PROCESS IMPROVEMENT IN MANUFACTURING INDUSTRY USING TIME STUDY AND WORK MEASUREMENT ANALYSIS

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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

by

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DECLARATION

I hereby, declared this report entitled "Process Improvement in Manufacturing Industry using Time Study and Work Measurement Analysis" is the result of my own research except as cited in references.

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Date : 1st September 2021

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as partial fulfillment of the requirement for the Degree of Bachelor of Manufacturing Engineering (Hons.). The member of the supervisor committee is as follow:

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ABSTRAK

Analisis kajian masa dan kaedah pengukuran kerja merupakan pendekatan analisis saintifik yang bermaksud mencari cara optimum bagi melakukan tugas dan mengukur waktu yang digunakan oleh para pekerja di tempat kerja yang ditetapkan untuk menyelesaikan tugas tertentu. Matlamat utama projek adalah meningkatkan produktiviti di syarikat biskut dengan melaksanakan analisis kajian masa dan kaedah pengukuran kerja. Kerana proses pengeluaran yang panjang, industri tidak dapat memenuhi permintaan tinggi biskut tongkat dari pelanggan. Objektif kajian adalah untuk melakukan masa analisis dan kaedah pengukuran kerja di barisan pembuatan. Kaedah pemerhatian dan rakaman video digunakan bagi mengenal pasti aliran proses biskut tongkat. Kajian tertumpu pada tujuh proses utama dalam pembuatan biskut tongkat, daripada jumlah keseluruhan 17. Bagi kajian terperinci, setiap proses utama dibahagikan kepada beberapa elemen kerja. Pemerhatian pada tujuh proses utama, dengan pertimbangkan masa dan pergerakan setiap tugas yang dilakukan oleh pekerja, dan waktu piawai ditentukan dengan mengambil kira elaun dan penilaian prestasi. Gambar rajah sebab dan akibat digunakan bagi analisis tujuh masalah dalam proses pengeluaran kini. Empat dari tujuh masalah kritikal dianalisis menggunakan 5 mengapa teknik, dan diberi penanggulangan. Tujuan penyelidikan ini juga adalah menyediakan alternatif proses bagi mengurangkan masa pembuatan. Aliran proses yang menuju pengeluaran yang panjang telah ditentukan; terdapat satu proses utama dan tiga elemen kerja yang menyebabkan usaha diperlukan untuk menghasilkan biskut tongkat. Terdapat empat penyelesaian yang telah dicadangkan untuk meningkatkan masa pengeluaran, iaitu penggunaan teknik 5S untuk Proses 1, penggunaan standard baru prosedur operasi (SOP) untuk Proses 2, dan penggunaan peralatan baru untuk proses 4 dan 7. Alternatif yang dicadangkan mampu mewujudkan stesen kerja yang teratur, menjadikan kaedah kerja lebih mudah, dan mengoptimumkan tenaga kerja untuk melaksanakan tugas tertentu.

ABSTRACT

Time study analysis and work measurement method is defined as a scientific analysis approach meant to find the optimum way to do a regular task and measure the time spent by an average worker in a set workplace to accomplish a particular task. The primary goal of this project was to enhance productivity at the biscuit company by implementing time study analysis and work measurement methods. Due to the lengthy production process, the industry was unable to meet the high demand for long rusk biscuits from customers. The objective of the study is to conduct time analysis and work measurement method in the manufacturing line. The approach of direct observation and video recording was used to identify the present process flow of the long rusk biscuit. This study only focuses at the first seven processes in the manufacture of long rusk biscuits, out of a total of 17. For detailed study, each main process was divided into several work elements. The observation was carried out on the seven key processes, taking into consideration the cycle time and motion of each job done by the worker, and the standard time was established by taking allowances and performance rating into account. A cause-and-effect diagram was used to examine seven problems in the present production process. Four of the seven critical issues were analyzed utilizing 5 whys techniques, and each problem was given a countermeasure. Another aim of the research is to provide a process flow alternative to reduce manufacturing time. The process flow that leads in a prolonged production line has been determined; there is one main process and three work elements that cause effort required to produce the long rusk biscuit. There are four solutions that have been proposed to improve the production time, which is adoption of 5S techniques for Process 1, adoption of new Standard Operating Procedure (SOP) for Process 2, and adoption of new equipment for process 4 and 7. The proposed alternatives are capable of creating a well-organized workstation, making the work method easier to execute, and optimizing the labor action to perform the specific task.

DEDICATION

Only

To my beloved parents, who have raised me to be the person who I am today. Thank you for all your unconditional love and for encouraging me when I give up and continue to provide me with moral and emotional support. You are the reason for all the achievements in my life.

To my brothers, who have always shared their words of advice to inspire and encourage me throughout my studies. You're infinitely loving, and giving the spirit is what inspires me when things get difficult.

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I dedicate this work to all of you and I wish you all the happiness.

Thank you so much. May Allah bless all of you.

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LIST OF ABBREVIATIONS

SMEs	-	Small and Medium-sized Enterprises
MTM	-	Method Time Measurement
PTSS	-	Predetermined Time Standard System
MOST	-	Maynard Operation Sequence Technique
PTS	-	Predetermine Time Standard
PMTS	-	Predetermine Motion Time Standard
DTS	-	Direct Time Study
SDS	-	Standard Data System
5S	-	Sort, Set in order, Shine, Standardize, Sustain
SOP	-	Standard Operating Procedure
MCO	-	Movement Control Order
DIY	-	Do It Yourself
OPL	-	One Point Lesson

LIST OF SYMBOLS

R_f	-	Rating factor
P	-	Pace of rating factor
D	-	Job difficulty
S	-	Standard deviation
x	-	Average time of work element
$\bar{x}$	-	Average time of process
n	-	Number of cycles
t	-	t-distribution
k	-	Interval size
T_n	-	Normal time
A_f	-	Allowance factor
T_{std}	-	Standard time

CHAPTER 1

INTRODUCTION

This report illustrates the implementation strategy to increase productivity by a production line in the manufacturing sector. This chapter explains the overall review for the task description including the background of the study, problem statement, objective, and scope of the project development.

1.1 Overview

Productivity enhancement is now one of the most impacted by company processes and management. Both the manufacturing and services industries may be considered as applicable (Piyachat, 2019). According to Hayes et al., (2008), due to the different factors impacting the production line, the efficiency of productivity can encourage a complicated process to be determined where is; Business strategy, vendor competence, machinery competence, manufacturing taxation, the effect of human factors, and variations. This makes it necessary for identity management of the production to evaluate, perceive accurately (Diego et al., 2014). A series of complementary approaches may be adopted or applied as a recommendation for growing efficiency in the industrial sector. This report discusses different approaches to increasing efficiency.

1.2 Background of Study

Time study analysis is the assessment of a particular worker's completion of a specific job or activity to find the most appropriate approach in terms of time reduction. According to Meyers, time standards can be defined as "the time needed to produce a product with the three conditions at a workstation: I a skilled, well-trained operator, (ii) operating at a regular speed, and (iii) performing a specific task.", (Meyers and Stewart, 2001). A constant quest for improvement improves the competitiveness of the market. A constant quest for the enhancement of processes, goods, and services in all organizations improves the competitiveness of the market. If a business does not focus on cost control and maintaining the quality of what it sells, its market survival is threatened. The idea of lean manufacturing and its tools, which seek to minimize all forms of waste within a company, is illustrated in this context.

Time and motion analysis offers strategies for a detailed evaluation of an activity or task, for measuring which actions bring value, and for reducing or eliminating those that do not contribute positively or are perceived loss. It is possible to quantify its potential and improve its efficiency and productivity using a time and motion analysis of a production process, making the company more efficient to the point of getting lower production costs, offering the consumer a quality product at a lower price. A better way to perform the operations of a process can be created by using the analysis of time and motion. Standard movements and times are allocated to each operation, which must be followed so that the company finds better results in the market in which it works. According to Souto (2002), methods engineering studies and analysis work systematically which develop practical and efficient methods, to standardize the process.

1.3 Problem Statement

Generally, the industrial sector leads to the increase of the economy and has an impact on the growth of sustainable production establishment (Yati and Yanfitri, 2010) (Marcel et al., 2018) (Emilia, 2015). Due to the development of the economy, establish value and customer satisfaction are the expectations of the entire manufacturing sector. Promising means that sufficient emphasis is put on the market of goods in order to attract consumers and to build customer loyalty at a certain level. With a rapid increase in demand for production, manufacturing industries need to enhance their production and efficiency potential in order to remain competitive against their competitors. This research was carried out at one of the Small and Medium-sized Enterprises (SMEs) which based in Jasin, Malacca. The nature of the business with this enterprise is the bakery foodstuffs, and long rusk biscuit "Biskut Tongkat" was a best-seller, among other products.

The company is unable to meet the high demand for long rusk biscuits from customers The customer demand of biscuit is 350 to 450 packets per week However, currently the biscuit production is 300 to 340 packets per week, due to the longer production process. The workers have difficulty completing their jobs with the task time allocation by the company. Based on the observation, the planned production process flow is not reliable and consumes a lot of time to meet the customer's requirements and incentives. There is a lack of suitable tools and equipment in the production line, which causes time data variances in several job elements. The current tools and equipment used in the production line also give and effect on the process flow. This will lead the SMEs businesses sector to be unable to adequately schedule their production and satisfy consumer requirements. Long processing times can occur without an acceptable standard operating process and the commodity cannot be shipped on schedule. This is not only unacceptable to consumers, but also a poor reputation for SMEs businesses themselves. This study will expose the factor of affecting the problem occur thereby presenting an effective method for minimizing production time to enhance the productivity in SMEs industry.

1.4 Objectives

The main goal of the project is to increase the industry's productivity. Several sub-objectives have been established and must be accomplished in order to make this project a success:

i. To implement Time Study Analysis and Work Measurement Method in long rusk biscuit production.
ii. To analyze the critical issues of the current biscuit production process flow.
iii. To propose the alternatives for process flow to improve production time.

1.5 Scopes

The scope of this study will concentrate on implementing a time study analysis and a work measurement method in the long rusk biscuit production to determine the standard time necessary to complete each task. The study will focus on the first seven processes out of a total of 17 in the manufacturing of long rusk biscuit at the SMEs of biscuit company. The proposed idea will be given to the company representative in the form of a set of proposals in order to receive feedback. The idea proposed in this study will not be executed or evaluated due to the pandemic Covid-19.

1.6 Significant of Study

Time study analysis and work measurement method are highly significant to be used in manufacturing industry both are regarded as key tools to enhance productivity. It is an impetus to keep the organization going forward and earnings rising. This approach will directly watch and measure skilled labor with a timing device to determine the time necessary for a qualified worker to do the task at a specified level of performance.

1.7 Organization of Report

The segment shows the organization of report which has been divided into five chapter. The report consists of Introduction, Literature review, Methodology, Result and Discussion and Conclusion. The Table 1.1 briefly explain and show the structure of the report.

Table 1.1: Organization of report

Topic	Description
Chapter 1: Introduction	The first chapter provides a brief overview of the study's background and provides detailed information about the problem that has occurred in the production line. The study's objectives will be described in the research, and the scope of the investigation will be briefly mentioned.
Chapter 2: Literature Review	The second chapter focuses often on a review of previous research related to the time study and work measurement analysis. The preceding journal's information will be quoted to back it up the claimed description. It also contributes to a better comprehension of the topic.
Chapter 3: Methodology	The third chapter describes the main method that has been used to perform this study. It includes the methodology from the start of the study to the end of the study.
Chapter 4: Results and Discussion	This chapter focuses on the data collecting approach. Due to the implementation of the time study method, the time value will be collected, analyzed, and evaluated. Thus, the possible solution will be given to improve the production line of long rusk biscuit.
Chapter 5: Conclusion and Recommendation	Explain the general findings of the studies and briefly propose several approaches for continuous improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 History of Time Study Analysis and Work Measurement

Before the uprising of the technology, there was no management philosophy before the early 1900s (Kamerkar et al., 2017). A prominent American engineer Frederick Winslow Taylor (1856-1915) was the man behind the invention of the time study, also regarded as the father of the scientific management movement (Nelson, 1974). Taylor was a mechanical engineer who was particularly interested in the form of work performed in factories and manufacturing. Taylor and his colleagues were the first people to scientifically research the work process and introduced the revolution for science management. They looked at how work was done and how this had an effect on the productivity of employees (Nelson, 1974). Kamerkar et al., (2017) state that soon thereafter, two management theorists, Frank B. Gilbreth (1868-1924) and his wife, Lillian Gilbreth (1878-1972) came up with the idea of made enduring contributions to the field of time analysis. Since then, their ideas were brought together in one process for analysis of the most productive way to carry out a task called time and motion study, and it is now known as time study analysis and work measurement.

2.2 Relationship of Time Study Analysis, Work Measurement and Standard Time

The time study analysis and work measurement are directly connected. The definition of time study analysis and work measurement is about assessing the time needed to execute a work unit. Time study is a systematic method by using a timing device that tracks and directly calculates the work of a skilled worker so that the time needed to complete any detailed aspect of his work at a given level of performance is calculated. Krenn (2011) described the time study analysis and work measurement are commonly used to create an integrated work method. It helps to identify why employees struggle to follow normal timescales and to make the use of machines as effective as possible.

Time studies include the initial data required for estimation of the optimal sequence of tasks and standard times for each task in the case of multiple machines by a single worker. Time studies often show how individual activities minimize the time needed. Time study is efficient and most beneficial in an industry that has a wide production of standardized products on repetitive jobs. Meanwhile, standard time is the time allowed for a worker to perform the assigned tasks under the specified requirement and performance level described. Time study is not that useful for non-standardized products; it is almost impossible for operators to carry out a series of semi-standardized work in a random sequence. It is highly agreed by Groover., (2007), Krenn (2011), and Salvendy (2001), that time study analysis and work measurement should be applied when repeated work cycles occur and various sub-tasks have been performed. It is important to see that the product, manufacturing configuration, logistics chain, machinery and instruments, materials and parts, lot size, working environments, workplace arrangement, working methods, and sequence of movement are standardized before performing a time study.

Table 2.1: Definitions

Time Study	Analysis of time taken to find the most efficient methods for completing the specific job.
Work Measurement	Determination of the amount of time required to perform a unit of work.
Time Standard	Time is taken by the worker to completing their task and delays avoidable.

2.2.1 Methods to Determine Time Standard

Standard time is an amount of time that should be required to process work per unit by an average worker using the standard method and operating at a regular rate. In industrial settings, the time standard will be effective by implementing a system for job estimation from labor savings as a result of the event distribution of manual tasks among a minimum number of employees (Mehmet et al., 2017). The function of time standards could be to provide a way of translating the workload into the manpower and resources required by allowing rational evaluation of alternative approaches. Setting the time standard would be achieved using four working calculation techniques: direct time analysis, predetermined motion time study, standard data system, and work sampling. The important thing to do is to create a time standard for producing a product at a workstation. It is correlated with efficiency. Method research and job assessment are two key work study tasks that emerged from the work of F.W.Taylor (Ishwar & Singh, 2014). The methods may have been constructed as shown in Figure 2.1.

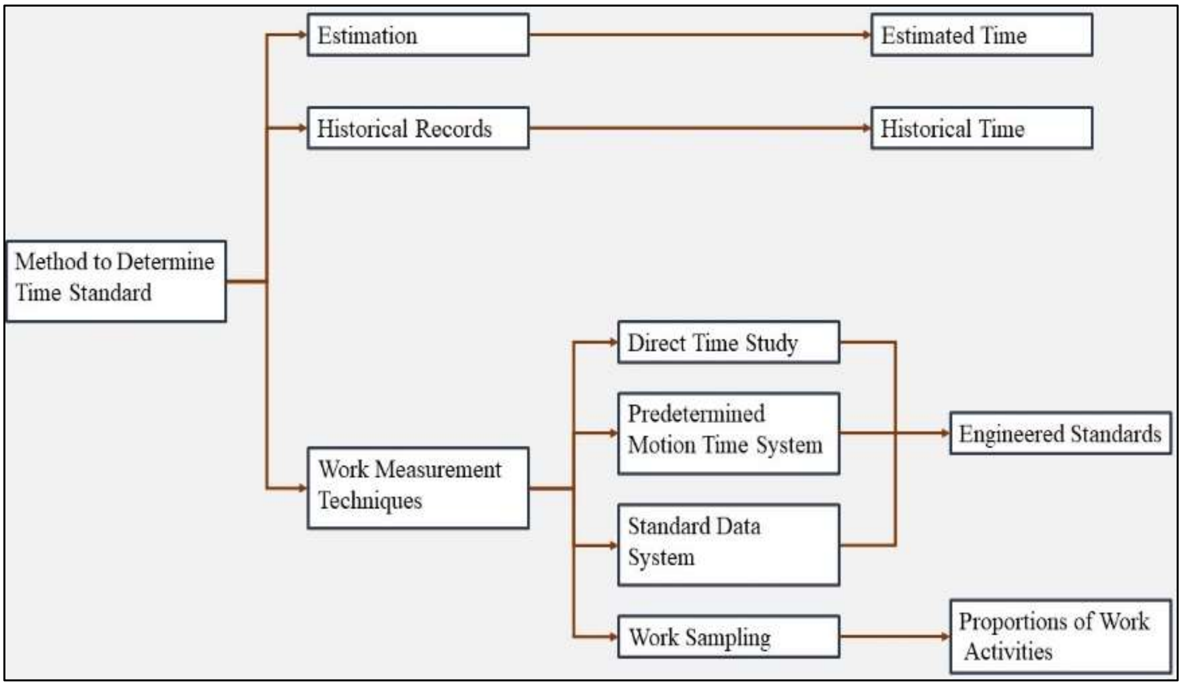


Figure 2.1: Method to Determine Time Standard

The contribution of the standard time is important especially for manufacturing, where manual techniques are often employed as work processes. It should consider all the advantages of employees, including performance ratings and allowance time. Performance evaluation is an operation used to measure the pace of the work of an operator (Surianto et al., 2008). In comparison to the capability of the present levels, which is the standard of employee's ability in normal conditions, the output ranking is received. While the allowance consists of the assignment of fatigue time for the operator, personal needs, and other considerations beyond the control of the operator (Wignjosoebroto, 2008). By adding an allowance to normal time, standard time is derived. Allowance is also included, which would cause the person to stop working and do other activities. There are three types of allowances: personal allowance, fatigue allowance, and delay allowance (Lusia, 2016). In order to secure allowances, environmental considerations were also used. Four factors must be standardized before set the time standard: standard input work unit, standard method, average worker, and standard performance.

2.3 Introduction of Technique for Time Study Analysis

Regular processing times play an integral role in efficient production control and are measured using work measurement techniques. Time study is a method widely used for job estimation in repetitive production cycles (Ateeq et al., 2019). The Time Study is the most common work measurement method used to calculate and record the time needed for a skilled person to perform certain work at normal speed under a particular situation using a decimal-minute stopwatch. The outcome of the time studies is the time for a person to do the job at a regular or normal speed who is skilled in a particular process. Based on Table 2.2, there is a summary of previous studies that have been done by several researchers in different production lines.

Table 2.2 Summary of time study techniques

Bil.	Author(s)	Industry	Time Study Techniques
1.	Afraz et al., (2020)	Thermocole Manufacturing Plant	• Stopwatch Time Study • Motion Study • Standard Data
2.	Bakhtiar et al., (2019)	Cement Bagging Station	• Time Study • Work Measurement • Motion Study • Method Time Measurement (MTM) • Principles of Movement Economics
3.	Aldri and Arry., (2017)	Pay Parking Station	• Stopwatch Time Study • Predetermined Time Standard System (PTSS)
4.	Sukwon, (2017)	Pump Manufacturing	• Stopwatch Time Study • Maynard Operation Sequence Technique (MOST) • Standard Data

5.	Senthil and Haripriya (2016)	Manufacturing Industry	• Stopwatch Time Study • Predetermine Time Standard (PTS) • Predetermine Motion Time Standard (PMTS) • Maynard Operation Sequence Technique (MOST)
6.	Apoova and M. Moham (2016)	Machining Fixture	• Stopwatch Time Study • Video Tape Time Study • Work Measurement • Standard Data
7.	Patange, (2013)	Manufacturing Industry	• Stopwatch Time Study • Work Sampling • Standard Data
8.	I Wayan et al., (2012)	Food Services	• Time Study • Video Camera Motion Study • Principle of Economic Motion • Predetermined Motion Time Standard (PMTS)
9.	Seratun et al., (2009)	Furniture Manufacturing	• Stopwatch Time Study • Standard Data • Work Sampling
10.	Mohd and Wan (2005)	Federation of Malaysian Manufacturer (FMM)	• Time Study • Motion Study • Standard Data

2.3.1 Equipment for Time Study Analysis

Table 2.3 shows the summary of the common equipment uses by the researcher during time study analysis in the industry. The equipment most needed to conduct the time analysis method in the industry is the observation board and equipment linked to the time measurement equipment.

Table 2.3: Summary of time study equipment

Bil.	Author	Equipment
1.	Senthilnand Haripriya (2016)	• Stopwatch • Microsoft Excel • MOST calculation sheet
2.	Satish et al., (2014)	• Stopwatch • Videotape camera • Time study board • Time study sheet
3.	Krupesh and Rushabh (2019)	• Stopwatch • Notepad • Microsoft Excel
4.	Abdul and Daiyanni (2010)	• Stopwatch snapback • Stat Fit software • Pro Model software
5.	Rio and Siti (2017)	• Stopwatch • Time study board • Time study sheet • Stationery • Calculator

2.4 Stopwatch Technique

Time study is a systematic procedure that involves direct observation and calculation time to complete manual or machine work. This can be achieved by using the pacing method to measure the time required for experienced employees to finish a job at a specified level of efficiency. Stopwatch presented as a standard approach to track and quantify aspects of a job under particular circumstances and further review of data for the measurement of the standard time known as working improvement instructions. (Lusia, 2016). The name of the stopwatch technique goes its name since the time study was conducting using a stopwatch. The stopwatch is one of the essential timing instruments used to measure a worker's time for completing a job. The stopwatch is a precise timekeeping device that can typically run for half an hour or an hour and record the time. There are two methods for reading a stopwatch which is continuous reading and snapback (Ashutosh et al., 2014). With an appropriate description in Table 2.4, the two techniques are defined.

Table 2.4 Summary of stopwatch technique

Bil.	Author(s)	Stopwatch Technique	Description
1.	Ashutosh et al., (2014)	Continuous / Non-flyback	This stopwatch technique is used for cumulative timing. Stopwatch begins where the process starts from the first activity and continues to the completion of the activity. At the end of each feature, the time value shall be recorded on the study sheet. When the winding knob is pressed for the first time, the watch starts and the long hand begins to move, now if the winding knob is pressed for the second time, the long hand stops. The hand returns to the zero position if the winding knob is pressed for the third time.
2.	Ashutosh et al., (2014); Ivan et al., (2011); Rio and Siti (2017)	Snapback / Flyback	When two items must be timed and the second element comes immediately after the first, a flyback stopwatch is necessary. The stopwatch is initiated at the start of the procedure and reset after the time value for the first element has been captured. A slide in a fly-back stopwatch will be used to start and stop the watch. The same method is repeated, and the watch is reset to zero each time a value for an element is recorded. As a result, each time value obtained is for a particular element. The slide is utilized to avoid the hand at some point. This watch is used to keep track of the time continuously.

2.4.1 Importance of Stopwatch Technique

The adoption of time study analysis is to measure working time seeks to overcome problems during the development processes and to increase the quality and effectiveness of the execution of the work. Time study is largely used for workers' assessment work and is often used for other reasons, although it was primarily used for wage incentives (Reddy et al., 2016; Lusia, 2016). The summary of the vital stopwatch time study process is shown in Table 2.5.

Table 2.5: Summary of importance of stopwatch technique

Bil.	Author(s)	Description
1.	Irwan et al., (2019)	• Data is evaluated by measuring data quality and data sufficiency. • The data were used to determine the balance of the assembly line, the general ranking factor, the normal time, and the standard time.
2.	Ibrahim et al., (2019); Abdul and Aliza	• It should be structured and planned such that with time and methodology it can be achieved more safely, reliably, and ergonomically. • To investigate and develop working environments for a wide variety of human studies.
3.	Pedro and Jose (2018)	• To evaluate an action or mission in-depth, to measure which operations add value and how to minimize and remove those that do not add value or are considered a loss.
4.	Nitin et al., (2017)	• To determine the time standard for the performance of specified work and thereby assist the company in organizing. • To monitor working hours and rates for part of the specified work conducted under defined conditions and to analyze the data in order to obtain the time required to perform the specified work at the specified performance level.
5.	Kunal et al., (2016)	• The overall time is thoroughly measured and extended to separate operational procedures conducted in the machining system. • Improved utilization of human power, decreased lead time, reduced cost of the component by incorporating this observed approach in operating processes.

2.5 Requirement of Conducting Time Study Analysis

A variety of requirements are needed to undertake out a time study analysis. All the requirement mentioned in Table 2.6 is composed of a credible and reliable report and books. According to Abdul and Daiyanni (2010), the gathering and interpretation of data are important since these findings are reliable. The subsequent action must then be defined by complying with this provision.

Table 2.6: Requirement of time study analysis

Bil.	Author(s)	Requirement	Description
1.	Ibrahim et al., (2019)	Factor influences for conducting a time study	The impact factor should consider whether or not it is appropriate at the early stage of the time analysis in the organization to be carried out. This is essential before disruption or diversion, to set the target.
2.	Mohd et al., (2005); Ibrahim et al., (2019)	Specific observation to be the task	This requirement may be carried out by splitting the work into the elements and defining each element about its relation to the work. The job is typically separated into particular roles or activities that are comprehensive.
3.	Abdul and Daiyann (2010); (Tayla Training)	Primary observation	The key insight would serve to give researchers the ability to align themselves with the operational situation in a working area.
4.	Ibrahim, et al., (2019); Duran et al., (2015)	Separate work element	The divisional aspect of the chosen area should be as minimal as possible during the development of the task. Time assessment time and time of the system will be independently considered.
5.	Mohd et al., (2005); Kayar (2017); Kim et al., (2017)	Select skilled worker to perform the task	It is important to assess a job by a person that has the skill to complete a work activity. The supervisor is supposed to educate the operator and the supervisor also relies on the assistance department's methods and guidelines for this role.
6.	Abdul and Daiyanni (2010); Ibrahim et al., (2019)	The variance of data collection	Data collection should include a range of hours and conditions of service, such as during hectic, time after time spot inspections, such as the temporary shutdown of production.
7.	Abdul and Daiyanni (2010); (Tayla Training)	Full of concentration for the whole period	During the data collection process, the researcher must ensure that there are no issues with the production process, such as equipment and social problems that could negatively impact the production process indirectly.

2.6 Work Sampling Technique

Work sampling is a random sampling procedure is a random process requiring the monitoring of workers at selected random times and the analysis of the sort of behavior detected. The most important application of job sampling is to collect information on the calculation of allowances, to assess the distribution of work tasks, and to decide the efficient and non-productive use of workers. Work sampling is a technique in which a significant number of experiments are conducted by one or a group of machines, systems, or workers over some time. Each observation tracks what is happening at the moment and the number of observations recorded during a given task or pause is a measure of the percentage of time the delay occurs throughout that process. The method of sampling work can be used to evaluate the work performed by the workers. Work sampling is considered an excellent and cost-effective approach that can be done on all production lines. (Ferreira et al., 2019).

2.6.1 Performance Rating

Performance rating or also known as performance evaluations is the method of assessing the performance of employees by comparing the actual performance with the standards already established, which have already been communicated to employees, and then giving feedback to employees on their level of performance to improve their performance as required by the organization. Performance reviews help management teams and employees to define, communicate, and revisit goals, priorities, and success in meeting organizational plans. (Bacal, 2004; Lusia, 2016). It aims to improve the contribution workers make to the priorities and success of a company. (Carrie et al., 2014). During the assessment, the engineer or superior closely observes the worker's efficiency of the working process. This performance is rarely compatible with the particular concept of average or normal. It is then appropriate to apply any adjustment which calls performance rating to the mean-observed time in order to arrive at the time that the usual operator would have needed to do the job while running at an average speed.

The output is the quality that means both performance and efficiency consideration, effectiveness relates to the achievement of the goal. However, it does not state the expenses incurred in the pursuit of the target. That is where productivity comes in. Performance assesses the ratio of user inputs to hit outputs. The higher the output for the input, the higher the performance. It's a productive employee, who not only works better concerning efficiency but also decreases issues for the company by working on a schedule, not losing days, and reducing the number of injuries related to jobs. Rating is the evaluation of the features, attributes, and performance of others. The systematic monitoring of workers by managers is part of the industry's success management. Employees would also want to know their place in the organization.

2.6.2 Allowance Factor

During working hours in the production line or workstation, the worker cannot operate effectively continuously throughout the day, so the unavoidable delays need to be included (Benjamin, 1993). Thus, some extra time needs to be added to the normal time. Pacing allowances may be described as extra time estimates to additionally take into account some specific condition and the policy of the company or entity within the general time of the operation. The standard time of a worker is achieved by applying the simple or usual time of the job to certain allowances. According to Lusia (2016), Allowance is also included, which would cause the person to stop working and do other activities. There can be categories by three types of allowance, which is a personal allowance, fatigue allowance, and delay allowance. The description for each allowance factor that needs to be count as explained in Table 2.7. Personal and delay allowances are very necessary for any company (Gunesoglu and Meric, 2007) A poor standard time has a significant effect on production, operators, and efficiency including other business metrics.

Table 2.7: Allowance Factor

Bil.	Author(s)	Type of Allowance	Description
1.	Biswas and Chakraborty (2016); James and Daryl (2004)	Personal	The allowance for personal needs is the time associated with the regular human needs of staff, which involves going to the bathroom, phone calls, going to the water fountain, chatting to friends about meaningless things, going around the production line without completing production work, getting lunch, going to pray or some other monitored purposes for non-continuing work and related interruption.
2.	Mahmud et al., (2011); Conor and Kriengsak (2013); Raut (2014); Sabina and Mariusz (2017)	Fatigue	Fatigue is a condition of severely impaired or tiredness, and these may be physiological, emotional, or mixed. Fatigue may decrease the ability of the worker to such a degree that it may affect their power, speed, response time, coordination, decision-making, or equilibrium. Ordinarily, exhaustion happens due to lack of sleep, and this allowance must be included in the normal production time to enable the body and the brain to heal.
3.	Arunagiri et al., (2013); Hussein and Adel (2019); Naveen and Babu (2015)	Delay	Due to exhaustion, it was concerned about lag workers, but delay allowances are concerned with disruption forcing work to pause. Typically, in workstations such as downtime machine, signature acceptance, cleaning session, and leader briefing, it may refer to associated activities.

2.7 Introduction of Technique for Work Measurement Method

Work Measurement Study is a general term used to characterize the systematic use of industrial engineering approaches for determining the work content and time taken to complete a task or series of tasks. Work measurement is very necessary in order to maximize the efficiency of the management. The function of the work calculation consists of a broad variety of techniques for the detection, detailed review, and adjustment of the operating processes, taking into account the raw materials, the arrangement of the outputs, the operation or order work, the tolls, the workplace, and the equipment for each stage of the process and the human actions needed to perform each step of the process (Abdul & Daiyanni, 2010). It allows management to compare alternative approaches and even to conduct initial recruiting. The assessment of work is the basis for careful planning. Before efficiency changes can be made, the actual degree of productivity of the production must be calculated. This estimate is then used as a benchmark to assess if the success indicators have changed.

Work measurement seeks to uncover the areas of waste, uncertainty, and non-standardization that exist in the workplace and are not value-added. Experiments in job calculation illustrate how to make work efficient and deliver products or services more easily and safely. The techniques of work and time calculation encourage the producer to maximize efficiency by determining the right operating process, standard time and optimizing the usage of resources (Tuan et al., 2019). Normal time, also referred to as base time or level time, is the time a skilled person requires to finish the job at a normal rate. The standard time is the time required by an employee to finish the job with any inevitable conditions leading to delays, with 100 percent reliability. The key contrast between the regular period and the standard time is that the time when work should be done without interruption is the normal time. Normal time, however, is the time that the employee requires to complete the job with any inevitable delays.

Two types of working processes can be considered for work measurement: continuous work and snapback work. A cumulative approach is also known as continuous work. This category of work in which, during the time spent on the job, the main activity or set of operations repeat continuously. This refers to very short time work periods. The snapback approach is considered as the flyback technique. This style of work may involve some kind of work repair and maintenance, where the work cycle itself is hardly ever identically recycled. The techniques of work measurement consist of four types: direct time study (DTS), predetermined motion time system (PMTS), standard data system (SDS), and work sampling.

2.8 Motion Study

Motion study is a simple approach used to examine body movements used to execute a task of removing or minimizing unsuccessful movements and encouraging efficient movements (Al-Saleh, 2011; Houshyar and Kim, 2018; Kim et al., 2017) Since workers use motions to work intentionally or unintentionally through machines. Referring to Antara et al., (2016), motion study is the fundamental approach for the study of people's efforts in the use of hands, manual machinery and equipment, and industrial equipment. Managing people requires real decision-making about work, processes, diverse relationships between jobs and computers, and control and communication processes. Job interface designers with dynamic interactions between operating personnel, administrators, and experts, who are not standard system extensions (Antara et al., 2016). The comfort, safety, and wellbeing of operators are considered and analyzed in the redesign of human effort work in industrial engineering (Narayana, 2019). The purpose of the motion study is to enhance the human operator's work efficiency by examination and enhancement of body and hand movements. Motion study can indeed be thought seen as a micro-level device improvement and is part of a human initiative in industrial engineering (Narayana, 2019; Antara et al., 2016).

2.9 Relationship of Work Cycle and Time Cycle

A sequence of events or motions needed to complete a task can be defined as the work cycle. While undergoing a study it is better to break the operation down into elements as this ensures greater accuracy. Rating is also straightforward over short cycles and timing errors appear better. Uneven times for cycles may show up poor skill but they may reveal something wrong working process (Tayla Training). According to Jelena et al., (2014), the duration of the cycle consists of productive and non-productive time. Cycle time involves elements of the task from cycle to cycle, during which the machine is worked to get it closer to output, and time delays during which the work unit is expended waiting for the next step to be taken. Cycle time is known as the existing volume and capacity of the current work process; it is necessary to identify how much cycle time should be achieved in order to conduct time studies (Bagri and Raushan, 2014; Noor et al., 2014; Perumal et al., 2019). Cycle time duration is a productive and non-productive time (Jelena et al., 2014). Simply stated, cycle time is the time spent moving a work unit from the beginning to the end of the physical process.

2.10 Cause Effect Diagram

Cause-and-Effect Diagram, also referred to as Fishbone Diagram (Luca, 2016) since the whole schematic resembles the skeleton of a fish. Since originally inventor Kaoru Ishikawa, a Japanese consistency expert, is often referred to as Ishikawa Diagram (Scott and James, 2009). Fishbone Diagram is also used in industries to visualize the cause of an issue. The diagram represents the primary causes and secondary causes of a scenario. According to Scott and James, (2009), It is used to systematically evaluate and graphically depict the cause of the problem and to show interrelationships between different hypotheses of the root cause of a problem (Watson, 2004). According to Vivek (2008), there are three major intentions of the diagram in cause and effect: to define the potential root cause, real effect, issue, or condition; to figure out and explain any of the relationships between the variables that influence a certain process, and to examine current issues in order to take corrective measures. Therefore, the main purpose of the Fishbone diagram is to illustrate graphically the relationship between a given result and all the variables that influence this event. The approach is mainly used to examine quality issues and their origins in the quality management framework is a more systematic solution to an issue such as the Five Whys tool than any other brainstorming methods available (ACT Academy). Table 2.8 shows the following steps for constructing the Cause-and-Effect Diagram.

Table 2.8: Steps to construct Cause and Effect Diagram

Author(s)	Analysis of Step
Vivek (2008); Scott and James, (2009)	**Step 1**: Identify the problem statement specifically

Gheorge and Carmen, (2010); Luca (2016)	**Step 2**: Documentation of issues concerns
Vivek (2008); Gheorge and Carmen (2010);	**Step 3**: Determine primary and secondary causes
Vivek (2008); Gheorge and Carmen, (2010);	**Step 4**: Identify the factor effecting
Vivek, (2008); Gheorge and Carmen, (2010);	**Step 5**: Analyze the Cause-and-Effect Diagram

2.11 5S Technique

The 5S approach is a simplistic but successful lean manufacturing methodology that assists businesses in simplifying, cleaning, and maintaining a productive work environment (Dinesh et al., 2014; Gupta and Chanda, 2019). According to Jagtar et al., (2014), The 5S technique is a systematic methodology implemented by companies that is derived from the Japanese terms Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain). The adoption of the 5S method is capable of overcoming any sort of industry-related difficulty. The use of 5S tools in the manufacturing industry is heavily reliant on the work of upper management, who must have a thorough understanding of each concept. The appropriate use of the methods allows for the elimination of all waste and the establishment of a productive and high-quality environment (Devkar & Raut, 2017; Kansal & Singhal, 2017). The 5S methods are described in detail in Table 2.9.

Table 2.9: Description of 5S

Author(s)	**5S**	**Description**
Vipulkumar and Hemant, (2014); Raid (2011)	Seiri (Sort)	Remove and dispose of any undesirable, unneeded, or irrelevant things from the workstation.

Vipulkumar and Hemant, (2014); Ramesh et al., (2014); Raid (2011)	Seiton (Set in order)	Place everything in its appropriate locations by labelling the position of each material.
Vipulkumar and Hemant, (2014); Ramesh et al., (2014); Raid (2011)	Seiso (Shine)	Cleaning and enhancing the look of the workplace in order to create a healthier atmosphere.
Ramesh et al., (2014); Raid (2011); Rojasra and Qureshi, (2013)	Seiketsu (Standardize)	Using standard tools, documenting the job approach
Ramesh et al., (2014); Raid (2011); Rojasra and Qureshi, (2013)	Shitsuke (Sustain)	Continuing to develop, controlling the work approach, and embracing the 5S as a new habit.

2.12 Decision Matric Analysis

A decision matrix is a matrix diagram that may be used to systematically identify, evaluate, and rank the strength of connections between different sets of data. This technique allows for the comparison of a large number of decision factors as well as the evaluation of each factor's relative relevance (Stuart, 2009). A decision matrix can be used in selecting a project, assessing various solutions to issues, and creating remedies for quality improvement initiatives. According to Safarudin (2018), six steps are involved in decision matrix analysis: identify a list of options with detailed descriptions, identify the selection criteria in the form of a table, assign weight to each criteria based on its hierarchy of important factors, design a scoring system with a specific range of values, rate the scoring as well as each of the weighted, and evaluate the total score for each option provided.

2.13 Productivity of Manufacturing Industry

Generally, productivity is defined as the ratio between output volume and input volume. In other terms, it measures how efficiently output inputs like labor and capital are used in the economic field for a certain level of production (Krugman, 1994). The phrase “productivity” can be used to determine or calculate how far a particular output from a given input can be extracted (Kanawaty, 1992). The definition of productivity from the manufacturing engineering industry point of view is the sum of efficiency and good quality tasks performed, typically through reducing time spent on unnecessary duties and with the more focused on completing a desirable objective or creating time for more enhancing activities. In organizations, including the manufacturing industry, productivity plays a significant or important role. There are many reasons why productivity is decreasing and there is a lot of technique to use depending on the case, which needs a wise decision. Nelson (1974) claims in his research, Taylor believed that efficiency would improve by maximizing and simplifying specific jobs. The father of the scientific management movement also stated that there were needs for employees and employers to collaborate.

2.14 Summary

This section aims to gather an understanding of the specific issue that several researchers have examined. The review of previous journals and articles could help to build knowledge and identify appropriate solutions to help the idea of improving the SMEs business. Based on the overview in this section, the method that has been applied in other industries is using time study analysis and work measurement method. During the implementation of this section in the next chapter, all the information will be used as references for the time study and work measurement analysis.

CHAPTER 3

METHODOLOGY

This chapter provides a snapshot of the approach focused on the specific research method that will be used in this project. According to Rajasikar et al., (2006), theoretical procedures, laboratory experiments, quantitative schemes, and statistical algorithms, are included in research methods to solve the problem occurring in the manufacturing industry. In order to achieve the aim of this project, the methodology will be acknowledged in detail on how to execute the project development. This methodology will be conducted in two semesters. Appendix A and B shows the Gantt chart for this project.

3.1 Flow Chart of the Methodology

The flow chart of the methodology for this project is being described as a framework that provides step by step description process for problem-solving and process management in the manufacturing sector. One of the most significant factors for process creation and development is the process flow diagram (Robin, 2016). This flow chart consists of three major phases of this project as shown in Figure 3.1. All these three phases of the process are necessary to carry out the framework of improved productivity in the manufacturing industry by enhancing the production process. The explanation for each method is given below. The phase flow chart for the process in this project is illustrated in Appendix C and all steps are discussed in detail.

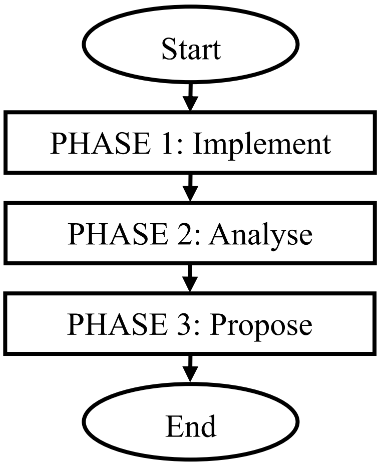


Figure 3.1: Process flow chart of methodology

To accomplish the three goals in the development of this project, the variation in the major phase of the technique should be used. The first objective will be to implement Time Study Analysis and Work Measurement Method in long rusk biscuit production in Phase 1. The second objective of this project is to analyze the critical issues of the current biscuit production process flow. The second objective will be to implement the framework in Phase 2. The third objective is to propose the alternatives for process flow to improve production time that could be accomplished using Phase 3 approach. In order to accomplish all the aims for each phase, a list of potential solutions should be constructed.

3.2 Implement Phase

The flow chart of the analysis phase is shown in Figure 3.2. The main development techniques use in the first phase is by implementing time study and work measurement analysis to analyze the unnecessary process. Meanwhile, the standard time also could be determined for a process per unit work. This phase would be continuing from the previous phase which collecting data. So that, an idea from Joel (2014) which data analysis is a technique of establishing statistics to solve the study issue could prove as mentioned.

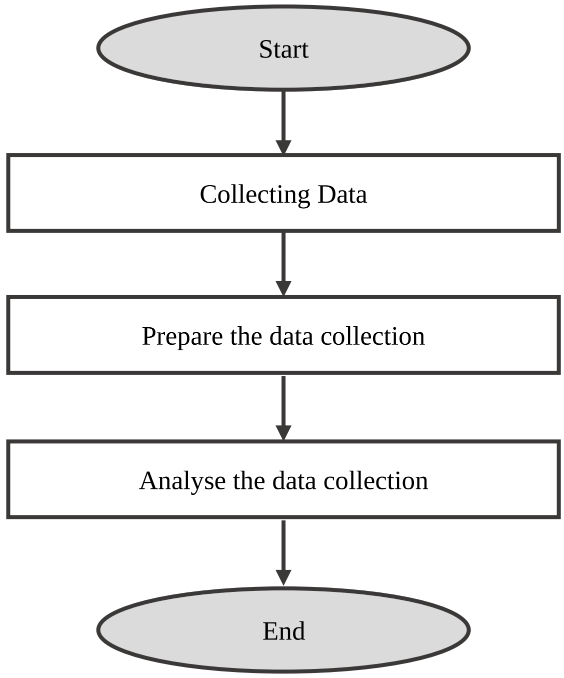


Figure 3.2: Process Flow Chart for Phase 1 to achieve Objective 1

3.2.1 Conduct Time Study Analysis and Work Measurement Method

Data collection to be defined as the information or data needed for the study of reliable research insights using standard validated methods. Data collection is the main and most important phase in the study and review. The data collection methodology can be justified in this section. Good data collection requires a transparent method to ensure that the data collected is accurate, precise, and consistent. Therefore, the time study analysis and the work measurement method were highlighted in this study in order to minimize the operation cycle time and maximize the output volume. The time study analysis reveals the exact time required by the worker to complete the production process. By implementing the time study process, the elements of the job are obtained and the exact time the worker takes to complete the task using the technique mentioned in Figure 3.3(a) and 3.3(b).

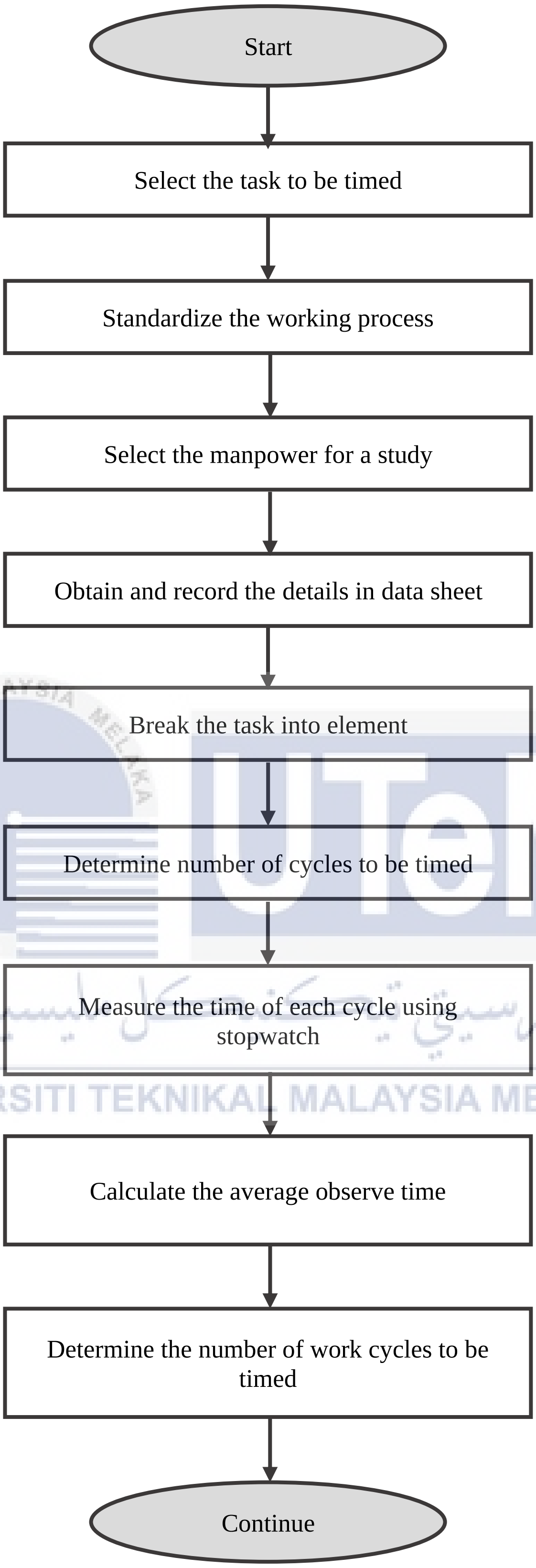


Figure 3.3(a): Process to conduct time study

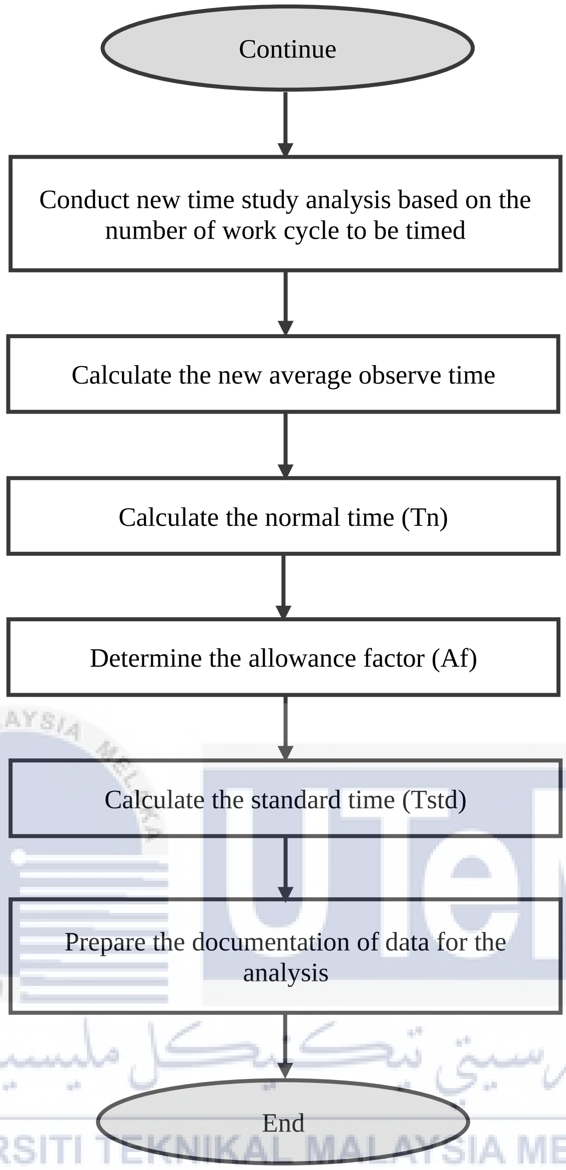


Figure 3.3(b): Process to conduct time study

The depiction of components in flowchart:

1. Select the task to be timed.

   The specific task in the production line to conduct time study analysis has been selected, beforehand the knowledge of time study method was given to the worker.

2. Standardize the working process.

   Determine the volume of worker, understanding job for each worker, identify the normal flow process for the manufactured product, normal of the daily output.

3. Select the manpower for a study.

   This involves the specific worker which perform the task during the process.

4. Obtain and record the details in data sheet.

   The detail regarding the zone such as the name of the main process step and the end product pf the zone was collected.

5. Break the task into element.

   The element of main process step was arranged according to the appropriate sequence. In order to obtain the accurate time of the job element and the motion performed by the worker.

6. Determine number of cycles to be timed.

   The cycle time or each component was taken for 10 times in order to get accurate data by eliminate the uncertainties.

7. Measure the time of each cycle using stopwatch.

   The strategy builds up a work task where the pace of all other work was compared. After the comparison of the pace, an optional factor doled out to the next job demonstrates its relative difficulty, each time taken will be measured using stopwatch and the data was recorded. The rating factor communicated as below:

   $$R = P \times D \qquad \text{Equation 3.1}$$

   Where:

   P = Pace rating factor

   D = Job difficulty

8. Calculate the average observe time.

   The average observe time was computed dividing the total number of recorded times and number of observations.

   $$\text{Average observe time} = \frac{\text{number of recorded time}}{\text{number of observation}} \qquad \text{Equation 3.2}$$

9. Determine the number of work cycles to be timed.

   The total cycle time and average of cycle time was calculated according to how many cycle times has been recorded.

   $$n = \left(\frac{t_{a/2} \times S}{k\bar{x}}\right)^2 \qquad \text{Equation 3.3}$$

   $$S = \sqrt{\frac{(x-\bar{x})^2}{n-1}} \qquad \text{Equation 3.4}$$

   Where:

   S = Standard deviation

   x = Average time of work element

   $\bar{x}$ = Average time of process

   n = Number of cycles

   t = t-distribution

   k = Interval size

10. Conduct new time study analysis based on the number of work cycle to be timed.

    The number of cycle time was detected in earlier step, the results of the number of cycles were checked to determine the validity of data. If lower than 10, the data is valid, the computation of new number of cycles to be added were not performed.

11. Calculate the new average observe time.

    Repeat step 7 to 9.

12. Calculate the normal time (Tn).

    The normal time was calculated using this formula:

    $$T_n = \frac{\text{Average observe time}}{\text{Performance Rating}} \qquad \text{Equation 3.5}$$

13. Determine the allowance factor (Af)

    There are different allowances for man and machine: For man allowances personal allowances plus with fatigue allowances. For machine allowances, take account the delay allowances. The allowances factor was considered in the calculation

14. Calculate the standard time (Tstd)

The standard hour for man and machine were determined by performing this formula:

$$T_{std} = T_n \text{ x } (1 + \text{allowance factor}) \quad \text{Equation 3.6}$$

15. Prepare the documentation of data for the analysis

The completed data will be gathered and will proceed the analysis phase.

3.3 Analyze Phase

Phase 2 might include an overview of the project's boundaries that will interpret the step to be taken. The identification process may include a clarification of the problem statement, the objectives, and the scope of the project to be assessed. When a concern has been recognized, it is essential to establish possible and potential alternatives to overcome the existing problem (Roni and Erika, 2009). As in Figure 3.4, the step used in the identification phase is carried out. The ultimate purpose of the second phase is to analyze by record the overall process procedure on the production line and to evaluate the possible problem that occurs from the collection of data through the process flow. The step may include the methods to achieve Objective 2 and will be carried out as explained in another section.

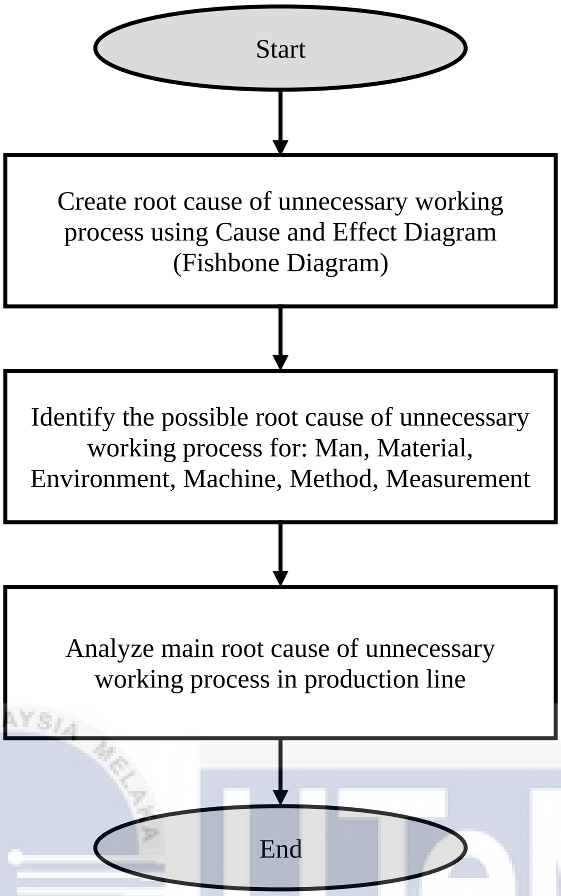


Figure 3.4: Process Flow Chart for Phase 2 to achieve Objective 2

3.3.1 Create Cause and Effect Diagram

The cause-and-effect diagram is also one of the six sigma lean methods that help to define, sort, and show potential triggers of a particular problem or quality function (Vivek, 2008). The relationship between a given result and all the variables affecting the result is graphically explained in this technique. The classical fishbone diagram provides the list and group influences in material, method, machinery, mother nature, and manpower categories (Institute for Healthcare Improvement, 2016). The problem is seen on the right side of the fish's head. Although the concern of the focus areas can construct on the ribs of the fishbone. Figure 3.4 shows the step to construct the cause-and-effect diagram.

3.3.2 Develop Five Whys Technique

The techniques of developing the Five Whys Technique could be determining the root cause of a problems by asking multiple ‘why’ questions. This statement is supported by research by Oliver (2009) which has mentioned that it helps to start with the outcome, focus on what influenced it, and query the question five times while seeking to solve a conflict. There are three major elements of effective use of the Five Whys Technique as stated in Oliver (2009) analysis where the technique was developed for the Toyota Industries Company by Sakichi Toyoda. is Precise and comprehensive problem statements, absolute authenticity in response to questions, and desire to get to the source of concerns and rectify problems.

3.4 Propose Phase

Figure 3.5 shows the process flow chart of the final stage after implementation of time study analysis and work measurement method and analyze the critical issues of the current process flow in the production line. The solution and options for enhancing the production line and eliminating it would be decided. To propose a new suggestion for improvement, it would be referring to the identification of a problem from the analysis in the objective. The new alternatives propose based on common tools used in industry to improve the productivity. This stage has a drawback in that the proposed idea will not be developed in the organization to assess whether the idea is successful. The reason for the limitation is that the Malaysian government has issued a Movement Control Order (MCO) to all districts in Malaysia as a result of a surge in Covid-19 instances.

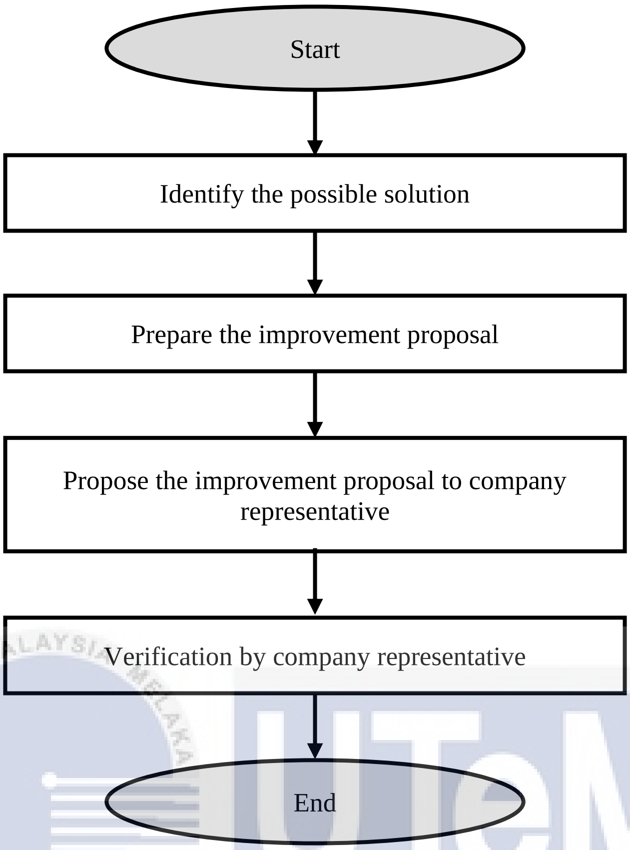


Figure 3.5: Process Flow Chart for Phase 2 to achieve Objective 2

3.4.1 Proposal of Improvement

The new enhancement idea will be included in a comprehensive proposal to the client. The aim of the proposal is to provide an opportunity to explain the effectiveness of the study to the organization, which would either approve or reject the idea.

CHAPTER 4

RESULTS AND DISCUSION

This chapter includes project results and discussion. The production process was clearly identified through direct observation and video recording at the production line. The data collection for the time study and work measurement analysis was documented on the time study sheet. Thus, the number of cycle time, normal time, and standard time of job element have been calculated for each of work element. A cause-and-effect diagram and the five whys approach were used to analyze the major concerns in the current working process. The proposed alternatives for process flow have been provided at the end of the chapter in order to enhance the production time.

4.1 Introduction

The biscuit company is a Small Medium-sized Enterprise (SMEs) which located at Jasin, Melaka. The factory has been in business since 2000. This SMEs is a bakery factory that focuses on producing long rusk biscuits due to significant market demand, particularly from elderly customers. However, most of the work to produce long rusk biscuits was done manually by workers, with just three people in the production line. The workers have a multi-tasking job scope since they will help each other after their part is done. The primary goal of this study is to implement time study analysis and work measurement methods in the biscuit company to enhance production efficiency. Due to their sluggish production periods, the factory is unable to satisfy the huge demand for long rusk biscuit output throughout Malaysia.

4.2 Flowchart of Long Rusk Biscuit Production

Figure 4.1 depicts the production process for long rusk biscuits at the biscuit company. The primary observation was conducted in order to comprehend the flow process and procedure of the long rusk biscuit. In the biscuit company, there are 17 processes in the production of long rusk biscuits as shown in Appendix D. In this field of research, however, only the first seven processes are studied in detail as shows in Figure 4.1 and Appendix E. The procedure begins with preparing the ingredients and culminating with arranging the small pieces of dough in the tray. Every step of the long rusk biscuit production process was segmented into numerous elements to ensure a decent comprehension of the overall process.

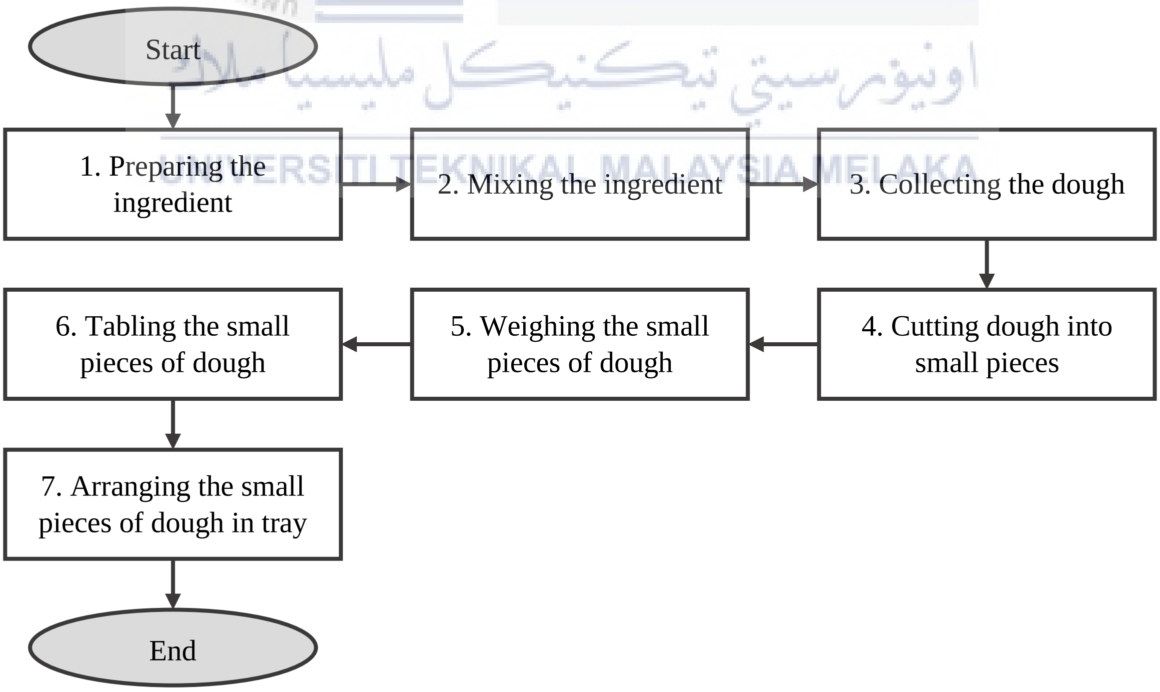


Figure 4.1: Flowchart of long rusk biscuit production

4.3 Implementation of Time Study and Work Measurement Analysis

This section will go over the process involved in the manufacturing of long rusk biscuits in detail, based on the specific task of seven sequences. Every sequence has been broken down into a few working elements to conduct an analysis of the products in production line. The data gathering for each element was done by observation, interview, and video recording.

4.3.1 Work Element of Process 1

Figure 4.2 depicts the major task that workers must perform in the work element in first process, which is ingredient preparation. The first task is required the process of mixing ingredient A which consist of three ingredients: water, yeast, and salt. Then, continue with the process of mixing ingredient B which is sugar, margarine, and shortening. Lastly, ingredient A, ingredient B, eggs, and flour are mix in mixing bowl. The detailed steps in each procedure are discussed in the next section.

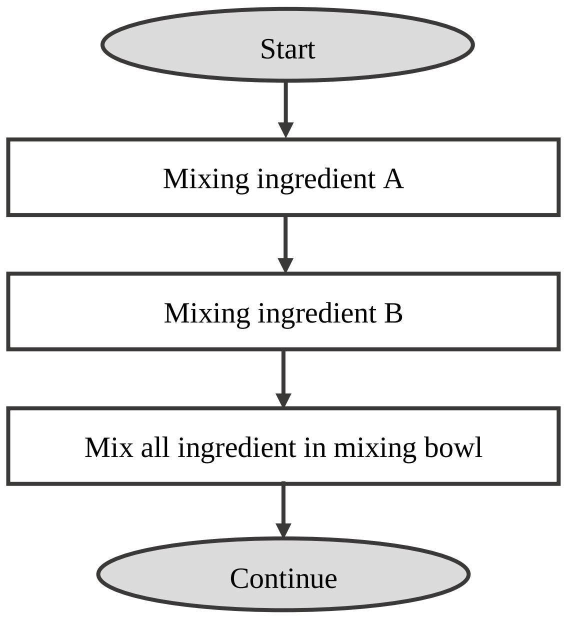


Figure 4.2: Process 1 – Preparing the ingredient

Figure 4.3 shows the flow process of mixing the water, yeast, and salt. Fill the plain water in the empty jug and place the water aside. Prepare the next ingredient, which is yeast by pour in small bowl A, stirring together with water, and place the yeast aside. Then, prepared salt by pour into small bowl B and place the salt aside.

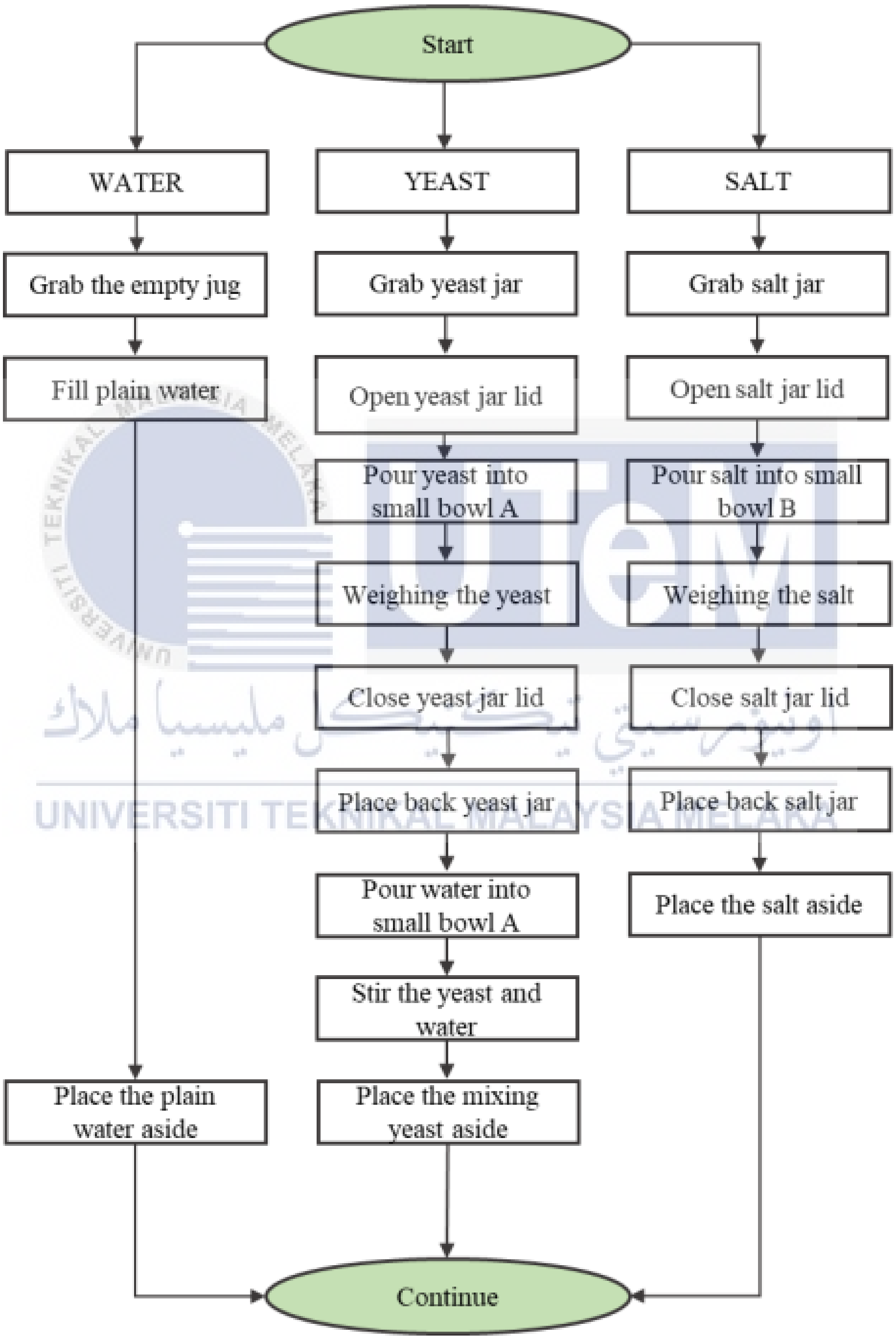


Figure 4.3: Process of mixing ingredient A

The process of prepared sugar, margarine, and shortening has shown in detail in Figure 4.4. All the ingredient B need to be poured and mix in big bowl A. Then, place the big bowl A aside.

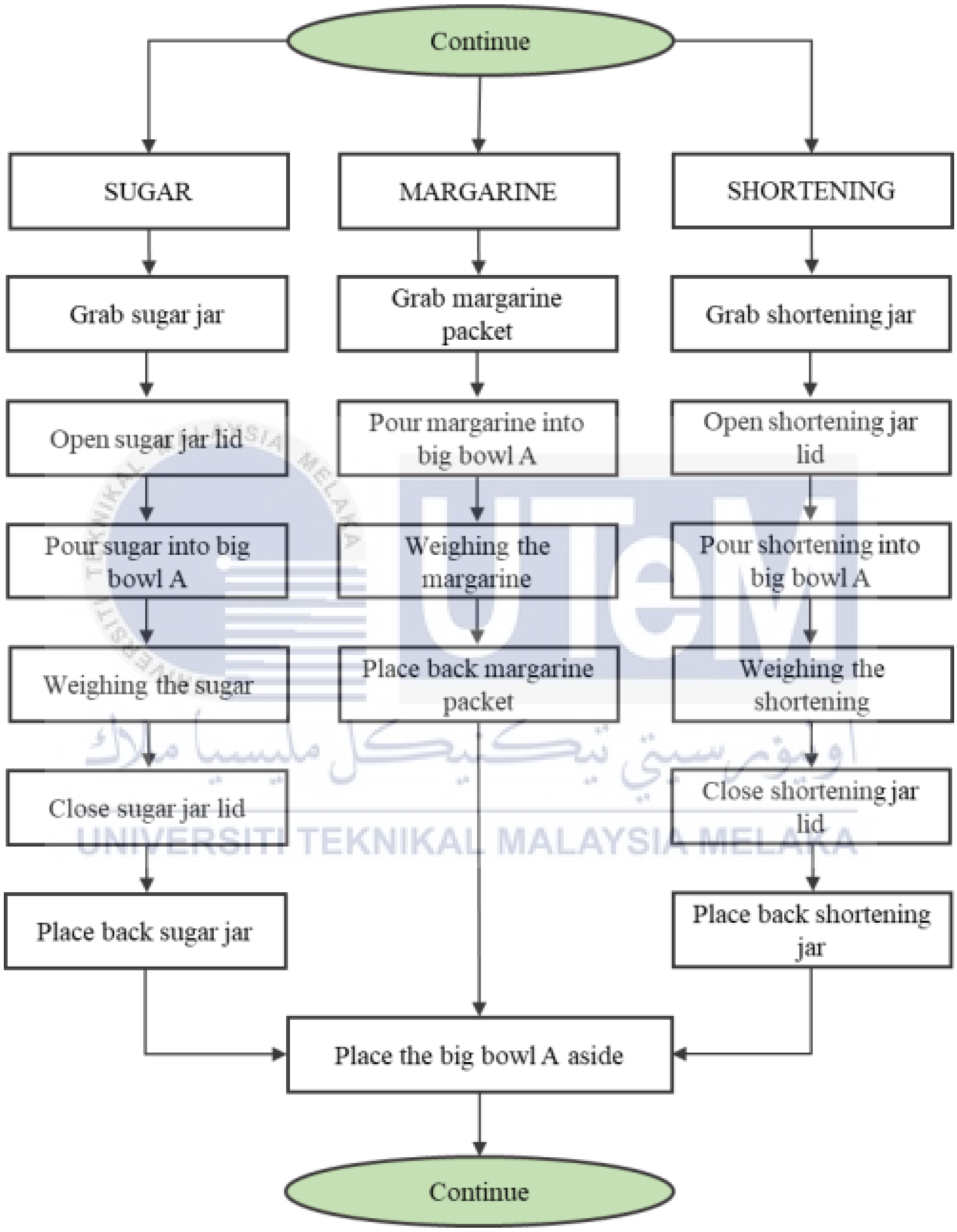


Figure 4.4: Process of mixing ingredient B

In figure 4.5 Shows the detailed explain for the final step in work element of process 1 which is preparing ingredient. Ingredient A, mix of ingredient B, eggs, and flour is pour into mixing bowl. Then, the ingredient can be proceeded in the next process.

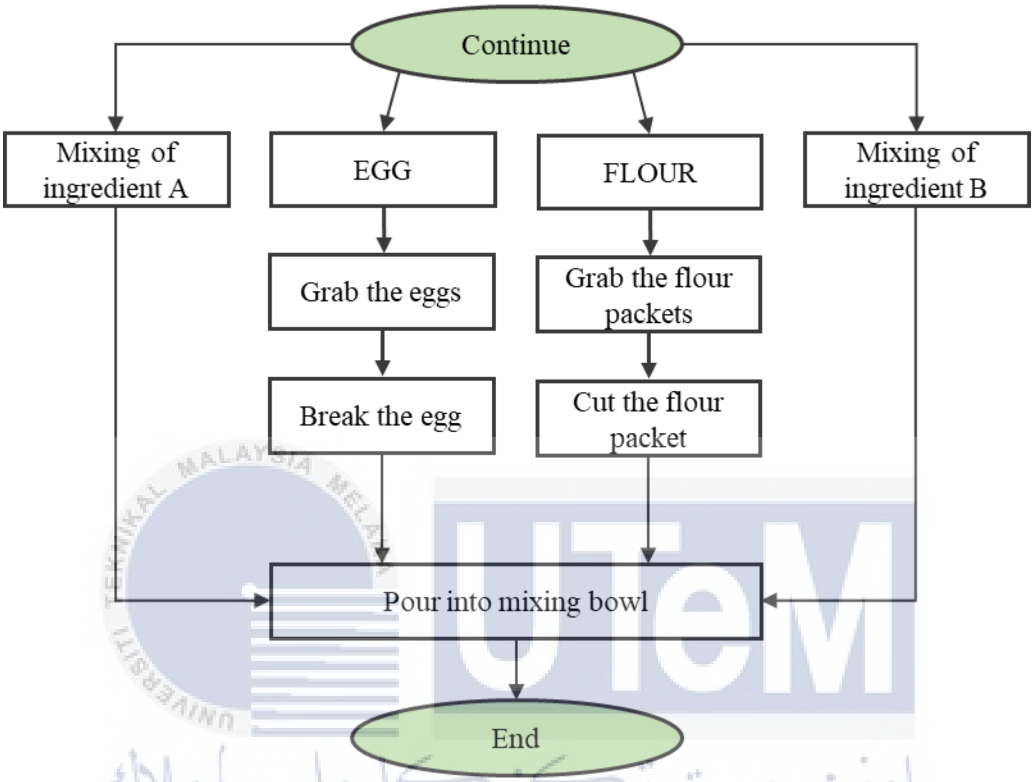


Figure 4.5: Process of mix all ingredient in mixing bowl

4.3.2 Work Element of Process 2

Work element of process 2 which is the process of mixing ingredients has shown in Figure 4.6 This phase included the efforts of an average worker and a mixer machine. As part of this procedure, a worker must carry a mixing bowl from the ingredient preparation station to the mixer machine station. The worker will install mixer equipment so that the beater may be mixed. The mixing machine is then ready to use.

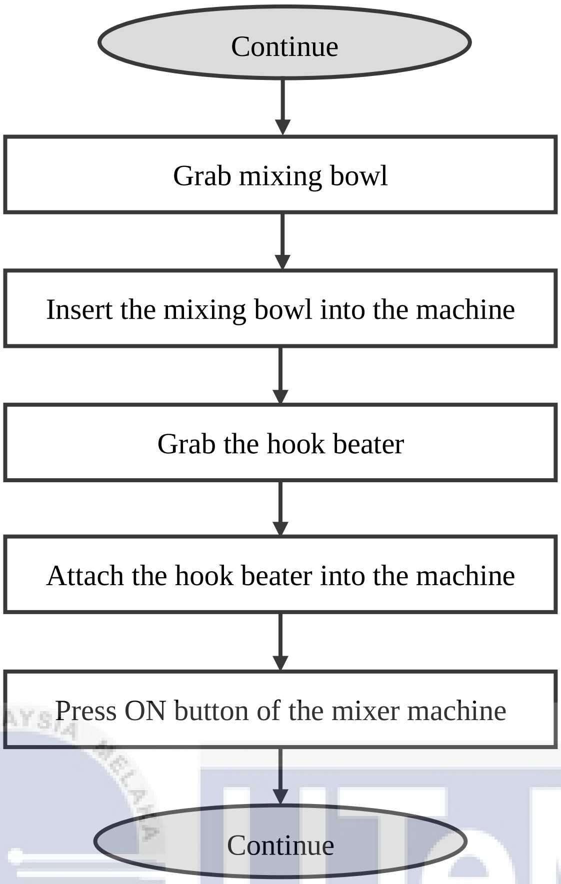


Figure 4.6: Process 2 – Mixing the ingredient

4.3.3 Work Element of Process 3

Process 3 will continue on the task by collecting the dough from the mixer machine station and transferring it to the dough preparation station. During this stage, a worker will manually remove and clean the hook beater as well as the dough from the mixing bowl using a dough cutter to the working table as shown in Figure 4.7. Then it's ready to go through to the next procedure.

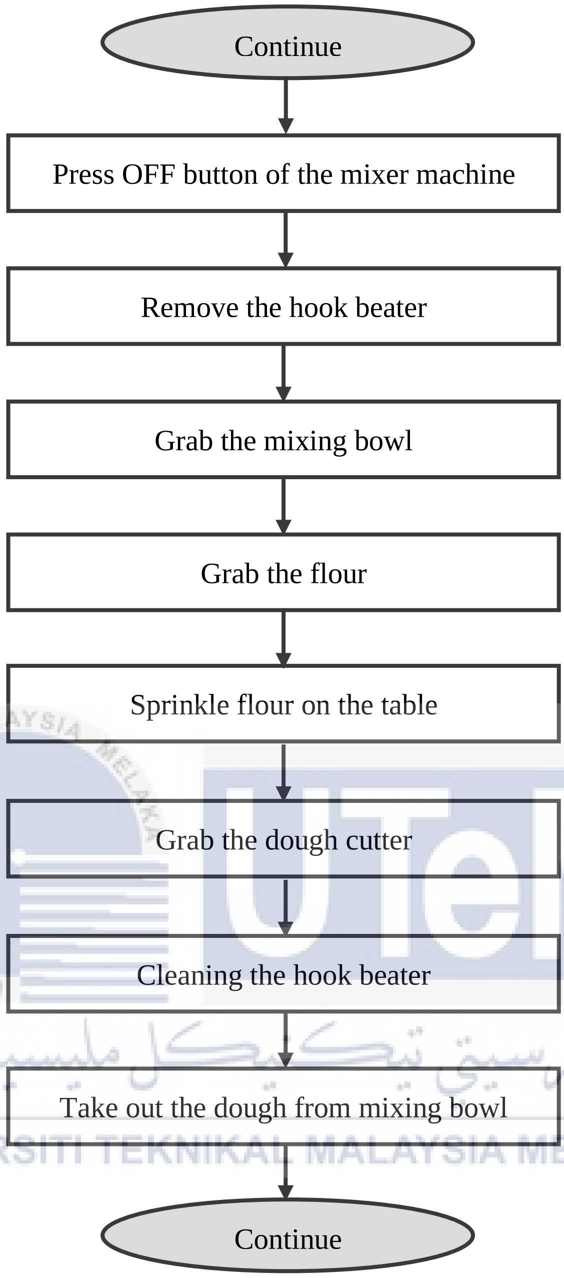


Figure 4.7: Process 3 – Collecting the dough

4.3.4 Work Element of Process 4

Figure 4.8 depicts the work element involving process 4, which is cutting the dough into small pieces. Cutting the 3kg dough into 204 small pieces is the task at hand in this procedure. Two workers will cut the dough into small pieces as part of this procedure, which will be done manually. As a result of this, it is now ready to be used in the following process.

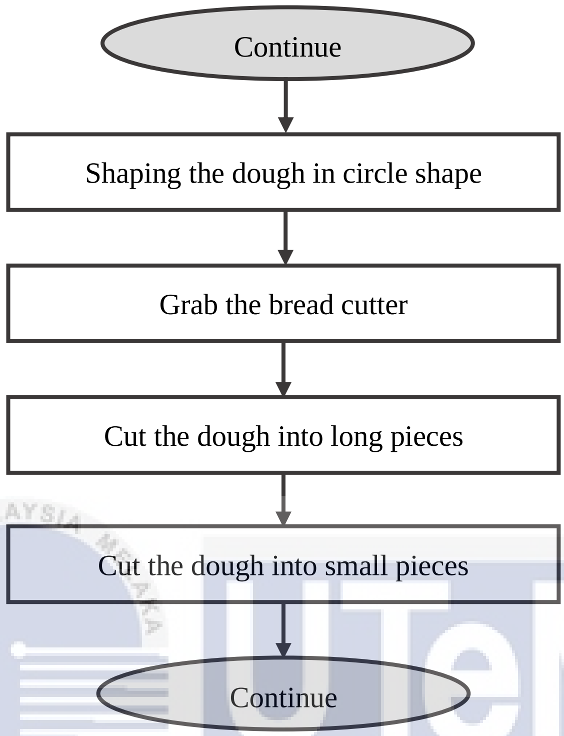


Figure 4.8: Process 4 – Cutting dough into small pieces

4.3.5 Work Element of Process 5

This is a crucial point in the process, since all 204 pieces of dough must be weighed. There should be 24g to 25g weight of dough in the following bulk for a great baking and tasty result. The process flow in Figure 4.9. clearly states the breakdown elements of weighing the small pieces of dough process.

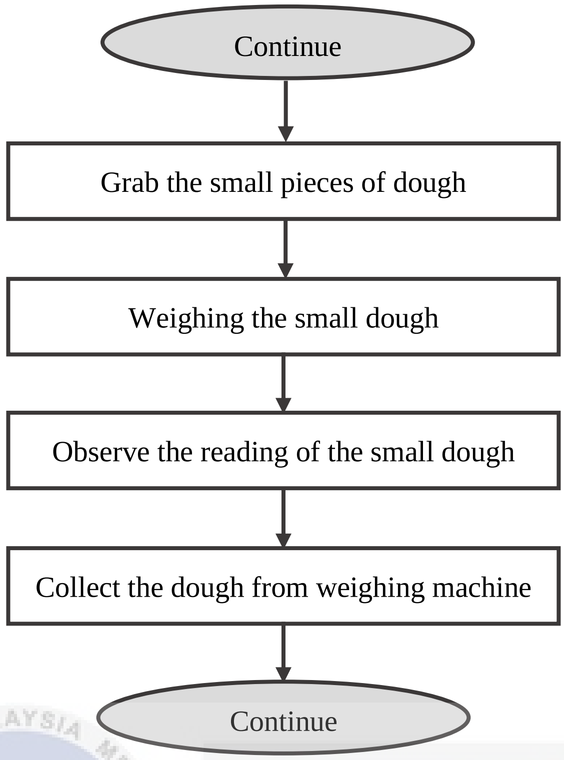


Figure 4.9: Process 5 – Weighing the small pieces of dough

4.3.6 Work Element of Process 6

After all of the small dough pieces have been weighed, the procedure of tabling them takes place. The worker manually shaped the dough pieces using both of their hands to provide strength and structure at this moment, which is known as the shaping process. The elements of the tabling process are depicted in Figure 4.10 below.

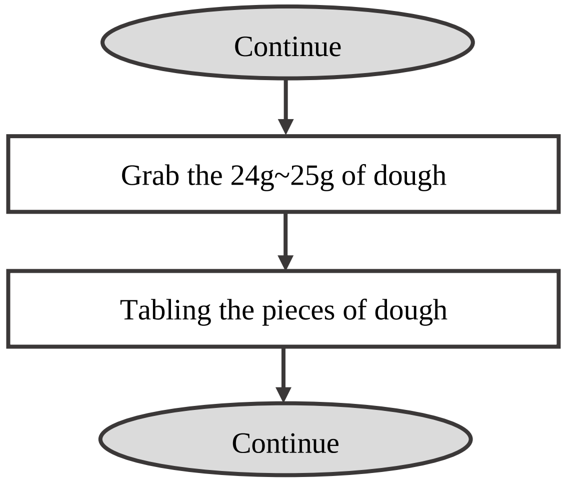


Figure 4.10: Process 6 – Tabling the small pieces of dough

4.3.7 Work Element of Process 7

Figure 4.11 depicts the work elements of Process 7, which involves arranging small pieces of dough in a tray. This process can be carried out after all of the dough pieces have gone through the tabling step. This procedure is done manually by the worker, who arranges the pieces of dough layer by layer while taking numerous measures such as greasing the tray with butter before arranging in order to retain the nice texture and ease of baking.

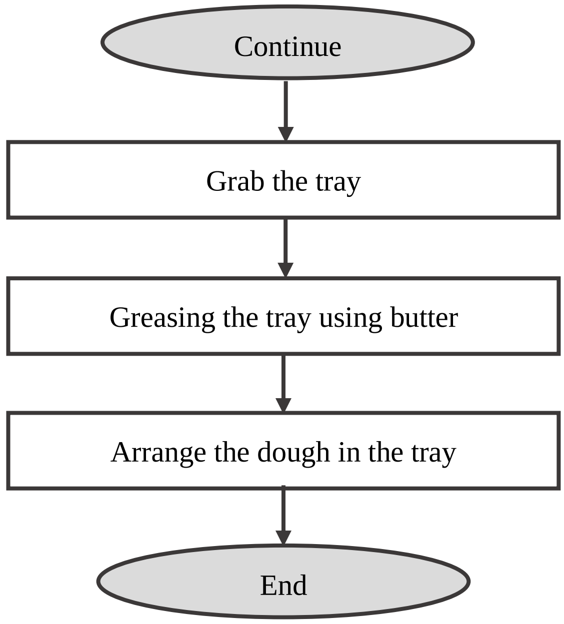


Figure 4.11: Process 7 – Arranging the small pieces of dough in tray

4.4 Data Collection of Time Study

This section presents the data collected, documented, and analyzed about the time required for an average worker to complete the long rusk biscuit production process at the biscuit company. Each work part has been segregated from the beginning to the end of the procedures. The number of cycles that must be calculated for each component has been set at 10 cycles. Tables 4.1 through 4.7 clearly show the computed average value for each element as well as the value for total of the average observe time.

4.4.1 Observation Time of Process 1

Table 4.1 depicts the time study data collection for process 1, which is ingredient preparation. The total of the average observes time for 42 sequences is 3.684 seconds. The longest average observation time is recorded during the second step, which involves filling an empty jar with plain water. It was recorded as the longest average observe time owing to the distance that workers had to go from the ingredient preparation station to the water filter machine. Furthermore, the water flow should be addressed, since it might be quick, moderate, or sluggish. During the pouring process, the ingredients in sequences 5, 19, and 24 are likewise regarded the greatest since they take 11.485 seconds, 12.407 seconds, and 13.109 seconds, respectively. This is due to the fact that the worker manually poured the ingredients from the jar into the bowl with a spoon, without using any appropriate baking equipment. The worker is also frequently perplexed when it comes to selecting sugar and salt.

Table 4.1: Observation Time of Process 1

TIME STUDY SHEET												
Process 1: Preparing the ingredient						**No. of Cycles:** 10						
Seq.	**Description of Steps**	**Observed Time Process (sec)**										**Average Observed Time (sec)**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1.	Grab the empty jug	1.12	1.11	1.01	1.85	1.22	1.00	1.23	1.06	1.00	1.45	1.205
2.	Fill plain water	20.25	20.45	19.56	23.36	18.45	19.86	22.45	20.87	20.22	22.65	20.812
3.	Grab yeast jar	1.02	1.03	2.00	1.15	1.56	1.25	1.36	1.22	1.47	1.18	1.324
4.	Open yeast jar lid	2.47	2.65	2.47	3.23	2.56	2.44	3.10	2.58	2.45	2.87	2.682
5.	Pour yeast into small bowl A	10.25	12.22	11.25	11.85	11.45	10.44	12.50	10.70	12.08	12.11	11.485
6.	Weighing the yeast	0.82	0.62	0.95	0.74	0.62	0.88	0.94	1.05	0.76	0.88	0.826
7.	Close yeast jar lid	2.30	2.22	2.14	1.95	2.23	2.22	2.15	2.05	2.15	2.08	2.149
8.	Place back yeast jar	1.25	1.62	1.45	1.48	2.01	1.65	1.23	1.55	1.32	1.10	1.466
9.	Pour water into small bowl A	3.26	2.95	2.69	3.33	2.84	3.01	3.66	3.45	3.12	3.68	3.199
10.	Stir the yeast and water	2.33	2.54	3.01	2.98	2.69	2.77	2.95	2.69	2.94	3.03	2.793

11.	Grab salt jar	1.36	1.25	1.02	1.26	1.30	1.23	1.26	1.19	1.26	1.24	1.237
12.	Open salt jar lid	2.56	3.02	2.26	2.36	2.45	2.16	3.06	2.96	2.54	2.74	2.611
13.	Pour salt into small bowl B	6.68	6.56	7.69	6.38	6.22	7.56	6.82	6.61	6.68	7.34	6.854
14.	Weighing the salt	0.85	0.66	0.96	0.89	0.90	0.87	0.86	0.82	0.64	0.79	0.824
15.	Close salt jar lid	2.36	2.68	2.46	2.59	2.57	2.09	2.54	2.63	2.49	2.17	2.458
16.	Place back salt jar	1.76	1.49	1.33	1.49	1.69	2.66	1.96	1.49	1.70	1.63	1.720
17.	Grab sugar jar	1.16	1.45	1.55	1.36	2.01	1.64	1.10	1.45	1.64	1.29	1.465
18.	Open sugar jar lid	2.45	2.46	2.18	2.97	2.46	2.37	3.00	2.64	2.39	2.57	2.552
19.	Pour sugar into big bowl A	12.66	10.21	12.41	13.38	12.49	12.44	12.37	12.38	13.27	12.46	12.407
20.	Weighing the sugar	0.64	0.90	0.68	0.93	0.71	0.68	0.76	0.80	0.71	0.69	0.750
21.	Close sugar jar lid	2.41	2.28	2.49	2.19	2.69	2.22	3.06	2.98	2.67	3.10	2.609
22.	Place back sugar jar	1.69	1.06	1.33	1.20	1.36	1.37	1.22	1.29	1.34	1.33	1.319
23.	Grab margarine packet	1.49	1.22	2.00	2.6	1.39	1.95	1.69	1.18	1.46	1.08	1.606
24.	Pour margarine into big bowl A	15.26	14.69	13.26	13.69	13.46	10.89	12.47	11.74	12.04	13.59	13.109
25.	Weighing the margarine	0.91	0.45	0.49	0.68	0.47	0.49	0.61	0.53	0.61	0.67	0.591
26.	Place back margarine packet	1.44	1.58	2.25	1.69	1.49	1.39	1.89	1.09	1.47	1.60	1.589

27.	Grab shortening jar	1.69	1.22	1.27	1.59	1.09	1.47	1.64	1.40	1.19	1.58	1.414
28.	Open shortening jar lid	2.55	2.66	2.48	2.41	2.32	2.06	2.51	2.47	2.41	2.44	2.431
29.	Pour shortening into big bowl A	9.28	9.16	8.82	9.06	8.69	8.11	8.67	9.08	10.45	8.16	8.948
30.	Weighing the shortening	0.88	0.69	0.49	0.66	0.78	0.69	0.79	0.80	0.99	0.67	0.744
31.	Close shortening jar lid	2.45	2.43	2.44	2.58	2.61	2.49	2.60	2.72	2.36	2.42	2.510
32.	Place back shortening jar	1.75	1.58	1.49	1.69	1.44	1.76	1.69	1.67	1.88	1.68	1.663
33.	Grab the eggs	2.12	2.65	2.72	2.49	2.77	2.47	2.46	2.68	2.48	3.01	2.585
34.	Break the egg	3.26	3.26	3.45	2.47	3.69	2.67	2.48	2.96	2.49	3.09	2.982
35.	Pour egg into mixing bowl	3.60	4.25	3.49	3.62	3.46	3.92	3.59	4.79	3.88	3.64	3.824
36.	Grab the flour packets	3.21	2.96	3.11	3.09	2.98	3.46	3.77	3.29	2.90	3.18	3.195
37.	Cut the flour packet	4.20	4.19	4.11	4.29	4.37	4.28	3.80	3.26	4.31	3.52	4.033
38.	Pour flour into mixing bowl	5.26	6.11	5.17	5.35	6.98	5.60	5.95	7.49	5.62	7.96	6.149
39.	Grab the mixing of ingredient A	2.79	3.06	2.58	2.49	2.48	2.69	3.22	2.47	2.99	2.86	2.763
40.	Pour ingredient A into mixing bowl	3.26	4.29	4.11	3.98	3.49	4.00	3.58	3.44	3.90	4.21	3.826
41.	Grab the mixing of ingredient B	2.34	2.30	3.02	2.85	2.66	2.39	3.04	2.64	2.62	2.97	2.683

42.	Pour ingredient B into mixing bowl	4.26	4.10	4.72	4.90	4.64	5.06	4.88	4.51	4.22	4.67	4.596
Total Average Observed Time (sec)												3.684

4.4.2 Observation Time of Process 2

According to the time study sheet in Table 4.2, the highest average for observe time is 6.555 seconds during the process of worker attaching the hook beater into the machine, followed by inserting the mixing bowl into the machine with an average observe time of 5.939 seconds. Due to the worker interacting with the mixing machine by attaching and inserting another component, both processes have the greatest average observe time value. This process has been done by single worker. The worker takes time to set up the machine and install the internal part in accordance with the user handbook. The procedure in sequence 1 reveals that the worker takes 5.248 seconds, which is due to the worker transferring the mixer bowl from the ingredient preparation station to the mixer machine station.

Table 4.2: Observation Time of Process 2

TIME STUDY SHEET												
Process 2: Mixing the ingredient							**No. of Cycles:** 10					
Seq.	**Description of Steps**	**Observed Time Process (sec)**										**Average Observed Time (sec)**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1.	Grab mixing bowl	5.86	4.77	5.71	5.22	3.32	4.25	7.08	4.88	6.21	5.18	5.248
2.	Insert the mixing bowl into the machine	8.75	4.26	4.28	7.80	3.82	5.16	4.74	5.36	8.20	7.02	5.939
3.	Grab the hook beater	3.21	5.02	4.00	6.61	5.68	5.33	5.27	5.48	4.26	6.05	5.091
4.	Attach the hook beater into the machine	6.66	5.27	6.25	5.84	6.23	9.88	5.87	6.01	5.05	8.49	6.555

5.	Press ON button of the mixer machine	2.21	1.92	1.03	2.05	1.65	2.25	2.55	1.68	2.24	1.38	1.896
Total Average Observed Time (sec)												4.946

4.4.3 Observation Time of Process 3

The total average observe time for the 8 sequences on the time study sheet for collecting dough is 10.941 seconds as shown in Table 4.3. The greatest average observation time of 35.559 seconds occurs in sequence 8, which is the task of take out the dough from the mixing bowl, followed by 34.331 seconds during the task of cleaning the hook beater. Both activities have the greatest gap value to the lowest average observe time in this process, which is 0.544 seconds. Sequence 7 and 8 has higher average observe time due to the worker took time to completely remove the remaining dough that attached to the hook part in an intention to cut off the occurrence of wastage.

Table 4.3: Observation Time of Process 3

TIME STUDY SHEET												
Process 3: Collecting the dough							**No. of Cycles:** 10					
Seq.	**Description of Steps**	**Observed Time Process (sec)**										**Average Observed Time (sec)**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1.	Press OFF button of the mixer machine	0.61	0.45	0.51	0.45	0.38	0.58	0.56	0.65	0.73	0.52	0.544
2.	Remove the hook beater	3.63	4.35	3.88	3.66	4.35	3.58	4.22	3.13	4.03	4.31	3.914
3.	Grab the mixing bowl	9.11	7.41	6.31	8.12	7.90	7.08	7.29	6.96	7.13	8.26	7.557
4.	Grab the flour	1.88	1.18	2.01	1.45	1.52	1.55	3.21	2.11	1.78	1.61	1.830

5.	Sprinkle flour on the table	1.68	2.03	0.95	2.19	2.09	1.59	2.89	1.88	1.91	3.01	2.022
6.	Grab the dough cutter	0.98	1.26	0.89	1.75	1.05	2.19	2.42	3.22	2.17	1.79	1.772
7.	Cleaning the hook beater	41.40	44.85	28.70	26.12	47.79	21.92	29.25	28.69	31.49	43.10	34.331
8.	Take out the dough from mixing bowl	28.98	29.83	38.01	38.20	34.73	39.0	40.59	34.12	35.12	37.01	35.559
Total Average Observed Time (sec)												10.941

4.4.4 Observation Time of Process 4

The total average observe time for the procedure of cutting dough into small pieces is 5.396 seconds, according to the time study sheet in Table 4.4. The longest time in this process is 15.074 seconds for shaping the 3kg dough into a circle shape. Only one person participates in this activity by manually shaping the dough with both hands. The second highest value for average observes time comes in the third sequence, during the operation of cutting the dough into long pieces. Because they only have a 10 cm dough cutter, the worker should re-cut the dough over a length of 20 to 23 cm.

Table 4.4: Observation Time of Process 4

TIME STUDY SHEET												
Process 4: Cutting dough into small pieces							**No. of Cycles:** 10					
Seq.	**Description of Steps**	**Observed Time Process (sec)**										**Average Observed Time (sec)**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1.	Shaping the dough in circle shape	12.51	13.35	10.42	13.70	13.29	15.5	22.52	17.47	16.53	15.45	15.074
2.	Grab the bread cutter	0.43	0.26	0.40	0.56	0.64	0.55	0.79	0.53	0.43	0.66	0.525

3.	Cut the dough into long pieces	4.96	4.73	3.16	4.26	5.15	5.40	6.10	4.38	4.85	5.55	4.854
4.	Cut the dough into small pieces	1.49	1.23	1.02	0.63	1.13	0.65	2.09	0.98	0.80	1.29	1.131
Total Average Observed Time (sec)												5.396

4.4.5 Observation Time of Process 5

Process 5, which is the process of weighing small pieces of dough, has a total value of 0.847 seconds for average observe time. Due to the sticky surface of the dough on the weighing plate, sequence 4 takes the longest to complete, as indicated in Table 4.5. The task of observing the reading has a greater value as well, which is 1.042 seconds. The worker is required to try and error for weigh the small dough since the dough should be in the range of 24 to 25g by using digital weighing machine.

Table 4.5: Observation Time of Process 5

TIME STUDY SHEET												
Process 5: Weighing the small pieces of dough							**No. of Cycles:** 10					
Seq.	**Description of Steps**	**Observed Time Process (sec)**										**Average Observed Time (sec)**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1.	Grab the small pieces of dough	0.35	0.41	0.33	0.35	0.22	0.31	0.42	0.26	0.37	0.33	0.335
2.	Weighing the small dough	0.42	0.69	0.65	0.46	0.66	0.60	0.53	0.55	0.49	0.56	0.561
3.	Observe the reading	0.91	0.89	1.23	0.90	0.99	0.89	1.12	1.06	1.13	1.30	1.042
4.	Collect the dough from weighing machine	1.59	1.03	1.09	1.70	1.75	1.50	1.43	1.49	1.29	1.63	1.450
Total Average Observed Time (sec)												0.847

4.4.6 Observation Time of Process 6

According to the data from the time study sheet for tabling small pieces of size, the total average observe time is 3.066 seconds. This process requires only two tasks: grabbing the dough with 24 to 25g and tabling the dough pieces into a sphere shape. The data in Table 4.6 shows that the worker spends the most time during the tabling procedure, which is 5.067 seconds, since they must perform it manually with both hands. The worker has worked hard to form the dough into a sphere shape. This procedure may cause workers' hands to become fatigued since they must move their hands repeatedly throughout the tabling process to ensure a uniform deformation of the dough.

Table 4.6: Observation Time of Process 6

TIME STUDY SHEET												
Process 6: Tabling the small pieces of dough						**No. of Cycles:** 10						
Seq.	**Description of Steps**	**Observed Time Process (sec)**										**Average Observed Time (sec)**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1.	Grab the 24g~25g of dough	0.59	0.79	1.16	2.72	0.63	0.51	0.84	0.90	0.85	1.65	1.064
2.	Tabling the pieces of dough	4.40	6.25	4.92	4.49	5.81	4.61	5.40	4.89	4.99	4.91	5.067
Total Average Observed Time (sec)												3.066

4.4.7 Observation Time of Process 7

According to the data in Table 4.7, the total average observe time is 7.047 seconds. The highest value in this process occurs in sequence 2 at 16.442 seconds, where the worker is needed to grease the tray with butter. The worker spent the most time on this activity since they were manually greasing the tray with a pastry brush and repeated the process until the whole surface of the tray was thoroughly greased with butter.

Table 4.7: Observation Time of Process 7

TIME STUDY SHEET												
Process 7: Arranging the small pieces of dough in tray							**No. of Cycles:** 10					
Seq.	**Description of Steps**	**Observed Time Process (sec)**										**Average Observed Time (sec)**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1.	Grab the tray	2.08	2.09	2.20	3.38	2.85	4.32	2.28	3.49	3.91	2.29	2.889
2.	Greasing the tray using butter	13.47	17.72	17.20	19.28	14.27	15.43	17.99	13.89	17.86	17.31	16.442
3.	Arrange the dough in the tray	1.65	1.78	1.95	2.36	1.73	1.54	1.51	1.86	1.79	1.93	1.810
Total Average Observed Time (sec)												7.047

4.5 Number of Cycle Time Analysis

The determination of the number of cycles has been examined throughout the data collection process in order to decrease statistical variance. The number of cycles has a significant impact on data validation. The assessment was primarily carried out to determine the adequate sample size. To begin the research, 10 cycles were used, and the number of cycles was computed and statistically justified based on the number of observations, as shown in Tables 4.1 and 4.7. Tables 4.8 to 4.14 relate to the average observe time and total average for observe time for each element in every process. The number of cycles (n) that must be observed should be derived using the formula for number of cycles to be timed, taking into consideration the required confidence level of 95 %, which would be 2.262 by referring to the t-distribution table in Appendix F. Meanwhile, the real mean of the time taken by the average observe time was within $\pm$30 seconds of being accurate. As mentioned in the previous section, 10 cycles have been observed. There is no need to observe additional cycles if the number of cycles is less than 10. Meanwhile, if the number of cycles exceeds 10, it is necessary to generate extra observations for those elements. However, the Malaysian government has issued a Movement Control Order (MCO) to all districts in Malaysia owing to a spike in Covid-19 instances, thus the additional observations that are required will not be carried out. The present results will be used for this analysis after a discussion with the industrial supervisor.

4.5.1 Number of Cycle Time for Process 1

The number of cycle time for process 1 which the process of preparing the ingredient has been detailed calculated in Table 4.8. The number of cycles for the sequence 2, 5, 20, 24, 29 shows the extremely high number of cycles required. This occurs when there is an inconsistency between the 10 cycles in each element.

Table 4.8: Number of Cycle Time for Process 1

NUMBER OF CYCLE TIME			
Process 1: Preparing the ingredient			
Seq.	**Description of Steps**	**Number of Cycle (n)**	**Number of Work Cycle Added to be Timed (n)**
1.	Grab the empty jug	2.858	Not required
2.	Fill plain water	136.529	Required
3.	Grab yeast jar	2.594	Not required
4.	Open yeast jar lid	0.467	Not required
5.	Pour yeast into small bowl A	28.317	Required
6.	Weighing the yeast	3.804	Not required
7.	Close yeast jar lid	1.098	Not required
8.	Place back yeast jar	2.288	Not required
9.	Pour water into small bowl A	0.110	Not required
10.	Stir the yeast and water	0.370	Not required
11.	Grab salt jar	2.789	Not required
12.	Open salt jar lid	0.537	Not required

13.	Pour salt into small bowl B	4.680	Not required
14	Weighing the salt	3.804	Not required
15.	Close salt jar lid	0.701	Not required
16.	Place back salt jar	1.797	Not required
17.	Grab sugar jar	2.294	Not required
18.	Open sugar jar lid	0.595	Not required
19.	Pour sugar into big bowl A	35.424	Required
20.	Weighing the sugar	4.01	Not required
21.	Close sugar jar lid	0.537	Not required
22.	Place back sugar jar	2.601	Not required
23.	Grab margarine packet	2.012	Not required
24.	Pour margarine into big bowl A	41.354	Required
25.	Weighing the margarine	4.453	Not required
26.	Place back margarine packet	2.041	Not required
27.	Grab shortening jar	2.400	Not required
28.	Open shortening jar lid	0.732	Not required
29.	Pour shortening into big bowl A	12.902	Required
30.	Weighing the shortening	4.023	Not required
31	Close shortening jar lid	0.640	Not required
32.	Place back shortening jar	1.903	Not required
33.	Grab the eggs	0.561	Not required
34.	Break the egg	0.229	Not required
35.	Pour egg into mixing bowl	0.0093	Not required
36.	Grab the flour packets	0.111	Not required
37.	Cut the flour packet	0.056	Not required
38.	Pour flour into mixing bowl	2.830	Not required
39.	Grab the mixing of ingredient A	0.395	Not required
40.	Pour ingredient A into mixing bowl	0.0093	Not required
41.	Grab the mixing of ingredient B	0.467	Not required
42.	Pour ingredient B into mixing bowl	0.387	Not required

4.5.2 Number of Cycle Time for Process 2

The number of cycle time for process 2 which the process of mixing the ingredient has been detailed calculated in Table 4.9. The number of cycles for all sequences is adequate and does not necessitate the extra time.

Table 4.9: Number of Cycle Time for Process 2

NUMBER OF CYCLE TIME			
Process 2: Mixing the ingredient			
Seq.	**Description of Steps**	**Number of Cycle (n)**	**Number of Work Cycle Added to be Timed (n)**
1.	Grab mixing bowl	0.030	Not required
2.	Insert the mixing bowl into the machine	0.255	Not required
3.	Grab the hook beater	0.0054	Not required
4.	Attach the hook beater into the machine	0.668	Not required
5.	Press ON button of the mixer machine	2.404	Not required

4.5.3 Number of Cycle Time for Process 3

The number of cycle time for process 3 which the process of collecting the dough has been detailed calculated in Table 4.10. The number of cycles for the sequence 7 and 8 shows the extremely high number of cycles required. This occurs when there is an inconsistency between the 10 cycles in each element.

Table 4.10: Number of Cycle Time for Process 3

NUMBER OF CYCLE TIME			
Process 3: Collecting the dough			
Seq.	**Description of Steps**	**Number of Cycle (n)**	**Number of Work Cycle Added to be Timed (n)**
1.	Press OFF button of the mixer machine	5.705	Not required
2.	Remove the hook beater	2.605	Not required
3.	Grab the mixing bowl	0.604	Not required
4.	Grab the flour	4.380	Not required
5.	Sprinkle flour on the table	4.198	Not required
6.	Grab the dough cutter	4.435	Not required
7.	Cleaning the hook beater	28.872	Required
8.	Take out the dough from mixing bowl	32.450	Required

4.5.4 Number of Cycle Time for Process 4

The number of cycle time for process 4 which the process of cutting dough into small pieces has been detailed calculated in Table 4.11. The number of cycles for the sequence 1 shows the extremely high number of cycles required. This occurs when there is an inconsistency between the 10 cycles in each element.

Table 4.11: Number of Cycle Time for Process 4

NUMBER OF CYCLE TIME			
Process 4: Cutting dough into small pieces			
Seq.	**Description of Steps**	**Number of Cycle (n)**	**Number of Work Cycle Added to be Timed (n)**
1.	Shaping the dough in circle shape	20.320	Required
2.	Grab the bread cutter	5.150	Not required
3.	Cut the dough into long pieces	0.064	Not required

4.	Cut the dough into small pieces	3.954	Not required

4.5.5 Number of Cycle Time for Process 5

The number of cycle time for process 5 which the process of weighing the small pieces of dough has been detailed calculated in Table 4.12. The number of cycles for all sequences is adequate and does not necessitate the extra time.

Table 4.12: Number of Cycle Time for Process 5

NUMBER OF CYCLE TIME			
Process 5: Weighing the small pieces of dough			
Seq.	**Description of Steps**	**Number of Cycle (n)**	**Number of Work Cycle Added to be Timed (n)**
1.	Grab the small pieces of dough	2.317	Not required
2.	Weighing the small dough	0.720	Not required
3.	Observe the reading	0.335	Not required
4.	Collect the dough from weighing machine	3.202	Not required

4.5.6 Number of Cycle Time for Process 6

The number of cycle time for process 6 which the process of tabling the small pieces of dough has been detailed calculated in Table 4.13. The number of cycles for all sequences is adequate and does not necessitate the extra time.

Table 4.13: Number of Cycle Time for Process 6

NUMBER OF CYCLE TIME			
Process 6: Tabling the small pieces of dough			
Seq.	**Description of Steps**	**Number of Cycle (n)**	**Number of Work Cycle Added to be Timed (n)**
1.	Grab the 24g~25g of dough	2.961	Not required
2.	Tabling the pieces of dough	2.961	Not required

4.5.7 Number of Cycle Time for Process 7

The number of cycle time for process 7 which the process of arranging the small pieces of dough in tray has been detailed calculated in Table 4.14. The number of cycles for the sequence 2 shows the extremely high number of cycles required. This occurs when there is an inconsistency between the 10 cycles in each element.

Table 4.14: Number of Cycle Time for Process 7

NUMBER OF CYCLE TIME			
Process 7: Arranging the small pieces of dough in tray			
Seq.	**Description of Steps**	**Number of Cycle (n)**	**Number of Work Cycle Added to be Timed (n)**
1.	Grab the tray	2.200	Not required
2.	Greasing the tray using butter	11.230	Required
3.	Arrange the dough in the tray	3.490	Not required

4.6 Standard Time of Work Element for Each Process

Each job element involved in the production of long rusk biscuits was given a standard time. The biscuit company produces long rusk biscuits through 17 procedures, however the standard time is only calculated for the seven major production processes. Preparation of ingredients, mixing of ingredients, gathering the dough, cutting the dough into tiny pieces, weighing the small pieces of dough, tabling the small pieces of dough, and arranging the small pieces of dough on tray are the processes that have been covered. To avoid bottlenecks, the long rusk biscuit production process must adhere to the standard time. The decrease of idle time in the SMEs sector might enhance output and raise the efficiency of production. Tables 4.15 describe the standard time of work element for this analysis.

The performance rating at the biscuit company has been taken into account by 95%, which was provided by an industrial supervisor based on worker experience, expertise level, and attitude in the production line. The pace at which a worker does their or her job is greatly dependent on the particular task at hand. As a result, the allowances factor value used in the analysis is 5% since production is heavily reliant on manual labor. The most common purpose for include allowances is to determine the normal time required to complete the task. Personal allowances, fatigue, and delay allowances are all elements of the allowance's component. It is predicted that allowances will be worth 5 %, due to the effects of working in poorly ventilated areas and a hot atmosphere at nearly every workstation because of the location of ovens near the working area.

Table 4.15: Standard Time of Job Element for Each Process

STANDARD TIME OF JOB ELEMENT		
Process 1: Preparing the ingredient		
Total Average Observed Time (sec)	**Normal Time (sec)**	**Standard Time (sec)**
3.684	T_n = Total of average observed time x Performace time $T_n = 3.684 \text{ x } 0.95$ $T_n = 3.50$	T_{std} = Total normal time x (1 + Allowance factor) $T_{std} = 3.50 \text{ x } (1 + 0.05)$ $T_{std} = 3.675$
STANDARD TIME OF JOB ELEMENT		
Process 2: Mixing the ingredient		
Total Average Observed Time (sec)	**Normal Time (sec)**	**Standard Time (sec)**
4.996	$T_n = 4.996 \text{ x } 0.95$ $T_n = 4.746$	$T_{std} = 4.746 \text{ x } (1 + 0.05)$ $T_{std} = 4.983$
STANDARD TIME OF JOB ELEMENT		
Process 3: Collecting the dough		
Total Average Observed Time (sec)	**Normal Time (sec)**	**Standard Time (sec)**
10.941	$T_n = 10.941 \text{ x } 0.95$ $T_n = 10.394$	$T_{std} = 10.394 \text{ x } (1 + 0.05)$ $T_{std} = 10.914$
STANDARD TIME OF JOB ELEMENT		
Process 4: Cutting dough into small pieces		
Total Average Observed Time (sec)	**Total Average Observed Time (sec)**	**Total Average Observed Time (sec)**
5.396	$T_n = 5.396 \text{ x } 0.95$ $T_n = 5.126$	$T_{std} = 5.126 \text{ x } (1 + 0.05)$ $T_{std} = 5.382$
STANDARD TIME OF JOB ELEMENT		
Process 5: Weighing the small pieces of dough		
Total Average Observed Time (sec)	**Normal Time (sec)**	**Standard Time (sec)**
0.847	$T_n = 0.847 \text{ x } 0.95$ $T_n = 0.805$	$T_{std} = 0.805 \text{ x } (1 + 0.05)$ $T_{std} = 0.845$

STANDARD TIME OF JOB ELEMENT		
Process 6: Tabling the small pieces of dough		
Total Average Observed Time (sec)	**Normal Time (sec)**	**Standard Time (sec)**
3.066	$T_n = 3.066 \times 0.95$ $T_n = 2.913$	$T_{std} = 2.913 \times (1 + 0.05)$ $T_{std} = 3.059$
STANDARD TIME OF JOB ELEMENT		
Process 7: Arranging the small pieces of dough in tray		
Total Average Observed Time (sec)	**Normal Time (sec)**	**Standard Time (sec)**
7.047	$T_n = 7.047 \times 0.95$ $T_n = 6.695$	$T_{std} = 6.695 \times (1 + 0.05)$ $T_{std} = 7.030$

4.7 Analysis of Critical Issues in Current Process Flow

This section presents an analysis of the redundant working processes based on the data obtained in the time study that was conducted in the production of long rusk biscuits, which include seven processes. The major goal of this study is to identify any superfluous working processes that might lead to problems in the production process. Once the potential problem has been identified, viable solutions to the present problem might be suggested. Productivity will increase as a result of modifications or improvements that minimize the time it takes to complete a task in the production of long rusk biscuits. All of the work done in long rusk biscuit production is done manually with the assistance of a machine. The analysis was carried out by constructing a cause-and-effect diagram and implementing the 5whys technique.

4.7.1 Analysis of Root Cause using Cause-and-Effect Diagram

This section will utilize a cause-and-effect diagram, also known as a fishbone diagram, to investigate the probable root causes for particular problems in each process element during the production of long rusk biscuits. This tool is an easy, simple yet powerful for visual tool which commonly used in a cross functional setting. Each cause or reason for imperfection is a source of variation which seen on the fish head. Then, the concern of the focus area located on the ribs of the fish. The cause-and-effect diagram was created by brainstorming likely explanation by asking why it happens and taking into account six factors: material, measurement, method, machine, manpower, and environment. The benefits of developing these tools include the potential to instantly identify the underlying cause when it is noticed repeatedly in the same or other casual sources. In truth, these tools allow for a seamless analysis of the reason through the use of high visual mind maps that display the difficulties and the problem as it occurs.

a) Cause and effect diagram for critical issues in process 1 – Preparing the ingredient

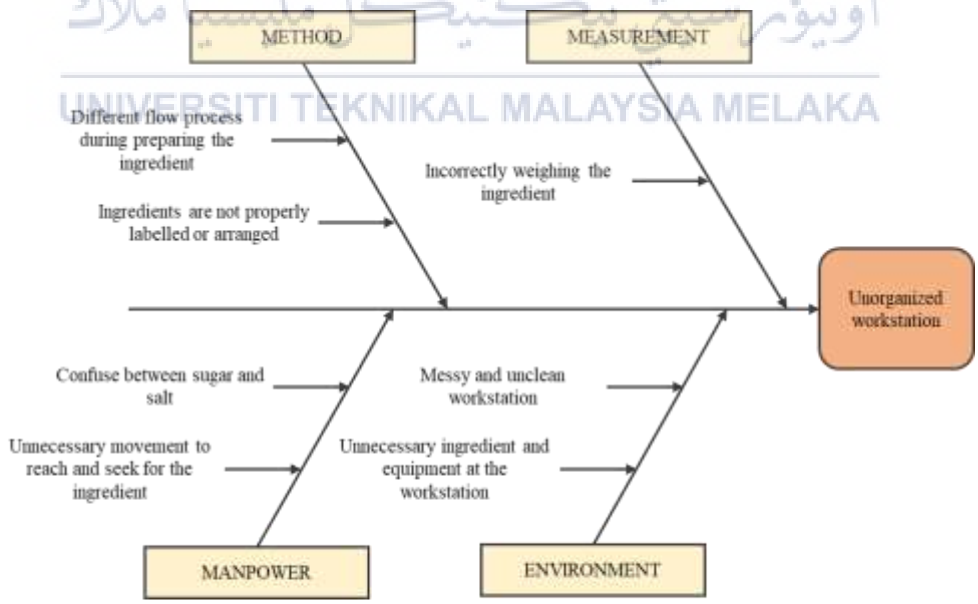


Figure 4.12: Cause and effect diagram for critical issues in process in process 1

b) Cause and effect diagram for critical issues in process 2 – Mixing the ingredient

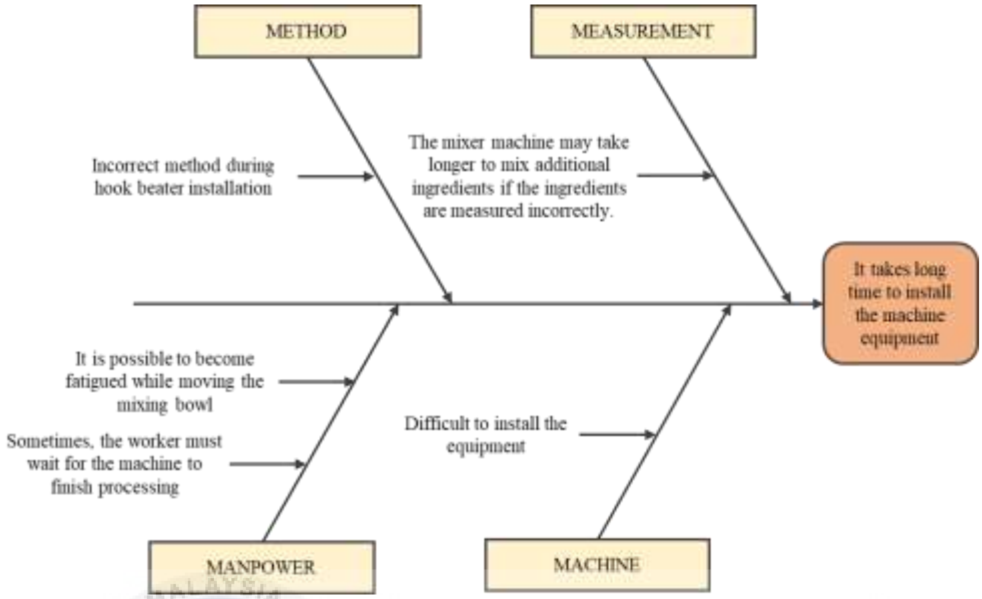


Figure 4.13: Cause and effect diagram for critical issues in process 2

c) Cause and effect diagram for critical issues in process 3 - Collecting the dough

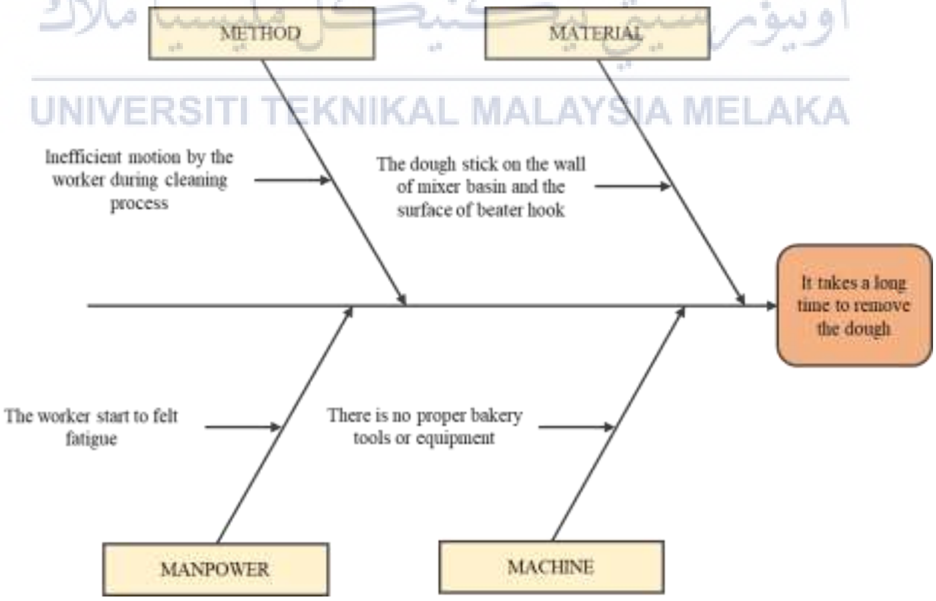


Figure 4.14: Cause and effect diagram for critical issues in process 3

d) Cause and effect diagram for critical issues in process 4 - Cutting dough into small pieces

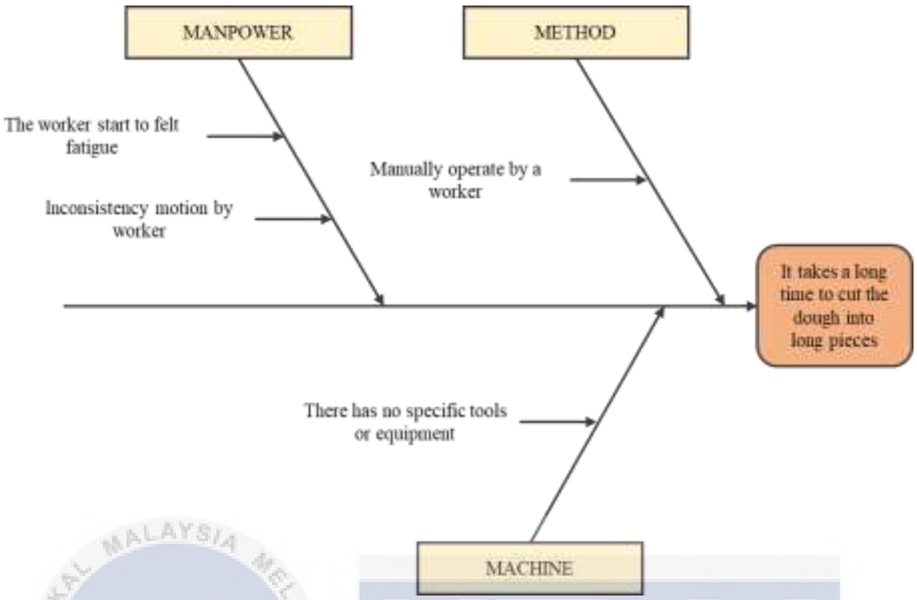


Figure 4.15: Cause and effect diagram for critical issues in process 4

e) Cause and effect diagram for critical issues in process 5 - Weighing the small pieces of dough

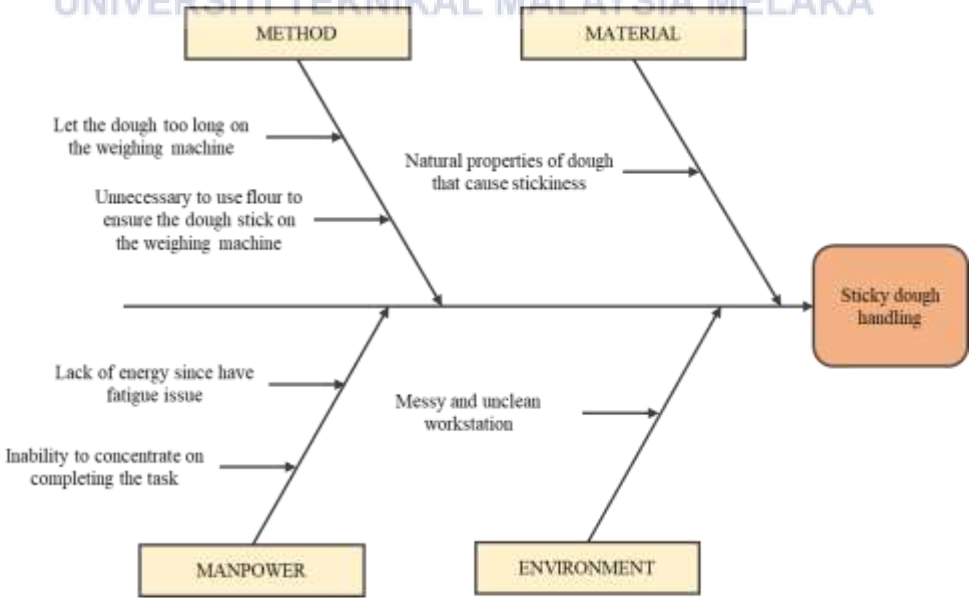


Figure 4.16: Cause and effect diagram for critical issues in process 5

f) Cause and effect diagram for critical issues in process 6 - Tabling the small pieces of dough

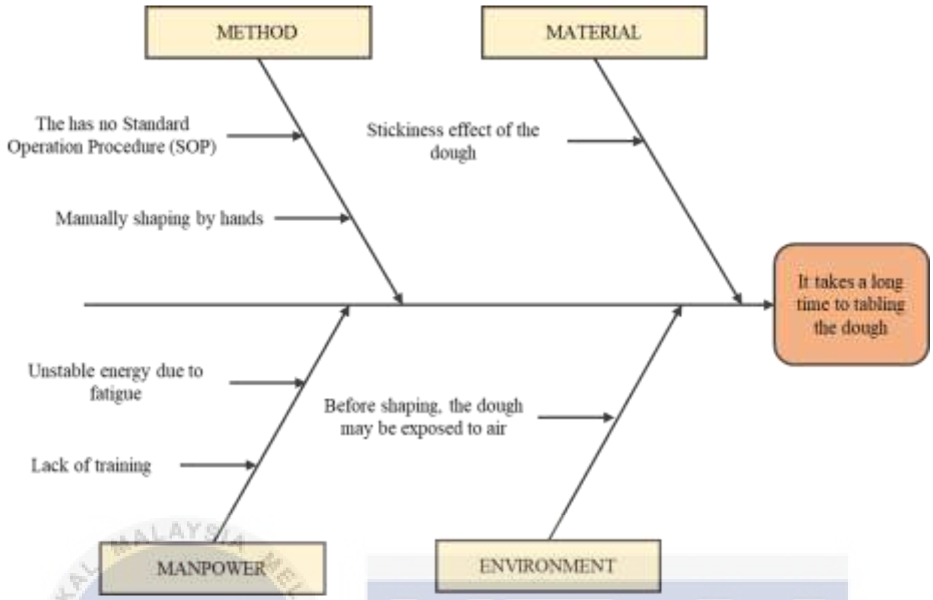


Figure 4.17: Cause and effect diagram for critical issues in process 6

g) Cause and effect diagram for critical issues in process 7 - Arranging the small pieces of dough in tray

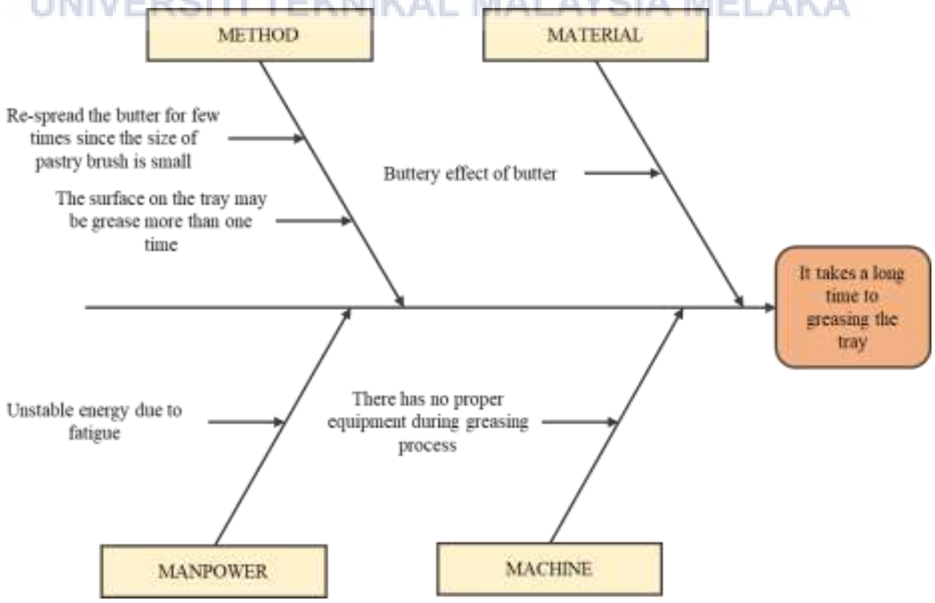


Figure 4.18: Cause and effect diagram for critical issues in process 7

4.7.2 Analysis of Root Cause using Five Whys Technique

This section will go through the 5 Whys approach and its analysis. In Lean management, the 5 Whys technique is one of the most effective tools for root cause analysis. This is a strategy for determining the underlying cause of an issue by asking the question "Why" five times in a row. It may be possible to peel away the layers of symptoms that lead to the underlying cause of the problem by repeatedly asking why. It also aids in the identification of the link between the many implicit causes of the problem. Table 4.16 depicts the 5 whys analysis based on the factors that affect the duration of the production line during the manufacturing of long rusk biscuits, as mentioned in the previous section. A countermeasure is an activity or series of activities designed to keep the problem from recurring. Table 4.16 shows the appropriate countermeasure for each of the factors.

Table 4.16: 5 Whys analysis

No.	Factors	Why 1	Why 2	Why 3	Why 4	Why 5	Counter Measures
1.	Preparing the ingredient	Takes time to identify the ingredient	The preparation station has unnecessary item	The ingredient unorganized	Distance of water filling machine and preparation table	There is no standard process	Implement 5's technique
2.	Attach the hook beater into the machine	Take time to attach and remove the hook beater	The worker confuses to rotates the tools to right or left side	The worker is not trained well	The worker position of worker stand is incorrectly	There is no standard process	SOP
3.	Cut the dough into long pieces	Takes time to cut the dough into the long pieces	The dough needs to be re-cut for several time	The worker not consistent during cutting process	The process is continuously	The process done by manual without specific tools or equipment	Using proper equipment

4.	Greasing the tray using butter	Takes time to grease all the surface of the tray	It might re-grease or ungreased for the certain surface	The butter is not in the convenient container	The size of the pastry brush is larger than the container	The motion of the worker inconsistent	Using proper equipment

4.8 Propose an Alternative for Improvement

This section will propose several viable solutions to the problem encountered in the preceding section's analysis of long rusk biscuit production. There are four procedures that have been recognized as processes that may minimize the time required to complete the task by applying the proposed solutions. The process includes Process 1 (Preparing the ingredient), Process 2 (Mixing the ingredient) during work element 4 (Attach the hook beater into the machine), Process 4 (Cutting dough into small pieces) during work element 3 (Cut the dough into the long pieces), and Process 7 (Arranging the small pieces of dough in tray (during work element 2 (Greasing the tray using butter). Therefore, there are four improvements recommended in order to minimize the time required for workers to complete their tasks at the biscuit company, which will be explained in detail in the next subsection.

4.8.1 Propose 5S Techniques for Process 1

The 5S technique is one of the lean manufacturing techniques that is a systematic type of visual management that contributes to the manufacturing industry's continuous improvement. 5S represents Japanese words that describe the five steps of a workplace organization: Seiri (sort), Seiton (set in order), Seiso (shine), Seiketsu (standardize), and Shitsuke (Sustain). The 5S technique is an economical and efficient in the preparation of ingredient process that may assist to control the workflow by systemizing a proposed integrated that is capable of solving any type of industry-related issue. The circumstances in the preparation station necessitate the use of the 5S method to improve a good systematic working atmosphere. Figure 4.19 depicts the existing framework of the long rusk biscuit production facility and shows the areas that will be subjected to the 5S technique.

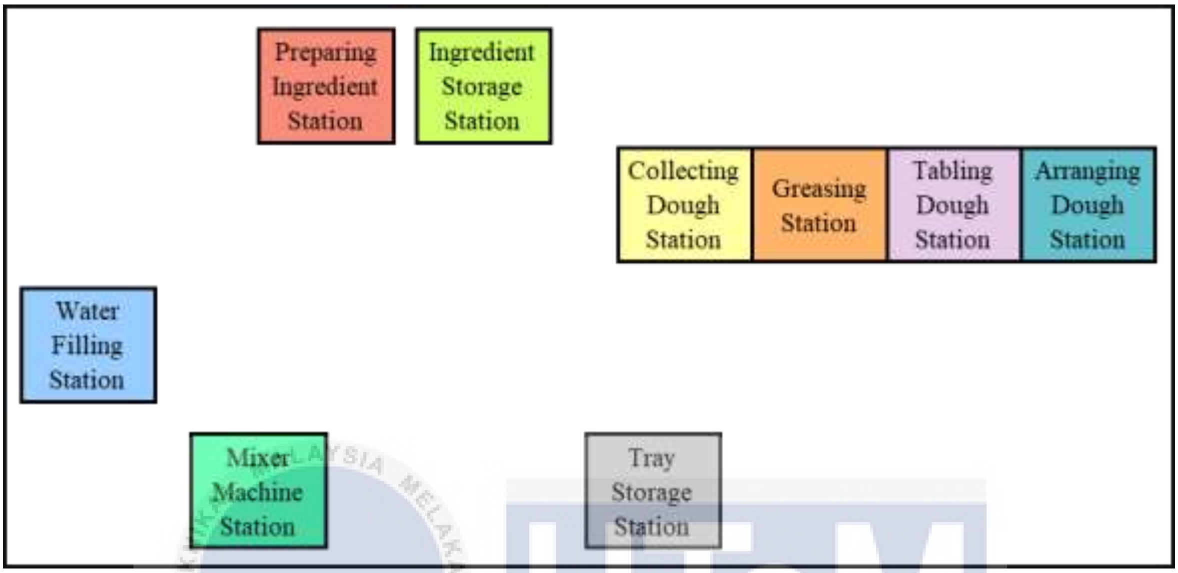


Figure 4.19: Current layout of the long rusk biscuit production

4.8.1.1 Sort

Sort, also known as Seiri in Japanese, is the first step of the 5S methods. The major aim at this step is to reduce clutter and tidy up the workstation by removing unnecessary items from the area. As described in the preceding section, the workstation's surroundings is disorganized and messy. Unused tools or equipment are occasionally discarded at the workstation. As a preliminary step, inspect the ingredients, tools, and equipment in the working area. Then, keep the objects that are essential and required while discarding those that do not belong in this space. Items that belong to another workstation should be returned there.

4.8.1.2 Set in Order

It was originally known as Seiton in Japanese, which means to put everything in order and called as Set in order. Organizing the workstation efficiently is the primary goal of this phase. Each item should be well-organized so that it is simple to identify, use, and return to its right position. The equipment that is often used during the process of producing long rusk biscuits, which are essential ingredients, should be positioned close to the working area. In the meanwhile, less often used equipment can be kept in a specific section of the workstation, where various teams from another production can share it. Tray storage and greasing tools are examples of items that are frequently used together. Each of these choices will make sense on its own but keeping track of everything may become difficult. Figure 4.20 depicts an alternate arrangement for the manufacturing of long rusk biscuits. As part of this procedure, it may be beneficial to design a 5S layout.

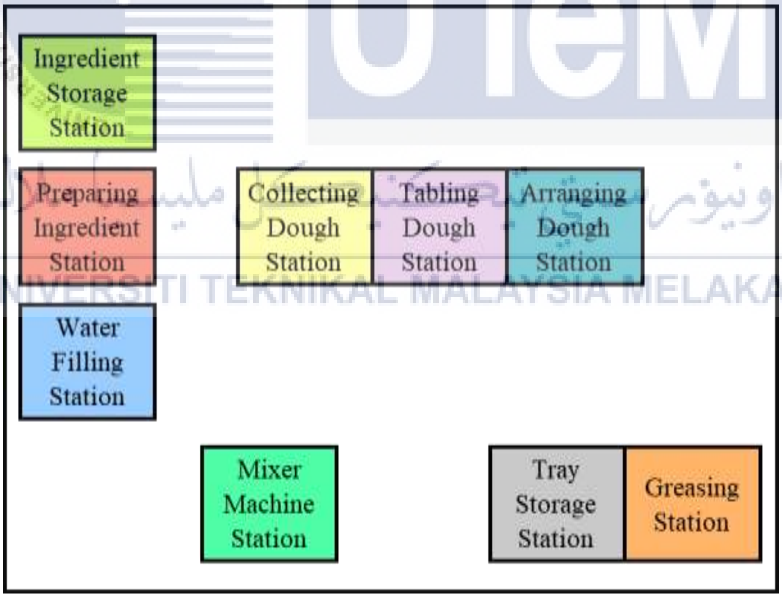


Figure 4.20: Alternatives layout of the long rusk biscuit production

Long rusk biscuits require eight essential ingredients: yeast, water, salt, sugar, margarine, shortening, egg, and flour. According to the present configuration in Figure 4.19, the ingredients are conveniently located adjacent to the preparing ingredient station. However, because most ingredients are not stored in distinct bottles or containers, the area becomes unorganized. Some ingredients are placed in a jar, but they are not correctly labelled, making it difficult for the worker to identify the ingredient, particularly sugar and salt. The ingredients should be stored in appropriate containers and labelled with their names so that workers can clearly identify and utilize the ingredients. By implement the 5S map as shown in Figure 4.20 for the ingredient station, this action could make the worker easy to grab the ingredient and equipment as shown in Figure 4.21, at the same time can avoid the zigzag motion. Workers should be held accountable for returning the ingredient or container to its right positions after usage. Those ingredients have been arranged in accordance with their intended purpose. By keeping the ingredients in a particular container, as illustrated in Figure 4.22, it reduces the exposure of remaining materials such as flour packets and margarine packets to air, which may result in reduced contamination of the contents. Because the ingredients have been placed to be closer to the preparation station. As a result, the worker will be able to grab the ingredient more effortlessly, and the time required to grab the ingredient will be reduced.

Figure 4.21: Alternatives maps for the ingredient station

Figure 4.22: Alternatives idea for organizing and labelling for ingredient station

4.8.1.3 Shine

Shine, or Seiso in Japanese, is the third stage of the 5S method. Once everything is sorted and organized, from each individual work area to the whole facility, it must be maintained. The primary goal of this stage is to begin the process of identifying and eliminating the source of waste and filth. This technique aids in keeping the preparation table free of cluttering objects while also keeping the area around it safe from dangers. During the production of long rusk biscuits, powdered and watery ingredients are frequently mixed together, resulting in a dusty working environment and a damp floor. After the manufacturing procedures, regular cleaning such as wiping, and sweeping are recommended. Every worker should take personal responsibility for their own workstation and be willing to pick up garbage, along with other things, in order to keep the workplace clean. Before leaving the workplace, the worker should attempt cleaning it thoroughly. After the shining process is completed, all cleaning equipment should be returned to its appropriate places.

4.8.1.4 Standardize

Standardize, or Seiketsu, guarantees that the first three phases of the 5S methods remain successful. The best practices established in the first three phases must be standardized. This phase necessitates that the preparation station be well-maintained and structured following the previous three rounds of development. It is possible to incorporate new practices into routine work procedures by writing down what is being done, where, and by whom as a checklist in the workplace, as illustrated in Appendix G. This approach assists the organization by making an effort to include everything in the preparation station, such as the rules, operation, and equipment, which may enable the ordinary worker fully to grasp the procedures and get involved in process management. People will most likely require reminders about 5S at first. Small amounts of time should be allocated up each day for 5S chores. The excellent procedures established in the first three phases must be standardized, paving the path for long-term improvement. As a result, it is necessary for managers to develop a work structure that will support the new behaviors and convert them into routines.

4.8.1.5 Sustain

The final stage is 5S Shitsuke or Sustain, ensuring that the company continue to continuation of the Sort, Set in Order, Shine and Standardize steps. This is the most essential stage in ensuring that all workers adhere to the 5S standards on a regular and systematic manner. For the 4S to continue to be practiced at the ingredient preparation station, a follow-up is required. This are some suggestions to the organization to sustains 5S improvement: -

i. Regular training. Regular training should be carried out by providing the worker with the updated standard. Changes in the workplace, such as new equipment, new goods, or new work regulations, may take place. If this occurs, the 5S standard must be revised and additional training provided to workers. This technique will prepare the worker to maintain the facility's processes running smoothly. It also helps new workers perform better and get more acquainted with their tasks.

ii. Daily checks. This approach should be used by supervisors to ensure that the procedure is followed on a daily basis and to assist workers when difficulties arise. The 5S approaches apply to the work process performed by the ordinary worker during the preparation of the ingredients. Therefore, implementation of 5S is their responsible in the workstation. Workers must be well-trained, reminded of the 5S purpose, and motivated to do so in order to achieve this. Providing supervisor assistance would result in a favorable outcome for the development of 5S methods in the workstation.

iii. Standard review. The standards developed as part of the 5S strategy should provide precise and quantifiable targets. By creating a standard review where the workstation being through the internal audit. There is no need to develop a complex checklist; instead, break the review work into discrete tasks as illustrated in Appendix G. Supervisors can verify for 5S compliance using a 5S checklist on a quarterly or monthly basis. So, they are capable of identifying and resolving any issues that arise throughout these evaluations.

4.8.1.6 Expectation Results of Implementing 5S Techniques

The expected outcome of applying 5S techniques at the biscuit company is that it would cut production times, allowing workers to prepare ingredients in less time in a tidy and organized environment. The neat and organized workplace will assist the worker in easily visualizing and searching for the ingredient while preparing and will decrease the Poka-Yoke that the worker makes while measuring the ingredients. Last but not least, an orderly and organized workplace reduces the needless motion performed by workers while preparing to seek for and access the ingredient.

4.8.2 Propose a Standard Operating Procedure (SOP) for Process 2

This section focuses on proposing a concept to enhance the working process in process 2, particularly working element 2 (inserting the mixing bowl into the machine) and working element 4 (attaching the hook beater to the mixer machine). As previously mentioned, the worker takes more time attaching and removing the hook beater from the mixer machine. In reality, the worker is confused during the process of determining whether the hook beater should be locked by rotating to the clockwise or anticlockwise side. As shown in Figure 4.23, the mixer machine used at the biscuit company is an Orimas universal mixer with model GF-201. Since the mixer bowl can hold up to 20 liters or 3 kg, this machine is frequently used in a bakery manufacturing of SMEs. Almost each electronic appliance comes with a user manual handbook that provides vital information such as how to install and set-up the device. Somehow, the instruction book given by the manufacturer is extremely difficult and complex to comprehend. By proposing a new Standard Operating Procedure (SOP) that provides better instructions, workers will be able to do their tasks more effectively.

Figure 4.23: Orimas Universal Mixer with Model GF-201

Figure 4.24 depicts the flow chart of the new SOP. The SOP was created after undertaking research on the website and observing worker A, who succeeds at process 2 which is mixing the ingredients. The mixer machine was initially set with a fixed speed and duration for the long rusk biscuit mixing procedure. So, the new SOP is excluding the process of setting the speed and timer on the mixer machine. Start by placing the mixing bowl in the base unit until it engages with the mixer machine and is securely locked in place. Then, on both the right and left sides, lock the mixing bowl with the fix lock. After that, insert the hook beater into the drive arm. Push the hook beater slightly upward into the attachment. Lastly, rotate the hook beater clockwise until it is properly engaged with the driver arm. Lastly, rotate the hook beater clockwise until it is properly engaged with the driver arm. An instruction poster is shown in the Appendix H while running the mixer machine. This poster may be placed near the mixer machine to serve as a guide for workers as they do their tasks.

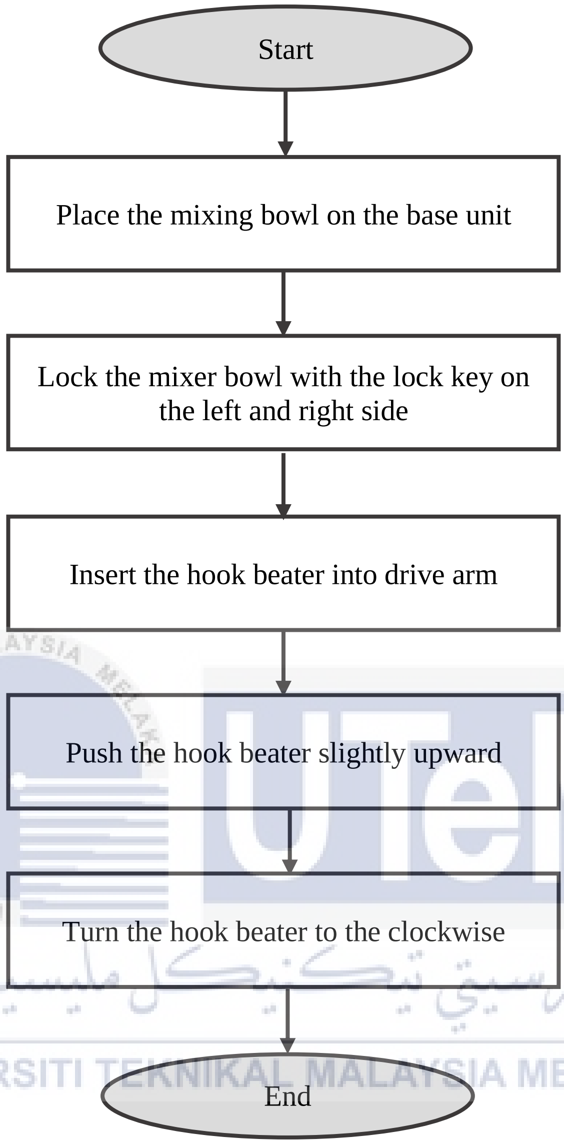


Figure 4.24: Standard Operating Procedure (SOP) for work element 2 and 4 in process 2

4.8.2.1 Expectation of Results of Implementing Standard Operation Procedure (SOP)

The expected result of following the SOP throughout the job of inserting the mixing bowl into the machine and attaching the hook beater to the mixer machine is that the time required to perform the operation will be reduced. By referring to the poster in the Appendix H, it was provided the depicted figure when the worker does the tasks as well as the arrow that shows the motion necessary in the process. It will provide a clear visual representation of the necessary workflow. Furthermore, it will assist current hires in grasping and doing their tasks in a timely manner by adhering to the SOP provided.

4.8.3 Propose a New Equipment for Process 4

This section will propose a solution to a problem that occurred in Process 4 during cutting dough into small pieces. During process 4 of work element 3, the worker has been required to execute the task of cutting the dough into long pieces. The working method takes a long time since they need to cut the dough using a 10cm dough cutter. Figure 4.25 depicts the plastic dough cutter that is now used at the biscuit company to cut the dough into long pieces. Table 4.17 presents a list of options to utilizing the present dough cutter. It has three replacement options: dual roller dough cutter, 5-wheel dough cutter, and single roller dough cutter. Furthermore, each choice is described in detail in Table 4.17.

Figure 4.25: Plastic dough cutter

Table 4.17: List of option for replace the use of dough for the dough cutting process

No.	Solution	Description	Example of Figure
1.	Dual Roller Dough Cutter	The dual roller dough cutter is made of rusk-resistant stainless steel. It is made up of two pieces of roller knife that are attached to the top of the handle and may be easily rolled when cutting dough. Both roller knives have been developed and tested to remain sharp while gliding smoothly over the surface of dough. Dual roller dough cutters are very simple to clean by hand. The price ranges between RM10 and RM15 each piece. It's also simple to obtain in a pastry store or through internet purchasing.	
2	5 Wheel Dough Cutter	The 5-wheel dough cutter is an improved dough cutter made of stainless steel, which is an anti-corrosion material. It is made up of five roller cutters with two handles at the end of each side, as indicated in the figure. The size of the dough to be cut with this roller cutter may be changed by loosening or tightening the extendable arm at the appropriate distance. The extendable arm has a screw that may be locked to ensure that the dough cutting process is precise and consistent. Thus, in one rolling procedure, four equally sized pieces of dough will be produced. The price is high, ranging from RM20 to RM28 each item. This item is available for purchase in both a physical store and an online shop.	
3	Single Roller Dough Cutter	The single roller dough cutter is the most basic roller cutter made of corrosion-resistant stainless steel.. It is made up of a roller knife with a streamlined handle that is easy to hold when rolling. To ensure safe use, a thumb and finger protection is positioned between the cutting wheel and the handle. This wheel cutter is simple to maintain. The price ranges between RM10 and RM15 each piece. It's also simple to obtain in a pastry store or through internet purchasing.	

4.8.3.1 Decision Matrix Analysis for Replace the Dough Cutter Option

Each alternative has its own set of benefits and downsides, as illustrated in Table 4.17. Thus, decision matrix analysis is a valuable tool to employ during the decision-making process. It works particularly well when there are a plenty of alternatives to choose from and a lot of different variables to think about. The outcome will be more assured and reasonable as a guideline for developing the decision making. Table 4.18 shows the decision matrix analysis unweighted assessment. The product criteria are stated on the table's vertical side, while the options are displayed on the table's horizontal side. There are six factors that must be met when adopting a replacement product: made of stainless steel, minimum cost, easy to purchase, ergonomic, safety, and save time. The score in the table's row is a rating for each solution ranging from 0 (bad) to 5 (excellent). All of the criteria were compiled with the goal of simplifying the greasing process and budgeting for SMEs in sight.

Table 4.18: Decision Matrix Analysis Unweighted Assessment

No.	Criteria	Weight	Solution 1: Dual Roller Dough Cutter	Solution 2: 5 Wheel Dough Cutter	Solution 3: Single Roller Dough Cutter
1.	Made of stainless steel		5	5	5
2.	Minimum cost		4	2	4
3.	Easy to purchase		3	3	3
4.	Ergonomic		3	3	3
5.	Safety		2	3	4
6.	Save time		1	4	1

The weighted decision matrix analysis weighted assessment is depicted in Table 4.19, which includes the ratings for each of the given criteria. The primary goal of replacing the old equipment is to reduce the amount of time workers spend cutting dough into long pieces with the present dough cutter. So that, among all criteria save time given the highest priority. Every business in the world wishes to select a product with the lowest possible cost and the highest possible quality. So that, minimum cost has a weighted of 5, safety aspect has a weighted of 4, and the dough cutter made of stainless steel has weighted of 3. Since this procedure requires manual tasks, the new dough cutter should be ergonomic and easy to use. The criteria with the lowest weighting are those that are simple to obtain in Malaysian physical or online stores. Based on the results obtained in Table 4.19, it is obvious that solution 2 (5-wheel dough cutter) is the best alternative.

Table 4.19: Decision Matrix Analysis Weighted Assessment

No.	Criteria	Weight	Solution 1: Dual Roller Dough Cutter	Solution 2: 5 Wheel Dough Cutter	Solution 3: Single Roller Dough Cutter
1.	Made of stainless steel	3	15	15	15
2.	Minimum cost	5	20	10	20
3.	Easy to purchase	1	3	3	3
4.	Ergonomic	2	6	6	6
5.	Safety	4	8	12	16
6.	Save time	6	6	24	6
Total			58	70	66
Continue			No	**Yes**	No

4.8.3.2 Expectation of Results for Change to the 5 Wheel Dough Cutter

The predicted consequence of changing the equipment used during the process of cutting the dough is that the time necessary to complete the work will be reduced. Process 4 (cutting dough into small pieces) has a crucial work element during the cutting of the dough into long pieces. As previously stated, the worker used a dough cutter with a length of 10cm. It will take extra time since the worker would need to cut the dough more than 10cm. Hence, by replacing the previous equipment with a 5-wheel dough cutter, workers may simply do their work by rolling the roller knife on the dough. Furthermore, four equal-sized pieces of dough will be created in a single rolling operation. As a result, it will save the worker time while cutting the dough into long pieces.

4.8.4 Propose a New Equipment for Process 7

This section will recommend a solution to an issue that occurred in Process 7 during the arrangement of the small pieces of dough in the tray. As indicated in the analysis section, the worker is needed to complete the task of greasing the tray with butter during process 7 in work element 2. The working procedure takes a long time since they simply use a pastry brush to spread the butter over the surface of the tray. Figure 4.26 depicts the pastry brush and butter that is now used at the biscuit company to grease the tray. The purpose of the greasing procedure is to prevent the dough from sticking to the pan or tray after it has been baked in the oven. Table 4.20 contains a list of alternatives from using butter for greasing. It has three replacement options: baking spray, baking paper, and DIY baking spray. Table 4.20 also includes a product description and example for each option.

Figure 4.26: Pastry brush

Table 4.20: List of option for replace the use of butter for the greasing process

No.	Solution	Description	Example of Figure
1.	Baking Spray	Baking spray, often known as nonstick baking spray, is a form of sprayable oil used to keep food from adhering to the surface of a pan. Baking spray is just oil in a can. The baking spray contains lecithin (an emulsifier), dimethyl silicone (an anti-foaming agent), butane or propane as a propellant, and flour (to ensure the baked good release perfectly). The baking spray is dispersed in a thin layer by all of the ingredients working together. The consequences of applying baking spray on the long rusk biscuit tray might be similar to spreading butter on the tray surface in a greasing process. It may also be a significant time saving when working with the bakery industry, which produces food on large trays. However, the baking spray is rather costly, ranging between RM12 and RM35 each bottle for 180ml to 250ml. In Malaysia, baking spray is available for purchase in both physical and online stores.	
2	Baking Paper	Baking paper, often known as parchment paper or butter paper, is essentially a replacement for cooking spray or baking butter. It's a nonstick baking sheet with a thin layer of silicon covering to keep food from sticking to the tray. Baking paper is often created by immersing paper pulp in chemicals like sulphuric acid or zinc chloride, or by coating the paper with a silicone-based agent. Baking paper is made from cellulose, which is derived from plants or vegetables. It is also frequently reusable, though it may wear after several usage, and it is easily disposed of. This is an easier procedure for nonstick applications, since it simply requires shredding the baking paper and laying on the tray. Baking paper is significantly less expensive, costing between RM3 to RM8 for 5m to 10m rolls. In Malaysia, baking spray is available for purchase in both physical and online stores.	

3	DIY Baking Spray	DIY (Do It Yourself) baking spray is a simple homemade baking spray. It's made using three ingredients: avocado oil (high heat), filtered water, and all-purpose flour. This approach also makes it a healthier alternative because the consumer is aware of the ingredients. When compared to commercial baking spray on the market, DIY baking spray is more affordable. It may be stored at room temperature and does not need to be refrigerated. In Malaysia, all the ingredient needed is available for purchase in both physical and online stores. Here are the ingredients and instructions for making the own baking spray: <u>Ingredients:</u> 1 cup avocado oil 1 cup filtered water 1 cup of all purpose flour <u>Equipment:</u> 1 Mixer machine 1 Spray bottle <u>Instruction:</u> 1. Place all ingredient in a mixing bowl 2. Mix the ingredients using mixer machine until properly mixture by slightly increase the speed. 3. Pour the mixture in spray bottle 4. DIY baking spray ready to be used	

4.8.4.1 Decision Matrix Analysis for Replace the Grease Option

According to the list of options shown in Table 4.20, each option has its own benefits and drawbacks. Thus, decision matrix analysis is a valuable tool to employ during the decision-making process. It's especially effective when there are a lot of solid options to pick from and a lot of various factors to consider. The outcome will be more assured and reasonable as a guideline for developing the decision making. Table 4.21 shows the decision matrix analysis unweighted assessment. The product criteria are stated on the table's vertical side, while the options are displayed on the table's horizontal side. There are six factors that must be met when adopting a replacement product: safe ingredient, minimum cost, good performance of non-stick, maximum life span, easy to purchase, and save time. The score in the table's row is a rating for each solution ranging from 0 (bad) to 5 (excellent). All of the criteria were compiled with the goal of simplifying the greasing process and budgeting for SMEs in sight.

Table 4.21: Decision Matrix Analysis Unweighted Assessment

No.	Criteria	Weight	Solution 1: Baking Spray	Solution 2: Baking Paper	Solution 3: DIY Baking Spray
1.	Safe ingredient		2	3	4
2.	Minimum cost		0	2	5
3.	Good performance of non-stick		4	4	4
4.	Maximum life span		3	3	1
5.	Easy to purchase		3	3	3
6.	Save time		4	2	4

Table 4.22 depicts the weighted decision matrix analysis weighted assessment, which contains the weights for each of the specified criteria. A safe component is a critical criterion in the food industry since food production must be guaranteed to be safe as well as of good quality from the beginning. So that, among other factors, the safe ingredients are given the highest priority. Every business in the world wishes to select a product with the lowest possible cost and the highest possible quality. So that, Minimum cost has a weighted of 5, saving time has a weighted of 4, and providing a strong performance as nonstick has a weighted of 3. The criteria with the lowest weighting are those that are simple to obtain in Malaysian physical or online stores. Based on the results obtained in Table 4.22, it is obvious that solution 3 (DIY baking spray) is the best alternative, despite the absence of maximum life span due to the lack of preservative ingredient.

Table 4.22: Decision Matrix Analysis Weighted Assessment

No.	Criteria	Weight	Solution 1: Baking Spray	Solution 2: Baking Paper	Solution 3: DIY Baking Spray
1.	Safe ingredient	6	12	18	24
2.	Minimum cost	5	0	10	25

3.	Good performance of non-stick	3	12	12	12
4.	Maximum life span	2	6	6	2
5.	Easy to purchase	1	3	3	3
6.	Save time	4	12	8	16
Total			45	57	82
Continue			No	No	**Yes**

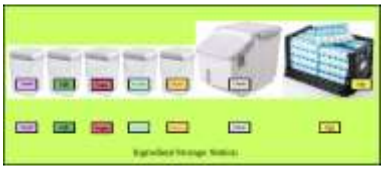
4.8.4.2 Expectation of Results for Change to DIY Baking Spray

The anticipated result of replacing the equipment used during the process of arranging the small pieces of dough in the tray is that the time required to accomplish the task will be decreased. The crucial work element in process 7 is the process of greasing the tray using butter. As previously stated, the worker used pastry brush to spread the butter on the surface of tray. Hence, by replacing the previous equipment with DIY baking spray will give a healthier alternative since the product are made from scratch. It’s also more affordable compared to existing baking spray in the market. The tray's surface will be properly greased by pressing the spray bottle.

4.9 Verification by Industry Representative

As in the preceding part, this section will discuss the verification of the suggested concept. As a description of industry enhancement, a set of technical proposals has been submitted to the founder of the biscuit company. The proposal also included a verification form, as shown in Appendix I, on which the company's owner will make comments indicating whether the concept will be approved or rejected. Table 4.23 summarizes the statements made by industry representatives during the oral interview.

Table 4.23: Summary of the comments by industry representative

No.	Propose an Effective Alternative	Summary of the Comments by Industry Representative
1.	 Adoption of 5S techniques for Process 1	The industry has approved the suggestion for use of 5S techniques for process 1, which is the preparation of the ingredient. The factory's owner acknowledged that because the manufacturing line's current layout was unorganized, workers often needed to look for items or equipment. The establishment of guidelines for internal 5S evaluation has been accepted since it will assist the organization in developing teamwork and promote a better workplace environment.
2.	 Adoption of Standard Operating Procedure (SOP) for Process 2	The proposed concept for the implementation of SOP for process 2, which is mixing the ingredient, has been approved by the industry. It is hard to overlook that the process of inserting the mixing bowl into the machine and attaching the hook beater to the mixer machine is difficult for the worker since they are not trained properly. The factory owner was glad to receive the updated SOP as well as the instruction poster. They believe that by hanging the poster near to the machine as a reference, the worker would be able to perform their duty more efficiently.
3.	 Adoption of 5-wheel dough cutter for Process 4	The industry has dismissed the idea of using new equipment, a 5-wheel dough cutter, for step 4, which involves cutting the dough into small pieces. The suggestion was rejected as this recommended equipment was unsatisfactory to perform the task. The dough is in a fluffy condition throughout the process. Thus, will be more difficult to accomplish the work if the dough is divided with the roller device.
4.	 Adoption of DIY baking spray for Process 7	The idea of using DIY baking spray for procedure 7, which involves arranging small pieces of dough in a tray, was rejected. The usage of liquid state for greasing may have an influence on dough quality since it produces an oily texture for the dough. Thus, the organization does not want to take a risk by implementing a new idea. They believed that applying butter using a pastry brush was a wiser option during the greasing procedure.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This chapter will summarize all the results and findings based on the objectives that have been proposed. It will describe all the findings from implementing the Time Study Analysis and Work Measurement Method in the manufacturing business. In addition, this chapter also highlighted the recommendations for further work.

5.1 Conclusion

This study discusses the objectives and associated problems based on the external problem occur at the biscuit company due to the high demand to produce long rusk biscuit poses a problem for the company, as it cannot produce a large number of products due to the slower production process. Time study analysis is one of the work measurement methods that may be viewed as a toolbox that can be extremely flexibly adapted to improve productivity in the manufacturing industry. Time study is a method for observing and calculating the work done by trained workers in order to complete their tasks at a certain level of performance.

The first objective was accomplished since the time study analysis and work measurement method were implemented in the manufacture of the long rusk biscuit. The workflow of the production has been thoroughly figured out by direct observation throughout the whole procedure. Out of 17 processes, the study mainly focuses on the seven processes of long rusk biscuit manufacture. Thus, each process has been divided into a few work elements in every process with total of 68 elements, and the time required to perform each task has been recorded using a video recording approach. Each work element has been observed by 10 cycles, and a few data are required to perform additional observes after the data has been validated. However, due to an increase in Covid-19 cases, the Malaysian government issued a Movement Control Order (MCO) to all districts in Malaysia, thus the additional observations required were not carried out with the mutual consent of the industrial supervisor. The time standard for each procedure has been set by considering the 95% performance rating, 5% allowances, and 95 % confidence level.

The second objective has been accomplished since the analysis phase on the critical issues of the present process flow in the manufacturing line has been performed. The purpose of conducting this analyze phase in to evaluate the possible problem occurs in the production line. The analysis was carried out utilizing two methods: cause and effect diagrams and the 5whys technique. For each of the major processes, a cause-and-effect diagram was developed. The probable reasons for each category were identified for each process, taking into account six factors: material, measurement, technique, machine manpower, and environment. The recurring difficulties were simply identified by establishing this technique. Another method of analysis is to utilize 5whys approaches, which involve asking "why" five times to simply peel away the layer to the cause, which leads to the four main factors that need to be considered. Thus, countermeasures for each of the factors that occurred were determined.

There are four improvements suggested in order to enhance the productivity in the industry as well as to achieve the third objectives. The founder of the biscuit company has been given a set of technical proposals to evaluate the need for improvement. Out of four alternatives presented to the company representative, two were approved: improvement in process 1 during ingredient preparation by using the 5S approach and process 2 during mixing the ingredient by establishing a new SOP for the work. Meanwhile, the company representative rejected another two suggested ideas since they were insufficient to enhance. As a conclusion, all the objectives were achieved in this study.

5.2 Recommendations

There are some of the suggestions listed below should be made for future work to get better outcomes in this case study:

i. Implement and evaluate if the recommended concept for Process 4 and 7 is successful or not.
ii. Further analysis can be done on another 10 process of long rusk biscuit production.
iii. Implement 5S technique for the entire of working station in the industry.
iv. Create a Standard Operation Procedure for the entire process of long rusk biscuit production.
v. Implement Kaizen method for the continuous improvement in the industry.

5.3 Sustainable Design and Development

Product quality, waste reduction, low-cost involvement, and customer expectations are constantly taken into account in the sustainable manufacturing industry. This research made extensive use of time study analysis. The approach was utilized to establish an efficient process flow in terms of reducing the time required to complete the task. Adopting a new idea for improved process flow in the existing production line would enrich the workers and ensure that the product produced meets the desired accuracy and reliability. The worker who executes the task in accordance with standard operating procedure is capable of minimizing the production process time and expectations of the customer's demand. Work standardization is essential for long-term sustainability. The recommended new standard operating procedure can be utilized by management to provide training to workers in order to improve their capabilities.

5.4 Complexity

The complicated step in this project was in Phase 1 (Implement), which involved collecting the time necessary to complete the task. The data gathering process must be carried out appropriately in order to achieve adequate data for analysis. The average worker should be easy to assign in order to obtain accurate data. Before conducting the study, the worker's health status should be determined so that reliable data can be obtained. During the data collection process, there should be no disruption occur due to the machine breakdown.

5.5 Life Long Learning

The development of each SOP in each process can lead to continuous improvement in the production line. The creation of the SOP can also be updated on a regular basis depending on alterations to the machine, equipment, or working area. Development of the SOP for the assessment of each process of production will simultaneously contribute to continuous improvement, while also making use of the data for further improvement. Furthermore, One Point Lesson (OPL) may be adopted throughout the industry by simply utilizing illustrations, symbols, basic language, or a brief document to describe how a task should be performed correctly. The various OPLs can be printed out and hung on the workstation so that they are immediately accessible.

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APPENDICES

Appendix A

Gantt Chart of Final Year Project 1

Appendix A: Gantt Chart of Final Year Project 1

PROJECT ACTIVITIES	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14
Select the project title, and supervisor	■													
Primary discussion with supervisor		■												
Choose company for case study			■											
Identify the problem statement, objective			■	■										
Identify the scope of project to be study				■										
Prepare and update the Chapter 1: Introduction					■	■								
Analysis the information of literature review in related field					■	■	■	■	■	■	■	■		
Prepare and update the Chapter 2: Literature Review							■	■						
Determine the appropriate of the related methodology								■	■					
Prepare and update the Chapter 3: Methodology										■	■			
Meeting with supervisor to discuss the progress of project	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Preparation of video presentation for FYP 1												■		
Preparation of final report for FYP 1					■	■	■	■	■	■	■	■	■	
Submission of the final report FYP 1														■

Appendix B

Gantt Chart of Final Year Project 2

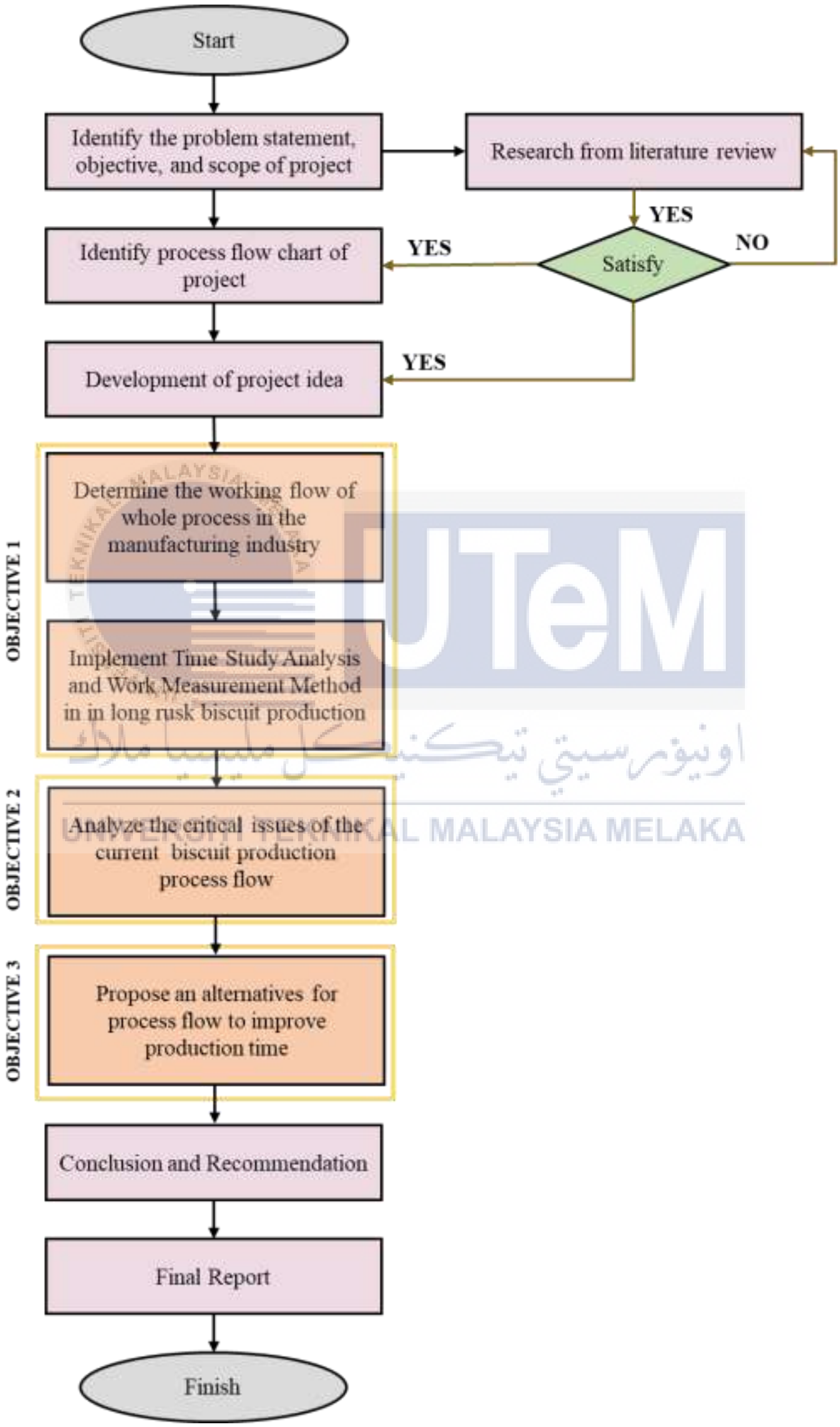
Appendix B: Gantt Chart of Final Year Project 2

PROJECT ACTIVITIES	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14
Industrial selection and visit	■													
Collect the data of time study at the industry		■	■	■										
Analyse the data collection			■	■	■	■								
Identify the critical issues in the industry						■	■							
Determine the effective alternatives							■	■						
Prepare and submit the proposal to the industry representative									■	■				
Prepare and update the Chapter 4: Results and Discussion		■	■	■	■	■	■	■						
Prepare and update the Chapter 5: Conclusion											■			
Meeting with supervisor to discuss the progress of project	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Preparation of video presentation for FYP 2												■		
Preparation of final report for FYP 2	■	■	■	■	■	■	■	■	■	■	■	■	■	
Submission of the final report FYP 2														■

Appendix C

Flow Chart of the Project

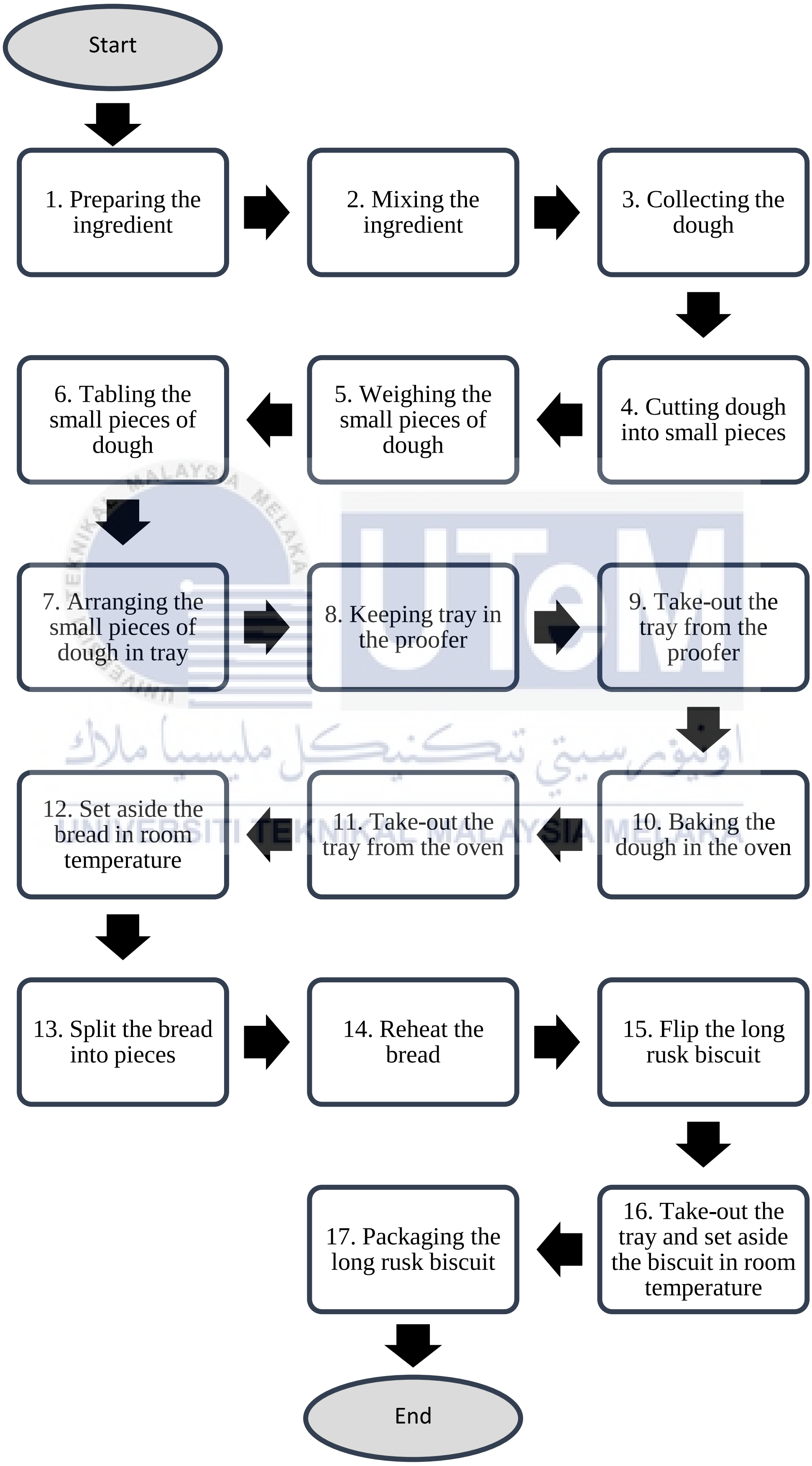
Appendix C: Flow Chart of the Project



Appendix D

Overall Flow Process Long Rusk Biscuit Production

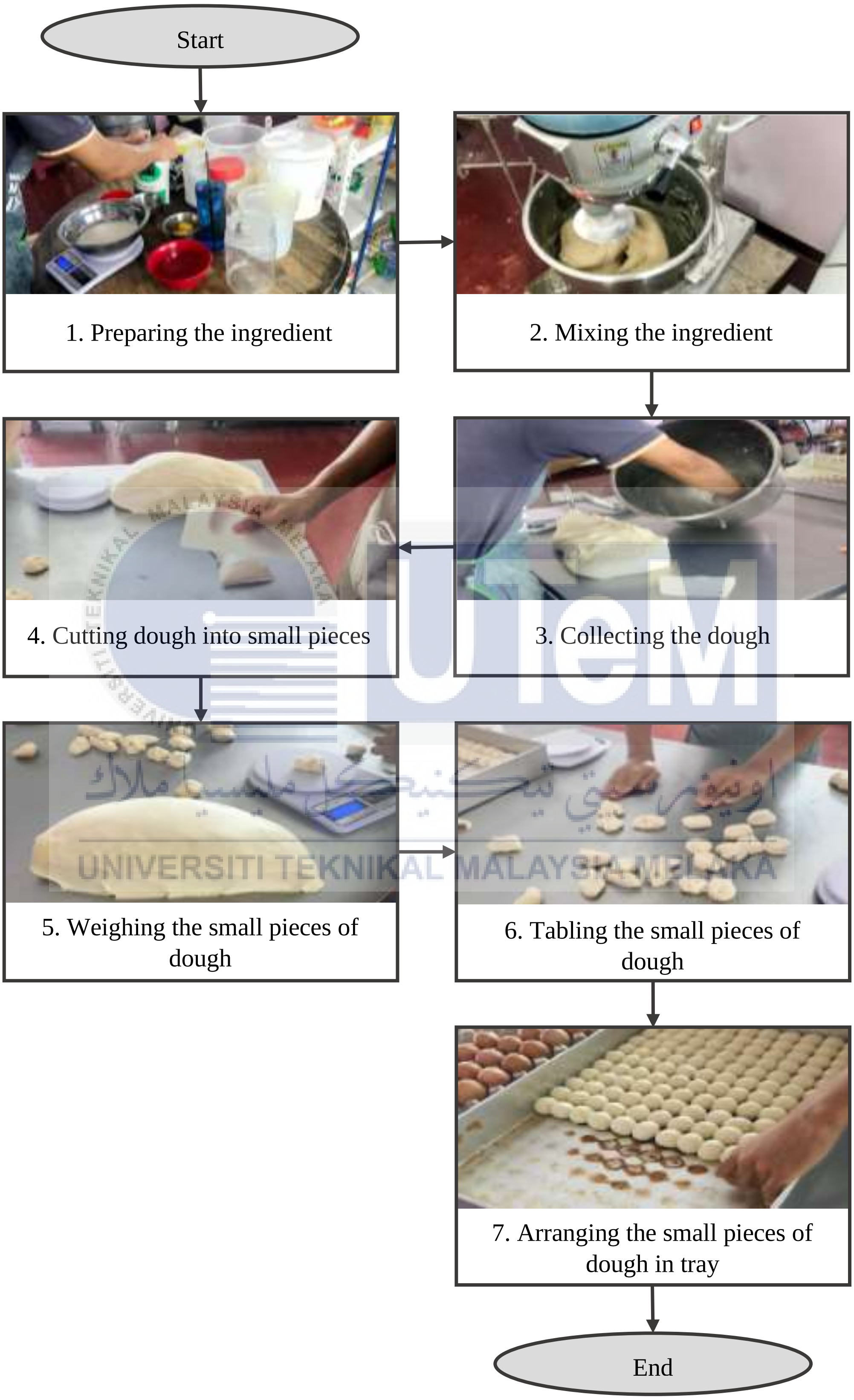
Appendix D: Overall Flow Process Long Rusk Biscuit Production



Appendix E

Main Flow Process Long Rusk Biscuit Production with Figure

Appendix E: Flow Process Long Rusk Biscuit Production with Figure



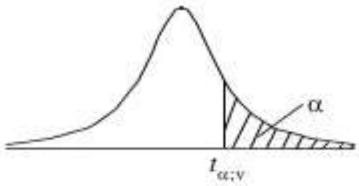
Appendix F

Table of t-distribution

Appendix F: Table of t-distribution

Table of the Student's *t*-distribution

The table gives the values of $t_{\alpha;\nu}$ where
$\Pr(T_\nu > t_{\alpha;\nu}) = \alpha$, with ν degrees of freedom



ν \ α	0.1	0.05	0.025	0.01	0.005	0.001	0.0005
1	3.078	6.314	12.076	31.821	63.657	318.310	636.620
2	1.886	2.920	4.303	6.965	9.925	22.326	31.598
3	1.638	2.353	3.182	4.541	5.841	10.213	12.924
4	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	1.345	1.761	2.145	2.624	2.977	3.787	4.140
15	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	1.328	1.729	2.093	2.539	2.861	3.579	3.883
20	1.325	1.725	2.086	2.528	2.845	3.552	3.850
21	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	1.319	1.714	2.069	2.500	2.807	3.485	3.767
24	1.318	1.711	2.064	2.492	2.797	3.467	3.745
25	1.316	1.708	2.060	2.485	2.787	3.450	3.725
26	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	1.311	1.699	2.045	2.462	2.756	3.396	3.659
30	1.310	1.697	2.042	2.457	2.750	3.385	3.646
40	1.303	1.684	2.021	2.423	2.704	3.307	3.551
60	1.296	1.671	2.000	2.390	2.660	3.232	3.460
120	1.289	1.658	1.980	2.358	2.617	3.160	3.373
∞	1.282	1.645	1.960	2.326	2.576	3.090	3.291

Appendix G

5S Checklist

Appendix G: 5S Checklist

Department: Supervisor:	5S AUDIT CHECKLIST						Completed By: Date:
0 = Compliance	1 = Verry Little Compliance	2 = Some Compliance	3 = Significant Compliance				4 = Total Compliance
	Eliminate unnecessary items from the working station.	0	1	2	3	4	Comment
SORT	Have unneeded ingredient or expired ingredient						
	All the tools and equipment used in the working station is clean from dirt						
	All tools and equipment are placed in the most convenient area						
	Safety hazard - Present sharp material (knife, scissors, etc.)						
	Organize and label the items. Space for everything and everything in its space.	0	1	2	3	4	
SET IN ORDER	The ingredients are place in the specific location						
	All ingredients' containers are label correctly						
	The equipment keeps in proper station						
	Safety equipment are in place and up to date (oven gloves, apron, etc.)						
	Cleaning and keep it clean.	0	1	2	3	4	
SHINE	Preparation table – Kept clean before and after used						
	Floors – Clean from dirt, and wet						
	Bins – Properly maintained and emptied on regular basis						
	Inspection by supervisor or leader						
	Keep checklist and standard to maintain the first 3S.	0	1	2	3	4	
STANDA-RDIZE	Every worker aware of their responsibility						
	Every worker clearly understands on performing their task in daily						
	The improvement idea is developed and use by worker in daily routine						
	The standard for the first 3S is up to date						
	Maintain high standard and constantly seek to improve.	0	1	2	3	4	
SUSTAIN	The 5S checklist is available and up to date						
	The 5S board are efficient to understand and up to date						
	Have improvement and suggestion from the last month review						
	Ability of the worker to explain the knowledge of 5S benefits						
	SUB TOTAL						
	TOTAL SCORE						

Appendix H

Poster for Process of Inserting Mixing Bowl and Hook Beater

Appendix H: Poster for Process of Inserting Mixing Bowl and Hook Beater

Appendix I

Verification Form by Company Representative

Appendix I: Verification Form by Company Representative

VERIFICATION FORM			
Company: Delima Ain Enterprise			
Prepared by: Ms. Nurulwahida Binti Mohd Zain			Issue Date: 8 August 2021
No.	**Idea of Improvement**	**Approvement**	**Comment(s)**
1.	Adoption of 5S Techniques in Process 1	(✓) Approve ( ) Reject	Good idea.
2.	Adoption of Standard Operating Procedure (SOP) for Process 2	(✓) Approve ( ) Reject	Just ok!
3.	Adoption of 5-wheel dough cutter for Process 4	( ) Approve (✓) Reject	not practical at all!
4.	Adoption of DIY baking spray for Process 7	( ) Approve (✓) Reject	not necessary
Checked by: Mrs. Yusnita Binti Rahmat, Founder of Delima Ain Enterprise			Date: 13.8.2021 (Company Stamp)

DELIMA AIN ENTERPRISE
(MA0095809-T)
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