IMPROVEMENT OF PRODUCT RELIABILITY THROUGH PRODUCTION PROCESS CAPABILITY STUDY AT FOOD AND BEVERAGES INDUSTRY

RADIN PUTERI FARZANA NATASHA BINTI RADIN MOHAMAD SHAMSUL ZAHRI

BACHELOR OF MANUFACTRUING ENGINEERING TECHNOLOGY WITH HONOURS

2021

Faculty of Mechanical and Manufacturing Engineering Technology

IMPROVEMENT OF PRODUCT RELIABILITY THROUGH PRODUCTION PROCESS CAPABILITY STUDY AT FOOD AND BEVERAGES INDUSTRY

Radin Puteri Farzana Natasha Binti Radin Mohamad Shamsul Zahri

Bachelor of Manufacturing Engineering Technology with Honours

2021

IMPROVEMENT OF PRODUCT RELIABILITY THROUGH PRODUCTION PROCESS CAPABILITY STUDY AT FOOD AND BEVERAGES INDUSTRY

RADIN PUTERI FARZANA NATASHA BINTI RADIN MOHAMAD SHAMSUL ZAHRI

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

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this Choose an item. entitled " Improvement of Product Reliability Through Production Process Capability Study at Food and Beverages Industry " is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Radin Puteri Farzana Natasha Binti Radin Mohamad Shamsul Zahri

Date : 17 January 2022

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 with Honours.

TS. DR. AMIR HAMZAH BIN ABDUL RASIB
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan Pembuatan
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

Signature :

Supervisor Name : Ts. Dr. Amir Hamzah Bin Abdul Rasib

Date : 17 December 2022

DEDICATION

To my dear father, mother, siblings, and friends, who have always been there for me spiritually and emotionally.

Ts. Dr. Amir Hamzah Bin Abdul Rasib, my supervisor, for mentoring, instructing, and assisting me in finishing my thesis.

ABSTRACT

With the numerous obstacles encountered by rivals in the same sectors, particularly in the food and beverage industries, the manufacturing sectors are increasingly improving their performance. Process capability refers to the ability of a process to produce a product that can provide a service capable of meeting the customer's specifications. The issue here is that the manufactured items are supplied to customers, resulting in items or services that do not satisfy their expectations. Therefore, this research aims to improve product reliability through production process capability. The primary objective is to identify product reliability in ways similar to process capability. First, the literature review is done based on the product reliability, and Cp, Cpk is collected and turned into knowledge. Next, the collection of production data from the selected food sector as an actual case study is required at the start of developing a capability based on a production system. Hence, the second objective of this research is to conduct and analyze the Cp Cpk method to improve product reliability through process capability study in the food and beverages industry. The technique in data collection is gathered by using a spreadsheet and capturing the photo. Only after the data has been studied to identify solutions to challenges in the food sector can the desired outcome be achieved. The final goal of this research is to offer an improvement activity based on the Cp and Cpk studies. Analyses are carried out using data that has been acquired. Analyzing the product's reliability and conformance to customer specifications is critical to determining its value. Based on the examination of Cp and Cpk, the most impacted aspect was determined and used as a proposal for improvement. At the same time as presenting the findings to the industrial representative, these recommendations are discussed.

ABSTRAK

Dengan pelbagai halangan yang dihadapi oleh pesaing dalam sektor yang sama, terutamanya dalam industri makanan dan minuman, sektor pembuatan semakin meningkatkan prestasi mereka. Keupayaan proses merujuk kepada keupayaan sesuatu proses untuk menghasilkan produk yang dapat menyediakan perkhidmatan yang mampu memenuhi spesifikasi pelanggan. Isunya di sini ialah barangan perkilangan dibekalkan kepada pelanggan, menyebabkan barangan atau perkhidmatan tidak memenuhi jangkaan mereka. Oleh itu, penyelidikan ini bertujuan untuk meningkatkan kebolehpercayaan produk melalui keupayaan proses pengeluaran. Objektif utama adalah untuk mengenal pasti kebolehpercayaan produk dengan cara yang serupa dengan keupayaan proses. Pertama, kajian literatur dibuat berdasarkan kebolehpercayaan produk, dan Cp, Cpk dikumpul dan dijadikan pengetahuan. Seterusnya, pengumpulan data pengeluaran daripada sektor makanan terpilih sebagai kajian kes sebenar diperlukan pada permulaan membangunkan keupayaan berdasarkan sistem pengeluaran. Justeru, objektif kedua penyelidikan ini adalah untuk menjalankan dan menganalisis kaedah Cp Cpk bagi meningkatkan kebolehpercayaan produk melalui kajian keupayaan proses dalam industri makanan dan minuman. Teknik dalam pengumpulan data dikumpul dengan menggunakan hamparan dan menangkap foto. Hanya selepas data dikaji untuk mengenal pasti penyelesaian kepada cabaran dalam sektor makanan barulah hasil yang diinginkan dapat dicapai. Matlamat akhir penyelidikan ini adalah untuk menawarkan aktiviti penambahbaikan berdasarkan kajian Cp dan Cpk. Analisis dijalankan menggunakan data yang telah diperolehi. Menganalisis kebolehpercayaan dan pematuhan produk kepada spesifikasi pelanggan adalah penting untuk menentukan nilainya. Berdasarkan pemeriksaan Cp dan Cpk, aspek yang paling terkesan ditentukan dan digunakan sebagai cadangan penambahbaikan. Pada masa yang sama semasa membentangkan penemuan kepada wakil industri, cadangan ini dibincangkan.

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.

My utmost appreciation goes to my main supervisor, Ts. Dr. Amir Hamzah Bin Abdul Rasib, Universiti Teknikal Malaysia Melaka (UTeM) for all his support, advice and inspiration. His constant patience for guiding and providing priceless insights will forever be remembered that who constantly supported my journey.

Last but not least, from the bottom of my heart a gratitude to my beloved parents, Radin Shamsul and Sarimah Jurimi, for her encouragements and who have been the pillar of strength in all my endeavors. Also, for their endless support, love and prayers. Thank you to all my colleagues for their helping, supporting and understanding. Finally, thank you to all the individual(s) who had provided me the assistance, support and inspiration to embark on my study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

Cp	-	Process Capability
Cpk	-	Process Capability Ratio
Pp	-	Process Performance
Ppk	-	Process Performance Index
RQ	-	Reseach Question
SPC	-	Statistical Process Control
DfR	-	Design for Reliability
LCL	-	Lower Control Limit
UCL	-	Upper Control Limit
LSL	-	Lower Specification Limit
USL	-	Upper Specification Limit
±	-	Plus and Minus (average)
σ	-	Sigma or Standard Deviation
4M	-	Man, Method, Material & Machine
PCIs	-	Process Capability Indices
F&B	-	Food and Beverages
DMAIC	-	Define, Measure, Analyze, Improve and Control
Sdn. Bhd.	-	*Sendirian Berhad*
Mardi	-	Malaysian Agricultural Research and Development Institute
FAMA	-	Federal Agricultural Marketing Authority
SME	-	Small and Medium Enterprises
SIRIM	-	Standard and Industrial Research Institute of Malaysia
SMIDEC	-	Small And Medium Industries Development Corporation
MARA	-	*Majlis Amanah Rakyat*
Jakim	-	*Jabatan Kemajuan Islam Malaysia*

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Research Background

In the present era of competitive manufacturing, the challenge is to be on the cutting edge of producing excellent products at the lowest possible cost. This is unlikely without a detailed approach, which can be found in what is known as statistical quality control or Industrial Statistics. As identified by Rastogi et al. (2016), process capacity of analysis is a part of quality management that can be observed and discussed with the product. Nothing is more dominant than ensuring certification that the procedure can fulfill the specific process capability when organizing the quality aspects of operations. The concept of process capability is crucial for mechanical directors to comprehend (Pawar et al., 2016).

In production, process Capability (Cp) is known as an appropriate compensation of a process capable of consistently producing parts within given parameters. By focusing on the range of products and, the procedure used to calculate the standard deviation or sigma value there have several methods that can be calculated. Developers can measure to see just how their method is functioning with Cp (Process Capability), Cpk (Process Capability Ratio), or Pp (Performance Index) and Ppk (Performance Centering Index).

Inside of reasonable categories, sample, variance, or deviation mean are used in the Cp and Cpk measurements. Coefficient of variation or standard deviation is used in the Pp and Ppk measurements, which are based on observed results on the whole population. The Cp and Cpk indices are used when a sample, not the population, and are testing the potential capability of a process to meet customer needs. The Pp and Ppk indices are used when the entire population and are testing the performance of a system to meet customer needs (QI Macros, 2018).

Based on the capability of the process, there will include many product requirements for their needs. Here, to know the reliability of products is to improve the production process in the F&B industry. The capacity of a device or component to operate under specified conditions over a given period is referred to as reliability. It was founded by IEEE (1990) that efficiency, which is commonly characterized as a components or platforms ability to operate at a particular stage or interval of period, is genetically similar to reliability.

Process reliability refers to the consistency as to how far a process's production separates from any predetermined values. In most cases, high reliability is the goal, particularly when the output quality is critical for a subsequent process. Process efficiency can be improved in a variety of ways, but the most common one is to monitor past output and change certain factors appropriately.

1.2 Problem Statement

Process capability indices are a way of measuring how well an in-control process adheres to a collection of specifications. Process Capability Studies are used to determining the processes are capable of under controlled environments. Moreover, it is because of the water volume is inconsistent at the F&B industry. The research examines how efficient a method is under optimal conditions for a short period. The advantages of performing a processing capacity assessment are that it helps to evaluate a process's short-term reliability and capability.

The issue that arises in F&B industry is the quality in which is manufactured products are delivered to products, resulting in products or services that do not satisfy their requirements. Most organizations believe in development activities without even considering anything like a well-thought-out strategy. Reliability is a metric that assesses the consistency or accuracy of test results. The capability to replicate a test or research results.

The use of process capability indices in production to meet product requirements is a way to increase product reliability through process capability in the F&B industry. A process-capability inspection is used to evaluate a method that ability to meet requirements. As a result, this method would aid in maintaining that product reliability improves in the F&B industries.

1.3 Research Question

Three research questions are identified based on the problem statement.

RQ1: What is the root cause that related on product reliability on the F&B industry?

RQ2: What is the technique that applied to solve product reliability?

RQ3: How process capability helps in making sure product reliability in production at the F&B industry?

1.4 Research Objective

The overarching goal of this case study is to improve product reliability in the F&B industry by studying production process capability. This project has a set of underlying objectives:

i) To identify product reliability in ways similar to process capability.

ii) To conduct and analyze Cp Cpk method to improve product reliability through process capability study at food and beverages industry.

iii) To propose an improvement activity based on process capability study.

1.5 Research Scope

This research will concentrate on process improvement, often known as the production process in F&B industry production assembly procedures. The major strategy is to enhance the product reliability of the industry's F&B process. Process capability has become one of the key goals for ensuring that products' requirements are fulfilled. As a result, utilizing process capability indices such as Cp and Cpk makes the study scope quite appropriate, methodical, and dependable.

1.6 Expected Result

The study's expected outcome is to identify the factors that affect product reliability as a result of process capability in the F&B industry. Validate new ideas for improvement through process capability studies after redefined and found solutions for improving reliability and production. Present the method of change to the F&B industry sector after completed the verifiable evidence. This research aids in the application of information and research in a real-world situation. This is an excellent opportunity to gain experience outside of the college. This research aids in determining the production process in the industry, identifying its flaws, and making improvements derived from the findings.

Into the bargain, the expected result for this study is to measure a process capability to evaluate a process's ability to meet product reliability requirements in production. Based on the findings, a process capability study in the F&B industry was conducted to strengthen, develop, and approach product reliability. Last, but not least, the expected outcome is to recommend an improvement activity based on process capability study on the F&B industry.

1.7 Thesis Frame

The first chapter of this study is devoted to its introduction. This chapter describes the research history that informed into this report essay. Moreover, in this chapter, the research of problem statements is discussed. The research issue is then described using the problem statement as a guideline. Although the research question is clearly stated in this document, the research objectives are also written down, and the research scope is also described in this chapter. This study's expected outcome as well as the thesis frameworks is mentioned and the study's summary will be present.

The second chapter is all about preparing the studies of literature review. To prepare for the writing of this chapter, all relevant information about this study, such as reliability, product, production, and process capability study is found and read in this chapter. Discovering historical journals and articles, as well as gaining knowledge from these recent journals and articles, was true as the method used to write this thesis essay. Then, for the topic by topic, write down what individuals learned in this chapter. As a result, there will be several sub-topics in this chapter, each of which is related to this research.

Next, the methodology introduced in this analysis is then applied in the third chapter. The methods and tools were described in this chapter, as well as the guidelines for conducting the research. In this analysis, the processes and approaches will be thoroughly explained. In this chapter, individually also learn about major issue strategies to perform. The conclusions and recommendations of this analysis will be presented in chapter four.

This analysis will use the methods and techniques described in Chapter 3 in this chapter. There is more detail on how to use skills and methodologies. This chapter would analyze the outcomes of using these methods and techniques. The discussion will be based on the results which will help to achieve the study's goals of the thesis requirement.

Eventually, in chapter five, the report's thesis will be applied. The findings of the overall research will be summarised in this chapter. This report's progress will be visible. The future for launching an updated F&B industry of process and management system of production is discussed. The proposal's procedure results were shown as supporting documents to strengthen the framework. The improvement will be demonstrated, and the accurate understanding, as mentioned in the thesis, will be described in this article.

1.8 Summary

In the nutshell, because of product demands and competition with other industries, F&B industry development is increasingly accelerating. By the same token, efforts should be made to improve the quality and efficiency of the F&B industry process. Besides, to maintain the industry's efficiency and productivity on processing a product on production stage. Applications of reliability, such as process capability, are one method of improving product reliability. The method of reliability is to optimize and accurately produce a product that will meet the needs of the consumer. This approach is derived from quality management and Cp Cpk, which are especially useful in F&B industry environments.

CHAPTER 2

LITERATURE REVIEW

2.1 Preliminaries

Today's engineers must perform in the production industry and determine if the product can give the same parameterized outcomes or supply inadequate faulty components to consumers. However, there seems to be a unique impact of process capabilities on the cost of production in every F&B industry sector. Process capability is needed to ensure that the output and machineability are within identified tolerances (Pawar, 2010). In process capability, reliability is the phrase that relates towards the uniformity of either a research study or measuring test in psychological studies. Hessing (2015) identified that, the intrinsic statistical variability of an idiosyncratic mixture of instruments, materials, procedures, and require collaboration in making a quantifiable development may be measured using statistical methodologies.

The quality proceeding has evolved into one of the widest market decision factors when deciding between competing goods and processes (Mbohwa, 2016). As a direct consequence, the method has been assessed as important to maintain production efficiency. The totality of all qualified as well as organizational efforts to regulate the F&B industries skills to improve and maintain efficiency is known as statistical process control (SPC).

Statistic Methodology Controlling begins with the assessment of understanding the system to the point of what is known as process performance identified by (Senvar and Tozan, 2010). Process capability, often known as Cp and Cpk, is an identifiable attribute of an operation that is represented as a process capability index. This research focuses on product reliability through production process capability in the F&B industry.

2.2 Reliability

Reliability is the potential that a product or mechanical device will perform satisfactorily for a given period under normal operating conditions. McLeod (2013) confirmed that in psychological research, the term reliability refers to the consistency of a research study or measuring test. Despite this, quality is concerned with a product's or service's beginning effectiveness, whereas reliability is associated with continuing performance over time. A product that performs better at first may fall short of the same performance later. In such a case, a product is deemed untrustworthy were state by (Benafqir et al., 2020). As a result, manufacturers must generate high-quality products and products that are dependable.

The term "reliability" or "dependability" is used in various industrial and manufacturing contexts. In general, the concept of reliability is used when it is critical to achieving the same results repeatedly states by (Brake and Brake, 2015). For example, a manufacturing process is reliable when consistently producing the same results within defined limits. A car, or any other type of product, is considered reliable if it performs consistently and meets expectations.

Shmula (2021) highlights that the dependability of financial and other data types may be affected by how they are compiled and prepared. Personnel is considered credible when they perform equally well and meet predefined goals.

In industries such as engineering, reliability is also an important subject. Plants, processes, materials, and various other aspects of the manufacturing process are all subjected to rigorous testing to ensure their dependability. However, Ippolito (1996) hypothesis that because reliability often does not imply perfection, continuous efforts are made to improve the dependability of a wide range of manufacturing functions. The dependability of such processes has a direct impact on a manufacturing industry's financial performance as well as the dependability of its products.

2.2.1 Product Reliability

Product reliability is critical not just for the manufacturer as well as to the customer. When customers purchase, they have expectations about how well those products could function and how long they will last claims by (Mohamad, 1987). When industries provide an extended warranty, they demonstrate their confidence in their products' dependability. Generally, the manufacturing company assumes the cost of any repairs or defects during the warranty period and, in some cases, may even exchange goods at no additional expense (ASQ, 2021).

When determining a product's reliability, the conditions under which it is used must also be considered. If a product hasn't been used appropriately or is not well maintained, its operating time and reliability may be reduced. Reliability data in the form of curves or charts is extremely useful when making critical decisions was agreed by (Shmula, 2021).

A successful manufacturer has never stopped introducing new features or enhancing existing ones for a production. The newer features or product updates manufacturer can bring to products, the happier they will be. Industries may spend less time managing fires and more time consistently delivering to products thanks to reliability engineering (Mcleod, 2013). This would have an effect on the essential factors that contribute to an industry's product reliability.

2.2.2 Factors of Reliability

Reliability refers to the accuracy and precision of a measurement procedure was founded by (Tong and Chen, 1998). The relative lack of error in an instrument is referred to as reliability. Furthermore, the properties of the underlying construct being tested, the test itself, the groups being evaluated, the testing context, and the object of evaluation all influence reliability.

Numerical value, intended function, life, and environmental condition are the several factors associated with the reliability of products was identified by (Abdullah et al., 2019). For starters, a numerical value estimates the probability that the product will perform satisfactorily at a given time. For example, a probability of 0.93 means that 93 of 100 products will operate after a defined amount of time, while 7 products will not. The failure rate of units of product can be defined using specific probability distributions.

A product's intended function is defined as a product that would be designed for specific applications and also is expected to perform those tasks. An electric hoist, for example, should be able to lift a load that exceeds the design requirements. The life of a product refers to how long it is supposed to last. Abdullah et al., (2019) mentioned that product life is described as a function of use, time, or both, while environmental conditions refer to products that are engineered for indoor use but cannot be expected to work consistently outside in the sun, wind, or precipitation. It is also are included the validity of the product on the F&B industry.

Besides, the term of reliability and validity have been used to examine the effectiveness of the findings. Terms describe the accuracy with which a methodology, approach, or measurement instrument information. Validity is concerned with an initiative's precision, whereas reliability is concerned with its persistence.

2.2.3 Relationship Between Reliability and Validity

Reliability relates to the how consistency through which a technology evaluates some measurement. When the same outcome could be produced that uses the same procedures under these parameters, the process was called precise (Benmoussa et al., 2015). Validity refers to the precision by which a method decides what it would be intended to estimate. Whereas research seems to have a significant level of accuracy, the outcomes are linked to actual traits, characteristics, and variances (Middleton, 2019). The degree to which an instrument measures the same way each time it is used under the same conditions and with the same subjects is referred to as reliability as shown in figure 2.1.

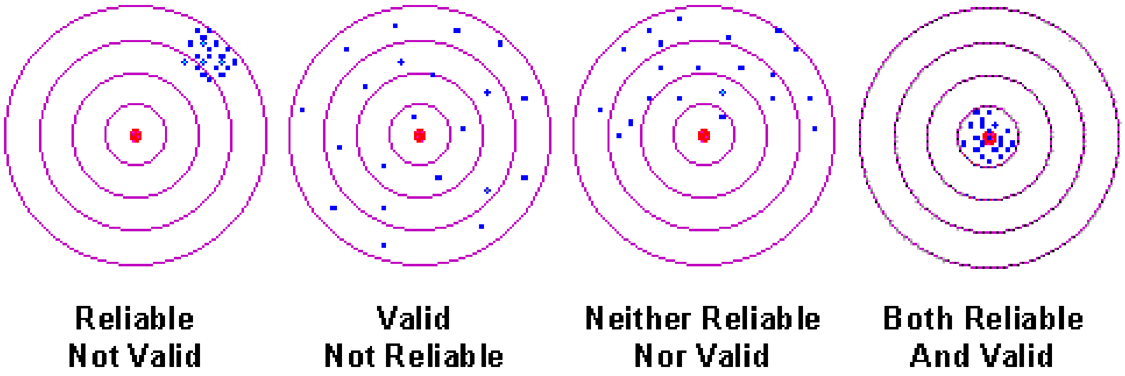


Figure 2-1: The different between reliability and validity (Trochim, 2020)

In a nutshell, it refers to the consistency with which companies calculate their production. Middleton (2019) was highlighted if a product receives a similar score on the same test given to them twice, the measure is considered accurate. It's important to keep in mind that reliability is an expectation rather than a measurement.

On the other hand, validity refers to how accurately an analysis represents or evaluates the particular definition that a consumer is attempting to measure. Trochim (2020) stated that validity is focused on achieving the intended measure, while reliability is concerned with the accuracy of the actual measurement technique or produces. Through this situation, industries can achieve reliability of product.

2.2.4 Achieving Reliability

Reliability can be achieved by four phases related to the production on process capability. It is included emphasis, system reliability, design, and production in F&B industry. Increased emphasis is being given to product reliability to the Consumer Protection Act is one of the reasons for this focus on the reliability of the product. Automation, where products are often unable to manually operate when an automatic component fails, is another cause for the increased focus on reliability (Abdullah et al., 2019). In terms of system reliability, as products become more complex with more parts, the possibility of them working rises. As a result, the method of arranging the components affects the overall system's reliability.

Furthermore, the design which should be as simple as possible, is the next most important element of reliability. The lower the amount, the more trustworthy it is. A backup or redundant component, similar to a parallel component, is another way to achieve reliability. When the primary component fails, another is triggered to take its place. When achieving a certain level of reliability, it is frequently less costly to use inexpensive redundant components rather than a single expensive component.

As explained by Ippolito (1996) the design for Reliability (DfR) is a set of instruments and processes for assuring compliance that a product meets the reliability requirements for the duration of its existence in its intended environment. DfR is used in the product design process to improve product reliability ahead of time.

Meanwhile, simple quality procedures in F&B industry can reduce the chance of product unreliability. The focus should be on the components that are the least reliable. In F&B industry, it also can take steps to ensure that the specification industries using is appropriate for the job and to figure out which conditions result in the most reliable product.

2.3 Process Capability

This potential of a method of creating output is referred to as functions of process capability was founded by (Benmoussa et al., 2015). Meanwhile, it is can provide a service that capable of meeting the specifications set by the product or designer. Instead, it describes to such a system's intrinsic capacity consistency create comparable parts over a prolonged period underneath a specific set of circumstances.

On the other hand, Shmula (2021) pointed out that process capability is the maximum limit for how much a methodology can generate in a given time, which is much more receptive and responsive to improvement. There are several ways to improve a system's process capability, including some reasonably priced ones that most industries should be successful in implementing, and it's critical to study this aspect of your organisation to know how to prepare it for the future.

During F&B industry manufacturing, any product may require a part tolerance so fine that machines are incapable produce it. Regarding assembling, it's indeed hard to manufacture items ranging again from the upper end including its specified parameters to the lower end of the spectrum of the specified parameters.

Apart from this, assessing process capacity helps the industry meet product requirements. Process capability principles can help product manufacturers and service providers make decisions about product or process requirements, suitable F&B industry methods, machine to use, related equipment and time commitments.

The author Pawar et al. (2016) described process capability as a critical concept for engineering coordinators to comprehend. The ambition in a contemporary market economy is to be at the forefront of technology of supplying high-quality items at the lowest feasible cost. This is unlikely without a depth measurement, which can be found in what is known as statistical quality management or Industrial Statistics. Udroiu & Braga (2020) also mention that each production capability study seems to be the component of quantifiable product quality discussed within.

2.3.1 Process Capability Study

This process capability study would be necessary to ensure that perhaps the output and machineability are beyond the established tolerances throughout the problem statement, as a higher probability of failure resulted in decreased production. Based on the results, Critical Quality Characteristics (CQC) are detected upon measurements of extruded components during the Measure process are obtained from Pareto charts (Nassir et al., 2016).

The analysis step identifies the causes and effects of the increased defect rate on the F&B industry process. Improve phase suggested ways to reduce the elements that impact performance and impact the economy. Eventually, this controlling process being utilized for regulating the overall method in accordance mostly with enhanced specifications including its F&B industry system.

Reduced demand costs, as indicated by Caulcutt (2004), assist industries classed as Small and Medium Enterprises (SME) remain viable in the commercial center on process capability analysis. Manufactured expenses are split and analyzed into three categories, with new methodologies and modest enhancements in the constant process enhancing environment and facilities.

The amount of defective goods generated during a F&B industry system that may be used to evaluate the importance of production was mention by (Udroiu & Braga, 2020). That's because there are limits to how often a procedure can generate a successful quality. Procedures that require immediate adjustment, even those that do not, may be emphasized as a consequence of the manager's or engineer's efforts. Process capability studies indicate if a process can produce almost any conforming commodity. When the process is competent, project performance controllers can be utilized to manage it, allowing standard approval efforts to be decreased or abolished entirely.

Following a process capability analysis, an operation would be classed as competent or incompetent, as illustrated in the diagram on Figure 2.2 and Figure 2.3. When one process becomes incapable of creating almost all conforming products, it also seems to be incompetent, therefore 100% of inspections should remain a component of the process.

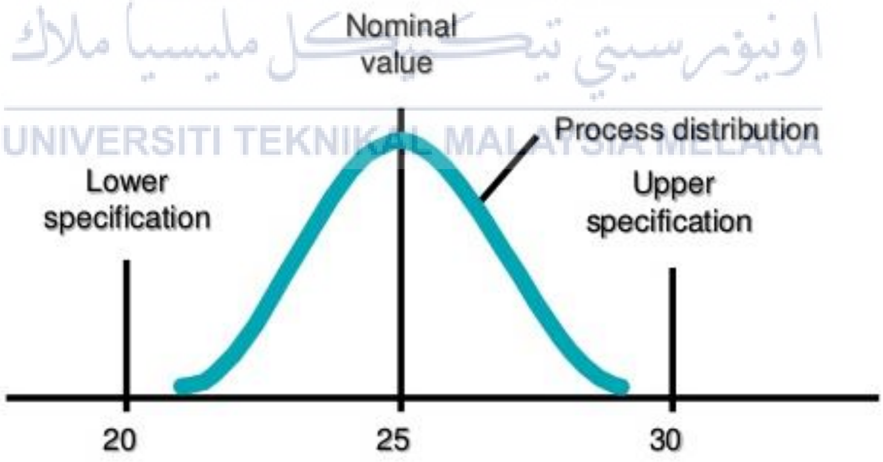


Figure 2-2: This process is capable (Caulcutt, 2004)

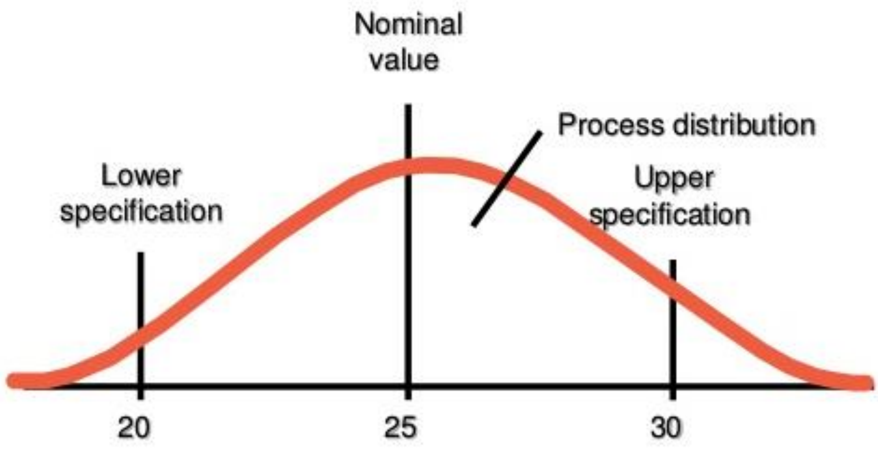


Figure 2-3: The process not capable (Caulcutt, 2004)

2.3.2 Relationship between Control Limit and Specification Limit

It's crucial to understand that a process under static control can or may not meet the product's specifications. There is a difference between a method that relates to specifications and one that operates under statistical control. Control limits and specification limits are two distinct measurements.

There may not have much influence over the product's specifications as a second degree, but they can focus on adjusting control limits. Shifting or changing the control limit is, once again, a time-consuming process. As a result, we will have to put in extra effort to shift or change the control limit following the specification limit given by the customer on the product.

2.3.2.1 Control Limits

The production control chart's control limits reflect process variance and aid in identifying when a process is out of control. For each control chart, control limits are determined using process data. The limits of an X-bar chart and an individual measurements chart can vary as stated by (Podder, 2015). On the other hand, according to Bottani et al., (2021), the horizontal lines above and below the central axis are utilized to establish even when a technique is well out of range. The irregular variation of the process determines the upper and lower control limitations. Minitab's control limits were indicated three standard deviations near the outer midline by default in figure 2.4.

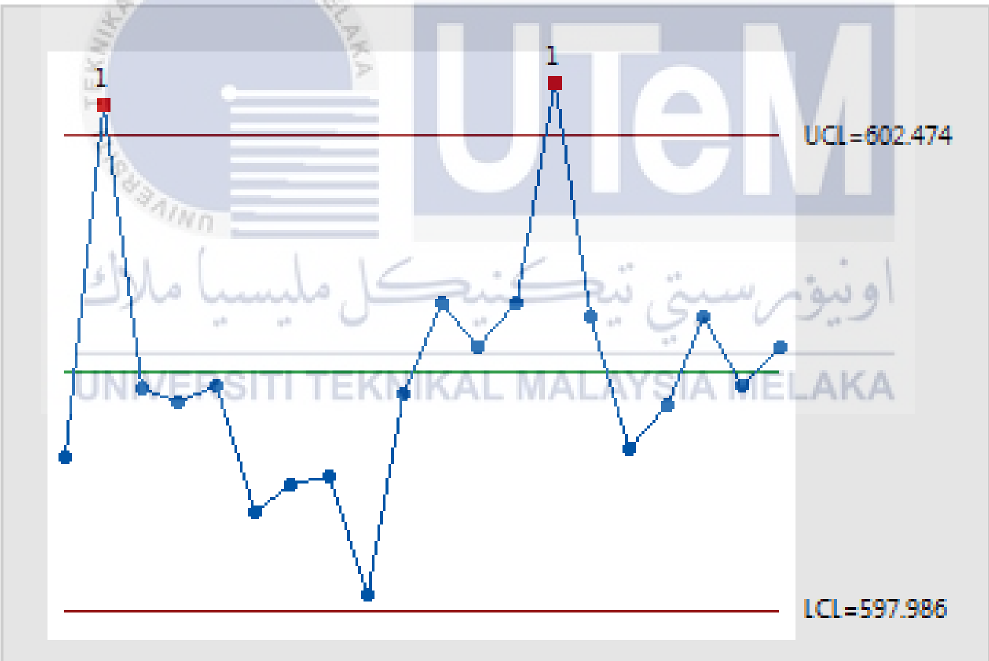


Figure 2-4: The example of function on control limit

(Minitab express, 2019)

The limit set by the product is known as the specification limit. There are two kinds of control limits which are LCL means of (Lower Control Limit) and UCL is (Upper Control Limit). Dunning (2017) also mentions that, on even a control chart, UCL stands for upper control limit and LCL stands for lower control limit. The control chart is a graphical representation that depicts what would be happening in the process of production across the period.

In the same way, the control limit is the property of the process of data. Kumar et al. (2018) founded that any process's control limit indicates that all deviation from the predicted source is contained within this limit. In general, only a small portion of variation is contributed by special causes, and if a source contributes a large amount of variation, that source is no longer special, but more normal. Only the product's voice varies within the control limit.

Phase cantering is represented in the middle line. Limits reflect the amount of difference in the method for the R and X charts. It also includes a forecast of the variance that the process will exhibit shortly, as well as a control limit that indicates the truth of the variation process according to (Yusuf et al., 2019).

2.3.2.2 Specification Limits

Process capability analyzes the actual result of an in-control procedure to a specifications limitation through capabilities index. Suboohi Safdar (2014) were stated that relation including its difference seen between production parameters and specifications "width" to a range of an important product, as measured via 6 processes sample variance values, is used to construct the process "width" comparison.

It similar to Hessing (2015), the product's specification limits are considered described here as product's opinion. Control limits are measured according to the control chart they are using, while specification limits are calculated according to the specification limits. The X-Bar chart in figure 2.5 below shown illustrates the problem on specification limit.

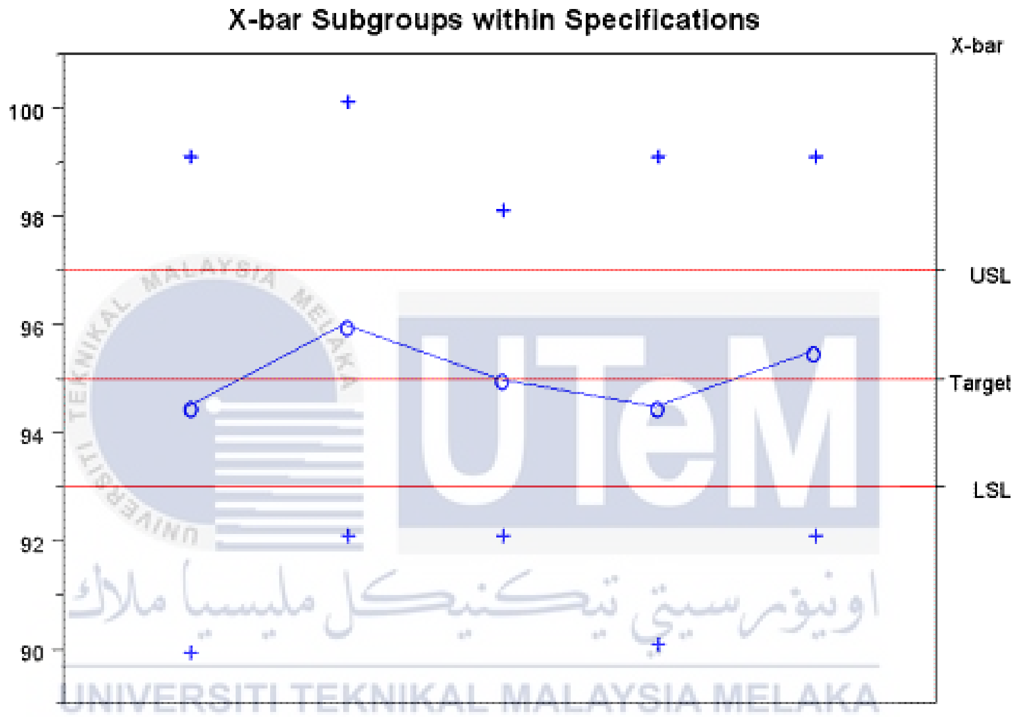


Figure 2-5: The illustrates of the problem on specification limit (Kumar et al., 2018)

The limit set by the product is known as the specification limit. There are two kinds of specification limits which are LSL (Lower Specification Limit) and USL (Upper Specification Limit). As identified by (Kumar et al., 2018), the product's requirement is quantified by these constraints. These products said to meet their product's expectations if it falls within the USL/LSL range. Here, if any product does not fall into the USL/LSL range, it does not meet the customer needs of the products.

2.3.3 Assessing Process Capability

This was difficult to assess process capabilities in terms of dependability. Some instructions awareness and consumer should delay till the system recognizes equilibration before taking any sample and calculating the standard deviation. However, Mondal (2016) expressed their opinion that was impossible to predict if the process would achieve balance and whether the mandated sampling is typical of a process. The examination of method capability is more complicated than that.

Table 2-1: Assessing Process Capability

(Mondal, 2016)

Sample	**Period**			
	1	**2**	**...**	**10**
1	X	X	...	X
2	X	X	...	X
.	.	.	...	...
30	X	X	...	X

Thus, by referring to Table 2.1, that would have several F&B industry processes having fewer time intervals each F&B industry process for even more confidence. Estimates of process capability generated using this technique will be informative as well as independently of processes means changeability between sampling intervals in this case. It is similar to (Mondal, 2016), there is no way for the pooled, the within-group standard deviation is likely to be tainted by attachable variances. Thus, since it was calculated on measurements taken close together in time.

2.4 Process Capability Indices

As identified by Kumar et al., (2018), there is no commonly acknowledged meaning for the word "process capability". It is widely accepted that its primary goal is to decide how well a process produces production that meets design requirements for a product or service.

Overall distributions of processing capacity indices estimation techniques might not have been technically useful, necessitating modifications to avoid wrong judgments and misstatements of real quality products. An investigation of such non-normality influence upon production capacity calculation method is so far beyond the scope of this brief communication (Lepore et al., 2018). However, even though various approaches for managing non-normal processes were previously proposed.

To evaluate the process capability indices, several capacity indices have been proposed. Cp and Cpk are two of the most widely used indices in the F&B industry such as Cpm and Cpmk are more advanced indices. These capability indices assess a product's or service's current ability to meet design specifications (Lepore et al., 2018).

2.4.1 Standard Deviations, σ

A standard deviation seems to be a computation of such range among observations relative to respective means which highlights the fact because measurements to differ from either the means contain different preferences. (Neil, 2021) were states that the standard deviation originally defined even as the square root of variances between both the observation and also the average. The average ± standard deviations are also the two most commonly had been using measurements for defining a distribution.

A standard deviation (SD, a Greek letter sigma r) seems to be a statistical metric used to assess the degree of variation or dispersion of a sequence of data variables. A lower standard deviation shows that the research points are near toward the mean of the collection, also known as normal estimates. The higher standard deviation shows that the data samples were dispersed throughout a variety of parameters. The standard deviation by Zhang and Lu (2016) was given by formula (2.1) below:

$$\sigma = \sqrt{\frac{1}{N}(x_i - \bar{x})} \quad (2.1)$$

2.4.2 Capability Index, Cp

Process capability indices (PCIs) have garnered considerable attention in recent years as a way to assess process capability. Cp, Cpk, and Cpm are the most commonly used indexes. Process capability index is a straightforward and easy-to-understand measure of process capability. Based on Abdullah et al., (2018), the process index is a numerical representation of variance in comparison to the tolerance or specification. It means that if the distribution is less, the Cp will rise.

However, Podder et al., (2018) states that Cp just considers how easily visible the figures' measurements are. As a result, Cp is simpler to use but less useful. It seems to me; the Cp is easier compare to Cpk to make measurements for some process. The following formula (2.2) below can be used to measure Cp descripts on figure 2.6.

$$Cp = \frac{USL - LSL}{6\sigma} \quad (2.2)$$

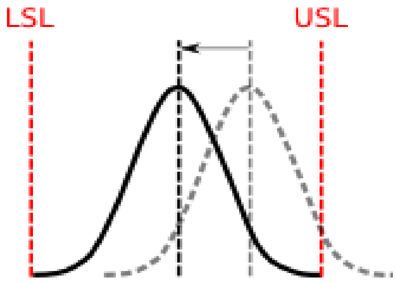


Figure 2-6: The formula and chart of Capability Index, Cp

(Rob, 2019)

2.4.3 Process Capability Ratio, Cpk

The Process Capability Ratio becomes a straightforward metric that illustrates as proximity processes are to fulfilling the specified limitations in contrast to its inherent variability (Polhemus, 2021). It means that capability ratio is an index that measures the possibility of a process producing a defective product that is either upper or lower specification.

Similarly, Podder (2018), one of the most common metrics for assessing process capability is Cpk. It's used to see how the product fits within the product's requirements. It is known as the Process Capability Index. The higher the index, the less likely any object would be out of specification.

Schuh et al., (2020) indicated that many functional processes in the real world violate the expectation that the process is normally distributed, and that the application of Cpk leads to severe errors unless the process distribution is normal. The following formula (2.3) below can be used to measure Cpk shown on figure 2.7.

$$Cp = min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right) \tag{2.3}$$

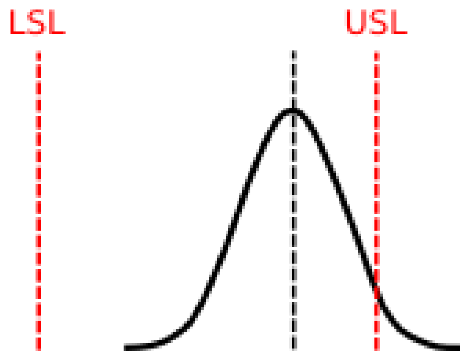


Figure 2-7: The chart of Capability Ratio, Cpk

(Podder, 2018)

A process capability of at least 1.33 implies that perhaps the operation would satisfy that product's requirements. This has a process yield of 99.99 percent and a sigma level of 4.0, indicating that nearly all measurements are within the product's requirements (Podder, 2018) are represents on table 2.2.

Table 2-2: The sigma level for Capability Ratio, Cpk

(Develve.net, 2019)

Cpk	**Sigma**	**Yield %**
0.33	1.0	68.27
0.67	2.0	95.45
1.00	3.0	99.73
1.33	4.0	99.99
1.67	5.0	99.9999
2.00	6.0	99.9999998

2.4.4 Relationship between Cp and Cpk

Since it considers the mean and standard deviation in its measurement, Cpk is more commonly used than Cp. The difference between Cp and Cpk shows how much the process' average deviates from the targeted specification. The difference between Cpk and Cp closes as the process average reaches the target value. Oracle (2016) confirmed that Cpk is equal to Cp when the specification's average is equal to the target value. Cpk would never be larger than Cp. Here means that the generation of descriptive statistic views and histograms can be used to measure Cp and Cpk.

Similar to that statement, both Cp and Cpk describe the process capability, Cp is referring to the data spread and width of the data range. While Cpk refers to data points close to the mean. Even though these offer process capabilities, Cpk presents another more extensive process capability (Chitranshi, 2018). Cp typically provides datasets between USL and LSL, sees the data point with the mean. There is a chance that data points are in the middle of the specification range yet fall short of the target. As a result, reducing the space between of dataset and the objective makes this mechanism more competent.

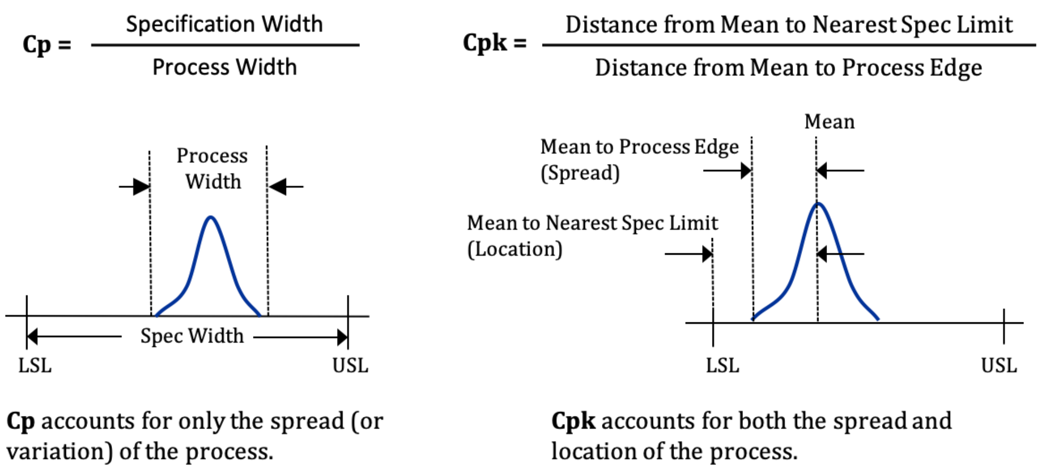


Figure 2-8: The relationship Cp and Cpk (1Factory, 2011)

According to Abdullah et al., (2018), if Cp is 1.0 or more, the operation is possible to produce a product that fulfills specifications. The Cp value doesn't accommodate for process centering. But when the process is centered, on the other hand, Cp is equaled to Cpk as shown on figure 2.8. Then, if Cp is greater than or equal to 1.0 and Cpk is 1.00 or greater, it indicating that the process is F&B industry a product that meets the products' expectations.

It similarly with Montanari et al. (2021) state the indexes show that the process is not centered; indeed, while the value of the Cp is satisfying and higher than the target of 1.33, the value of the Cpk is deficient. Several simulations have been run using an Excel spreadsheet to improve the Cpk.

When Cpk would be less than 1.00, however, it suggests that the process is creating a product that does not fulfill the requirements of the products. Hsu and Shu (2008) agreed that Cp and Cpk can be extremely useful in determining whether or not a process is capable of generating goods or services that meet the required specifications on its measurement.

2.5 Tools of Process Capability

Process capacity research aims to measure whether or not an operation can satisfy the specified restrictions. By using the tools of process capability, it's can make measurements for a production process's inherent precision. Ribbins & Whale (1991) highlighted that usually since accurate estimates upon this process during operating environment are not feasible, the system can be monitored implicitly through estimating product uniformity.

When only random variation exists, it should be the range of personal desires of a quality feature produced either by the process that is generally anticipated to decline. In addition, the procedure should be statistically controlled.

2.5.1 Statistical Process Control, SPC

SPC is a statistical system used to managing and controlling such as management a procedure either F&B industry or service using statistical methods (Ellis,1996). SPC is a statistical technique for controlling and reducing variance in processes. The elimination of variation is an important aspect of improving quality.

As identified to the author, there are two key causes of variation which are assignable or special and normal or chance (Oakland, 1999). According to Does et. al (1999), Western Electric's variance reduction initiatives have occurred in various sort of situations, there are both specific and typical reasons.

Since special causes of variance aren't built into the process, they're easy to recognize (Oakland, 1999). They are greater and necessarily require certain process/system changes to be eliminated. As related to the previous author, Deming (1986) states that special causes are variations that should be avoided, such as machine inaccuracy or worker exhaustion. Since common causes are often present in a process, they affect all of the process's products or services.

This was important to remember that SPC keeps the control charts to demonstrate if something is problematic with a procedure and it may be out of statistical control (Caulcutt, 2004). However, it does not specify what is wrong with the process to the user (or operator). The primary application domain for SPC charts, (Stoumbos et al., 2001) has been in process management and process enhancement in F&B industries.

2.5.2 X-Bar Chart

The X bar-chart represents the method's cantering or changes within that sample average. Graphs depict the average values of variables. If the variance structure is standard, the mean value appears to be these control measurements upon the majority of all the other measures are collected (Neil, 2021). Since the chart must be interpreted to decide if the process is stable, it is shown. The chart's control limits are determined using both the spread and the center of the processes. Formula (2.4) and (2.5) below presents the X-bar chart formula, where A_2 has become the control chart coefficients that vary depending on the size of the sample subgroup.

$$UCL = X + A_2\bar{R} \tag{2.4}$$

$$LCL = X - A_2\bar{R} \tag{2.5}$$

2.5.3 R-Chart

Over time, the process range (R-Chart) of variables data for subgroups is displayed. This control chart is widely used in industrial applications to evaluate process capacity (Gejdo, 2015). It would use R-Charts to observe process variation in subgroups on component length. The R-Chart is displayed although it may be read to determine whether the system is competent.

These control limits of the X-bar chart are calculated using both the spread and the center of the processes. Whereas if R-Chart has been out of range, the X-Bar chart's control limitations may be erroneous, incorrectly suggesting or misdiagnosing an out-of-control state. The R-Chart may be beneficial when the subgroup size equals 8 or smaller. The difference between the highest and minima within each data set is denoted by range. Formula (2.6) and (2.7) below represents the R chart formula, where D_3 and D_4 constitute control chart coefficients that vary depending on the size of the data subset.

$$UCL = D_4\bar{R} \tag{2.6}$$

$$UCL = D_3\bar{R} \tag{2.7}$$

2.5.4 S-Chart

Control charts such as X Bar-S charts are frequently used to investigate the process mean and standard deviation over time. These charts are used when the sample size for the subgroups is large, and the S chart provides a better understanding of the spread of subgroup data than the range chart. The essential difference between X bar-S charts and X Bar-R Control charts is that X bar-S charts plot the subgroup standard deviation, whereas R charts plot the subgroup range defined by (Hessing, 2015). The selection of an appropriate control chart is critical in control chart mapping; otherwise, the data will have inaccurate control limits.

Shmula (2021) has explained how to use X Bar-S control charts when the sampling procedure is the same for each sample and is followed consistently or when the data is assumed to be normally distributed. Furthermore, the X bar-S chart should be used when the subgroup size is more significant than ten, and the collected data is continuous, such as length or weight, and is captured in time order. Formula (2.8) and (2.9) below represents the S chart formula:

$$UCL = B_4\bar{S} \quad (2.8)$$

$$UCL = B_3\bar{S} \quad (2.9)$$

2.6 Summary

As has been noted, in F&B industry reliability is the important thing before producing a product in production. The accuracy and precision of a measurement method are referred to as reliability (Thorndike et al.,1991). The relative lack of error in an instrument is referred to as reliability. To make this case more relevant, process capability is needed to configure which is process is capable or conversely.

As identified by (Kiran, 2017), the term process capability refers to a process's capacity to create a product. Besides, capability indices assess a product's or service's current ability to meet design specifications. (Kane, 1986). Using standard deviation, capability index, and process capability ratio could be able to meet design requirements that determine a product's or service's current ability. Moreover, process tool capability also important to make the system more efficient by using several statistical methods. Hence, it will improve product reliability through this capability process.

CHAPTER 3

METHODOLOGY

3.1 Preliminaries

This chapter will explain the process that was used to complete the project from beginning to end. In the beginning, the design of studies is a research design strategy for determining the details of a study. It is to make sure the analysis on qualitative and quantitative research are fulfilled based on the research objective. A process flowchart is created based on the analysis in order to provide a clearer workflow. The phase flowchart helps the function more effectively by acting as a roadmap for completing the study series of steps. Aside from that, the method used to complete each process was well explained in this chapter. As a result, this research will run smoothly if the processes and procedures are well-organized. Then, before the analysis, it needs a good way to collect data from the industry.

As a result, while conducting this report, this chapter will also clarify the required data collection process. Data is collected by observation, interview, recording, and other methods. After collecting the data, data analysis will carry out by using Process Capability Indices. As a consequence, data collection is a critical task that must be carried out with accuracy in order to allow for further research. Following that, the improvements will be made and discussed later.

3.2 Design of Studies

The design of studies is a method of research design that is used to determine the specifics of a study. For instance, qualitative and quantitative analyses were used to describe and classify the method. Specific interactions, thoughts, hypotheses, and other exploratory data analyses are all part of qualitative research. The most prominent form of qualitative research is an interview to obtain other people's perspectives, a literature review based on what they find and collect data to know what the process are used for.

On the other hand, quantitative analysis is concerned with collecting quantifiable data, statistical methods, and other observable data. As a result, case studies, questionnaires, and other quantitative analysis methods exist. In this project, Figure 3.1 demonstrates the design of studies that resolve the goals by using a suitable method such as a literature review, an interview, collect and a case study.

(i) Research approach

There are two main research approach in this research which is qualitative and quantitative approach.

(ii) Process

The study method is designed to fulfil the specified goals. This technique of study design entails finding, validating, and proposing the research.

(iii) Method

The way how the data will be collected.

(iv) Source

The collection of origin data from research.

(v) Size

The quantity of journals gathered from various, the firms involved, and the time necessary to do this investigation.

(vi) Research objective

Based on the objectives that have been research.

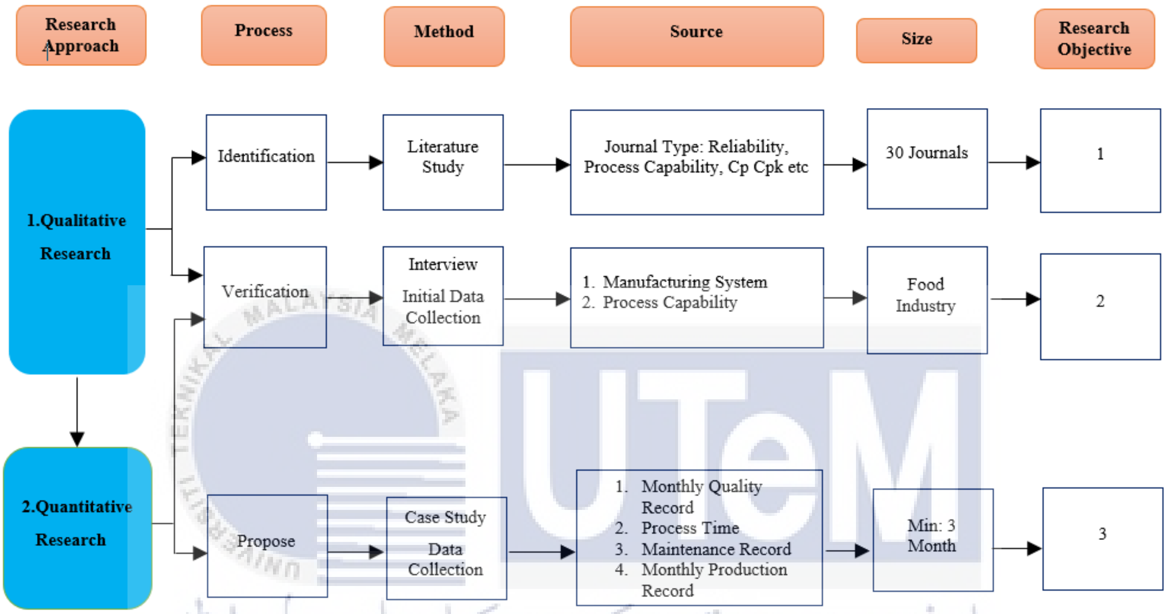


Figure 3-1: Design of Studies

3.3 Process Flow Chart

A flowchart is commonly used in the development of a process or computer software. A flow chart is a diagram that depicts the steps of a workflow or process in a proper sequence, assisting in the resolution or completion of a task.

Figure 3.2 shows the process flowchart that depicts the procedures and strategies performed to achieve the study's goal and objectives. This flowchart is a research approach for implementing the procedures to successfully and complete this project. The flowchart depicts the procedure in detail, step by step, from starting to conclusion, in order to accomplish the research aims.

Fundamental, the current element will be defined first in order to determine the problem statement and research questions. Establish objectives and factors to overcome the obstacles and improve the current condition based on the problems discovered. Establish the challenges, define the study scope, and begin reading journals, articles, and other informational resources to develop expertise based on the scope. After that, find trustworthy information and summarise it. Check to see if the data gathered is sufficient, or keep gathering.

Subsequently, as part of the verification process, collect data to acquire information. Normally, there are several techniques to collect data, such as using Microsoft Excel spreadsheets, sharing photos of the facility layout and processes during the manufacturing process, or employing process capability to perform system analysis. The following steps will be to analyze the acquired data, characterize the system's problems, and make improvements. Ensure that the manufacturing system runs smoothly and that unnecessary processes are eliminated in order to improve customer reliability through a production process capability study in the manufacturing industry. While collecting data and improving the system, conduct a conversation and provide conclusions based on the findings.

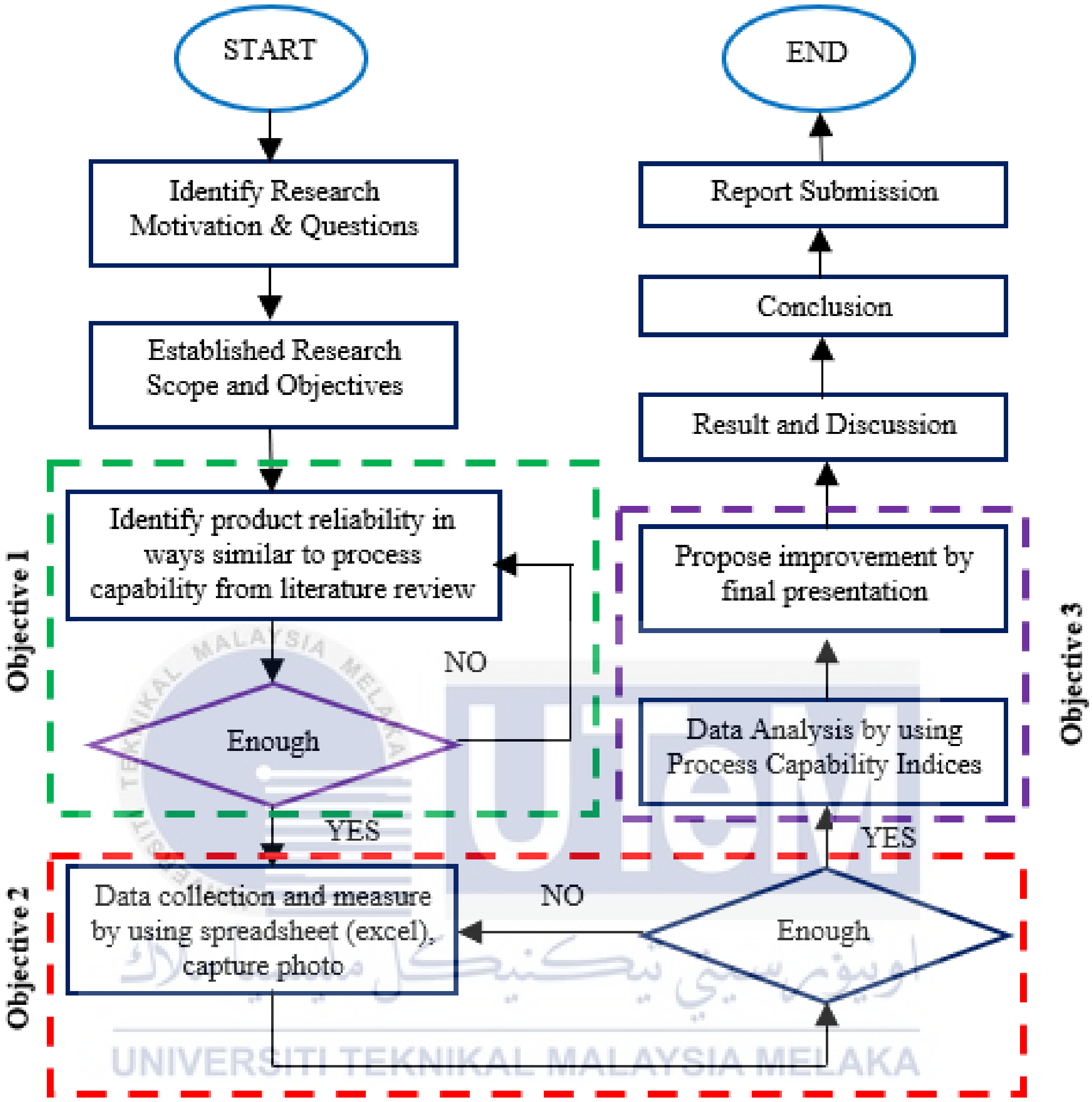


Figure 3-2: Detailed Process Flow of Research Methodology

3.3.1 Identify Research Problem and Question

The first step of process flow chart is to establish the issues and questions that this study has raised. A research problem is a specific topic, issue, inconsistency, or knowledge gap that the study must address. Any practical or theoretical challenges that can lead to improvement or knowledge expansion. The problem statements derived from the literature review for the current scenario are presented at this phase. This research problem is a way to improve product reliability through a production process capability study in the beverages industry.

Apart from it, any area of concern study needs a suitable research question to guide it. One or more questions must be formulated once the problem has been clearly described. It would be beneficial to combine the knowledge and methodologies that will be used to fix the issues. The research question is about the factors that influenced factory assembly quality and the approach employed to tackle the problem.

3.3.2 Established Research Scope and Objectives

The next step is to identify the research scope and objectives, which entails expanding on the challenges that have been described and categorizing them into categories. Because the research scope and objectives are founded on the problems, establishing research scope and objectives comes after recognizing the research problems and questions. Identify the objectives and develop the aim for resolving the problems by thoroughly analyzing the problems and categorizing them. The research objectives are designed to ensure that the research problems can be authoritative approach once all of the objectives have been fulfilled.

Furthermore, a research aim is a declarative, logical observation that directs the relationship among the variables under study. The study goals are focused on how to assess the elements, such as identifying and characterizing them. This project aims to improve product reliability on production process capability in the beverages industry. Hence, all planning should be implemented to accomplish the aim of this study.

3.3.3 Identify Product Reliability in ways Similar to Process Capability from Literature Review

A review of the literature is a thorough examination of previous research on a topic. For a certain study subject, a literature review examines scientific journals, books, and other relevant sources. This previous work should be listed, defined, summarised, evaluated critically, and explained. Additionally, the evaluation of literature acknowledges the efforts of earlier researchers and so informs the reader that the study was well-conceived.

By referring to prior work in the subject of study, it is assumed that the author has read, processed, and reintegrated this work into a given task. The literature review might be valuable in offering information or indications over where the researcher intends to go for a certain topic to be explored that related to objective 1 as shown as Figure 3.3.

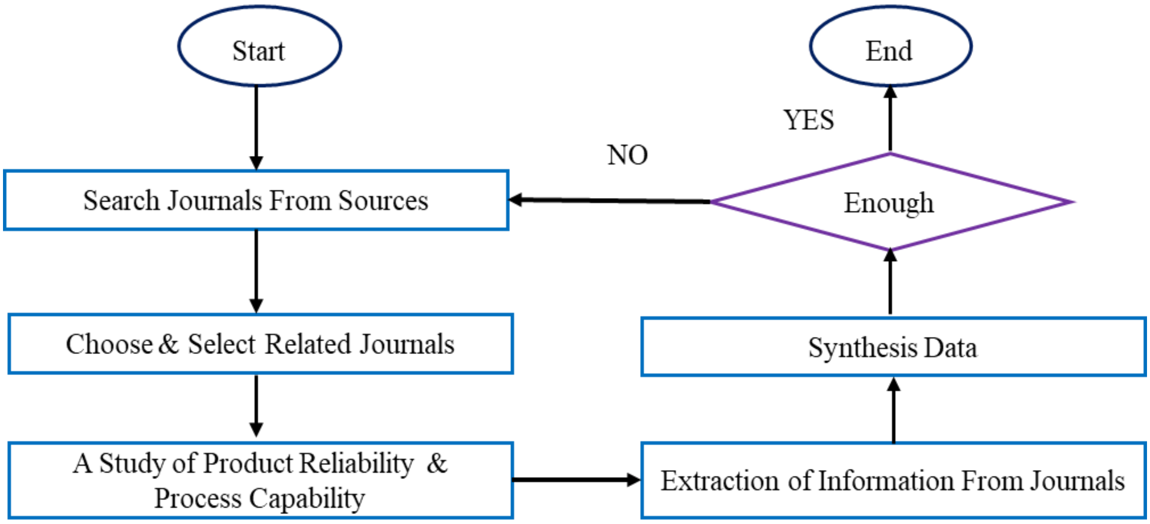


Figure 3-3: Process Flow for Objective 1

3.3.3.1 Search Journals from Sources

The literature studies will look at a maximum of 50 journals that have published the bulk of their content in the last five years. The journals found are mostly concerned with reliability, product reliability, process capability, process capability study, product quality, operation, and production management.

3.3.3.2 Choose and Select Related Journals

This project's paternoster includes reliability, improvement, and process capabilities. The primary focus of the literature study is on how product reliability impacts a food and beverage sector product's production processes capabilities. Aside from that, the literature study focuses on how the manufacturing process competence contributes to product reliability. So, here there will have 30 journals that are related to the research which is to improve product reliability through production process capability.

3.3.3.3 A Study of Product Reliability and Process Capability

In this research, the literature review focuses on improved product reliability through production using process capability in manufacturing industries. Product reliability is the consistency with which a process's output deviates from any predictive values. High dependability is usually the aim, especially when the output quality is essential for a later operation. While, process capability is a measurable statistic of a process's capacity to consistently produce items within defined tolerances. Indicators of process capabilities the output of a process is compared to the specification limitations set by the goal value and tolerance range in Cp and Cpk.

3.3.3.4 Extraction of Information from Journals

Furthermore, to improve product reliability, process capability indices are employed to answer the challenges in this study. The capability of the manufacturing process to consistently generate goods within spec is the linkage between the specifications, drawings, or design requirements and the manufacturing processes. As a result, studying past articles will aid those who are in charge of writing and performing extensive study on this subject.

3.3.3.5 Synthesis Data

Literature reviews synthesize the materials utilised to explore a specific topic and explain to viewers how the literature is used in a broader field of study. A theoretical framework is a methodical approach to examining and analysing prior research. Thus, a literary review gives a definition, synopsis, and complete knowledge of specific works on the research topic under consideration.

3.3.4 Conduct Cp Cpk Method to Improve Product Reliability Through Process Capability at Food and Beverages Industry

Cp Cpk charts demonstrate a process's capacity to satisfy criteria beyond elemental quality control. Using this data, companies can better understand which processes need to be changed, where it has possibilities for increased efficiency, and how to prioritise improvement initiatives. Figure 3.4 shows the process flow for conduct and analyze Cp Cpk method.

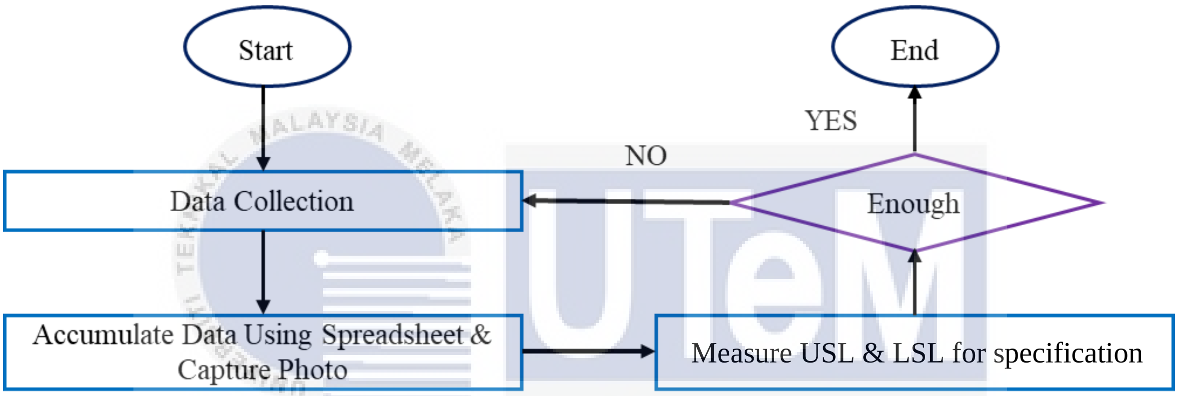


Figure 3-4: Process Flow for Objective 2

3.3.4.1 Data Collection

Using descriptive techniques, data collection is described as collecting, estimating, measuring, and analyzing detailed information for research purposes. A researcher may test their theory based on the information gathered. Regardless of the field of study, data collection is the initial and most critical phase in research.

Although the data for this project will be gathered from the food industry as a real-life case study. Data from the food industries successfully updated must be collected based on the project's goals. In the food industry, there are two kinds of data collection: (i) primary data and (ii) secondary data. The spreadsheet (excel) can be used to gather quantitative data. In addition, interview industry experts about the production process capabilities for qualitative evidence that can be collected by taking photographs of the manufacturing process.

(i) Primary data

Primary data is concerned with gathering anecdotal information that cannot be counted. As a result, data will be gathered through interviews with industry practitioners and photographs of the manufacturing process. The primary data will obtain from the interviews which are about the details of the production process. Other than that, the data also can be gathered from observation and take the factory’s photos as evidence.

(ii) Secondary data

Collecting objective data was that secondary data is all about. The comprehensive details of the industry, which records the process input and output of the manufacturing process, are the primary focus data for secondary data. The previous records, such as regular reports and annual reports, aid in determining the production system's input and output capabilities

3.3.4.2 Accumulate Data Using Spreadsheet & Capture Picture

A spreadsheet In MS Excel is essentially a worksheet divided into rows and columns to store data about business inventories, income, expenses, debts, and credits. Electronic spreadsheets have replaced antiquated paper-based worksheets in today's business world. The method of obtaining a digital photo from a sensor system, such as a camera, is known as image capture which is recognition and image. This typically entails a hardware interface known as a frame snatcher, which captures single video frames, converts the analogue values to digital, and feeds the result into computer memory.

(i) Spreadsheet (Excel)

Microsoft Excel (MS Excel) is a spreadsheet program that allows the researcher to organize and calculate numbers. It has the ability to analyze data, calculate numbers, build pivot tables, and view data as a graph. Excel has the same basic features as other table applications in that it uses a series of cells to organize and manage data in rows and columns. Graphs, histograms, and line graphs will all be used to display data. Excel allows developers to arrange data in such a way that multiple variables can be seen from various perspectives. Visual Basic is used to create a variety of complex numerical techniques for use in Excel software as demonstrates on figure 3.5 below.

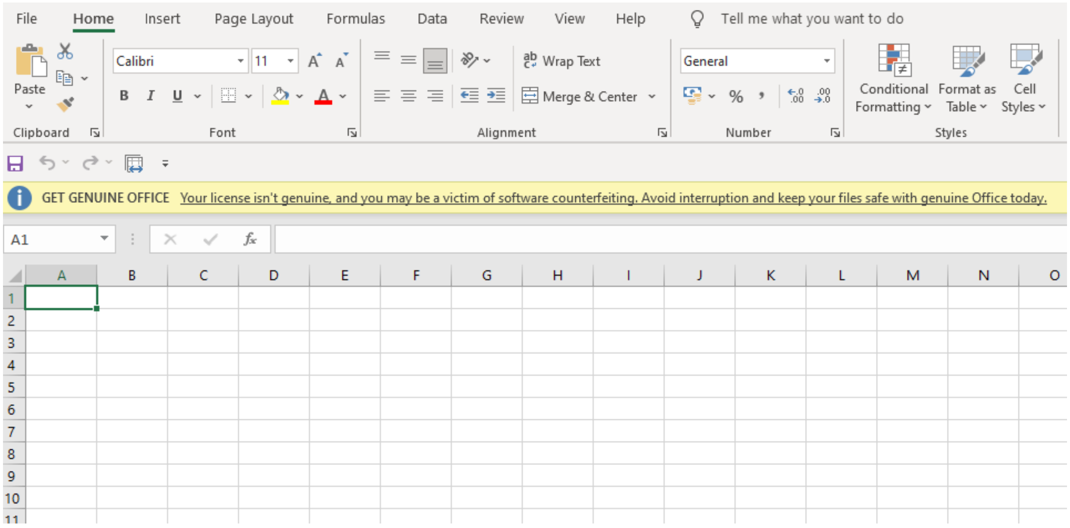


Figure 3-5: Example of spreadsheet of MS Excel

(ii) Capture photo

Capturing process images is critical for documenting the F&B industry's manufacturing flow line. The aim of photographing the company's manufacturing process is to analyze and understand all of the processes involved. The process can be identified one after the other in those pictures, as shown by the images. Furthermore, offering images, rather than the traditional method of presenting data, provides an additional means of communication. The researcher's goal of taking a photo is to equate the existing approach with the new procedure or any proposed changes to demonstrate an accurate research study. Figure 3.5 below shows production stock of soybean in F&B industry.

Figure 3-6: Example photo of production stock

3.3.4.3 Measure LSL & USL for Control Limit

Cp Cpk is a metric that indicates how far the specification boundaries are from the process's center. Some techniques allow to accomplish this graphically. Others need an equation. To determine Cpk, we must first compute a Z score for the upper specification limit (referred to as Z USL) and a Z score for the lower specification limit (referred to as Z LSL) (called Z LSL). Formula(3.1) and (3.2) below show the formula for Cp and Cpk measurement.

$$Cp = \frac{USL - LSL}{6\sigma} \tag{3.1}$$

$$Cpk = \min\left(\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\right) \tag{3.2}$$

3.3.5 Propose Improvement Activity based on Process Capability Study

In the beginning, the process of transforming something in order to make it better is known as a proposal for improvement. It was also known as management's modification or change work in order to get more profitability and revenue for the organizational performance. Figure 3.6 shows the process flow for propose improvement activity.

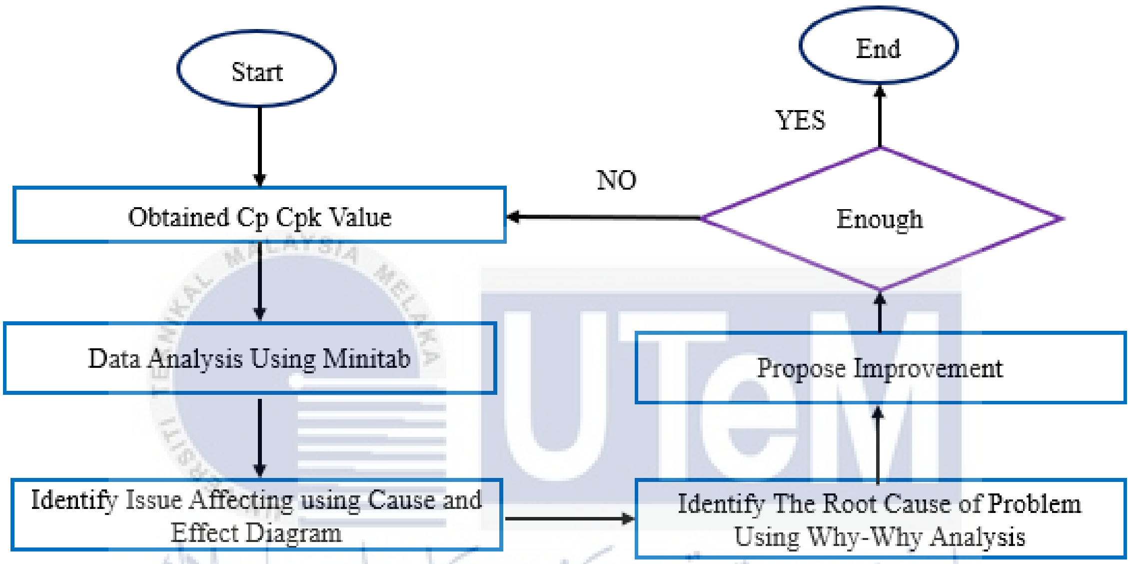


Figure 3-7: Process Flow for Objective 3

3.3.5.1 Obtained Cp Cpk Value

Process Capability refers to Cp and Cpk. In this situation, we want to see if the process can fulfil the Customer CTQs (requirements). Process Capability is denoted by Cp and Cpk. This is typically used when a process is statistically controlled. This is common with a mature process that has been in place for some time. Process capacity is defined by the process sigma value as determined by the Moving Range, Range, or Sigma control charts.

3.3.5.2 Data Analysis Using Minitab

Minitab uses statistical analysis and process optimization tools to assist industries and organisations in identifying patterns, resolving issues, and obtaining meaningful information from data. Minitab also makes it easier to enter data for this research. Minitab provides a quick, appropriate solution for the degree of analysis that most initiatives require. The gathered data is standardized so that data operations can be conducted easily, and the data set may be modified. Minitab analysis is used to determine the mean, standard deviation, variance, minimum and maximum value, as well as skewness.

3.3.5.3 Identify Issue affecting using Cause and Effect Diagram

A cause-and-effect diagram is a visual representation of the systematic connection between a symptom of an effect and its potential causes. It is a useful technique for methodically generating and presenting thoughts regarding the problem's causes in an organized manner. Dr. Kouro Ishikawa invented this tooling approach, which is also known as the Ishikawa Diagram. Because of the design of the entire structure, the tool is also known as the Fish-Bone Diagram, as we've seen previously figure 3.7 demonstrates the cause and effect diagram. In this scenario, the best-proposed improvement tool approach to acquire customer satisfaction in manufacturing is to employ a cause-and-effect diagram.

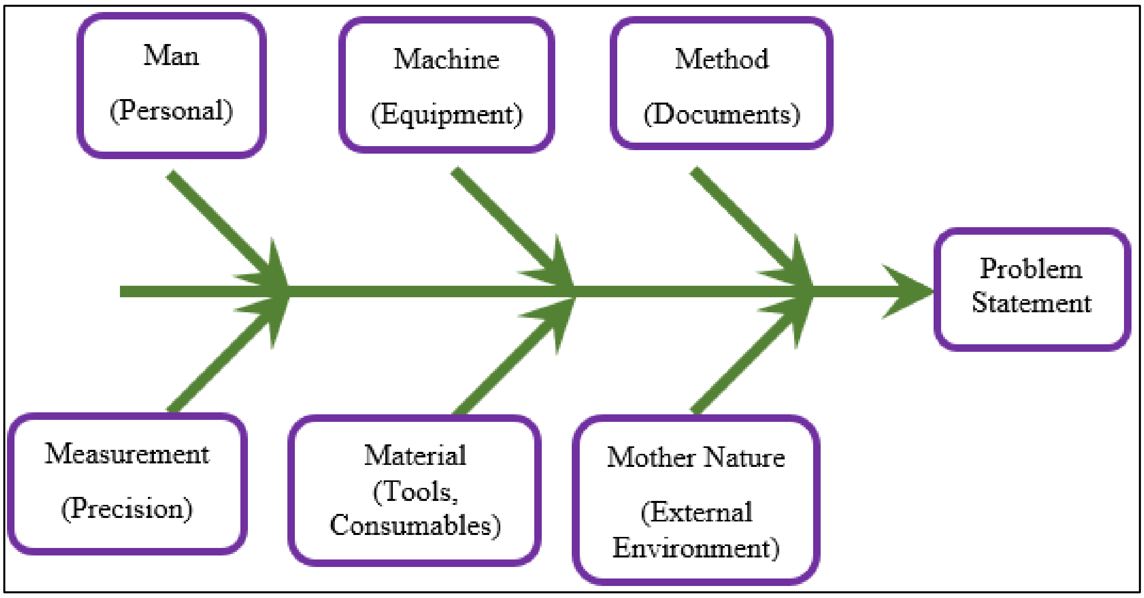


Figure 3-8: Example of cause-and-effect diagram

3.3.5.4 Identify the Root Cause of Problem Using Why-Why Analysis

Amongst the most effective approaches for determining root cause in manufacturing is the 5 Whys strategy on process capability. The 5 Whys may be used to identify the fundamental cause of any problem and prevent a process from recurring mistakes and failures. When using the 5 Why s methodology, it should go to the root of the problem and then solve it, even if the root of the issue is unpredictable. In reality, the issues which are perceived as a technological problem turn out to be human and process problems. The 5 Why s approach is an alternative and convenient problem-solving tool. The primary objective is to discover the exact reason that causes a given problem by asking a series of questions about "why" as shown as table 3.1 below.

Table 3-1: Example of why-why analysis template

Main Factor	Problem	Why 1	Why 2	Why 3	Why 4	Why 5	Root Cause

3.3.5.5 Propose Improvement

This section suggests ways to improve product reliability. It exposes them to a better solution that could help them improve their production of process capability. A final presentation should suggest the improvement. There are times when suggested improvements are not suitable for a company's current situation due to cost, tooling, or operator skill. So, they can either adopt the proposed improvement or request a different method that fits the F&B industry's capabilities.

3.3.6 Result and Discussion

The results and discussion section demonstrates and examines the research's findings. The results will be discussed in this part, as well as how they relate to the Cp Cpk technique. Then, research to find a solution and techniques to tackle the problem will be discussed. Throughout this investigation, the process capability will be used to tackle difficulties that arise from this study. Furthermore, this section will demonstrate how the performance of the Cp Cpk approach is connected to the F&B industry.

3.4 Summary

The methodological chapter of this research, for example, covers the path to accomplishing the objectives. In a research project, the methodology chapter is crucial since it clarifies the entire project flowchart. This flowchart is quite helpful in a research study since it allows researchers to undertake step-by-step inspection and eliminate any false facts that should be not included in the research proposal. The first step is to identify the difficulties and concerns that plague the industry. The purpose of this research is to improve customer reliability on process capabilities as a goal and aim to focus on. Data gathering was accomplished using spreadsheets and capture photo to gather additional information needed to make this research an accomplishment.

Furthermore, before an issue has been resolved, Why-Why analysis is utilized in data analysis to determine the sources of the problem. Following that, the data method is used to analyze the data and answer the problem by using secondary data such as cause-and-effect diagram principles gained from the literature research. A suggested improvement, on the other hand, is indeed a method to enhance everything which requires adequate maintenance. Developing or changing a specific organization to generate a product and increase the company's financial performance is another name for it. Finally, deliver the report to the industry, make a final presentation, and recommend an improvement strategy.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Preliminaries

This chapter may present an overview of the issues in this research. The next chapter might highlight why and how the production Process Capability Study could be utilized to solve problems in the F&B industry. For this chapter, we will use DMAIC method to improve the problem by defining, measuring, analyzing, improving, and controlling. This chapter will begin with defining a problem definition and several discussions on the difficulties encountered by the firm under investigation.

Following that, the data collected during this investigation was continued in this phase, including flowcharts, plant layouts, and water volume quality data as primary data. In contrast, secondary data is information that the firm has gathered. After all data gathering has been cleared, data analysis will be performed, and the company's change strategy will be implemented.

In addition, by measuring, the data is gathered by taking inventory, monitoring, and asking relevant personnel about the issue. After all data gathering has been cleared, data analysis will be performed, and the company's change strategy will be implemented. Data analysis can help resolve difficulties that have developed as a result of the data collection. A few instruments will be utilized to examine the data collected.

Furthermore, Minitab export data collection was utilized to create an analysis graph to identify the problem. Aside from that, fishbone and why-why analysis were employed to address more complex inventory problems. That's why data analysis should be carried out to assist in resolving the issue of eliminating the output failure in this report are in analyzing phase.

Afterward, the F&B industry would be advised to improve the manufacturing system to solve the existing situation. It might be advantageous and benefit the company to improve reliability and maximize the beverage process. Finally, depending on their capabilities and needs, the company could control the technology to manufacture soybean drinks.

4.2 Product Reliability Issue in Soybean Production

The soybean drink production line at F&B industry (IKS) was chosen as the manufacturing company for this research. The first phase of this research is to investigate or define the business-related problems. The concerns that must be maintained or improved are highlighted, and the justification for the research is also outlined. Furthermore, there are serious issues in the firm that must be addressed. Here, there have several issues of problems that affected the company's production.

According to the problem specification, the time spent manually reducing the volume of water in the soy bottle is the issue that impacts the process capability and productivity in the manufacturing line. The water reduction technique is completed entirely by hand, with no assistance from machinery.

It is because there are thousands of bottles of soybean drinks created, this manual method took a long time to complete because each bottle needed to be reduced of water and had to be placed on each one individually. In addition, the second issue of product reliability is inadequate worker performance. In order to execute the process capability approach in the F&B industry, there is a shortage of knowledge. It is due to some employees' lack of understanding regarding productivity management. Furthermore, the workers have a poor ability to manage productivity since they are slow owing to the non-rush scenario to make soybean beverages.

Furthermore, there is a process capability element that does not clearly recognise production difficulties such as machines in the F&B industry. The worker acknowledged the machine failure issue during the interview. Because the machine is continually failing, the soybean machine must be shared with the tamarind drinks manufacturing line. Because of the processing period for the machine's turn, the soybean manufacturing process is not as smooth in this situation. As a result, the F&B industry lacked a backup machine to cover production when the machine failed. To summarise, these three concerns are product dependability issues that must be considered promptly in order to enhance the quality of soybean production.

4.3 Data Collection

This study's actual research project is an examination of F&B industry production system. The manufacturing sector chosen to execute the procedure analyzed in this research study is F&B industry on June 29, 2009 it was founded. This F&B industry is a local enterprise that produces, distributes, and markets flavored soybean products, carbonated beverages, and *Asam Jawa*. The industry believes in the importance of the successful and best-selling local industry by supplying pre-and post-sale goods. They receive clarification from *Mardi*, FAMA, SIRIM, SMIDEC / SME Corp, SME Bank, MARA, JAKIM, and *Jabatan Pertanian* in terms of developing their enterprise.

The F&B industry began by manufacturing and marketing soybean-based drink items for the street market. *Duyong* is however the located in a soybean production facility. The soybeans were bottled with the potential, and a new branch in *Telok Emas* was established. With the use of their current technology, they can make more lasting soy, and this product contains no preservatives. After several years, they acquired a firm that produces *Asam Jawa*, *Asam Boi*, and carbonated beverages with tastes including soda, strawberry, sarsi, grape, orange, and cola, as well as soy in new flavors including original soy, soy *bandung*, maize soy, and black sugar soy.

In contrast, the F&B industry employs 14 workers at its *Telok Mas* branch. The Administration Department and the Production Department are two departments that the personnel are separated within. The administrative department has just one person, while the production department is divided into three divisions which is *Asam Jawa* Line Production has 4 workers, Carbonated Drinks Production has 5 workers, and Soybeans Drinks Production has 4 workers.

The purpose of this analysis will be on the soybean production process. It will go through the overall process of drinking soybeans, from daily production scheduling to final goods stored in the storage facility. Initially, data will be collected over a 30days or month period in order to identify the production issues. Following that, process capability study is utilized to determine the system's productivity based on the data obtained. Then, using the information gathered, data analysis may be performed.

4.3.1 Primary Data

Data collection is indeed one of the foundations and fundamental parts of statistical analysis, and primary data is the most basic data that can be acquired in this process. Primary data is information obtained directly from primary sources by researchers through interviews, surveys, investigations, and so on. Typically, original data is received directly from the source. Typically, primary data sources are intentionally chosen and altered to suit the criteria or needs of a certain report. The following are data collection regarding to the primary data on soybean production.

4.3.1.1 Process Flow Chart of Soybean Production

The flowchart of a soybean process at the F&B industry is shown in Figure 4.1. The flowchart depicts the process of entering the industry from the beginning of the product to the finish of the procedure. In the beginning, the soybean raw material will be steeped in boiling water for 240 to 300 minutes. Then, to separate the soybean seed covering, the filtration procedure commenced. When the soybean seed coating is full, storage will be kept close to the filtering process, and only then will the soybean seed coating be removed. Following that, the soybeans were cooked for 60 minutes in two batches daily. Each batch of soybean water is capable of refilling 1,732 bottles.

The filtration process is then started manually by pushing cloths over the machine. After that, an automated machine fills bottles with the filtered soybean water. On a daily basis, the two batches of cooked soybean water may fill roughly 3,464 bottles. Furthermore, following the soybean filling procedure, the foil covering procedure begins manually on the bottles. The foil-wrapped bottles were then retorted to eliminate any remaining air or bacteria. The bottles will be inspected to see whether they are excellent items, and then the defective bottles will be discarded afterward.

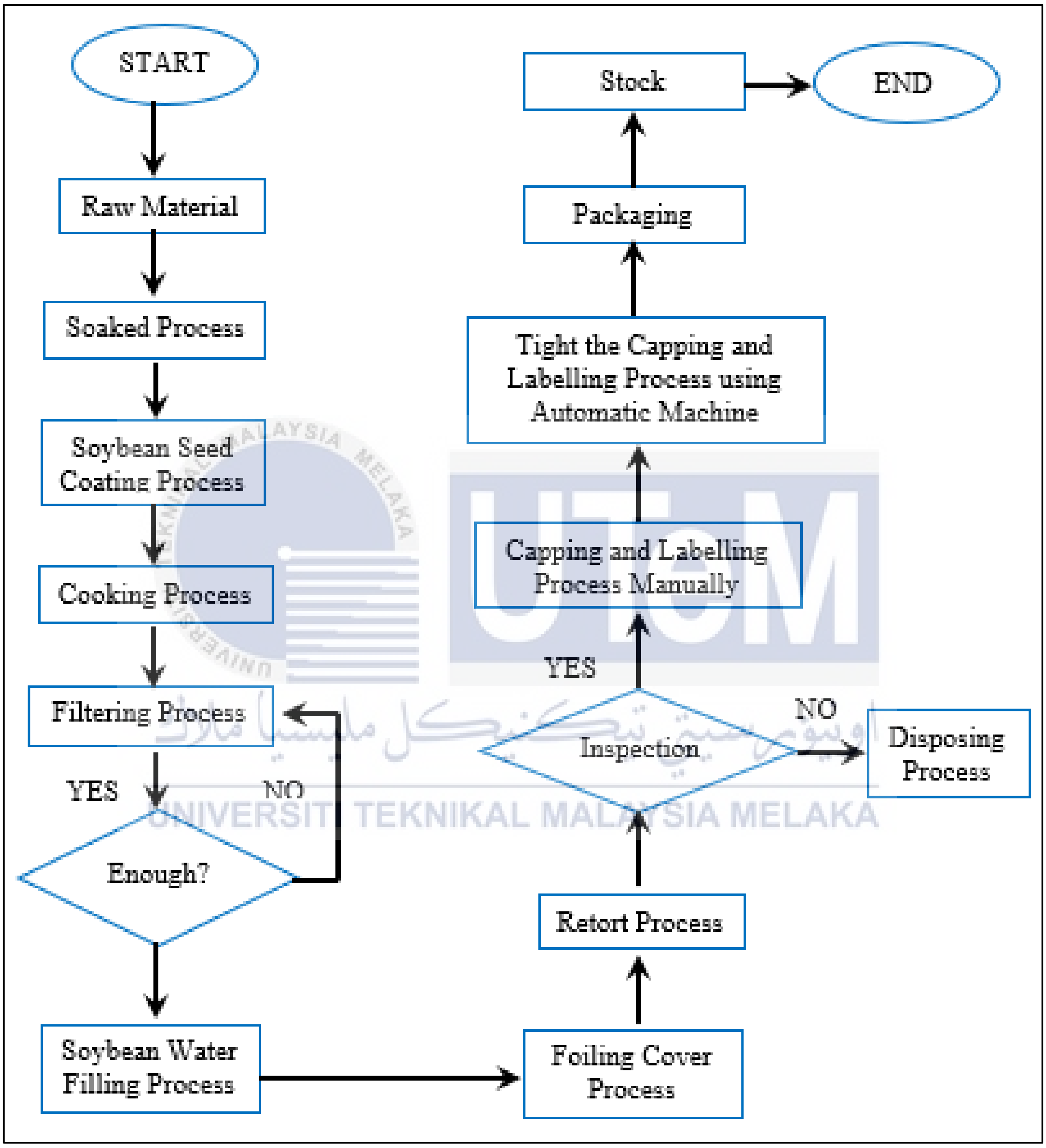


Figure 4-1: Process Flow Chart of Soybean Drink Production

4.3.1.2 Facility Layout

The process plans for the manufacture of soybean drinks in F&B industry is shown in Figure 4.2. It represents two rooms, the first of which is the soybean drink manufacturing process, and the second of which is the soybean drink capping, labeling and packaging process.

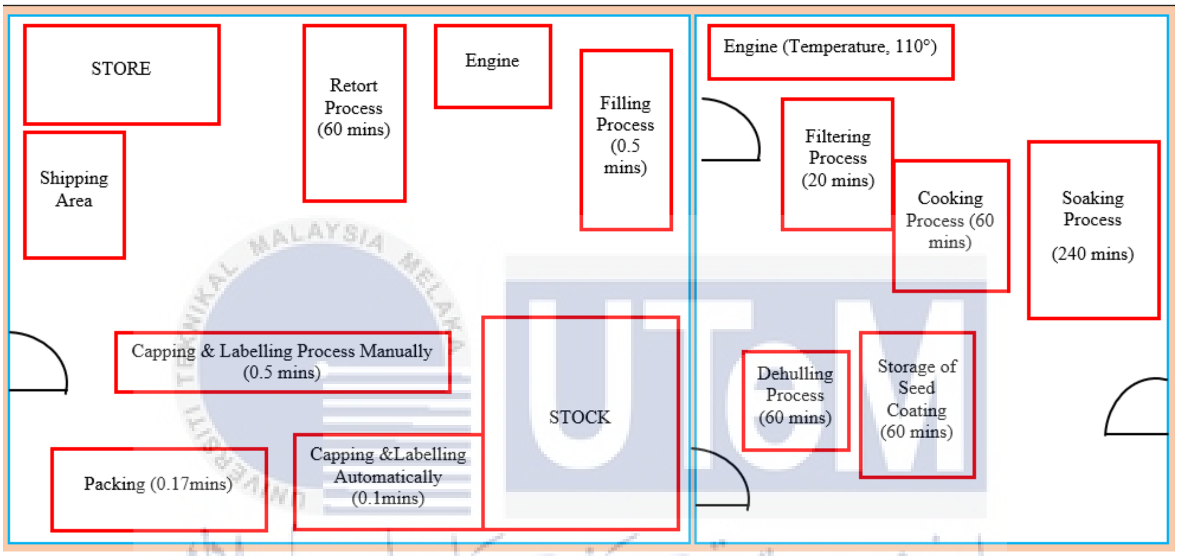


Figure 4-2: Process Layout of Soybean Production

4.3.1.3 Quality Data of Water Volume

The water volume of soybean production determines the data collection for 30 days. This data has been collected 30 days with 10 samples a month in the year 2021. Depending on customer demand, Soybean Drinks will be produced twice on certain days. However, there are days when no data is logged, or production occurs. The following 30 days with 10 samples water volume details are presented in the table 4.1 below. Figure 4.3 below is the example method to measure a water volume and stock of soybean in F&B industry.

Table 4-1: 30 days of water volume quality data

Subgroup (SG)	Sample (n)									
	1	2	3	4	5	6	7	8	9	10
1	309	310	309	309	310	310	309	310	309	310
2	309	310	309	309	308	308	308	309	307	307
3	307	309	307	309	307	309	307	308	308	309
4	306	307	307	305	306	308	307	307	308	308
5	308	309	308	309	309	308	308	309	309	309
6	309	309	309	307	308	307	308	307	307	309
7	307	308	309	308	307	309	308	309	308	308
8	307	306	307	307	307	306	307	306	307	306
9	310	308	309	310	310	309	309	308	309	310
10	308	308	308	308	307	308	306	308	306	308
11	308	309	309	308	309	308	308	309	308	309
12	308	308	305	306	306	308	308	307	308	306
13	309	308	308	309	308	308	309	309	308	308
14	308	307	308	307	307	308	308	307	308	308
15	308	308	307	307	309	307	307	308	309	309
16	307	309	307	307	307	306	306	308	308	308
17	308	308	309	308	308	309	309	309	308	309
18	309	309	311	309	310	309	310	309	310	309
19	310	307	309	309	310	307	310	309	308	308
20	308	309	309	308	308	309	308	308	309	308
21	306	305	306	308	307	308	308	307	306	308
22	308	307	308	307	308	307	308	307	308	307
23	308	310	308	310	310	309	308	308	309	309
24	307	308	308	308	307	308	307	307	308	307
25	307	307	306	308	305	308	306	308	308	307
26	309	308	308	308	308	309	309	309	308	309
27	308	307	308	306	307	307	307	307	306	308
28	308	309	308	308	309	309	308	309	308	308
29	309	309	310	309	309	309	311	310	310	310
30	307	308	308	307	308	308	308	307	307	307

Figure 4-3: Example of weigh soybean after seal capping

4.3.2 Secondary Data

Secondary data is information collected by someone other than the customer. Censuses, data collected by government agencies, operational records, and data collected for other research objectives are all frequent sources of secondary data in social science. Secondary data analysis can save time that might otherwise be spent obtaining data and can offer bigger and higher-quality datasets, particularly for quantitative data that would be impossible for any individual researcher to gather through their own.

The soybean production process requires the following inputs which is 33kg of soybeans, 18kg of sugar, and 60g of artificial sweeteners. This input is for the production of one batch of soybeans. They will typically produce two batches of a product during a single production process. Therefore, the output of a single batch of soybean drink will be approximately 1,500 bottles.

However, as the workers explain, the output is usually greater than 1,500 bottles due to the condensation of water caused by steam during the cooking process whereby the bottles are produced. A more detailed breakdown of the time required for soybean production can be found in Table 4.2. The specifics of each process are recorded, including the number of workers involved in the process, the length of time it took to complete the process, and the output of the process.

Table 4-2: Data Collection of Soybean Production

Data Collection For Soybean Drinks Production							
Process	No. of Workers	No. of Machine	Process Time (mins)				Unit
			1	2	3	Average	
Soaking	1	-	240	-	-	240	1 Batch
Filtering	2	-	45	-	-	45	1 Batch
Craking	2	1	40	-	-	40	1 Batch
Cooking	1	1	30	-	-	30	1 Batch
Filtering	1	-	60	-	-	60	1 Batch
Filling	1	1	0.167	0.15	0.183	0.167	8 Bottles
Foiling	2	1	0.217	0.18	0.2	0.189	8 Bottles
Retort	1	1	50	-	-	50	1 Batch
Cleaning	2	-	30	-	-	30	-
Capping (Manual)	3	-	0.138	0.141	0.148	0.1423	1 Bottle
Labelling (Automatic)	2	2	0.367	0.333	0.333	0.3443	3 Bottle
Packaging	3	1	1.4	1.333	1.317	1.35	1 Carton

Total Output = 1645 (68 Cartons)
Total Failure = 3 Bottles

4.3.2.1 Factor Affecting Product Reliability Production Based on Literature Review

In this section describes the technique for achieving the case research aim and objectives, which are to discover the factors influencing the production of the targeted beverages industry. A literature review, as previously mentioned, is investigated to assess the elements that might impact production.

Based on table 6 below, there are 33 journals of literature or references that connected to the research study that has already been researched, analyzed, and chosen. The table below depicts the most relevant aspects in the beverage sector as determined by process capability studies.

Table 4-3: Examine factor of Product Reliability

Factor Affecting Production	Literature References	Total Related Journal	%
Material	*Mason & Antony (2000), Ramanathan et al. (2017), Trez & Luce (2011), and Horch et al. (2010)*	4/33	12
Machine	*Stauder et al. (2014), Bracke & Bracke (2015), Sansone et al. (2016), Motorchu & Gullu (2006), and Yamada et al. (2021)*	5/33	15
Method	*Choi et al. (2020), Basu et al. (2014), Hsu & Bsu (2007), Palumbo et al. (2017), Wu et al. (2009), Otsuka & Nagata (2018), Bottani et al. (2021), Pawar et al. (2020), Podder et al (2018), Genta & Galetto (2018), Joshi et al. (2021), Mobin et al. (2019), Antonucci et al. (2020), Wu & Chen (2014), Bronzo et al. (2012), Thorpe et al. (2003), Deleryd (1998), Benmoussa et al. (2014), and Jagadeesh & Babu (1993)*	18/33	55
Man	*Lukas et al. (2020), Pawar et al. (2020), Kumar et al. (2018), Mondal (20140, Lager et al. (2016), and Benafqie et al. (2020)*	6/33	18

Based on the results of Table 4.3 above, it can be justified that the majority of the factors affecting production in the food and beverage industry are caused by the method of handling the process, followed by the man, the workers, who also have an impact on production. Also included are the machine problems and, finally, the raw material effects, primarily caused by environmental factors and defective materials before they are even put through their levels.

4.4 Data Analysis

Data analysis in the qualitative approach is the process of evaluating data using logical tools or statistical processes that are used consistently. The data analysis will discuss in detail the difficulties that have been highlighted and will identify some potential sources of the problem. Data analysis is carried out in this integrated graph analysis, Ishikawa diagram, and why-why analysis.

Second, the Ishikawa diagram is utilized to determine the underlying source of a problem in the Soybean Drink inventory. In order to discover as many causes and effects as feasible, this approach is split into four primary causes by man, material, method, and machine. The brainstorming process is necessary for the completion of the Ishikawa diagram.

Finally, the why-why analysis tool used to list key elements as well as specific causes and consequences. It is a questioning approach that aids in the discovery of probable underlying causes of an issue. This why-why analysis greatly aids in identifying the true root cause and the action required to address the underlying issues discovered.

4.4.1 Analysis by Capability Analysis (Minitab)

Minitab includes all the tools and resources necessary to assist users of all levels of expertise and empower individuals in data analysis and visualization. Minitab's user-friendly and intuitive interface complements popular textbooks and has a familiar worksheet look and feel. Moreover, researchers can quickly learn how to use Minitab to identify distributions, correlations, outliers and then easily visualize the findings using a variety of graphs and charts as shown figure 4.4 below.

Minitab assists manufacturers of consumer goods, food, and beverages in identifying efficiencies, enhance and ensuring critical quality, and identifying cost savings. Food manufacturers are tasked with the responsibility of creating and producing delectable, consistent, and high-quality foods and beverages. See how data analysis with Minitab can assist in resolving some of the most critical challenges encountered in this F&B industry, which is to determining the specification limit of tolerance required to meet customer demands for product reliability.

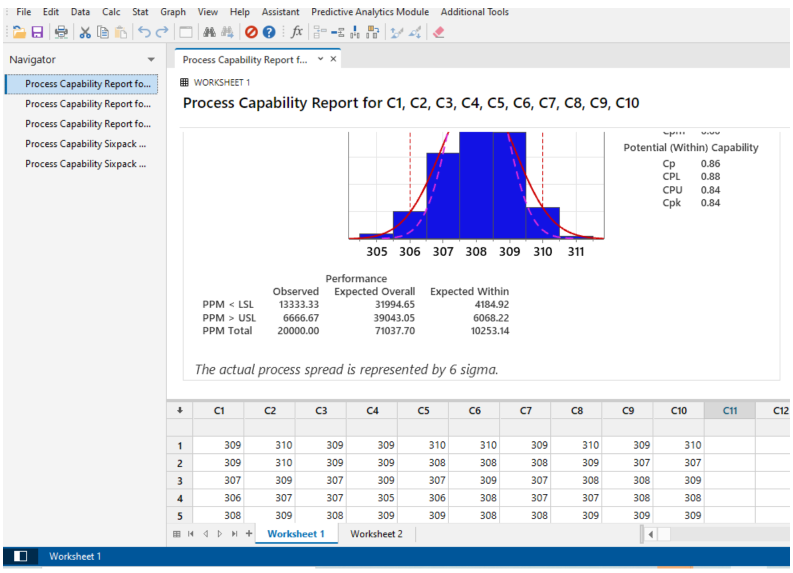


Figure 4-4: Minitab Software

Subsequently, the ability of a process to meet a customer's specification is known as process capability. Additionally, the results of process capability studies can measure how well an industry's output meets customer specifications on product reliability. Product reliability can be calculated, measured, and determined using two methods. The Xbar-S chart and the capability histogram are included in the process capability.

4.4.1.1 Xbar-S Chart

First method is control charts can be used to verify the statistical stability of the process, which can be done using the Xbar-S chart. Due to subgroup sizes greater than or equal to 10, the Xbar-S chart is more accurate than the Xbar-R chart. The data collected on the size of the subgroups in this problem is 30.

Further, S and X bars show that statistical control has been maintained. For example, the X-bar chart depicting process centering shows that the water level is centered around the specified value of 2 ml. Thus, a detailed analysis of the S chart shows that the water levels were not always consistent.

Next, the sample mean and X-bar depicts subgroup number on the graph illustrates in the figure 4.5 below. UCL is 308.78 ml, LCL is 307.32 ml, and the Xbar-bar control limit is 308.05 ml. The process is still under control because the USL and LSL were all within the range. A variance of one standard deviation from the center-line of more than 3.00 indicates that the red diamond's subgroups 1, 4, 8, 9, 12, 16, 18, 21, 23, 25, 27, and 29 processes outside of their control limits and called as the point of ad failure. All of them are the ideal control limit for the blue diamond point.

Furthermore, the S chart at figure 4.6 below also demonstrates the UCL and LCL, representing the sample standard deviation and subgroup number. The upper control limit (UCL) is 1.28, the lower control limit (LCL) is 0.21, and the control limit (S bar) is 0.74. The majority of the points relate to defining the control limit.

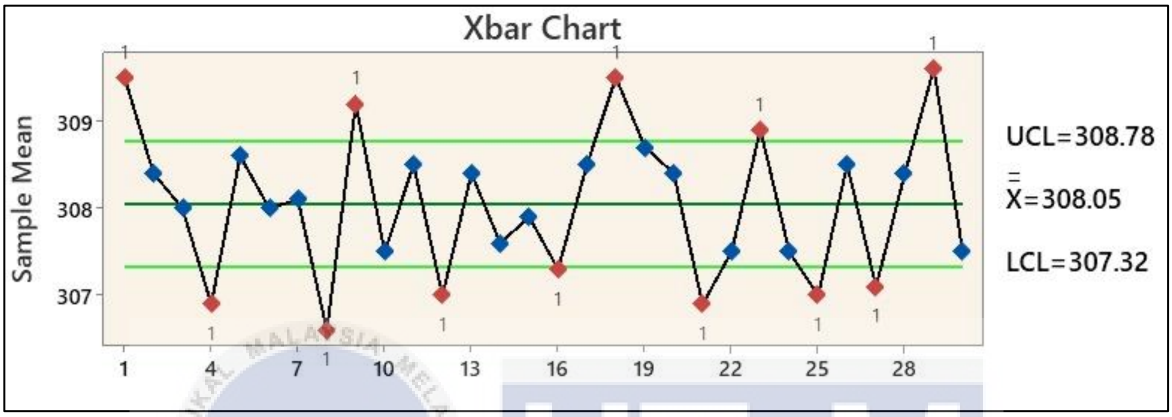


Figure 4-5: X-bar chart of sample mean

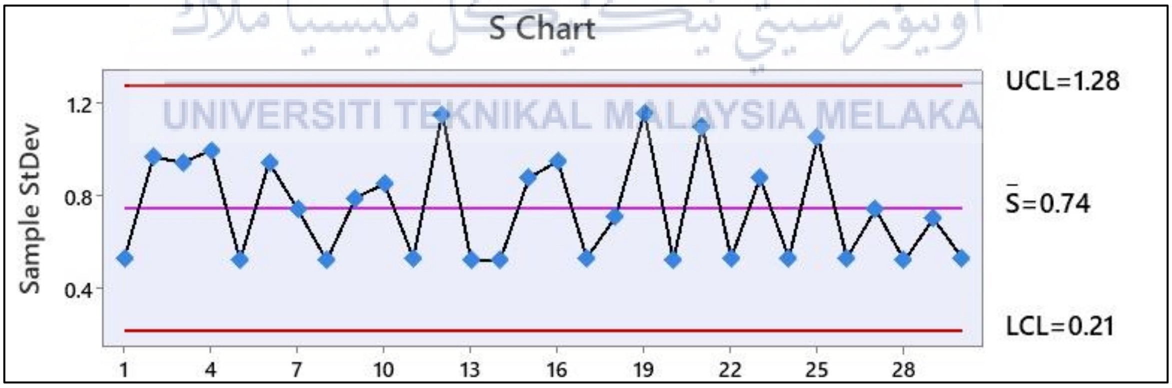


Figure 4-6: S chart of sample standard deviation

4.4.1.2 Capability Histogram

The following technique that would be to use is a capability histogram, and the actual process spread is 6sigma. Throughout the context of the graph shown in the following figure 4.7 and the data gathered, the estimated or target measurement result is 308ml based on the LSL value of 306ml and the USL value of 310ml. It also shows that the standard deviation within the same range as sigma is 0.777.

Afterwards, it can be seen that some values, such as 305ml and 311ml, fall outside of the LSL and USL limits. Consequently, the product may not have been checked correctly because the mean and maximum values should match. According to the potential incapacity, Cp and Cpk are 0.86 and 0.84, respectively. Using Cp calculations, it was discovered that the process is now producing water that does not meet standards. Here, the process needs to be improved.

However, the value of Cpk is nearly identical to the value of Cp, which indicates that the process complies with the specification. Thus, this indicates that the process is incapable with a value of less than one ($Cp < 1.0$). As noted in the S chart, Cp and Cpk values show that the process has an irregular amount of variation.

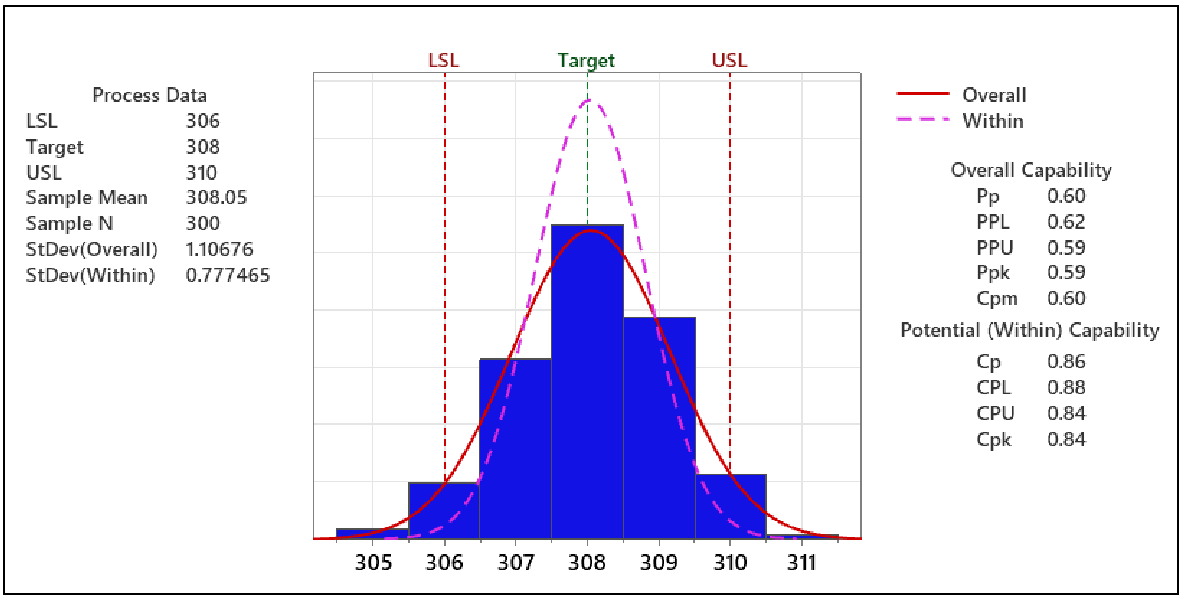


Figure 4-7: The target of specification limit of Process Capability Study graph report on Minitab Software

4.4.2 Analysis by Ishikawa Diagram

The Ishikawa diagram as known as fishbone diagram is used to discover general underlying causes by breaking down concepts into usable components. The studies Ishikawa diagram was applied in detail based on factor 4M, which is method, machine, material, and man. This graphic will spark thoughts for determining the root cause of the problem and most problem on method, man and machine. Figure 4.8 demonstrates the Ishikawa diagram, which will be used to solve the problem.

According to the Ishikawa diagram, the majority of the aspects or issues affecting product reliability in production are primarily caused by Method, Man and Machine. Material has the lowest percentage, meaning it has the lowest effect of the 4M factors. As a result, Materials have been completely disregarded in Why-Why Analysis part. Thus, the Method factor contributes the most, with 55%, followed by Man (18%), and finally Machine (15%), according to the justification on factor of product reliability in table 4.3.

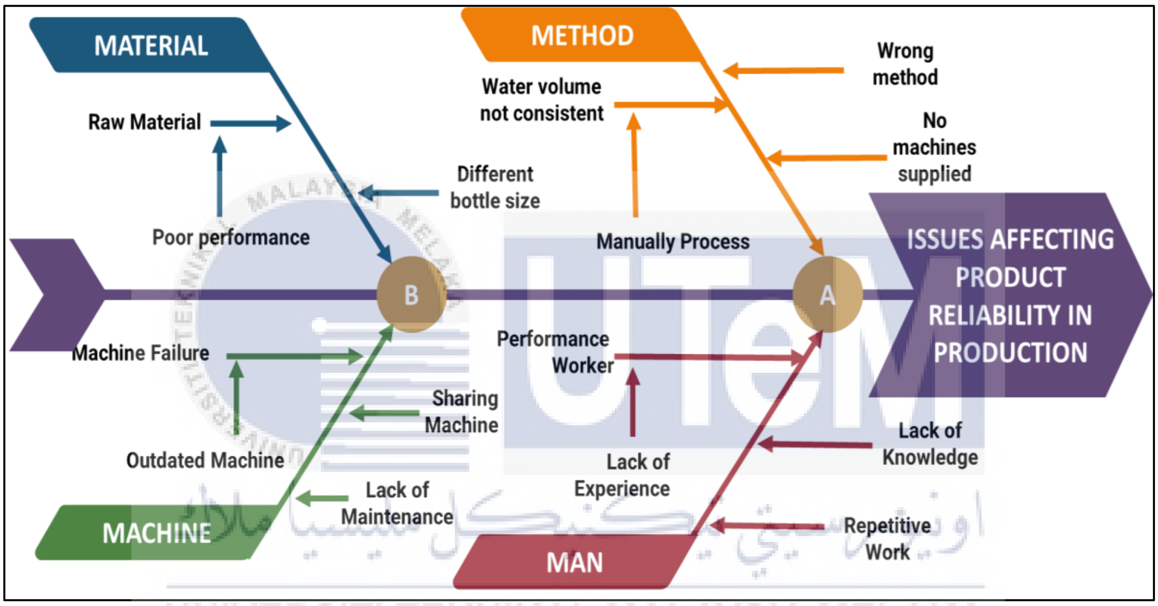


Figure 4-8: Ishikawa diagram for issue affecting product reliability

As stated in the preceding paragraph, the method factor that is used during production has the most significant impact on product reliability. This is because the industry employs the incorrect method due to insufficient systematic format instruction. Furthermore, the water volume is not consistent due to the manual reducing process, which means that no machines are supplied.

The second factor is man, and in this case, workers are the issues affecting product reliability in production. Aside from that, workers have a poor performance on workers due to a lack of experience among them. As a result, there is no capable person in charge with good knowledge, and the worker is always doing repetitive jobs.

Finally, the last issue affecting product reliability in production is machine factor contribution. This is since the Machine takes longer to process the product that is being placed. Next, mostly every week, a machine could fail because the boiler machines in this industry are outdated. Following that, the process of capping and labelling will be delayed because the Machine in soybean production is always having problems, necessitating the sharing of the Machine with Tamarind production. Otherwise, a lack of maintenance among workers impacts the issue of product reliability in manufacturing.

4.4.3 Why-why Analysis

The why-why analysis is performed to determine the causes and underlying cause of an issue in the workplace. The why-why analysis is a method of analyzing and determining the fundamental reasons for a problem. It will discover genuine reasons and prevent failures from recurring. Genichi Taguchi developed this approach, which is based on the Ishikawa diagram revolutionary, to provide a simple and rapid tool for determining the root causes of an issue.

Following that, each root cause identifies appropriate behaviours that reduce the likelihood of the cause's occurrence or consequence. According to the why-why analysis, there are three main factors in soybean production such as method, man, and machine that related with Ishikawa diagram, as shown in Table 4.4 below.

Table 4-4: Why-why Analysis with root cause

Main Factor	Problem	Why 1	Why 2	Why 3	Why 4	Why 5	Root Cause
Method	**Water volume is inconsistent**	Manually reduces the quantity of water on the soy bottle	Have no specific machine to reduce water	No machine supplied	No investment	No financial support	Not enough investment on automatic machine
				Improper systematic format	Not supporting tools for approach improvement	Lack of knowledge	Poor instruction & job description
Man	**Poor Performance Worker**	Less manpower	Worker not interested on department	No proper planning	No knowledge	No training	No training cost provided
			No proper worker's working division	Repetitive work	Workers become bored & fatigued	-	Lack of motivation
Machine	**Sharing Machine for each product**	Soybean Machine Failure	Outdated machine	Lack of investment on new machine	No financial support	No person in charge	Poor monitoring
			Improper handling machine	Lack of knowledge about machine	Lack of experience	Lack of training	Inadequate experience

The method factor is the first major contributor to the problem based on the table above. This is due to inconsistent water reduction process methods and lack of higher quality consistency of workers in soybean production. During this step, the water in the soy bottle is reduced manually by flicking using a finger. For example, workers have to use flicking the bottle to reduce water and ensure there is space to facilitate the sealing process so that water does not overflow. Apart from that, the employee said that the minimum amount of water is 306ml, and the maximum amount is 310ml.

Moreover, the lack of investment by the industry in financing automated machines has forced workers to use manual processes in water reduction. Consequently, the lack of support for improvement, the weak systematic format, and the poor instructions and job descriptions makes the method incorrect and a significant problem. As a result, the manual process is one of the problems in production process capability in soybean manufacturing.

A man is the second factor in the soybean production problem. The poor performance of employees and a lack of skills among them are critical issues in the food and beverage industry. Employees are also probably unwilling to engage in their department because they have no other option. This is because some of them lack the required training and knowledge.

Manpower shortages impact overall production because this soybean production requires a large number of workers in terms of quality and timeliness. Another issue caused by humans is the skilled workers' lack of proper division of work. Because the workers should accomplish the task manually, they will be required to repeat the task, which may cause fatigue and boredom. This is due to employees' low levels of motivation, which can impact factors in soybean production.

Finally, machinery is the last factor affecting the industry for soybean manufacturing. It becomes a problem factor due to poor monitoring from the people in charge. In this industry, there is only one automatic labeling machine used. This machine is used in the final stage of soy beverage production before packaging, which is intended to print the date of manufacture. As a result, the labeling machines used should be shared to produce soybean drinks and tamarind.

However, the most serious sequence is the workers' improper manner and handling of the machine. Furthermore, the lack of investment in new machine has resulted in the machines that make soy drinks obsolete because the machines used are relatively outdated machines. This is also due to poor care and maintenance from the beginning of production. As a result, studies of soybean production process capability have negatively impacted.

4.5 Improvement Proposal

The process improvement strategy is the vision, goals, and set of steps that will allow an organization's processes to attain a sustainable competitive advantage by addressing inefficiencies, waste, asset condition, and culture within the process and its industry leaders. Based on this statement, there have several improvements are made to improve the product reliability of soybean production in the F&B industry. Table 4.5 below shows the root cause and proposed action for improvement.

Table 4-5: The root cause and proposed action

No	Root Cause	Proposed Action
Method	Not enough cost to investment on automatic machine	Find a lower cost way to invest and rebalance regularly on automatic machine
	Poor Instruction & job description	Make a proper work instruction
Man	No training cost provided	Provides a specific training that related with their position on it
	No creativity on work	Provides a clean and fragrant environment, large space
Machine	Inadequate maintenance	Provides a schedule for maintenance
	Inadequate experience	Taking advantage of free online resources can be a low risk way to expand knowledge

The industry can afford better ways to invest and rebalance periodically on automated machines, which is the first improvement suggestion. At the same time, the industry can help employees by automating processes that reduce the amount of water in the bottles. Based on the result of capability analysis, the Cp and Cpk has to improve to 1.0 above to get a good inspection on specification limit.

Further, new machines using better building materials, design concepts, material control, and handling may be more water-efficient than existing equipment. More efficient equipment often saves energy, labour, and materials. Additionally, to overcome the issue of inadequate instructions and job descriptions, the industry can provide better working documents. Or they might assign a department head so that others can follow instructions more carefully.

After that, the improvements that can be discussed for the man cause is by providing specific training relevant to their position. The training place can produce skilled, knowledgeable, and experienced employees if it has been financially supported. Thus, the industry can save money on new hires. The industry must also provide a clean and fragrant environment so that employees are not bored, fatigued, or uncomfortable.

Finally, the machine's root is essential in preparing a maintenance schedule. So the industry knows the situation and when the machine can be damaged. Through the link with Inadequate Experience, employees might use good streaming resources to expand their knowledge. For example, they can visualise resources from work-related YouTube channels or other internet sources.

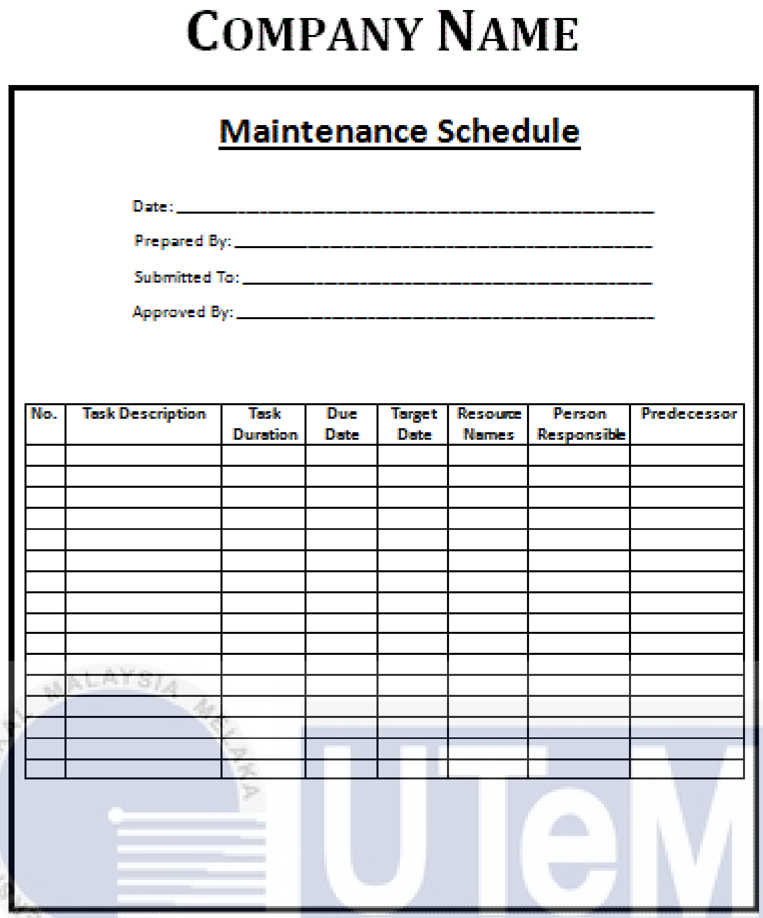
4.6 Controlling the Improvement

To the best of our knowledge, the method of control required by the industry is the application of the DMAIC principle in the final section of the research. The purpose of that would be to make sure that the proposed improvements to the manufacturing process are carried out consistently and sustainably. The following are suggestions for continuous control and improvement for the F&B industry such as preventive maintenance, performance checklist and arrange time to check water level.

4.6.1 Perform Preventative Maintenance on a Regular Basis

Preventive maintenance is essential to avoid larger, costly fixes down the line. A preventive maintenance plan can save a company money because it will employer and employee to focus on preventing machine failure rather than reacting in case of emergencies. In general, machine maintenance scheduling includes recommended maintenance tasks and the frequency with which those tasks should be completed. Industry should do the schedule maintenance routines monthly for the employees.

It can be shown on figure 4.9 below as an example of maintenance schedule. As a result, a better maintenance schedule can ensure that all machine is inspected at the appropriate frequency to control the machine failure that requires maintenance.



COMPANY NAME

Maintenance Schedule

Date: ____________________

Prepared By: ____________________

Submitted To: ____________________

Approved By: ____________________

No.	Task Description	Task Duration	Due Date	Target Date	Resource Names	Person Responsible	Predecessor

Figure 4-9: Example maintenance schedule (*Wordpress, 2020*)

4.6.2 Develop a Process Performance Checklist

Process monitoring is also required to improve process performance and efficiency. Machine monitoring devices keep users notified of their machine's status, allowing the industry to react immediately in case of failure or poor performance. A checklist is a list of elements that the industry must verify, check, or inspect.

Industry can be used in various fields, from construction to health care, but in this case, the checklist is used to monitor process performance. A process performance checklist assists in identifying performance actions on machine to keep it in perfect working condition and improve product reliability in production. Figure 4.10 shows an example of a checklist that could be used in the industry.

MANAGING POOR PERFORMANCE CHECKLIST

MANAGING POOR PERFORMANCE

This is a summary document intended to assist the supervisor, or the executive when undertaking the performance management of an individual employee where they are not meeting the work or conduct standards expected by the County. The document outlines the key steps to consider and document when conducting a performance management process.

Check performance management framework	Documentation	Circle
1. Is there any agreement, County policy or SOP that sets out steps that must be followed when conducting performance review?	Local #1348 agreement, DCEMS SOP or County Handbook policy	*Yes / No*
Review Preliminary Support	**Useful Documentation**	***Circle***
1. Does the employee really understand what is expected of their role?	Job description	*Yes / No*
2. Are your performance expectations reasonable? Would your standards for performance be seen as reasonable by a 3rd party?	Other Shift Supervisors, Human Resources officer, or Medical Director.	*Yes / No*
3. Has the employee received appropriate and reasonable support and training to assist them to perform their role?	DCEMS SOP Manual, Name of Mentor, Agenda of Training courses	*Yes / No*
4. Do you have the following documentation (evidence)?	▪ *Dates of incidents / copies of complaints / relevant emails or documents*	*Yes / No*
	▪ *Administrative notes of meetings outlining issues discussed*	*Yes / No*
	▪ *Copies of useful supporting documentation provided (eg complaints or incident reports)*	*Yes / No*

Figure 4-10: Example of performance checklist (*examples.com, 2020*)

4.6.3 Time Arrangement for Workers to Check the Water Level

The method is to control or check the volume of water effectively. As a result, before the employees begin their job responsibilities in the morning, employees must conduct the activity by inspecting each bottle of soybean water daily. As a result, the ideal way to conduct an inspection is to weigh water bottles on a kitchen-related beverage weighing scale. By using a digital scale, for example, to ensure that the value is accurate. That would be to avoid any inconsistent water levels. At the same time, it can improve the product's reliability to market demands.

4.7 Summary

To sum it all up in this chapter, the following steps are taken using the DMAIC concept, beginning with the definition of the study's problem. As stated in the problem statement, there is a problem with product reliability related to process capability. The information was gathered by visiting an F&B industry and collecting primary and secondary data.

Noteworthy, the research concentrates on the soybean production line in this research study. The process flow chart thus aids in the coverage of the soybean cycle, beginning with daily production capability and ending with completed goods being processed in the storage area. In typical manufacturing, two batches of soybean drink will be prepared at the same time daily basis. Labeling, filling, packing, capping, and placing the bottles in the provided storage is the fundamental technique for soybean drinks. Within three months of the collected data, it illustrates the production input and output data for soybean beverages

The third DMAIC concept is to use the collected data in the analysis of the study. The Capability Analysis ensures that an industry's output meets customer specifications for product reliability while staying within specification limits. According to the results, Cp Cpk may further achieve 1.3 or higher (Cp > 1), indicating that the process is acceptable and meets specifications.

The study is then researched further in the Improvement phase, where the Ishikawa diagram and Why-Why analysis are used to determine the root cause of the product's reliability. This phase is critical because it ensures that the company can improve its production process due to the suggestions made. Finally, the final aspect of DMAIC, Control, is presented for the F&B industry. It's also critical for the company to control its manufacturing process after the improvements are made.

CHAPTER 5

CONCLUSION

5.1 Conclusion

Process capability is the upper limit to how many processes can be created in a given amount of time, and it is much more flexible and subject to modification. There are several ways to increase system process capabilities. It includes some very affordable things to most businesses and should be implemented effectively. At the same time, it is essential to examine this part of the company to understand how to develop this for future projects.

Capability studies assist in determining the capacity to produce within the tolerance limits and technical standards for the company's production. Capability analysis can be applied to machines or machine tools and production periods. Here, the situation is similar to the first objective, which is to identify the product's reliability in a way similar to the process capability.

Furthermore, the process is about learning how to implement Cp Cpk in knowing the upper or lower specification limits required to resolve issues in companies in the F&B industry. Therefore, the second objective is to run and analyze the Cp Cpk method to improve the product's reliability. In contrast, capability studies provide information about system changes and features during production. This is used to find out how the system behaves between tolerance boundaries. As a result, it is possible to find irregularities and defects in the average process dimensions.

Finally, creating Cp Cpk as an improvement achieved product reliability in the manufacturing process. Process capabilities can also discover and correct the root cause of an issue based on documentation and research and identify data analysis. Using Process capabilities is to improve and determine the reliability of the products produced by the current production system. The Cp Cpk approach will be used in the project and given to the organization to resolve the situation.

5.2 Contribution

The significant contribution of the Cp Cpk technique is to apply continuous product reliability improvement to the F&B Industry. Following that, it may increase reliability while lowering management expenses, valuable tools for the F&B industry. Furthermore, the organisation may evaluate manufacturing performance by implementing the Cp Cpk approach, which displays the upper and lower limits of the product based on data analysis. Furthermore, it will assist an organisation in optimally producing the completed product and showing interest in the employee's skill in accomplishing the assigned work on time.

Moreover, the F&B industry may effectively utilise this strategy to develop and sustain beverage productivity. At the conclusion of this research, the corporation will learn how to execute the appropriate approach that can give effective product reliability to customers and how to deal with the issue of creating more goods in the long - term. Furthermore, the F&B industry will recognise and realise that it has a lot of potential if it is being used appropriately.

5.3 Suggestion for Future Research

Therefore, this proposal provides adequate training on machines and methods to give employees more inventiveness. Another suggestion is for the F&B industry to invest in machines and equipment for automated closing and labeling procedures. Besides, the F&B industry also could invest in automated, reducing water level regarding getting the same level or weight of soybean production. Apart from the Cp Cpk Technique, the Pp and Ppk techniques are more accurate than Cp Cpk. Therefore, it is one of the most valuable methods to control and improve production processes in the F&B industry, including products and equipment. The application of Pp and Ppk techniques can be used in the F&B industry and other industries, such as metals, semiconductors, automotive, and plastics.

REFERENCES

A

Antonucci, Y. L., Fortune, A., & Kirchmer, M. (2020). An examination of associations between business process management capabilities and the benefits of digitalization: all capabilities are not equal. *Business Process Management Journal*, *27*(1), 124–144. https://doi.org/10.1108/BPMJ-02-2020-0079

B

Barratt, M., Choi, T. Y., & Li, M. (2011). Qualitative case studies in operations management: Trends, research outcomes, and future research implications. *Journal of Operations Management*, *29*(4), 329–342. https://doi.org/10.1016/j.jom.2010.06.002

Bottani, E., Montanari, R., Volpi, A., Tebaldi, L., & Maria, G. Di. (2021). Statistical Process Control of assembly lines in a manufacturing plant: Process Capability assessment. *Procedia Computer Science*, *180*, 1024–1033. https://doi.org/10.1016/j.procs.2021.01.353

Bracke, S., & Backes, B. (2015). Multidimensional analyses of manufacturing processes: Process capability within the case study shape drill manufacturing. *IFAC-PapersOnLine*, *28*(3), 2380–2386. https://doi.org/10.1016/j.ifacol.2015.06.444

Basu, S., Dan, P. K., & Thakur, A. (2014). Experimental design in soap manufacturing for optimization of fuzzified process capability index. Journal of Manufacturing Systems, 33(3), 323–334. https://doi.org/10.1016/j.jmsy.2014.03.001

Benafqir, M., Hsini, A., Laabd, M., Laktif, T., Ait Addi, A., Albourine, A., & El Alem, N. (2020). Application of Density Functional Theory computation (DFT) and Process Capability Study for performance evaluation of Orthophosphate removal process using

Polyaniline@Hematite-titaniferous sand composite (PANI@HTS) as a substrate. Separation and Purification Technology, 236(August 2019), 116286. https://doi.org/10.1016/j.seppur.2019.116286

Benmoussa, R., Abdelkabir, C., Abd, A., & Hassou, M. (2015). Capability/maturity based model for logistics processes assessment: Application to distribution processes. International Journal of Productivity and Performance Management, 64(1), 28–51. https://doi.org/10.1108/IJPPM-08-2012-0084

Bronzo, M., de Oliveira, M. P. V., & McCormack, K. (2012). Planning, capabilities, and performance: An integrated value approach. Management Decision, 50(6), 1001–1021. https://doi.org/10.1108/00251741211238300

Brühl, R., Horch, N., & Osann, M. (2010). Improving integration capabilities with management control. European Journal of Innovation Management, 13(4), 385–408. https://doi.org/10.1108/14601061011086267

C

Caulcutt, R. (2004). Control charts in practice. *Significance*, *1*(2), 81–84. https://doi.org/10.1111/j.1740-9713.2004.024.x

Chitranshi, U. (2018). *How To Measure Process Capability And Process Performance*. Grey Campus. https://www.greycampus.com/blog/quality-management/how-to-measure-process-capability-and-process-performance

Cp and Cpk (Oracle Quality Help). (n.d.). Retrieved June 19, 2021, from https://docs.oracle.com/cd/A60725_05/html/comnls/us/qa/cpcpk.htm

Cp Cpk % out of tolerance. (n.d.). Retrieved June 19, 2021, from https://develve.net/Cp Cpk %2525 out of tolerance.html

Cpk vs Ppk | Cp Cpk versus Pp Ppk | Compare to Sigma. (n.d.). Retrieved December 23, 2021, from https://www.qimacros.com/process-capability-analysis/cpk-vs-ppk/

Choi, Y. H., Na, G. Y., & Yang, J. (2020). Fuzzy-inference-based decision-making method for the systematization of statistical process capability control. Computers in Industry, 123, 103296. https://doi.org/10.1016/j.compind.2020.103296

D

Deleryd, M. (1998). On the gap between theory and practice of process capability studies. *International Journal of Quality and Reliability Management*, *15*(2), 178–191. https://doi.org/10.1108/02656719810204892

E

Ellis, Ed. "Trains Must Achieve Reliability, but Can They?" Trains Magazine, August 1996, 14-15.

G

G, A. (n.d.). *Process Capability | Quality-One*. Quality-One. Retrieved June 19, 2021, from https://quality-one.com/process-capability/

Gartner, W. B., Naughton, M. J., Deming, W. E., Gitlow, H. W., Gitlow, S. J., Mann, N., Scherkenbach, W. W., & Walton, M. (1988). The Deming Theory of Management. *The Academy of Management Review*, *13*(1), 138. https://doi.org/10.2307/258362

Glen, S. (2016). *Reliability and validity in research: definitions, examples - Statistics How To*. StatisticsHowTo. https://www.statisticshowto.com/reliability-validity-definitions-examples/

H

How Design for Reliability (DfR) Best Practices Impact Electronics Production. (n.d.). Retrieved June 19, 2021, from https://www.dfrsolutions.com/blog/how-design-for-reliability-dfr-best-practices-impact-electronics-production

How to Calculate Cp and Cpk Values and When to Use Them. (n.d.). Retrieved June 19, 2021, from https://www.latestquality.com/how-to-calculate-cp-and-cpk/

Hashim, Mohammad. "Measuring Reliability in Service Industries." Management Decision, July 1987, 46-51.

Hsu, B. M., & Shu, M. H. (2008). Fuzzy inference to assess manufacturing process capability with imprecise data. European Journal of Operational Research, 186(2), 652–670. https://doi.org/10.1016/j.ejor.2007.02.023

H. Ketan, M. Nassir, Aluminium hot extrusion process capability improvement using Six Sigma, Adv produc engineer manag 11 (1) (2016) 59–69, https://doi. org/10.14743/apem2016.1.210

I

IEEE ENGINEERING MANAGEMENT REVIEW - 0360-8581 | MIAR 2020 live. Information Matrix for the Analysis of Journals. (n.d.). *IEEE Engineering Management Review*. Retrieved June 19, 2021, from http://miar.ub.edu/issn/0360-8581

Ippolito, Richard A. "A Study of Wages and Reliability." Journal of Law and Economics, April 1996, 149-89.

L

Lepore, A., Palumbo, B., & Castagliola, P. (2018). A note on decision making method for product acceptance based on process capability indices Cpk and Cpmk. *European Journal of Operational Research*, *267*(1), 393–398. https://doi.org/10.1016/j.ejor.2017.12.032

Lager, T., Samuelsson, P., & Storm, P. (2017). Modelling company generic production capabilities in process industries: A configuration approach. International Journal of Operations and Production Management, 37(2), 126–161. https://doi.org/10.1108/IJOPM-11-2014-0544

M

Middleton, F. (2019). Reliability vs Validity in Research | Differences, Types and Examples. In *Scribbr*. https://www.scribbr.com/methodology/reliability-vs-validity/

Mondal, S. C. (2016). Process capability – a surrogate measure of process robustness: a case study. *International Journal of Quality and Reliability Management*, *33*(1), 90–106. https://doi.org/10.1108/IJQRM-12-2013-0202

McLeod, S. (2013). What is Reliability? | Simply Psychology. Simply Psychology. https://www.simplypsychology.org/reliability.html

Mobin, M., Li, Z., Cheraghi, S. H., & Wu, G. (2019). An approach for design Verification and Validation planning and optimization for new product reliability improvement. Reliability Engineering and System Safety, 190(October 2018), 106518. https://doi.org/10.1016/j.ress.2019.106518

Motorcu, A. R., & Güllü, A. (2006). Statistical process control in machining, a case study for machine tool capability and process capability. Materials and Design, 27(5), 364–372. https://doi.org/10.1016/j.matdes.2004.11.003

Mondal, S. C. (2016). Process capability – a surrogate measure of process robustness: a case study. International Journal of Quality and Reliability Management, 33(1), 90–106. https://doi.org/10.1108/IJQRM-12-2013-0202

O

Otsuka, A., & Nagata, F. (2018). Quality design method using process capability index based on Monte-Carlo method and real-coded genetic algorithm. International Journal of Production Economics, 204, 358–364. https://doi.org/10.1016/j.ijpe.2018.08.016

Ozlem Senvar and Hakan Tozan (2010). Process Capability and Six Sigma Methodology Including Fuzzy and Lean Approaches, Products and Services; from R&D to Final Solutions, Igor Fuerstner (Ed.), ISBN: 978-953-307-211-1

P

Process Capability Index, Cpk, 1 (2017) (testimony of Six Sigma Material). https://sixsigmaninja.com/process-capability-index-cpk/

Process Capability Analysis: Estimating Quality - 1st Edition - Neil W. (n.d.). Retrieved June 19, 2021, from https://www.routledge.com/Process-Capability-Analysis-Estimating-Quality/Polhemus/p/book/9780367572518

Pawar, H. U., Bagga, S. K., & Dubey, D. K. (2020). Investigation of production parameters for process capability analysis: A case study. *Materials Today: Proceedings*, *43*(xxxx), 196–202. https://doi.org/10.1016/j.matpr.2020.11.627

Podder, B., De, T., Saikumar, S., & Kumar, K. R. (2018). Process capability study of flow formed shell diameter. *Materials Today: Proceedings*, *5*(13), 27094–27099.

https://doi.org/10.1016/j.matpr.2018.09.015

Process capability. (n.d.). Retrieved June 19, 2021, from https://www.slideshare.net/rmsenthik/process-capability-90134103

Process Capability - an overview | ScienceDirect Topics. (n.d.). Retrieved June 19, 2021, from https://www.sciencedirect.com/topics/engineering/process-capability

Process Reliability vs Process Capability: The Differences -. (n.d.). Retrieved December 22, 2021, from https://www.shmula.com/process-reliability-vs-process-capability-the-differences/25663/

Pandža, K., Polajnar, A., Buchmeister, B., & Thorpe, R. (2003). Evolutionary perspectives on the capability accumulation process. *International Journal of Operations and Production Management*, *23*(7–8), 822–849. https://doi.org/10.1108/01443570310486310

R

Rastogi N I T A N K Trivedi M K 2016 PESTLE techniquea tool to identify | Course Hero. (n.d.). Retrieved June 19, 2021, from https://www.coursehero.com/file/p382os84/Rastogi-N-I-T-A-N-K-Trivedi-M-K-2016-PESTLE-techniquea-tool-to-identify/

Reliability. (n.d.). Retrieved December 22, 2021, from https://www.referenceforbusiness.com/encyclopedia/Pro-Res/Reliability.html

Reliability of a Product: Definition, Measurement and Improvement. (n.d.). Retrieved December 22, 2021, from https://www.yourarticlelibrary.com/products/reliability-of-a-product-definition-measurement-and-improvement/90710

Ribbins, P., & Whale, E. (1991). Managing Quality. Management in Education, 5(2), 20–22. https://doi.org/10.1177/089202069100500208

S

Suboohi Safdar, E. A. (2014). *Process Capability Indices for Shape Parameter of Weibull Distribution*. https://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/ReferencesPapers.aspx?ReferenceID=1160522

Stauder, J., Buchholz, S., Klocke, F., & Mattfeld, P. (2014). A new framework to evaluate the process capability of production technologies during production ramp-up. *Procedia CIRP*, *20*(C), 126–131. https://doi.org/10.1016/j.procir.2014.05.043

Singh, R., Kumar, R., Ahuja, I., & Grover, S. (2018). Process capability analysis for frictionally welded dissimilar polymeric materials. *Materials Today: Proceedings*, *5*(9), 18502–18509. https://doi.org/10.1016/j.matpr.2018.06.192

Schuh, G., Bergweiler, G., Lukas, G., & Abrams, J. A. (2020). Feasibility and process capability of polymer additive injection molds with slide technology. *Procedia CIRP*, *93*, 102–107. https://doi.org/10.1016/j.procir.2020.03.057

Samuelsson, P., Storm, P., & Lager, T. (2016). Profiling company-generic production capabilities in the process industries and strategic implications. *Journal of Manufacturing Technology Management*, *27*(5), 662–691. https://doi.org/10.1108/JMTM-06-2015-0042

Stoumbos, Z. G., Reynolds, M. R., Ryan, T. P., & Woodall, W. H. (2001). The state of statistical process control as we proceed into the 21st century. In Statistics in the 21st Century (pp. 243–255). CRC Press. https://doi.org/10.2307/2669484

T

Ted Hessing. (n.d.). *Process Capability (Cp & Cpk)*. https://sixsigmastudyguide.com/process-capability-cp-cpk/

Trez, G., & Luce, F. B. (2012). Organizational structure and specialized marketing capabilities in SMEs. Marketing Intelligence and Planning, 30(2), 143–164. https://doi.org/10.1108/02634501211211957

Tong, L. I., & Chen, J. P. (1998). Lower confidence limits of process capability indices for non-normal process distributions. International Journal of Quality and Reliability Management, 15(8), 907–919. https://doi.org/10.1108/02656719810199006

Trochim, W. M. K. (2020). Theory of Reliability | Research Methods Knowledge Base. https://conjointly.com/kb/theory-of-reliability/

U

Udroiu, R., & Braga, I. C. (2020). System performance and process capability in additive manufacturing: Quality control for polymer jetting. Polymers, 12(6). https://doi.org/10.3390/POLYM12061292

W

Wu, C. W., Pearn, W. L., & Kotz, S. (2009). An overview of theory and practice on process capability indices for quality assurance. *International Journal of Production Economics*, *117*(2), 338–359. https://doi.org/10.1016/j.ijpe.2008.11.008

What is Process Capability? Capability Estimates & Studies | ASQ. (n.d.). Retrieved June 19, 2021, from https://asq.org/quality-resources/process-capability

What is Reliability? | Simply Psychology. (n.d.). Retrieved December 22, 2021, from https://www.simplypsychology.org/reliability.html

What is Reliability? Quality & Reliability Defined | ASQ. (n.d.). Retrieved August 26, 2021, from https://asq.org/quality-resources/reliability

X

X Bar S Control Chart - What you need to know for Six Sigma certification. (n.d.). Retrieved December 22, 2021, from https://sixsigmastudyguide.com/x-bar-s-chart/

Y

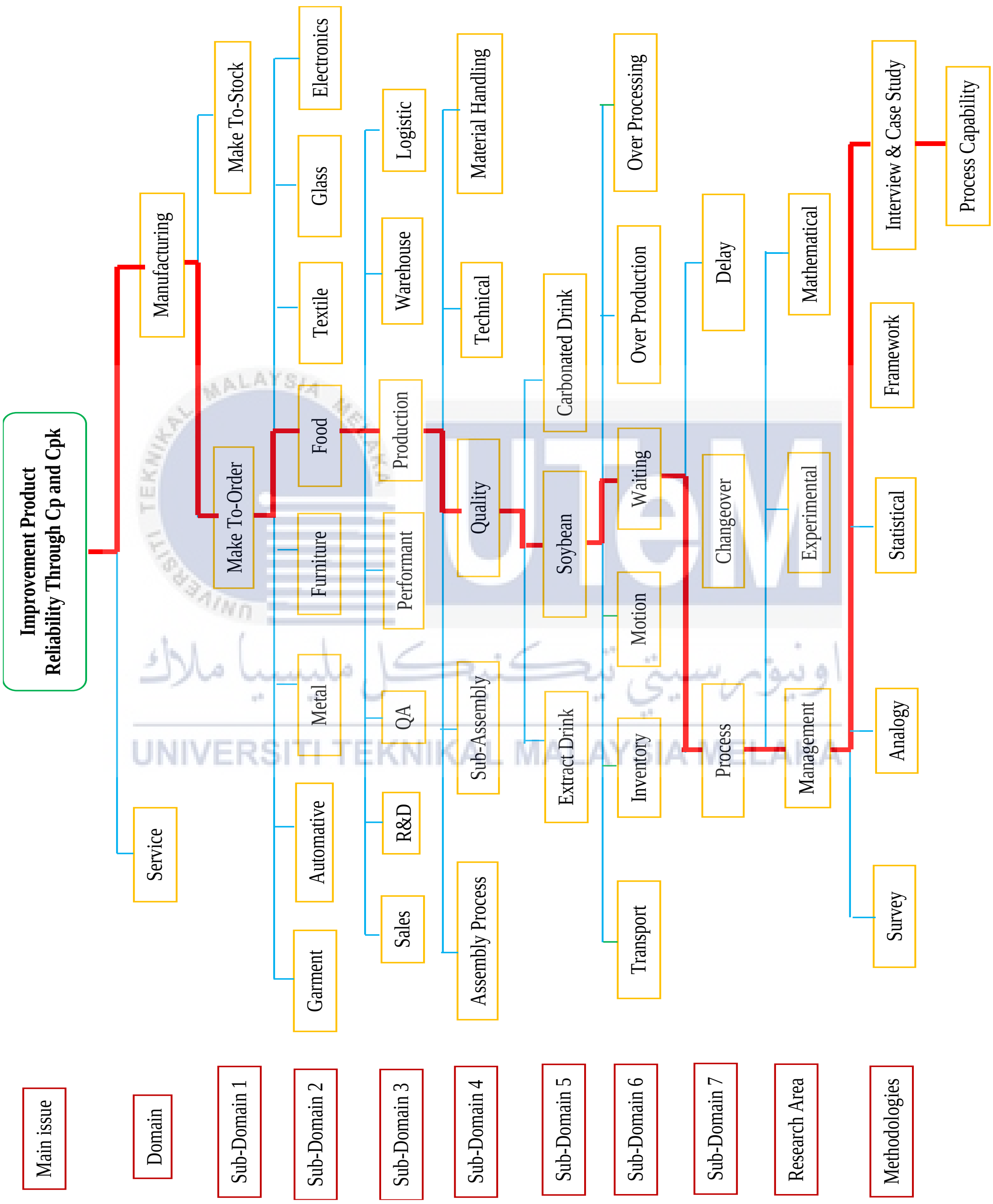
Yu, W., Ramanathan, R., Wang, X., & Yang, J. (2018). Operations capability, productivity and business performance the moderating effect of environmental dynamism. Industrial Management and Data Systems, 118(1), 126–143. https://doi.org/10.1108/IMDS-02-2017-0064

Yusuf, Abdullah, Abdul Rasib. 2018. Quality Control, For Engineering Technologist, 2th Edition, UTeM.

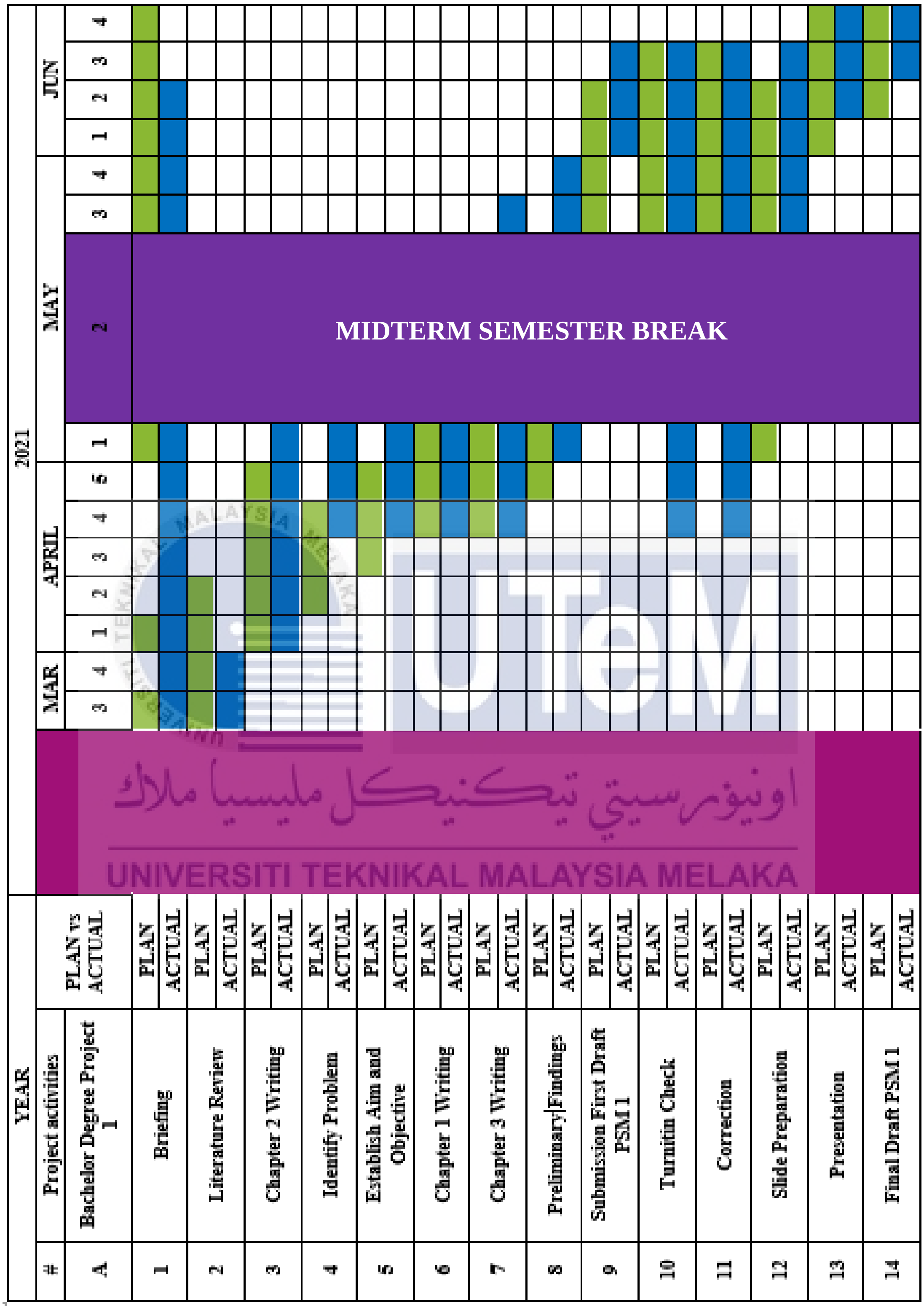
APPENDICES

APPENDICES

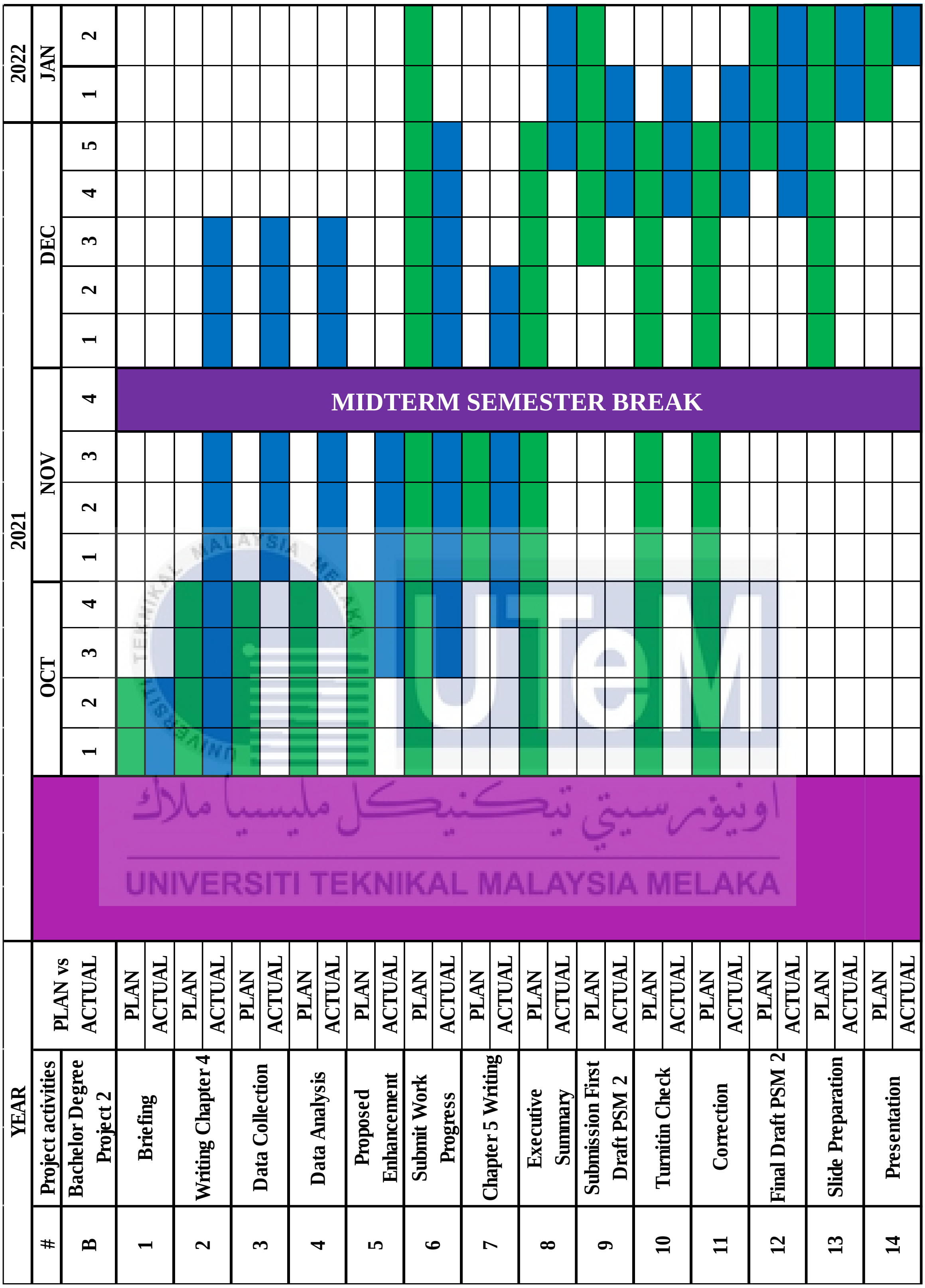
APPENDIX A K-Chart for Research Scope



APPENDIX B Gantt Chart PSM 1 & 2



Accomplishment Literature Review	W8
Accomplishment Introduction	W8
Accomplishment Methodology	W10
Accomplishment Preliminary Findings	W11



Accomplishment Result and Discussion	W10
Accomplishment Data Collection	W8-W9
Accomplishment Data Analysis	W9-W10
Accomplishment Proposed Enhancement	W11
Accomplishment Conclusion and Suggestion	W12
Thesis Submition	W16

APPENDIX C Industrial Visit


2021.11.10 10:26


Z&Z
www.groombig.biz
Z&Z


ZALIZA FOOD INDUSTRIES
Contact:
06-261 9903/019-655 7273
MeSTI
SME Bank
2021.11.10 10:21


2021.11.10 11:07

Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka, Malaysia.

+606 270 1000
+606 270 1022
www.utem.edu.my

APPENDIX E Thesis Classification Letter

FAKULTI TEKNOLOGI KEJURUTERAAN MEKANIKAL DAN PEMBUATAN
Tel : +606 270 1184 | Faks : +606 270 1064

Rujukan Kami (Our Ref):
Rujukan Tuan (Your Ref):
Tarikh (Date): 31 Januari 2021

Chief Information Officer
Perpustakaan Laman Hikmah
Universiti Teknikal Malaysia Melaka

Melalui

Dekan
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

Tuan

PENGKELASAN TESIS SEBAGAI TERHAD BAGI TESIS PROJEK SARJANA MUDA

Dengan segala hormatnya merujuk kepada perkara di atas.

2. Dengan ini, dimaklumkan permohonan pengkelasan tesis yang dilampirkan sebagai TERHAD untuk tempoh **LIMA** tahun dari tarikh surat ini. Butiran lanjut laporan PSM tersebut adalah seperti berikut:

Nama pelajar: RADIN PUTERI FARZANA NATASHA BINTI RADIN MOHAMAD SHAMSUL ZAHRI (B091810053)
Tajuk Tesis: IMPROVEMENT OF PRODUCT RELIABILITY THROUGH PRODUCTION PROCESS CAPABILITY STUDY AT FOOD AND BEVERAGES INDUSTRY

3. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"
"KOMPETENSI TERAS KEGEMILANGAN"

Saya yang menjalankan amanah,

TS. DR. AMIR HAMZAH BIN ABDUL RASIB
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan Pembuatan
akulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

Ts. Ds. AMIR HAMZAH BIN ABDUL RASIB
Penyelia Utama/ Pensyarah Kanan
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

APPENDIX F Thesis Status Verification Form

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA

TAJUK: **IMPROVEMENT PRODUCT RELIABILITY THROUGH PRODUCTION PROCESS CAPABILITY STUDY AT FOOD AND BEVERAGES INDUSRTY**

SESI PENGAJIAN: **2021/22 Semester 1**

Saya **RADIN PUTERI FARZANA NATASHA BINTI RADIN MOHAMAD SHAMSUL ZAHRI** mengaku membenarkan tesis ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐ SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

☐ TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☑ √ TIDAK TERHAD

Disahkan oleh:

Alamat Tetap:
No. 67, Jalan Kemboja 31
Taman Aman 42700 Banting
Selangor Darul Ehsan

Cop Rasmi:
TS. DR. AMIR HAMZAH BIN ABDUL RASIB
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan Pembuatan
akulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

Tarikh: 17 Januari 2022

Tarikh: 17 Jan 2022

** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.