process of improving the management that must be carried out to achieve optimal performance (Bendell et al., 1995).

One of the fathers of total quality, Edwards Deming, proposes new ways to measure it. Mr Edwards deming aimed to increase customer satisfaction by offering products at the lowest possible price. According to deming, this resulted in the company ceasing to innovate and improve. In one of his 14 points, deming stated that quality, rather than quantity, should be the foundation of business performance. To improve production data and thus identify errors quickly, it was based on statistical methods.

Next, The theories of Philip B. Crosby, such as "zero flaws" and "taking advantage of the day," are well-known in the business community. Philip crosby's theory is based on the idea that failures in business can be attributed to ineffective management rather than bad employees. According to him, there are four main points that should be considered when trying to achieve the desired level of quality in administration. These are: "Quality is defined as compliance with specifications," "the quality system is prevention," "the execution standard is zero faults," and "the price of compliance is the measurement of quality." From there, he developed a quality-improvement methodology consisting of 14 steps (Godina et al., 2016).

After that, Kaoru Ishikawa, The Japanese Ishikawa is recognised for using statistics to simplify quality control processes. To accomplish this, he created the cause-and-effect diagram that reflects his nick name. He believed that the aim of quality should extend to sales departments and personal lives of all employees. Three points may be highlighted to summarise its philosophy, which is as follows: Controlling quality entails carrying out necessary tasks. Quality control begins and ends with training at all levels, and appropriate corrective actions must be implemented on a continuous basis.

Furthermore, Juran Joseph was raised in Romania and worked in Japan during his career. It defines quality in a variety of specific ways. Two of these are critical for businesses: completeness and adaptability to intended use. Quality planning is one of the program's three critical components of a quality improvement programme, and it is one of the most important. Controlling and improving the product's quality are two important goals.

Genichi Taguchi, a Japanese engineer and statistician was recognized for developing a strategy to increase product quality. To achieve this, they used data to determine which areas or methods needed to be improved. It was necessary to observe the entirety of a product's manufacturing process, from design to delivery to a customer. Taguchi invented the loss function, which enabled him to evaluate the quality of any product by calculating the societal loss it would cause over its useful life.

Individuals identified as quality gurus have made a significant contribution to the improvement of the quality of goods and services (Neyestani, 2018). The six quality gurus summarize their major contributions are highlighted in Table 2.1.

Table 2.1 Quality Gurus and Their Major Contribution

Quality Guru	Major Contribution
Walter A. Shewhart	Aided in the comprehension of process variability and the author created a statistical control chart concept.
W. Edwards Deming	Developed "14 Points" to assist businesses in improving their quality.
Joseph M.Juran	Developed quality cost concept
Philip B. Crosby	The author coined the phrase "Quality is complimentary" and created concept of zero defect.
Kaoru Ishikawa	Created a cause and effect diagram and recognized the concept of "internal customer"
Genichi Taguchi	Concentrate on the quality of product design and develop the Taguchi loss function.

2.5 Remanufacturing Process

An end-of-life "core," as it is known internationally, undergoes a variety of industrial operations, involving inspection, disassembly, cleaning and inspection, part restoration and replacement, cleaning, reassembly, and testing, in order to be remanufactured to satisfy the exact same product standards as a brand-new one (Shewart,1931). Figure 4.4 demonstrates the primary industrial and operational processes.

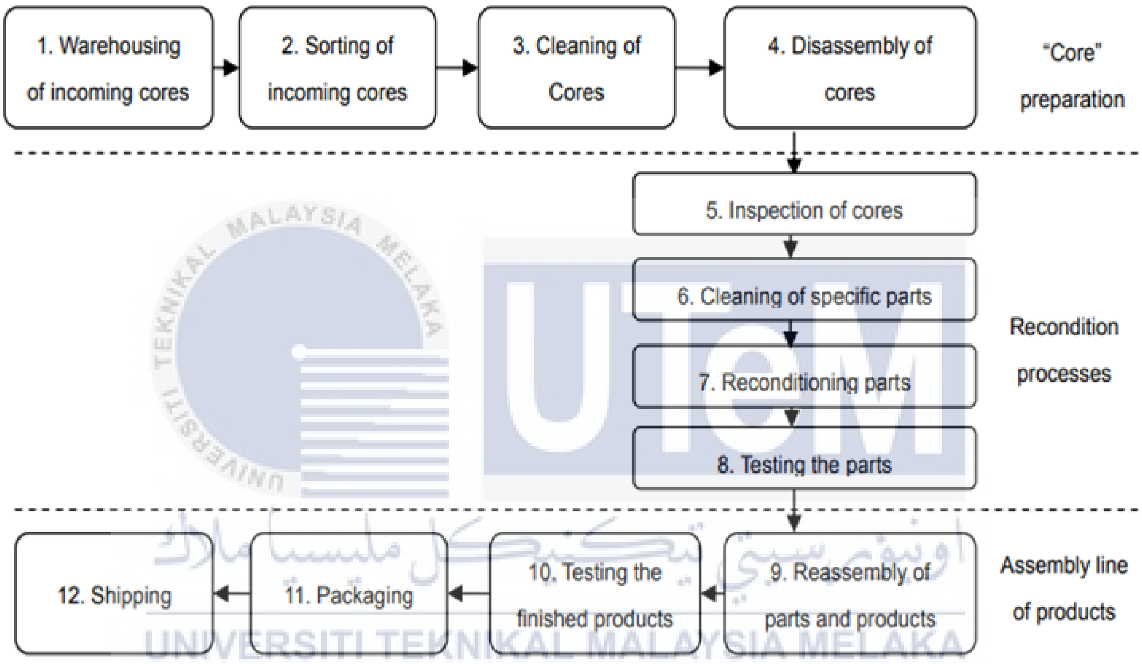


Figure 2.1 Twelve Main Processes in General Remanufacturing Process (Shewart,1931)

2.5.1 Process Flow

Referring to Figure 4.5, the process of remanufacturing typically includes the following essential stages: inspection/grading, disassembly, component reprocessing, and reassembly/testing of the finished product. Figure 4.4 shows general remanufacturing process and material flows.

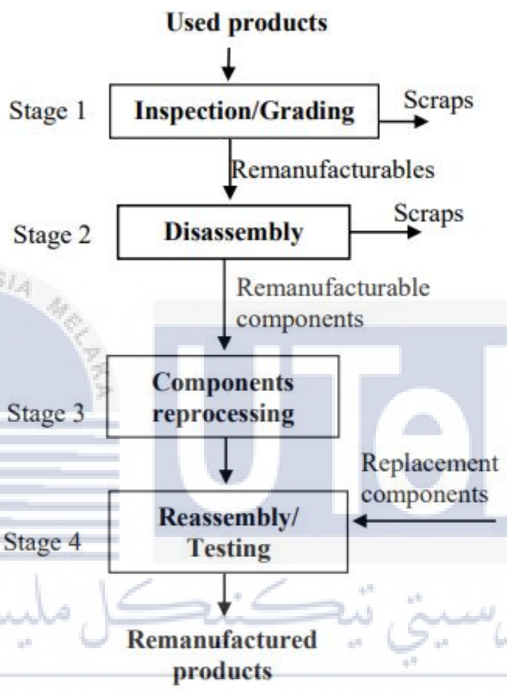


Figure 2.2 Remanufacturing Process and Material Flow (Shewart,1931)

2.5.1.1 Inspection/ Grading

Throughout this phase, the remanufacture ability of used products is determined depending on their quality condition. This process often entails a comprehensive visual inspection, with inspection times being equal for used products of the same type and source. Additionally, used products obtained from the waste stream are likely to necessitate a lengthy examination period and specialised inspection equipment.

2.5.1.2 Dissambly/Inspection Process

An item that can be remanufactured is disassembled into its components, which are subsequently separated into their individual components. The disassembly of complex used products may necessitate the employment of robotic arms, although general-purpose tools, such as power drills, are frequently employed. Disassembly times for identical remanufacturables are equal independent of origin or quality level. In general, the time required to disassemble a product is proportionate to its structural complexity.

2.5.1.3 Reprocessing of Remanufacturable Constituent Components

This process typically entails cleaning, repairing (e.g., machining worn-out holes), and surface finishing to restore components to their original state. The component's quality group significantly determines the number of operations and length of time required to reprocess each component to its initial state.

2.5.1.4 Reassembly

Assembling component parts into remanufactured items with a simple structure frequently requires the use of general-purpose tools. Remanufacturing objects with complicated structures may necessitate the use of robotic arms to reassemble component parts. The initiation of the reassembly process is greatly influenced by the completion of the preceding processes, i.e., the reassembly process does not begin until all relevant components (reprocessed and new) are available.

2.5.2 Engine Remanufacturing

Engine remanufacturing is the process of making a used engine work like new again by using precise methods that meet remanufacturing standards. Engine remanufacturing is different from both making new engines and doing a regular engine overhaul. It starts with used engine reverse logistics, using repairable parts as processing objects and going through disassembly, cleaning, inspection, and repair steps. After disassembly and recovery of the product's components, the project resulted with a process that is similar to the original production.

2.5.3 Technical Process of Engine Remanufacturing

As shown in figure 4.5, the technical process flows of remanufacturing a motor include disassembly, classification and cleaning, inspection, repairing, reassembly, etc.

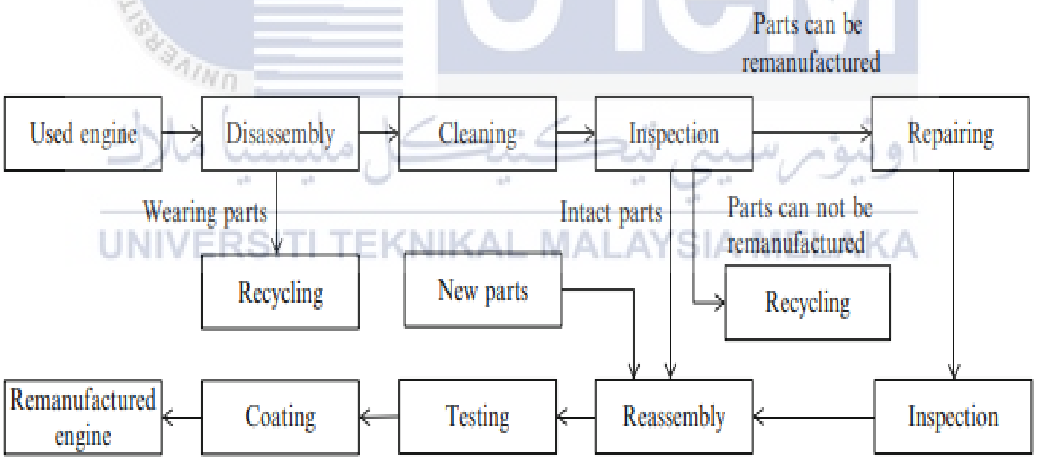


Figure 2.3 Technical Process Flows of Engine Remanufacturing (Neyestani, 2018)

2.5.3.1 Full-Scale Assembly

It is essential to the recovery of resources and products because it allows for the selective separation of required components and materials. During engine disassembly, the piston assembly, main shaft bushing, oil seal, rubber hose, and cylinder head gasket are immediately removed. During reassembly, these components will be replaced with new ones since they cannot be remanufactured or have minimal value for remanufacturing. Figure 4.6 illustrates the engine's key components after disassembly.

Figure 2.4 Major Components After Disassembly (Kholif et al., 2018)

2.5.3.2 Component Cleaning

After disassembly, each part of product is thoroughly cleaned, which includes clearing away the dirt and dust and degreasing, removing oil and grease, removing rust, and removing any old paint. Various cleaning processes, such as pyrogenic decomposition, chemical cleaning, ultrasonic cleaning, and liquid spraying, can be utilised depending on the kind of material and contamination.

2.5.3.3 Inspection and Identification

It is necessary to inspect disassembled and cleaned components to determine their reuse and recondition ability. There are two crucial inspection factors in remanufacturing:

a) Specification of the requirements and conditions attributes that are necessary for determining the state of the components in their entirety.

b) Making and using testing equipment that is both useful and affordable. During inspection, the parts are tested and then sorted into those that can be used again straightaway and those that need to be repaired. For example, the cylinder block assembly, connection rod assembly, crankshaft assembly, fuel injection pump assembly, and cylinder head assembly are prepared for remanufacturing.

2.5.3.4 Remanufacturing Repairable Components

When repairing failure parts, there are a few different approaches and technologies that can be utilised. For example, the application of advanced surface technology in surface dimension restoration can be used to achieve a higher level of performance than the original parts, and the application of mechanical manufacturing technology can be used to reprocess the remanufactured parts in order to meet the assembly tolerance range.

2.5.3.5 Reassembly

Remanufactured components are reassembled into a new product using the same power tools and equipment used in the assembly of new components. The reconditioned engine will then undergo testing, coating, and packaging.

2.6 Background of 7QC Tool

The Seven QC Tools are a group of simple statistical tools that can be used to solve problems and improve the overall quality of the product (Dale et al., 1998). These tools were developed or introduced in Japan by quality gurus such as Deming and Juran. These are the most important in terms of value. Kaoru Ishikawa asserts that these seven tools are capable of resolving 95% of all problems. These instruments were instrumental in Japan's remarkable post-1945 industrial renaissance. Furthermore, it is used to analyze the manufacturing process, detect major issues, control product quality variations, and propose alternatives to avoid future defects. To effectively apply the seven QC techniques, statistical literacy is required. These tools use statistical techniques and knowledge to collect and analyze data. As a result, the seven quality control tools are illustrated in Figure 2.1 below.

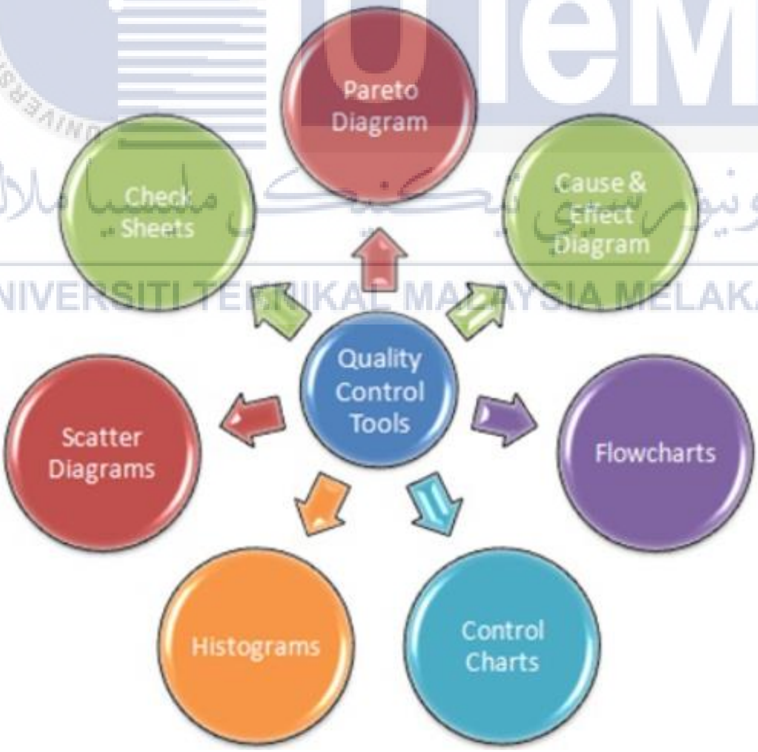


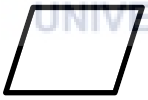
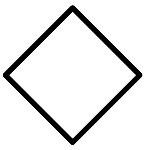
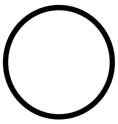
Figure 2.5 Quality Control Tools

2.7 Tools Of Quality

2.7.1 Flowchart

Flowcharts are the most frequently used of the seven quality tools. This tool is used to depict a technique, event, workflow, system, or other sequence of steps. A flowchart not only displays the entire process, but it also highlights the connection between steps and the process from beginning to end. A flow chart is a visual or graphical representation of a process. It can be used to improve understanding and analysis of a process. With the help of a flow chart, it can carry out the workflow sequences for a specific procedure. The flow diagram process cycle time will be reduced, which will benefit workers by allowing them to execute their jobs more efficiently by (Patel et al., 2014).

Table 2.2 Symbol Flowchat

Symbol	Name	Function
	Start/end	An oval represents a start or end point
	Arrows	A line is a connector that shows relationship between the representative shapes.
	Input/Output	A parallelogram represents input or output
	Process	A rectangle represents a process
	Decision	A diamond indicates a decision
	Connector symbol	Usually used within more complex charts, this symbol connects separate elements across one page.

2.7.2 Check Sheet

The check sheet is used to collect, record, and analyse data in real time at the place where the data is made. The check sheet is one of Dr. Kaoru Ishikawa's seven basic tools for making sure quality is good. Also, it can record both quantitative and qualitative information. When there are quantitative on the check sheet, it is sometimes called a "tally sheet." Data collection is the first step in making tools that help improve processes and solve problems. This information should be combined with other quality tools like the Pareto Diagram and histogram. The example of check sheet is represented in Figure 2.2

Defect	Machine 1	Machine 2	Machine 3	Total
Matter cut	376	365	239	980
Improper sealing	227	223	175	625
Printing mistakes on baker card	87	89	53	229
Dust on toothbrush	63	61	33	157
Cross cut	60	63	33	156
Misplacement	16	15	9	40
Absence of nylon wire in hanger	13	15	10	38
Paper damage	15	16	8	39

Figure 2.6 Example of Check Sheet (Akash S Shinde, 2020)

2.7.3 Histogram

Histograms are one of the fundamental quality tools. A histogram is a representation of the estimated distribution of numerical data. Karl Pearson introduced it initially. It is used to visually summarise and depict a process data set's distribution and variation. It was first introduced by Karl Pear-son and he estimated the probability distribution of a variable. A frequency distribution indicates the frequency with which each distinct value in a set of data occurs. A histogram's primary use is to determine the form of a data set (Magar and Shinde, 2014). Figure 2.3 is an example of a histogram.

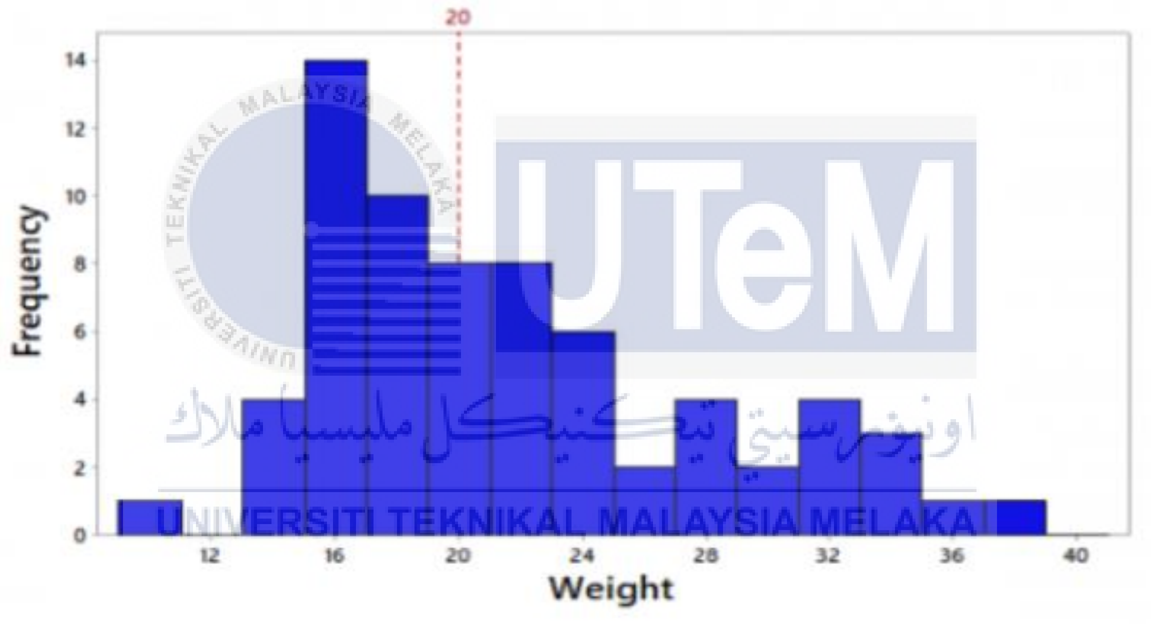


Figure 2.7 Example of Histogram (Magar and Shinde, 2014).

2.7.4 Pareto Chart

A Pareto Chart is essentially an attribute data frequency distribution (or histogram). Vilfredo Pareto, an Italian economist and sociologist who performed a wealth and poverty study in Europe in the early 1900s, formulated the idea. It is made up of "a series of bars, the heights of which reflect the frequency or severity of problems.". From left to right, the bars are organised in declining height order. It is particularly beneficial to identify the components that have the biggest cumulative influence on the system and categorise them according to their weighted effect in order to concentrate on them, referring to a study by (Wilkinson, 2006). Figure 2.4 represents an illustration of a Pareto Chart.

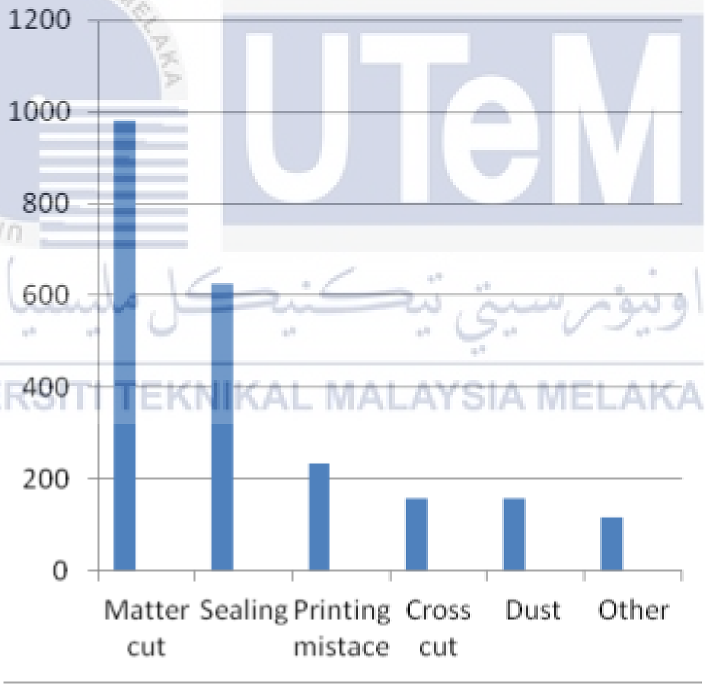


Figure 2.8 Pareto Chart (Akash S Shinde, 2020)

2.7.5 Cause and Effect Diagram

A cause and effect diagram, also known as an Ishikawa diagram or a fishbone diagram, depicts the problems and their underlying causes graphically. This tool illustrates the systematic relationship between an effect's symptom and its potential sources. This instrument was created by Dr. Kouro Ishikawa. Moreover, a cause and effect diagram is an effective tool when utilised by a group or team. Each person may have a few theories regarding the causes, and his thinking is limited to those hypotheses. The brainstorming technique is useful in producing this cause-and-effect diagram since it engages more specialists and helps identify the largest number of causes (Pavletic et al., 2008). An example of a cause and effect diagram is shown in Figure 2.5

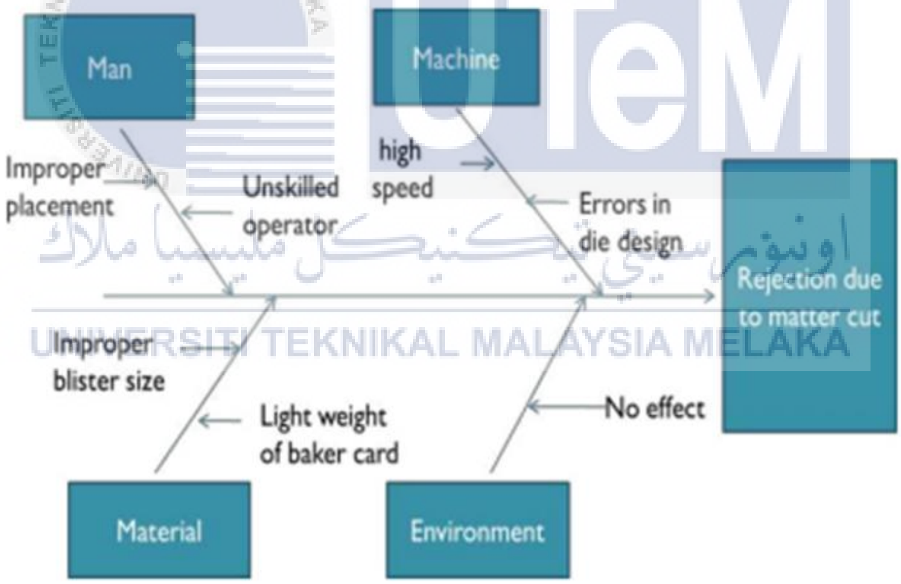


Figure 2.9 Cause & Effect Diagram (Shinde and Patil, 2020)

2.7.6 Scatter Diagram

Scatter diagrams are pictures that are used to figure out how two variables are related to each other. The shape of a scatter diagram shows how two variables are related to each other. There may or may not be a link between the two things. If there is a relationship, it could be positive or negative, strong or weak, simple or complicated. Sparks, (2017) say that one of the two variables is plotted on the horizontal axis, and the other is plotted on the vertical axis. The way the points are spread out in the quadrant shows a lot about how the two variables are related. The English scientist John Frederick W. Herschel in 1833 was the first person to make a scatterplot. When trying to solve a problem, it's important to know how two things are connected. Figure 2.6 Example shows patterns using the Scatter Diagram and its correlation.

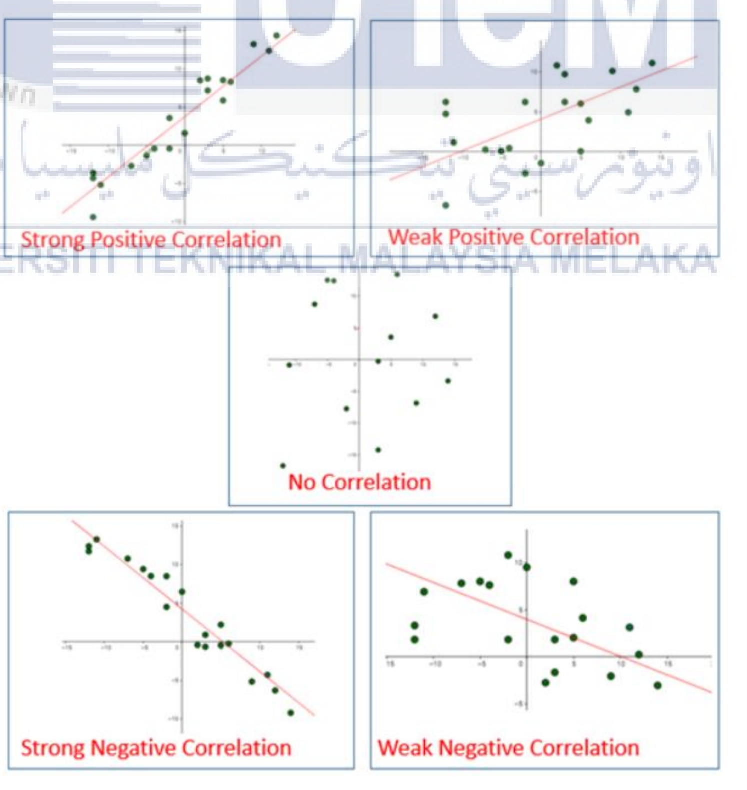


Figure 2.10 Example Shows Patterns Using Scatter Diagram (Sparks, 2017)

2.7.7 Control Chart

A control chart is an essential component of statistical process control because it demonstrates how much variation a system can tolerate. So, it helps to determine if a process operates consistently or if something has altered the process' variation. Dr. Walter A. Shewhart, who worked in the 1920s at Bell Telephone Laboratories, developed the control chart. The Control-Chart is the most essential tool for measuring an organization's performance. The control chart employs the upper control limit and the lower control limit as control limits. According to Nelson (1984), the two primary categories of control charts are variable charts and attribute charts. Variable control charts are applied to measure continuous product qualities, while attribute control charts are utilised to manage qualitative product attributes that cannot be quantified on a numeric scale.

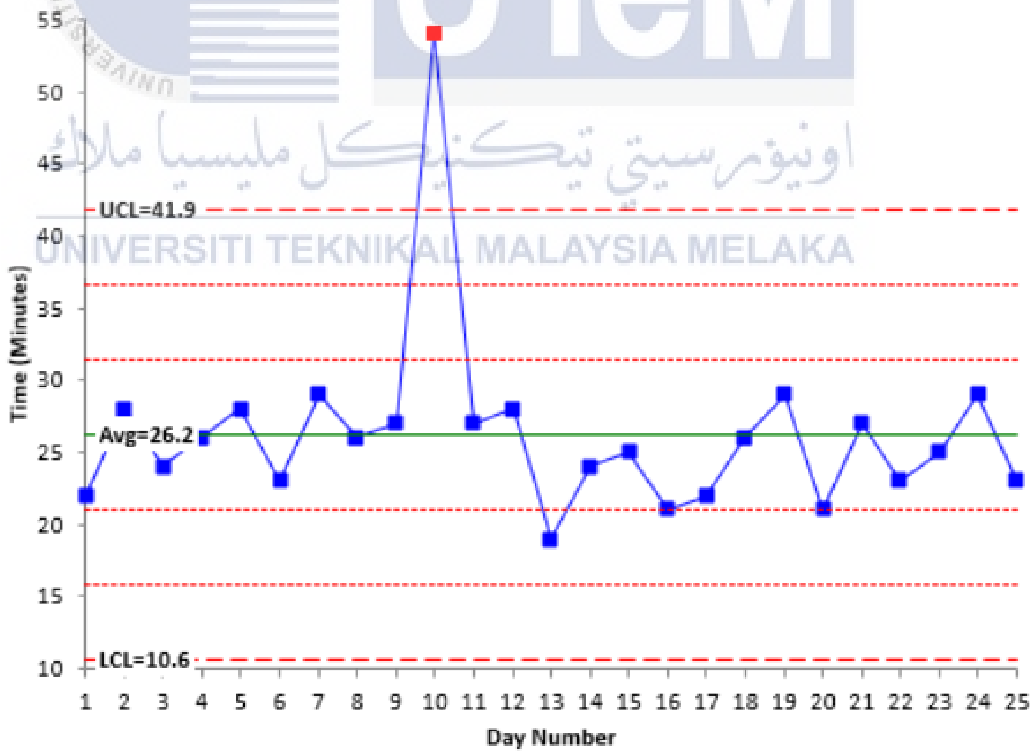


Figure 2.11 Example of Control Chart (Nelson 1984),

2.7.7.1 Control Chart For Variable

Variables control charts are utilised to examine process variance when the measurement is a variable. There are two primary types of variables control charts (x-bar R-chart and x-bar S-chart) that examine sample variation. Non-random patterns (signals) in these charts' data might suggest a possible changes in central tendency between sampling periods. Non-random patterns in the data plotted on the control charts indicate whether the process is under control.

Formula x-bar R-chart:

$UCL_{\bar{X}} = \bar{\bar{X}} + A_2\bar{R}$ $UCL_R = D_4\bar{R}$ .... (1)

$LCL_{\bar{X}} = \bar{\bar{X}} - A_2\bar{R}$ $LCL_R = D_3\bar{R}$ .... (2)

Formula x-bar S-chart:

$UCL_{\bar{X}} = \bar{X} + A_3\bar{S}$ $UCL_S = B_4\bar{S}$ .... (3)

$LCL_{\bar{X}} = \bar{X} - A_3\bar{S}$ $LCL_S = B_3\bar{S}$ .... (4)

Where;

UCL = Upper control limit

LCL = Lower control limit

$\bar{\bar{X}}$ = Average of subgroup averages

$\bar{R}$ = Average of subgroup ranges

$\bar{S}$ = Average of subgroup sample standard deviations

$\bar{X}$ = Average of subgroup

$A_2, D_3, D_4, A_3, B_4, B_3$ = value found in table of factor for computing centre line and three sigma control limits.

2.7.7.2 Control Chart For Attribute

Attribute Control Charts are a collection of control charts made for monitoring of issues (also called non-conformities). p-charts and np-charts are control charts that show the number of nonconforming units. If a unit has one or more flaws, it doesn't meet the standards. The p-chart is used when the data is in subgroups of different sizes. If the data is collected in subgroups that are all the same size, then a np-chart is used. C-charts and u-charts are types of control charts that count the number of defects or things that don't work right with a product. A c-chart has subgroups of the same size, while a u-chart has subgroups of different sizes. Table 2.8 shows that there are four types of control charts for attributes.

Table 2.3 Summary of Types of Attribute Control Chart

Type	What is counted	Sample size
P-chart	Defective items	Varies
np-chart	Defective items	Constant
C-chart	Defects on an item	Constant
U-chart	Defects on an item	Varies

2.7.7.3 Process Capability

Process capability refers to the ability of a process to produce products or provide services capable of meeting the customer's or designer's specifications. Additionally, process capability refers to the inherent ability of a process to produce similar parts for an extended period of time under a given set of conditions. Process capability ideas can help manufacturers and service providers make judgements regarding product or process specifications, acceptable manufacturing processes, equipment to be employed, and time commitments.

Studies of process capability reveal if a process is capable of producing approximately all conforming product. If the process is capable, statistical process controls can be utilised to monitor it, and conventional acceptance efforts can be reduced or eliminated.

After performing a process capability analysis, a process will be categorised as either capable or incapable. When a process is not capable of producing practically all conforming products, it is deemed incapable, and 100 percent inspection must continue to be a part of the process

2.7.7.4 The Capability Index, Cp

Process index that numekirically describe variation relative to the tolerance or specification. The thinner the distribution the higher the Cp. The Cp index is used to summarize a system's ability to meet two-sided specification limits (upper and lower).

$$\text{Cp} = \frac{\text{Voice of customer}}{\text{process behaviour}} = \frac{\text{Voice of customer}}{\text{process behaviour}}$$

$$\text{Cp} = \frac{\text{USL} - \text{LSL}}{6\sigma}$$

Hence, the table below shows capability index is interperated as follows:

Table 2.4 Cp Value and Six Sigma Definitions

Cp Value	Quality status
Cp < 1.0	Process is not capable
Cp = 1.0	Capable
Cp = 1.3 – 1.5	Satisfactory
Cp = 2	Excellent, that is 6 sigma

2.7.7.5 The Capability Index, Cpk

Process capability ratio, or Cpk, is a statistic that evaluates the possibility that a process may produce defective products related to either the upper or lower specifications. The capability ratio is an additional indicator of process capability.

$$C_{pk} = \min \left\lfloor \frac{\bar{X} - LSL}{3\,\sigma} \right\rfloor, \ \left\lfloor \frac{USL - \bar{X}}{3\,\sigma} \right\rfloor \text{ ....(5)}$$

The following describes the relationship between the Cp and Cpk:

a) When Cp is 1.0 or greater, the process is capable of creating products that meet specifications.

b) The Cp-value does not represent centering of the process.

c) Cp = Cpk when the process is centred.

d) Cpk is never more than or equal to Cp

e) When Cp is larger than or equal to 1.0 and Cpk is greater than or equal to 1.00, it shows that the process is creating products that meet standards.

f) A Cp value less than 1.00 shows the incapability of the process.

g) A Cpk value of zero signifies that the process average is within one of the tolerance limits.

h) A negative Cpk value demonstrates that the average value is beyond the specified limitations.

2.8 Statistical Process Control (SPC)

Statistical Process Control (SPC) is the application of statistical approaches to manage and control a process so that it produces a product that conforms to specifications to the greatest extent possible. SPC illustrates how a process works consistently to generate the most compliant product with the least amount of waste. Control charts, continuous improvement, and design experiments are all valuable tools in SPC according (Madanhire and Mbohwa, 2016).

SPC has an advantage over other quality systems, such as inspection, because it focuses on the early discovery and prevention of problems, as opposed to identifying and fixing problems after they have occurred.

Figure 2.8 shows that when using SPC, it is important to understand and highlight the key customer-important product attributes or key process variations. The most important things to do to put SPC into practise are:

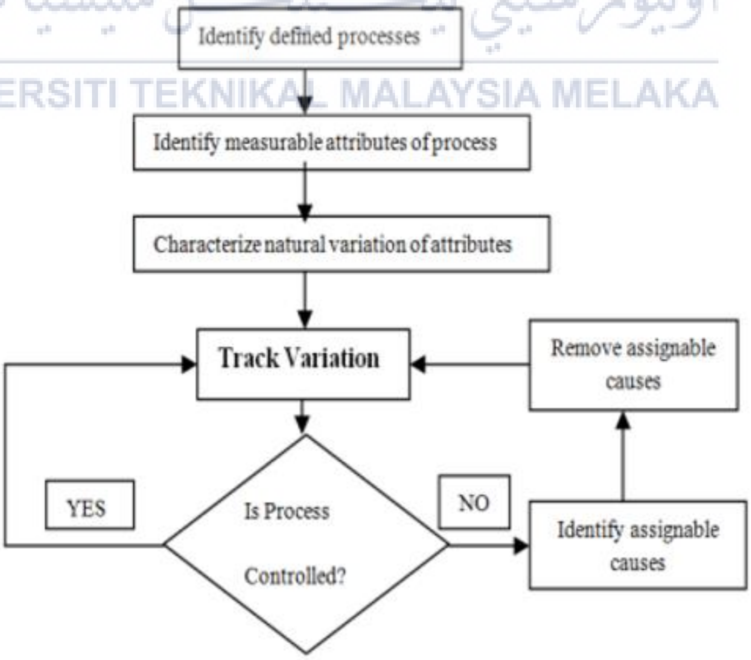


Figure 2.12 Steps in SPC Implementation

2.9 Benefits of Quality Control

Implementing quality control ensures that customers achieve the best products possible. Aside from that, quality control has a positive effect on the behaviour of employees. When quality control is implemented, it is possible that employees will be encouraged to provide high-quality goods, resulting in increased consumer satisfaction.

Next, The major benefit of quality control is that it makes factory workers more aware of quality, which is a huge help in getting the level of product quality that was organised. Moreover, buyers benefit greatly from quality control since they acquire products of greater quality. It meets their needs.

Reduced manufacturing costs can be achieved through effective process and operation inspections and control measures. Hence, to preventing the creation of defective goods and wastage, quality control reduces manufacturing costs significantly.

Moreover, quality control permits the production of high-quality products, which is incredibly advantageous for attracting more customers and increasing sales. It is particularly advantageous in terms of sustaining current demand and generating new demand for the product. It has been mentioned accurately that quality control is a valuable tool for increasing both domestic and foreign markets.

2.10 Application of 7QC Tool in Manufacturing Industry

Many literature has been published about the effective application of the 7 QC tool concept in productivity improvement, quality improvement, defect rejection, and so on. The case study revealed that the process performance had improved. In this section, the authors explain how the old researchers develop quality control tools in industry. Numerous research have focused on those problem-solving strategies considered to be highly effective in manufacturing environments.

Memon, Jamali, et al.,(2019) utilize traditional 7QC methods to analyse and optimise chassis and trim line defect reduction in an assembly line. This work designed and implemented seven classic QC techniques to improve efficiency. The study found that after implementing the QC tools, the defect level at the chassis line decreased by 90%. Similarly, the trim line defect level was decreased by 80%.

Memon, Ali, et al., (2019) This study examines the use of 7QC tools in an automotive production to eliminate paint shop defects. An inspection of the production line within four months identified defects and used 7QC tools to successfully reduce total defect rate by 70%. The cause and effect diagram was essential for identifying the root causes of issues.

Memon, Ali, et al., (2019) analyzed rejection in the sealing, cutting, and packing shops of Colgate brushes, proving the use of 7QC tools to reduce rejection. It identified the fundamental causes of quality, process performance, waste cost, and QC tools appropriate for some significant tooth brush card rejections after applying 7 quality tools. The matter cut defect is decreased by up to 95% and the sealing defect is decreased by up to 98% after remedial actions. Remedial actions effectively reduce rejections from 3.42 percent to 2%.to 98 %. Due to the application of remedial actions, total rejections are reduced from 3.42% to 2%.

As shown By Supapan and Chutima, (2019), in-mould decorating (IMD) is a process that combines PET film with decorative designs are moulded together with ABS resins to reduce the subsequent step of decorative screen printing by using DMAIC Six Sigma. The case study company recently manufactured components with a high defect rate of 22.3 percent. The fault rate of in-mould decoration process reduced from 22.3 percent to 0.7 percent after improving PET film peeled off by selecting appropriate parameters and applying control plan and SOP (Standard Operation Procedure).

Foulla, (2021), A complete and systematic analysis of the PDA cycle for quality improvement. To practise this approach, this research introduces the methodology to practise this way with support tools (the seven fundamental quality tools), and it provides specific pathway with a successful application of PDCA for restaurant late order problems.

Realyvásquez-Vargas et al., (2018) provided a case of various defects found in the welding process of electronic boards and Thru-Holes components. This article examines a lean manufacturing situation. Also, three double production lines for electronic boards will be expanded by 20%. Defects decreased by 66%, 79%, and 77% in three product models studied. The PDCA cycle, Pareto charts, and flowcharts are good quality technologies that allow reduce defective component quantities.

Al Khamisi et al., (2019) developed a knowledge-based system (KBS) to enable the deployment of Lean Six Sigma (L6s) principles to improve quality management performance in healthcare. Using L6s concepts to improve QM performance in healthcare involves a pre-assessment of the organization's capabilities. The KBS enables a better organization's strategic decision-making hierarchy in order to reach a standard of performance.

Neves et al., (2018) suggested applying Lean techniques to the Textile Industry by combination of 5S, 5W2H and PDCA cycle. The results showed a considerable effect in the Weaving production, with gains of 10% in the operator's useful available time.

Hsin-Chieh Wu, (2017) By evaluating previous work and current methods, a case study was conducted on quality issue and quality control in 3D printing. Several methods (cause-and-effect analysis) have been significantly employed; others (experiment design) have not been precisely and totally used, limiting quality. Control charts and taguchi method can improve 3D-printed object quality, however they need repeated experiment, that might not fit the 3D printing workflow.

Uluskan, (2019) developed a PDCA cycle based Total Productive. Maintenance (TPM), Toyota Production System (TPS) and Total quality management (TQM) model with an implementation guideline. Based on the research findings, a cutting-edge model of TPM, TPS, and TQM practises is produced. The created model and implementation guideline's exclusivity keeps manufacturing sectors competitive and productive.

Using the PDCA cycle, Ezawa et al., (2017) created an integrated TPM, TPS and TQM model. The three systems' originality, common practises, and implementation guidelines are retained. Based on the research findings, a cutting-edge model of TPM, TPS, and TQM practises is built. The established model and implementation guideline's uniqueness allows manufacturing industries to remain efficient and successful.

Dieste et al., (2019) studied how Lean Manufacturing might enhance environmental performance. The research approach used was a single case study, which provided more depth of information. The study established a link between Lean techniques (Kaizen, PDCA, Ishikawa Diagram, Poka-Yoke, and Standardized Work) and reducing an organization's environmental effect. These practises reduced energy and water usage.

Shahar and Salleh, (2017) used PDCA, observation, the PUGH technique, and design software (CATIA) to study the process of grinding cutting tools. The goal of this project was to make a machine for ABC Cutting Tool Industries to get rid of carbide sludge. Since carbide sludge is filtered in the filter machine, it had to be moved into the waste barrel once a month as part of maintenance. Carbide sludge had to be cleaned out of the filter machine, which took time and two to three people. This new idea helped make the process of getting rid of carbide sludge cheaper and safer for the operators.

Rosa et al., (2017) performed a research to optimise the production lines of steel wire-ropes used to regulate basic functions in cars, such as window elevation. Using Lean and PDCA approaches, it was possible to execute some of the established solutions, as well as subsequent processes, and record them for future reference. This study improved significantly efficiency.

Similarly, Jagusiak-Kocik,(2017) conducted a case study of a manufacturing company using PDCA cycle to solve quality issues during photo frame production. As a result Non-conforming material reduced by over 60%.

Kholif et al., (2018) used the PDCA cycle to increase quality in laboratories. The number of tainted UHT milk samples dropped from 368 to 85. Capability index raised from 0.52 to 1.07. The decrease in contaminated milk samples and rise in CP enhanced efficiency from 68.02% to 74.06% and efficiency from 88.95 to 96.85. Therefore, PDCA approach was successfully developed to decrease problems and improve process capability of dairy laboratory.

Rahman et al., (2018) worked on projects to reduce faults and reduce rework. Pareto analysis was used to find the top seven defect spots, where 80% of the errors happen, and where the most attention should be to reduce the failure rate. 5S & PDCA were utilised to efficiently minimise error.

Pavletic and Sokovic,(2014) propose a nanoemulsion example to support the effective application of all seven quality control tools in each stage of the PDCA cycle. The damage functions of nanoemulsions are considered, such as non-uniform size distribution, limited encapsulation efficiency, and expensive production techniques. Seven quality control tools are summarised in this review to ensure optimal nanoemulsion quality in a company.

Lepore et al., (2018) The purpose of this study is to ascertain why the process capability index (Cpk) for drop impact resistance (DIR) does not meet the specification. Using the following strategies, the company profited from the study's findings. The decrease in standard deviation from 1.80 to 1.48 and the increase in the Cpk index from 0.48 to 1.79 indicate that the process is under control and capable.

Phruksaphanrat, (2019) The company encountered issues with machine efficiency, specifically with its most important product, Axminster carpet. For a long time, Axminster carpet production has underperformed. So the prototype machine was improved using Six Sigma DMAIC. Overall efficiency improved 12.01 percent from the baseline 52.05 percent to 64.06 percent.

Therefore, A comparative study was conducted between old researcher. Hence, Table 2.2 summarises study articles and case studies on the technique utilised by old researchers in manufacturing industries.

Table 2.5 The Technique Used From Previous Research

No	Author, Year, Publisher	Technique, Method
1	Memon, Jamali, et al., (2019)	SPC and 7QC tools (flowchart, check sheet, histogram, Pareto chart, cause and effect diagram, scatter diagram, and control chart)
2	Memon, Ali, et al., (2019)	Employing 7QC tools (flow chart, check sheet, histogram, Pareto chart, cause, and effect diagram, scatter diagram and control chart)
3	Memon, Ali, et al., (2019)	The author impelement 7QC which are flow chart, check sheet, histogram, Pareto chart, cause, and effect diagram, scatter diagram and control chart in the case study
4	Supapan and Chutima, (2019)	DMAIC Six Sigma. The cause-and-effect diagram and associated scoring matrix help determine measurement techniques.
5	Foulla, (2021)	The PDCA Cycle. The flowchart, cause and effect diagram, check sheets, control chart, pareto chart, scatter diagram, and histogram are used to guide the application of PDCA.

6	Realyvásquez-Vargas et al., (2018)	The Plan-Do-Check-Act (PDCA) cycle is utilised as a strategy. The Pareto chart and flowchart are utilised as additional tools
7	al Khamisi et al., (2019)	Application of Lean sig sigma concepts in order to improve the performance of Quality Management (QM)
8	Neves et al., (2018)	Through the use of PDCA (Planning-Doing-Checking-Acting) and the 5S (Seiri, Seiton, Seiiso, Seiketsu, Shizuke) tools, find out the issues and discover solutions.
9	Hsin-Chieh Wu, (2017)	The application of QC techniques (cause-and-effect analysis) and Taguchi methods
10	Uluskan, (2019)	Combination of Pareto histograms, brainstorming, process flow maps, supplier–input–process–output customer (SIPOC), control charts, plan-do-check act and Ishikawa diagram.
11	Ezawa et al., (2017)	Using the PDCA cycle in creating an integrated of Total Productive. Maintenance (TPM), Toyota Production System (TPS) and Total quality management (TQM) model.

12	Dieste et al., (2019)	The study established a link between Lean techniques (Kaizen, PDCA, Ishikawa Diagram, Poka-Yoke, and Standardized Work)
13	(Shahar and Salleh, 2017)	Analysed process using PDCA, observation, PUGH technique, and design software (CATIA).
14	Rosa et al., (2017)	Optimise the production Using Lean and PDCA approaches
15	Jagusiak-Kocik, (2017)	Develop case study of a manufacturing company using PDCA cycle to solve quality issues
16	Kholif et al., (2018)	Using the PDCA cycle to increase quality and process capability as well as reduce issues.
17	Rahman et al., (2018)	Pareto analysis used to find the defect and 5S & PDCA were utilised to efficiently minimise problem.
18	Pavletic and Sokovic, (2014)	The use of 7 QC tools in the PDCA cycle to ensure the optimum quality of industries

19	Lepore et al., (2018)	SPC was utilised in conjunction with the PDCA cycle, as well as Cause and Effect Diagram, Nominal Group Techniques, and the (5W1H) approach
20	Phruksaphanrat, (2019)	Utilizing the Six Sigma DMAIC (define, measure, analyse, improve, and control) methodology and improvement methods.

2.11 Summary

The overall view of the topic study was revealed through, The quality control tools, which are effective instruments extensively used by manufacturing companies to manage overall operations and continuous process improvement, illuminated the entire perspective of the issue study. Continuous monitoring is used to enhance the process using quality tools including the Check Sheet, Pareto Diagram, Histogram, Cause-and-Effect Diagram, Control Chart, and Scatter-Diagram. According to research, the 7QC tools are typically utilised in conjunction with the PDCA cycle for enhancing industries. PDCA is confined within a circle and is infinite, allowing all implemented and applied solutions to serve as an indicator for future improvement actions. Benefits of PDCA cycle in quality problem solving; gives the approach to practise this method with support tools (7QC); offers comprehensible instructions for the successful use of PDCA. Numerous studies have demonstrated that knowledge production has a favourable effect on a project, and that a successful project enhances organisational performance.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter would be devoted to the methodology and proposed procedure that are required to evaluate the research analysis. It also includes a flow chart that must be followed in order for the study results to be more successful and finished in time, and it is crucial to employ the correct strategy to ensuring that the plan achieves its objectives. The methodology is the section that describes the phase in the procedure used to research and support the study from the beginning stage through to the conclusion. In this chapter will also brief about the implementation of 7QC tools methodology at the manufacturing process production. Next, emphasis on how the tools and methods will be utilised to assure the success of the study. There is also a Gantt chart for FYP 1 and 2 that depicts the full study project's scheduled planning and deadlines.

3.2 Project Planning

This project consists of two sections which are Final Year Project 1 and Final Year Project 2. This study has been conducted over the course of two semesters in one academic year. Introduction, Literature Review, and Methodology are the chapters that comprise FYP 1. In addition, FYP 2 has the sections Result, Discussion, and Conclusion. This project's findings are updated weekly for the Project Supervisor, Dr. Mohd Soufhwee Bin Abd Rahman. Presentation is carried out at the end of each semester to respective panels to provide a summary for the findings of the project.

3.3 Research Flow

The flow chart in Figure 3.1 represents the progress planning for the bachelor's degree project and it showed the process flow of the general methodology to conduct quality control tools and productivity improvement study. This is the flow where the project was followed and has been completed. Preparing the flow chart is important to this project to make this project going smoothly as well. Therefore, a flow chart in figure 3.1 is constructed to enable the ease of understanding of the overall process.

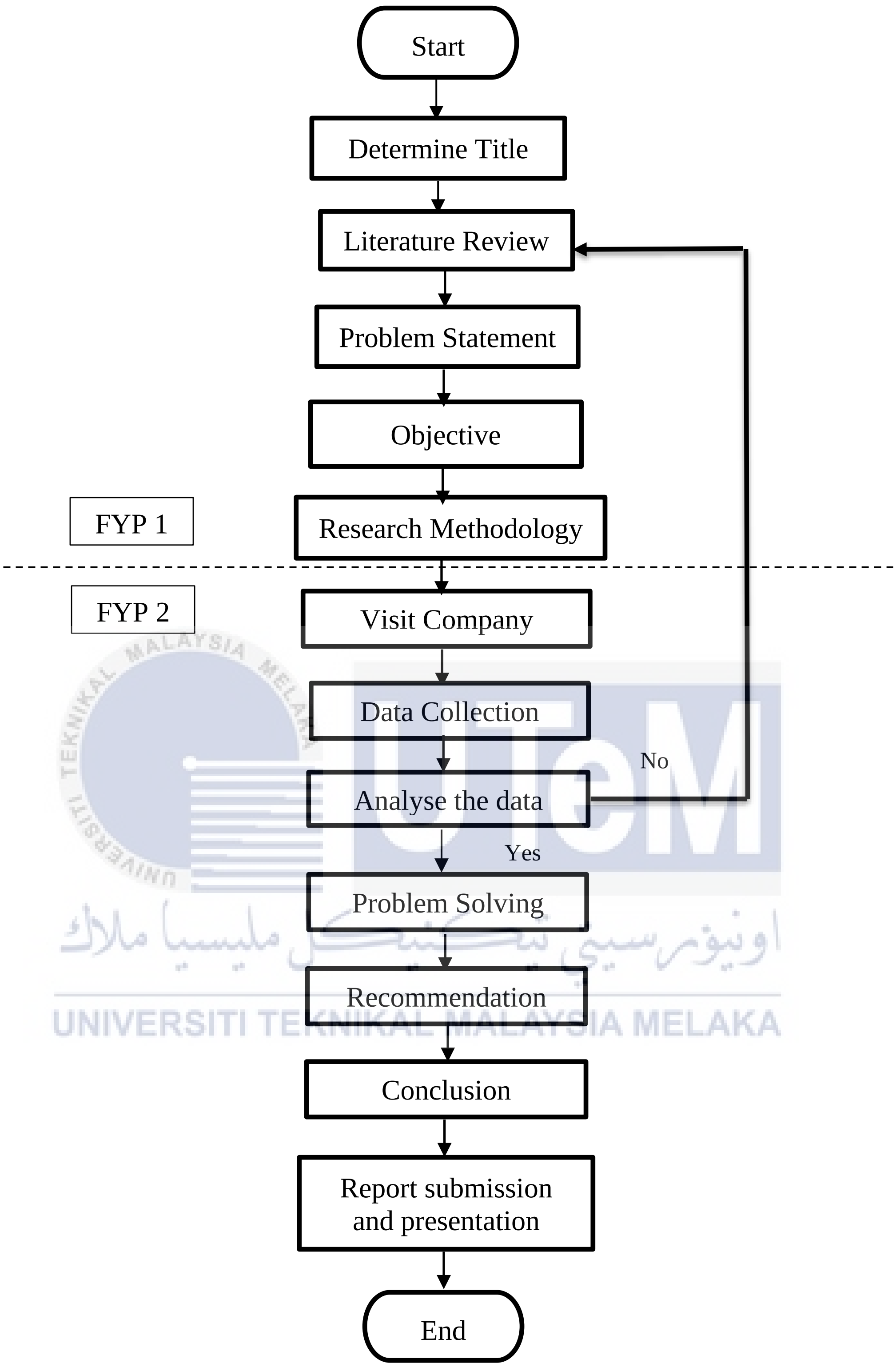


Figure 3.1 Overall Project Planning Flowchart

3.4 Research Phase

As presented in figure 3.2, the scientific investigation was categorised into three key phases by the researcher based on the research objectives. These phase focused on the research objectives as cited in chapter 1. The researcher employed the methods as presented below regarding the study impact.

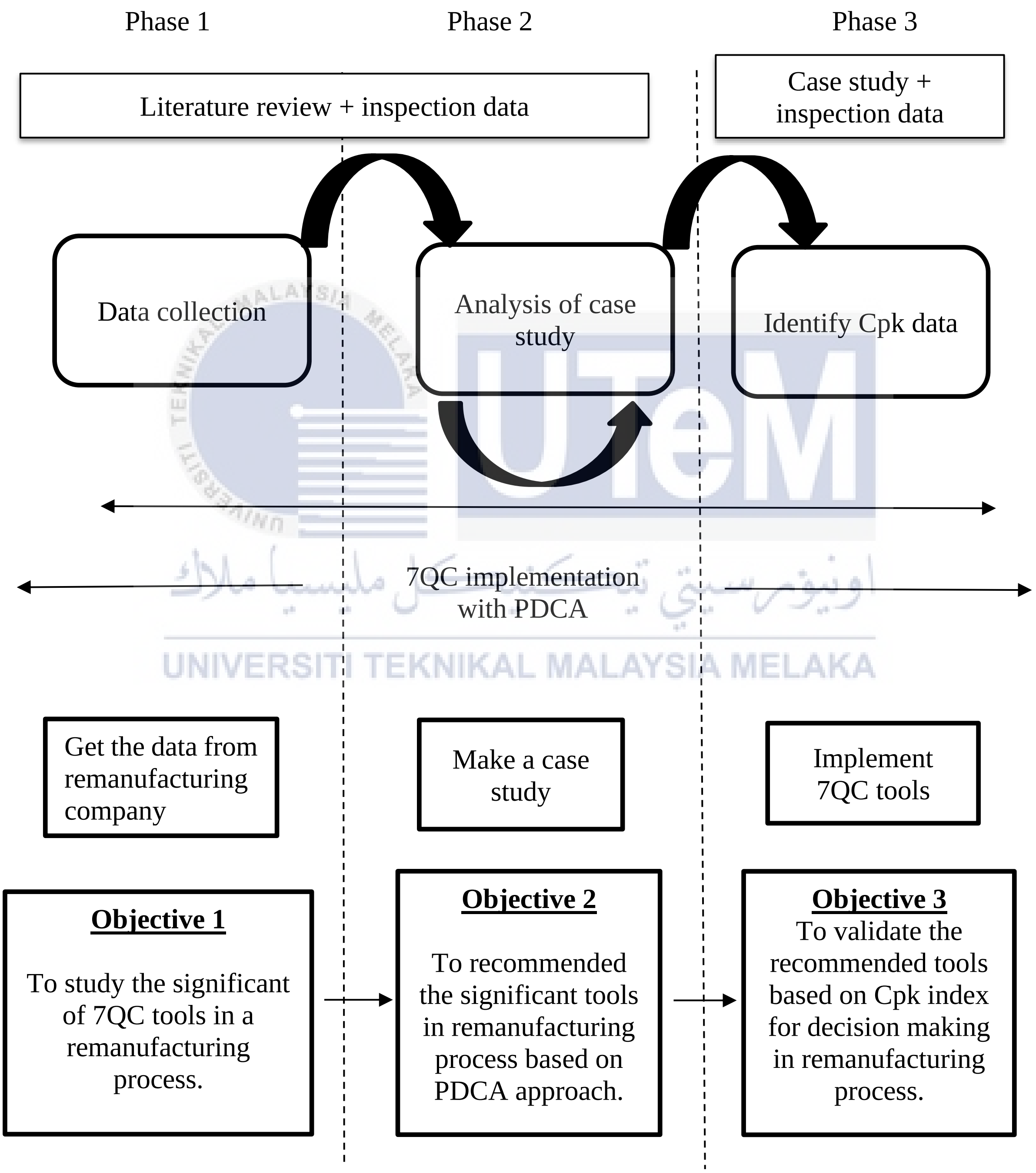


Figure 3.2 Research Phase

3.5 Research Methodology

The research methodology is a flow step that explained the systematic step to guide the researcher in conducting the study. The flow chart in Figure 3.4 presents the process of the case study. This is the step until the result outcome process approach used PDCA. The main objective of this part is to explain the techniques and tools utilized for data gathering, analysis, and interpretation. Therefore, a flow chart in figure 3.1 is a method for systematically solving the research problem.

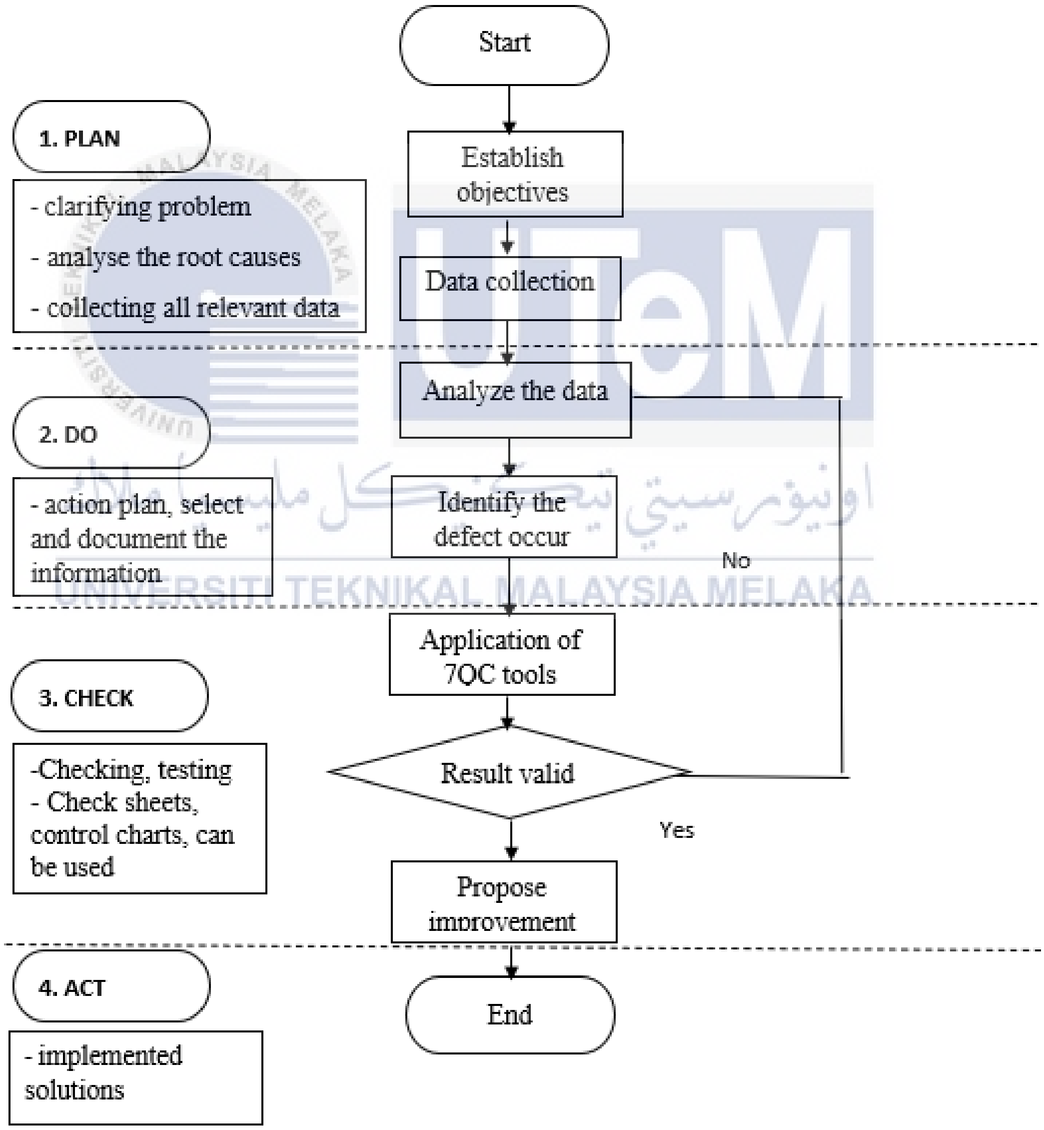


Figure 3.3 Research Methodology

3.5.1 PDCA Cycle

The PDCA cycle has four main parts that can be degraded into the required step-by-step activities for solving problems. PDCA is used because it is a model for a process of continuous improvement (P.Brian,2003). It is made up of four steps that are done over and over again to improve and learn: plan, do, check, and act.

3.5.1.1 Plan

Plan is the first step in the PDCA process. This step involves figuring out what the problems are and gathering all the relevant data. Then, the team has to figure out what's really causing the problems so they can make a plan that has been tried and tested. First of all, though, the main focus is on finding the key stakeholders and understanding what customers want. The Plan phase takes longer than others since it requires rigorous problem clarification, root cause analysis, and solution or countermeasure development.

3.5.1.2 Do

In this phase, the action plan will be implemented, and information will be selected and documented. Additionally, unanticipated events, learnt lessons, and acquired information must be taken into account

3.5.1.3 Check

Step means to check or test to see if the solutions introduced to a company worked well. The measurements are taken and compared to the values written on the plan. Control charts and check sheets can be used to help. If the solutions were put into place in the right way, the next step in the PDCA cycle is "Act." If they weren't, the next step is "Plan" (this is a critical area in the process of improvement).

3.5.1.4 Act

At this stage, it makes advantage of the solutions that have been developed. After demonstrating in step 3 that they had achieved the desired outcome, they began the process of standardising their procedures and monitoring how they carried out their work. In these procedures, in addition to the fixed points that are established, there are also carefully characterised approaches to solve difficulties, as well as personnel responsible for their implementation.

3.5.2 Combination of PDCA Cycle and 7QC

With the use of lean tools, Rejection and Rework can be eliminated. With the aid of the approach, we will increase both the product's quality and its production by eliminating rejection issues. When process improvement is preceded by rigorous planning, it results in corrective and preventative measures backed by suitable quality assurance instruments. Table 3.1 depicts the correlation between seven fundamental quality tools and the four phases of the PDCA cycle.

Table 3.1 Seven Basic Quality Tools (7QC Tools) in Correlation With PDCA-Cycle

	Steps of PDCA-cycle			
Seven basic quality tools (7QC tools)	Plan	Do	Check	Act
	Problem identification	Process analysis	Result evaluation	Decision making
Flow chart	√	Not available	Not available	Not available
Check sheet	Not available	√	Not available	Not available

Pareto diagram	Not available	√	Not available	Not available
Cause-and effect diagram	Not available	√	Not available	Not available
Control charts	Not available	Not available	√	√
Histogram	Not available	Not available	Not available	Not available
Scatter diagram	x	x	√	Not available

According to Table 3.1, To reduce the engine defect in remanufacturing process, following methodology of 7QC Tools with PDCA is adopted. Literature review on production line and assembly techniques to understand basic quality tools for problem solving. For 1st phase, which is plan included problem identification of the remanufacturing company and the flow of process by using flowchart. Next, for Do phase, analyze the process which analyze and collection of rejected part using check sheet for a duration 6 months which the data are getting rejected at the time of remanufacturing. By collecting this information it will be easier to find the frequently rejected components. Once the data from the check sheet has been compiled, it is easy to identify the defect of engine part that is being rejected most frequently. Then identify the frequently defect of rejected component by the help of pareto chart. The following step could be to identify why the most common defect is being rejected and reasons can be represented by a cause-and-effect diagram. By reviewing the current process and mode of operation, it is easy to figure out the root causes. Then, the Check phase, which employs control charts to analyse the results. The following and final phase is act to develop a solution to this problem by determining the cpk value in order to make a decision utilising a scatter diagram.

3.5.3 Process Improvement

To address the issues of core parameter in remanufacturing company, seven quality control instruments with a PDCA approach that has a significant impact on improvement were suggested. If the proposed enhancements are applied, connecting rod dimension parameter defects will be minimized. Then, the index cpk value will develop to measure the ability of a process to produce output within customer's specification limits. This index indicates, whether the process is capable of producing products to specifications.

3.6 Gantt Chart PSM 1

Below is the Gantt chart for this project. Gantt chart is to make sure our project runs and is finished on time before the submission date. Gantt chart is the process from the beginning of this project until the end of this project.

NO	TASK PROJECT	PLAN/ ACTUAL	PSM 1														
			WEEK														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Select theme of the project	Plan															
		Actual															
2	Briefing title with supervisor	Plan															
		Actual															
3	Construct milestone & research flow	Plan															
		Actual															
4	Analysis article	Plan															
		Actual															
5	Drafting literature review	Plan															
		Actual															
6	Writing literature review	Plan															
		Actual															
7	Define objective & scope project	Plan															
		Actual															
8	Research on methodology	Plan															
		Actual															
9	Visit company	Plan															
		Actual															
10	Data collection	Plan															
		Actual															
11	Analyse the data	Plan															
		Actual															
12	Problem solving	Plan															
		Actual															
13	Report submission & evaluation	Plan															
		Actual															

Figure 3.4 Gantt Chart PSM 1

3.7 Gantt Chart PSM 2

NO	TASK PROJECT	PLAN/ ACTUAL	PSM 2														
			WEEK														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Meeting and discussion	Plan															
		Actual															
2	Gathering data & analysis	Plan															
		Actual															
3	Applying all 7QC tools	Plan															
		Actual															
4	Find the suitable tools and technique	Plan															
		Actual															
5	Drafting chapter 4	Plan															
		Actual															
6	Submission result and discussion	Plan															
		Actual															
7	Writing conclusion	Plan															
		Actual															
8	Submission of full report	Plan															
		Actual															
9	Finalize the correction of full report.	Plan															
		Actual															
10	Preparation and presentation psm 2	Plan															
		Actual															
11	Panel evaluation	Plan															
		Actual															

Figure 3.5 Gantt Chart PSM 2

3.8 Summary

In this chapter, the entire approach and procedure provided for conducting the study and developing an integrated plan for determining the best way to improve the organization have been outlined. This chapter explains the general processes for conducting the overall project, as well as the specific strategy to resolving production line problems using quality control tools and the PDCA cycle. The tool and technique used to manage the problem in the remanufacturing company. Focusing on meeting the objectives has led to the collection of data and the development of the process solution's flow. The availability of a planning study will facilitate the task's timely completion.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this section, the author discuss the findings and accomplishments of the study and how they relate to its research objectives. This chapter focuses on attaining productivity gains on the production line and describes the data gathering that is required to examine process productivity improvements when employing the quality tools approach. Here, all of the information is gathered, including specifics about the product, the manufacturing process, and the method that was used to solve the dimension of the parameter in the engine part. The data is taken from the remanufacturing company as a case study.

4.2 Plan phase

4.2.1 Background Company

This research is being conducted at Motor Teknologi & Industri Sdn Bhd (MTI) which is located at Taman Industri Integrasi, Rawang, Selangor. The present study deals with the remanufacturing of engine parts in an automotive truck. The company manages assets to ensure availability for operations, including the remanufacturing of engine components. This company supplies connecting rods for automotive trucks, and it has been producing connecting rods for trucks for various applications.

4.2.2 Product Description

In this research, author investigated product of engine part from remanufacturing company. The product to be considered in the case study which is connecting rod as shown in figure 4.1. The types of part that is choosen for the engine truck model is 3508 – DITA. A connecting rod is an engine component that transfers motion from the piston to the crankshaft and functions as a lever arm.

Figure 4.1 Connecting Rod

4.2.3 Process Flow of Connecting Rod

In the producing connecting rod, various machining operations are carried out to produce the connecting rod make it fit for use. Die casting, facing, thread hole, and finishing (coating) most common machining methods in current practice. Figure 4.2 shows the flow process of manufacturing connecting rod in the remanufacturing company.

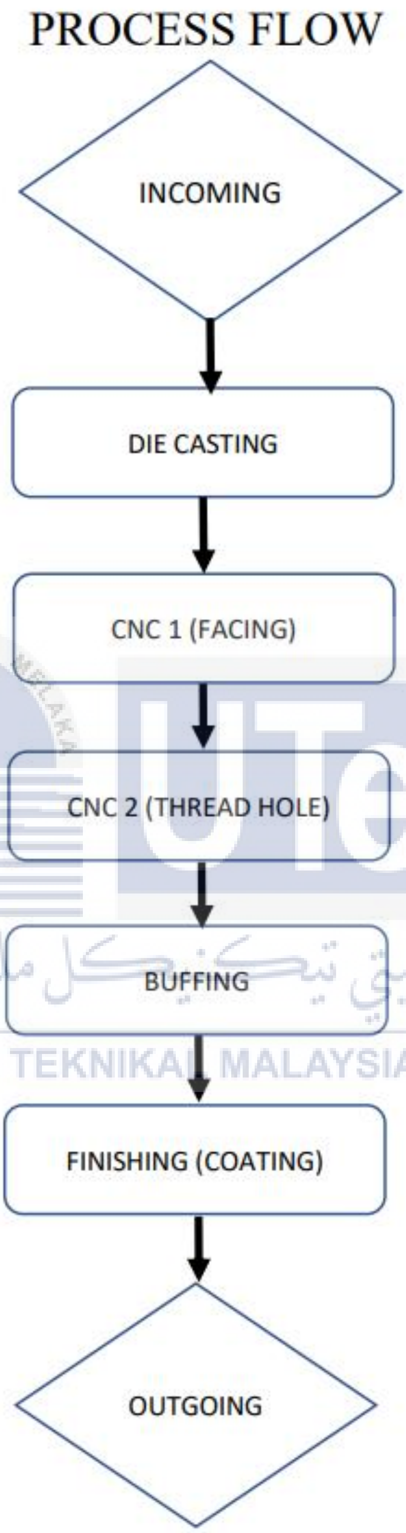


Figure 4.2 Flow Process of Connecting Rod

4.2.3.1 Incoming

Incoming is the method of inspecting the quality of materials and parts used in the production of a product before to the beginning of production or a process. With incoming inspection, irregularities, flaws, and other inconsistencies can be discovered well before the products are shipped. In this process, inspection involves verifying the specifications, quality, and amount of raw materials according to specified acceptance criteria. When an object is labelled as approved, conditionally accepted, or rejected, an identifying tagging system determines the activities that must be taken.

The aim of this incoming inspection checklist is to make it easier to evaluate findings and necessary actions based on the identity tagging system. The following is the checklist to easily perform

- Specify the purchase order number, material description, and quantity
- Capture and store an infinite number of images of flaws or labelled materials
- Send real-time alerts for upcoming scheduled inspections.
- Assign actions for material that is accepted, conditionally accepted, or denied

4.2.3.2 Die Casting

The parts connecting rods are manufactured by high pressure die casting. The connecting rod is formed by injecting molten metal under 650 Mpa of pressure into a steel mould or die using a die casting process. It is then poured into a cool chamber, where a hydraulically-powered plunger forces the molten metal into the mould. The brand of machining used are buhler as shows in figure 4.3

Figure 4.3 Die Casting Machine

4.2.3.3 Facing

Facing process is used after producing connecting rod part using die casting process. This method eliminates material by turning the face tool anticlockwise as the workpiece is fed across the cutter by the table. Using the three major axes (X, Y, and Z), the material is reduced to the appropriate shape of connecting rod.. The machine is to facing the product is by using CNC FANUC ROBODRIL. It employs a facing tool that creates a flat surface perpendicular to the rotational axis of the workpiece. Facing will reduce the length of the workpiece to its final length.

Figure 4.4 Facing CNC Machine

4.2.3.4 Thread Hole

The connecting rod large ends are often threaded directly such that the split portion holes passing up the connecting rods to the side top end bearings.Threading is a part process that involves using a die tool to create a threaded hole on a part. These holes functions in connecting two parts. Threading is a method of machining internal with threading tools. The through hole is a type of threaded hole that is used to create internal threads. It is created by drilling a hole in the material.This process also using CNC FANUC ROBODRILL 3 axis for making thread hole.

Figure 4.5 Threaded Hole Connecting Rod

4.2.3.5 Buffing

Buffing is a finishing method that involves the use of a wheel with loose abrasive material. This is utilised at the large and small end diameters. This manufacturing company may utilise a wheel with an abrasive disc to polish this component. It removes product residues or excess to provide a smooth surface and appearance. As cutting compounds, it employs a cloth wheel impregnated with loose abrasives. The cloth buff carries the abrasive substance that eliminates the surface material and flaws to create a uniformly shiny surface.

Typically, buffing is conducted in initial cut buff. Cut buffing is the most coarse buffing technique. This is the preliminary buffing process to eliminate significant discontinuities and surface roughness.

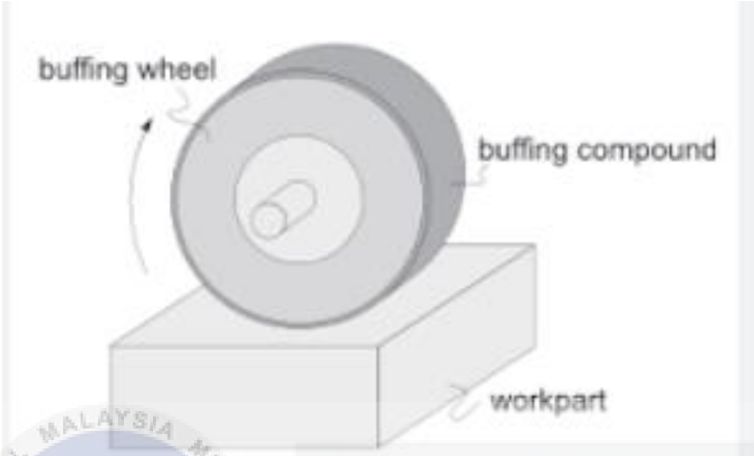


Figure 4.6 Schematic Buffing Operation

4.2.3.6 Finishing(Coating)

This is the last process of producing connecting rod part. Finishing operation is by using coating. Finishing is the process of modifying the surface of a produced component to obtain the desired look. Primarily, finishing serves to prevent rust. Electroplating is utilised to coat connecting rod components. This procedure involves an electric current that implants the material on the surface of the workpiece. This method applies a metallic coating on the surface. A positively charged electrical current is passed through a solution containing dissolved metal ions, while a negatively charged electrical current is passed through the metallic component to be plated.

4.2.3.7 Outgoing

Outgoing is the final step before products are delivered to customers, and it is essential that all packages are defect-free. This procedure refers to the shipping inspection performed by the supplier in compliance with the standards specified in the agreement or order between the supply and demand parties, prior to the shipment of the finished product. 100% product inspection in accordance with the ANSI statistical sampling process standard (ISO 2859-1).Numerous redundancies are performed to ensure the validity of previous processes. Hence, specific aspects that must be inspected or checked before a product is sent for shipping the connecting included:

i. Perform visual and functional inspection
ii. Apply sampling-based or 100% inspection
iii. Conduct reliability testing
iv. Verify that corrective or improvement actions have been effectively applied

4.2.4 Identify Problem

This section highlights the issues as well as the situation confronted by the remanufacturing company of producing rejected engine part, which is connecting rod having the most commonly observed defects are dent marks, burr, dimension out, sink mark and overbuffing. The rejection that had been face in connecting rod during manufacturing. Various cases are discussed and implemented with various aspects with due impact. The impact of implemented action is measured with few parameters. The parameters used to measure impact are rejection quantity per month

In this case study, the author investigate defect occur in producing connecting rod within 6 months from Jun untill November. The rejection section that had been faced in connecting rod manufacturing shows in figure 4.7 below. The dent mark defect happen when depressions on the surface along with the thick-walled. Burr represent the formation of rough edges on the connecting rod piece. Dimension out represent in the manufacturing process and the tools involved in its production. Next, sink mark referring to partial overheating of the die and overbuffing represent inefficient polishing with an aggressive abrasive compound.

With the use of 7QC tools and the PDCA methodology, the improvement potential is analysed and the appropriate corrective actions are implemented. This study utilises numerous 7QC techniques, including flowchart, pareto cause and effect diagram, control charts, and scatter diagram, to offer the framework for required actions. The analysis yielded several recommendations and findings. This analysis may be implemented efficiently with the help of 7QC tools with PDCA method employed in the process of quality management.

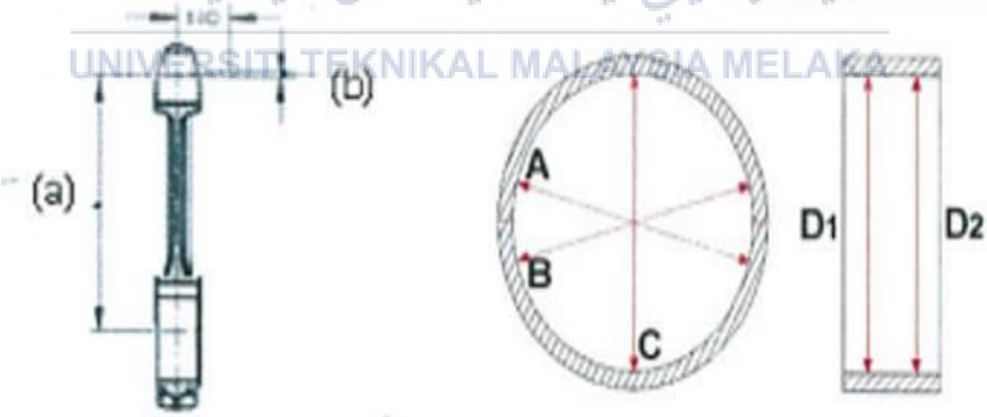


Figure 4.7 Diagram of Measuring Variations

4.3 Do Phase

4.3.1 Check Sheet

The check sheet is utilised for real-time data collection and analysis at the location where data is created. Data Collection is the beginning for valuable process enhancement and problem-solving tools. Table 4.1 presents a check sheet detailing the types of connecting rod manufacturing defects. The industry data is provided in the appendix, however this table demonstrates using a check sheet. It indicates the types of defects and rejections that encountered over that time period. The rejection data was obtained from the remanufacturing process and tabulated for convenience of use and interpretation. Typically, rejection check sheets are huge data sheets displaying the whole information regarding rejected products. The statistics from the rejection sheet have been simplified and are provided in the table below.

Table 4.1 Defect of Connecting Rod of Remanufacturing Process

Model: 3508-DITA	**PART NAME: CONNECTING ROD**	**CHECK SHEET- DEFECT REJECTION OF CONNECTING ROD**					**PART NO. 95Y01104**
Defect	**Months**						**Total**
	JUN	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	
Production	**2320**	**1874**	**2122**	**1242**	**1481**	**1142**	
Dent mark	5	3	5	6	3	5	**27**
Dimension out	7	7	8	10	11	16	**59**
Sink mark	9	13	7	6	0	1	**36**
Overbuffing	6	0	6	0	1	4	**17**
Burr	15	13	10	0	4	0	**42**
Total Rejection	42	40	36	22	24	17	**181**
Monthly Rejection %	1.81%	2.13%	1.70%	1.77%	1.62%	1.49%	**10.52%**

During the production of connecting rod it was observed that all the produced product including connecting rod do not conform to the desired quality requirements. Due to the connecting rod defects some of them are rejected completely and few of them are considered for rework. The data of defect occurrence was considered from the company records and segregate into the above mentioned defect categories. The rejection data due to defects occurred during the remanufacturing process has been taken monthly rejection reports for six months starting from Jun 2022 to November 2002 as shown in table 4.1 It gives the details regarding the quantity of rejected and the reason of rejection because of different connecting rod defects like dent marks, burr, dimension out, sink mark and overbuffing. Total number of rejections and the percentage rejections of the connecting rod for every month has been calculated. The overall rejection of Connecting rod for six months due to connecting rod defects is 10.52%.

After identifying the data collection inspection points, check sheets were constructed to collect or highlight the defective data for further examination. Checklists are the most fundamental of the seven tools. Check sheets are forms designed specifically for data collection by simple checkmarks. Check inspectors utilised these sheets during the process of checking or inspecting, such as when examining the incidence of defects. This research involved the creation and usage of check sheets for ascribed data, such as the number of different types of flaws identified on the connecting rod.

4.3.2 Pareto Diagram

The Pareto Analysis is used to determine the significant defects that contributes to the most of rejections percentage. Pareto provides accurate identification, thus it is performed and demonstrates the type of connecting rod defects during the Production Line. Pareto displays all defects and their respective percentages. A bar graph represents the defects in descending order of the frequency of occurrences, with a trend line indicating the cumulative percentage of defects. This chart allows prioritisation of defects with a high frequency.

Table 4.2 Defect of connecting rod and their percentage contribution

Defect	Frequency	% Contribution	Cumulative precentage
Dimension out	59	32.60%	32.60%
Burr	42	23.20%	55.80%
Sink mark	36	19.89%	75.69%
Dent mark	27	14.92%	90.61%
Overbuffing	17	9.39%	100.00%

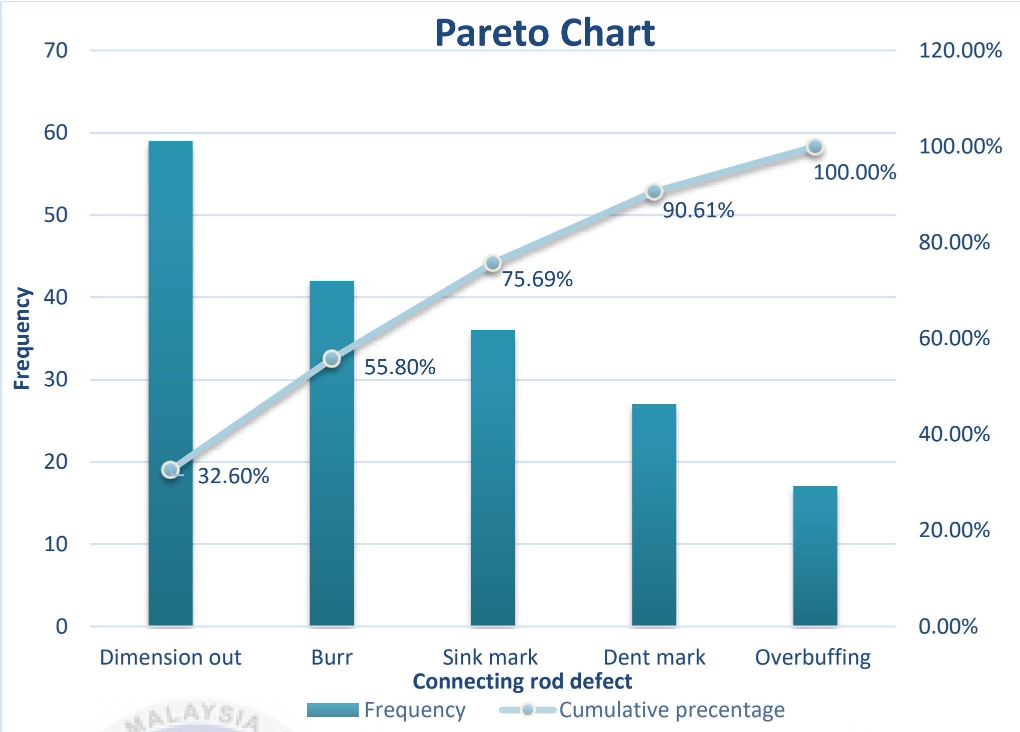


Figure 4.8 Pareto Chart of Connecting Rod

According to Pareto in figure 4.8 dimension out are major defects and other contributing to it. From the statistical analysis, defect of connecting rod in engine part are dimension out with percent rejection of 32.60% followed by defect of burr is 23.20% and sink mark 19.89%. It is a detailed analysis of the development trend of key factors for connecting rod engine defects in Jun - November 2022. Hence, according to analysis, that the most effecting defect of connecting rod in engine part is dimension out. It was necessary to find out actual reasons behind the defects with use of Cause and Effect Diagram for analysis purpose.

4.3.3 Cause and Effect Diagram

Cause and Effect Diagram is one method for identifying potential causes. It is used to determine the root causes of problems in products, processes, and systems. Using this tool, the causes of defective connecting rods can be usually identified. Thus, a cause and effect diagram was developed to determine the root causes of the defects. Below is a cause and effect diagram for the organization's most significant defect. Figures 4.9 respectively illustrate the cause and effect diagram for dimension out defects.

This establishes the potential causes of problems. When creating this diagram, the process of brainstorming proved to be extremely useful, as it involved a greater number of specialists and helped to uncover the greatest number of potential reasons. Based on figure 4.9 represent Cause-and-effect diagram with the help of the brainstorming technique where it identifies the causes dimension out during the production process of connecting rod.

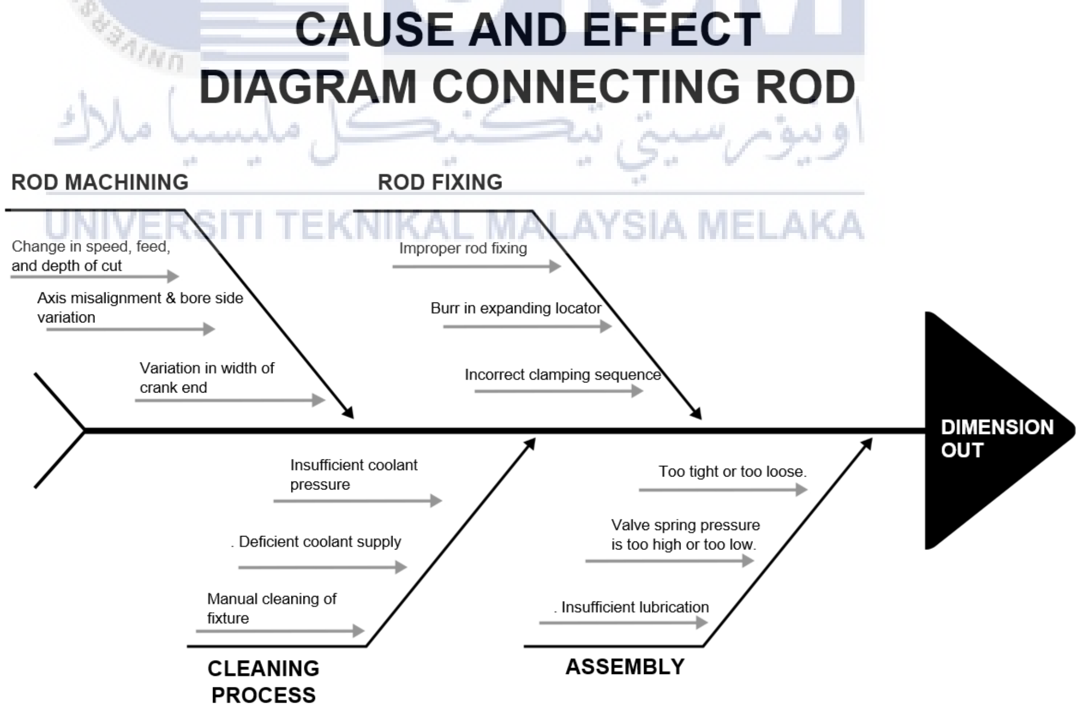


Figure 4.9 Cause and Effect Digram of Connecting Rod

Table 4.3 Causes of Connecting Rod Out of Dimension and Their Description

Causes	Description
Rod fixing	• Improper rod installation, rough handling, can causes of the stresses involved. • Burr is found on the locating fixture, because of that component did not rested on pad properly. • Sequence of clamping incorrectly adjusted. It can also influence part position and orientation
Rod machining	• Change parameter during machining can affect the overall performance of connecting rod. • .Pin bore axis and crank bore axis of connecting rod need to be perfectly parallel with each other.
Assembly	• Tightening the fasteners by torque value alone is not an acceptable method for installing the rod cap • Too tight or too loose can cause major problems at either end of the rod. Also, make sure rod bearings have the proper crush fit • The piston pin was not or was insufficiently lubricated when it was assembled.

Cleaning process	• Operating with low coolant pressure can lead to many problems because a coolant cannot protect surfaces that it does not contact. • Clean tool holders significantly contribute to precision in machining. When fixtures manually cleaned, this process does not ensure that swarf and residues from processing media get removed reliably

Table 4.4 Analysis of Fish Bone Diagram of Connecting Rod

Problem	Rod fixing	Rod machining	Assembly	Cleaning process
Discription	(i)Change in speed, feed, and depth of cut (ii) Axis misalignment (iii) Variation in width of crank end	(i) Improper rod fixing (ii) Burr in expanding locator (iii) Incorrect clamping sequence	(i) Too tight or too loose. (ii) Valve spring pressure is too high or too low. (iii)Insufficient lubrication	(i) Insufficient coolant pressure (ii)Deficient coolant supply (iii) Manual cleaning of fixture

After discussion with an engineer, it found that the most causes of connecting rod which affected their dimension are incorrect clamping sequence and manual cleaning of fixture in buffing process of big end diameter and small end diameter. When handling buffing process, it is necessary to be placed on the jig. So it is possible that the product will be slit from exact position. Hence, when the product is slit but still countinues buffing process, overbuffing can happen so it is out of specification can causes dimension problem. When it is not within the specification, so dimension out can happen. Next, when the part was placed on the jig, make sure clamp the jig properly to secure and prevent movement during clamping the product. When there’s have movement at the jig it can effect dimension out because of the incorrect clamping.

A session of brainstorming has been conducted to identify root causes, and solutions have been identified. The company's quality control department has been given with a table including a suggested action plan for improvement based on the discovered solutions.

Table 4.5 Proposed Action Plan for Dimension Out Deficiency

Types	Suggestion for an action plan for dimension out
Machine setup and operation	- Increase the machine's speed to the optimal level - Modify the time between the feeder and machine to get the correct loading position
Material	- Devoid of contamination - Must have the correct mix ratio to ensure the correct density
Man(operation)	- Be able to rapidly and properly detect flaws as well as know how to fix them. - Defect awareness is required.
Machine and equipment	- Maintenance actions to guarantee the machine's continued good condition

.....

4.4 Check

4.4.1 Scatter Diagram

A scatter diagram is used to shows the distribution of dimension defect rejected which illustrate dimension defect had happen every months from jun to November. From that, dimension critical is study to test how far dimension out of spect Among the two variables one variable is plotted on horizontal axis which is months and other variable is plotted on vertical axis which is defect dimension. For this case study, there is positive correlation between two variables. If the line in a scatter diagram has a positive slope, the variables are positive correlated.

Table 4.6 Dimension Defect From Jun to November

MONTH	DIMENSION DEFECT
Jun	7
July	7
August	8
September	10
October	11
November	16

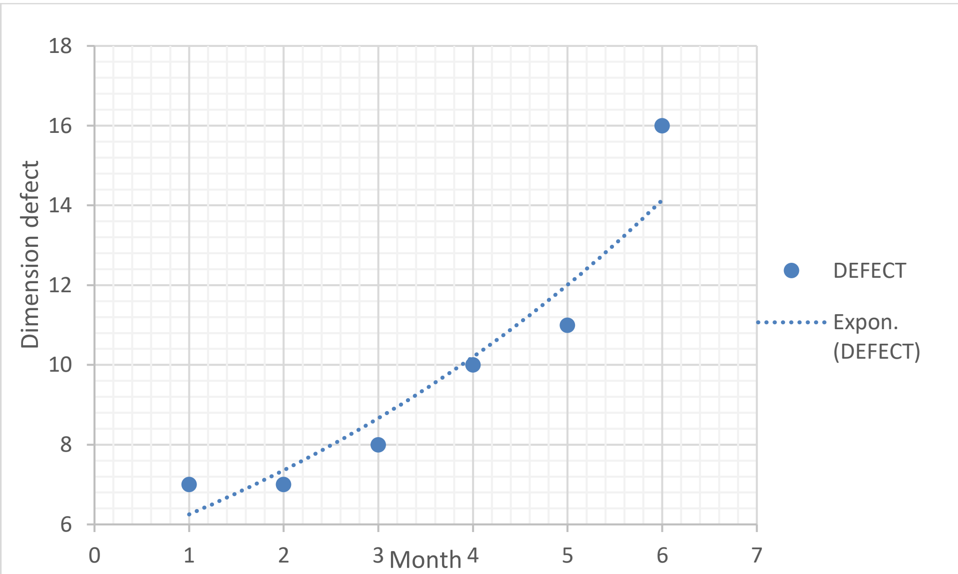


Figure 4.10 Scatter Diagram of Dimension Out

4.4.2 Control Chart

Control-Chart is used most important quality tool to determine organization performance of the remanufacturing company. The dimension defect need to be control so control chart had been used to illustrate the condition. Control chart is most important to tell about the process stability and variability. The types of Control Chart used is variable Chart. This Control Chart helps to determine the Process capability and Process performance to determine that if process work within specification limits.

Table 4.7 Data for Control Chart

Mean	9.83
Standard deviation	3.13

Months	Defect dimension	Mean	Upper control limit	Lower control limit
Jun	7	9.83	19.23	0.44
July	7	9.83	19.23	0.44
August	8	9.83	19.23	0.44
September	10	9.83	19.23	0.44
October	11	9.83	19.23	0.44
November	16	9.83	19.23	0.44

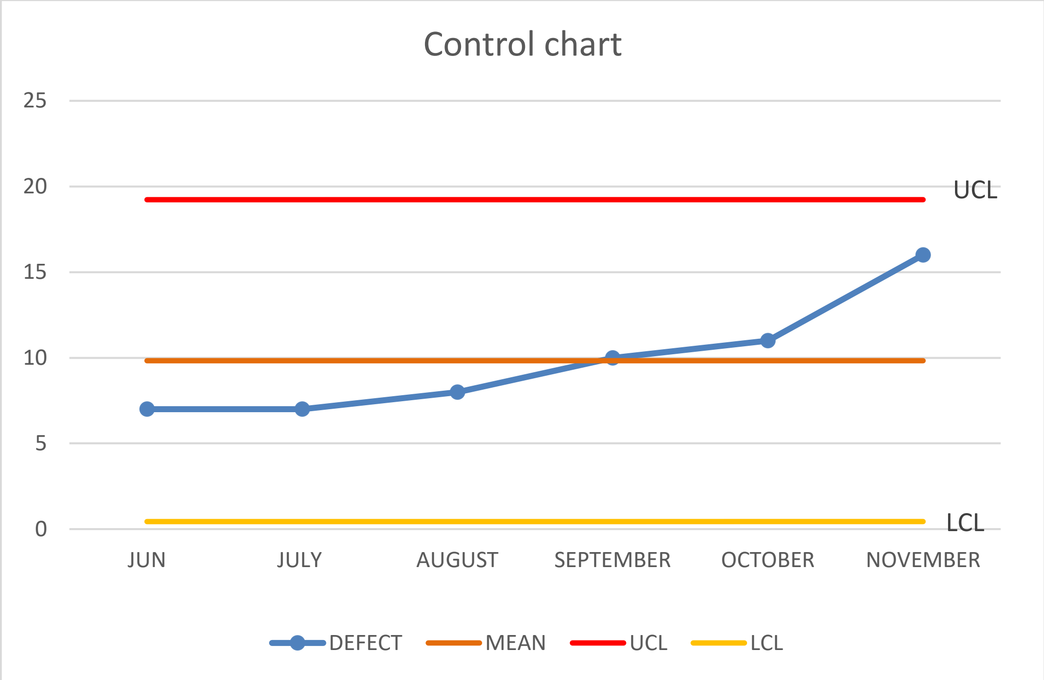


Figure 4.11 Control Chart for Connecting Rod

From the analysis, data has been collected, hence, 1 dimension had been recorded to know the condition of control chart within the range or not. Figure 4.11 shows the dimension defect is within control limit of upper control limit (UCL) and lower control limit(LCL). The variations that are always present in processes. Variations control limits indicate that the process is working. It can be seen that the results curve oscillates in a random way around the target value and within the control limit. This process is indicates under control. The six consecutive points are above or below than the average which is 9.83 and the trend line of this control chart is increasing.

4.5 Act

4.5.1 Process Capability

Process Capability is a statistical measurement of a process's ability to produce parts within specified limits. It is used to know the capability of the process. So, from that, data is taken in industry as shown in appendix but it is illustrate as shown in table 4.7

Table 4.8 Dimension Data of Connecting Rod

Sample	a	b	c	Average	Max	Min	Range
1	143.020	143.015	143.020	143.018	143.020	143.015	0.005
2	143.120	143.015	143.015	143.050	143.120	143.015	0.105
3	143.040	143.130	143.015	143.062	143.130	143.015	0.115
4	143.020	143.015	143.115	143.050	143.115	143.015	0.100
5	143.030	143.014	143.050	143.031	143.050	143.014	0.036
6	143.140	143.150	143.015	143.102	143.150	143.015	0.135
7	143.020	143.200	143.015	143.078	143.200	143.015	0.185
8	143.015	143.020	143.015	143.017	143.020	143.015	0.005

Average of average	143.051
Standard deviation	0.051
Range	0.08575
Value d_2 based on 3 subgoup size	1.693

Tolerance: 143+/- 0.2	
USL	143.200
LSL	142.800

i. Process capability, Cp

Upper specification (USL) = 143.200

Lower specification (LSL) = 142.800

$$Cp = \frac{(143.200 - 142.800)}{6(0.051)} = 1.3$$ (Process is capable)

ii. Capability index, Cpk

Upper specification (USL) = 143.200

Lower specification (LSL) = 142.800

Average of average: 143.051

Standard deviation 0.051

$$C_{pk} = \min \left[\frac{\bar{X} - LSL}{3\ \sigma}\right], \left[\frac{USL - \bar{X}}{3\ \sigma}\right]$$

$$= \min \left[\frac{143.051 - 142.800}{3\ (0.051)}\right], \left[\frac{143.200 - 143.051}{3(0.051)}\right]$$

= min (1.64**, 0.97**)

C_{pk} = **1** (Process can be rework)

4.6 Decision Making Through Cpk Result.

Figure 4.12 as shown below to describe the flow of process analyzing connecting rod defect by using the correlation of 7QC tools and method of PDCA. In this research, the author had merged 3 component 7QC and method of PDCA. So through this combination, the author had produce the idea on decision making for the critical dimension out defect through cpk value. This PDCA cycle is used in different cases for continuous improvement or any change. It used also for quality problem solving. PDCA cycle is an iterative four steps managing technique, The Plan phase consisted of investigating problem which using flowchart. The Do phase consisted of process analysis using Check sheet, Pareto diagram and Cause and effect diagram. The result evaluation was verified in scatter diagram and control chart. The final phase Act where decision making was made either the process can be remanufactured or rejected by Cpk value. Cpk have a few categories which is Cpk < 1was not capable, Cpk = 1 is capable, Cpk 1.3 – 1.5 indicates satisfaction. This one is decision for the rejected part or can be remanufacturing. After calculated data from the inspection data, the process is capable which the Cpk value is 1 where the process can be remanufactured.

DECISION MAKING FLOW

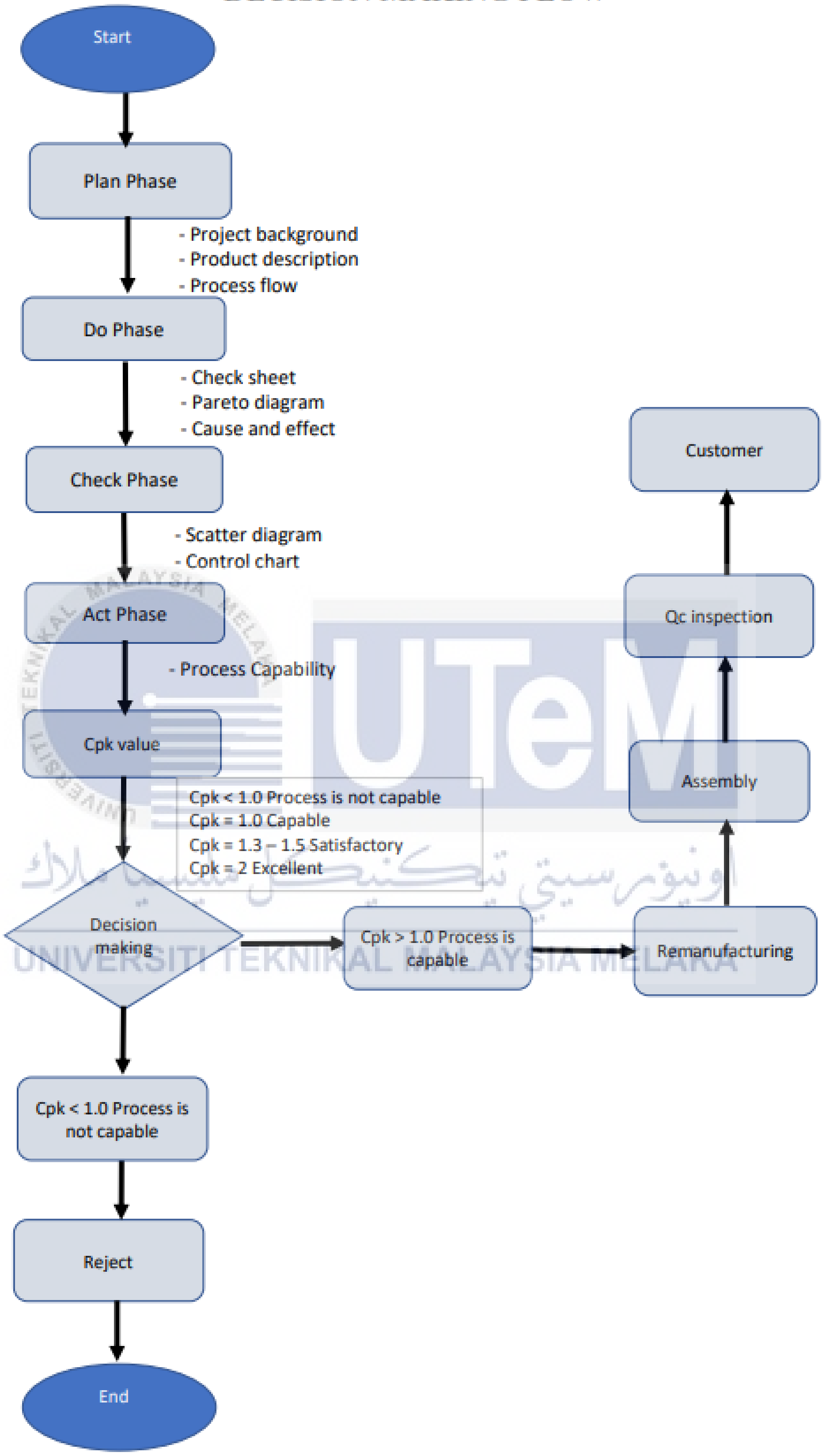


Figure 4.12 Decision Making Flow

4.7 Summary

Utilizing seven quality control tools such as flowcharts, check sheets, Pareto analyses, cause and effect diagrams, control charts, and scatter diagrams in combination with the PDCA method result in an improvement in quality. Following the application of this methodology, process control has been improved. Detailed investigation of the problem's root cause will result in a permanent solution. Effective utilization of the solutions reduces connecting rod rejection rate and improves product quality.

This analysis simply implemented efficiently with the use of seven quality instruments utilised in the process of quality enhancement. The check sheet is used to collect and analyse data pertaining to defective connecting rods from June to November. The dimension out defects of the connecting rod have been prioritised using Pareto diagrams, which are typically used to identify crucial areas, by placing them in decreasing order of priority. Then, a cause and effect diagram is used to investigate the roots of defects through a brainstorming session and to decide which causes have the biggest impact. It is proposed that corrective actions be taken to remedy the dimension out defect of connecting rod. Control chart is utilized to determine if a dimension is within control limits, whereas a scatter diagram illustrates the relationship between two variables. Lastly, the cpk value is calculated as a decision making where this process is capable which means cp>1 where the process can continue to the next process or process can be rework.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This chapter contains conclusions based on the findings of the study and is relevant to the objectives specified in Chapter one. In this case study, author had been apply 7QC tools with Plan, Do, Check, Action (PDCA) approach methods to solve the issue of defect in remanufacturing company. The crucial dimension out was identified as the most rejected area of the connecting rod during the process, and this observational study was examined utilising flowcharts, check sheets, pareto diagrams, cause and effect diagrams, scatter diagrams, and control charts. After implementing these technologies, the process would be more effectively managed. A permanent solution to a problem will arise from a thorough investigation of its root cause. Reduction in the rejection rate of remanufactured engines and enhancement of product quality are the effects of a successful implementation of the solutions.

Quality control tools are very useful and have an impact on quality activities and to tackling quality issues in the remanufacturing industry. In this research, author standardized the 7QC tools along the remanufacturing process and Cpk index was used as indicator for decision making to know the acceptance condition. The cpk value indicates the process is capable and can be rework or remanufacturing to the next process such as assembly, inspection and proceed to the customer. Then, standardizing 7QC tools in remanufacturing company where properly step had been apply and among all the 7qc tool only histogram can’t be applied bacause of unsufficient data given from company.

5.2 Recommendation

Reviewing the relevant articles and researching a variety of other online resources led to the conclusion that 7QC tools are an excellent method of improving the remanufacturing process. Then, the outcome of this reserch are PDCA concept could be able to be merged with it. In the observation made through a literature review as well as data collection from the remanufacturing company, the author highlights the application of 7QC tools with PDCA approach and as a consequence of this, evaluation of the fundamental factors should yield a manufacturing index that is based on Cpk. After that, develop the 7QC tool to make an analysis on the defective product that occurred in the production line. In addition to this, the author offer an appropriate step on how the correlation between 7QC with PDCA and employ Cpk as a decision through product produce in industries that involve remanufacturing.

As a recommendation, first piece buy off need to be implement which is detect the actual problem in setting and testing 1 product before ongoing process. Next, applying IPQC (inprocess inspection control) for each 1 or 2 hour to make dimension checking to know setting problem in the process. Then, Proper fixture maintenance and machine maintenance schedule were established, and regular checks were included in the check lists. In manufacturing, 7QC tools is based on the field. In remanufacturing, it is suitable to use 6 elements in 7QC tools. But in other field such as pharmacy or manufacturing maybe can used all the 7QC tools. To apply all the 7QC tools, preparation into data need to update. Lastly, The significant QC tool has been studied and suggested in a remanufacturing process. The validation of QC tool has been establish and 6 tools of 7QC have been applied in the case study. Histogram cant be apply because of insufficient data. If the industry want to investigate by using histogram, the data need to be completed.

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APPENDICES

APPENDIX A

	MOTOR TEKNOLOGI & INDUSTRI SDN BHD

Examination Report

Engine Type	3508 - DITA	**Customer**	EXXONMOBIL
Serial No	95Y01104	**Customer Order No.**	-
MTI Order No.	-	**MTI Job No.**	WO-ENG 0860
~~Vessel~~ / ~~Vehicle~~	NIL		
Operating Hours	NIL		
Reason for Inspection	Routine Maintenance	**Report No.**	02
Designation 1	Major overhaul		
Designation 2	Inspection of Connecting rod		

1. Nature and Extent of Examinations.

- To examine the condition of connecting rod.

2. Examination Result.

- All big end diameter bore within tolerance. (Refer to measurement datasheet)
- All small end bushes were out of tolerance.

3. Recommendation.

- All small end bushes need to be replaced.

4. Client's Remarks

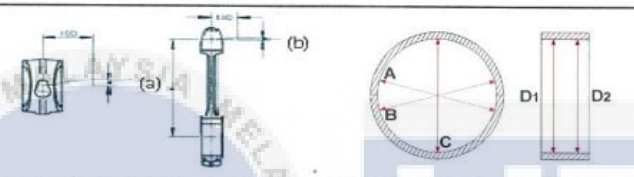
QA/QC Officer	**Hairul / Ajahar**	**QA/QC Manager**	**Matthias Lorch**	**Client Reps:**	
Date :		**Date :**		**Date :**	

APPENDIX B

BEFORE

CONROD DATA SHEET

Job No. : WO-ENG 0860
Description.: Main Engine
Engine Model. : 3508 - DITA
Engine No. : 95Y01104



Measuring Point.:		Basic Dimension:	1	2	3	4	5	6	7	8
Big End Dia:	A	Min : 143.013	143.020	143.020	143.020	143.020	143.020	143.015	143.020	143.015
	B	Max : 143.043	143.015	143.015	143.020	143.015	143.015	143.020	143.015	143.020
	C		143.020	143.015	143.015	143.015	143.020	143.015	143.015	143.015
Small End Dia:	A	Min : 69.992	70.010	70.010	70.010	70.005	70.010	70.020	70.010	70.010
	B	Max : 70.008	70.010	70.010	70.015	70.010	70.010	70.015	70.005	70.005
	C		70.005	70.010	70.010	70.010	70.005	70.015	70.010	70.010
Alignment:		Twist (B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Parallelism (A)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Remarks:
- All big end dia. Bore within tolerance.
- All small end bush were out of tolerance.

Recommendation: All small end bushes need to be replace.

MOTOR TEKNOLOGI & INDUSTRI SDN BHD QA Dept.

MOHD HAIRUL BIN MOHMED KHALIB
QC OFFICER
QA/QC DEPARTMENT

Date.: 24 / 10 / 2012	Examiner or QC.: Hairul	Item ID.:
Valid From.:1	Edition Index.:1.1	
Replaces Edition.:1.2	Issued By.: QC	
Compiled By.:	Approved By.: Matthias	
Machinist.: NIL		

APPENDIX C

APPENDIX C

Model: 3508-DITA	PART NAME: CONNECTING ROD	CHECK SHEET- DEFECT REJECTION OF CONNECTING ROD					PART NO. 95Y01104
Defect	Months						Total
	JUN	JULY	AUG	SEPT	OCT	NOV	
Production	**2320**	**1874**	**2122**	**1242**	**1481**	**1142**	
Dent mark	5	3	5	6	3	5	**27**
Dimension out	7	7	8	10	11	16	**59**
Sink mark	9	13	7	6	0	1	**36**
Overbuffing	6	0	6	0	1	4	**17**
Burr	15	13	10	0	4	0	**42**
Total Rejection	42	40	36	22	24	17	**181**
Monthly Rejection %	1.81%	2.13%	1.70%	1.77%	1.62%	1.49%	**10.52%**

APPENDIX D

MOTOR TEKNOLOGI & INDUSTRI SDN BHD

VERIFICATION

MOTOR TEKNOLOGI & INDUSTRI SDN BHD			
PREPARED BY	MOHD HAIRUL	CHECKED BY	MR. MATTHIAS LORCH
DESIGNATION	QA/QC DEPARTMENT	DESIGNATION	QA/QC MANAGER
SIGNATURE	MOHD HAIRUL BIN MOHMED KHALIB QC OFFICER QA/QC DEPARTMENT	SIGNATURE	
DATE	31/10/2012	DATE	31.10.2012

MOTOR TEKNOLOGI & INDUSTRI SDN BHD
QA Dept.

CHECKED BY	MR. HANSEN
DESIGNATION	PRODUCTION MANAGER
SIGNATURE	
DATE	31-10-2012

EXXONMOBIL REPRESENTATIVE	
CHECKED BY	
DESIGNATION	
SIGNATURE	
DATE	