LEAN MANUFACTURING IMPLEMENTATION FOR REDUCTION OF PRODUCTION TIMES AND QUALITY ISSUES IN INDUSTRY

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

by

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DECLARATION

I hereby, declared this report entitled “Lean Manufacturing Implementation for Reduction of Production Times and Quality Issues in Industry” is the result of my own research except as cited in references.

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Date : 9 SEPTEMBER 2021

APPROVAL

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

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ABSTRAK

Kajian ini telah dilakukan di kilang proses pengeluaran ayam untuk mengenal pasti sumber masalah yang menyebabkan kelewatan pengeluaran dan masalah kualiti di industri. Kajian ini telah melaksanakan teknik kajian masa langsung untuk mengenal pasti masa yang dihabiskan untuk setiap proses dan Peta Aliran Semasa (CSM) dibina untuk menunjukkan aliran semasa proses di kilang pengeluaran. Aktiviti tanpa nilai tambah telah dikenal pasti menggunakan rajah Ishikawa dan Analisis Kegagalan Mod dan Kesan (FMEA) dalam setiap elemen proses dan lima jenis pembaziran telah dijumpai iaitu menunggu, bergerak, pengangkutan, kecacatan dan sisa inventori. Oleh kerana tidak ada peralatan yang tepat untuk proses penyembelihan dan pengendalian mesin secara salah di kilang proses pengeluaran ayam maka ia meningkatkan masa pengeluaran dan menyebabkan masalah kualiti. Rancangan penambahbaikan yang terdiri daripada Penyangkut Unggas Automatik, 5S teknik, susun atur kemudahan ruang kerja baru dan Prosedur Operasi Piawaian (SOP) telah diusulkan kepada industri untuk mengurangkan pembaziran, memperbaiki kaedah pengeluaran semasa dan membuang unsur-unsur yang tidak perlu. Peta Aliran Masa Depan (FSM) untuk penggunaan waktu yang disemak semula dari proses yang dipulihkan telah menunjukkan peningkatan penggunaan waktu sebanyak 21%.

ABSTRACT

This study has been carried out at a chicken production process factory to identify the source of problem that caused production delays and quality issues in the industry. This study has conducted a direct time study to identify the time spent for each process and a Current Stream Map (CSM) was developed to show the flows of the process in current production plant. The non-value-added activities have been identified using Ishikawa diagram and Failure Modes and Effects Analysis (FMEA) in each element of the process and five types of waste has been found which are waiting, motion, transportation, defects, and inventory waste. As there are no proper equipment for slaughtering process and handling machine wrongly in chicken production process factory increased the production time and led to quality issues. An improvement plan which consists of Automatic Poultry Hanger, 5S pillars, new facility layout and Standard Operating Procedure (SOP) has been proposed to the industry to reduce the waste, improve the current production method, and remove the unnecessary elements. A Future State Map (FSM) of the revised time utilization of the process were developed which shows an improvement of time utilization by 21%.

DEDICATION

To my beloved family, who always giving me a moral support and encouragement.

To my supervisor, who always give me support, guidance, and motivation in completing my final year project (FYP).

To all my friends, who always lending your hands and support me whenever I need it.

Lastly, to myself since you are a tough one.

Thank you.

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In the name of Allah and all praises to The Almighty, for blessing me with the endless blessings, health, knowledge, patience throughout this semester to finish my projects. Firstly, my great thank to my respectful supervisor, Mr. Nor Akramin Bin Mohamad for his patience, supervision, encouragement, and uncountable guidance throughout my final year project.

Also, a special thank for all my friends who always give their time to support and help me with their love and knowledge when I need it. Last but not least, I would like to thank my beloved parents that provide me emotional and physical support throughout the completion of my project. The current situation has given a big impact to me but without all the support, this project will not be complete.

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LIST OF ABBREVIATIONS

C/O	-	Changeover Time
C/T	-	Cycle Time
CSM	-	Current State Map
CTQ	-	Critical to Quality
ESTRN	-	Equivalent Strain
FEA	-	Finite Element Analysis
FMEA	-	Failure Modes and Effects Analysis
FSM	-	Future State Map
JIT	-	Just in Time
LM	-	Lean Manufacturing
NVA	-	Non-Value Added
QFD	-	Quality Function Deployment
SMEs	-	Small and Medium Enterprise
SOP	-	Standard Operating Procedure
TPS	-	Toyota Production System
U/T	-	Uptime
URES	-	Resultant Displacement
VA	-	Value Added
VOC	-	Voice of Customer
VSM	-	Value stream mapping
WIP	-	Work in Progress

LIST OF SYMBOLS

mm	-	Millimetre
kg	-	Kilograms
%	-	Percent
MPa	-	Mega Pascal
GPa	-	Giga Pascal
°C	-	Degree Celsius
s	-	Seconds
BPH	-	Broiler per hour
g	-	Millimetre per minute
N	-	Newton
Hz	-	Hertz
pcs	-	Pieces

CHAPTER 1

INTRODUCTION

This chapter consists of the overall research analysis, including the background of the study, the statement of problems and objectives. The scope and significance of the research are also explained in this chapter.

1.1 Research Background

Manufacturing industries company must be ready to face challenges and competition in marketplace to be able to meet the market needs. The examples of the challenges are to operate with high productivity and produce high quality of products. An improvement plan must be construct so that industries company able to provide solutions to the problems. Other than that, manufacturers should be more creative and innovative to apply advanced manufacturing technique and skills to plan a better system of production. One of the methods is to merge the improvement activities with the quality. In order to obtain a competitive advantage for most manufacturing industries, productivity and quality improvement are combined intentionally (Soufhwee et al., 2017).

A Japanese automotive company, Toyota, proposed the idea of Lean Manufacturing (LM) during the 1950s, which was well known before as the Toyota Production System (TPS) (Jafri and Seyed. 2015). Lean manufacturing tools is a good approach to solve the problems by the industry practitioner since it provides tools and strategies that can review and identify the problem and reach the objectives of the manufacturing industries company. Since customer always require fast production with the best quality so to response to these requirements, LM has been applied because it reduces waste without additional resource requirements (Jaiprakash and Kuldip, 2014). Waste is an activity along the value stream that does not provide value added in the process. One of the most important requirements for obtaining maximum outputs with minimum inputs in all processes is to remove waste elements.

There are 7 types of waste in lean manufacturing listed by Toyota which are overproduction, inventory, transport, defects, processing, motion, and waiting (Seher and Hatice, 2015). This waste has been reviewed as the problems that usually donate to high time usage in production and quality issues. According to Soufhwee et al. (2017) by implementing a lean manufacturing tool, we can identify the root problems and plan a solution. Therefore, by implementing LM tools, it helps to reduce the production times and quality issues experienced by the industry. Industry will become more reliable since the productivity and quality issue has been resolved.

1.2 Problem Statement

The manufacturer practitioner in industrial sector is required to be more innovative, effective, and adaptive. Standardization is important to overcome the gap between competitors in terms of production speed or efficiency, improve product quality and lowering the average failure. To fulfil the customer demand, industry must be able to commit and complete the customer order on time. Study by Rekha et al. (2017) and Lopes et al. (2015) has identified issues such as unnecessary movements of man and material on work area, less time utilization and non- value-added activities that somehow slowed down the production rate. Any excess beyond the requirement for equipment, materials, parts, and working time is generally referred as the waste (Prakash and Mothilal, 2018). Hence. waste production time to manufacture the product must be reduced to increase productivity. Another essential goal of the manufacturing process is to produce product with good quality but to be efficient in speed for production may cause lots of quality issues. A case study by Jimenez et al. (2019) experienced increase index on the products returned in the year 2015. Non-conforming products has been identified to not meeting the required specifications caused by lack quality controls. Another study of quality by Soufhwee et al. (2017) has also identify lack of training and not following the instructions. This measure reflects the company's high costs and the key triggers of returns, as it is related with non-compliance with consumer specifications and product quality issues.

This study has been conducted at Mohamed Akbar Enterprise which is a chicken processing factory that mainly process and distributes chicken in Rawang area. The company also known as a Small and Medium Enterprise (SMEs) company. Based on internal and external customer's complaints, there are several problems the company faces in producing the good products to satisfy their customers in the production process. A highly demand of chicken that need to be distributes give the problem to the company as they cannot provide the required number of chickens needed due to the slower production process. In addition, some of the chicken feather appear on the skin of the chicken. The inconsistency on the appearance lead to customer complaints. Issues that arise can be categorized as waste, therefore the suitable solution to remove the waste need to be identify in order to solve the problems. A systematic approach such as production line analysis, data collection, and using technical approach need to be consider in solving the problems.

1.3 Objectives

The objectives of this study are:

1. To apply direct time study technique on the production line of the chicken production process
2. To develop Current State Map (CSM) for the chicken production process
3. To evaluate the waste in current chicken production process using root cause analysis
4. To develop Future State Map (FSM) with proposal solution for the chicken production process

1.4 Research Scope

This project will focus on doing an analysis on the production line using direct time study for all six processes in chicken production process. This study also will concentrate on conducting waste analysis only on the first three processes. Lastly, this study will focus on reducing the production times and quality issues using lean tools by proposing a solution.

1.5 Significance of the Study

Solution development for production line that experience productivity and quality issue is very crucial to ensure the industry able to fit in meeting the customer demands. Implementation of Value Stream Mapping (VSM) will help to find out and effectively gather the information on how the process is achieved with the help of the information obtain through the analysis. In addition, this tool helps in reducing quality issue since it provides systematic flow of waste prevention.

1.6 Organization of Report

This report will start off with Chapter 1 that consist of an introduction of the project, problem statement, the objective that needs to be achieve, the research scope and its significance. It will follow by Chapter 2 that consist of a literature review of previous study on Lean manufacturing tools and technique. Lastly, the last chapter is Chapter 3 that will consist of solving methods that will be implemented to rectify the issue that faced by the current industry.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter will be discussing on the literature study. For some information, literature review is an individual part of the research that give some reviews from some references such as articles, journals, books, and the thesis project that relate to the project research.

The topic that will be cover in this chapter is something related to the project to make better understanding on lean manufacturing and how it helps in reducing production times and quality issue in current industry. The idea on the source and the type of the problems will be further discuss in order to have understands on how the problem should be solve. Previous studies will be reviewed to see the scenarios that happen in current industry to gain more ideas on suitable method to be used in solving the problems.

2.2. Definition of Lean Manufacturing

Cambridge Business English Dictionary (2011) gives lean its definition as efficient. Lean is an adjective where in management category, lean can be described as using fewer staff or less cash while continuing to function effectively in order to minimize waste. Lean is a systematic method of strategies for minimizing and then removing the seven wastes when combined and matured (Wilson, 2010).

García-Alcaraz et al. (2014) described lean manufacturing as combination of few methods to remove activities that obtain no add value by increasing the value of each operation to the product, service and process. This helps companies significantly reduce activities that has no value and improve the activities with value, ultimately improving their operational performance (Shah and Ward, 2002; Chavez et al., 2013; Bortolotti et al., 2015). Akdeniz (2015) added that lean is a concept focused on the customer's delivery of value, because it can be decided from the perspective of the customer when an operation constitutes value-added work. Lean manufacturing methods are rational and can be thought of as a journey to a more profitable future as the techniques are applied (Dudbridge, 2011). Tortorella et al. (2020) highlight that not only was lean manufacturing (LM) simple to implement, but it also provided companies with large returns.

2.3. The History of Lean Manufacturing

Before lean manufacturing exist, there are several previous studies and implementation before the concept of lean manufacturing widely used. Each of those studies will be explained more briefly as follows.

2.3.1. "Mass Production System" by Henry Ford

It started off with the idea to fulfil the industry requirement by Henry Ford. Anil and Ali (2020) acknowledge the technological advances in mass production from the past to the present come to mind in the history of mass production enterprises. Ford's assembly line revolutionised everything, as it had never been done before (Winter, 1996). According to History.com (2020), Henry Ford invented moving assembly line for mass-production of an entire car. Time has been shorten through his breakthrough from more than 12 hours to one and a half hour to manufacture a vehicle. According to Banton (2020) as a consequence of Ford's mass production, cars became a product that the general public could afford, rather than a luxury product that only limited for people had access to.

The immediate result was revolutionary for the production line. The use of internal changeable components allows laborers for continuous work progress and more time on job. Goss (2020) emphasized that specialize of workers resulted in waste reduction and the final product was higher in quality. The assembly line improved lives of those working by

Ford significantly as the workday was shortened from nine hours to eight hours in order to make it easier to introduce the three-shift workday concept.

2.3.2. Toyota Production System (TPS)

The Toyota Production System (TPS) is recognised for changing production in the same manner that Henry Ford's assembly line changed manufacturing half a century before (Marksberry, 2012). When TPS was established in the second part of the twentieth century, it donates benefits from years of continuous improvement to improve production speed and efficiency. According to Fritze (2016), the founder of the Toyota Production System (TPS) whom also the founder of lean management, Taiichi Ohno is very well known. Gupta (2018) states that in 1932, initially he was a part of Automatic Loom Works and then joined the Toyota family which later began producing cars under the Toyota Motor Corporation. Next, the Loom Works was transformed into a Motors Works during the turmoil of World War II and Taiichi Ohno made the transition to the production of car and truck parts (Becker, 2016).

Toyota Production System always aim for efficiency (Marksberry, 2013). The Toyota Production System is a production method that aims to optimize processes, minimize resource waste, leading to improved performance, quality and profitability (Merih, 2017). According to Osono et al. (2008), the main finding was the success of Toyota can be found not only in its famous production process, the "Toyota Production System," but also in the unusual management method of developing and fostering within the company a fascinating collection of contradictions, opposites, and paradoxes. Managers of every organization will introduce these paradoxes, with powerful effects.

2.3.3. "Lean Production" Term by John Krafcik

While lean production derives from TPS, John Krafcik actually came up with the term "lean" in his 1988 essay, "Triumph of the Lean Production System" which continues to be important today (Sharp, 2017). The word "lean production" was arguably first used in an article by John Krafcik in the MIT Sloan Management Review (Graban, 2013) but, popularized by Daniel Roos, Daniel T. Jones, and James P. Womack in the book The Machine That Changed the World (Autry et al, 2013). According to Zokaei et al., (2013) the term was used by Krafcik, who researched the comparative performance of automotive assembly in Japan versus the West, to characterize the ability of Toyota to do much more with far less.

Lean production also identified as a production method that focuses on waste reduction, continuous improvement (Kaizen) and quality obsession (Womack et al., 1990 as cited in Thomas and Darina, 2014). According to Moyano-Fuentes et al. (2012), in order to enhance quality, cost, and delivery, the reasons of uncertainty or losses (anything that the consumer assume as added value) and the causes of inflexibility (anything that does not meet to the customer's request) must be considered. Lean allows only what is necessary to be generated, only when it is needed and only in the quantity requested. Therefore, Manea (2013) highlights on the fact that lean production is predominantly centred on just-in-time manufacturing.

The idea of lean processes is still at the core of most production operations in the whole world today and becoming highly relevant in other sectors of the industry, including distribution and financial services (Records, 2018). Nwanya et al. (2019) believes with evolution of events and time, the principle should be able to change industries that apply the techniques.

2.4. Wastes

There are 3 categories of waste in lean manufacturing which the explanation is in the following subsection.

2.4.1. Muda, Mura and Muri

According to Do (2017), the Toyota Production System, which evolved into the Lean concept, is meant to cut down on the three types of errors that indicate poor resource allocation. In Figure 2.1 shows an illustration of Muda (無 駄, waste), Mura (斑, not same), and Muri (無理, overwhelming) which are the three kinds.

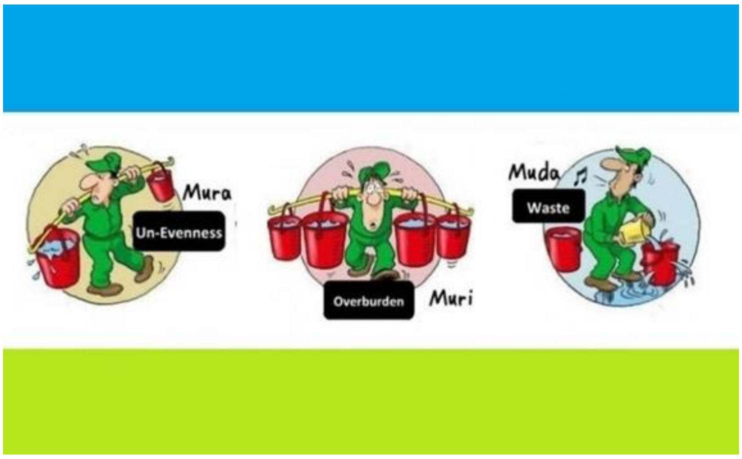


Figure 2.1: Illustration of Muda, Mura and Muri

According to Bubbard (2010) ‘Muda’ is a list of predetermined Japanese word for an operation that is unnecessary or unproductive while Tony (2020) described ‘Muda’ as the Japanese term used by Toyota to describe a method or waste that does not add value. According to Bradbury (2018) such forms of waste does not assist the organization or staff. They raise costs and make it much longer for activities than they should. Customer considers value-added activities are which they willing to pay, and any non-value- adding action from the customer's perspective and operations that absorb too much the resources that relate with the effects and values they generate are treated as waste (Wahab et al., 2013).

Mura is defined as exceeding the capacity of a piece of equipment, a facility, or a human resource. In his article Identifying and Eliminating the Seven Wastes or Muda for the Asian Institute of Management, Domingo (2015) explained how the lean system fights and eliminates Mura or overload, Muri or unevenness, as well as ‘Muda' or waste. Hence, flaws are manufactured into goods, consumers receive inconsistent products or services, and the factory floor fails to finish large orders and remains idle as orders slowdown said Bradbury (2018). More worryingly, ‘Mura’ produces ‘Muri’ (overburden), which in turn undermines efforts to remove the seven ‘Muda’ waste.

Henshall (2018) interpret Muri as unevenness. Muri is one of the most common causes of bottlenecks, which occur when a process fails to achieve its output, causing waste to be created in other processes that are unable to reach their full or optimal output. In Netland (2017) blog, he translated Muri into an overburden of machines, people, and processes in a production factory. It is "totally unreasonable" because overload would make the output break down. Lastly, Thürer et al. (2016) conclude all three, with Muda being regarded waste in the literature and Mura and Muri being considered waste causes, or situations that contribute to waste creation.

2.4.2. Seven Wastes of Lean

As part of the Toyota Production System, seven primary forms of waste have been reported. However, this list has been amended and extended by numerous lean manufacturing practitioners (Khalil and Muhammad, 2013). In reducing waste, organizations make widespread usage of waste reduction methods in production which if correctly implemented, it capable of eliminating waste at all stages of growth and production. (Kučerová et al., 2015). But before eliminating any waste, waste must be identified first. Transportation costs, waiting costs, overproduction costs, cost of defects, inventory costs, cost of movement and excess cost of processing stream are the seven wastes (Sabaghi et al., 2012) which could be located by VSM (Prieto-avalos et al., 2014). Figure 2.2 below shows the segregation of waste according to categories.

Figure 2.2: The segregation of waste according to categories

a) Transportation

Transportation waste happens whenever goods or materials are moved (Pereira, 2009). Kučerová et al. (2015) said that transportation is part of the manufacturing process that cannot be removed, but does not give the final product any value, and that is why it needs to be reduced to the lowest possible level.

b) Inventory

This Muda refers to raw materials, work in progress, or finished products distributed across the warehouse and shop floor (Simboli et al., 2014). Excess inventory continues to disturb the factory floor which must be discovered and addressed in order to improve operational efficiency. Excess inventory lengthens lead times, takes up valuable workspace, delays problem identification, and complicates communication.

c) Waiting

There is a waste of time when items are not moving or being processed. In typical batch-and-queue processing, more than 99 percent of a product's life is spent waiting for an ongoing procedure. Much of a product's lead time is spent waiting for the next step. This problem occurs when material flow is poor, the production process takes too long, or the distance between work areas is too large.

d) Defects

Quality failures that result in rework or scrap cost companies a lot of money and have a direct impact on the bottom line. Inventory quarantine, rescheduling, re-inspection, and a shortage of capacity are all related expenses. In many firms, the overall cost of faults accounts for a significant portion of the entire manufacturing cost.

e) Over-processing

This situation happens when more work is performed on the production line than is required. This often requires the use of materials which are more complicated or costly.

f) Overproduction

When there is more demand for an item than there is supply, this Muda refers to the waste of completed goods inventories. Excess production, in turn, necessitates the use of capital in advance, and the above requires warehouses to keep finished items as well as supplies awaiting sale.

g) Motion

This waste is synonymous with ergonomics, which was defined as bending, extending the body, walking, moving, and reaching in all situations. In today's capitalistic society, there are also worries about health and safety, which are becoming more of a problem for businesses.

2.5. Non-Value-Added Activities

Removal of waste must follow by the knowledge of non-value-added activities. According to Beels (2019) in his blog, a non-value-added activity including process that use resources but does not add value to the service or product. Shrut and Suyash (2015) believe that these are the practices that contribute to increasing the time spent on a product or service without substantially contributing to improve the value of goods or services to a consumer. A dramatic time and cost reduction in the manufacturing processes can be obtain by eliminating such activities.

A study by Parkhan et al. (2018) shows a reduce of lead time of up to 440.4 seconds. It is achieved when eliminating 17 behaviours of non-value activities. The production can then be increased by up to 21%, which is equivalent to 5022 parts. In another case study by Haryati and Zakaria (2016) on construction work which can also supports the idea when they identify that 78 percent of non-value-added occurred are defective and waiting time. Therefore, a significant effect on the time, expense, quality and efficiency of the project by removing defects and waiting times during structural and architectural work. From the study, by knowing the non-value-added activities, we know the importance to identify the activities into different classes so the characteristics of the respondents towards waste categories and waste variables were clearly analysed (Alwi et al., 2002).

2.6. Principles of Lean Manufacturing

There are 5 principles of lean manufacturing that must be follow in order to achieve a success results implementation to the industry. The principles of lean manufacturing will be explained on the following subsections.

2.6.1. The Five Lean Manufacturing

Figure 2.3: Five principles of lean

Figure 2.3 above shows the Five Lean Principles in Lean. Do (2017) said that Roos et al., (2014) explained in their book, The Machine That Changed the World, describing the five principles of Lean Manufacturing. They described all the principles according to pages. The five principles are considered as the best way in improving efficiency at the workplace which includes:

a) Defining value

From page 16, they describe that it is important to understand the value in order to completely understand the first principle of defining customer value. What the customer is willing to pay for and discovering the customer's real needs. Clients may not know what they want or are unable to articulate it sometimes.

b) Mapping the value stream

Next, in page 19, The second Lean concept are used to identify and map the value stream. It is a reference to identify all the activities that do not add value to the final consumer which regarded as waste. The waste can be divides into two categories: added activities but necessary and non-value-added activities. The non-value added is waste and should be eliminate and the former should be reduced to the highest level.

c) Creating flow

On page 21, following the removal of waste from the value stream, the next step is to guarantee that the flow of the remaining processes continues smoothly. By removing process, reconfigure production steps, workload levelling, develop cross-functional divisions, and produce multi-skilled worker is the ways to ensure the smooth flow of value-adding activities.

d) Using a pull system

Inventory is one of the largest wastes in almost all production systems. The objective of a pull-based system is to avoid items of inventory and work in process (WIP) while ensuring that the required materials and data are available for a better process flow. Essentially, a pull-based system guarantees the supply and manufacturing of just-in-time items, which are manufactured at the precise moment and quantity necessary. This principle was described in page 67.

e) Pursuing perfection

Lastly, the fifth step was discussed in page 25 on pursuing perfection which is the most vital among all of them. The organization's culture includes lean thinking and continuous improvement. Each worker should strive for perfection while delivering products only on what customer required.

2.7. Lean Manufacturing (LM) Tools and Technique

Table 2.1: Lean manufacturing tools and technique

No	Tools	Descriptions	References
1.	Value Stream Mapping (VSM)	Useful to identifies value added and the non-value-added time for each phase, analysing it for waste and then making a future map of the state by removing the found waste.	(Deshkar et al., 2018; Rekha et al., 2017; Shaik Dawood A.K et al., 2018)
2.	Takt Time	Takt time is used in manufacturing environments to identify lines pace and the time it took to complete successive end product units.	(Neha et al., 2013; Sundar et al., 2014)
3.	Just in Time (JIT)	The theory of management applied in production includes getting the right products in the right place and at the right time with the exact quality and quantity.	(Mothilal B and Prakash C, Kootanaee et al., 2013)
4.	Cellular Manufacturing	Reviewed as a simplified form and grouping of diverse parts manufacturing equipment and product organization that carries out production in manufacturing plan.	(Sundar et al., 2014; Sílvio and Anabela, 2002)
5.	5S	A Japanese originates acronym which begins with the letter S: Seiri, Seiton, Seiso, Seiketsu and Shitsuke is to create a workplace that encourages industry workplace standardization, visual control and visual display to minimize the waste of waiting and movement as things is easier to find.	(Rekha et al., 2017; Mothilal B and Prakash C, 2018; Lopes et al., 2015)
6.	Andon	A visual control that allows the operator to inform the manufacturing process status of the machines and production line.	(Shaik Dawood A.K et al., 2018; Mohammad et al., 2019)
5.	Jidoka	Jidoka is a method and a framework in the field of lean manufacturing that can be described as a collection of design principles for automation systems aimed at separating human operation from machine cycles so that a human operator can participate in few machines, preferably in different types of sequence work and systems.	(Ohno, 1998; Romero et al., 2019)
6.	Poka Yoke	Poka-Yoke is an error and defect detection system where the idea that producing even a small number of faulty products is not appropriate.	(Shaik Dawood A.K et al., 2018; Mothilal B and Prakash C, 2018)

2.8. Production Times

Production times is basically the time duration of a product to be develop from the first process until the end. The process includes from the raw material until it was kept in the inventory. Reducing production time frees up existing inventory, allows fixed assets to be better used, helps speed up replication rates, and helps to improve performance. Therefore, no waste such as inventory or over production will happen.

2.9. Value Stream Mapping (VSM)

Value Stream Mapping (VSM) can be defined as ‘‘a tool that assist to visualize and understand the flow of materials and product as it passes through the value stream” (Rother and Shook, 1999). Value Stream is a compilation of all Value Adding (VA) and Non-Value Adding (NVA) activities undertaken to produce a part starts from raw materials into a part of the product family chosen (Deshkar et al., 2018). Lukmandono et al. (2019) emphasize that VSM is a technique that makes it easier to identify value-added and non-value activities that have been added to the manufacturing sector to find the root problem in a process. With the assistance of VSM, it was possible to identify many wastes during the production process (Abdulmalek and Rajgopal, 2007).

The mapping process of the value stream allows creation of a detailed visualization on all the steps in the production process. It is a representation of an organization the flow of their products from the manufacturer to customer as it shows all the significant steps taken to produce from its start until finish. It enables you to visualize every task the operator is working on and provides the status reports on the progress of each task. Deshkar et al. (2018) also state that VSM involves mapping the current state of the process, analysing its waste, and then constructing a potential map of the state by removing the found waste.

2.9.1. Commonly Used Value Stream Mapping Symbol

To start drawing a map of production plan in one's industry, the important element is to know the symbol that is used to produce the map. According to Langstrand (2016), for value stream mapping, there is no standard measurement, but there are some commonly used symbols when starting to learn the method that provide a good starting point. Figure 2.4 below shows the common symbol to draw a value stream map.

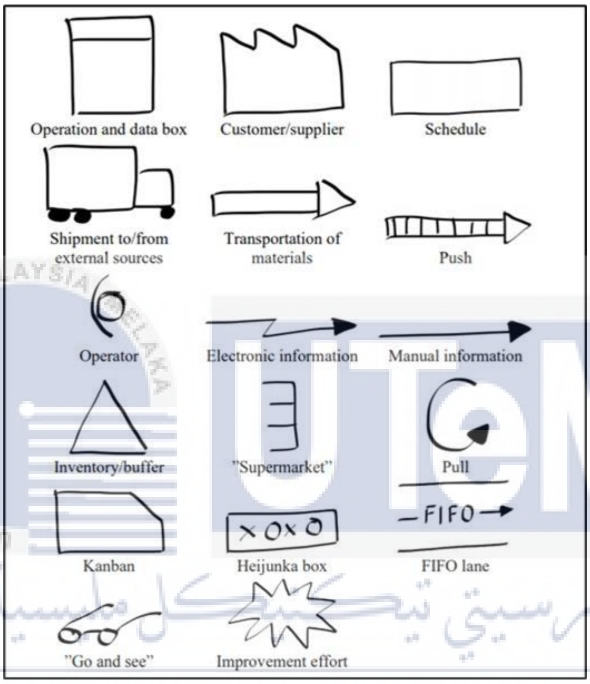


Figure 2.4: Common symbol to draw a value stream map

2.9.2. Current State Map (CSM)

Shweta and Sunith (2015) said that all details on each step of process and how each phase is operating and processed are represented in the current state map. The current situation needs to be defined and then identified the aim together with the gap between current situation and where the other situation that need to be recognized. This will help to identify the causes of issues and thus the means of improving the process's flow and the efficiency. Other than that, Deshkar et al. (2018) also state that prior to mapping the current state, the prerequisites are:

i. Cycle time, Changeover time, Uptime
ii. Inventory
iii. Customer request
iv. Schedule of supply
v. Sequence of operation
vi. Number of workers on each process
vii. Number of shifts working time and breaks.

In Figure 2.5 shows an example of current state map diagram and the important elements needed in order to develop the map.

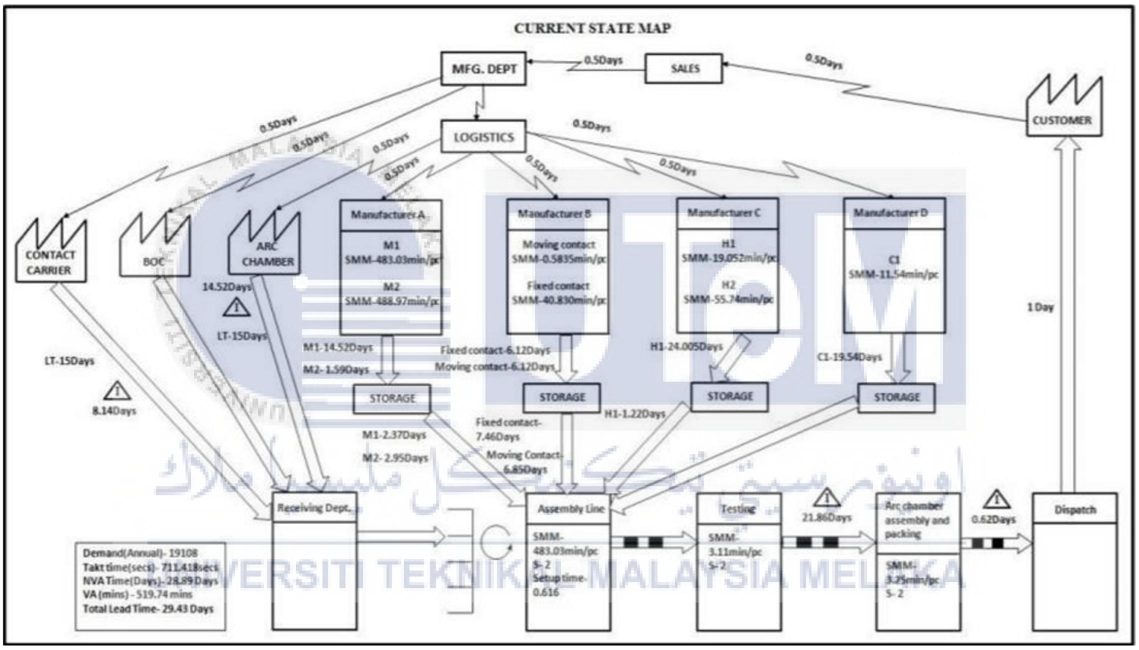


Figure 2.5: Current State Map (CSM) (Shweta and Sunith, 2015)

2.9.3. Future State Map (FSM)

Future state map is another step to complete value stream mapping implementation where it will show the progress or future of one's organization after implementing lean tools. Masuti and Dabade (2019) highlights that the FSM assists the user to identify location to implement the changes and how to use the Kaizen burst symbol to tackle them. The important thing before developing a future state map is to do a line balancing. When there is production line involved, a value stream is necessary. It because, queuing effects are one of the problems that cause waiting between processes (Jafri and Seyed, 2015). This led to the creation of the bottleneck by gathering work in an uncontrolled process. Removing bottlenecks and make a continuous flow were suggested to help producing a better FSM. Figure 2.6 shows the example of future state map where improvements has been implemented.

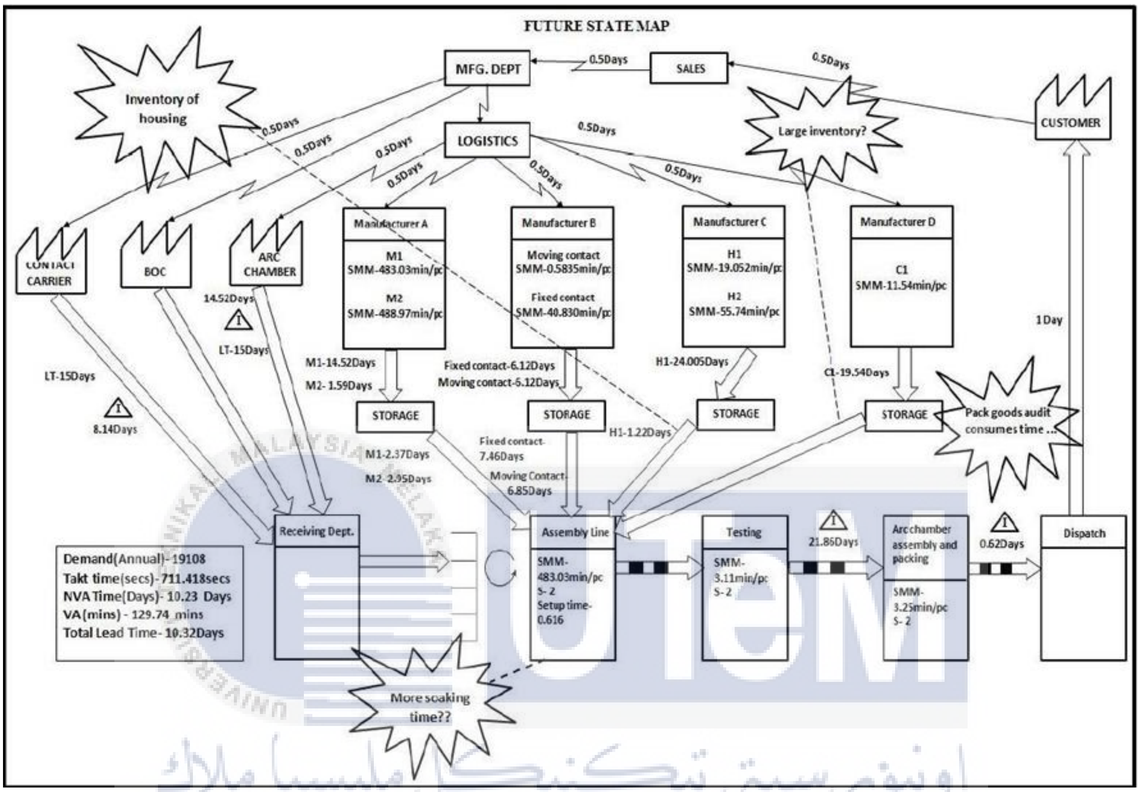


Figure 2.6: Future State Map (FSM) (Shweta and Sunith, 2015)

2.9.4. Benefits of Value Stream Mapping

According to Li (2014), Value Stream Mapping increase the understanding of process that provide customers with a good quality product. VSM process provides effective method to set better directions for a good decision-making and work pattern. Other than that, the method is suitable in solving different kind of issue of waste. In fact, due to its ease of adaptation to a wider range of environments, the application of VSM has extended to many industry sectors in recent years (Romero and Arce, 2017). Table 2.2 below shows the application of VSM in different environments.

Table 2.2: Application of VSM in different environments

No	Sectors	Source
1	Construction	(Matt et al. 2013; Hayati and Zakaria, 2016)
2	Innovation Management	(Peek & Chen, 2011)
3	Mining	(Kumar, 2014)
4	Food loss reduction	(Steur et al., 2016)
5	Service maintenance	(Kasava et al., 2015)

2.10. Product Design Analysis

Design management in the context of Small and Medium-Sized Enterprises (SMEs) for academic interest has grown rapidly over the past several decades which is particularly important and challenging (Carneiro et al., 2021) to be applied for industry. According to Zhang et al. (2019) an innovative product design framework is provided that takes make-or-buy analysis and supplier selection into account at the same time. The consumer preferences are firstly determined to classify them into different categories. Then, the potential design is derived from material databases or projections utilising computer-aided methods. Steps in determining design selection will be explained on the following subsections.

2.10.1. Critical to Quality (CTQ)

In order to provide consumers with the highest level of satisfaction, accurate evaluation of their needs and clear understanding of their expectations are required (Aguwa et al., 2017). The customer or consumer needs can be obtain through Voice of the Customer (VOC) which is a vital procedure that accurately records consumers' feedback defining their product and service needs and expectations on the product. Then, through the Voice of Customer, Sérgio and Eusébio (2019) recommend that companies must select which CTQ parameters will be regulated, in which process, and how the control technique will be implemented.

2.10.2. Planning Matrix

A planning matrix is a useful tool in project management as it can summarize the rank for design complexity. The key elements of a product can be identify through the implementation of planning matrix. A matrix-based method will be suggested as an alternative to standard project planning methodologies, with the goal of meeting management claims (Kosztyán, 2015). Palmer (1987) stated that this matrix approach is essentially a project planning tool that defines project inputs, outputs, and intermediate and higher objectives in terms that can be measured or objectively verified.

2.10.3. Quality Function Deployment (QFD)

Quality Function Deployment is based on customer quality assurance and product planning approach that translates qualitative consumer demand into quantitative measure by allowing the customer's voice to be included into technical characteristics (Akansha and Sanjay, 2021). According to Xingli and Huchang (2021), the QFD's primary goal is to identify "the voice of the customer" for the conceptual design of products or services by converting customer request into design production. Although QFD has been widely used to create products based on customer needs, it may be used in decision-making situations where alternatives must be assessed using criteria defined by technical experts and final consumer.

2.10.4. Morphological Chart

To fulfil customer or user requirements, a conceptual design will be developed to establish the initial idea of the product. Dereje and Fakhruldin (2014) described conceptual design as a design activity that includes problem definition, idea generation, concept firming up into concept variations, and assessment to determine the best concept for future development. The concept generation process generates a several number of concept variants, which must be evaluated thoroughly before the optimal design can be chosen. Lo et al. (2010) further described that morphological chart consists of a table arrangement that connects the intended product functions (left-hand side) with the alternative solutions for each of them (right-hand side) and lists as many technical future characteristics/specifications as feasible. Then, the processed data that was integrated into morphological matrices with the findings confirmed by conceptual design tests (Dragomir et al., 2016).

2.10.5. Screening and Scoring Concept

A several options of product design cause a stir of choices for development of a product. Essentially, screening and scoring concept may be utilised whenever a decision must be made amongst several options. The goal of screening and scoring is to reduce a large number of concepts into a smaller, more manageable group. There are two procedures that must be conducted to finalize the design of the product which are:

a) Screening concept

The initial technique employed was screening concept, which consisted of simply comparing each design to the original. Concept screening is a technique for filtering out ideas that aren't worth exploring further. This method uses basic criteria to make "continue or no" choices.

b) Scoring concept

Then, scoring concept is used to create a qualitative hierarchy of design options after specific design concepts have been developed. The ideas are graded quantitatively against a benchmark using provided scales to decide the concept that will be employ for the development of product.

2.11. Fundamental of Engineering Analysis

Engineering analysis is a project's internal guideline as it is a breakdown a design, system, problem, or issue into its fundamental parts in order to determine its key qualities and their connections to one another and to other aspects. According to Alves (2020), an engineer must be able to comprehend and quantify difficult challenges such as determining impact loadings, getting material characteristics at high strain rates, and assessing structural response and effects. Hence, from identification of the problematic area will produce a solution.

2.11.1. Finite Element Analysis (FEA)

According to Paul (2021), FEA is commonly utilised for structural analysis, coupled thermo-mechanical analysis, and thermal analysis. The capacity to develop solutions for individual components before putting them together to represent the full issue is a key characteristic of the finite element technique that distinguishes it from other numerical methods (Jagota et al., 2013). This implies for tackling a problem in stress analysis, a discovered force–displacement or stiffness characteristics of each individual part and then the combined elements to obtain the stiffness of the overall structure. In general, a complicated problem reduces to a succession of significantly simpler problems.

a) Static Nodal Stress Plot

This simulation is a process of applying a certain amount of force on the specific nodes of the design produced. The analysis takes place at Gauss points which produce the stress and strain outputs of the simulation. For the nodal value plots, after the simulation calculates the solution at each Gauss point, the data is extrapolated to the corresponding element node for that Gauss point. Failure criteria employ the von Mises stress to determine ductile material failure.

b) Static Displacement Plot

Static displacement plot is a process to determine the degree of deflection from the applied force. When a deflection test is performed, the surface of the object is displayed as a gradient of colours, with each hue representing a specific degree of deflection according to the provided scale labelled "URES" or can be called as resultant displacement. URES will determine the deflection part of the design produced.

c) Static-Strain Plot

Lastly, a nonlinear research static strain plots are a useful tool for visualising elastic or plastic strain. Strain plotting are useful for identifying areas of the design produced that have been undergo deformation. The yielded regions have produced a redistribution of the locally high stresses around the design. The provided scale to describe the yielded region is "ESTRN" or can be called as equivalent strain.

2.12. Quality

To achieve a perfect environment for zero defects in manufacturing, machines and skilled labour are required (Umanshankar et al., 2019). A lot of problems encountered by manufacturing company is due to lack of skill and lacking in technology of their machines. Hashi (2016) said that because of these obscurities, consistency, productivity, cost and even performance effects have occurred. Therefore, quality requirements are part of a firm standard operating process, product creation and production planning. To gain quality, a process inspection and some data collection must be done. Inspection systems are a means of directing the survey process through its various phases with consistent procedures (Rafaela and Núria, 1993). As a result, the data collection is systematic, and the production of inspection reports is simpler consistent and more detailed (Green, 2019).

2.12.1. Standard Operating Procedure (SOP)

A standard operating procedure (SOP) is a formal document that contains precise instructions on how to carry out a certain activity. According to Righi et al. (2016), standard operating procedures are one approach to cope with complexity and enhance performance in complicated and safe-critical areas. It was difficult to offer consistent direction for the operation among the groups within the organization without SOPs to refer to (Chi et al., 2018). Effective SOPs ensure consistency in the implementation of processes or procedures (even when staff changes) and can minimise employee effort, which can boost efficiency.

2.13. Summary of Literature Review

As a summary, literature study helps to identify every function of lean technique or tools in order to be used for solving the issue arise in the industry. Other than that, literature study on previous case helps to understand the benefits each of the lean tools. Lean offers a range of strategies for enhancing productivity and competing in the current market. In this chapter, it was shown that a lot of research was done over the years in Value Stream Mapping (VSM). It was clear that VSM is helpful in reducing wastages and help to improving quality.

CHAPTER 3

METHODOLOGY

This chapter will be explained about the methodology that will be used to accomplish the project. Methodology is the guide to solve the problem with particular elements for example tasks, techniques, phases and tools. In order to accomplish the objective of this project, the methodology is one of the important things to do to get the result. Methodology must be organized according to the primacy of the research flow to get the accurate information and data in order to complete the research. The methodology contains of five parts where the first part is preliminary study, and the second part is collection of the data related to the field. Then, the third part is implementation of technique and for the last part is discussion and analysis of the output data from the study.

3.1. Gantt Chart of Overall Project

In order to have a proper research, planning must be done before conducting it. Gantt chart becomes very handy when it comes to project planning and scheduling. It will assist you in determining the length of a project, the resources required, and the order in which tasks will be completed. It can also be used to keep track of task dependencies. The overall time estimation to complete the project is 14 weeks which can be seen on **Appendix A**

3.2. Flowchart of Project

From Figure 3.1, the flowchart shows the steps that will be carried out in this study in order to improve the current production line of the company.

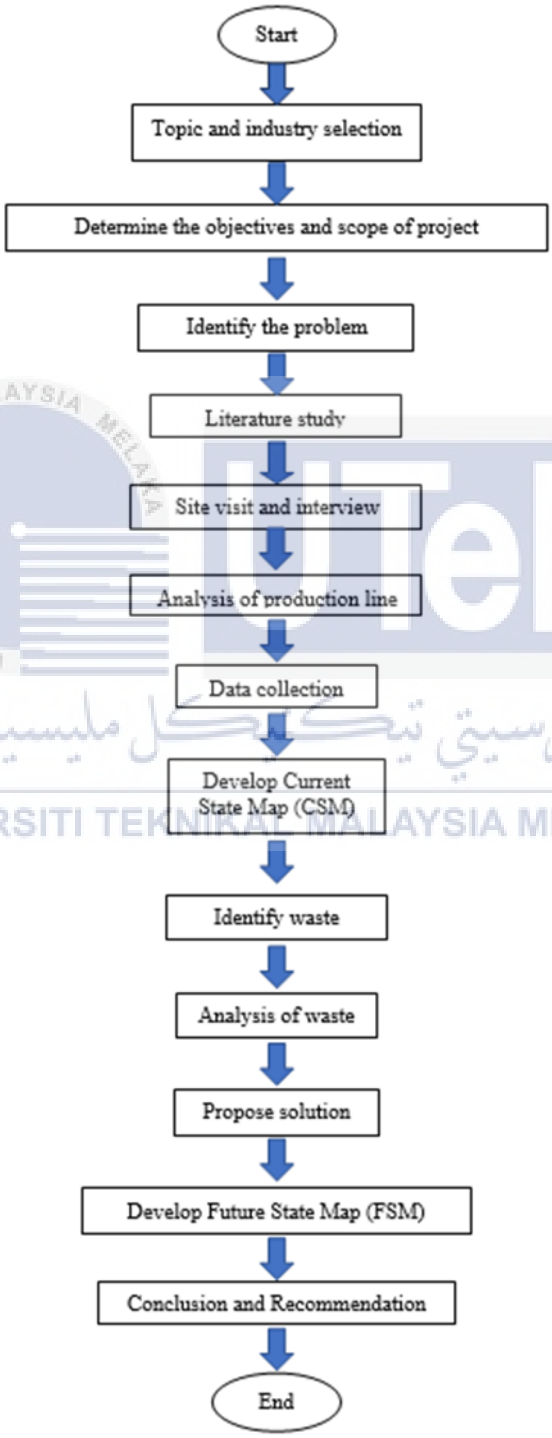


Figure 3.1: Flowchart of the steps carried out in this study

3.3. Methodology of the Study

In this part, all the method that will be implement in order to achieve all the objectives will be explained further.

3.3.1. Preliminary Study

Figure 3.1 above shows the flow chart of the methodology that will be used for this project. The most important element before proceeding with any research or project is to make a proper planning. In this project, the first thing is to do a diagnosis on the problems that arise. It is essential to have a better understanding on the problems in order to proceed on the next step.

3.3.1.1. Literature Study

A few studies through some journal and the articles will help to gather the information or the technique that will be used. The data that have gain from all of the reference make it easier to understand the problem of the research and to identify suitable solution to be implemented on the production line. Thus, all the information from the literature study will help to assist the research and improve the understanding on the method that will be used in order to develop a better and systematic production line.

3.3.1.2. Site Visit and Interview

The next step for this study will continue by doing a site visit to familiarize with production line. This helps to understand the overall process in order to produce the product in the company. During the visit, interview with the worker and supervisor should help to obtain the information of the product and the process flow in the production line. The information that will be collected from the interview are the internal and external customer's complaints, working hours, lead time, customer demand, quality or defects issues, process time, number of operators and production from the supplier.

3.3.2. Objective 1: To apply direct time study technique on the production line of the chicken production process

To achieve the first objective, a direct time study technique will be apply on the production line of the chicken production process. This will start by conducting an analysis on the production line to identify the process flow and the process elements. Then, a data collection will be conducted to obtain the cycle time, changeover time, uptime, TAKT time and inventory of the production line. This will helps to ease the steps to achieve the second objective of this study.

3.3.2.1. Analysis of the production line

Analysis of the production line is the next step towards the objective. This activity will helps obtain the number of operations, types of operations, the operation elements, current sequencing of operations and the current production rate. Analysis of the production line will help to understand the process flow of production line. By this method, we can identify the problem operations area that contributes to the issues.

3.3.2.2. Data Collection

Direct time study technique will be implemented to identify the time utilization in the current production line. From the identified process elements, the time taken for each element will be obtain using a stopwatch. The element will be observed, and the time taken will be taken 10 times in order to get the average reading. Data collection for this study include cycle time, changeover time, uptime, TAKT time and inventory for data analysis will be explained further below.

i. Cycle Time

In manufacturing, cycle time is the consideration from the initial preparation all the way to 100% completion. In manufacturing process, there is no two-process occurred at the same time and it often involve multiple production element and phases. The actual length of cycle time is largely determined by how many steps involved in development of products.

Cycle time is important to know in manufacturing industry so workers will be able to estimate the expected time to complete a finished product. Once it is identified, it can improve manufacturing work processes in many ways such as productivity improvement or logistics.

ii. Changeover Time

A termination of a period of time represents the changeover from the production/processing of one product or service to another different product or service in the production plant.

iii. Uptime

The duration of the machine or equipment in the production plant to functioning or able to function represents the uptime. The time of the machine or equipment able to function indicates the system is reliable for the process.

iv. TAKT Time

Takt time is a manufacturing cycle efficiency measure. It is the rate which you need to complete a product to meet customer demand. It is a sell rate, and it allows to optimize the capacity in the most appropriate way to meet the demand without having too much stock in the inventory. The suitable method to calculate the takt time is by calculating using this formula:

$$TAKT\ time = \frac{Total\ Available\ Production\ Time}{Average\ Customer\ Demand}$$

v. Inventory

Raw material, semi-finished product and final product of a production process is categorized as inventory in the production facility.

3.3.3. Objective 2: To develop Current State Map (CSM) technique of chicken production process

Current state map is a static method and only captures a daily snapshot (Gurumurthy and Kodali, 2011). So, in order to present the whole process of the production line, the CSM will be developed to give a better view of the whole process. Since the time utilization has been calculated in the data collection part, it eases the process to produce the CSM. Here are a few steps that must be used to produce the CSM which are:

i. Calculate the TAKT time (Completed in data collection part).
ii. Walk from the front to the back through the process.
iii. Draw the little saw topped box representing our customer and insert the information.
iv. Then, start from the process at the end and then draw the map back to the front.
v. Focus on things' material flow side (Focus on process box and data box).
vi. Next, add the inventory/ waiting times.
vii. Draw the information flow
viii. Lastly, add the timeline to bottom of value stream map.

3.3.4. Objective 3: To evaluate the waste in current chicken production process using root cause analysis

In this part, root cause analysis will be conducted to identify and pinpoint the contributing factors in the production line. Root cause analysis provides a systematic process of identification of the problem that donate to the waste.

3.3.4.1. Identify waste

Waste identification will be conducted in the production line as it is a step of assigning the process whether the steps is a value-added or non-value added but needed and then non-value added but unneeded. In a production line, there are seven types of waste to be identifies which are overproduction, inventory, motion, defects, over-processing, waiting, and transport.

3.3.4.2. Analysis of waste

Following the identification of wastes, those wastes must be analysed to determine which wastes are the most critical in the production line. The supervisor will be interviewed and discussed in order to identify common and critical wastes. By brainstorming the concerns, the Ishikawa Diagram (fishbone) will be created to represent the likely cause of the problem. The Failure Mode and Effects Analysis (FMEA) will be conducted to examine all of the root causes after that. From this analysis, the waste that has the highest priority number will be proposed for a solution.

3.3.5. Objective 4: To develop Future State Map (FSM) with proposal solution for the chicken production process

In this part, the waste that has been identify will be proposed for a solution in order to remove the waste to improve the current production line. Then, a Future State Map (FSM) will be developed to show the improvement from the proposed solution.

3.3.5.1. Propose a solution

Solution is an action towards an improvement from the identified problem or waste. After the waste has been identify in the production line, solution for the problem will be propose to the industry.

3.3.5.1.1. Designing a poultry hanger

A poultry hanger for the usage of the worker at the industry will be designed according to the customer requirements. Firstly, the customer requirements will be obtain through the planning matrix form to identify the customer needs. Then, the requirements will be transform to a detailed engineering specifications using the Quality Function Deployment (QFD). Next, a morphological chart from previous industries design was developed to obtain the conceptual design. This chart enables a visualization of possible solution by considering alternative combinations.

Then, the conceptual design will undergo screening and scoring concept to reduce all the concepts options. To fulfil the customer requirements, the final concept that are closer with their needs will be chosen as the final design. As for the material for the product, most widely used material will be compared and analysed to determine the best material for the product.

A computer aided design will be implemented to produce the design that has been finalize from the analysis. The design produced will undergo an engineering analysis where static analysis will be performed. Three types of plotting to identify the deformation, yield limit and displacement of the design will be performed which are static nodal stress plot, static displacement plot and static strain plot.

3.3.5.1.2. Propose the 5S pillars

5S pillars is a method that provide ways to Sort (Seiri), Set in Order (Seiton), Shine (Seiso), Standardize (Seiketsu) and Sustain (Shitsuke) at the industry for reduction of waste and help optimizing productivity at the workplace. Any unnecessary work elements will be sort for removal then workstation will be set in order for smoother flow of work. Next, workstation will be clean for better work environment. Then, the job scope at the workstation will be standardize according to every worker. Lastly, sustain steps will be implemented to ensure the industry maintain the efficiencies of workstation.

3.3.5.1.3. Planning a new facility layout

A facility layout is an arrangement of different aspects of manufacturing in a proper position by considering the unit space, final product and convenience of process flow. The design of the new layout will also consider the overall objectives that the industry wants to achieve. A new facility layout will be proposed to the industry for a smooth and steady flow of production material, equipment and worker. This helps to provide an optimum space to organize workstation and facilitate movement of products. A proper position and closer workstation also help in increasing the production capacity of the factory.

3.3.5.1.4. Developing a Standard Operating Procedure (SOP)

Standard Operating Procedure (SOP) mainly used to achieve a uniformity of performance at the industry by providing a steps-by-steps work instruction. A proper instruction and documented operating procedure will be plan for the workstation to ensure it met the standard compliance. SOP helps to ensure the industry meet the production requirements. Then, following the development of SOP for workstation, a standard check sheet will be provided to ensure the worker will record every activities that follow the SOP and adhere to the schedule.

3.3.5.2. Develop Future State Map (FSM)

Next, as the solution to remove the waste in current state map has been proposed to the industry, a future plan map will be generates to indicates the improvement. The Future State Map helps to visualize the area and time utilization after the improvement.

3.4. Summary

As a summary, this chapter focus in accomplishing the objectives of this study by carrying out all the procedures to identify the waste that donates problem to the production line. Current State Map (CSM) helps to visualize the entire process of the production line and the elements of the process. Then, analysing the seven wastes at the important parts of the process flow will helps to identifies the issue. From analysis of waste which has been identified from the process, a solution will be proposed to the industry to remove the waste. Lastly, development of Future State Map (FSM) helps to visualize the improvement area after the implementation of solution.

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter consists of results and discussion of the project. It will be consist of all the data collected from the research. Data such as cycle time, changeover time, uptime, TAKT time and inventory was analysed in order to produce the current state map of the project. The waste occurred in the process also will be analyse in order to find the major problem in the industry. Then, the results of the research will be tabulated in a table for it to be discussed for the further improvement. Lastly, the future state map was developed after removing all the waste.

4.1. Introduction

This research was placed at Mohamed Akbar Enterprise which are a chicken processing process factory owned by Encik Mohamed Akbar located at Lot 5025, Kampung Stesen Sungai Choh, Rawang, Selangor. This factory is a Small and Medium-sized Enterprise (SMEs) that will supply processed chicken in Rawang, Kuala Kubu Bharu and Hulu Selangor areas. The processed chicken will be supplied to big market Rawang, grocery store, restaurant, canteen and catering. This factory has been operated since 1992 until now and being one of the main and reliable processed chicken suppliers all over Rawang area. The factory was operated with the help of both manpower and machine. There are six processes in the production plant therefore the scope of this study will only be focusing the first three process which the layout was shown in **Appendix B**. The time consuming at production plant has created a slower production for it to meet the customer demand. The places that they supplies need the processed chicken at such early in the morning usually at timeframe around 7:00 A.M until 10:00 A.M. This has created a few problems which they cannot meet the production times required by the customer. Other than that, the quality issues have affected the production of the processed chicken. This case study will help to reduce the problem occurred at all processes with the help of lean manufacturing.

4.2. Critical to Quality (CTQ) Tree

The development of the CTQ tree required the data that has been analysed from the Voice of Customer (VOC). The customer's complaint has been analysed and classified as a requirement. Then, the customer requirements were sorted into the VOC table and the results of the investigation has been implied on the CTQ tree. The VOC table can be refer in **Appendix C**. These steps help to understand the customer requirements in order to find the root cause to enable in providing the solution. From the VOC table, it relates the critical requirements (CTQs) for the issues that are identified and shown in Figure 4.1.

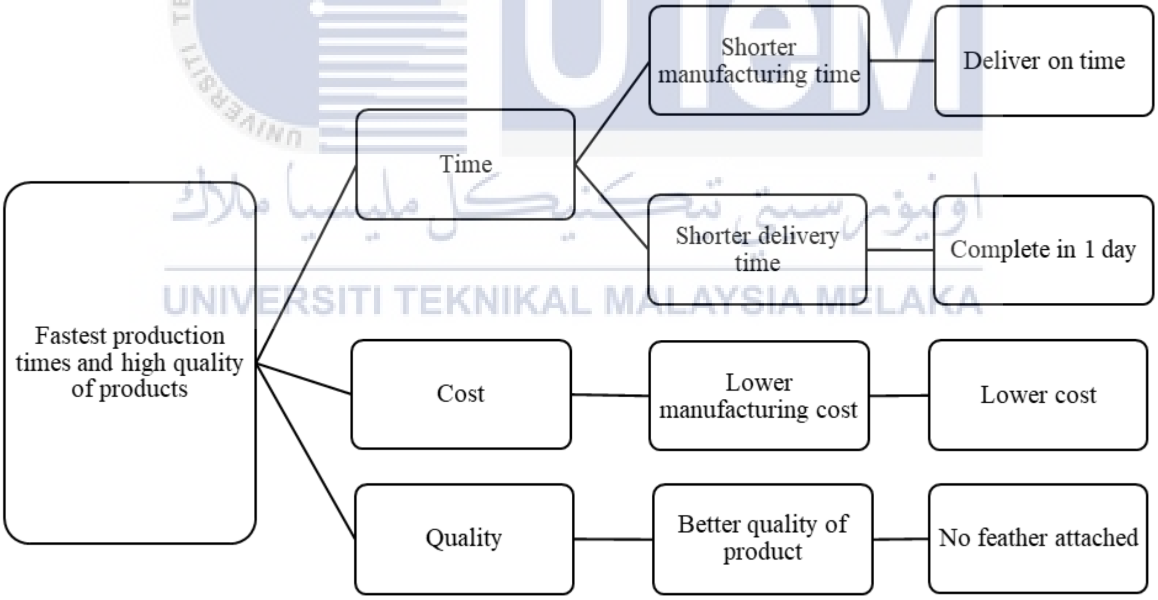


Figure 4.1: Critical to Quality (CTQ) Tree based on customer's complaints.

4.3. Project Charter

This part provides a project charter which marked the beginning of this project and all its phases. This project charter formally validates this project's existence and served as a future reference point. From beginning to end, this charter provided as a good project management which show a good direction and a sense of purpose. Table 4.1 below shows the Project Charter of this case study.

Table 4.1: The Project Charter

ELEMENTS	TEAM CHARTER
1. **Project Title**	Lean Manufacturing Implementation for The Reduction of Production Times and Quality Issues in Industry
2. **Project Description**	The main concern of this company is they cannot satisfy the customer demand because of the longest production times and low quality of the product. As this company catered quite a wide area in Rawang, they must be able to deliver their product on time every day with minimal defects in order to meet customer requirements. Hence, in order to reduce the production times and quality defects in this company, there are six processes to be observed and reviewed including the non-value-added activities and wastes that will be identified and eliminate.
3. **Objectives**	To reduce the production times and quality defects by implementing lean manufacturing methods.
4. **Project Scopes**	The goal of this research is to reduce production times and quality defects in the manufacturing process. The VSM method was used to examine waste and non-value-added activities. This study covered all six processes in the production plant but will only be focusing on first three processes.
5. **Business Cases**	Mohamed Akbar Enterprise is a chicken processing factory that known as a Small and Medium Enterprises (SMEs) company. This factory only focuses on chicken processing production since they are one of the main suppliers that cater Rawang area for processed chicken. They received a high demand from the customer especially from the big market, restaurant or canteen owner and supplies all around Rawang area.
6. **Project Team**	-Team leader: Encik Mohamed Akbar -Team members: Cik Aqilah, Cik Fatin, Mr. Yousef, Mr. Wak, and other 7 workers.
7. **Benefits Of the Project**	Production times will be shortened by reducing manufacturing lead times. The company will be able to reduce defects issues and improve production times by eliminating all waste and non-value-added activities and making improvements to the selected processes. This can assist the company in producing more high-quality products, delivering them on time, and reducing quality defects in order to meet customer demand.
8. **Schedule**	Start: 25th February 2021
	End: 13th August 2021

4.4. Process flow of chicken production process

In this part, it will consists of a few subsections that explained processes involved in this study. Figure 4.2 below shows all six processes undergo in the chicken production process. The process elements in the subsections helped in describing more detailed about the processes. The choice of product family is critical to be the first step in developing the current state map (CSM) based on the production process flow from the supplier to the customer. The Future State Map (FSM) is then created by analysing the CSM's consequences.

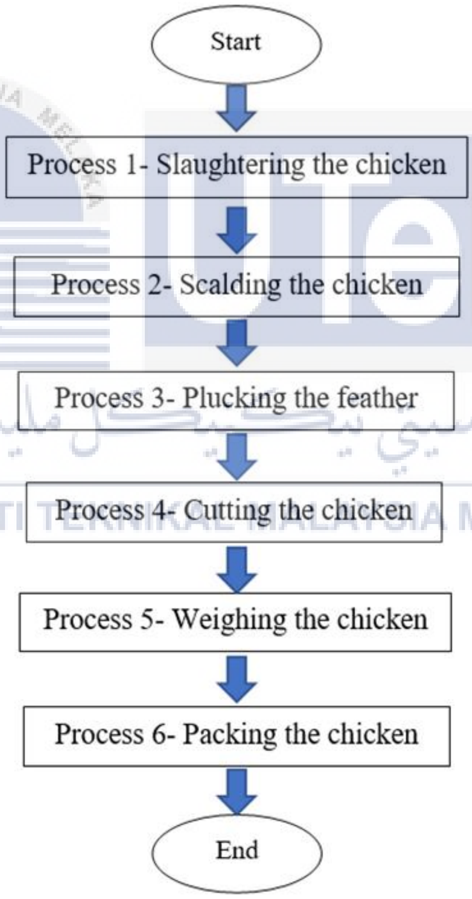


Figure 4.2: The process flows of the chicken production process

4.4.1. Process Elements

In this part, the elements of the processes involved in the production of the product will be explained properly. During the visit, the steps of the process and the machine used for the production has been observed. Therefore, every detail for each element from process 1 to process 6 was collected and recorded in the table.

4.4.1.1. Elements in Process 1- Slaughtering the chicken

The process flow shows in Figure 4.3 below shows a more detailed elements in process 1 which is slaughtering of chicken. In process 1, all of the raw and alive chicken was placed near the workplace. This process required two workers from the time the chicken was slaughtered until it was placed in the basin. Figure 4.4 below shows how the normal and manual way the chicken was slaughtered by the workers.

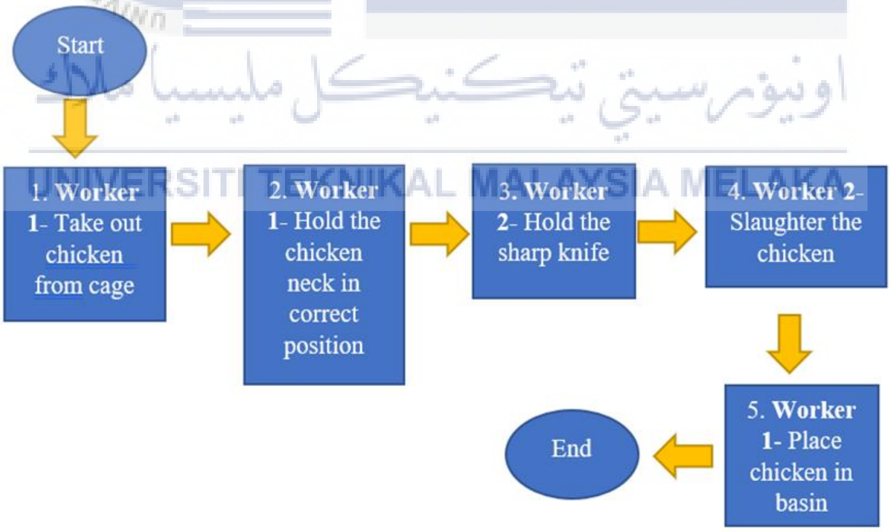


Figure 4.3: The process flow of the elements in process 1- Slaughtering the chicken

Figure 4.4: Normal and manual way the chicken was slaughtered by the workers

4.4.1.2. Elements in Process 2- Scalding the chicken

After the slaughtered chicken has been placed in the basin, next will be the scalding process. This process involved to help speed up the process of removing the feather of the chicken. The machine involved in this process only able to fit 12-14 chickens in the 5 minutes span. Figure 4.5 shows the method of the chicken was placed in the machine. All the chicken was scalded in the machine that filled with hot water at temperature of 65°c.

Figure 4.5: The method of the chicken was placed in the machine

In Figure 4.6 below shows the process flow of the elements in process 2 while Figure 4.7 shows the current machine used in the industry

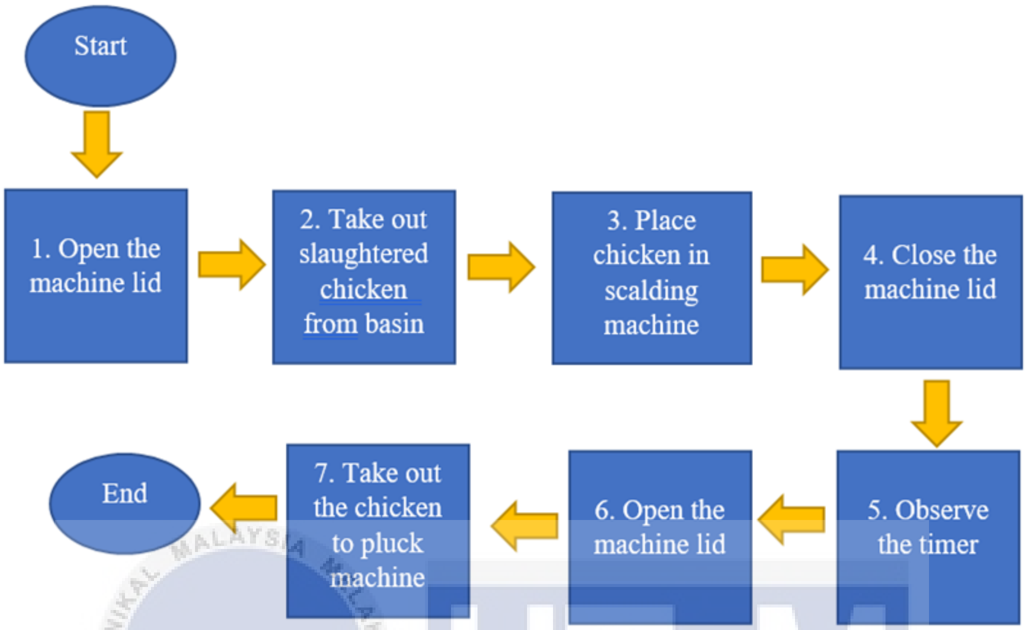


Figure 4.6: The process flow of the elements in process 2- Scalding the chicken

Figure 4.7: The current machine used in the industry

4.4.1.3. Elements in Process 3- Plucking the feather

The scalded chicken then was placed in a plucking machine to remove the feather. The machine can fit up to 12-14 chickens and were let run for 2 minutes. The current method requires the worker to manually pluck off the feather after it runs in the plucking machine since the machine does not fully pluck off the feather. Figure 4.8 shows the process flow of the elements in process 3. In Figure 4.9 below shows the plucking machine used in the industry and Figure 4.10 shows the worker manually pluck off the feather.

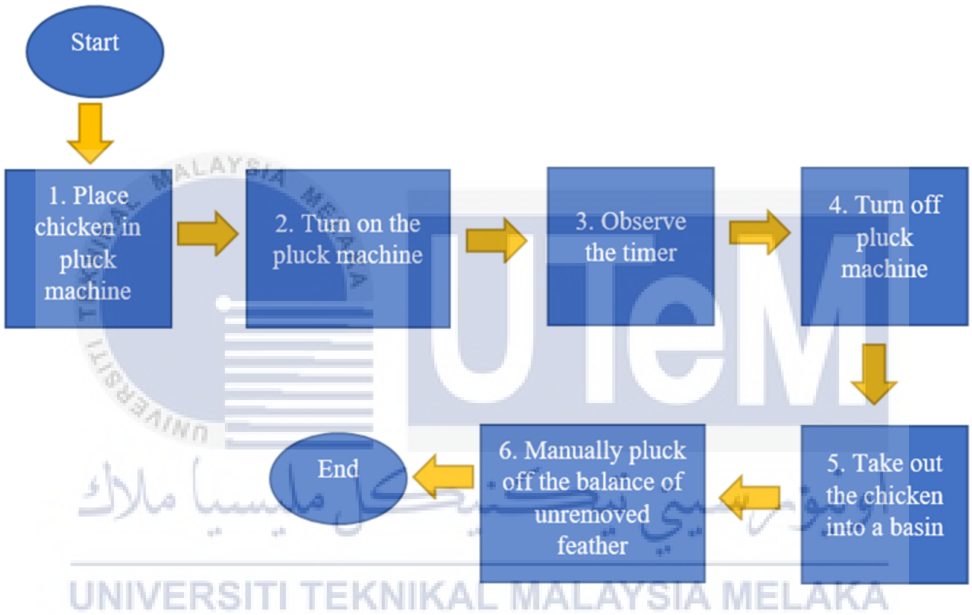


Figure 4.8: The process flow of the elements in process 3- Plucking the feather

Figure 4.9: The plucking machine used in the industry

Figure 4.10: The worker manually plucks off the feather

4.4.1.4. Elements in Process 4- Cutting the chicken

Another step before distribution is cutting the chicken. After the plucking process, in Figure 4.11 below shows a clean chicken was cut into a few pieces before it was distributed to customer. Figure 4.12 shows the process flow of the elements in process 4 in order to cut the chicken.

Figure 4.11: The cutting process of clean chicken before distributed to customer

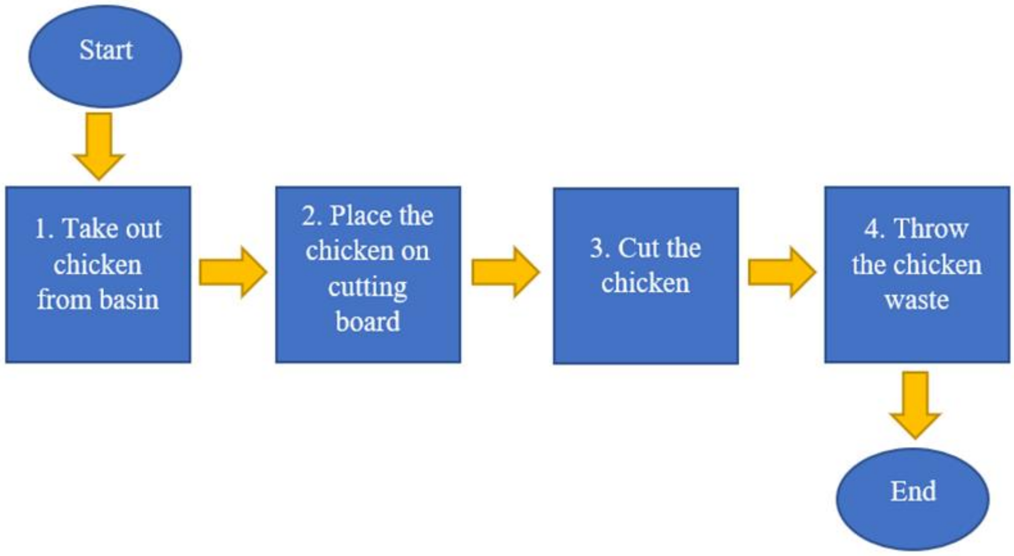


Figure 4.12: The process flow of the elements in process 4- Cutting the chicken

4.4.1.5. Elements in Process 5- Weighing the chicken

Another important element is weighing the chicken in order to ensure that customer received the requested weight. Figure 4.13 shows the process flow of the elements in process 5 to ensure that they fulfilled the customer demand.

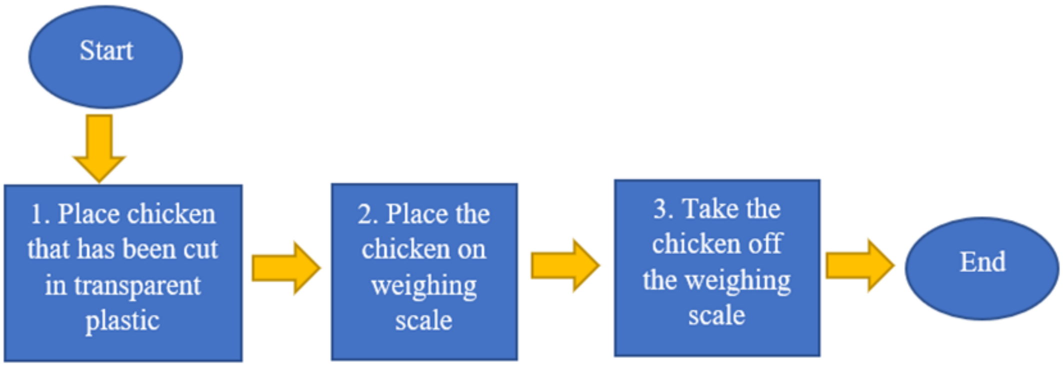


Figure 4.13: The process flow of the elements in process 5- Weighing the chicken

4.4.1.6. Elements in Process 6- Packing the chicken

The last process is to pack the chicken before it was distributed to the customer. The packed chicken then was placed on storage area which already been segregated according to area of the customer. In Figure 4.14 below shows the process flow of the elements in process 6 for packaging process.

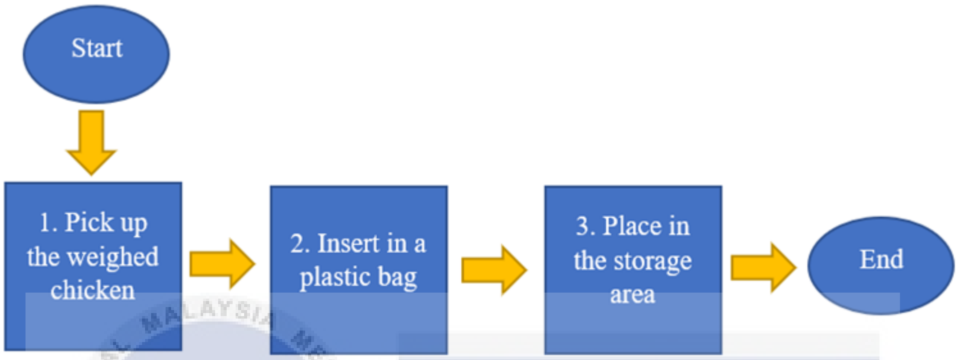


Figure 4.14: The process flow of the elements in process 6- Packing the chicken

4.5. Data Collection

In this part, all data required to construct a current state map (CSM) were collected by the direct time study technique during the visit at the factory. Other than that, an interview with the industrial supervisor was also conducted to obtain the required data. The observation was recorded and tabulated in a table for it to be analysed. In order to construct a CSM diagram, the important elements are:

i. Cycle Time (C/T)
ii. Changeover Time (C/O)
iii. Uptime (U/T)
iv. TAKT Time
v. Inventory

4.5.1. Cycle time (C/T) of production line

The cycle time of all processes were recorded in a table as shown in Table 4.2, Table 4.3, Table 4.4, Table 4.5, Table 4.6 and Table 4.7 below. The cycle time was obtained by using direct time study method through 10 observations and the time were recorded using a stopwatch. In Table 4.8 shows the summary of the total cycle time for each process and the longest elements in each process.

a. Process 1: Slaughtering the chicken

Table 4.2: Cycle times of Process 1

Seq	Steps	TIME TAKEN (MINUTES)										
		t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	Ave
1.	Worker 1- Take out chicken from cage	0.02	0.03	0.03	0.04	0.02	0.03	0.04	0.03	0.03	0.02	0.029
2.	Worker 1- Hold the chicken neck in correct position	0.16	0.17	0.16	0.18	0.16	0.16	0.17	0.18	0.17	0.18	0.169
3.	Worker 2- Hold the sharp knife	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.014
4.	Worker 2- Slaughter the chicken	0.08	0.09	0.08	0.07	0.08	0.09	0.09	0.08	0.07	0.08	0.081
5.	Worker 1- Place chicken in basin	0.04	0.05	0.06	0.05	0.06	0.04	0.05	0.05	0.04	0.06	0.05
TOTAL CYCLE TIME												**0.343**

b. Process 2: Scalding the chicken

Table 4.3: Cycle times of Process 2

Seq	Steps	TIME TAKEN (MINUTES)										
		t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	Ave
1.	Open the machine lid	0.02	0.01	0.02	0.03	0.01	0.02	0.02	0.02	0.02	0.02	0.019
2.	Take out slaughtered chicken from basin	0.06	0.07	0.06	0.06	0.08	0.06	0.07	0.06	0.06	0.06	0.064
3.	Place chicken in scalding machine	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.015
4.	Close the machine lid	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.017
5.	Observe the timer	5.01	5.00	5.30	5.02	5.00	5.01	5.00	5.08	5.01	5.20	5.063
6.	Open the machine lid	0.01	0.02	0.03	0.02	0.01	0.03	0.02	0.03	0.03	0.02	0.022
7.	Take out the chicken to pluck machine	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.033
TOTAL CYCLE TIME												**5.233**

c. Process 3: Plucking the feather

Table 4.4: Cycle times of Process 3

		TIME TAKEN (MINUTES)										
Seq	**Steps**	**t1**	**t2**	**t3**	**t4**	**t5**	**t6**	**t7**	**t8**	**t9**	**t10**	**Ave**
1.	Place chicken in pluck machine	0.02	0.01	0.02	0.03	0.01	0.02	0.02	0.02	0.02	0.01	0.018
2.	Turn on the pluck machine	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.013
3	Observe the timer	1.91	2.00	1.98	2.01	1.99	2.03	2.00	1.98	1.99	2.00	2.187
4.	Turn off pluck machine	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.015
5.	Take out the chicken into a basin	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.017
6.	Manually pluck off the balance of unremoved feather	0.16	0.12	0.15	0.16	0.15	0.14	0.16	0.14	0.16	0.15	0.149
TOTAL CYCLE TIME												**2.399**

d. Process 4- Cutting the chicken

Table 4.5: Cycle times of Process 4

		TIME TAKEN (MINUTES)										
Seq	**Steps**	**t1**	**t2**	**t3**	**t4**	**t5**	**t6**	**t7**	**t8**	**t9**	**t10**	**Ave**
1.	Take out the chicken from basin	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.017
2.	Place the chicken on cutting board	0.16	0.12	0.15	0.16	0.15	0.14	0.16	0.14	0.16	0.15	0.149
3.	Cut the chicken	0.55	0.49	0.58	0.54	0.55	0.58	0.49	0.55	0.58	0.55	0.546
4.	Throw the chicken waste	0.01	0.01	0.01	0.03	0.02	0.01	0.02	0.03	0.03	0.01	0.021
TOTAL CYCLE TIME												**0.733**

e. Process 5- Weighing the chicken

Table 4.6: Cycle times of Process 5

		TIME TAKEN (MINUTES)										
Seq	**Steps**	**t1**	**t2**	**t3**	**t4**	**t5**	**t6**	**t7**	**t8**	**t9**	**t10**	**Ave**
1.	Place chicken that has been cut in transparent plastic	0.13	0.12	0.14	0.12	0.12	0.13	0.12	0.12	0.13	0.12	0.125
2.	Place the chicken on weighing scale	0.08	0.07	0.08	0.08	0.08	0.07	0.06	0.08	0.07	0.08	0.075
3.	Take the chicken off the weighing scale	0.02	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.02	0.03	0.029
TOTAL CYCLE TIME												**0.229**

f. Process 6- Packing the chicken

Table 4.7: Cycle times of Process 6

		TIME TAKEN (MINUTES)										
Seq	**Steps**	**t1**	**t2**	**t3**	**t4**	**t5**	**t6**	**t7**	**t8**	**t9**	**t10**	**Ave**
1.	Pick up the weighed chicken	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.017
2.	Insert in a plastic bag	0.16	0.12	0.15	0.16	0.15	0.14	0.16	0.14	0.16	0.15	0.149
3.	Place in the storage area	0.09	0.08	0.08	0.09	0.08	0.08	0.09	0.09	0.08	0.07	0.083
TOTAL CYCLE TIME												**0.249**

Table 4.8: Summary of the cycle time and the longest elements in all processes

Process	Cycle Time of the Process, (minutes)	Longest Process Element	Time Taken for Longest element process, (minutes)
Process 1- Slaughtering the chicken	0.343	Worker 1- Hold the chicken neck in correct position	0.169
Process 2- Scalding the chicken	5.233	Observe the timer	5.063
Process 3- Plucking the feather	2.399	Observe the timer	2.399
Process 4- Cutting the chicken	0.733	Cut the chicken	0.546
Process 5- Weighing the chicken	0.229	Place chicken that has been cut in transparent plastic	0.125
Process 6- Packing the chicken	0.249	Insert in a plastic bag	0.149

4.5.2. Changeover time (C/O) of production line

The changeover time is the activities required to prepare an operation or process for a different product type. Changeover time, also known as setup time, is the amount of time allotted for one process. Since the company only have one type of product which is processed chicken, there are no changeover time between the processes.

4.5.3. Uptime (U/T) calculation

Uptime or available time is the time when the equipment and machine is ready for the production. The number of the uptime can be obtained from the following formula:

$$Uptime = \frac{Actual\ \ production\ time}{Total\ available\ time} \times 100\%$$

$$= \frac{9\ hours \times 3600s}{9\ hours \times 3600s} \times 100\%$$

$$= 100\%$$

4.5.4. TAKT time calculation

TAKT time is the frequency or pace of production required to meet the customer demand. To identify the TAKT time of the production, the calculation of the takt time was shown below:

$$TAKT\ time = \frac{Available\ time}{Customer\ demand}$$

$$= \frac{9\ hours \times 3600s}{1800}$$

$$= 18s/pcs$$

4.5.5. Inventory

Inventory is a place for sourcing and storing both raw materials and completed products. The time spent of the product stores in the inventories or buffers is referred to as inventory lead time. The estimation method is employed in this study to develop time standards for solely the inventory lead times that are included in the production process. The estimation was made by a worker who was experienced with the job. The followed calculation is the estimated time given by the worker:

i. Inventory lead time from raw materials storage (incoming goods) to Process 1

Taking out the chicken from the storage area takes 3 seconds since the worker has placed the chicken cage near Process 1 working area.

ii. Inventory between Process 1- Slaughtering the chicken and Process 2- Scalding the chicken

Inventory lead time from Process 1 and Process 2 is 7 seconds because the transportation between the workstation is quite far.

iii. Inventory between Process 3- Plucking the feather and Process 4- Cutting the chicken

Inventory lead time from Process 3 and Process 4 is 3 seconds because the transportation between the workstation located less than 1 meter.

iii. Inventory lead time for storage area (finished goods)

Inventory lead time from Process 6- Packing the chicken (finished goods) is 5 seconds because it is located is 1 meter from the workplace.

4.6. Development of Current State Map (CSM)

Value stream mapping (VSM) provides a systematic depiction of the important steps, illustration of the process flow and accompanying data that we need to comprehend to intelligently enhance the entire process. In order to enhance the process, current state map was produced then followed by future state map. The current state map will detect the current process flow to be evaluated to find process gaps and/or wastage that may be simplified for efficiency. Both the current state map and future state map was developed using Microsoft PowerPoint. In this study, the mapping will be on all six processes of processed chicken production. But for the enhancement, only the first three processes were involved. The process flow of the map started from the supplier which is alive chicken cage until the customer which is storage area. The six processes that involved in this study are Process 1- Slaughtering the chicken, Process 2- Scalding the chicken, Process 3- Plucking the feather, Process 4- Cutting the chicken, Process 5- Weighing the chicken and lastly, Process 6- Packing the chicken. All the acquired data, including information, material and procedures was monitored carefully. An interview with the industrial supervisor was also conducted to obtain further details regarding the production process. All of this data is necessary in order to visualize the current status map. This is a useful starting point for learning how all of the activities and processes work together.

All the information were used to find and eliminate all the wastes in the processed chicken production for the future state map (FSM) development after implementing the improvements. According to the data in CSM, the processing time is equal to the cycle time which is 551.16 seconds. For inventory, from alive chicken storage (incoming goods) to Process 1 takes 3 seconds. As from Process 1 to Process 2 takes 7 seconds while Process 3 to Process 4 takes 3 seconds. Next, the inventory lead time for storage area (finished goods) takes 5 seconds. Hence, the total lead time for the six processes is 569.16 seconds. The total raw material supply for one batch is approximately 1800 alive chickens. The normal maximum production demand per day is 1800 chickens except during celebration day such as Hari Raya. Then, one storage area able to fit 14 processed chickens. The available time that has been calculated is 9 hours and they have breaks for one hour in one day. Other than that, there is no changeover time between the processes because there is no shift for the production. Then, this factory only makes one type of products in one time. The uptime for the whole process is 100% as all the equipment is ready during the production process. The TAKT time for these processes is 18 seconds per pieces. Figure 4.15 below shows the CSM of the chicken production process.

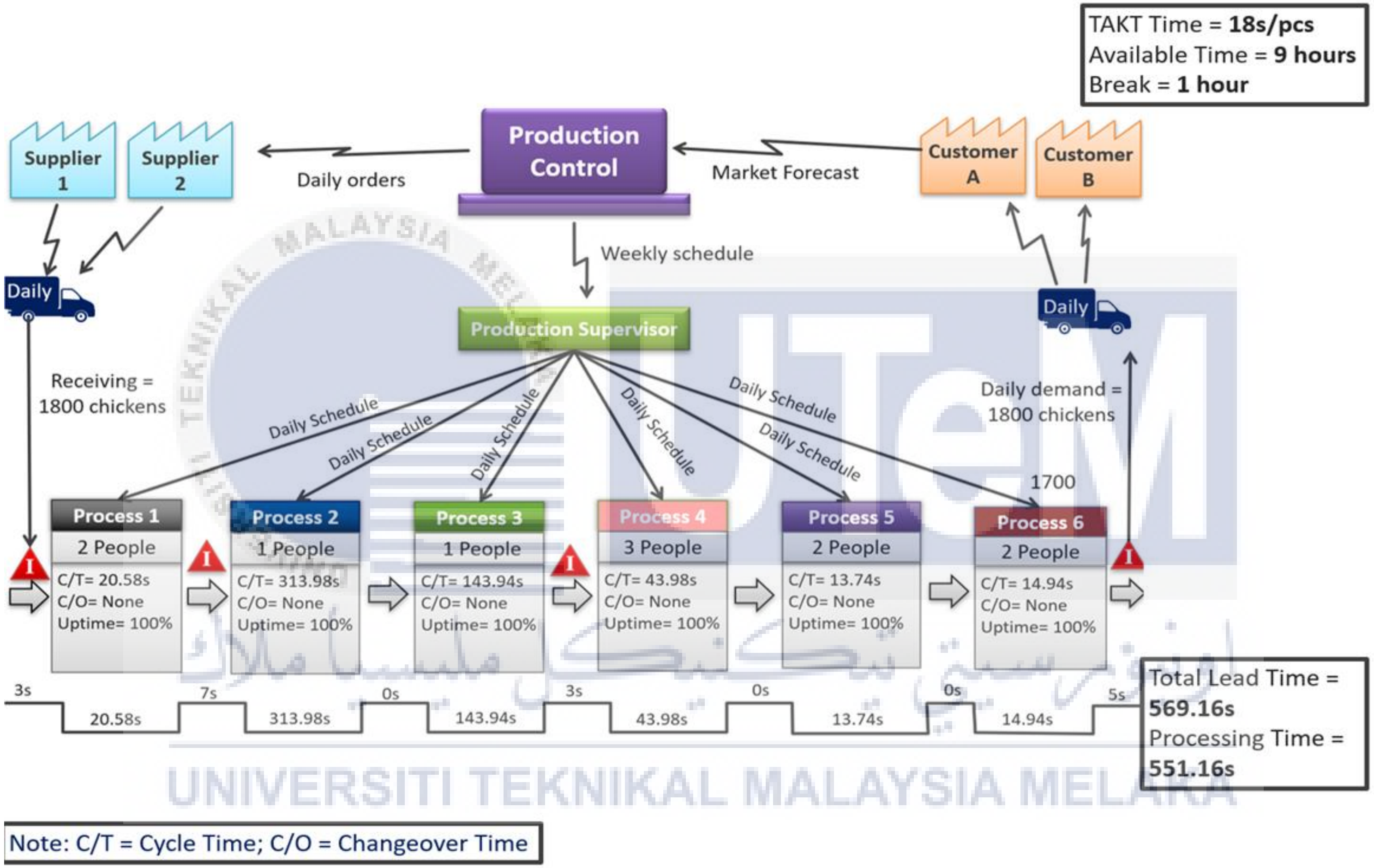


Figure 4.15: The Current State Map (CSM) of the chicken production process

4.6.1. Analysis on value added, and non-value added

The implementation of CSM fulfilled the goal of identifying and eliminating non-value-added processes (wastes) in the product development process in order to reduce lead time. Developed CSM proved the actual application of lean thinking concepts. The activities involved in the product development process which are based on lean thinking principles can be divided into three categories which are:

a) Value added = A required activities which must be done
b) Non-value added but necessary = Required to assist activities but did not add value
c) Waste = Does not assist activities and must be eliminate

According to the CSM, the overall lead time, which includes both values added and non-value-added processes, is 569.16 seconds. While the overall processing time, which is the time required to appropriately handle an item within a process step, is 551.16 seconds. Order preparation time, run time, move time, inspection time, and put-away time are all included in the processing time, also known as cycle time. Wastes are actions that slow down the value stream without providing any advantages. Hence, the seven types of wastes were eliminated in order to reduce production times and quality problems. As a result, after the CSM has been analysed, all seven categories of wastes have been reviewed to be removed. The seven types of waste are waiting, motion, defects, inventory, overproduction, overprocessing, and transportation. In the next step, the analysis of waste will be explained further.

4.7. Analysis of wastes

In this part, for reduction in production delays and quality defects of the product, all seven forms of waste were analysed in the CSM by observation of the production processes. Followed by the observation and interview with the industry supervisor, all the wastes were divided into two parts which are wastes that occurred in the current six processes which shown in Table 4.9 and the inventory wastes shown in Table 4.10. Despite that, there were also certain wastes that not occurred in the process.

Table 4.9: The wastes occurred in the current six processes

Process	Types of waste	Justification
Process 1- Slaughtering the chicken	Waiting	Workers spend too much time holding the chicken before it was slaughter due to no proper equipment to hold chicken
	Defects	Chicken did not die from the slaughtering process (must die from first cut due to Halal issue) causes it is rejected due to inconvenience slaughter place
	Motion	Unnecessary movement when dropping the slaughtered chicken into the basin due to no proper method to store the chicken
Process 2- Scalding the chicken	Waiting	Workers need to wait for the machine to finish operating because the machine can only fit 12-14 chicken at one time only.
	Transportation	Workers need to move to process 1 to take the chicken out from the basin due to far workstation
	Motion	Workers need to open and close the lid cause fatigue hand to worker due to current machine method ways to start the process
Process 3- Plucking the feather	Waiting	Workers need to wait machine in Process 2 to finish operating before placing the chicken in pluck machine
	Motion	Workers are tired because they need to take out the chicken from pluck machine manually due no passage out for the chicken after the process finished
	Defects	The chicken feather is not properly plucked causes rework due to mishandling of the machine by worker
Process 4- Cutting the chicken	Motion	Workers feels tired because they need to move to Process 3 to take the chicken out from basin before it was cut
Process 5- Weighing the chicken	None	None
Process 6- Packing the chicken	None	None

Table 4.10: The inventory waste occurs in the between of the six processes

Process	Justifications
Inventory from the incoming goods	Waiting time for the inventory from the alive chicken storage.
From process 1 to Process 2	Slaughtered chicken waiting for scalding process.
From process 3 to Process 4	Clean chicken waiting for cutting process.
Inventory from finish goods	Waiting time for the inventory to storage area.

Table 4.11: The wastes that not occurred in all the six processes

Wastes	Justifications
Overproduction	There is no overproduction since every chicken was needed by customer
Overprocessing	All order were made a day before production therefore all chicken was processed following customer order.

Next, the waste that not occurred in all six processes are tabulated in Table 4.11 above. Then, all the waste occurred in the current chicken production process has been visualize in the Current State Map (CSM) in order to clearly understand location of the waste occurred which shown in Figure 4.16 below.

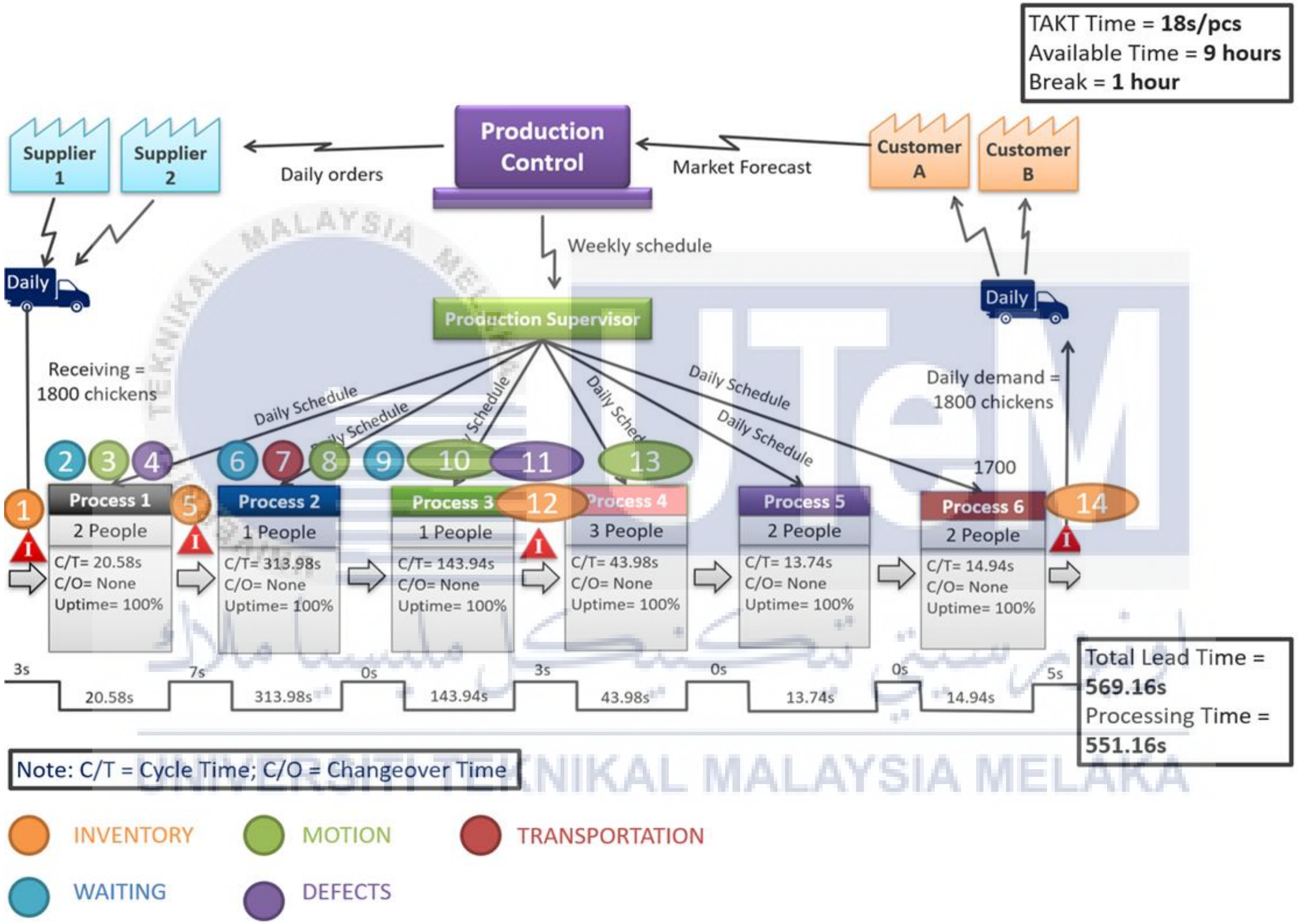


Figure 4.16: All the waste occurred in the current chicken production process

4.7.1. Wastes root cause analysis

In this part, a root cause analysis was used as an approach and carried out to identify the issue that arises in each process as a result of the wastes of waiting, motion, transportation, defects, and inventories. In order to understand all the possible reason, the Ishikawa diagram approach was used to list all of the wastes produced by each process. The problem was reviewed together with the industrial supervisor and workers. Failure Modes and Effect Analysis (FMEA) were then used to identify the processes with the highest risk priority.

4.7.1.1. Development of Ishikawa diagram

In this part, the Ishikawa diagram was created by discussing various reasons by asking why it happens and considering the six variables of measurement, technique, materials, manpower, machine, and environment. It is a diagram that illustrates the causes of an event and is frequently used in manufacturing and product development to describe the many steps in a process, highlight where quality control concerns may arise, and determine which resources are necessary at key moments.

4.7.1.1.1. Ishikawa diagram for waiting waste

There are three Ishikawa diagram that have been discussed for waiting wastes in each process and shown in the section below:

a) Figure 4.17 below shows the Ishikawa diagram for waiting in Process 1-Slaughtering the chicken where the worker spent too much time holding the chicken’s neck to carry out the slaughtering process since there is no equipment to hold. Hence, worker need to hold the chicken’s neck using their own hands.

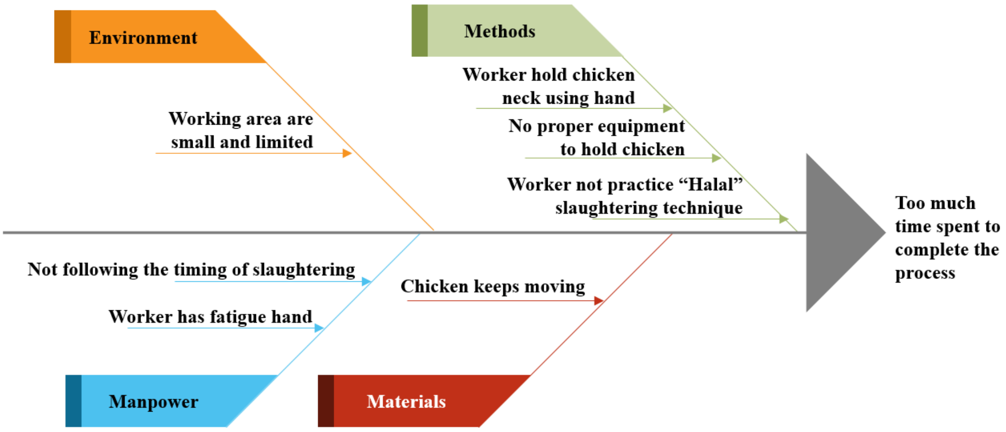


Figure 4.17: The Ishikawa diagram for Process 1- Slaughtering the chicken

b) Figure 4.18 below shows the Ishikawa diagram for waiting in Process 2- Scalding the chicken where worker need to wait for machine to finish operating in order to continue the next process because the machine need to manually starts by worker.

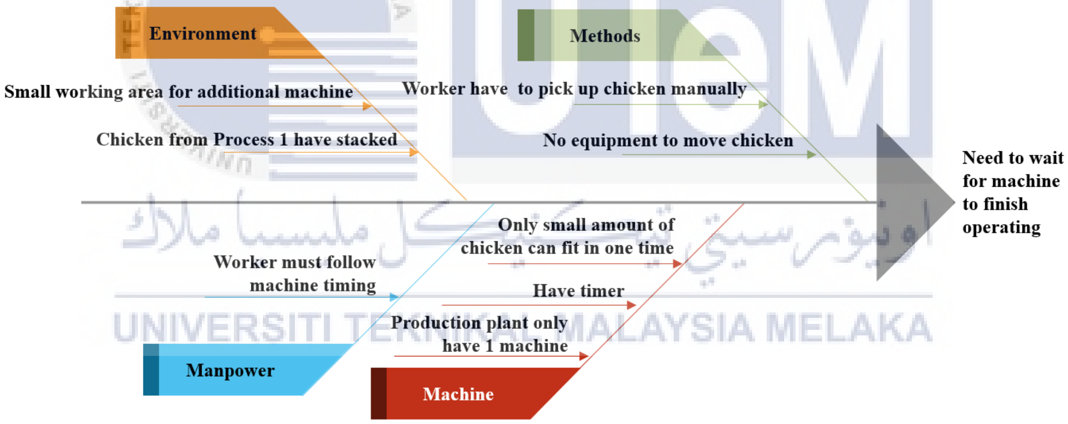


Figure 4.18: The Ishikawa diagram for Process 2- Scalding the chicken

c) Figure 4.19 below shows the Ishikawa diagram for waiting in Process 3- Plucking the feather where worker have to wait the machine to finish operating then only, they can take out the chicken from the machine in order to insert the new ones.

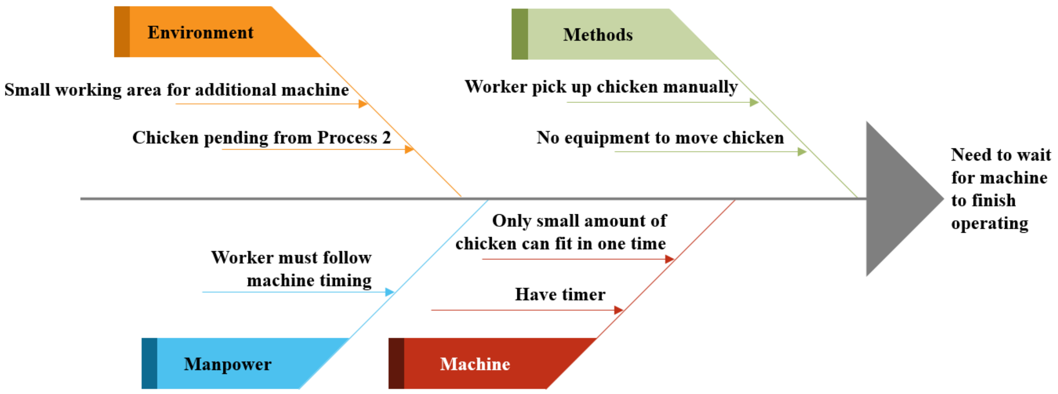


Figure 4.19: The Ishikawa diagram for Process 3- Plucking the feather

4.7.1.1.2. Ishikawa diagram for motion waste

There are four Ishikawa diagram that have been discussed for motion wastes in each process and shown in the section below:

a) Figure 4.20 below shows the Ishikawa diagram for motion in Process 1- Slaughtering the chicken where there is no proper equipment to hold the chicken after it was slaughtered. So, worker must drop the chicken in a basin to keep the chicken for Process 2.

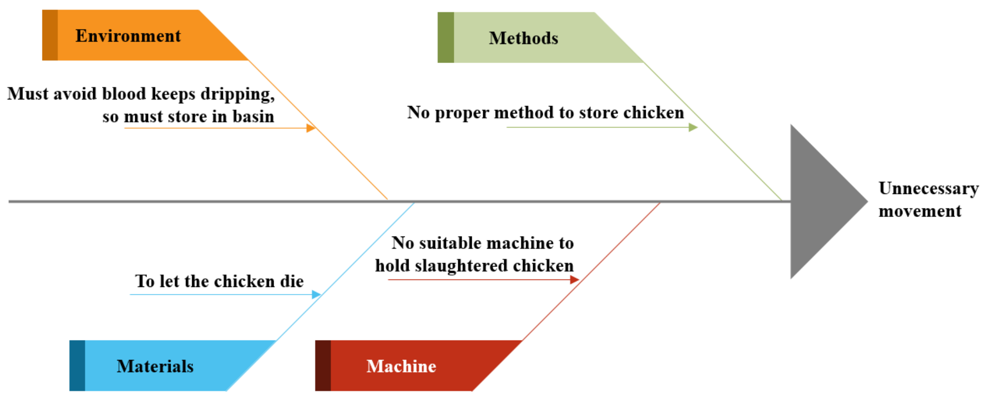


Figure 4.20: The Ishikawa diagram in Process 1- Slaughtering the chicken

b) Figure 4.21 below shows the Ishikawa diagram for motion waste in Process 2- Scalding the chicken where worker has to open and close the lid to run the machine which cause fatigue hand on the worker.

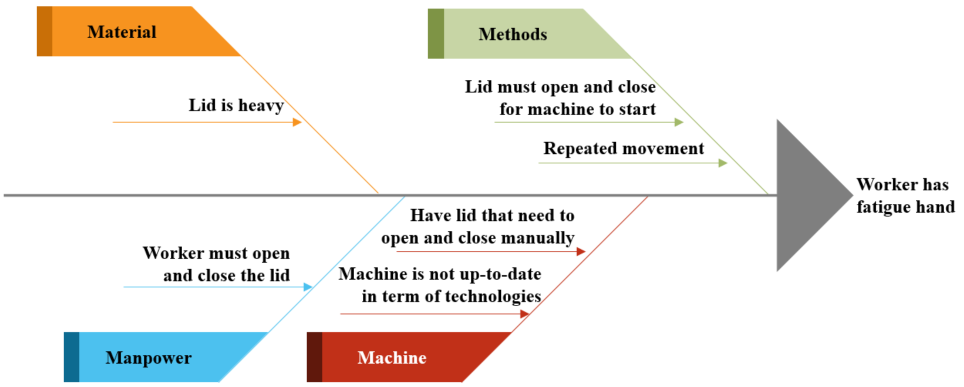


Figure 4.21: The Ishikawa diagram in Process 2- Scalding the chicken

c) Figure 4.22 below shows the Ishikawa diagram for motion waste in Process 3- Plucking the chicken where the worker have to manually take out the chicken from the machine as there is no passage out for the chicken after the machine run which causes the worker to feel tired.

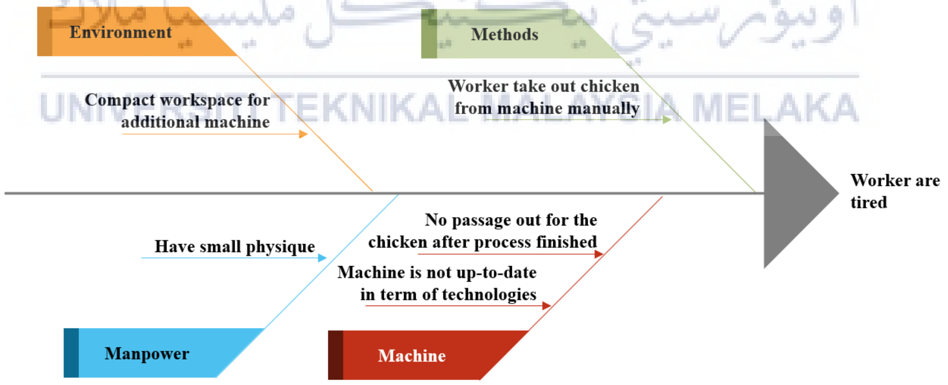


Figure 4.22: The Ishikawa diagram in Process 3- Plucking the feather

d) Figure 4.23 below shows the Ishikawa diagram for motion in Process 4- Cutting the chicken where worker feels tired when they need to pick up the chicken from Process 3 in order to continue Process 4.

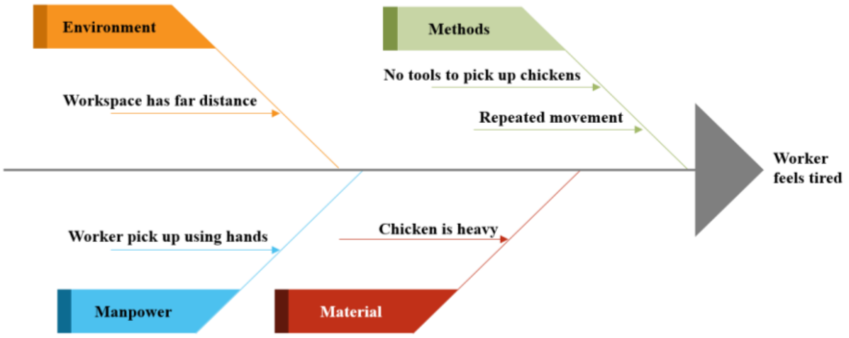


Figure 4.23: The Ishikawa diagram for Process 4- Cutting the chicken

4.7.1.1.3. Ishikawa diagram for defects waste

There are two Ishikawa diagram that have been discussed for defects wastes in each process and shown in the section below:

a) Figure 4.24 below shows the Ishikawa diagram for defects in Process 1- Slaughtering the chicken where chicken was rejected if it didn't die from the first cut due to a few causes.

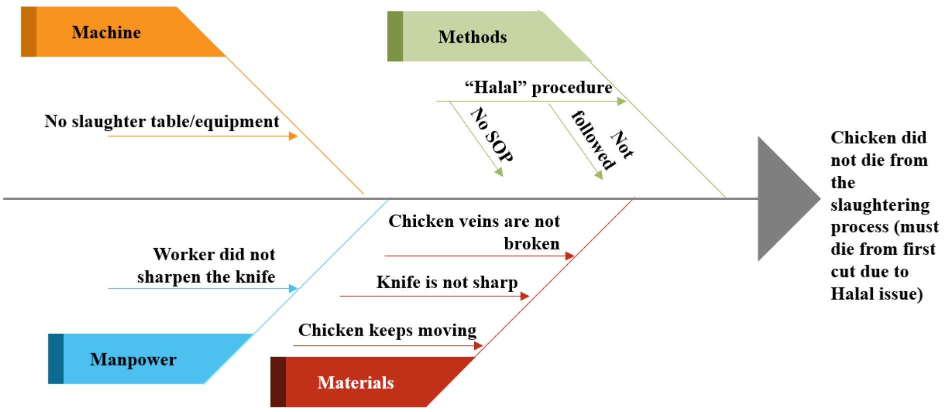


Figure 4.24: The Ishikawa diagram for Process 1- Slaughtering the chicken

b) Figure 4.25 below shows the Ishikawa diagram for defects in Process 3- Plucking the feather where it needs to be reworked due to the machine did not pluck the chicken's feather entirely.

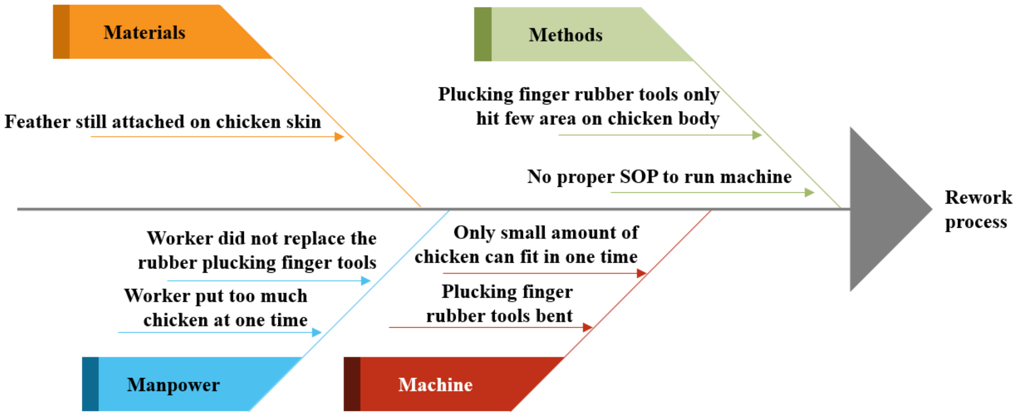


Figure 4.25: The Ishikawa diagram for Process 3- Plucking the feather

4.7.1.1.4. Ishikawa diagram for transportation waste

Only one transportation waste detected at Process 2- Scalding the chicken where worker need to move to Process 1- Slaughtering the chicken in order to take the chicken out from the basin to be placed in the scald machine. Figure 4.26 shows the Ishikawa diagram for transportation waste.

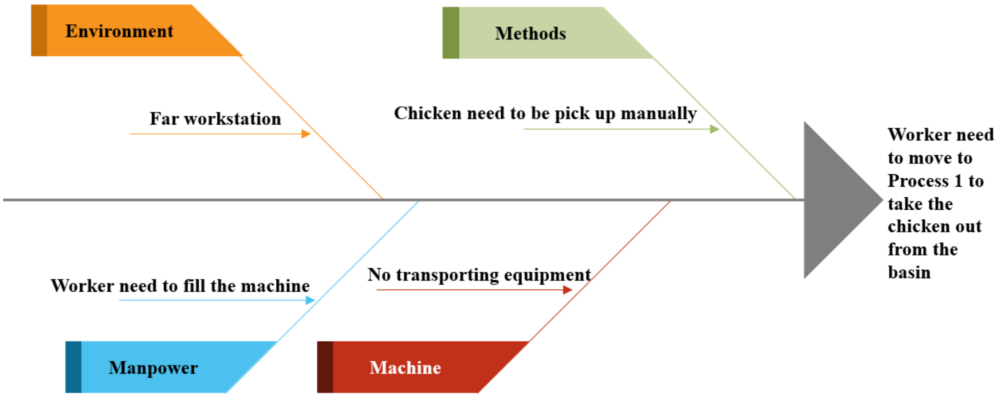


Figure 4.26: The Ishikawa diagram for transportation waste in Process 2- Scalding the chicken

4.7.1.1.5. Ishikawa diagram for inventory waste

There are two inventory waste that have found between process which is inventory between Process 1- Slaughtering the chicken and Process 2- Scalding the chicken, also Process 3- Plucking the feather and Process 4- Cutting the chicken. This chicken will be put to wait because the machine is not ready to process the chicken or waiting to be cut. The Ishikawa diagram for inventory waste between Process 1 and Process 2 are shown in Figure 4.27 while for Process 3 and Process 4 are shown in Figure 4.28.

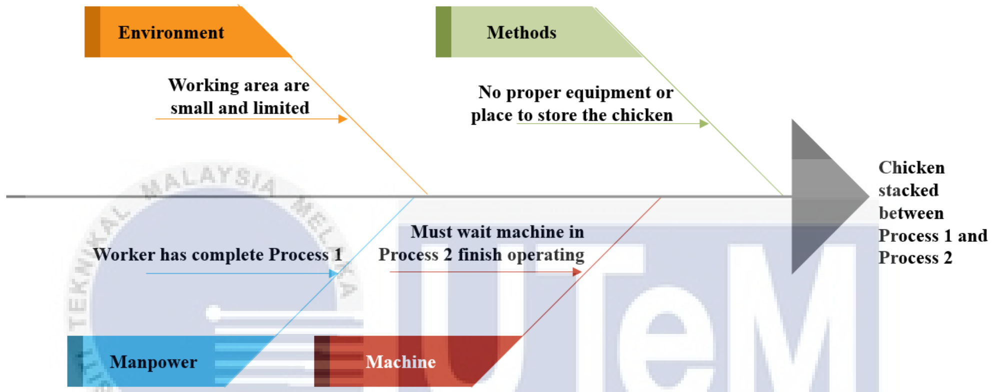


Figure 4.27: The Ishikawa diagram between Process 1 and Process 2

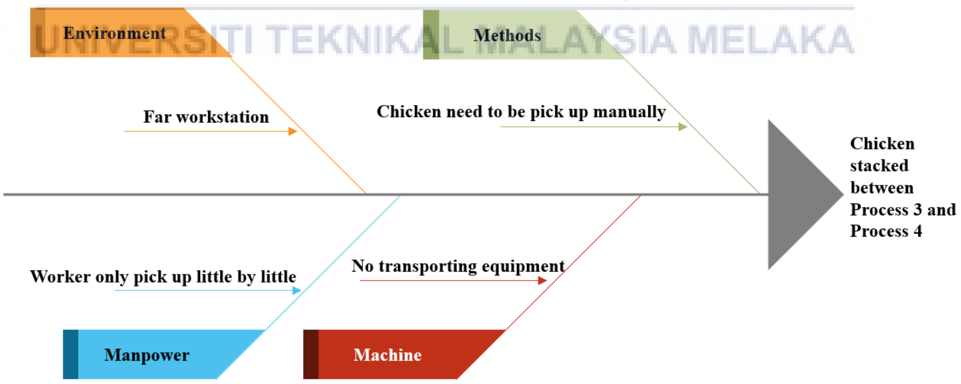


Figure 4.28: The Ishikawa diagram between Process 3 and Process 4

4.7.1.2. Waste analysis using Failure Modes and Effects (FMEA)

In this part, the Failure Modes and Effects Analysis (FMEA) has been applied in order to take prevention and minimizing failures for improvement. All waste which are waiting, motion, defects and transportation wastes has gone through FMEA to find the highest RPN of each waste. Therefore, it was conducted to find the highest RPN for waiting, motion, transportation and defects wastes. For waiting and motion wastes, Process 1- Slaughtering the chicken has the highest RPN which is 576. As for defects wastes comes from Process 3- Plucking the feather which has the highest RPN which is 576. Then, the transportation waste occurs in Process 2 with RPN 576. Table 4.12, 4.13 4.14 and Table 4.15 below shows the analysis of the FMEA for waiting, motion, defects, and transportation wastes. The rubric for severity, occurrence and detection that used to rank the score is shown in **Appendix D**.

4.7.1.2.1. FMEA for waiting waste

Table 4.12 below shows the FMEA for waiting wastes that have that have been done for each process to select the process with the highest RPN. Therefore, Process 1 get the highest RPN which is 576.

Table 4.12: FMEA for waiting waste

Waste	Potential Failure Mode	Potential Failure Effect	Severity	Potential Causes	Occurrence	Current Control	Detection	RPN
Waiting	**Process 1**: Time is wasted when the chicken needs to be hold for slaughter	Too much time spent to complete the process	9	No proper equipment to hold chicken	8	None	8	576
	Process 2: Time is wasted during the duration for the machine to finish operating	Chicken from Process 1 will stack	7	Machine is not big enough	8	Place more than 14 chicken	8	448

	Process 3: Waste of time waiting for machine at Process 2 to finish operating	Slower rate of progress at Process 3	6	Machine can only run once machine in Process 2 finished	5	None	7	210

4.7.1.2.2. FMEA for motion wastes

Table 4.13 below shows the FMEA for motion wastes that have that have been done for each process to select the process with the highest RPN. Hence, from all the processes, Process 1- Slaughtering the chicken shows a high number of RPN which is 576.

Table 4.13: The FMEA for motion waste

Waste	Potential Failure Mode	Potential Failure Effect	Severity	Potential Causes	Occurrence	Current Control	Detection	RPN
Motion	**Process 1:** Dropping the slaughtered chicken into the basin	Unnecessary movement	9	No proper method to store the chicken	8	None	8	576
	Process 2: Open and closing the machine lid	Hand fatigue	8	Current machine method ways to start the process	8	None	8	512
	Process 3: Workers need to take out the chicken from pluck machine manually	Workers are tired	5	No passage out for the chicken after the process finished	5	None	4	100
	Process 4: Workers need to move to Process 3 to take the chicken before it was cut.	Workers feels tired	4	Far workstation	5	None	4	80

4.7.1.2.3. FMEA for defects wastes

Table 4.14 below shows the FMEA for defects wastes that have that have been done for each process to select the process with the highest RPN. In Process 3- Plucking the feather shows a high number of RPN which is 576.

Table 4.14: The FMEA for defects waste

Waste	Potential Failure Mode	Potential Failure Effect	Severity	Potential Causes	Occurrence	Current Control	Detection	RPN
Defects	**Process 1**: Chicken did not die from the slaughtering process	Rejected (must die from first slaughter due to Halal issue)	7	Improper slaughter method	8	None	8	448
	Process 3: The chicken feather is not properly plucked	Rework	8	Mishandling of the machine by worker	8	Pluck the feather manually	8	576

4.7.1.2.4. FMEA for transportation waste

Table 4.15 below shows the FMEA for transportation wastes in Process 2 which has a high number of RPN. In Process 2- Scalding the chicken recorded 576 RPN. The implementation of a new facility layout enables a smooth movement of processes and will improve the rate of production.

Table 4.15: The FMEA for transportation waste

Waste	Potential Failure Mode	Potential Failure Effect	Severity	Potential Causes	Occurrence	Current Control	Detection	RPN
Transportation	**Process 2**: Worker move to Process 1 to take out chicken from basin	Repeated movement	8	Far workstation	8	None	8	576

4.8. Suggestion for improvement

In this part, after analysis has been conducted through the Ishikawa diagram and Failure Mode and Effects Analysis (FMEA), there are three processes has been detected with highest Risk Priority Number (RPN) which is Process 1, Process 2 and Process 3 with score of 576. Process 1 has recorded two highest wastes which are waiting and motion. Transportation waste was recorded in Process 2 and lastly highest defects waste was recorded at Process 3. All the proposed improvement will be discussed in the next subsection.

4.8.1. Improvement of waste at Process 1-Slaughtering the chicken

There are two improvement plan that was proposed for Process 1 in order to reduce the waiting waste and motion waste which are Automatic Poultry Hanger and 5S pillars.

4.8.1.1. Waiting waste improvement plan

As detected in FMEA, Process 1- Slaughtering the chicken obtained the highest RPN which 576 for waiting waste. This is due to no proper equipment to hold chicken which causes the workers spent too much time holding the chicken neck for slaughtering process because the chicken keeps moving and worker need to wait for another worker that carried out slaughtering process to finish the process. In order for the chicken to die on first cut, worker must hold the neck of the chicken in the correct position. This step is the most vital to ensure the chicken is “Halal” before it was distributed to customer. The worker spent 0.169 minutes specifically on that step and the total cycle time spent on Process 1 is 0.343 minutes. Due to this reason, the production times in providing the processed chicken to customer took a longer time. Hence, an Automatic Poultry Hanger was proposed to the company so that worker will only need to hang the chicken at the overhead conveyer which helps in properly place the chicken into its position for slaughtering process.

The worker does not need to waste their time holding the chicken neck while waiting the other worker that do the slaughtering to finish the step. By using this Automatic Poultry Hanger, the chicken will be hanged, and it will have a proper slaughtering position. The proposed Automatic Poultry Hanger will use the concept of overhead conveyer system which able to hang an estimated 180-200 chickens at one time. The concept of this conveyer system will hold the chicken on horizontal moving conveyer for the chicken placed at a correct position for slaughtering process which shown in Figure 4.29. It will then hold the chicken and move for the next process.

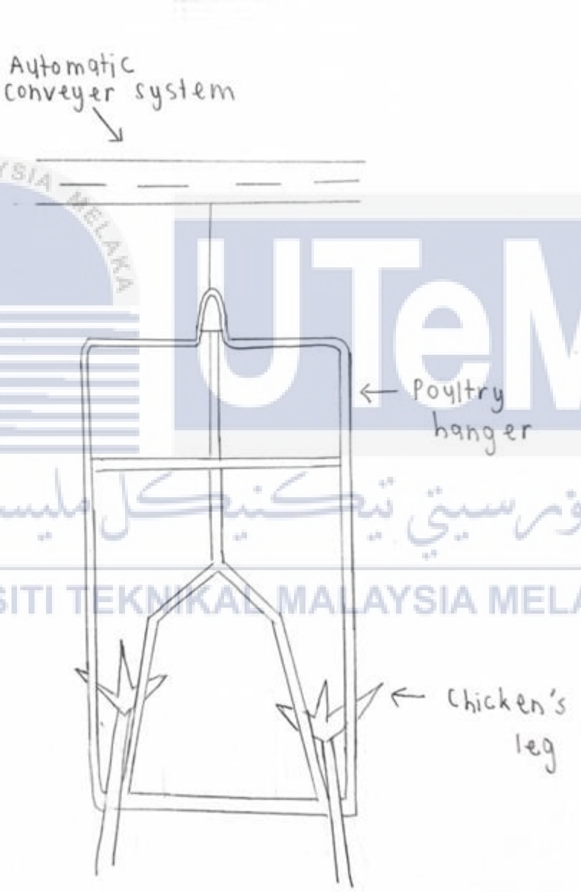


Figure 4.29: The concept of the conveyer system

This Automatic Poultry Hanger is a 1000 birds per hour (BPH) model which the details of the machine are shown in the Table 4.16 below.

Table 4.16: Details of the Automatic Poultry Machine

Specifications	Details
Capacity	1000 birds per hour
Type of bird	Broiler
Average live weight	900 grams – 2.5 kilograms
Pitch	6 inches
Electricity	220-380V/50Hz up to 440V/60hz

For this study, the company requested a poultry hanger that has an easy method to hang the chicken and do not use painful method. To fulfil the requested design, a few analyses were conducted before the design was produced. Then, as shown in Figure 4.30 the technical drawing and Figure 4.31 shows the 3-D image of the poultry hanger from the analysis was produced using CATIA V5 software. The concept and design of the system was drawn and proposed to the industry, and it was discussed for an approval.

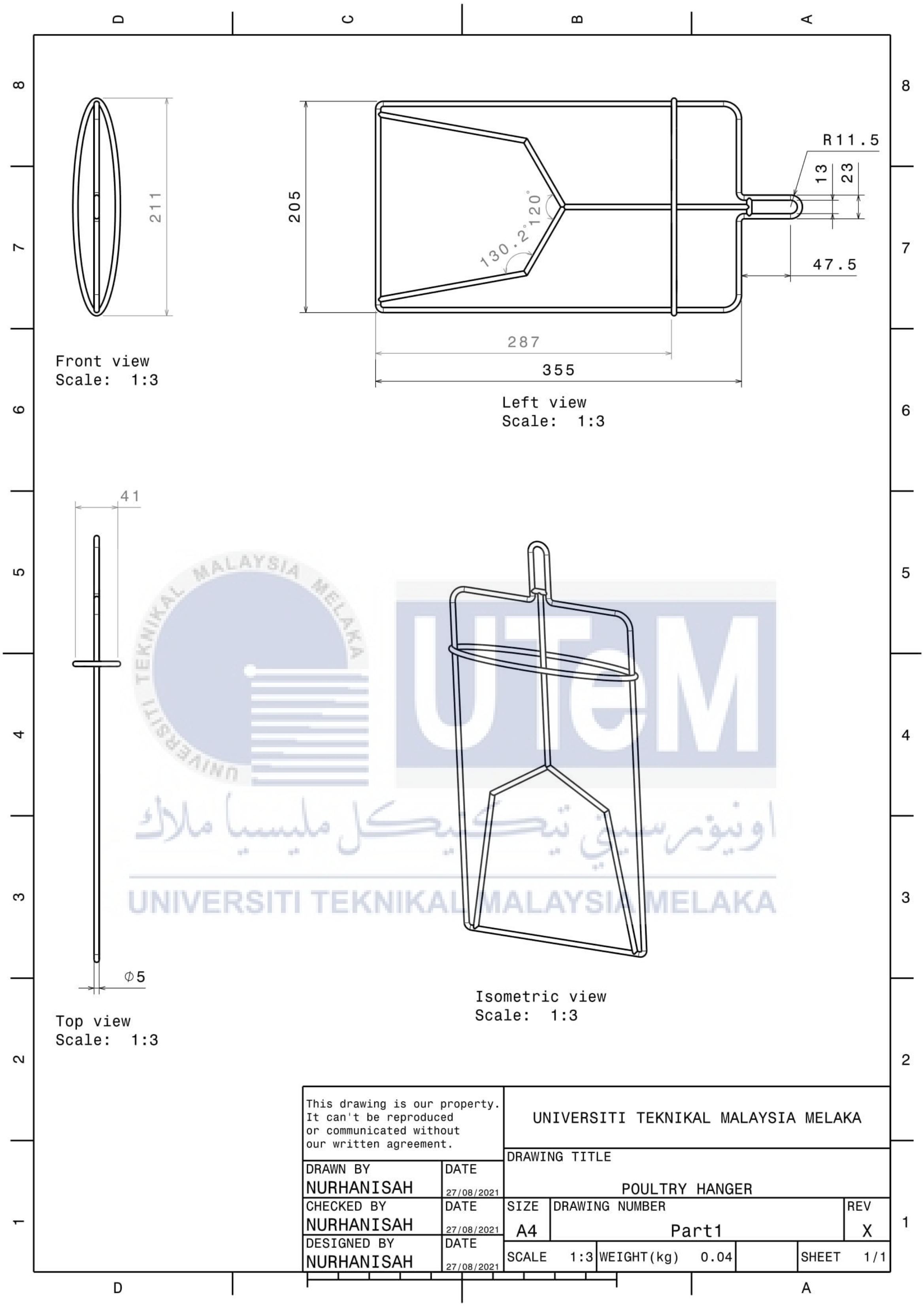


Figure 4.30: The technical drawing of the poultry hanger

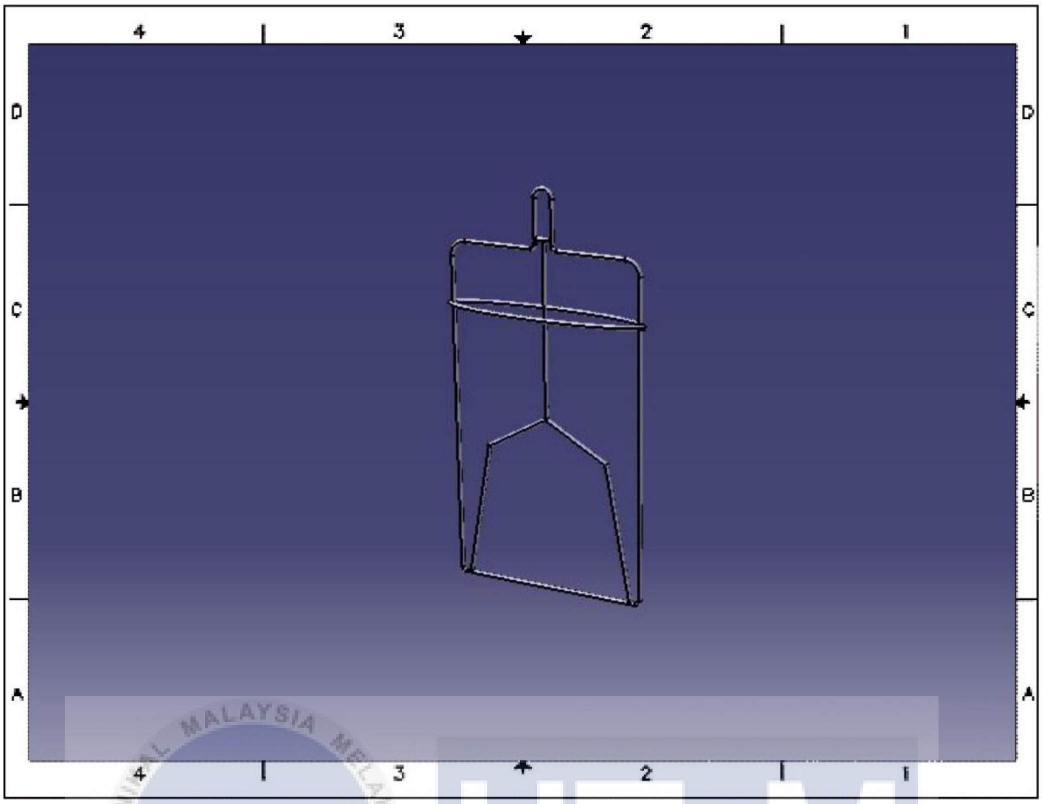


Figure 4.31: The 3-D image of the poultry hanger

a) Planning matrix of customer requirements

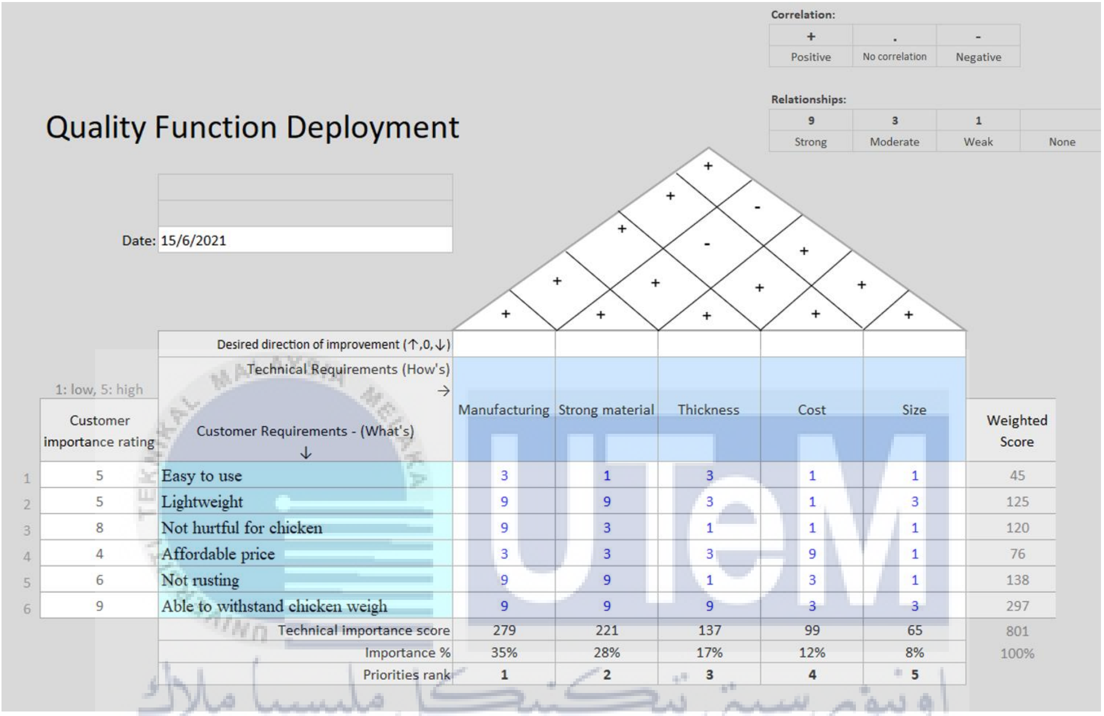
Before the design in Figure 4.29 above was produced, the design requirements were obtained from interview and discussion with the owner, supervisor and two workers from Process 1. A planning matrix was produced as a guidance before producing a design of the hanger. Table 4.17 below shows the planning matrix of the customer requirement form which contain all the important criteria required for the design.

Table 4.17: Planning Matrix of Customer Requirement form

Design Requirement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Total Score**	**Importance Rating**
Score	**1**	**2**	**3**	**4**	**5**		
Easy to use	0	0	0	0	3	15	17.65
Lightweight	0	0	0	1	2	14	16.47
Not hurtful for chicken	0	0	0	2	1	13	15.29
Affordable price	0	0	0	2	1	13	15.29
Not rusting	0	0	0	0	3	15	17.65
Able to withstand chicken weight	0	0	0	0	3	15	17.65
TOTAL						85	100.00

b) Quality Function Deployment (QFD) on Design Requirements

Figure 4.32 below shows the QFD results after the customer requirements and technical requirements has been considered. This method was used to translate the customer requirements into a quantitative parameter in order to achieve the required design.



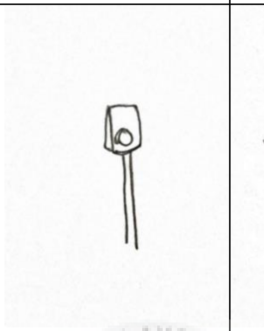
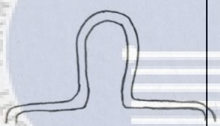
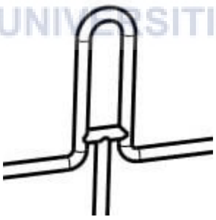
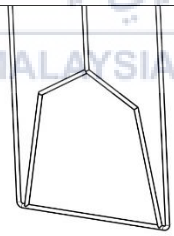
	Customer importance rating	Customer Requirements - (What's)	Manufacturing	Strong material	Thickness	Cost	Size	Weighted Score
1	5	Easy to use	3	1	3	1	1	45
2	5	Lightweight	9	9	3	1	3	125
3	8	Not hurtful for chicken	9	3	1	1	1	120
4	4	Affordable price	3	3	3	9	1	76
5	6	Not rusting	9	9	1	3	1	138
6	9	Able to withstand chicken weigh	9	9	9	3	3	297
		Technical importance score	279	221	137	99	65	801
		Importance %	35%	28%	17%	12%	8%	100%
		Priorities rank	1	2	3	4	5	

Figure 4.32: Quality Function Deployment (QFD)

c) Morphological Chart for Conceptual Development

Table 4.18 below shows the morphological chart to help visualize the conceptual development. This chart is a visual representation of the required product functionality, as well as different methods and combinations for delivering it.

Table 4.18: Morphological chart

Concept	Connector	Hook	Leg area shape	Diameter (mm)	Material
1			Not applicable	10 mm	Steel
2		Not applicable		8 mm	304 Stainless Steel
3		Not applicable		5 mm	304 Stainless Steel

d) Product Screening and Scoring

Table 4.19 below shows the screening concept before designing the products. All the concepts that are eligible were brought forward in order to conduct the scoring concept.

Table 4.19: Screening concept

CONCEPT CRITERIA	MANUAL METHOD	CONCEPT 1	CONCEPT 2	CONCEPT 3
Easy to use	0	0	+	+
Lightweight	0	+	-	+
Not hurtful for chicken	0	-	+	+
Affordable price	0	+	+	+
Not rusting	0	0	+	+
Able to withstand chicken weight	0	0	0	+
Sum of "+"	0	3	4	6
Sum of "0"	0	2	1	0
Sum of "-"	0	1	1	0
NET SCORE	**0**	**1**	**3**	**6**
RANK		**3**	**2**	**1**
CONTINUE	**NO**	**NO**	**YES**	**YES**

Table 4.20 below shows the scoring concept after conducting the screening concept. The scoring scale in Table 4.21 is used to rate the design concept. The highest score with the first rank is concept 3.

Table 4.20: Scoring concept

SELECTION CRITERIA	**WEIGHT**	**CONCEPTS**			
		CONCEPT 2		**CONCEPT 3**	
		RATING	**WEIGHT SCORE**	**RATING**	**WEIGHT SCORE**
Easy to use	10	4	0.40	5	0.50
Lightweight	20	3	0.60	5	1.00
Not hurtful for chicken	30	5	1.50	5	1.50
Affordable price	10	4	0.40	5	0.50
Not rusting	10	5	0.50	5	0.50
Able to withstand chicken weight	20	4	0.80	5	1.00
TOTAL	**100%**	**4.20**		**5.00**	
RANK		**2**		**1**	
CONTINUE		**NO**		**YES**	

Table 4.21: Scoring scale

CONCEPTS	RATING
Much worse than reference	1
Worse than reference	2
Same as reference	3
Better than reference	4
Much better than reference	5

e) Analysis of material selection

The industry required a light material, not rusting and affordable price for the poultry hanger that will be used on the automatic overhead conveyer system. The material was selected based on the common usage in the poultry industry also considering the request from the company to use the stainless steel specifically for the product. In this study, AISI 304 Stainless Steel has been chose for the poultry hanger that will be used in the company production plant. Considering Covid-19 situation, CES Edupack software was unable to use at university facilities hence analysis was based on the information from internet. The results of the comparison of the material properties were tabulated in Table 4.22 below:

Table 4.22: Results of the comparison of the material properties

Properties	Steel	AISI 304 Stainless Steel
Categories	Metal	Metal; Ferrous Metal Heat Resisting; Stainless Steel; T 300 Series Stainless Steel
Elements	Iron and carbon	Iron, carbon, 10.5% chromium, nickel, nitrogen, and molybdenum
Poisson's Ratio	0.25	0.29
Young's Modulus	200 GPa	193 GPa
Ultimate Tensile Strength	420 MPa	505 MPa

From the table, we can see the properties of steel and stainless steel has been compared to choose the best material for the poultry hanger. The stainless steel made of more elements in its body while steel is only made of two elements. As the company required corrosion and rusting-free material for a longer lasting lifespan, stainless steel is the best material since 10.5% chromium, nickel, nitrogen, and molybdenum produced an anti-corrosion anti-rusting properties as steel are prone to rust and corrode. The Poisson's ratio for each material has low deformation as both are in between 0.1-0.35 so these two materials is suitable for the poultry hanger. The Young's modulus of both materials has a good elastic range of deformation which is from 45 GPa (6.5 x 106 psi) to 407 GPa (59 x 106 psi) but stainless steel shows a lower reading of elastic deformation which is good for the poultry hanger to accommodate the weight of the chicken. Then, stainless steel has a high ultimate tensile strength which 550 MPa compared to steel which is 420 MPa. From the comparison, stainless steel shows a high resistance in terms of deformation to hold the chicken with anti-rusting value added. Hence, AISI 304 Stainless Steel will be used for the poultry hanger at the factory.

f) Simulation Test Analysis of Product Design

An engineering analysis was conducted for the design of the poultry hanger to identify the strength of the material and any possible failure. A stress analysis using the Solidworks simulation software was conducted for the design that was produced. The analysis was conducted using a stainless-steel material with an applied force from the weight of a chicken which is 17.65N. There are three types of plots were conducted for the design which is Static Nodal Stress, Static Displacement and Static Strain.

i. Static Nodal Stress Plot

The static nodal stress plot shows a good result for all area of the design. Based on Figure 4.33, most of the surface on the design displayed blue colour for the degree of deflection. Despite the good result, the test also shows a weak green on the middle of the leg area which show small increase of its yield limit.

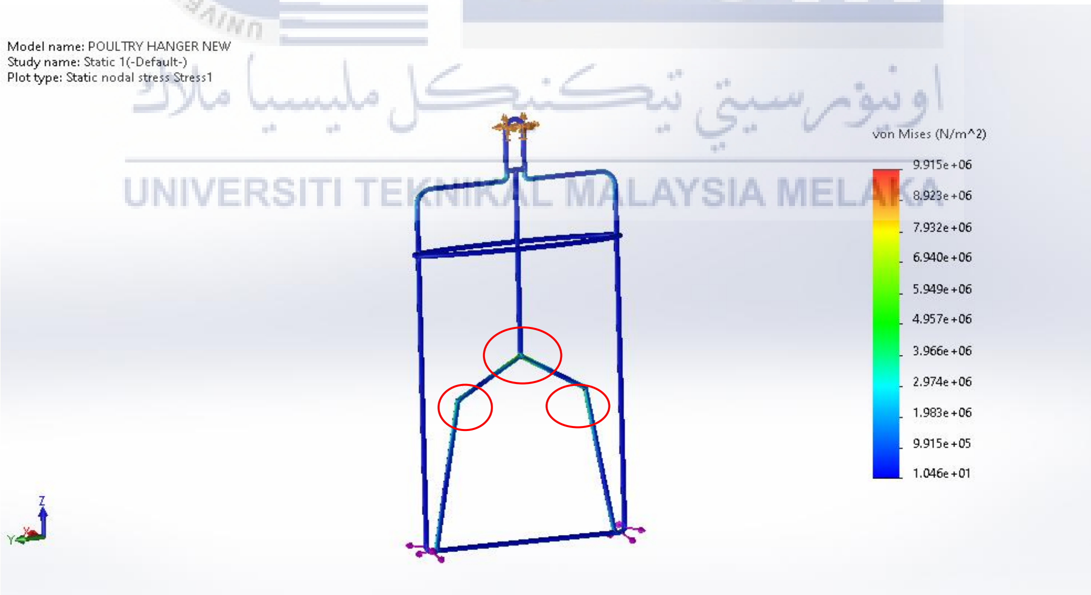


Figure 4.33: Static Nodal Stress Plot

ii. Static-Displacement Plot

Figure 4.34 shows the results of static displacement plot for the design and the surface shows a weak green on the lower surface which shows an increase of deflection when it has an applied force. Next, the results also show weak red on the middle of leg part area which the reading show a quite high increment for degree of deflection. The deflection might cause bend on the part during the hanging process. Therefore, the hook of the hanger still shows blue colour which gives low degree of deflection on that part which will not lead the hanger to fall from the overhead conveyer system.

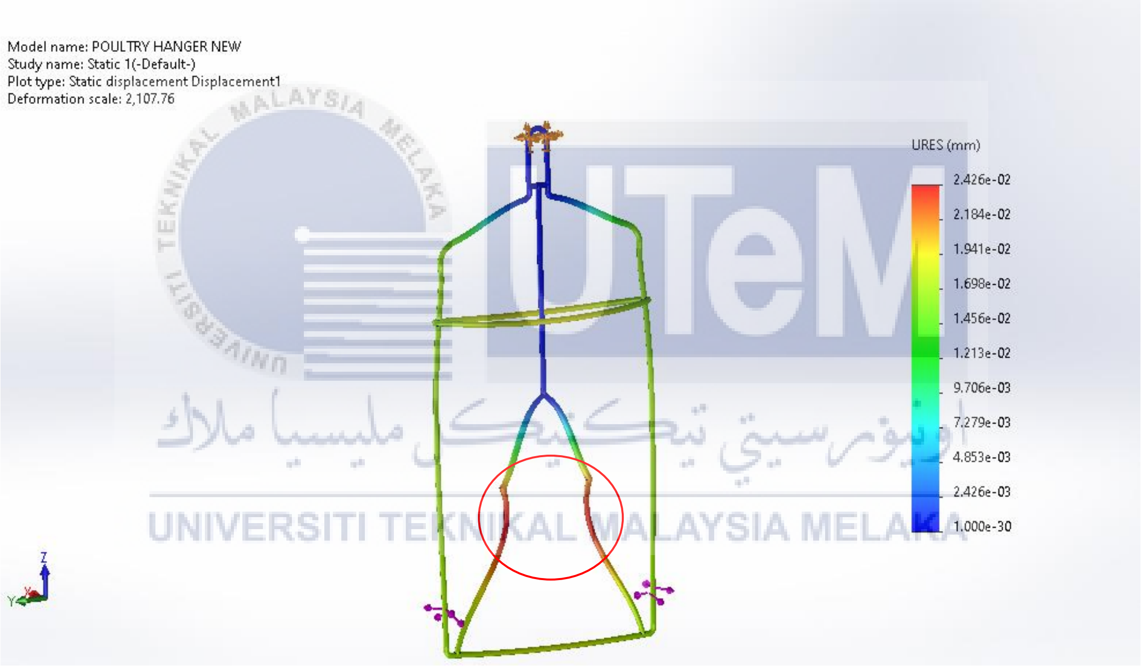


Figure 4.34: Static-Displacement Plot

iii. Static-Strain Plot

The last plot is the static strain plot which the results shown in Figure 4.35 below. The equivalent strain on the design shows a blue colour on almost all of the surface but there is a slight increase of the equivalent strain on the middle of the entrance of leg area.

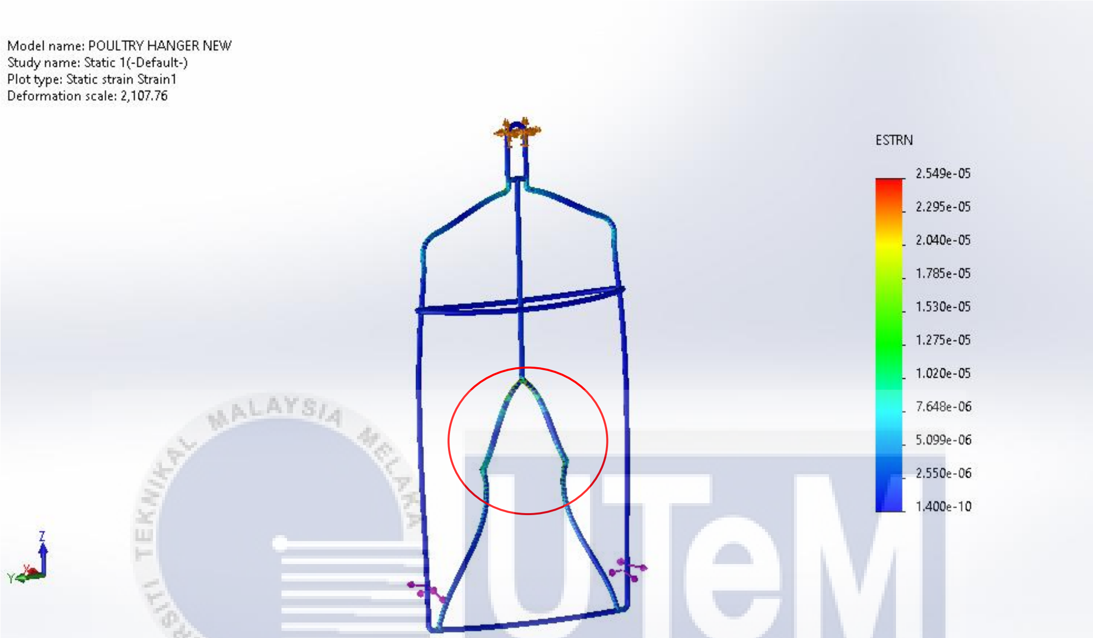


Figure 4.35: Static-Strain Plot

4.8.1.2. Motion waste improvement plan

Other than that, the highest RPN also detected from FMEA at Process 1-Slaughtering the chicken. No proper place to store chicken causes an unnecessary movement of workers since they need to place the chicken in a basin after it was slaughtered. It can be categorized as unnecessary since the chicken is required for next process. Therefore, the suggested improvement in this process is to implement 5S method to eliminate this waste. Implementation of 5S able ease the worker to do their work and smoothen the overall process. This implementation will also remove the unnecessary motion and also the production process can move faster to finish. 5S consists of 5 steps which are Seiri, Seiton, Seiso, Seiketsu, Shitsuke.

i. **Seiri- Sort:** Decide which elements is important for Process 1. This step is important to remove any unnecessary elements in Process 1. Table 4.23 below shows the old method elements while Table 4.24 below shows the unnecessary elements for Process 1 marked with red colour. The elements were removed and replaced to reduce the motion waste which are indicated in Table 4.25.

Table 4.23: The old method elements

Sequence	Steps
1	Worker 1- Take out chicken from cage
2	Worker 1- Hold the chicken neck in correct position
3	Worker 2- Hold the sharp knife
4	Worker 2- Slaughter the chicken
5	Worker 1- Place chicken in basin

Table 4.24: The unnecessary elements for Process 1

Sequence	Steps
1	Worker 1- Take out chicken from cage
2	Worker 1- Hold the chicken neck in correct position
3	Worker 2- Hold the sharp knife
4	Worker 2- Slaughter the chicken
5	Worker 1- Place chicken in basin

Table 4.25: Elements that were removed and replaced to reduce the motion waste

Sequence	Steps
1	Worker 1- Take out chicken from cage
2	Worker 1- Hang chicken to poultry hanger
3	Worker 2- Hold the sharp knife
4	Worker 2- Slaughter the chicken

ii. **Seiton- Set in order:** Chicken cage placed besides hanging area to ease worker to hang the chicken to the poultry hanger.

iii. **Seiso- Shine:** Properly clean every area from spilled blood during the slaughtering process. Ensure that spilled blood did not splatter on the floor and make sure to clean them every day.

iv. **Seiketsu- Standardize:** Standardize the job scope of every worker on their own process elements. Table 4.26 below shows the process elements and the person in charge.

Table 4.26: The process elements and the worker in charge.

Person in charge	**Process elements**
Worker 1	Take out chicken from cage
Worker 1	Hang chicken to poultry hanger
Worker 2	Hold the sharp knife
Worker 2	Slaughter the chicken

v. **Shitsuke- Sustain:** This step is vital to ensure that all the workers follow the rules in 5S. It can also help the company work efficiently after unnecessary elements in chicken production process has been eliminated. This creates a proper and tidy environment for work.

4.8.2. Improvement plan for transportation waste at Process 2- Scalding the chicken

The FMEA for transportation wastes in Process 2 recorded a high number of RPN which is 576. This is because worker need to travel to Process 1 to manually pick up the chicken. Process 2 located 2 meters away from Process 1 which is far and caused hustle to worker. The old method scald machine can fit up to 12-14 chickens, so they need to repeatedly move to Process 1 to pick up the chicken in order to start Process 2. A new facility layout has been proposed to the company where the workstation will be placed near with each other. The implementation of a new facility layout enables a smooth movement of processes and will improve the rate of production.

As shown in **Appendix B,** the workstation of Process 2 requires worker to manually pick up the chicken at Process 1 to fit in the scald machine. Therefore, the proposed facility layout aimed to adjust all the workstation position then reduced the distance of Process 1 and Process 2. Next, the implementation of Automatic Poultry Hanger at Process 1 will transport the chicken to Process 2 using the overhead conveyer system and will dip the chicken directly on the scald machine which shown in Figure 4.36. Therefore, the worker will no longer involved in transferring the chicken to Process 2.

In Figure 4.37 below shows the new facility layout of the factory where all the workstations were adjusted that will help to improve the rate of production. The current facility layout has a space which 20 feet x 60 feet. As the company has plan to develop a new site with a space of 60 feet x 120 feet for the company, so the proposed facility layout will be applied once it was approved by the owner and supervisor.

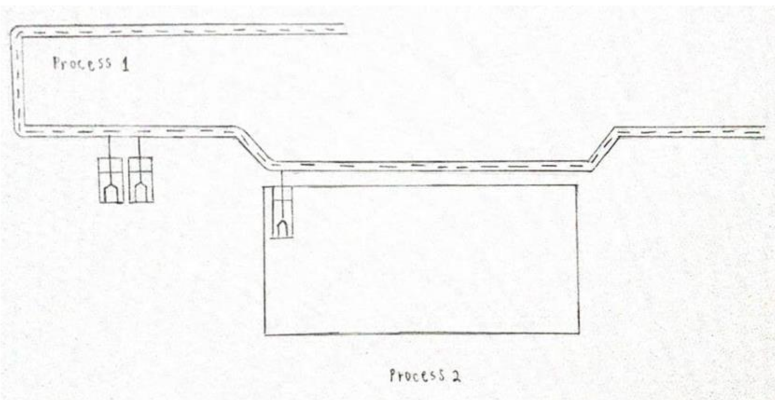


Figure 4.36: The concept of conveyer system between Process 1 and Process 2

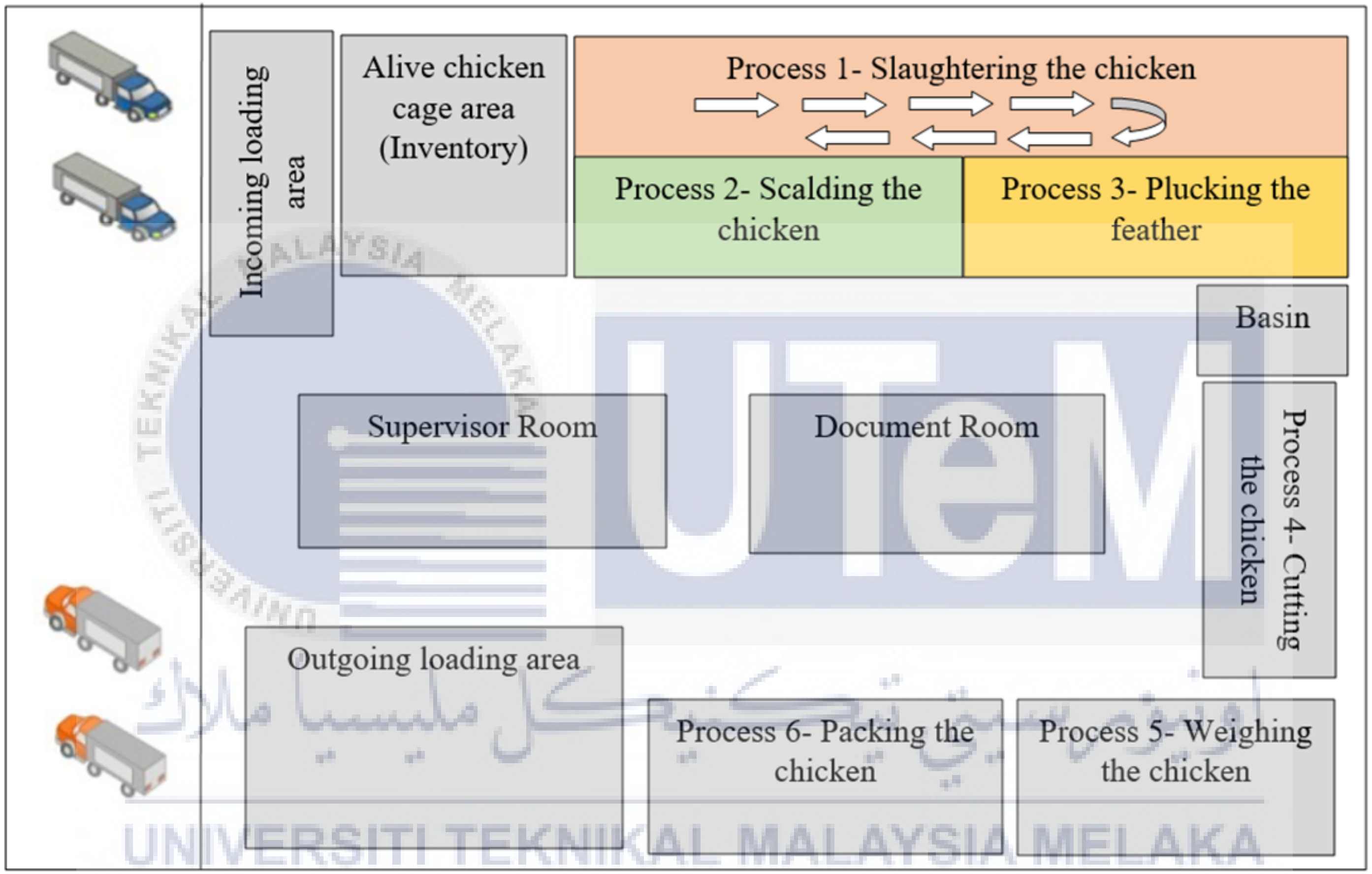


Figure 4.37: The proposed new facility layout of the factory

4.8.3. Improvement plan for defects waste at Process 3- Plucking the feather

For the last improvement conducted at the company was at Process 3. It is because FMEA in Process 3- Plucking the feather has recorded a high RPN for defects waste which is 576. In previous method, worker has done a few errors which was mishandled the machine and ignored a correct method to run this process. Figure 4.38 below shows the common condition of chicken found after it undergo Process 3 where worker ignores the SOP of handling the machine. Worker did not change the rubber plucking finger on the machine daily which led to condition shown in Figure 4.39 below where the rubber is exhausted and bent. This has led for rework where the chicken is not fully clean since the feather is still attached on the chicken skin.

Figure 4.38: Common condition of chicken with feather still attached

Figure 4.39: The rubber is exhausted and bent

Therefore, the suggested improvement in this process is to make a SOP on how to properly handle the machine. Workers are required to follow the SOP provided to avoid repeated process and rework problem. A proper SOP has been developed by considering the opinion from the owner and supervisor. Other than that, an interview was done with the current worker at Process 3 since they understand the machine well and have a lot of experience. By implementing a new SOP, the suggested improvement will help the company to reduce the defects of the products. Figure 4.40 below shows the SOP to handle the machine. Then, a plucking finger rubber tools check sheet was prepared in order to ensure that worker that run the machine will record the change of rubber tools so that the supervisor can identify whether the worker change the plucking finger rubber tools every day. The plucking finger rubber tools check sheet was shown in Figure 4.41 below.

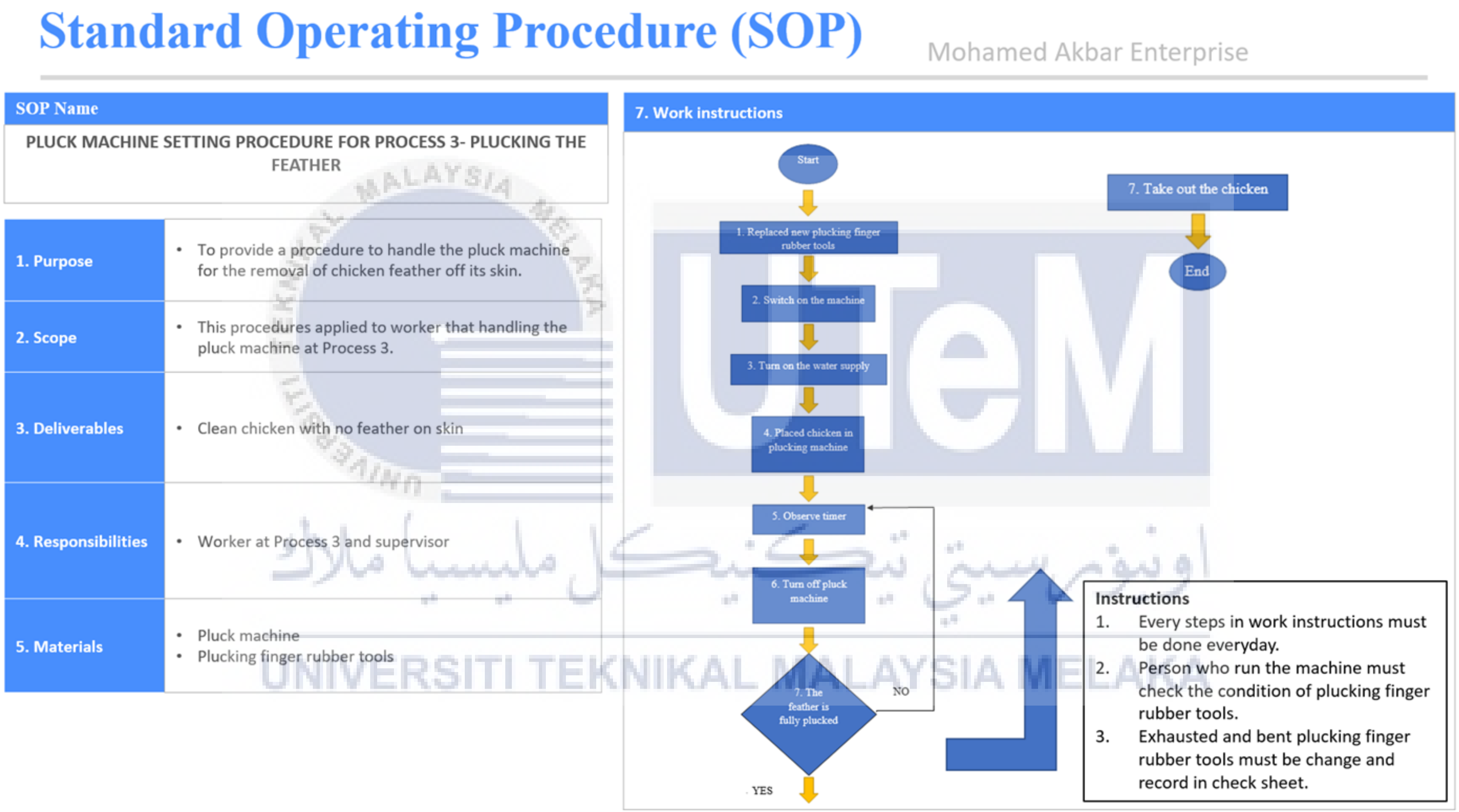


Figure 4.40: The Standard Operating Procedure (SOP) to handle the machine

Plucking Finger Rubber Tools Change Cheek Sheet

Mohamed Akbar Enterprise

Date	Name	No of plucking finger changed	Sign	Checked by

Figure 4.41: Plucking finger rubber tools check sheet

4.9. Approval of the improvement plan proposal

An approval form of the improvement plan for all three processes was prepared to get an approval from the company side. The improvement proposal contains the Automatic Poultry Hanger, 5S pillars, new facility layout and Standard Operating Procedure (SOP) that was then presented to the company representatives and has been approved by Encik Mohamad Akbar which is the owner of the company. Figure 4.42 below shows the proposal and the comments from the company on the proposal.

Approval Form

This form was prepared in order to get an approval for the improvement proposal from the company side. Please tick (/) on the approvement area and comment (if any) for the idea of the proposal that will be implemented to the company.

Company: Mohamed Akbar Enterprise

Prepared by: Ms. Nurhanisah binti Mahyuddin

No	Process Area	Idea for Improvement	Approvement	Comment(s)
1.	Process 1	Automatic Poultry Hanger and 5S pillars	Approve (/) Reject ( )	Good! As company plan
2.	Process 2	Implementation of new facility layout	Approve (/) Reject ( )	Good! Follow advice from company
3.	Process 3	Implementation of Standard Operating Procedure (SOP)	Approve (/) Reject ( )	Very good!

Approved by: ____________________ Date: 20. 8. 2021

MOHAMED AKBAR BIN WAZIR MOHAMEL
(000862663-D)
NO. 12, JALAN RP 7/10,
RAWANG PERDANA, PRIMA VILLE,
48000 RAWANG, SELANGOR D. E.
H/P: 012-268 3464

Figure 4.42: The approval form of the improvement plan

4.10. Failure Mode and Effects Analysis (FMEA) after the improvement

After all the improvement plan to reduce the waste in the industry has been implemented, the FMEA was then developed to show the action recommended for the waste that was not in the proposed improvement plan. The waste on the process that has been improved was marked in red to differentiate between the waste that has not been improved yet. Table 4.27, Table 4.28, Table 4.29 and Table 4.30 below shows the FMEA for waiting, motion, transportation and defects waste respectively.

The FMEA for waiting waste for Process 1 has been improved by implementation of Automatic Poultry Hanger. For Process 2, the action recommended to reduce the waste is to let the automatic machine with the hanging slaughtered chicken runs above an open concept scalding machine. In Process 3, it is recommended to let the automatic machine with scalded chicken drop the chicken into the pluck machine so the worker will no need to wait for the process to finish operating.

For FMEA of motion waste for Process 1 has been improved by implementation of 5S pillars where Process 1 work elements has been standardized using the method. Next, for Process 2 it is recommended to implement an open concept of scalding machine so worker will skip the open and closing the lid. As for Process 3, the action recommended to remove the motion waste is by implementing a pluck machine with passage out for the chicken after the process finished. Then, it is recommended to place Process 3 and Process 4 closer with each other so worker will no need to move back and forth to take the chicken.

Transportation waste in Process 2 has been completely removed by the implementation of new facility layout where Process 1 and Process 2 located nearer and allow the Automatic Poultry Hanger to transport chicken in a shorter distance. For defects waste in Process 3 has been improved by the implementation of Standard Operating Procedure (SOP) where worker will change the plucking finger rubber tools every day and jotted the activity in a check sheet. Lastly, it is recommended to improve the defects waste in Process 1 by implementing a proper Halal slaughter method. All the action recommended can be used for further study to implement at the company.

Table 4.27: The FMEA for waiting waste after the improvement

Waste	Potential Failure Mode	Potential Failure Effect	Severity	Potential Causes	Occurrence	Current Control	Detection	RPN	Action Recommended	Responsibility	Action Taken	Severity	Occurrence	Detection	RPN
Waiting	**Process 1**: Time is wasted when the chicken needs to be hold for slaughter	Too much time spent to complete the process	9	No proper equipment to hold chicken	8	None	8	576	Implement a new automatic machine to hold the chicken	Workers in Process 1	Workers must hang the chicken on the new automatic machine for slaughter	3	3	3	27
	Process 2: Time is wasted during the duration for the machine to finish operating	Chicken from Process 1 will stack	7	Machine is not big enough	8	Place more than 14 chicken	8	448	Let the automatic machine with the slaughtered chicken runs above an open concept scalding machine	All workers	Ensure the chicken fully dipped into the open scalding machine	3	4	4	48
	Process 3: Waste of time waiting for machine at Process 2 to finish operating	Slower rate of progress at Process 3	6	Machine can only run once machine in Process 2 finished	5	None	7	210	Let the automatic machine with scalded chicken drop the chicken into the pluck machine	Worker at Process 3	Ensure the hanger drop the chicken properly into the pluck machine	2	3	3	18

Table 4.28: FMEA for motion waste after the improvement

Waste	Potential Failure Mode	Potential Failure Effect	Severity	Potential Causes	Occurrence	Current Control	Detection	RPN	Action Recommended	Responsibility	Action Taken	Severity	Occurrence	Detection	RPN
Motion	**Process 1**: Dropping the slaughtered chicken into the basin	Unnecessary movement	9	No proper method to store the chicken	8	None	8	576	Standardized the workplace by implementing 5S	Supervisor	Implement 5S	3	3	3	27
	Process 2: Open and closing the machine lid	Hand fatigue	8	Current machine method ways to start the process	8	None	8	512	Implement an open scalding machine	All workers	Ensure the chicken fully dipped into the open scalding machine	3	4	4	48
	Process 3: Workers need to take out the chicken from pluck machine manually	Workers are tired	5	No passage out for the chicken after the process finished	5	None	4	100	Implement a pluck machine with passage out for the chicken after the process finished	Worker at Process 3	Ensure all chicken has completely go through the passage	2	3	3	18
	Process 4: Workers need to move to Process 3 to take the chicken before it was cut.	Workers feels tired	4	Far workstation	5	None	4	80	Place both process with short distance	Supervisor	Adjustment of facilities layout	4	3	3	36

Table 4.29: FMEA for transportation waste after the improvement

Waste	Potential Failure Mode	Potential Failure Effect	Severity	Potential Causes	Occurrence	Current Control	Detection	RPN	Action Recommended	Responsibility	Action Taken	Severity	Occurrence	Detection	RPN
Transportation	**Process 2**: Worker move to Process 1 to take out chicken from basin	Repeated movement	8	Far workstation	8	None	8	576	Plan a new facility layout	Supervisor	Adjustment of workstation	3	3	3	27

Table 4.30: FMEA for defects waste after the improvement

Waste	Potential Failure Mode	Potential Failure Effect	Severity	Potential Causes	Occurrence	Current Control	Detection	RPN	Action Recommended	Responsibility	Action Taken	Severity	Occurrence	Detection	RPN
Defects	**Process 1**: Chicken did not die from the slaughtering process	Rejected (must die from first slaughter due to Halal issue)	7	Inconvenience slaughter place	8	None	8	448	Implement proper Halal slaughter method	Workers in Process 1	Make sure workers follow the slaughter method	3	3	3	27
	Process 3: The chicken feather is not properly plucked	Rework	8	Mishandling of the machine by worker	8	Pluck the feather manually	8	576	Make a SOP for the handling the machine	Workers in Process 3	Ensure the workers follow the new SOP	3	4	4	48

4.11. Analysis of impact from the improvement

In this part, the impact of the improvement was analysed by recording the new cycle time after the implementation. After the implementation, the improvement of the time utilization and the return of investment (ROI) was calculated to identify the improvement rate.

4.11.1. Impact of improvement at Process 1- Slaughtering the chicken

There are two types of improvement applied at Process 1 in order to reduce the waiting and motion wastes. The implementation of Automatic Poultry Hanger and 5S has reduce the cycle time spent for Process 1 from 0.343 minutes by 0.322 minutes due to the adjustments. Table 4.31 below shows the cycle time at Process 1 after the implementation where the unnecessary elements has been removed and the hanger has helped to hold the chicken for slaughtering process.

Table 4.31: The cycle time at Process 1 after the implementation

		TIME TAKEN (MINUTES)										
Seq	**Steps**	**t1**	**t2**	**t3**	**t4**	**t5**	**t6**	**t7**	**t8**	**t9**	**t10**	**Ave**
1.	Worker 1- Take out chicken from cage	0.02	0.03	0.03	0.04	0.02	0.03	0.04	0.03	0.03	0.04	0.031
2.	Worker 1- Hang chicken to poultry hanger	0.04	0.05	0.05	0.06	0.06	0.04	0.05	0.05	0.04	0.04	0.048
3.	Chicken moves to Worker 2	0.14	0.15	0.14	0.15	0.15	0.15	0.14	0.15	0.15	0.15	0.147
4.	Worker 2- Hold the sharp knife	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.02	0.02	0.015
5.	Worker 2- Slaughter the chicken	0.08	0.09	0.08	0.07	0.08	0.09	0.09	0.08	0.07	0.08	0.081
TOTAL CYCLE TIME												**0.322**

4.11.2.Impact of improvement at Process 2- Scalding the chicken

The new proposed facility layout has reduced the distance between Process 1 and Process 2 since the worker does not need to move to Process 1 to place the chicken at scald machine. The proposed facility layout suits with the implementation of Automatic Poultry Hanger since distance of Process 1 to Process 2 has been shorten. The conveyer system will too help to transport the chicken automatically without human help. Table 4.32 below shows the reduced elements and the total cycle time at Process 2.

Table 4.32: The cycle time at Process 2 after the implementation

		TIME TAKEN (MINUTES)										
Seq	**Steps**	**t1**	**t2**	**t3**	**t4**	**t5**	**t6**	**t7**	**t8**	**t9**	**t10**	**Ave**
1.	Chicken moves to Process 2	1.81	1.80	1.81	1.79	1.81	1.80	1.81	1.80	1.81	1.80	1.804
3.	Chicken dip in scalding machine	2.00	2.00	2.01	2.01	2.00	2.01	2.00	2.08	2.01	2.01	2.013
TOTAL CYCLE TIME												**3.817**

4.11.3. Impact of improvement at Process 3- Plucking the feather

The previous method in Process 3 has led to defects problem and rework. The major problem that caused the rework is the worker has not changed the rubber plucking finger daily according to the need. By providing a correct SOP in handling the machine in Process 3 for the worker, the defects waste will be reduced, and rework can be avoided. The scalding process took shorter time compared to before the implementation since the machine is now working at good condition. All the workers will be trained to follow the right way to use the machine. Other than that, the involvement of the Automatic Poultry Hanger helped in reducing a few elements in Process 3. It is because the system will transport the chicken from Process 2 to Process 3 automatically. Table 4.33 shows the reduced elements and an improved total cycle time in Process 3.

Table 4.33: The cycle time at Process 3 after the implementation

Seq	Steps	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	Ave
		TIME TAKEN (MINUTES)										
1.	Chicken moves to Process 3	0.08	0.80	0.81	0.79	0.81	0.80	0.81	0.80	0.81	0.80	0.804
3.	Turn on pluck machine	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.015
2.	Plucking process	1.01	1.02	1.01	1.05	1.02	1.02	1.01	1.02	1.02	1.05	1.125
3.	Turn off pluck machine	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.015
4.	Take out the chicken into a basin	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.017
TOTAL CYCLE TIME												**1.976**

4.11.4. Time utilization improvement calculation

From the implementation of all improvement plan, the improvement of time utilization to produce the chicken has been calculated below:

$$\text{Rate of Improvement} = \frac{\text{Current Production Time} - \text{Future Production Time}}{\text{Current Production Time}} \times 100\%$$

$$\text{Rate of Improvement} = \frac{569.16s - 447.56s}{569.16s} \times 100\%$$

$$= 21\%$$

4.11.5. Return of investment calculation

The return of the investment for the Automatic Poultry Hanger was calculated to identify the ratio of profit the company would obtain from the implementation. The gross profit from the chicken's sale was calculated firstly before it was divided with the total investment of the machine.

i. The gross profit:

Table 4.34 shows the details of the elements that will be used to calculate the profit from the chicken's sale in Mohamad Akbar Enterprise for one year after the implementation of improvement plan.

Table 4.34: Details of elements for calculation of profit

Details	Gain	Spend
Number of chickens produced per day	1800	
Number of days in one year	365	
Price of one chicken per kg	RM17	
Salary of worker		RM2000
Number of workers		11 workers
Utilities for a month		RM 20,000
Number of months		12 months

$$\text{Gross profit} = (1800 \text{ chickens } \times 365 \text{ days} \times \text{RM}17) - (\text{RM } 2000 \times 11 \text{ workers} \times 12 \text{ months}) - (\text{RM } 20{,}000 \times 12 \text{ months})$$

$$= \text{RM } 11{,}169{,}000 - \text{RM}264{,}000 - \text{RM}240{,}000$$

$$= \text{RM } 10{,}665{,}000$$

ii. Investment

Table 4.35 shows the details of the elements to calculate the investment by Mohamad Akbar Enterprise on the Automatic Poultry Hanger.

Table 4.35: Details of elements for calculation

Details	Amounts
Automatic poultry machine	RM 4,195,000
Number of poultry hanger	1000 pieces
Weight of the poultry hanger in kg	0.4 kg
Price of stainless steel per kg	RM 11.11

$$\text{Investment} = \text{RM } 4{,}195{,}000 + (1000 \text{ pieces} \times 0.4\text{kg } \times \text{RM } 11.11) = \text{RM } 4{,}199{,}444.4$$

iii. Return of Investment

$$\text{ROI} = \frac{\text{Return (gross profit)} - \text{Investment (expense)}}{\text{Investment (expense)}} \times 100\%$$

$$\text{ROI} = \frac{\text{RM } 10{,}665{,}000 - \text{RM } 4{,}199{,}444.4}{\text{RM } 4{,}199{,}444.4} \times 100\% = 153\%$$

4.12. Development of Future State Map (FSM)

The developed CSM has able to visualize all six processes in the production plant and all the waste occurred has been identified. Therefore, only 5 out of 13 wastes that has been analysed and suggested for improvement as it requested by the company to only focused on the first three processes as it is the major problems that affects the production rate and quality issues. The implementation of Automatic Poultry Hanger, 5S method, adjustment of facility layout and implementing proper Standard Operating Procedure (SOP) has totally reduced the total lead time from 569.16s to 447.56s while the processing time reduced from 551.16s to 436.56s. The time utilization has been improved by 21% from the proposed improvement plan. By implementing Automatic Poultry Hanger, the company able to eliminate waiting and motion waste in Process 1- Slaughtering the chicken. Other than that, the inventory waste between Process 1 and Process 2 has been eliminated from the implementation of Automatic Poultry Hanger. For transportation waste at Process 2- Scalding the chicken, the implementation of Automatic Poultry Hanger and adjustment of facility layout helped in reducing the elements and cycle time. Lastly, by providing a proper SOP to handle scald machine for worker in Process 3- Plucking the feather, it reduced the defects that customer always complaint. Figure 4.43 below shows the Future State Map that has been developed based on the improvement.

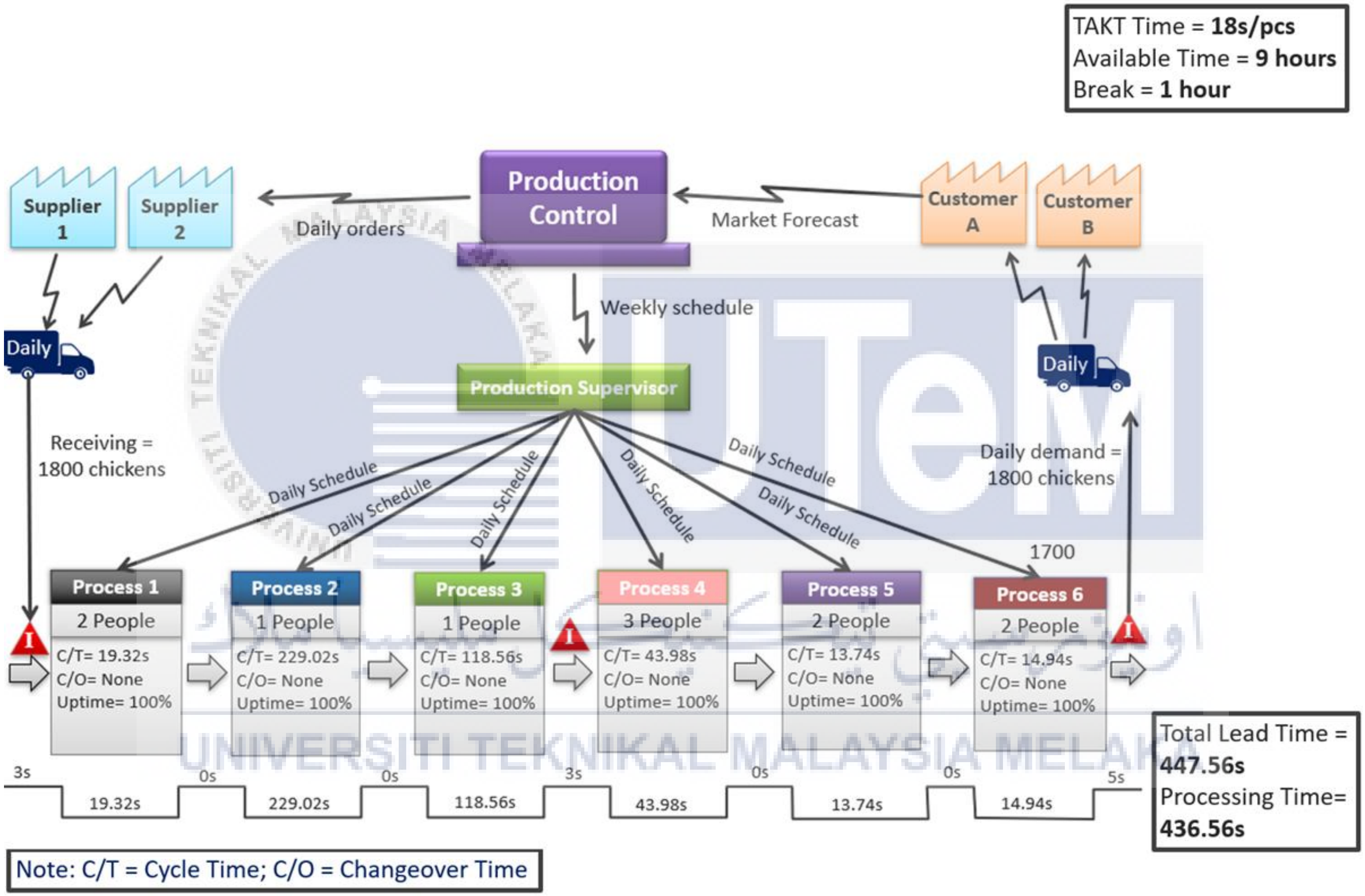


Figure 4.43: Future State Map (FSM)

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

In this part, all the results obtained from the study to achieve the objectives will be summarized in this chapter for better understanding. Therefore, a few recommendations for future study also will be stated in this chapter.

5.1. Conclusions

The first objective of this research is to apply time study technique on the production line of the chicken production process The data collected was analysed and significant conclusions for this objective as follows:

(a) A process flowchart and process elements has been developed from the implementation of time study technique on the production line of the chicken production process.

(b) 6 processes with 28 total elements have been identified from the application of time study technique.

(c) The time utilization of the current production line has been obtained from the technique which is 569.16s of total lead times and 551.16s of total processing time.

Next, for the second objectives of this research is to develop Current State Map (CSM) for the current chicken production process to visualize the process involved at the production line, the total lead time and processing time of the whole process. Hence, the important conclusions from the finding are:

(a) Current State Map (CSM) of the current production line of the chicken production process has been developed using the information of cycle times, machine's uptime, changeover time and inventories.

(b) All the important activities at the factory such as transportation of raw material, the inventories, flow of process, product's outgoing and time utilization for entire process has been mapped.

The third objectives of this study are to evaluate the waste in current chicken production process using root cause analysis by using the Ishikawa diagram and Failure Modes and Effect Analysis (FMEA) for all the waste occurred at the production line. The finding can be concluded as follows:

(a) There are 14 wastes in total occurred at the chicken production line which has been evaluated from the interview with the supervisor and worker at the industry.

(b) 12 Ishikawa diagrams of the wastes has been developed to identify its causes and effects.

(c) Waste that occurred in the industry consists of 5 types of waste which are waiting, motion, transportation, defects, and inventory that donates to the increase of production times and quality issues.

(d) The wastes that recorded Highest Priority Number (RPN) which 576 in the FMEA are waiting and motion waste in Process 1, transportation waste at Process 2 and defect waste at Process 3.

Lastly, the fourth objectives in this study are to develop Future State Map (FSM) with proposal solution for the chicken production process has been successfully achieved. The significant conclusion is as follow:

(a) The Future State Map (FSM) has been developed to visualize the condition after the implementation of the improvement plan by considering the time reduction and inventory removal through the proposal solution.

(b) 4 types of improvement plan have been proposed to remove the waste that occurred which are Automatic Poultry Hanger, 5S pillars, new facility layout and Standard Operating Procedure (SOP).

(c) Automatic Poultry Hanger has been proposed to remove waiting waste that occurred in Process 1- Slaughtering the chicken where worker will only need to hang the chicken at the poultry hanger. The implementation also able to remove inventory waste between Process 1 and Process 2.

(d) For motion waste at Process 1, the 5S pillars has proposed to standardize the workstation to have a smoother process flow.

(e) A new facility layout has been proposed to the company to remove the transportation waste at Process 2- Scalding the chicken. The implementation has reduced the distance between the workstation in the production line.

(f) For Process 3, the defects waste has been improved by the implementation of Standard Operating Procedure (SOP) where the worker will have a better work instruction to run the machine and remove rework steps

As a conclusion, from the analysis and proposed solution, the total lead time has been reduced from 569.16s to 447.56s while the processing time has been reduced from 551.16s to 436.56s. Hence, the time utilization of the improved production line has shown an increase by 21%.

5.2. Recommendations

For further study, there are few recommendations for the next researcher in order to get the better results which are listed as below:

i. To conduct further analysis of waste, occur at Process 4, Process 5 and Process 6 in the chicken production process.
ii. To propose a proper inventory method between Process 3 and Process 4
iii. To make a Standard Operating Procedure (SOP) on the entire production plant.

5.3. Sustainability Element

This study was inspired by industry slaughtering house that commonly implement automatic overhead conveyer system to reduce operator's motion and transportation problem. From social perspective, implementation of Automatic Poultry Hanger and closer workstation able to help operator from having a fatigue hand during slaughtering process and help to transport chicken from one process to another. In economics view, the implementation able to push the production rate and more chicken can be sold. Hence, the company able to produce more chicken in time and gain more profit. In environmental pillars, implementation of SOP able reduce rework process so no more chicken will be rejected due to quality issues.

5.4. Lifelong Learning Element

Lifelong learning element in this study was obtained through the implementation of SOP for the process. As worker always ignore the operating procedure to run the machine or to conduct a process, SOP helps to improve current work method from time to time. A standard work instruction will help to enhance the production line at the company and avoid rework. The company can progress to develop and enhance SOP in other workstation or process hence together building a One Point Lesson for continuously process improvement.

5.5. Complexity Element

The highest degree of complexity in this study is to design the poultry hanger for the industry use. The design was produced using CATIA V5 Software that undergo a few steps where the image must be construct from 2-D image before it was convert to 3-D image version. Then, after the design has been constructed, the design must go through simulation analysis using Solidworks software to undergo static analysis. Static analysis using the software able to identify the design's strength, yield limit and deformation. Hence, the use of software increases the complexity of the study conducted.

Next, this study also implements lean thinking which is Value Stream Map (VSM), a tool that helps to visualize and analyse the process flow in industry. Developing the Current State Map (CSM) and Future State Map (FSM) helps to properly map the key steps of the production and helps in identifying waste that occur in production line. Also, this tool added a new knowledge of manufacturing by understanding VSM symbol that represents the elements involved in a production line such as material flow, process box and transportation. The corresponding data will be used to propose a proper improvements solution that optimize the entire process.

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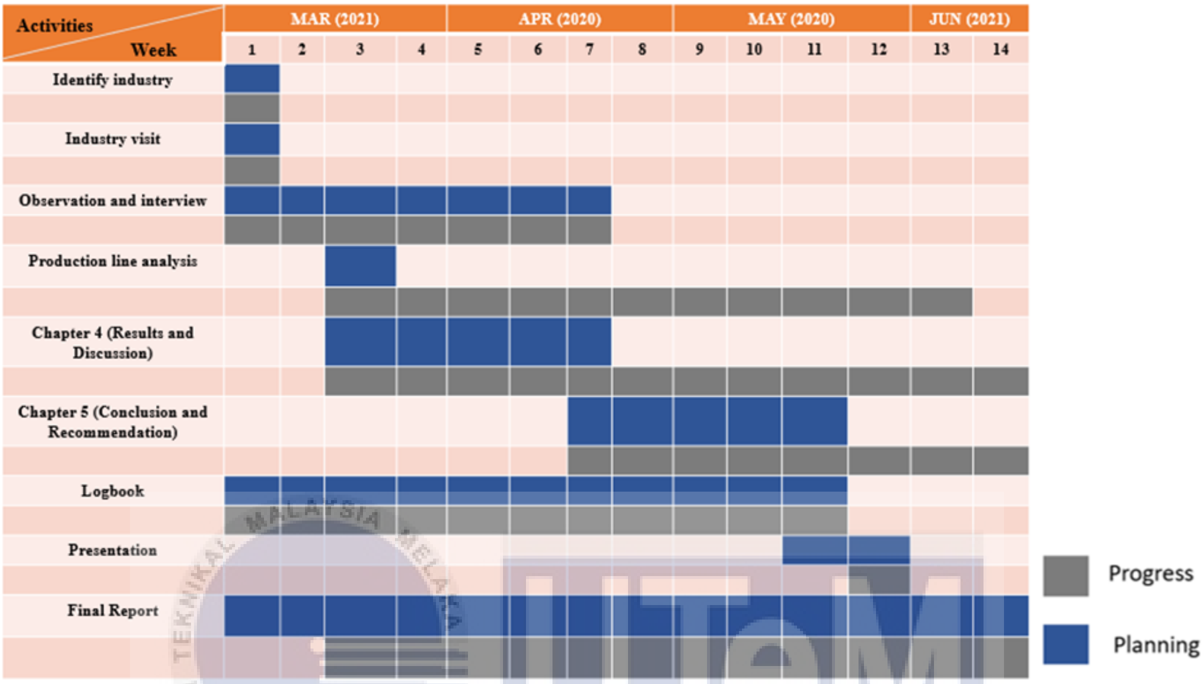
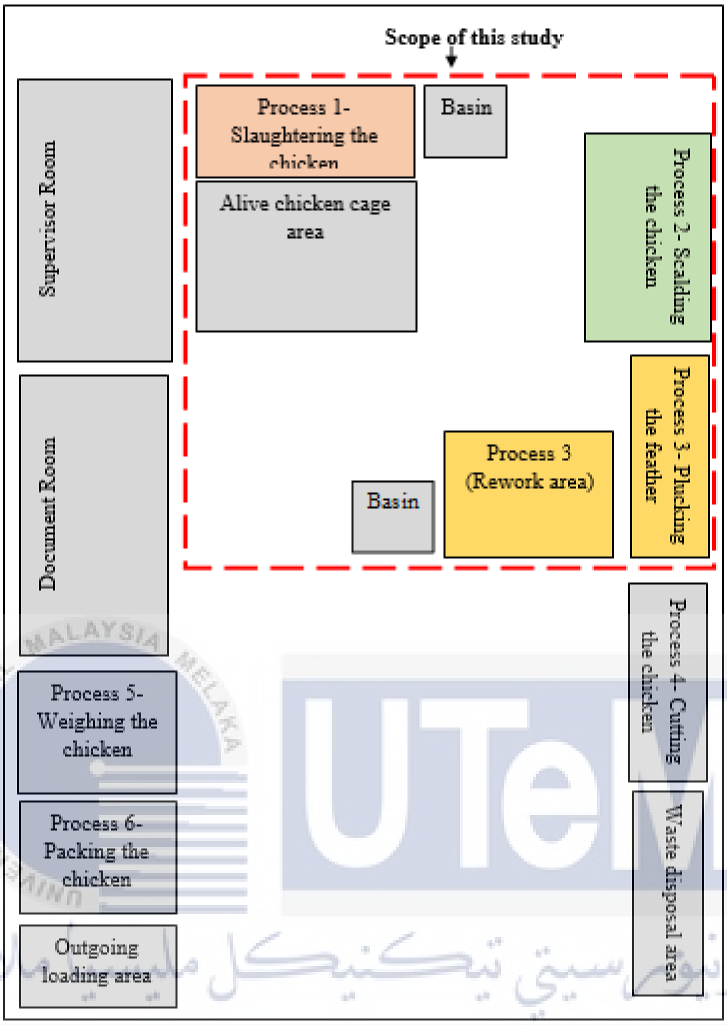
APPENDICES

A Gantt Chart



B Facility Layout



C Voice of Customer Table

	Voice of Customer (VOC)						
Customer priority	5	4	3	2	1		
Quality Characteristics / Customer Requirements	Manufacturing time	Delivery time	Quality of the product	Purchase cost	Manufacturing cost	Total	Rank
Deliver on time	10	10	5	0	1	106	1
Lower cost	9	2	8	10	8	105	2
Faster response	8	5	7	0	2	83	5
Complete in 1 day	10	9	5	0	1	102	3
Good quality	2	0	10	0	0	40	5
Appearance	0	0	10	1	1	33	8
Consistency	4	2	5	0	0	37	7
No feather attached	7	5	10	1	0	87	4

D FMEA Rubric

SEVERITY OF EFFECT	LIKELIHOOD OF OCCURRENCE	ABILITY TO DETECT	RANKING
Hazardous without warning	Very high: Failure is almost inevitable	Cannot detect	10
Hazardous with warning		Very remote chance of detection	9
Loss of primary function	High: Repeated failures	Remote chance of detection	8
Reduced primary function performance		Very low chance of detection	7
Loss of secondary function	Moderate: Occasional failures	Low chance of detection	6
Reduced secondary function performance		Moderate chance of detection	5
Minor defect noticed by most customers		Moderately high chance of detection	4
Minor defect noticed by some customers	Low: Relatively few failures	High chance of detection	3
Very minor defect noticed by discriminating customers		Very high chance of detection	2
No effect	Remote: Failure is unlikely	Almost certain detection	1