IMPLEMENTING OVERALL EQUIPMENT EFFECTIVENESS (OEE) ON AUTOMATIC BLISTER AT TEXTILE MANUFACTURING COMPANY

NORHISYAM BIN ISA
B052010039

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2024

IMPLEMENTING OVERALL EQUIPMENT EFFECTIVENESS (OEE) ON AUTOMATIC BLISTER AT TEXTILE MANUFACTURING COMPANY

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

by

NORHISYAM BIN ISA

B052010039

010416-06-0445

FACULTY OF INDUSTRIAL AND MANUFACTURING TECHNOLOGY AND ENGINEERING

2024

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Tajuk: **IMPLEMENTING OVERALL EQUIPMENT EFFECTIVENESS(OEE) ON AUTOMATIC BLISTER AT TEXTILE MANUFACTURING COMPANY**

Sesi Pengajian: **2023/2024 Semester 2**

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Disahkan oleh:

Alamat Tetap:
KAMPUNG TANJUNG JAMBU,
27200 KUALA LIPIS,
PAHANG
Tarikh: 12 JULY 2024

Cop Rasmi: PROFESSOR TS. DR. EFFENDI BIN MOHAMAD
Faculty of Industrial and Manufacturing Technology and Engineering
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Tarikh: 14 JULY 2024

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Signature : ……………………………………….

Author's Name : NORHISYAM BIN ISA

Date : 12 July 2024

APPROVAL

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

PROFESSOR TS. DR. EFFENDI BIN MOHAMAD
Faculty of Industrial and Manufacturing Technology and Engineering
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

………………………………………………………

(Prof. Ts. Dr Effendi Bin Mohamad)

ABSTRAK

Tajuk projek ini ialah *Implementation of Overall Equipment Effectiveness (OEE) on Automatic Blister (AB) Machine at Textile Manufacturing Company*. OEE ialah alat untuk menentukan tahap keberkesanan penggunaan peralatan. Projek ini bertujuan untuk melaksanakan dan menentukan tahap keberkesanan mesin dengan menggunakan kaedah OEE, mengenal pasti faktor yang menyebabkan enam kerugian besar menggunakan *Failure Mode and Effect Analysis (FMEA)*, dan memberikan cadangan penambahbaikan untuk meningkatkan keberkesanan mesin. Kajian ini dijalankan ke atas sebuah mesin di bahagian pembungkusan *Automatic Blister (AB) Packaging Machine*. Syarikat ini terlibat dalam produk jahitan seperti jarum, pin keselamatan, cangkuk, dan mata, *AB Packaging Machine* ialah mesin yang digunakan untuk membungkus produk dengan pin lurus. Pelaksanaan OEE pada AB Packaging Machine memperoleh 79.64% iaitu di bawah piawaian OEE, 85%. Kemudian, teruskan dengan menganalisis kerugian pada mesin ini menggunakan enam kerugian besar. Daripada analisis enam kerugian besar, diketahui bahawa kerugian yang dominan adalah kehilangan kelajuan ialah 48.15%, dan kerugian kedua terbesar ialah kerugian persediaan dan pelarasan, iaitu 39.16%. Kedua-dua kehilangan ini mengakibatkan nilai OEE yang rendah pada *AB Packaging Machine*. Selepas itu, gambarajah *Fishbone* digunakan untuk mencari punca kerugian. Punca besarnya kerugian ini ialah tiada *Standard Operating Procedure (SOP)* yang jelas dan rekabentuk mesin. Untuk meningkatkan kecekapan mesin dan mengurangkan nilai enam kerugian besar pada mesin pembungkusan, *FMEA* telah dilakukan untuk menentukan punca yang paling kritikal. *FMEA* ialah prosedur untuk mengenal pasti punca kegagalan produk yang berpotensi. Dua cadangan penambahbaikan yang disyorkan untuk mengurangkan kerugian adalah dengan menyediakan latihan kepada pengendali untuk meminimumkan masa kerosakan. Cadangan kedua ialah menyediakan SOP yang jelas untuk operator bagi mengurangkan kerugian masa.

ABSTRACT

The title of the project is Implementation of Overall Equipment Effectiveness (OEE) on Automatic Blister(AB) Machine at Textile Manufacturing Company. The OEE is a tool for determining the level of effectiveness of the use of equipment. This project aims to implement and determine the machine's level of effectiveness by using the OEE method, identify the factors causing the six big losses using Failure Mode and Effect Analysis (FMEA), and provide suggestions for improvements to increase the effectiveness of the machine. This study was conducted on a machine in the packaging department, the AB Packaging Machine. The company is engaged in sewing products such as needles, safety pins, hooks, and eyes, The AB Packaging Machine is a machine used to pack products with straight pins. The implementation of OEE at the AB Packaging Machine obtained 79.64%, which is below the OEE standard, 85%. Then, continue by analyzing the losses on this machine using six big losses. From the six big losses analysis, it is known that the dominant loss is speed losses are 48.15%, and the second-largest loss is setup and adjustment losses, which is 39.16%. Both of these losses result in low OEE values on AB packaging machines. After that, the Fishbone diagram is used to find the root cause of the losses. The cause found is no clear Standard Operating Procedure (SOP) and machine design. To increase the machine's efficiency and reduce the value of the six big losses on the packaging machine, the FMEA was performed to determine the most critical cause. FMEA is a procedure to identify potential causes of product failures. Two suggestions for improvements to reduce losses are to provide training to the operator to minimize breakdown time. The second recommendation is to provide a clear SOP to the operator to reduce the speed losses.

DEDICATION

To my beloved parents,

Supporting family,

Respected supervisor,

Helpful friends

ACKNOWLEDGEMENT

I would like to thank for the management of case study company who give me the opportunity in applying the knowledge learned on packaging machine with OEE parameters is perfectly match with the requirement of the study where availability and performance ratio is a crucial to determine the performance of the machine. Without time data of downtime elements on the packaging process, this study couldn't be carried such successfully as this and all the concepts can't be applied.

Besides that, I was contact with many people from the company during which the implementation of the OEE. Among them include Mr. Prakash the engineer who gives full support along when the study was carried out by assigning and allocating resource required such as historical data of downtime elements, quality production and others. Not forgetful of the technician and operators who are responsible on packaging department and my understanding of the process flow, element of downtime and nature of manufacturing environments on ranking section.

Nevertheless, I would like to thank my thesis supervisor, Prof. Ts. Dr Effendi bin Mohamad and acknowledge the advices and guidance he gave to me. I could not have survived this one-year project without the support and direction from him.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AB	-	Automatic Blister
FMEA	-	Failure Mode and Effect Analysis
MTO	-	Make to Order
OEE	-	Overall Equipment Effectiveness
SOP	-	Standard Operating Procedure
TPM	-	Total Productive Maintenance
TMS	-	Time Measurement Sheet

CHAPTER 1

INTRODUCTION

This chapter introduces the background of the company and the background of work altogether. It is followed by the problem statement that will be the initiative presented by the study. Subsequently, the objective and scope of the study will be carried out in this chapter and also provide an anticipated outcome of this study.

1.1 Background

High productivity is the goal of almost every industry to turn a profit. The industry is more focused on improving output success in quality to achieve greater productivity since highly productive performance is closely linked to process management and equipment reliability. (Azizi 2015). Companies must enhance their equipment by optimizing machine effectiveness. To perform at its best, the machine has to be in good working order. Good maintenance is necessary to minimize damage and interruption to the machine that would stop the production process. Adopting care can both prevent harm and enhance the machine system's performance.

The textile manufacturing company is where this project is being completed. This company makes sewing products, including zippers and pins, among other things. For this reason, the machinery in this business must operate efficiently to the fullest. Productivity inside the organization can rise if the machine is functioning efficiently. OEE will be applied to the packing machine in this project. Additionally, six big losses in the machine can be discovered with OEE product operational activity. Furthermore, the OEE for use can be used to group the six major losses in the six big losses into three main components. Three categories of losses are used to gauge a machine's performance: defect, speed, and downtime (Nakajima, 1988).

The packaging process is the last in the production line in the case study company. The packaging process is a crucial part of production since it requires most of the time compared to other processes. The packaging process will indicate how much time is required to complete the customer's order. In addition, quality is crucial to contribute to the increment of company profit, meeting the customer requirements and on-time delivery. Nevertheless, the packaging process neglects and overlooks the machine's performance. The working time and delays and identifying the causes of downtime need to be measured where the manufacturing industry needs to be focused.

Overall Equipment Effectiveness (OEE) stands as the primary benchmark employed in production operations to demonstrate the efficiency of a system, simplifying complex production challenges into a clear and understandable presentation of information. OEE is commonly utilized as a pivotal metric in Total Productive Maintenance (TPM) and Lean Manufacturing initiatives, offering a consistent method for gauging the effectiveness of TPM and other efforts by establishing a comprehensive framework for assessing production efficiency.

1.2 Problem Statement

The machine owned by the company was found to be operating below optimal conditions in this investigation due to frequent disruptions that resulted in the machine stopping unexpectedly. As a result, there will be a brief pause in the production process. The measurement of a machine's Overall Equipment Effectiveness (OEE) number can be used to determine how effective the machine is. It is possible to measure the machine's effectiveness based on its observation. Thus, the six big losses are a way to identify the dominant factors of the loss resulting from stopping the engine and an overview of the loss's dominant factors.

Column1	Total hours Comp. Manuf. (1,000 Uo	Component Run Hour	Total Run Hour (including packaging
1.56	1.80	3.11	10.22
0.39	1.40	3.94	19.91
0.32	0.81	1.93	5.60
0.32	3.38	8.05	14.23
0.37	2.56	7.42	11.09
0.37	3.48	9.28	12.36
0.37	3.48	9.28	11.93
0.02	0.17	0.02	4.34
0.13	2.17	0.77	3.94
0.14	1.63	0.82	3.98
0.14	3.11	0.84	3.09
0.15	3.14	0.88	4.04
0.19	3.26	1.12	7.73
0.13	6.58	3.23	12.46
0.13	6.58	3.23	9.64
0.13	6.60	3.25	9.67
0.14	6.78	3.40	13.06
0.14	6.78	3.40	9.86
0.14	13.05	3.45	16.57
0.14	6.85	3.48	10.37
0.14	12.98	3.50	19.26
0.14	12.98	3.50	16.49
0.14	6.85	3.50	9.93
0.14	6.85	3.50	11.55
1.80	0.38	3.60	162.55
0.15	13.05	3.63	16.56
0.15	13.05	3.63	17.05
0.15	13.10	3.65	17.11
0.15	13.10	3.65	16.52
0.15	13.28	3.75	16.70
0.15	13.28	3.75	16.70
0.15	7.20	3.83	14.74
0.15	7.20	3.83	10.27
0.15	13.33	3.85	16.96
0.15	13.68	3.85	17.10
0.18	14.13	4.48	17.55
0.19	13.60	4.65	20.08

Figure 1.1: Screenshot component run hours from company record

Based on figure 1.2, shows the component run hour in company system. The number in red represents the cycle time is too high while the number in purple shows the cycle time is too low.

1.3 Objectives

Three objectives need to be achieved to complete this project which are:

a) To study the current flow process of the packaging machine.
b) To implement Overall Equipment Effectiveness (OEE) at the packaging machine.
c) To analyse the cause that contributes to the low effectiveness of the packaging machine and propose solution.

1.4 Scope

This research concentrates on assessing the Overall Equipment Effectiveness (OEE) of a packaging machine, as requested by the company supervisor in the packaging department. The primary objectives are to pinpoint the factors contributing to downtime and enhance the cycle time. Additionally, the study aims to introduce and apply the concept of stopwatch time study to monitor each process within the packaging section. It's important to note that the study's scope is limited by the unpredictable nature of machine operation, as it relies on customer orders rather than following a specific schedule.

1.5 Significant of The Study

Overall Equipment Efficiency (OEE) is a practical tool widely used in manufacturing to make things run smoother. This study is all about checking out how OEE can help companies by looking at the packaging department's machinery. The goal here of this project is to make the production line work better by improving productivity and product quality. For this project, it focusing in on a packaging machine that's causing a problem with breakdowns, low productivity, and rework. Using OEE, this study wants to figure out what's going wrong and fix it to make the packaging process more effective.

This study matters because it aims to show how well the packaging machine is doing with OEE. The study of past data, like how often it stops, variations in production speed, and defects will help to find the idea for this project. The idea is to give the packaging machine an OEE score, a kind of grade that shows how well the machine is operating. This score helps us find where things can be better like making sure the machine is available when needed, improving its performance, and making sure the quality is up to the best. The info that has been gathered will help to come up with practical suggestions, like how to take care of the machine, optimize processes, and control quality. Lastly the end goal, is a packaging machine that works better, making the whole manufacturing operation more successful by balancing productivity and product quality.

1.6 Organization of The Report

Chapter 1 of this study introduces the background, problem statement, objectives, scope, and significance of the research, forming the core of the entire study. The study's objectives are developed from a detailed problem statement.

Chapter 2 explores the literature related to the study, reviewing past research that is relevant to the current work. This chapter provides a clear understanding of the topics pertinent to the study, summarizing various published works that support the information presented.

Chapter 3 outlines the basic study methodology, explaining the chosen approach for conducting the research. It includes the study's planning process and offers a fundamental overview of the approach taken to achieve the study's objectives.

Chapter 4 summarizes the results and discussions arising from the study. This chapter presents the collected data and discusses the outcomes obtained.

Chapter 5 presents concluding findings and recommendations based on the insights and discussions from all previous chapters.

CHAPTER 2

LITERATURE REVIEW

This chapter discusses the literature review of Lean, Lean Manufacturing, Lean Waste, Lean Manufacturing Tools, and Lean advantages and disadvantages. From the literature review, Overall Equipment Efficiency (OEE) is selected for this project. Thus, further discussion about OEE will be further explained in this chapter.

2.1 Lean Principles

Lean principles, originating from the Toyota Production System, have become integral to optimizing processes across diverse industries. The book "The Machine That Changed the World: The Story of Lean Production--Toyota's Secret Weapon in the Global Car Wars That Is Now Revolutionizing World Industry" by James, et al.,2020; stands as a foundational resource within the last decade. Delving into the historical roots of Lean thinking, the authors trace its evolution and highlight its transformative impact on the automotive industry.

The principles of Lean production, including continuous improvement and waste elimination, are meticulously detailed, offering practical insights applicable across sectors. The book not only emphasizes the adaptability of Lean methodologies but also showcases real-world examples, demonstrating how Lean thinking extends beyond manufacturing to influence diverse organizational contexts globally. Despite its original publication in 1990, the 2020 update ensures the continued relevance of this work, underscoring the enduring impact of Lean principles in reshaping processes, fostering innovation, and promoting continuous improvement within the dynamic landscape of global industries.

2.2 Lean Manufacturing

Lean manufacturing is a systematic approach to the development and manufacture of physical products that involves the application of Lean practices, principles, and tools. The concept was initially proposed by Krafcik (1998), quite some time after the first introduction of the Toyota Production System. The philosophy of lean manufacturing is centered around identifying and eliminating waste in the production sequence through continuous improvement. This approach aims to optimize the use of resources, reduce lead times, and improve product quality, all while minimizing costs.

According to a literature review by Shah and Ward, (2003), lean manufacturing is characterized by its philosophy, various tools and techniques, and its application in the manufacturing industry. The review provides an in-depth understanding of the principles and practices of lean manufacturing, making it a valuable resource for researchers and practitioners in the field. The authors discuss the various tools and techniques used in lean manufacturing, such as value stream mapping, 5S, and Kaizen, and how they can be applied to improve production processes.

2.1.1 Lean Waste

As the OEE is a vital index to measure the performance level of lube blending plant, is a must to an organisation keeping their lean waste at the minimum level (Manzouri, et al., 2014). To reduce or eliminate the waste, it is important to understand exactly what waste is and where it exists. The sources for the NVA activity are Transportation, Inventory, Motion Waiting, Overproduction, Over-processing and Defects or as known as “7 Wastes”; Womack and Jones, 2003; Sutherland and Bennett, 2007; Son, et al., 2010; Helmold and Samara, 2019).

i. Transportation

Transport is the movement of materials from one location to another, this is a waste as it adds zero value to the product. Excessive transportation of material can lead to producing other waste such as defect. Example of this waste are: Transport of product from one functional area such as pressing, to another area such as welding.

ii. **Inventory**

Having more material than needed. Inventory costs money, and until it is sold to customer, company or organization need to pay for the cost. It also can add to hidden cost such as storage, utilities, maintenance, etc or in other word; inventory feeds many other wastes. Example of inventory, finished good, work in progress, and raw material.

iii. **Motion**

Waste of motion is any motion of man or machine which does not add value to the product or services. Example such as excessive walking, bending and reaching parts to assemble.

iv. **Waiting**

Waste of waiting is any idle time produced when two interdependent processes not completely balance or synchronized. Example; operator is waiting for the machine to complete the cycles.

v. **Over-Production**

The waste of overproduction is making too much or too early. Over-production is the worst kind of waste because it causes other waste or hides the need of improvement.

vi. **Over-Processing**

Over-processing is putting more into the product than is valued by customer. One of the biggest examples of over-processing in most companies is that of the "mega machine" that can do an operation faster than any other, but every process flow must be routed 24 through it causing scheduling complications, delays and so forth. In lean, small machine is appropriate.

vii. **Defects**

Defects are when products or service deviate from what the customer requires or the specification.

2.1.2 Lean Manufacturing Tools

Each lean approach has been assigned a likelihood of eliminating certain waste categories (Wyrwicka and Mrugalska, 2017). The ideal outcome of the manufacturing process can be achieved through the effective use of lean components. The majority of lean research depends on one, two, or a combination of two and three components. The successful deployment of lean manufacturing also depends on the order in which the implementation tasks are completed and all other lean components. In light of implementation concerns, this study outlines the integration and order of lean components during the transition process (Sundar et al., 2014).

Table 2.1: Lean Manufacturing Tools (Kirkpatrick,2013)

Lean Tools	Description
5S	A workplace organization method: Sort, Set in order, Shine, Standardize, Sustain.
Kaizen	Continuous improvement through small, incremental changes
Kanban	Visual scheduling system to control the logistical chain from a production perspective.
Value Stream Mapping (VSM)	Visualization and analysis of the flow of materials and information to identify waste and areas for improvement
Just-In-Time (JIT)**	Production strategy to improve ROI by reducing in-process inventory and carrying costs.
Poka-Yoke	Mistake-proofing techniques to prevent errors by designing processes to eliminate the possibility of mistakes.
Total Productive Maintenance (TPM)	Proactive maintenance approach aiming for perfect production (no breakdowns, defects, etc.).
SMED (Single-Minute Exchange of Dies)	Method to reduce the time for switching from one product to another on a production line, minimizing downtime.

2.3 Overall Equipment Efficiency (OEE)

Reyes et al. (2009) highlight the increasing prominence of Overall Equipment Effectiveness (OEE) as a quantitative metric in various industries. Beyond its traditional role in monitoring and controlling production equipment productivity, OEE has evolved into a multifaceted tool, serving as a crucial indicator and driver of process and performance improvements within manufacturing operations. Samad et al., (2012) emphasize its empowering impact on manufacturing companies, contributing to enhanced quality, increased consistency, and improved overall productivity.

Furthermore, Kumar et al. (2012), stress that OEE is not a static metric but serves as a dynamic tracking measure, essential for monitoring and ensuring the sustainability of improvements over time. This aligns with the principles of continuous improvement, emphasizing the ongoing assessment of the long-term effectiveness of implemented changes. In the broader context of manufacturing philosophy, Puvanasvaran et al., (2013) assert that OEE plays a central role in evaluating the progress of Total Productive Maintenance (TPM). As a comprehensive approach to equipment maintenance, TPM integrates considerations of availability, performance, and quality. OEE, with its inclusive evaluation framework, provides a holistic measure of the overall efficiency and effectiveness of maintenance practices, emphasizing its significance in optimizing broader maintenance practices for sustained operational excellence.

2.4 Parameters of OEE

The research on Overall Equipment Effectiveness (OEE) parameters searches into their importance for evaluating and improving manufacturing efficiency. Availability, a key OEE factor, was emphasized by Nakajima in 1988 for minimizing downtime through effective maintenance practices, covering both planned and unplanned downtime (Peters, 2003). The performance parameter, addressing actual equipment speed, was explored in lean manufacturing by Rother and Shook in 1999, highlighting its role in identifying and eliminating inefficiencies. Hansen (2000) and Gupta and Jain (2013) investigate its impact on overall OEE and productivity.

Quality, another crucial OEE aspect, was discussed by Juran and Gryna in 1993 for their role in manufacturing excellence. (Gupta and Jain,2013) stress the connection between quality and OEE, noting high-quality production is vital for overall operational efficiency.

(Puvanasvaran et al. ,2013) view OEE holistically, emphasizing the integration of availability, performance, and quality. This holistic approach, supported by Singh et al. (2014), underscores OEE as a multifaceted indicator. Additionally, Dittmann (2006), explores OEE in the semiconductor industry, illustrating its adaptability across manufacturing settings. In conclusion, the literature emphasizes each OEE parameter's pivotal role, their interconnections, and the need for a comprehensive approach. Understanding and optimizing these factors are vital for organizations aiming at operational excellence and continuous improvement in manufacturing. Figure 2.1 shows the impact of major losses during production time.

Overall Equipment Effectiveness	Recommended Six Big Losses	Traditional Six Big Losses
Availability Loss	Unplanned Stops	Equipment Failure
	Planned Stops	Setup and Adjustments
Performance Loss	Small Stops	Idling and Minor Stops
	Slow Cycles	Reduced Speed
Quality Loss	Production Rejects	Process Defects
	Startup Rejects	Reduced Yield
OEE	Fully Productive Time	Valuable Operating Time

Figure 2.1: Impact of major losses during production time.

2.4.1 Availability Ratio

The availability ratio, a crucial part of Overall Equipment Effectiveness (OEE), is figured out by finding the percentage of time that manufacturing equipment spends actively working during the planned production time (Castro and Araujo,2013). A high availability ratio means the equipment is ready and efficient, while a lower ratio suggests there's room for improvement in maintenance or operations.

$$Availability = \frac{Operating\ Time}{Planned\ Production\ Time}$$ Equation 2.1

In simple terms, Operating Time is the time the equipment is actively producing, not including planned downtime. Planned Production Time is the total time the equipment is available for production, including both when it's running and when it's intentionally stopped. So, the availability ratio is a useful tool for organizations wanting to make sure their equipment is reliable, and their manufacturing processes are running well, connecting with the broader goal of achieving operational excellence.

2.4.2 Performance Ratio

The concept of performance, as highlighted by Ngadiman in 2013, involves considering speed loss records, which encompass any factors leading a process to operate below its maximum potential speed during operation. Ngadiman emphasizes that performance is influenced by the extent of waste generated due to operating at less-than-optimal speed. This waste can manifest in various forms such as machine wear, the use of substandard materials, misfeeds, and inefficiencies in operator performance. The term "Net Operating Time" is introduced to denote the time that remains available for productive operation after accounting for these speed losses and associated inefficiencies. This perspective underscores the importance of minimizing waste and maximizing operational efficiency to enhance overall performance in industrial and manufacturing processes.

$$Performance = \frac{Net\ Operating\ Time}{Operating\ Time}$$ Equation 2.2

2.4.3 Quality Ratio

The term "quality ratio" generally refers to a metric used in manufacturing to quantify the proportion of defect-free, high-quality products to the total number of products produced. It is a measure of the efficiency and accuracy of a manufacturing process, indicating the success in producing products that meet or exceed quality standards. The quality ratio is typically calculated by considering the ratio of good, non-defective products to the total production output (Ngadiman,2013). This metric provides valuable insights into the effectiveness of the production line, helping organizations identify areas for improvement and maintain high-quality standards.

$$Quality = \frac{Good\ Units\ Produced}{Total\ Units\ Produced} \qquad \text{Equation 2. 3}$$

2.5 OEE Losses

The purpose of the Overall Equipment Effectiveness (OEE) approach in manufacturing is to systematically evaluate and improve the efficiency and productivity of production processes. OEE is a key performance indicator that provides insights into the effectiveness of equipment utilization. At same time, it is used to identify for an equipment the related losses for the purpose of improving total asset performance and reliability (Pal and Biswal, 2015). There are three categories of losses and relates to OEE factors to consider in Table 2.2 below:

Table 2.2: The factors that contribute to OEE losses (Vorne, I., 2002)

OEE Loss	OEE Factor
Availability Losses	Downtime: Unplanned stops in production. Setup and Changeover: Time spent preparing for a new production run. Equipment Failure: Breakdowns or malfunctions that halt production.
Performance Losses	Speed Loss: Operating below the maximum designed speed. Minor Stops: Short pauses in production that reduce overall speed.
Quality Losses	Process Defects: Products that do not meet quality standards. Reworks: Additional work required to correct defects.

In manufacturing, efficiency losses primarily stem from various factors, constituting a significant challenge in production processes. The primary objective of Overall Equipment Effectiveness (OEE) is to ascertain the percentage of manufacturing time that is genuinely productive. OEE serves as a "best practices" metric, offering a means to gauge manufacturing productivity and pinpoint losses in the production process. An OEE score of

100% signifies flawless production, where only high-quality parts are manufactured as swiftly as possible, and downtime is non-existent. Womack and Jones in 2003 emphasized OEE as a valuable tool for both benchmarking and establishing a baseline, providing a universal measure for assessing production effectiveness and identifying potential areas for enhancement. Tajiri and Gotoh in 1992 further categorized major losses into six groups, contributing to overall production losses. These six significant losses encompass breakdown losses, setup and adjustment losses, minor stoppage, reduced speed losses, and defect/rework losses (Zandich, 2012). The first two groups impact the availability factor of the machine, the third and fourth losses influence the performance factor, and the last two groups, known as quality losses, determine the quality rate of the machine. Refer to Table 2.3 for a breakdown of the Six Big Losses categories.

Table 2.3 :Six Big Losses Categories (Vorne, I., 2002)

Six Big Losses	Category	Description
Breakdown Losses	Downtime Loss	• A machine unexpectedly stops due to a mechanical failure, halting production until the issue is resolved. • Breakdowns are often unpredictable and can have a significant impact on production efficiency. Regular maintenance and monitoring are crucial to minimize breakdown losses.
Setup and Adjustment Losses	Downtime Loss	• Time is spent reconfiguring equipment for a new product, leading to a temporary halt in production. • Efficient setup procedures and quick changeover capabilities can reduce the impact of setup losses, allowing for more agile production.
Minor Stoppage	Speed Loss	• Short pauses occur throughout the production process due to small issues, causing brief interruptions. • While individually minor, these stoppages can accumulate, affecting overall equipment effectiveness. Addressing the root causes of minor stoppages is key.
Reduced Speed Losses	Speed Loss	• The equipment operates below its maximum speed, resulting in a slower production rate. • Optimizing equipment speed and addressing factors that contribute to reduced speed are essential for improving overall performance.
Defect/Rework Losses	Quality Loss	• Defective parts are produced, requiring additional work to meet quality standards. • Focusing on quality control measures, employee training, and process improvements can help minimize defects and the need for rework.
Startup Rejects	Quality Loss	• During the startup phase, a high number of defective products are produced before the process stabilizes. • Thorough testing and quality checks during startup can help reduce rejects, ensuring a smoother transition to full production.

The six major categories of losses, impacting the overall equipment performance, have been identified by Rajput and Jayaswal in 2012:

(a) Equipment failure or breakdown losses encompass both time losses, leading to reduced productivity, and quality losses resulting from the production of defective products.

(b) Set-up and adjustment time losses lead to downtime and the production of defective products, occurring when transitioning from the production of one item to adjusting the equipment for another.

(c) Idling and minor stop losses occur when production is temporarily interrupted due to malfunctions or when a machine is idle.

(d) Reduced speed losses denote the variance between the equipment's designed speed and its actual operating speed.

(e) Reduced yield occurs during the early stages of production, particularly during machine start-up stabilization, with quality defects and rework representing losses in quality attributed to malfunctioning production equipment.

2.6 Advantages of OEE

The OEE metrics place focus on improvement by increasing the visibility of losses with the process and quantifying them. Besides that, OEE has emerged as one important and universally accepted metric for measuring the overall performance of single automatic equipment (Puvanasvaran et al., 2013). Thus, others researcher was stated on their studies are:

a) The goal of measuring OEE is to improve the effectiveness of equipment. Since equipment effectiveness affects shop floor employees more than any group, it is appropriate for them to be involve in-tracking OEE and in planning and implementing equipment improvements to reduce lost effectiveness An OEE solution can be enable manufacturers to achieve world class status (Parihar and Bajpai, 2012).

b) Part of the original intent of this project was to show the benefit of a complete OEE capture method on a single piece of stand-alone equipment, and use the implementation of the OEE method to justify and prioritize the work of retrofitting all equipment (Neill and Miei, 2011)

c) It is learned that OEE provides many benefits and with proper implementation, OEE can serve as a tool to elevate the company's competitiveness in the industry (Ngadiman, 2013).

d) It provides such a comprehensive view of how machinery operates. But it actually goes deeper than this because it forces an organization to look at individual items of equipment and make sure that the maximum benefits are being obtained from the equipment (Raguram, 2014).

e) Fore and Zuze, (2010) was stated that OEE could be improved plant availability, reliability and plant equipment utilization and hence productivity; and improved operating performance (output and quality) and maintenance cost effectiveness. (cost effective maintenance program).

f) When an organization holds people with knowledge and experience of the typical shortages of OEE and its common implementation challenges, the probability of achieving the intended benefits of OEE will certainly increase (Iannone and Nenni, 2001).

g) OEE works best when it is used as a strategy i.e. as a part of overall organization improvement plan (Palanisamy and Vino, 2013).

2.7 Disadvantages Of OEE

While Overall Equipment Effectiveness (OEE) is widely recognized for its benefits, it is important to acknowledge certain challenges and disadvantages associated with its implementation. Here are the disadvantages of OEE:

a) OEE calculations may be sensitive to external factors such as demand fluctuations, varying production schedules, and changes in product mix, leading to fluctuations in OEE values that may not accurately reflect changes in equipment efficiency (Parlikad et al., 2011).

b) OEE primarily focuses on overall equipment performance and may not adequately capture variations in process stability and variability, critical factors for ensuring consistent and high-quality production (Yang et al., 2017).

c) OEE provides an aggregate measure of losses without differentiating between availability, performance, and quality losses, hindering a detailed understanding of specific issues affecting production efficiency (Mourtzis et al., 2019).

d) OEE tends to be machine-centric, potentially overlooking broader factors such as supply chain disruptions, workforce issues, or external dependencies that can impact overall production efficiency (Nikoo and Cudney, 2015).

e) Implementing OEE systems can be complex, requiring significant resources and efforts in data collection, integration with existing systems, and training personnel. This complexity may pose challenges, particularly for smaller manufacturing enterprises (Baudin et al., 2012).

Understanding these disadvantages is crucial for organizations considering the adoption of OEE, as it allows for a more nuanced and informed approach to its implementation.

2.8 Time Study

A time study is a systematic and structured observation and analysis of work processes to quantify the amount of time spent on each task or activity. It involves the measurement of the time required by a worker to perform a specific job or task, to identify and analyze the elements of work, process efficiency, and potential improvements. Time standards refer to "the amount of time necessary to bring a product to a workstation under specific conditions, including the presence of a skilled and properly trained operator, performing at an average pace and handling a specific task" (Meyers, 2002). Time studies are commonly used in industrial engineering and management to optimize work methods, set standards, and improve overall productivity.

2.8.1 The Importance of Time Study

Time studies, involving the systematic measurement of task durations, have become increasingly vital across various industries in the last two decades. The practical significance of time studies can be outlined as follows:

- Efficiency Improvement: Time studies help organizations identify and eliminate inefficiencies in their workflows, leading to streamlined operations and improved efficiency (Niebel and Freivalds, 2003).
- Resource Allocation: By understanding the time required for different tasks, businesses can allocate resources more effectively, ensuring optimal utilization of manpower and equipment (Niebel and Freivalds, 2003).
- Cost Reduction: Time studies contribute to cost reduction by pinpointing unnecessary steps, delays, or bottlenecks in processes, allowing organizations to implement cost-saving measures (Niebel and Freivalds, 2003).
- Process Enhancement: Analyzing time data enables organizations to identify areas for process improvement, leading to increased productivity and higher quality output (Groover, 2017).

- Standardization: Time studies play a role in standardizing work processes, ensuring consistency and quality in the output (Groover, 2017).
- Capacity Planning: Particularly relevant in manufacturing, time studies are essential for capacity planning, helping organizations maintain a balanced production schedule (Singh, 2011).
- Employee Performance: Time studies are used to evaluate and monitor employee performance, set realistic targets, and provide data for performance-based incentives (Groover, 2017).
- Health and Safety: By identifying tasks that may lead to fatigue or injuries, time studies contribute to creating a safer work environment (Niebel and Freivalds, 2003).

2.8.2 Stop-watch Time Study

The three common methods of reading and collecting data using stopwatch are:

a) Continuous Time Study:

Continuous time studies involve the uninterrupted observation and recording of a task from its initiation to completion. The process entails a continuous measurement of time by an observer, ensuring a detailed and seamless account of each step in the workflow. This method is particularly applicable to tasks characterized by a consistent workflow and minimal variability. By providing a continuous record of the time spent on each component of a task, continuous time studies offer a comprehensive understanding of the overall duration and individual elements of the process (Niebel and Freivalds, 2003).

b) Repetitive Time Study:

Repetitive time studies revolve around the repeated observation and time recording of a specific task over multiple cycle. In this approach, the task is performed, and the time is recorded; this cycle is then repeated several times to derive an average time. This method proves valuable for tasks that exhibit a repetitive nature, allowing for the identification of variations in the time taken from one cycle to the next. By obtaining an average time, repetitive time studies offer a more accurate representation of the typical duration of the task, accounting for potential fluctuations in each iteration (Niebel and Freivalds, 2003).

c) Accumulative Time Study:

Accumulative time studies break down a task into its distinct elements or motions, with the individual times for each element recorded separately. These times are then added together to calculate the total time required for the entire task. This method is particularly suitable for tasks with sequential components, allowing for a granular analysis of each element. By providing a detailed breakdown of the time spent on specific elements, accumulative time studies facilitate the identification of areas for improvement within the task. This approach contributes to a comprehensive understanding of the task's composition and helps guide targeted enhancements to efficiency (Groover, 2017).

2.8.3 Application of Time Study

Time studies are not just tools for measuring worker efficiency. They provide valuable insights into manufacturing processes, helping identify bottlenecks, optimize workflows, and ultimately improve overall productivity. Here are some applications of time study in manufacturing:

a) **Setting Work Standards and Improving Worker Performance**:

Time studies can be used to establish standard times for individual work elements or entire tasks. This helps ensure fair workload distribution and provides benchmarks for evaluating worker performance. Tiwari et al., (2023) used stopwatch time studies to analyze manual assembly lines in an Indian garment factory and set realistic work standards based on the collected data. This led to a 15% increase in worker productivity.

b) Identifying and Eliminating Process Waste:

By analysing the time spent on different elements of a work process, time studies can reveal inefficiencies and waste, such as unnecessary movements, waiting times, or poorly designed work processes. Al-Hussein et al., (2017) applied timelapse video analysis to study construction workflows. This helped identify inefficiencies in material handling and worker coordination, leading to a 10% reduction in work cycle time.

c) Evaluating the Impact of Process Improvements:

Time studies can be used to measure the effectiveness of implemented process improvements, such as new equipment, improved work processes, or updated work instructions. El-Abbasy et al. in 2020 used sampling studies to assess the impact of ergonomic improvements made in garment manufacturing processes. The study showed a 12% reduction in worker fatigue and a 5% increase in work quality.

d) Planning and Scheduling Production:

Accurate work cycle times obtained through time studies are crucial for production planning and scheduling. This ensures efficient resource allocation, minimizes waiting times, and helps meet delivery deadlines. Gunasekaran et al.,(2013) highlight the importance of using simulation-based time studies for planning and scheduling in flexible manufacturing environments. This allows for testing different production scenarios and optimizing resource utilization before actual implementation.

e) Ergonomics and Worker Safety:

Studying worker movements and postures can identify potential ergonomic risks and hazards through time studies. This information can be used to design safer work environments and prevent work-related injuries. Awasthi et al. in 2023 used timelapse video analysis to assess worker fatigue levels in automotive paint shops. The study identified work elements that caused excessive exertion and led to recommendations for improving work processes and workstation design.

These are just a few examples, and the specific applications of time studies in manufacturing. However, time studies remain a valuable tool for optimizing manufacturing processes, improving efficiency, and ensuring worker safety and well-being.

2.8.4 Advantages of Time Study

Process Enhancement: Time studies play a pivotal role in improving operations by detecting bottlenecks, minimizing waste, and refining workflows for increased efficiency and reduced costs. For instance, Tiwari et al., (2023) applied time studies to enhance manual assembly lines in a garment factory, resulting in a significant 15% rise in worker productivity.

Employee Evaluation: Time studies are instrumental in establishing fair work standards, evaluating employee performance, and providing targeted feedback for improvement. In the field of construction, Al-Hussein et al. in 2017 utilized time studies to identify inefficiencies, leading to an impressive 10% reduction in work cycle time and improved worker morale.

Optimized Planning and Scheduling: Accurate work cycle times derived from time studies facilitate improved production planning, resource allocation, and scheduling, ensuring timely deliveries and customer satisfaction. Gunasekaran et al. in 2013 emphasized the significance of simulation-based time studies in planning for flexible manufacturing environments, minimizing production delays through optimal resource utilization.

Informed Decision-Making: Time studies provide essential data for simulating various scenarios, aiding informed decisions regarding process modifications, investments, and resource distribution. El-Abbasy et al. in 2020 used sampling studies to evaluate the impact of ergonomic enhancements in garment manufacturing, resulting in a 12% reduction in worker fatigue and a 5% increase in work quality, influencing subsequent investment decisions

Prioritizing Worker Safety: Through the examination of worker movements and postures, time studies identify potential ergonomic risks, contributing to improved worker safety and well-being. Awasthi et al. in 2023 used time lapse video analysis in automotive paint shops to evaluate worker fatigue levels, leading to recommendations for refining work processes and workstation design, ultimately enhancing worker safety.

2.8.5 Method of Implementation

The key to developing Overall Equipment Effectiveness (OEE) lies in gathering and measuring information, primarily through data collection. This involves identifying losses in a specific process to enhance performance efficiency. It's crucial to note that accurate data collection is essential to reflect the real use of equipment. Puvanasvaran et al. in 2013 stress the importance of making data collection easy and classifying specific losses into the six categories in OEE. Kumar et al. in 2012 points out breakdown time, speed loss, and minor stoppage as critical elements in this process. Parihar, Jain, and Bajpai in 2012 identify three primary time losses during a process: downtime loss, speed loss, and quality loss. Pal and Biswal in 2015 classify equipment losses into various categories, including non-scheduled time, scheduled maintenance time, unscheduled maintenance time, setup and adjustment time, idle time without an operator, wagon waiting time, tippling delay, time losses due to job conditions, speed loss, and quality loss.

To evaluate data, a procedure involving analytical and logical approaches is employed to scrutinize each aspect of the supplied data. Rajput and Jayaswal in 2012 conducted a study in three shifts for two continuous hours each, using stopwatches to record any stops or situations leading to idle or stoppage time on equipment. The study spanned three consecutive days, and the average of all readings was calculated to determine the final values of various losses on respective equipment. In essence, meticulous data collection and thorough analysis are fundamental steps in the development and assessment of OEE, ensuring accurate reflections of equipment efficiency and identifying areas for improvement.

Excel is a handy tool for entering and organizing collected data, making calculations more manageable and automated. It functions similarly to a spreadsheet and is widely utilized in various industries. According to Ngadiman in 2013, a spreadsheet was created to simplify the calculation of Overall Equipment Effectiveness (OEE). This spreadsheet is structured to track the production process of a machine, listing potential sources of losses from start to finish.

Calculating OEE involves looking at how much time equipment operates in a plant, the six main losses, and the three OEE parameters. This connection is shown in Figure 2.2 below:

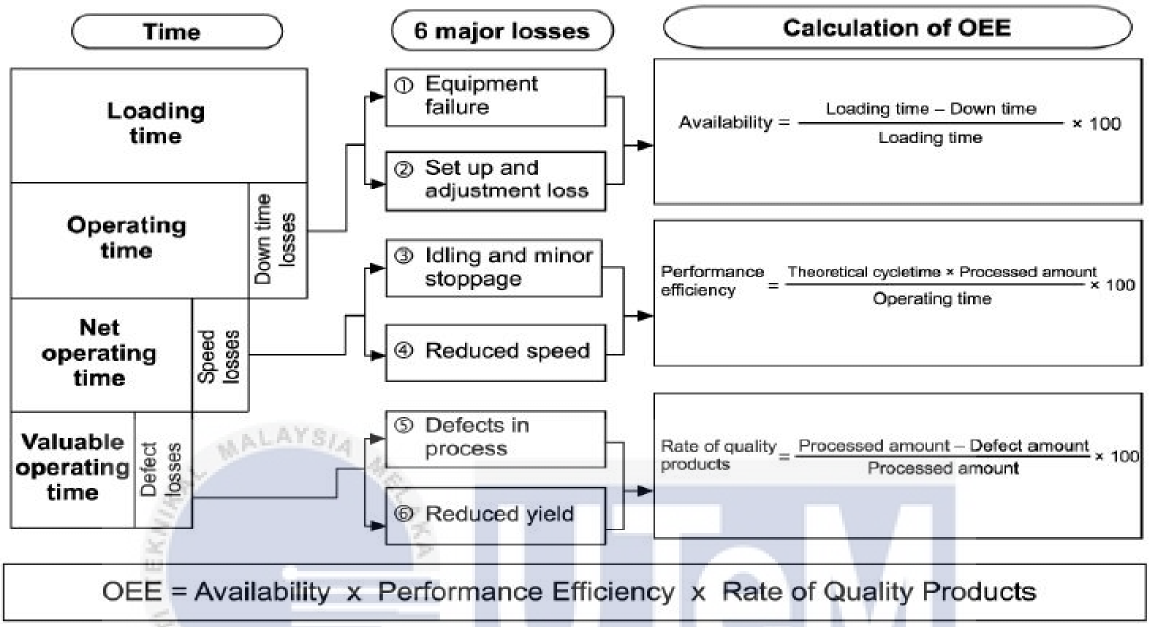

Figure 2.2: Calculation Of OEE

2.9 Failure Mode and Effect Analysis (FMEA)

The FMEA was created by the US Department of Defence in the late 1940s. The goal of these techniques is to make military hardware more effective. Schmidt and colleagues, 2014). In 1980, it was changed to MIL-STD-1629A since it did not comply with the military standard. However, the National Aeronautics and Space Administration (NASA) adopted and employed this strategy during the Apollo space mission in the 1960s (IEC 60812, 2006). The FMEA is applied as a technique for risk management that improves quality assessments, except the automotive and military sectors. FMEA is an important analytical indicator in the ISO-9000 series used by some international quality organizations, such as the International Organisation Standardisation (ISO). These days, the aviation, aerospace, equipment, medical food, and semiconductor industries all frequently use FMEA. The Risk Priority Number

(RPN) is typically used to calculate the likelihood of a loss. According to Chang et al. (2013), the PRN values are the product of severity (S), occurrence (O), and defection (D).

FMEA was one of the methods for selecting the important issue that action should be taken to strengthen the manufacturing operation system from a long-term and regular failure of machinery cantered on the maximum FMEA risk priority number (RPN). Additional essential equipment checkpoint and input system to other machines for related problems (Rozak et al., 2020). The statement is also supported by Casadai (2007), where FMEA is a systematic procedure for identifying and avoiding possible failures. A failure mode is anything that includes defects or failures in design, a condition outside the specified limit of specifications, or changes in the product that disrupt the function of the product through the disappearance of failure modes. FMEA will increase the reliability of products and services to increase customer statisticians with these products and services. FMEA is used to classify potential faults that affect the product's operation and identify actions to address the problem (Badariah et al., 2016).

Table 2.4 :Definition of FMEA

Failure	**Description**
Failure Cause	Why the process failed
Failure Mode	The cause of failure
Failure Effect	Effect of the failure in process terms, feature terms, or position of the object.
Failure Severity	Classification of the failure impacts the function of the object.
Failure Criticality	The mixture of the magnitude of the impact and the frequency of its occurrence or other characteristics of failure are measuring the need to fox and minimize the issue.

2.9.1 Concept of FMEA

FMEA is a tool used to locate an issue's sources and main causes. The process of creating the FMEA table begins with identifying the kind of failure that occurs, its effect, the cause, the necessary solution, and the attempts to overcome it. The result of brainstorming sessions between the production manager and inspection manager is used to determine the severity, occurrence, and detection values. Additionally, the RPN value is computed, which comes from multiplying the detection, occurrence, and severity values (Badariah et al., 2016). During FMEA sessions, the information was recorded and numbered for each process step, operation, possible failure mode, consequence, and failure prevention measure using the table below.

Table 2.5: Tables of FMEA

Process	**Input**	**Failure Modes**	**Effects**	**Control measures**	**S**	**O**	**D**	**RPN**

2.9.2 Calculation Risk Priority Number (RPN)

FMEA is utilized with the RPN to increase system dependability and quality performance. RPN is employed in evaluating the impact of failure. In addition, RPN has three indicators: detection (D), incidence (O), and severity (S). A number scale ranging from 1 to 10 is assigned to these three indicators (Chang et al., 2013). The table below describes the range of failure factor indices and criteria:

Table 1.6: Failure Mode Index Rankings (Shahin, 2004)

Level	Severity (S)	Occurrence (O)	Detection (D)
1	No	Almost never	Almost certain
2	Very slight	Remote	Very high
3	Slight	Very slight	High
4	Minor	Slight	Moderate high
5	Moderate	Low	Medium
6	Significant	Medium	Low
7	Major	Moderately high	Slight
8	Extreme	High	Very slight
9	Serious	Very high	Remote
10	Hazardous	Almost certain	Almost impossible

CHAPTER 3

METHODOLOGY

This chapter provides a comprehensive overview of the entire case study project. Initially, it outlines the methodology, detailing the overall steps involved in the project's implementation, starting from understanding the title to reaching the methodology stage. Subsequently, the chapter delves into the specific steps taken during the implementation of the project.

3.1 General Flow

Figure 3.1 illustrates the flowchart representing the comprehensive methodology employed for the entire project. The project commences with the identification of problems within the study area and the proposal of a study method. Following this, a study purpose is formulated based on the identified issues in the study area, and the associated requirements are determined. To support this study, a review of previous research becomes essential, providing insights into the work conducted by others in the field.

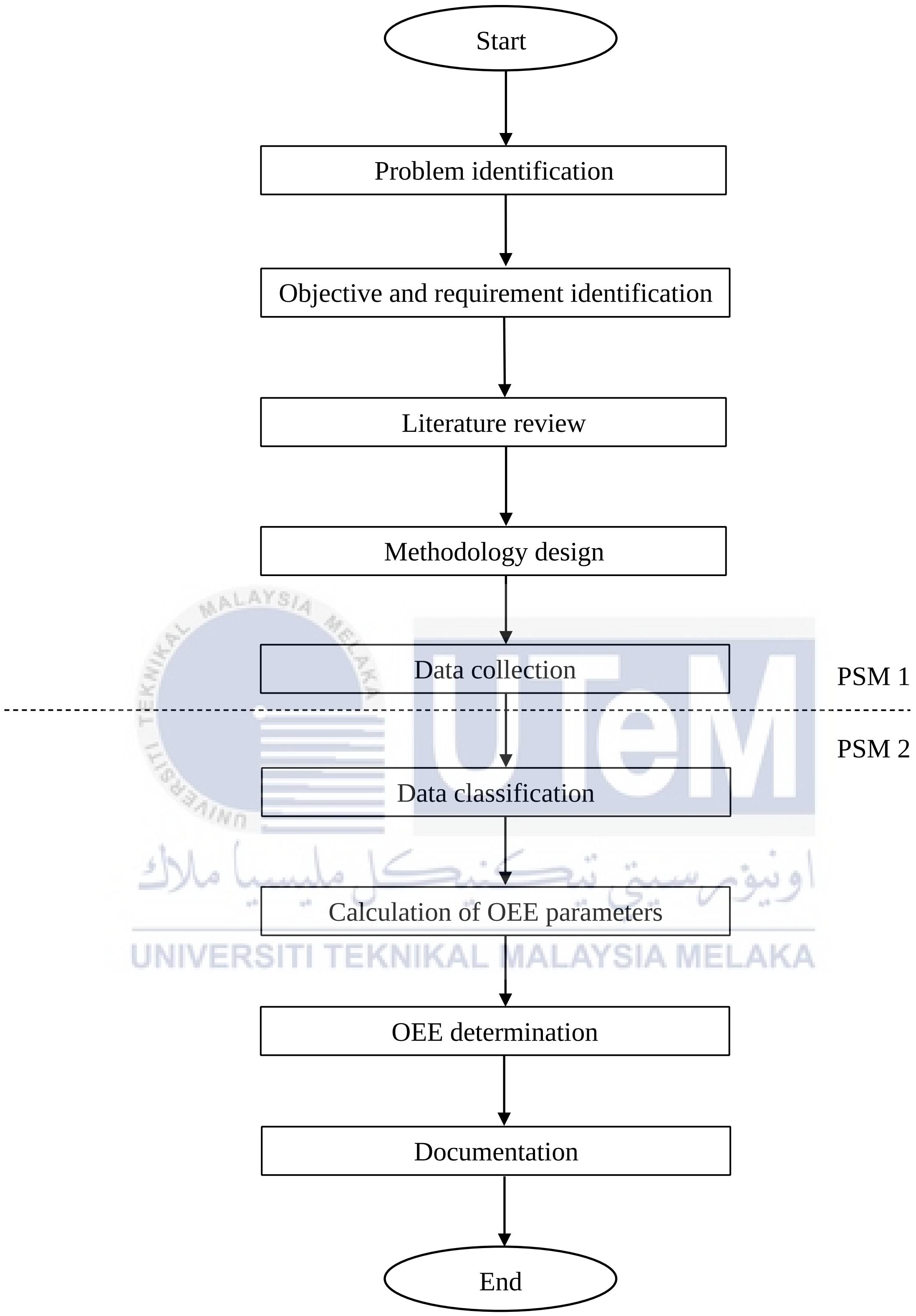

Figure 3.1: Flow chart of overall methodology

3.1.1 Problem Identification

At first, this study was conducted by observing the packaging machine that was selected. In this study, the machine to pack a straight pin was selected. The supervisor at the packaging department has been a guide to explain the flow process of packaging. In the meantime, the identification of problems that occurred in the process during operation has also been introduced. Therefore, a problem statement has been created according to historical data and machine performance.

3.1.2 Objective and Requirement Identification

The purpose of this study was established based on the identified problem. The primary aim is to determine the Overall Equipment Efficiency (OEE) in the packaging process. To accomplish this project, specific objectives and a suitable method have been defined, outlining the goals that need to be achieved.

3.1.3 Literature Review

The aim is to summarize, integrate, and analyze the arguments made by others. This study explores and analyzes the research gaps in the OEE field. The chapter includes a lot of information introducing previous research that uncovers similarities and differences in OEE methods. Additionally, the chapter establishes the connection between past research and this study, serving as supportive information for developing the methodology.

3.1.4 Methodology Design

Methodology design involves creating a plan for implementing a project and offering specific and accurate details on the procedures for data collection in the study. In this particular study, the time study and OEE methods have been chosen to assess the current performance of the selected machine.

3.1.5 Data Collection

In this research, the data collection process is essentially split into two main tasks. Initially, there is the observation of the production line to recognize downtime elements in the process and categorize them into six significant loss categories. The second activity involves performing a time study on the existing process to identify downtime elements while ranking the process, and these are documented on the time measurement sheet (TMS). A detailed explanation of these activities will be provided in Section 3.2.

3.1.6 Data Classification

During the data collection process, a crucial step involves categorizing downtime elements based on the OEE losses, enabling the calculation of downtime duration by referencing the six major loss categories. This classification is essential for generating the data required for OEE computation.

3.1.7 Calculation of OEE Parameters

The calculation of each OEE parameter Availability, Performance, and Quality ratio is performed to demonstrate the performance contribution in ranking the selected machine. This computation involves utilizing all the data collected during the time study and the classification of data to determine the overall OEE.

3.1.8 OEE Determination

The primary objective of this study is to assess the Overall Equipment Efficiency (OEE) of the packaging machine. This involves the collective calculation of Availability, Performance, and Quality ratios, which collectively represent the percentage of machine utilization.

3.1.9 Documentation

Documentation refers to the process of creating a comprehensive report that covers the entire study, starting from its initiation to its conclusion.

3.2 Methodology for Developing OEE

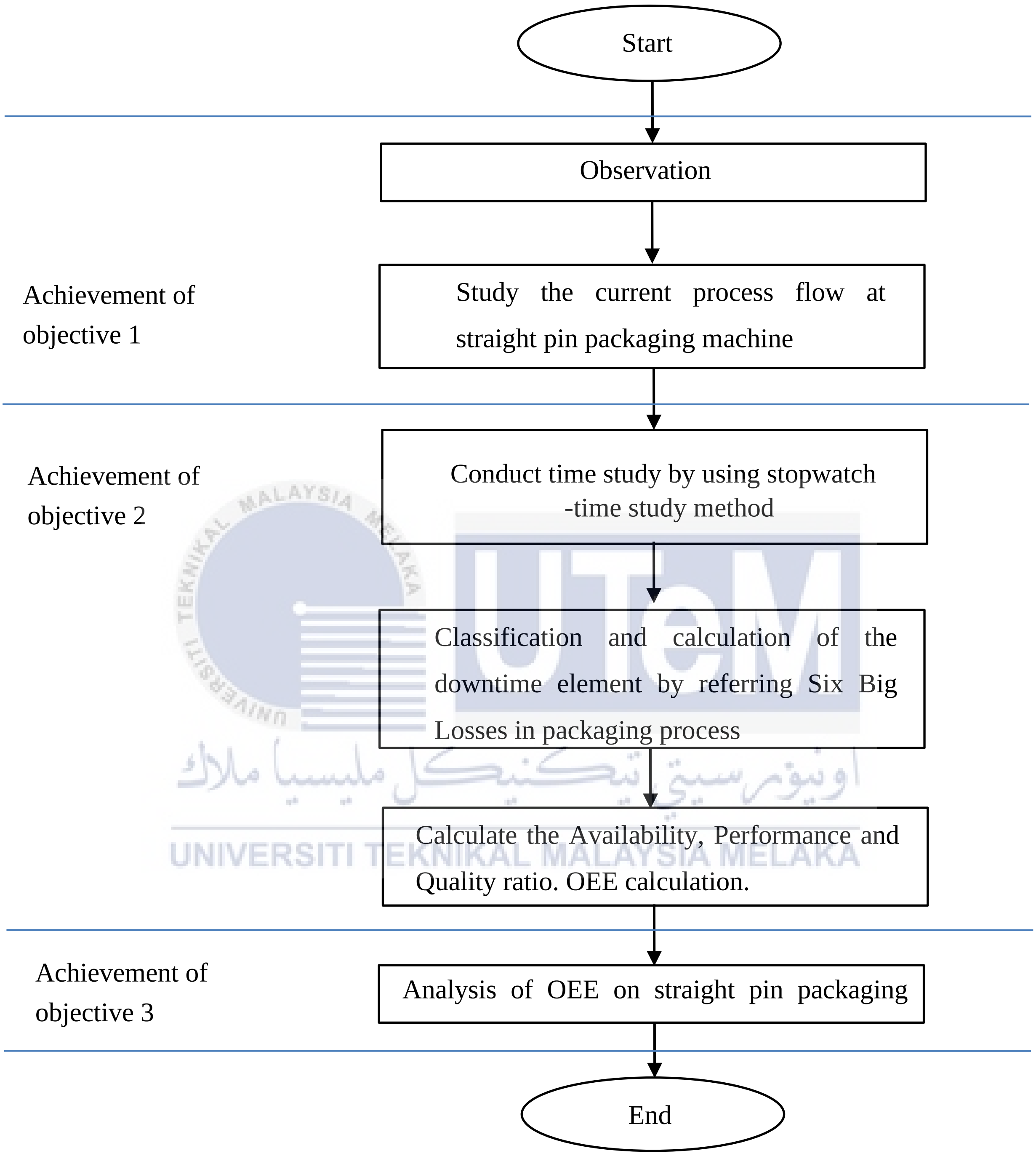

Figure 3.2: Methodology for developing OEE on the packaging machine.

3.2.1 To study the current flow process of the straight-pin packaging machine.

3.2.1.1 Observation

Figure 3.2 illustrates the methodology for establishing the OEE on the packaging machine. The study initiates with the selection of the machine at the case study company, specifically the straight-pin packaging machine recommended by the supervisor for the packaging department. The initial phase involves a comprehensive observation encompassing all aspects such as process flow and downtime elements within the process. During this stage, guidance from technicians in the packaging department is sought to gain an understanding of the process and downtime elements, drawing insights from historical data.

Figure 3.3: The machine that is observed.

With the assistance of the packing department supervisor, the current flow procedure was recognized during the observation.

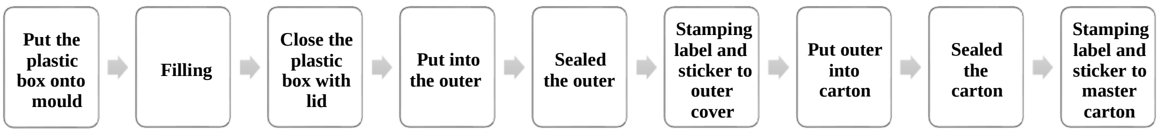

Figure 3.4: The current process flow of straight-pin packaging machine

3.2.1.2 Document Review

The packaging department's historical company information serves as the secondary data required for data analysis. The data company is examined to gather information about the machine's running hours, overall production, and the item number for product packing. The number that will indicate the kind of packing is the item number. Figure 3.5 shows data from the machine but has been included in Excel. This Excel data is given by the manager of the packaging department for observation purposes.

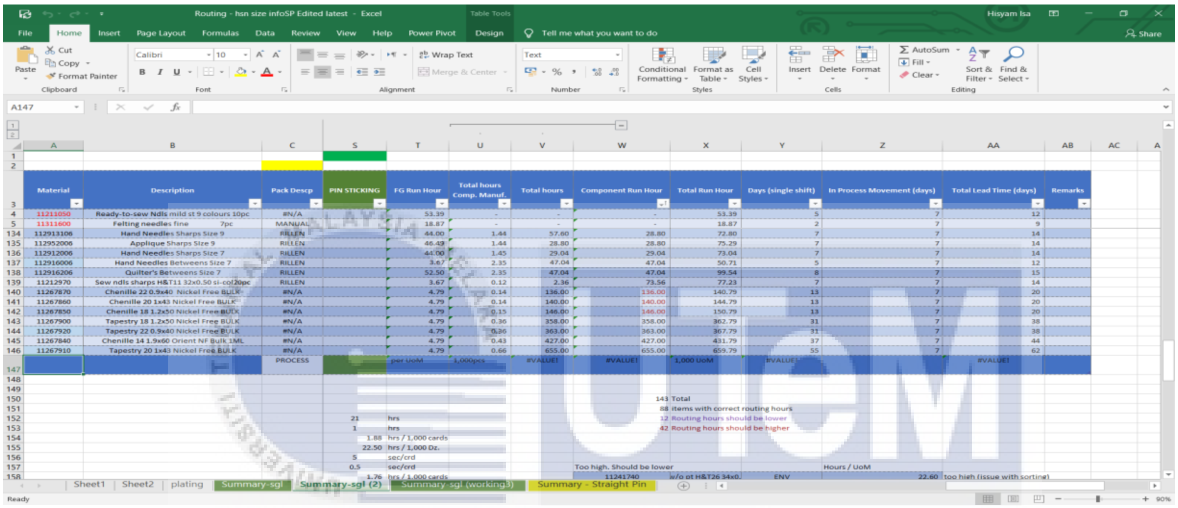

Figure 3.5: Data for straight pin in excel

3.2.2 To implement Overall Equipment Effectiveness (OEE) at the packaging machine

3.2.2.1 Data collection

To achieve the second objective, a time study is carried out on the selected machine. This activity requires the use of a stopwatch and the provision of a time measurement sheet. During this phase, the study is conducted while standing beside the selected machine, with a focus on the current downtime elements occurring during production. The data collection is specifically limited to the machine for straight-pin production.

A time measurement sheet (TMS) is developed to document all downtime elements during the packaging process, including the duration of each downtime occurrence. The TMS comprises details such as types of problems, machine numbers, product quantities, and the name of the observer. The template for the TMS is illustrated in Table 3.1 below:

Table 3.1 : Time Measurement Sheet Template

No.	Type of problem	Quantity	Date:	Observer
		Average Time (Sec)	Description	
1				
2				
3				
4				
5				
6				
7				
8				

The additional information was given by the supervisor to assist the calculation of OEE. Figure 3.6 shows the order sheets that shows the number of productions, duration to complete and some other information that might help the investigation.

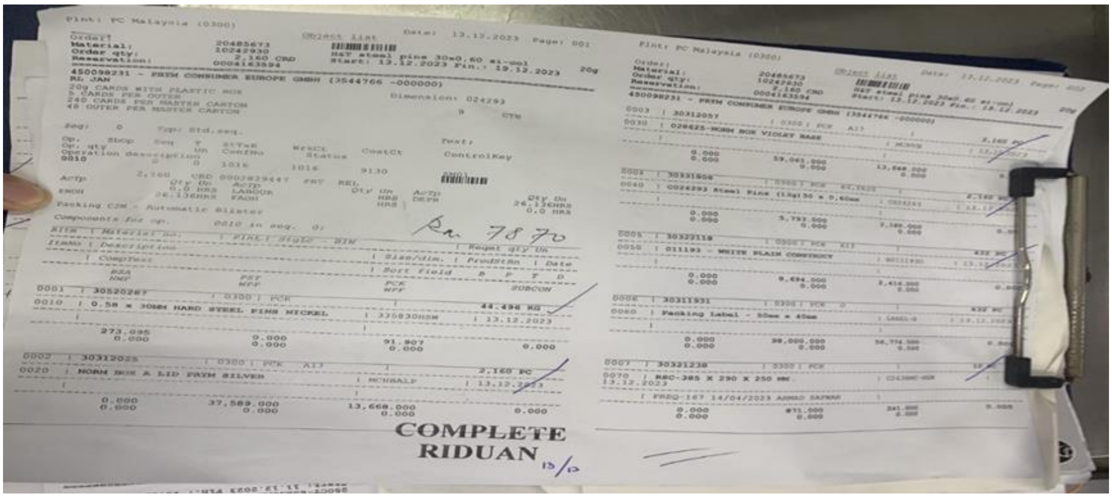

Figure3.6: Order sheet for straight pin.

3.2.3.1 Calculation of OEE

The availability computation involves considering all downtime of the straight pin packaging machine using planned production time. In this study, all equipment failures, setup, and adjustments are regarded as downtime. The operating time, in this context, pertains to the continuous running of the packaging process of the straight pin packaging machine without any interruption. The formula for calculating availability is presented in Formula below.

$$Availability\% = \left(\frac{(Planned\ Production\ Time) - (Downtime)}{(Planned\ Production\ Time)}\right) \times 100\% \qquad \text{Equation 3.1}$$

To calculate the performance ratio, the operating time and speed losses are employed, replacing the ideal cycle time. The operating time serves as the availability time, while speed losses encompass all small stops and reduced speeds occurring during the packaging process. The formula for determining the performance ratio in this project is presented in Formula below:

$$Performance\% = \left(\frac{(Operating\ \ Time) - (Speed\ Losses)}{(Operating\ Time)}\right) \times 100\% \qquad \text{Equation 3.2}$$

The quality ratio is determined by the output of the product from the packaging machine. In the packaging department, the quality is assessed based on good pieces, rework, and defects. Reworked items are included in the production at the end, and they are ranked in the subsequent packaging process. Defective products are rejected. After collecting raw data, processing is carried out, and the quality ratio is computed using the formula presented in Formula below:

$$Quality\% = \left(\frac{(Good\ Pieces)}{(Total\ Pieces)}\right) \times 100\% \qquad \text{Equation 3.3}$$

In relation to the previously mentioned first three parameters of OEE, as outlined above, the OEE in this study is characterized as the percentage of machine efficiency observed during the investigation of the straight pin packaging machine. Consequently, the OEE value is computed using the formula shown below:

$$OEE\% = Availability\% \ \times Perfomance\% \ \times Quality\% \qquad \text{Equation 3.4}$$

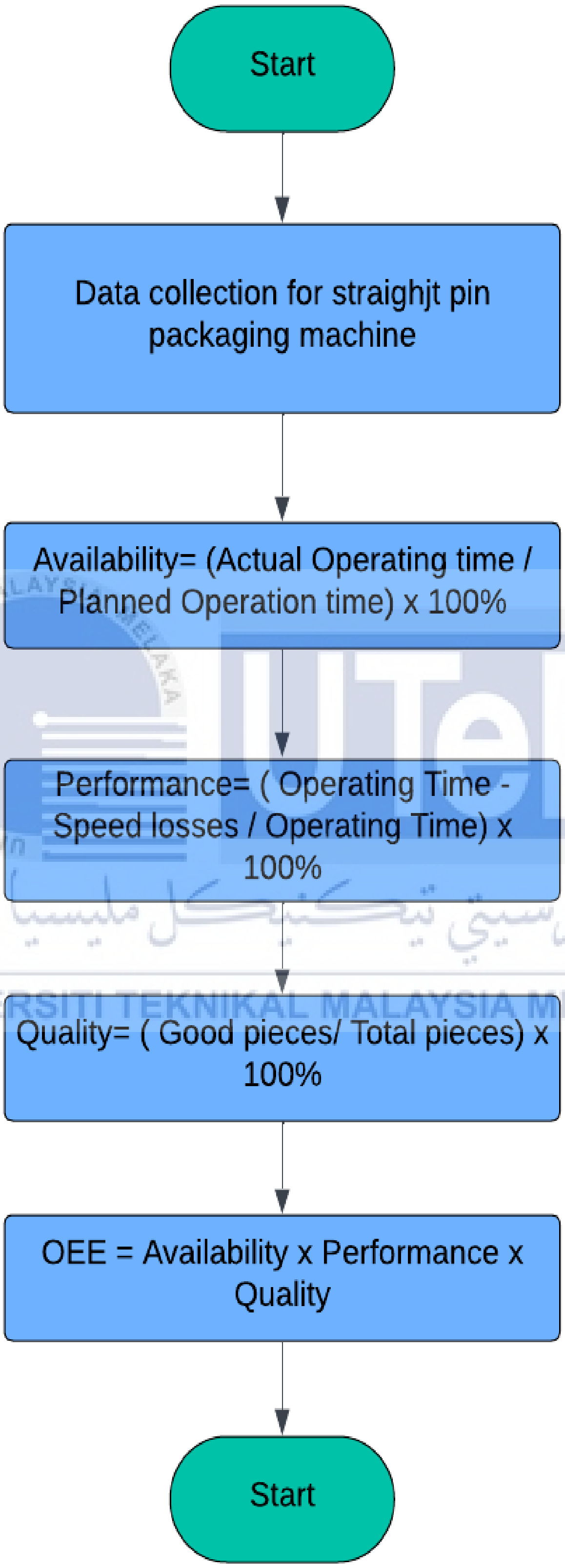

Figure 3.7: The flow of OEE calculation

3.2.3 To analyse the cause that contribute to low effectiveness of the packaging machine and propose a solution.

3.2.3.1 Classification of Downtime Elements into Six Big Losses

To accomplish the initial objective, the identification of downtime elements will be categorized into six major losses based on insights from a previous study related to downtime elements on the packaging machine. These six big losses in the packaging process will serve as a framework for referencing the identification of current downtime elements during the time study. The categories of the six big losses are:

a) Equipment Failure or Breakdown
b) Setup and adjustment
c) Small stop
d) Reduced speed
e) Start-up reject
f) Production reject

Table 3.2: Example of failure six big losses

Six Big Losses	Category	Description
Breakdown Losses	Downtime Loss	• Equipment failure • Unplanned maintenance • Breakdowns • Failure of tools
Setup and Adjustment Losses	Downtime Loss	• Setup or changeover • Major adjustment • Warm-up time
Minor Stoppage	Speed Loss	• Obstructed product flow • Miss feed • Sensor blocked • Cleaning or checking
Reduced Speed Losses	Speed Loss	• Rough running • Under design capability • Operator inefficiency
Defect/Rework Losses	Quality Loss	• Scrap • Rework • In process damage • Incorrect assembly
Startup Rejects	Quality Loss	• Scrap • Rework • In-process damage • Incorrect assembly

3.2.3.2 Data Analysis using Pareto Diagram

The data is processed as part of the data analysis process to determine the machine's effectiveness. And a calculation of six major losses can be used to analyze and potentially solve the current issue. It can be arranged based on the dominating level or priority of the lost time that transpires by utilizing the Pareto diagram. The categories of the six major losses are also compared using the Pareto diagram, which is organized from greatest to smallest in terms of magnitude.

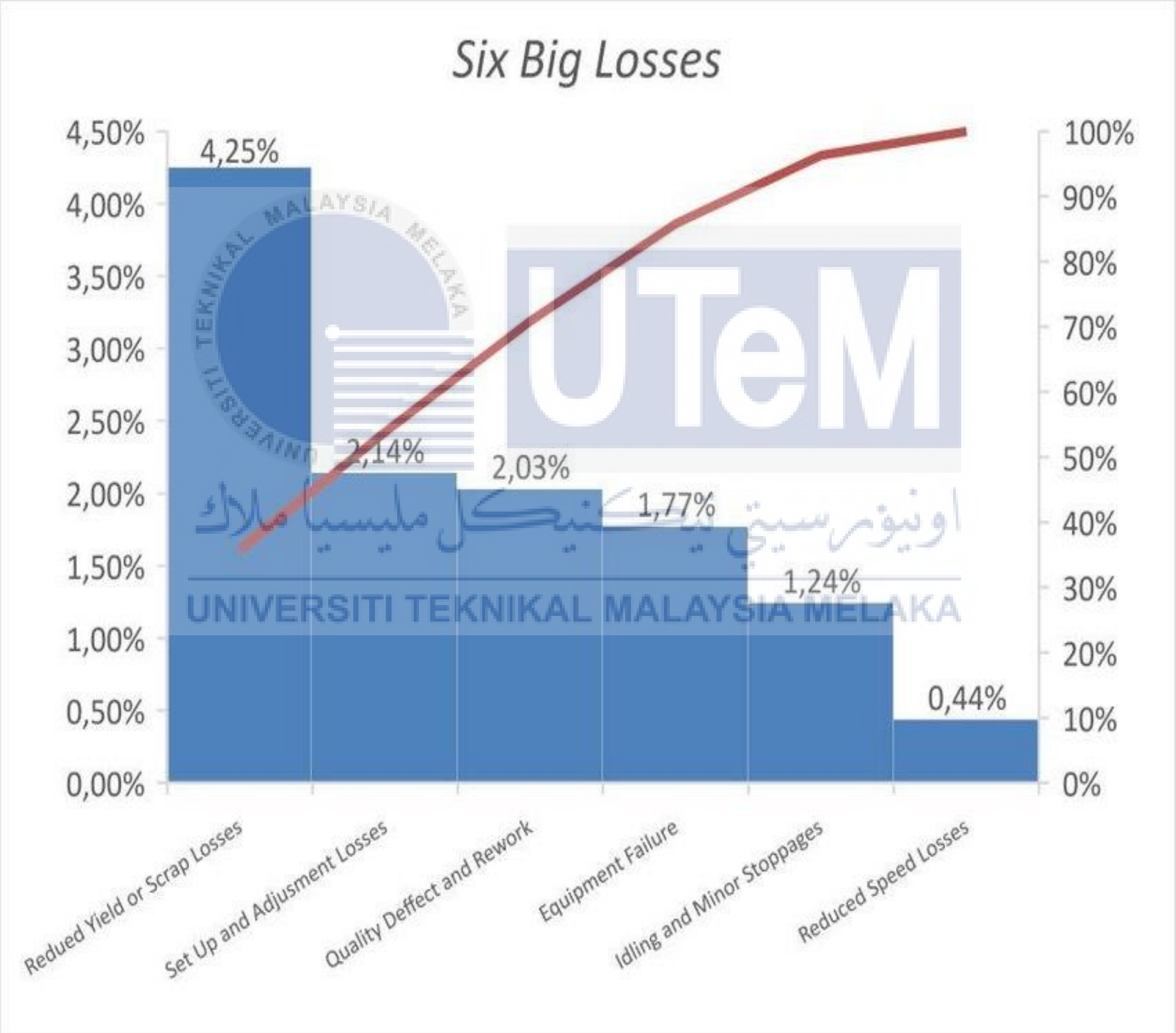

Figure3.8: Example of Pareto Diagram

3.2.3.2 Fishbone Diagram Analysis

The Fishbone diagram, also called the cause-and-effect diagram, is a graphic with shifting lines and symbols intended to show the primary cause of an issue as well as describe current issues. This graphic is frequently used to help come up with ideas for solving problems and to support additional research or fact-finding. In addition to the quality aspect, cause and effect diagrams are frequently employed to determine the root cause of process changes as well as the categories and subcategories of causes that influence particular quality attributes. Furthermore, the factors that cause loss time are analysed using a Fishbone diagram to find out the problem factors for low machine effectiveness. For this research, four categories of factors are studied to find the cause of the low effectiveness, which are man, method, machine, and materials. Figure 3.9 shows the template of the Fishbone diagram that used in this study. The results of this analysis can then be used as a reference to make recommendations for solutions to increase machine effectiveness.

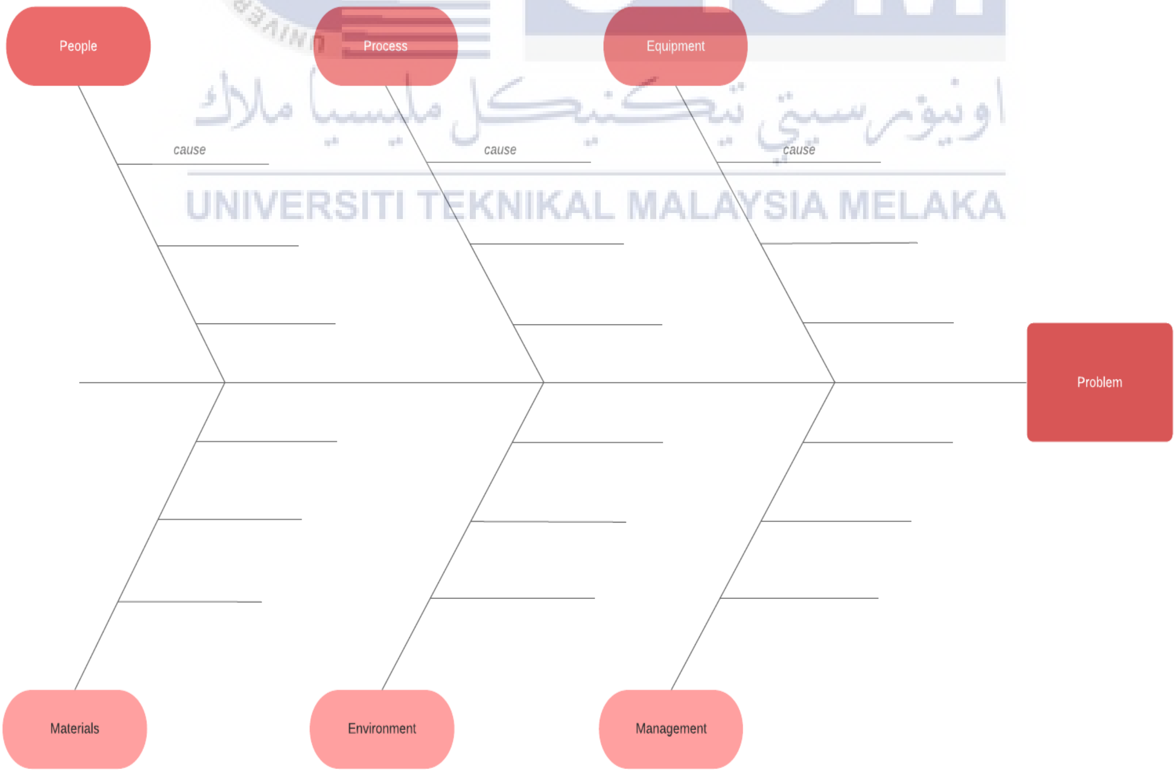

Figure 3.9: Example of Fishbone Diagram

3.2.3.3 Failure Mode and Effect Analysis (FMEA) Approach

Failure Mode and Effect Analysis (FMEA) will be used to analyse the largest losses out of six significant losses. The data analysis is presented and discussed in this step. FMEA from that will indicate this machine's possible failure. The risk priority number of potential failure modes is determined by the FMEA based on the severity, occurrence, and detection of each computed subprocess. Using a consistency tool would prioritise avoiding the failure option with the greatest RPN score.

Table 3.3: Example of failure six big losses

No	Steps	Description
1	Failure Identification, failure mode, and failure effect.	Identify and list out the potential failure mode of the system.
2	Give a rating to the severity(S)	A value of 1-10 is given to measure the seriousness of the impact on the FMEA.
3	Give a rating to occurrence(O)	A value of 1-10 is given depending on how often the impact occur FMEA.
4	Give a rating to Detection(D)	Calculate the ability to control failure that may occur during the process of using machine.
5	Risk Priority Number(RPN)	The RPN shows the priority that should be given to a problem that often occur. RPN is obtained by the multiplication of severity, occurrence and detection.

Severity is a rating that indicates the seriousness of the effects of a failure mode. Severity is a number from 1 to 10, where 1 indicates low risk and 10 indicates very risky. The severity criteria can be seen in Table 3.4 below.

Table 3.4: Ranking of Severity Value

Effect	Criteria	Ranking
Dangerous without warning	• Can harm consumers • Not in accordance with government regulations • No warning	10
Dangerous with warning	• Can harm consumers • Not in accordance with government regulations • There is a warning • Disrupt the smooth running of the production line	9
Very High	• Most of it becomes scrap, and the rest can be sort (can be reworked) • Dissatisfied customer	8
High	• Slightly disturbing the smooth running of the production line • A little become scrap and the rest can be reworked.	7

	• Dissatisfied customer	
Moderate	• Some pieces become scrap and the rest do not need to be reworked.	6
Low	• 100% product can be reworked • Product must be return by the customer.	5
Very Low	• Most of them can be reworked	4
Small	• Only small part is reworked and the rest is good.	3
Very Small	• Certain customer just give complains	2
Not Any	• No effect for consumer	1

Occurrence is a measure of how often a potential cause occurs. The occurrence value is in form of number 1 to 10, where 1 is the lowest and 10 is the highest. Occurrence Criteria can be seen in Table 3.5 below:

Table 3.5: Ranking of Occurrence Value

Chance Of Occurrence	Level Possible Failure	Ranking
Very High	1 in 2	10
	1in 5	9
High	1 in 10	8
	1 in 25	7
Moderate	1 in 90	6
	1 in 450	5
	1 in 2500	4
Low	1 in 18000	3
	1 in 200000	2
Very Low	1 in 2500000	1

Detection is a rating of how accurately it detects an error. A detection is a number from 1 to 10 where 1 indicates the pleasure of detecting a failure while 10 shows a detection using other tools to identify the problem. The detection criteria can be seen in Table 3.6:

Table 3.6: Ranking of Occurrence Value

Criteria	**Ranking**
Always clear and very easy to know	1
Clear to the human sense	2

Need inspection	3
Carefully inspect using human sense	4
Very careful inspection using the human sense	5
Requires help with tools and/or simple disassembly	6
Inspection and/or disassembly required	7
Complex inspection and/or disassembly required	8
Most likely cannot be detected	9
Failure cannot be detected	10

FMEA is conducting to find out what components are prioritized for immediate handling. FMEA processing is divided into several steps, as shown in Table 3.3. After the FMEA was performed, the potential failure with highest RPN value was taken and given the proposed improvement for the problem.

3.3 Summary

Overall Equipment Effectiveness (OEE) plays a crucial role in measuring machine efficiency within the manufacturing industry. Hence, this study concentrates on assessing the straight pin packaging machine at the case study company. The initial phase involves comprehending the packaging process and identifying downtime elements occurring throughout the machine's operation, with assistance from experienced technicians in the packaging department. Subsequently, this study employs the time study method to track each current downtime occurrence on the selected machine. The collected data is then categorized and calculated using the OEE parameters, referencing the Six Big Losses Categories in the packaging process. Ultimately, the OEE of the straight pin packaging machine is determined through the calculation of these parameters.

CHAPTER 4

RESULT AND DISCUSSION

The findings of this study are presented in this chapter. Short data are shown in tabular form. This chapter also provides findings and demonstrates a thorough understanding of the project and the approach used to complete it.

4.1 Result and Discussion of Objective 1

The AB Packaging Machine's present flow process is examined using the approaches from objective 1. This study included both primary and secondary data sources. Semi-structured interviews with operators was used to gather primary data about the machine, including how operators address issues that arise during production. Furthermore, regarding the secondary data extracted from the company record.

4.1.1 Observation

The observation is carried out by a visit to Tanjung Kling, Melaka's textile production company, which is the research company. Every Wednesday in the late afternoon, the company is visited; however, on other days, if there is no order or a failure on Wednesday, the machine may not operate. The company was visited for around six months in 2023/2024 throughout the first and second semesters. The research will run from November 2023 to April 2021. The journey to the company by ow transportation. The purpose of the company visit is to learn more about Packaging Machines and related research machines, production, and the plant itself. A great deal of knowledge about the machine and machine flow process can be learned by observation.

A) Straight Pin Packaging Machine

The Packaging Machine is a machine available in the packaging department at the textile manufacturing company. This machine is a packaging machine for straight pins. Figure 4.1 shows a straight pin and the case used to pack the products. This machine is the only machine that works to pack straight-pin products. This product is packed in an oval-shaped case.

Figure 4.1: Automatic Blister Packaging Machine and Product Packaging

B) Overview of Research Company

There are two shifts that employees at the research company work: the morning shift and the night shift. Employees work the morning shift from 8 a.m. to 8 p.m. Employees who work night shifts do so from 8 p.m. to 8 a.m. This Packaging Machine operates on a Monday through Friday schedule, with weekends off. When there are a lot of orders on the weekends, the business will do overtime. The morning shift and the night shift are the two work shifts. Table 4.1 following shows this company's working time data:

Table 4.1: Factory operating hours

Day	Morning Shift	Night Shift
Monday - Friday	8.00 am – 8.00 pm	8.00 pm – 8.00 am
Saturday	8.00 am – 1.00 pm	

This factory uses make-to-order (MTO) which the company will produce the product when receives orders from customers. The shop order form will show all the tasks, materials, and equipment used in the process of manufacturing the orders. Also, the quantity of the raw materials that are used to produce the order states such as the quantity of the cartoon used, type of case, and raw materials. Not only that, from this order, the duration from production and shipping to customers has already been decided, so the company needs to complete the order during the period provided. Below is one example of a shop order form for straight pin:

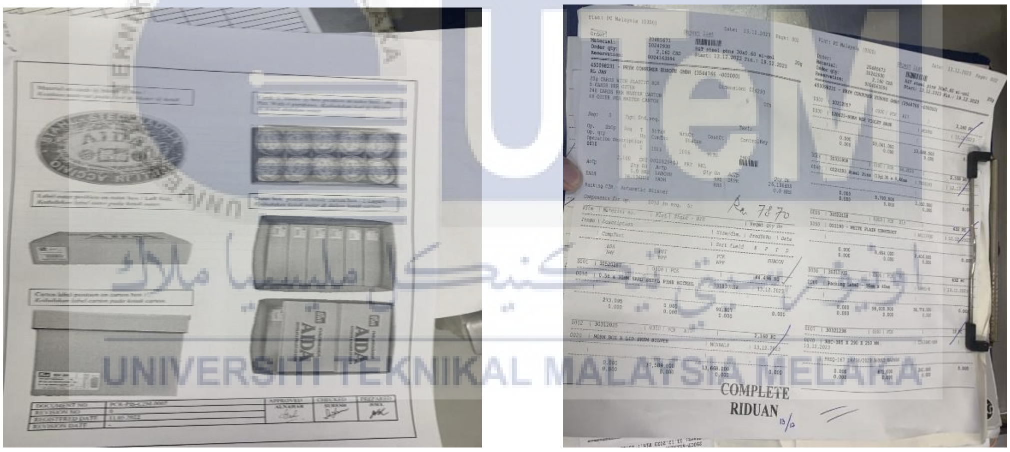

Figure 4.2: Order Sheet

C) Process of Packaging Machine

As mentioned above, four machines are operated by four different operators. The process begins by getting an order from the customer. Then raw materials such as boxes, outer and cartons are provided by the staff according to the order detail form. This machine is started with an operator inserting the box into the mold. The mold picture is shown in Figure 4.3. Then the mold will be pushed by a hydraulic arm to align with the filler. Figure 4.3 also shows the mold which aligns vertically with the filler.

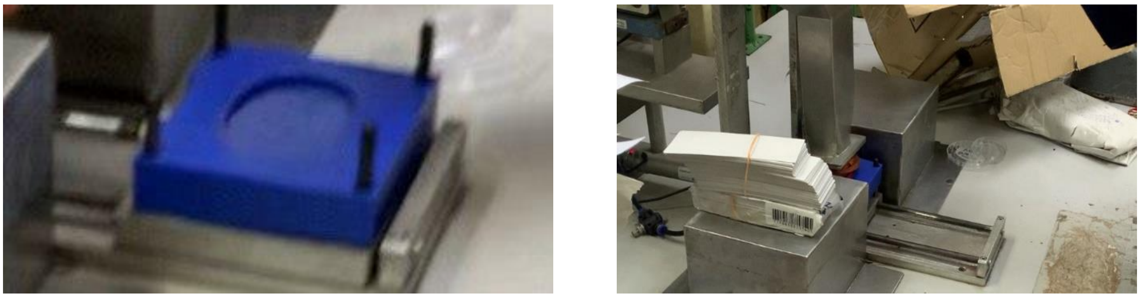

Figure 4.3: Mold for Oval Case

Once the mold is placed vertically aligned with the filler, the operator will press the button to start the filling process. The filling process continues until the setting weight of pins per box is achieved. The monitor shows the weight of the pins is shown in Figure 4.4. After the filling process stops, the hydraulic arm will push out the mold as show in Figure 4.4.

Figure 4.4: Weighing Monitor

Next, the operator took the box from the mold and an inspection was carried out to reject the pin and the condition of the pin inside the box. Figure 4.5 shows the operator using their bare hand to check the reject pin. The operator then closed the box with a lid and again an inspection was done to ensure the box is fully closed as shown in Figure 4.5.

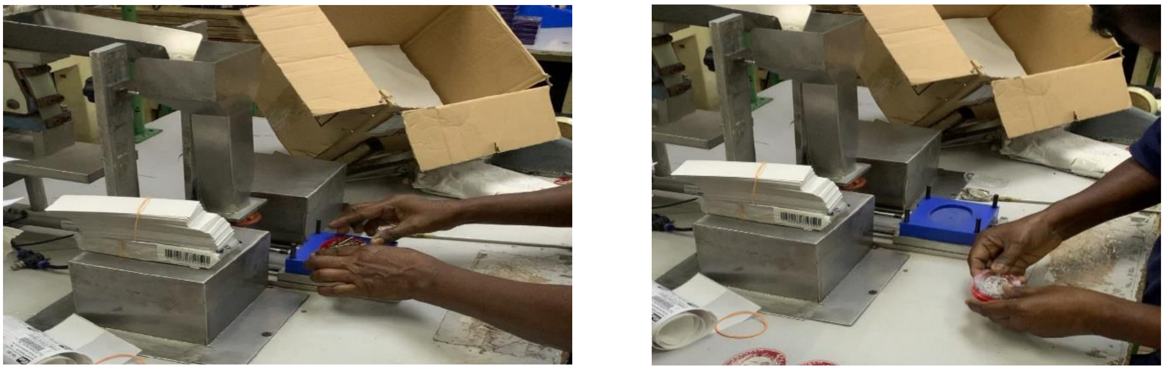

Figure 4.5: Checking Process

The operator repeats the process until the complete boxes reach 40 and above. The complete boxes then will be put into the outer. To ensure the box is arranged perfectly in the outer, the operator places a card as a divider. Figure 4.6 shows the operator gathering the box before transferring it into the outer while Figure 4.6 shows the operator putting a divider inside the outer.

Figure 4.6: Packing Process into Outer.

After the outer is full, the operator will close the outer and put it into the master carton. Each outer contains 48 boxes and each master carton consists of 5 outers. The master carton is sealed using Sellotape and a label or sticker related to the product information of the item inside the master carton is stamped. Figure 4.7 shows the outer is filled into the master carton and Figure 4.7 shows the master carton that has been sealed.

Figure 4.7: Box Securing

To easily understand the process flow of this machine, a flow chart of the packaging machine is provided in Figure 4.8. The flow chart shows the packaging process takes place on straight-pin packaging machine.

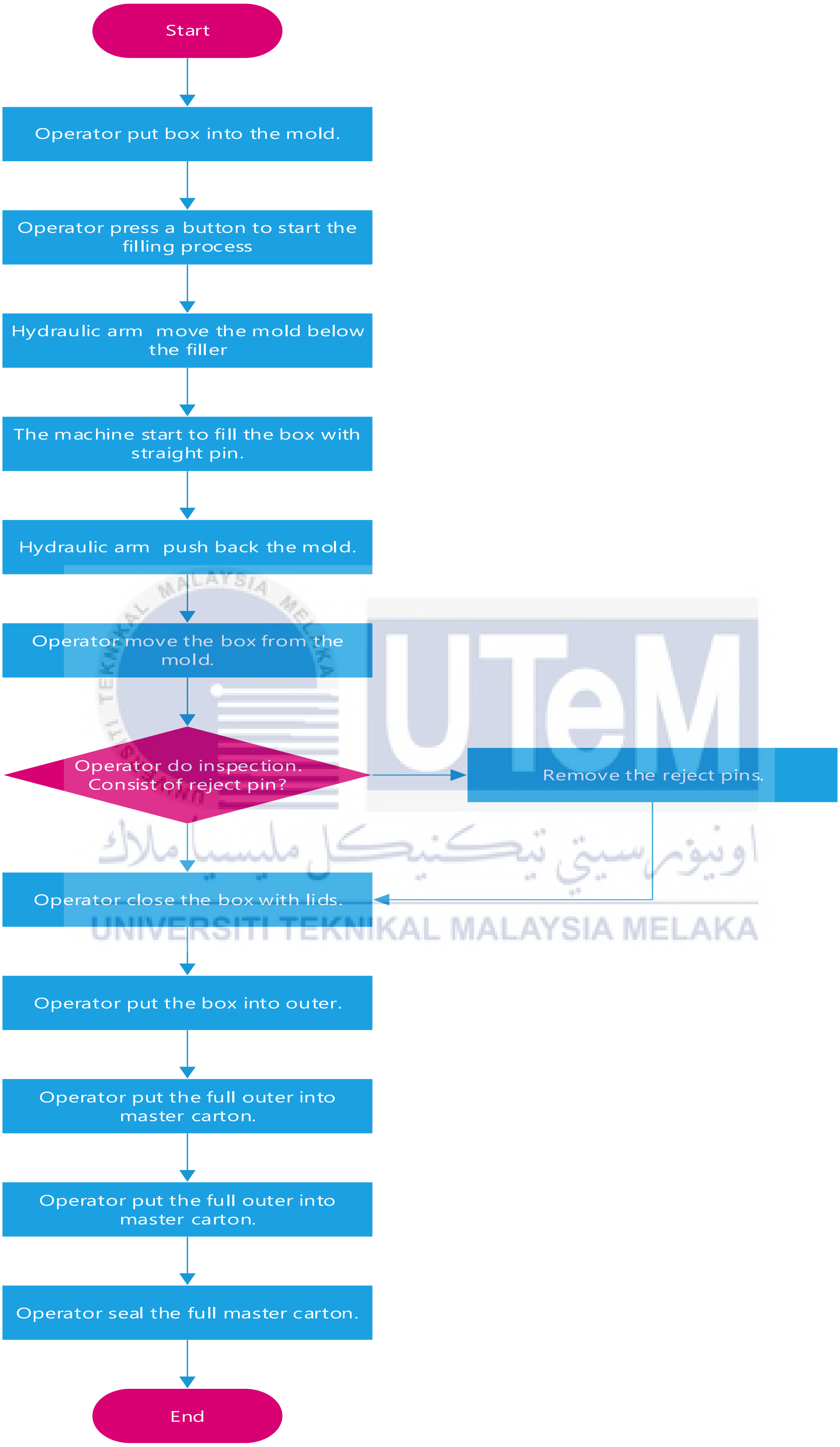

Figure 4.8: Flow chart

4.1.2 Document Review

Previous company data has been reviewed. From the data, some types of information about the machine, such as the product name, product output, product type, and duration of production. Each product has its name that includes the specification of the product. From company data, the ideal cycle time for the product on this machine is found. The ideal cycle time is calculated using the order detail. The table below shows some of the information gathered from the reviewed data.

Table 4.2: Data information gathered from company records.

Product name	Weight per boxes	Duration	Ideal cycle time (Pcs/hour)
H&T steel pin 34 x 0.6 si-col AIDA 25 g	25g	13.12.2023 – 19.12.2023	204

4.2 Result and Discussion of Objective 2

The methodologies of objective 2 are applied to implement the OEE in this machine. The data discussed in this chapter are taken directly from observation at the factory. The data collected is data from machines in the textile manufacturing company, which are straight-pin packaging machines. Data were collected for five days. The data taken are as total output per, total reject product, total downtime, and others.

4.2.1 Data Collection

To apply OEE in this machine, several data were required, including total machine breakdown and total reject product. unfortunately, the straight-pin packaging machine does not have any such data records. Only the entire output and operating hours have been recorded in the data. Data must be gathered before the OEE can be implemented in this machine.

As a previous study conducted by Samad et al., (2012), the use of the stop-watch is noted down whenever a stop or any other situation occurs, which leads to idle or stoppage time on equipment. The purpose of conducting a time study is to identify the real data and time of downtime elements during the ranking process. This stage is performed through a stop-watch time study at the packaging machine and provides the time measurement sheet (TMS) which it has records the downtime elements that occurred through the time study as performed by Jaffar et al., (2012). Thus, the data collection within five days is obtained and shown in Table 4.3 and Table 4.4:

Table 4.3 The summary of real downtime element through time study

No.	Events	Downtime (sec)					Total (sec)
		Day 1	Day 2	Day 3	Day 4	Day 5	
1.	Master check	454	622	428	532	502	**2538**
2.	Misalignment	36	-	45	33	-	**114**
3.	Unable to close	115	154	102	214	122	**707**
4.	Box preparation	88	91	85	82	93	**439**
5.	Arrangement	115	123	101	163	127	**629**
6.	Material problem	19	-	45	19	61	**144**
7.	Idle machine	47	52	48	47	44	**238**
8.	Out of boxes/lids	-	114	-	127	131	**372**
9.	Pin stuck	36	32	54	21	46	**189**
10.	Unorganized workplace	22	27	35	25	23	**132**

Table 4.4: The summary of productions through time study

No.	Product status	Quantity (boxes)					Total (boxes)
		Day 1	Day 2	Day 3	Day 4	Day 5	
1.	Total	500	500	500	500	500	**2500**
2.	Rework	11	8	12	12	18	**187**
3.	Reject	2	2	5	4	3	**35**

Table 4.4 shows the summary of production through time study within five days. Each production of one day consists of 500 boxes. There are two types of product status; rework and reject. Rework product is collected for the next packaging operation while rejecting product is defects and do not rework due to broken product and out of specification.

4.2.2 Calculate the downtime elements

After classifying the downtime elements into OEE losses, the summation of each downtime element's time has been calculated based on the OEE losses categories shown in Table 4.5 The value of these time data will used to calculate the next computation of OEE determination on the packaging machine.

Table 4.5: Total time of each OEE Losses

Event	**OEE Losses**		
	Downtime (in sec)	**Speed** (in sec)	**Quality** (in pcs)
Master check	2538	-	-
Misalignment	-	1214	-
Unable to close	-	707	-
Box preparation	439	-	-
Arrangement	629	-	-
Material problem	-	144	-
Machine idle	-	238	-
Out of boxes/lids	-	372	-
Pin stuck	189	-	-
Unorganized workplace	132	-	-
Reject product	-	-	187
Rework product	-	-	35
Total	**4165**	**2437**	**222**

According to Rajput and Jayaswal (2012) study, small interruptions were the biggest contributors to the time losses. Based on the Table 4.4 above, each of the OEE losses have been calculated and it shows that the higher duration of time losses is downtime losses occurred in five days in the packaging process. For the quality losses, it shows the less contribution in the packaging process throughout in five days even frequent occurred but it just small value in terms of time. On the other words, downtime losses are the major contribution in the packaging process during the study conducted.

4.2.3 Availability ratio

According to Samad et al., (2012) study, the calculation for availability data is performed for availability data in five days (three hour every day) from the previous study. Thus, the different of the planned production time is based on the production of the machine time of the study area. In this study, availability data are collected for five days where each day is 3 hour per production.

The availability is defined as the ratio of operating time over the planned production time. The operating time is the subtraction of the plant operating time, breaks and downtime in five days on the packaging department. The availability for packaging machine is calculated in Table 4.6 below:

Table 4.6: Availability data

Production data	Value (Time)
Shift length (Plant Operating Time: 8.00 am – 8.00 pm; 3 hours for 5 days)	180 x 5 = 900 min
Downtime	4165 sec or, 69.41 min
Planned Production Time = Shift length – Break (15min)	900 – 15 = 875 min
Operating time = Shift length – Downtime	875 – 69.41 = 805.59 min
Availability % = Operating Time / Planned Production Time	805.59 min / 875 min = 0.9206 @ 92.06 %

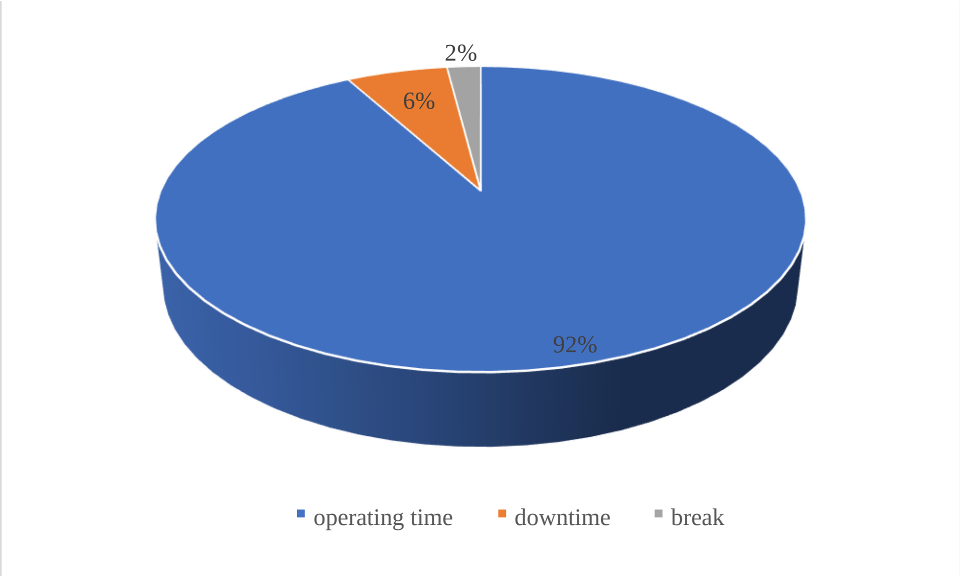

Figure 4.9: Flow chart

The pie chart in Figure 4.9 shows the percentage of availability data consisting of break time, downtime, and operating time. Since the study in five days, the packaging machine operated continuously and an operator who was assigned to that machine took a break, the machine stopped until the break finished for about 15 minutes and the percentage contributed time losses was 2%. It is the same in the Samad et al., (2012) study where the CNC machine was planned to shut to operators take a short break by 20 minutes and the percentage contributing time losses was 11%.

The downtime obtained in the packaging process is 6 %, which is based on the data collected from the time study. Thus, the operating time for packaging machine production is 92% which leads to available time to the packaging process within five days. It is a different percentage by Samad et al., (2012) study where the downtime and changeover time are obtained by 47 %. Therefore, the availability of packaging machines is 95.29% which is higher than the past study from Samad et al., (2012) which by 47.73%.

4.2.4 Performance ratio

Speed losses include any factors that caused the packaging process is operate at less than the maximum operating time when the machine is running (Pal and Biswal, 2015) and the speed losses are calculated in section 4.3.2. According to Zandieh (2012), the operating time is the time at which a machine is produced. However, the available time of the packaging process is called net operating time, and performance ratio for the packaging machine is calculated which is shown in Table 4.5 below:

Table 4.7: Performance data

Production data	Value (Time)
Operating Time	805.59 min
Speed Losses	2437 sec or, 40.61 min
Net Operating Time Operating time – Speed losses	805.59 – 40.61 = 764.98 min
Performance % = Net Operating Time / Operating Time	764.98 min / 805.59 min = 0.9495 @ 94.95 %

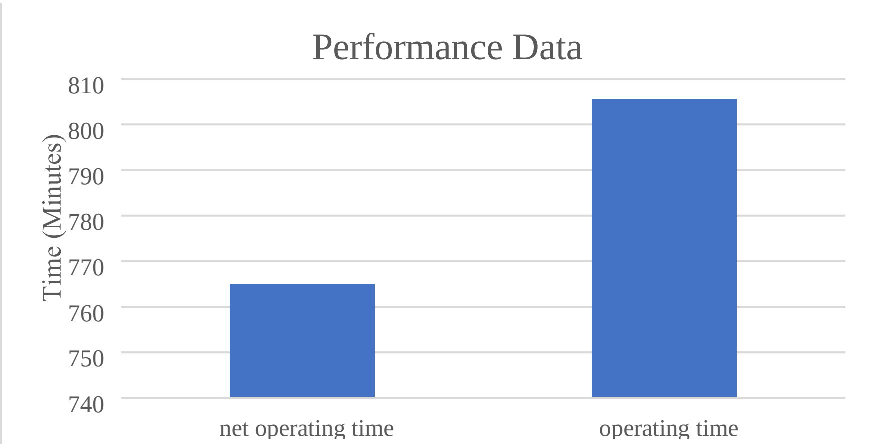

Figure 4.10: Comparison between net operating time and operating time

The figure above shows the comparison time between net operating time and operating time. It is similar to the past study conducted by Samad et al., (2012) which compared the performance data that has been calculated and illustrated the difference in how much losses contribute to the time losses. Based on the classification of OEE Losses in section 4.3.2, the obtained downtime elements time was calculated which is 40 minutes contributing to small stops and slow operations when the packaging process running. However, the contribution of the losses is small affecting the machine's efficiency. Thus, the performance ratio for packaging machines is 97.11% which is higher than the pass study from Samad et al., (2012) and Parihar et al., (2012), the result is obtained for performance ratio by 76.31% and 83.%.

4.2.5 Quality ratio

Based on the data collected, it is shown that a rework and reject product is an output of the packaging process for the packaging machine. It contributed to the percentage of quality for packaging machine production for five days of the study. Parihar et al., (2012) said that it is simply a measure of good product divided by the total product for production. The calculation of the quality ratio is shown in Table 4.6 below:

Table 4.8: Quality data

Production data	Value (Quantity)
Total pieces; 5 days x 1000 pieces	2500 pieces
Rework + Reject Product	187 + 35 = 222 pieces
Good Pieces = Total pieces – (Rework + Reject Product)	2500– 222 = 2278 pieces
Quality % = Good Pieces **/** Total Pieces	2278 pcs /2500 pcs = 0.9112@91.12%

Figure 4.11: The output of the production on packaging machine

The output of the packaging machine in five days consists of good pieces, reworked and rejected products. Based on Figure 4.6, shows that the good pieces of production are highest quantities than reworked and rejected products. In the packaging department, the reworked product is collected and processed for the next packaging operation while the rejected product is called a defective product and is not reworked. Thus, the quality ratio is 91.12% for packaging machines.

4.2.6 Overall Equipment Effectiveness (OEE)

According to Parihar et al, (2012), OEE can be used as a key tool to improve equipment effectiveness and consequently increase productivity. It is used to identify a single asset of machine or equipment-related losses to improve total asset performance and reliability (Williamson, 2006). The main purpose of this study is to determine the Overall Equipment Effectiveness (OEE) of packaging machines in the packaging Process. The availability ratio, performance ratio, and quality ratio that obtained and it`s been calculated in Table 4.9 below:

Table 4.9: OEE percentage for packaging machine

OEE for Machine	Value
Availability ratio	92.06 %
Performance ratio	94.95 %
Quality ratio	91.12 %
OEE	**79.64 %**

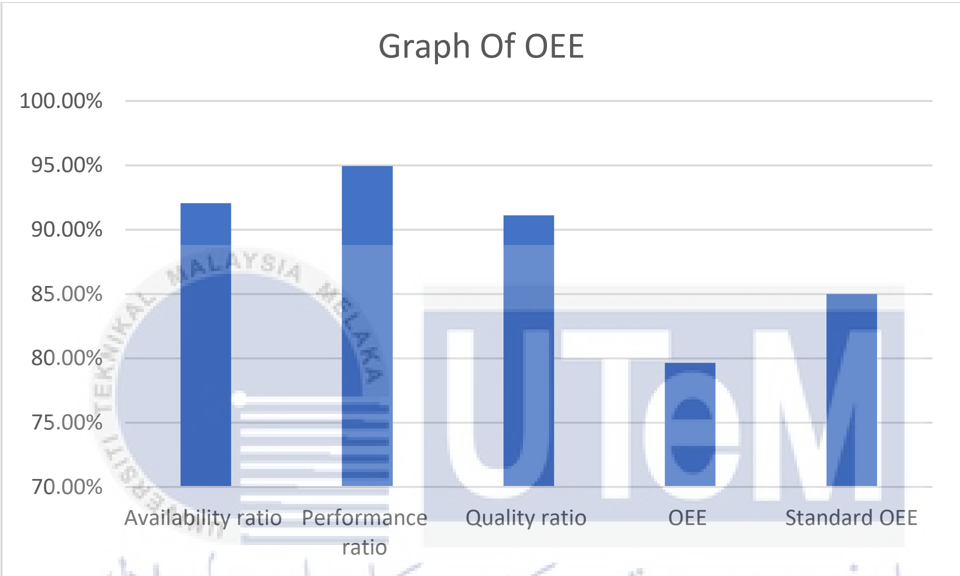

Figure 4.12: The percentages of OEE ratio on packaging machine

Based on Figure 4.12 above, three parameters of OEE represented the contribution to OEE for packaging machines. However, the Quality ratio is the lowest in the performance and availability ratio which is caused by the percentage of OEE. According to Castro & Araujo (2013), the OEE indicator is a result of the multiplication of three parameters that have a relevant role in the TPM philosophy. Thus, the OEE for the packaging machine has been determined by the multiplication of OEE ratios which is 79.64 %.

4.3 Result and Discussion of Objective 3

The third objective is to analyse the cause that contribute to the low effectiveness of the packaging machine. Six big losses are used to find the losses that contribute to low effectiveness. The data used for this finding is data gained from data collection in objective 2. The fishbone diagram is used to know the cause of the losses.

4.3.1 Losses Analysis of Six Big Losses

According to Parihar et al., (2012), one of the major goals of OEE is to reduce and/or eliminate what are called the Six Big Losses the most common causes of efficiency loss in manufacturing. Therefore, the downtime elements were identified and the causes have been described in details which have contributed to the losses in the packaging process. Therefore, the classification of the downtime elements relates to the Six Big Losses and also linked to the OEE Losses.

Table 4.10: Six Big Losses in the Packaging Process

OEE Losses Category	Six Big Losses Category	Event Examples
Downtime loss	Equipment failure or Breakdowns	• Machine problem • Pin stuck
	Setup and Adjustment	• Machine idle • Box preparation • Arrangement • Unorganized workplace • Master check
Speed Loss	Small stop	• Waiting
	Reduced Speed	• Misalignment • Unable to close • Material problem
Quality Loss	Start-up Rejects	• Out of boxes or lid • Rework • Reject
	Production Rejects	• Rework • Reject

4.3.1.1 Study the Downtime Elements

Regarding this study, it is important to recognize and understand the downtime elements that frequently occur during packaging operations. Through the next observation, the study is carried out based on the site visit and information received from the supervisor. There are several downtime elements have been recorded on the Preventive Maintenance Sheet. Table 4.11 shows the descriptions of downtime elements that occurred in the process flow in Figure 4.11 that related to the equipment.

Table 4.11: Summary of downtime elements based on the observation

No	Downtime Elements	Descriptions
1	Misalignment	The mould does not align vertically straight causing the pin might fall outside the plastic box. The mould is the place where the plastic box will be located.
2	Machine problem	The uncertainty problem may cause the machine stop from operation. It takes a long time to identify the main problem on the machine and do maintenance.
3	Unable to close	The condition of the pin inside the plastic box are mess. It requires the operator to sort the pin to ensure the pin are in horizontally so that the lid can be close.
4	Box preparation	The operator needs to fold the box and put a Sellotape to ensure the box in require shape. The divider will be put in it. The problem occurs here when the outer box did not seal properly and the divider are not sort properly inside the box causing the operator need to redo again.
5	Arrangement	The arrangement of plastic box in outer box affected by the divider in the outer box. The divider causes the plastic box cannot be filled properly.
6	Material problem	1. **Ineffective Adhesion:** Sometimes, Sellotape fails to stick securely to the intended surface, resulting in items coming loose or packaging not remaining sealed. This can be particularly problematic when securing important documents or packages. 2. **Tearing or Splitting**: Sellotape may tear or split unevenly, making it difficult to use effectively.
7	Unorganised workplace	The operator consumes a small time to get the material needed within work area since the material are not organized.
8	Machine idle	The operator usually takes a very long time to sealed the master carton since the size is big. The problem occurs due to the size and also the arrangement of the outer boxes in the carton are not in correct position.
9	Out of boxes or lids	The operator needs to move to supply area or ask the runner to send them the boxes ort lids. This will cause the delay to the production. The operation will start again after box and lids are refilled.
10	Pin stuck	The pins in the machine usually stuck at the filler tube causing the operator need to stop the machine and use a stick to push the stuck pins.
11	Machine idle	Starting from close the plastic box with lid until last process, the machine will be idle since those process are done during the machine is on.
12	Master check	This master check is the actual product specification or benchmarking for fresh products during packaging operation. This activity necessary to be done on machine to prevent the product packaging not according to specification.

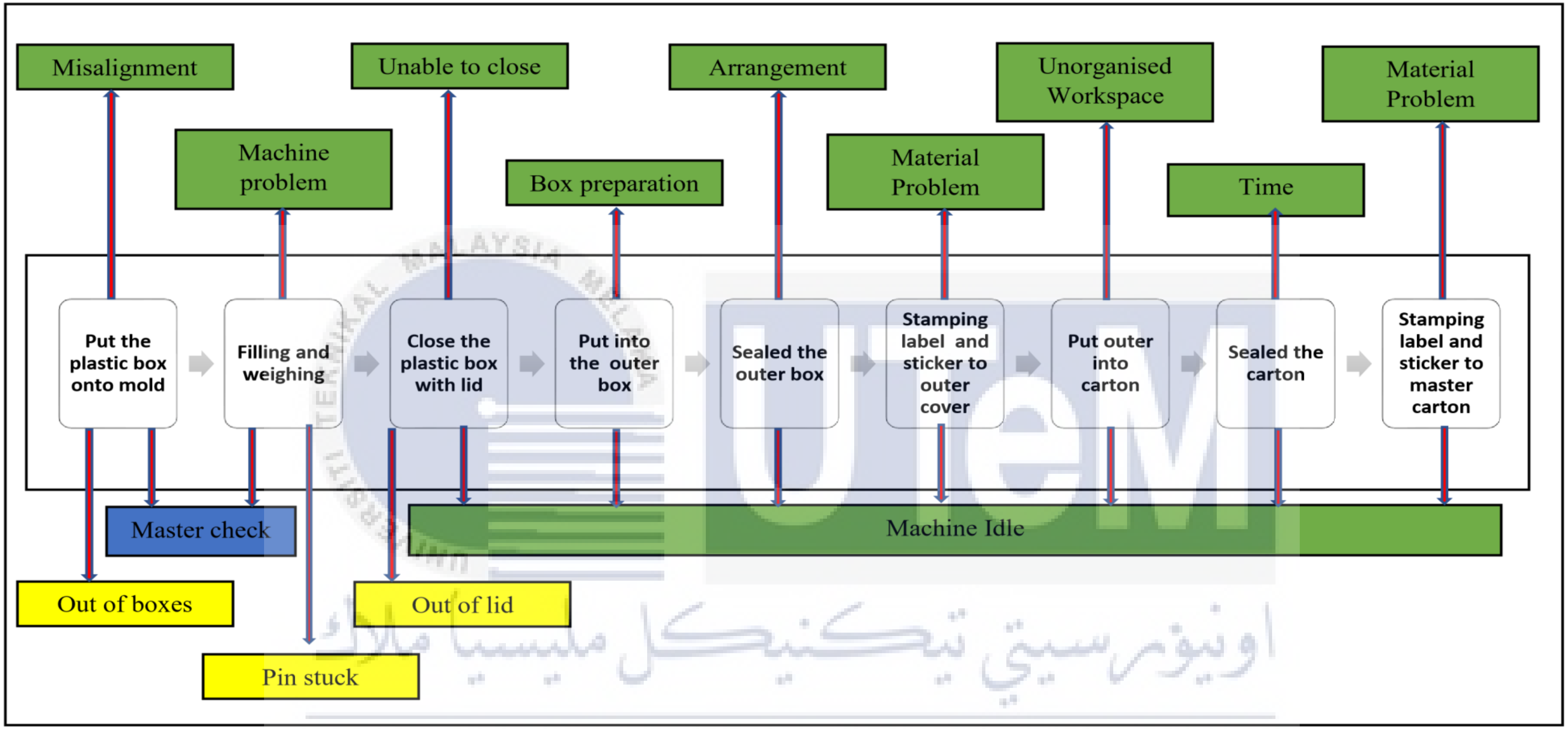

Figure 4.13: Downtime Elements in the Process Flow

Colours Indication

*Green – Downtime element frequently happen

*Yellow – Product problem

*Blue – The equipment requires to check to ensure it aligned with specification product

4.3.1.2 Calculation of Losses

Before the calculation continues, it is important to classify the downtime element into six big losses. Figure 4.3 show the classification of downtime elements.

Table 4.12: Classification of OEE Losses

Event	OEE Losses		
	Downtime	Speed	Quality
Master check	■		
Misalignment		■	
Unable to close		■	
Box preparation	■		
Arrangement	■		
Material problem		■	
Idle machine	■		
Out of boxes/lids			■
Pin stuck	■		
Unorganized workplace	■		

A) Breakdown Losses

There are two type of losses on availability rate, which are breakdown losses and setup adjustment losses. Breakdown losses are a type of loss that occurs as a result of a machine being damaged so that it cannot operate to produce output and requires repair or replacement. This loss is measured by how long it takes for damaged to be repaired. The breakdown losses formula can be written as follows:

Table 4.13: Element that contribute to breakdown losses

Element	Time(seconds)
Pin stuck	189
Unorganized workplace	132
Total(min)	321 seconds@ 5.35 minutes

Table 4.14: Calculation of Breakdown Losses Percentage

Loading Time(min)	Downtime(min)	Breakdown Losses
900	5.35	0.59%

From the table, the calculation of the percentage of breakdown losses is calculated, breakdown losses are due to the pin being stuck in the container or filler which requires the technician to repair. The other reason is an unorganized workplace which is the pin that scatters into the mold causing the hydraulic arm stuck.

B) Setup and Adjustment Losses

The second losses of availability rate are setup and adjustment losses. These losses are due to changes in operating conditions, such as starting the production process or starting shift changes, changing product specifications, and changing adjustments of settings. The formula for calculating these losses is as follows:

Table 4.15: Element that contribute to breakdown losses

Element	Time(seconds)
Master Check	2538
Box Preparation	439
Arrangement	629
Total(min)	3606 seconds@ 60.1 minutes

From the table above, it can be concluded that the Master Check element contributes the highest setup and adjustment losses. The time recorded for 5 days was 2538 seconds. The lowest time recorded for setup and adjustment losses was machine idle with 238 seconds.

C) Idling and Minor Stoppage Losses

Performance rate also has two losses, which are idling and minor stoppage losses. Idling and minor stoppage losses are caused by stopping the engine due to a temporary problem or idle machines. The formula for calculating idling and minor stoppage losses is as follows:

Table 4.16: Element that contribute to breakdown losses

Element	Time(seconds)
Machine Idle	238
Total(min)	238 seconds@ 3.97 minutes

Based on table 4. There was only one element that contributed to idling and minor stoppage which is machine idle. Machine idle usually happens during the operator needs to put the complete outer into the master carton.

D) Speed Losses

The second loss for performance rate is speed losses which is cause by a reduction in production speed from the speed designed for the machine. To measure this loss needs to compare the ideal capacity with the actual workload. The ideal cycle times are calculated by using the data given by the company as shown in Figure 4.3.2 below:

Material	=	10243510
Item	=	H&T steel pin 34 x 0.6 si-col AIDA 25 g
packaging info	=	25g per plastic box
	=	40 boxes per outer
	=	320 boxes per master carton
	=	8 outer per master carton

Time take to complete one box

Step	Action	Average (sec)
1	Put plastic box into mold	1.65
2	Fill the plastic box with pin	23.12
3	Close the lid	5.43
	Total	30.2

Total time to complete 320 plastic boxes	=	9664	sec
Total time to complete 1 master carton	=	9817.63	sec
	=	163.627167	min
	=	2.72711944	hrs

Step	Action	Average (sec)	Column1
1	Prepare master carton	15.2	0.05
2	Preparation for 8 outer	18.2	0.06
3	Stick label to 8 outer	28.32	0.09
4	Fill small boxes with case	31.32	0.10
5	Put 8 plastic boxes into master carton	41.2	0.13
6	Sellotape the master carton and stamp sticke	19.39	0.06
	Total	153.63	0.48

hrs/shift	=	9.5	hrs
Total of master carton per shift	=	3.48352912	master carton
	=	3	master carton

Total cycle time with 15% Allowance.	35.28		
Pcs / hour	102.03		
1000 pcs =	9.80	man hours	Retail pack (25 to 50 gram)
	11.76	"	Retail pack (> 50 gram)
	7.84	"	Retail pack (< 25 gram)

Figure 4.14: The calculation of ideal cycle time for product below 25g.

E) Quality Defect

Losses at the rate of quality also consist of two types of losses, which are quality defect losses and yield losses. Quality losses happen because, during the production process, defects occur in the products produced. Products that do not match the specifications need to be reworked or scraped. To carry out the rework process and make the material into scrap is also a form of loss for the company. Table 4.17 shows the total defects for five days.

Table 4.17: The number of defect in 5 days

No.	Product status	Quantity (boxes)					Total (boxes)
		Day 1	Day 2	Day 3	Day 4	Day 5	
1.	Total	500	500	500	500	500	**2500**
2.	Rework	11	8	12	12	18	**187**
3.	Reject	2	2	5	4	3	**35**

The calculation of Quality Defect Losses gives the result of 1.13% for total of 5 days of production. The defect is considered ideal since the percentage is below 2.5%.

F) Yield Losses

Meanwhile, yield losses occur because raw materials are wasted. The form of this loss is material loss due to product design and manufacturing methods, as well as adjustment losses due to product quality defects that are produced at the beginning of the production process or when there is a change in product specifications. The following is a formula for calculating yield losses:

From the OEE analysis, there was no product rejects that occur during the machine adjustment period to that productions run stable, so it seen that these losses get 0%. It can be concluded that yield losses do not apply to this machine.

4.3.2 Total losses on six big losses

Total time losses in the six big losses are carried out to find out how much total time is wasted or unproductive on this machine. Then the percentage of each of the six big losses will be measured so that it can be known what type of loss has the highest percentage, which will later take appropriate corrective steps to resolve this loss. After calculating the percentage value of six big losses, then calculate how much total time losses in these losses:

Below is an example of calculation time losses for breakdown losses. This calculation can be used for all losses by only changing the percentage of losses. Based on table 4.18, the percentage of breakdown losses is 0.59%. Here are the results of the calculations:

Table 4.18: The results of estimating time losses for each loss in six big losses

	Breakdown Losses	Setup and Adjustment Losses	Speed Losses	Idling and Minor Stoppages	Quality Losses	Yield Time Losses	Total
Percentages (%)	0.59	6.67	8.21	0.44	1.13	0	17.04
Time(min)	5.31	60.1	73.89	3.97	10.17	0	153.44

From the results of estimating time losses, it can be seen the total time losses. Based on these results, it can be seen that the total time losses during speed losses are the highest compared to other losses which are 73.89 minutes. More, the value that has the least time loss is yield with 0 value.

4.3.3 Analysis Pareto Diagram

After knowing the total time losses in each component of the six big losses, it is done cumulatively to determine the value of losses that affect the OEE value on this machine. The following shows the cumulative percent value for the six big loss components for the Packaging Machine. Based on the percentage of the ideas above, it can be seen that the total time wasted during those nine days was 153.44 minutes of loading time of 900 minutes.

Table 4.19: Cumulative Percent of Total Time Losses

Type of Losses	Time Losses (min)	Percentage (%)	Cumulative (%)
Speed	73.89	48.15	48.15
Setup and adjustment	60.1	39.16	87.31
Quality	10.17	6.63	93.94

Breakdown	5.31	3.46	97.4
Idling and minor stoppages	3.97	2.59	100
Yield	0	0	100
Total	153.44	100	

After knowing the total time losses of six big losses that affect the OEE level of the Packaging Machine, then the problem is solved that causes the high time losses found in the six big losses component. The Pareto diagram below is used to analyze the six big losses in order to determine the things that are dominant in analysing and overcoming time losses. By overcoming these dominant factors, the problem of low effectiveness can be overcome. Figure 4.15. below is the Pareto diagram of the six big losses that occurred in the Packaging Machine:

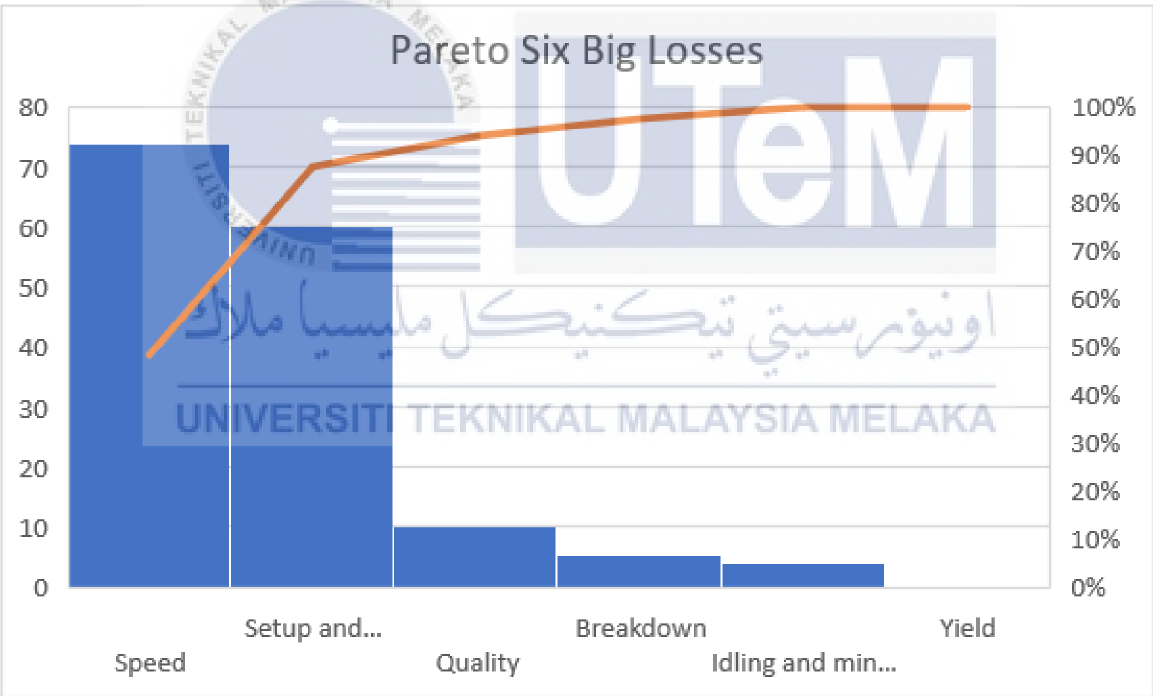

Figure 4.15: Pareto Diagram of Six Big Losses

Based on the figure above, it can be concluded that the most dominant losses that cause the low OEE value of this machine are speed losses and setup and adjustment losses. This is the most priority issue that must be addressed to achieve an increase in OEE value.

4.3.4 Analysis Causes of Low Effectiveness

The Fishbone diagram is a diagram that can explain the root cause of a problem. The depiction of the fishbone diagram is carried out on the losses factor that affects losses on the Packaging Machine. Two highest losses which speed losses and setup and adjustment losses, are analyzed to know the cause of low effectiveness. In order for repairs to be carried out immediately, the analysis of loss factors that result in the low effectiveness of the machine in calculating OEE is carried out using a fishbone diagram.

The root cause of the loss is obtained and analyzed through brainstorming or discussion to get ideas. The causes of the problem are solved in four categories, namely man (worker), method, material, and machine. Causes in terms of categories are described through brainstorming sessions and machine observations. Brainstorming was carried out together with machine operators and technicians by giving suggestions about the losses experienced by the Packaging Machine. The results of brainstorming and observations produced several causes that were considered true to affect speed losses and setup and adjustment losses.

Thus, based on the explanation above, this fishbone diagram will be used to analyze and determine the main factors causing losses to be discussed, which are breakdown losses and speed losses. The causal factor is that these losses usually have the same casual factors because, technically, the failure or damage that occurs in one function has between one type of loss and another.

A) Fishbone Diagram of Speed Losses

Speed losses are by far the biggest of the six big losses in industrial and manufacturing settings refer to the reduction in production speed compared to the maximum possible output. These losses occur due to several factors, including equipment inefficiencies, suboptimal process planning, and external disruptions. Equipment inefficiencies can stem from wear and tear, improper maintenance, or outdated technology, causing machinery to operate below its intended speed. Suboptimal process planning involves poor scheduling, inadequate workflow management, and inefficient resource allocation, which can slow down the entire production line. External disruptions such as supply chain issues, power outages, or unforeseen environmental factors further contribute to speed losses by interrupting the smooth flow of operations.

Additionally, human factors play a crucial role in speed losses. Operator errors, insufficient training, and lack of motivation can lead to slower operation speeds and increased downtime. Communication breakdowns within teams or between different departments can also delay decision-making and problem-solving, exacerbating speed losses. Below are the causes that cause speed losses.

Table 4.20: 5 why Speed Losses

	Cause	Why1	Why2	Why3	Why4	Why5
Man	Operator Ignore The Procedure	Awkward Movement	Operator Need To Always Stand Up	-	-	-
	Shoulder And Back Pain	Operator Age				
Method	Unskill Operator	No Written Procedure	Language Problem	Foreigner Operator	-	-
	Less Training	Do Not Have Proper Training	Operator Always Change			
Material	Unsuitable Design Of Cover/Lid	Company Allow The Customer To Choose Their Own Design	Customer Satisfaction	-	-	-
Machine	Poor Design	The Part Is Too Far To Reach	-	-	-	-

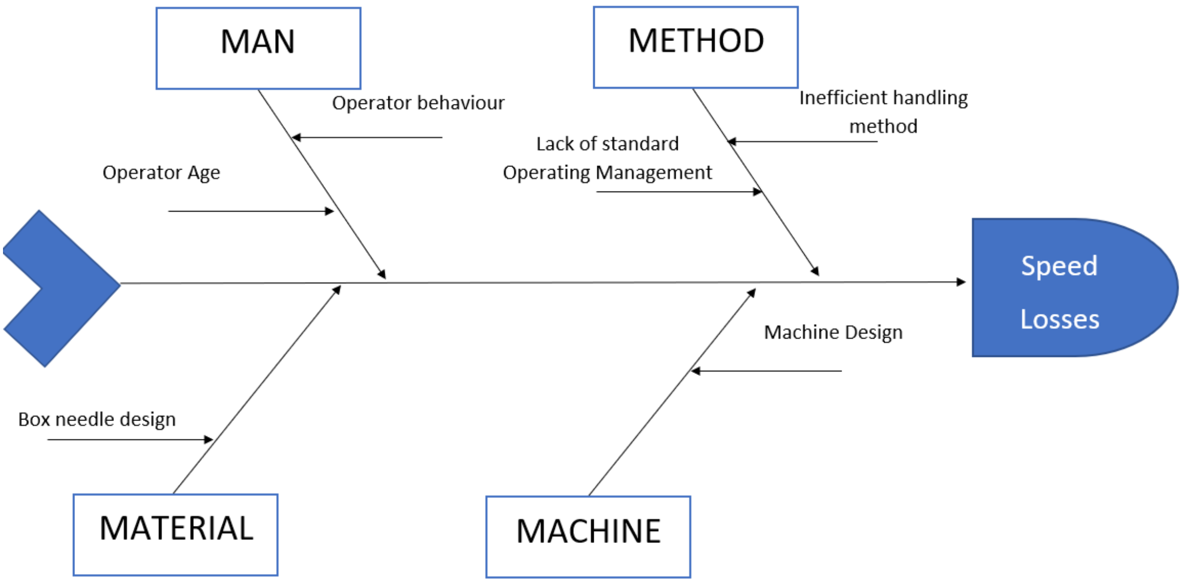

Figure 4.16: Speed Losses Fishbone Diagram

The fishbone diagrams above identifies causes based on four categories which are **man, method, material, and machine**. From the fishbone diagrams, it is known that the cause of speed losses is as follows

1. **Man** (Human Factors)

a) Operator Behaviour: The way operators conduct their tasks can significantly impact the speed of the production process. Poor work habits, lack of motivation, or improper techniques can lead to slower operations.

b) Operator Age: The age of the operators might influence their performance. Older operators might have more experience but could also face physical limitations or be less adaptable to new technologies compared to younger counterparts.

2. **Method** (Process and Procedures)

a) Lack of Standard Operating Management: The absence of well-defined and standardized operating procedures can lead to inconsistencies and inefficiencies in the production process. When operators are not following a standard method, it can result in variations and delays.

b) Inefficient Handling Method: Inefficient methods for handling materials or components during the production process can slow down operations. This includes poor layout design, inadequate tools, or cumbersome workflows that impede the speed of production.

3. **Machine** (Equipment and Technology)

a) Machine Design: The design of the machines used in the production process plays a crucial role in speed. Poorly designed machines can be less efficient, harder to operate, and more prone to breakdowns, all of which contribute to speed losses.

4. **Material** (Raw Materials and Components)

a) Box Needle Design: The design of materials, such as the box needle design mentioned in the diagram, can affect the speed of the production process. If materials are not designed for optimal compatibility with the machinery or are difficult to handle, they can slow down the production line

B) Fishbone Diagram of Setup and Adjustment Losses

Setup and Adjustment losses is the second-highest losses in the Pareto chart. Setup and adjustment losses refer to the time and productivity lost during the process of preparing and adjusting equipment. These losses include changeover time, tooling changes, calibration, and material loading. Tooling changes involve replacing and setting up new tools, dies, or fixtures required for the next production batch. Calibration entails fine-tuning machine settings to meet the specifications of the new product, often involving several trial-and-error adjustments.

Additionally, setup losses can include material loading and documentation. Loading new raw materials or components into the machine takes time, especially if the materials require specific handling or preparation. Documentation involves recording adjustments and settings for future reference, ensuring that the setup process can be replicated accurately in subsequent runs. These activities collectively contribute to setup and adjustment losses by delaying the start of actual production, thus reducing overall equipment effectiveness and impacting productivity. Figure 4.17 shows the fishbone diagram for setup and adjustment losses while Table 4.21 shows the 5 why.

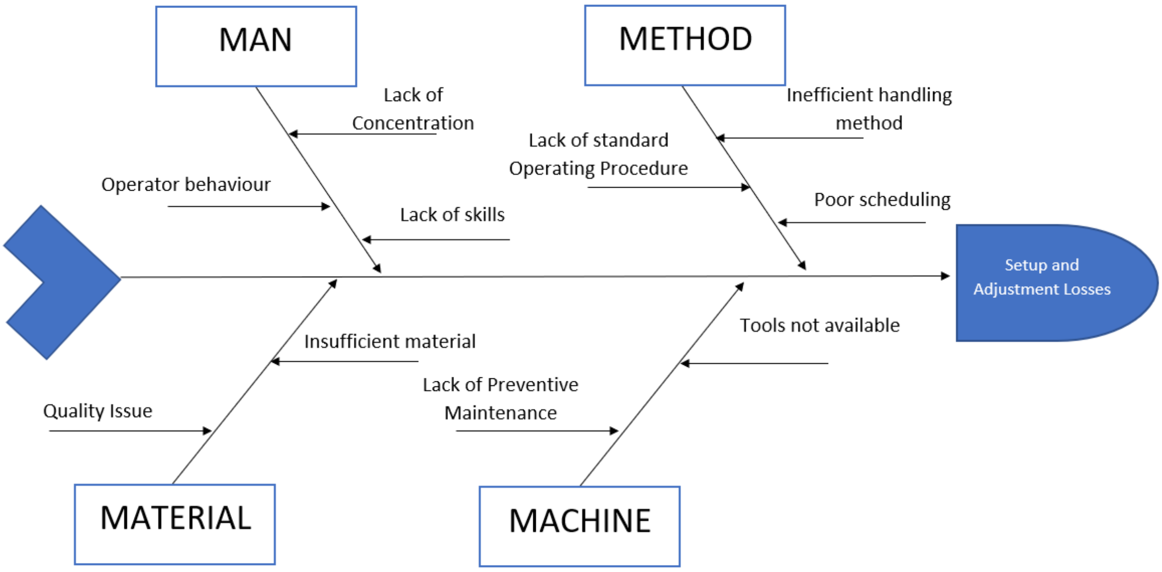

Figure 4.17: Setup and Adjustment Losses Fishbone Diagram

The fishbone diagrams above identifies causes based on four categories which are **man, method, material, and machine**. From the fishbone diagrams, it is known that the cause of speed losses is as follows

1. **Man** (Human Factors)

a) Operator Behaviour: The way operators conduct their tasks can significantly impact setup and adjustment times. If operators lack concentration or skills, they may take longer to perform setup tasks or make mistakes that require additional adjustments.

b) Lack of Concentration: Distractions or fatigue can reduce an operator's efficiency during setup, leading to longer times and more frequent errors.

c) Lack of Skills: Inadequate training or experience can cause operators to perform setup tasks more slowly and inaccurately, resulting in increased setup and adjustment losses.

2. **Method** (Process and Procedures)

a) Lack of Standard Operating Procedure: The absence of well-defined and standardized procedures can lead to inconsistencies and inefficiencies during setup. Operators might perform the tasks differently each time, leading to variability and delays.

b) Inefficient Handling Method: Poorly designed processes or workflows for handling materials or components can slow down the setup process. Inefficiencies in these methods increase the time required for adjustments.

c) Poor Scheduling: Inadequate planning and scheduling can cause delays, such as when machines are not available at the needed time, or when setup tasks are not coordinated properly, leading to extended downtimes.

3. **Machine** (Equipment and Technology)

a) Tools Not Available: The unavailability of necessary tools or equipment during setup can cause significant delays. Operators may spend extra time searching for tools or waiting for them to become available.

b) Lack of Preventive Maintenance: Without regular maintenance, machines may be more prone to breakdowns or malfunctions during setup, increasing the time required to make adjustments and ensure the equipment is functioning correctly.

4. **Material** (Raw Materials and Components)

a) Insufficient Material: A lack of necessary materials during setup can halt the process, requiring operators to wait for materials to be supplied, thereby increasing setup time.

b) Quality Issue: Poor quality materials can lead to additional adjustments during setup. Operators might need to rework or replace defective materials, causing further delays in the setup process.

4.3.5 Analysis Determined Critical Problem

Solutions are proposed to increase the effectiveness of the Automatic Blister Packaging Machine. Before giving the suggestions of improvements, critical problems were identified using the FMEA method. From the FMEA, it is known the failure that caused the losses to occur.

The FMEA is used to determine the critical problem that caused low effectiveness for the Packaging Machine. The purpose of the FMEA is to identify and assess the risks associated with potential failures and to prioritize corrective actions. Process FMEA is used in this problem to identify errors or failures in the production process that cause low OEE Packaging Machine values. The FMEA processing is carried out in several stages as below:

1**) Identify Potential Types of Failure of Each Process**

There are several failures that have the potential to occur during the production process of straight pin packaging on the MCB Packaging Machine.

2) Giving severity score (SEV)

Severity shows how much impact the intensity of an event has on the output of a process. The severity score is given by conducting interviews with operators and technicians. The scoring guidance for giving severity scoring shows in Table 3.4.

3) Giving occurrence score (OCC)

Occurrence is something that determines the average failure rate that will occur. The occurrence score is given by conducting interviews with operators. The scoring guidance for giving occurrence scoring shows in Table 3.5.

4) Giving a detection score (DET)

Detection is a measurement of the ability to control or find failures that may occur.

The detection score was given by conducting semi-structured interviews with the operators. The scoring guidance for giving detection scoring shown in Table 3.6.

5) Risk Priority Number (RPN) Calculation

RPN calculation is done using the equation below. The following is the calculation of RPN for lack of knowledge from breakdown losses:

$$RPN = SEV \times OCC \times DET$$

A) Failure Mode and Effects Analysis (FMEA) of Speed Losses

The highest Risk Priority Number (RPN) is 144 as shown in Table 4.21, which corresponds to the "Inefficient Handling Method" failure mode. This failure mode significantly impacts production by causing delays and increased cycle times, which are critical concerns for maintaining operational efficiency and meeting production targets. The primary causes of this issue are outdated handling methods and a lack of standardization, leading to inconsistencies and inefficiencies in the production process. Despite the presence of current controls such as process audits and Standard Operating Procedures (SOPs), these measures have limited effectiveness in early detection, as indicated by a detection rating of 6. The severity of the impact is rated at 8, reflecting the substantial negative consequences on production efficiency and customer satisfaction. The occurrence rating of 3 suggests that while the issue is not extremely frequent, it happens often enough to warrant attention. To mitigate this high-risk issue, it is recommended to optimize handling methods through process improvement initiatives and to provide thorough training for employees on these new, standardized procedures. Implementing these actions will help in reducing variability, improving efficiency, and ultimately lowering the risk associated with this failure mode.

Table 4.21: Table FMEA Speed Losses

Potential Failure Mode	Potential Effect(s) of Failure	Severity (S)	Potential Cause(s) of Failure	Occurrence (O)	Current Control(s)	Detection (D)	RPN (Risk Priority Number)	Recommended Action(s)
Operator Age	Reduced efficiency, increased errors	6	An aging workforce, physical limitations	2	Training	4	48	Ergonomic adjustments, regular breaks, skill enhancement programs
Operator Behaviour	Slow processing, mistakes	4	Lack of motivation, improper training	2	Supervision, training programs	5	40	Behavioral training, motivational programs, regular performance reviews
Inefficient Handling Method	Delays, increased cycle time	8	Outdated methods, lack of standardization	3	Process audits, SOPs	6	144	Method optimization, employee training on new methods
Lack of Standard Operating Management	Variability in speed, errors	6	Poor management practices	6	Management reviews, SOPs	3	108	Implementing standardized management procedures, regular management training
Machine Design	Downtime, slower operation	8	Outdated machinery, poor design	1	Maintenance schedules, design reviews	5	40	Upgrade machinery, redesign for efficiency, implement predictive maintenance
Box Needle Design	Jammed materials, slower speeds	7	Poor design, wear and tear	2	Quality checks, design standards	6	84	Redesign for durability, regular inspections, use of higher quality materials

B) Failure Mode and Effects Analysis (FMEA) of Setup and Adjustment Losses

The highest RPN in the FMEA table is 200, linked to the "Lack of Skills" failure mode, which significantly impacts production by causing inefficient setups and increased setup times. This failure mode's high severity rating of 8 underscores the serious consequences of inadequate operator skills, such as delayed production schedules and reduced overall efficiency. The occurrence rating of 5 indicates that this issue is moderately frequent, suggesting that a substantial number of operators lack the necessary skills, resulting in recurring inefficiencies. Detection is also rated at 5, meaning that while training programs exist, they are not sufficiently effective at identifying and mitigating these skill gaps before they affect production. The root cause of this failure mode is insufficient training, possibly due to outdated or inadequate training programs. To address this, it is recommended to implement comprehensive and ongoing training programs, along with regular skill assessments to ensure operators are adequately trained and can perform setups efficiently. This proactive approach will help reduce setup and adjustment losses, improve production efficiency, and ultimately lower the RPN for this failure mode.

Table 4.22: Table FMEA Setup and Adjustment Losses

Potential Failure Mode	Potential Effect(s) of Failure	Severity (S)	Potential Cause(s) of Failure	Occurrence (O)	Current Control(s)	Detection (D)	RPN (Risk Priority Number)	Recommended Action(s)
Lack of Concentration	Increased errors, setup delays	7	Operator fatigue, distractions	4	Breaks, ergonomic design	4	112	Regular breaks, minimize distractions, ergonomic improvements
Lack of Skills	Inefficient setups, increased time	8	Insufficient training	5	Training programs	5	200	Enhanced training programs, skill assessments
Inefficient Handling Method	Setup delays, inconsistent setups	8	Outdated methods, no standardization	4	Process audits, SOPs	6	192	Method optimization, standardize procedures, train operators
Lack of Standard Operating Procedure	Setup variability, delays	7	Poor documentation, no SOPs	5	SOPs	5	175	Develop and implement SOPs, training on SOP adherence
Poor Scheduling	Downtime, setup delays	6	Poor planning, unexpected changes	4	Scheduling software, planning meetings	4	96	Improve scheduling, use advanced planning tools
Insufficient Material	Setup delays, production stops	8	Poor inventory management	5	Inventory checks	4	160	Improve inventory management, implement JIT system
Quality Issue	Rework, setup delays	8	Poor supplier quality, inadequate QC	3	Quality checks, supplier audits	4	96	Strengthen supplier quality agreements, enhance QC measures
Lack of Preventive Maintenance	Unexpected breakdowns, setup delays	9	Infrequent maintenance	3	Scheduled maintenance	5	135	Implement preventive maintenance program, monitor equipment health
Tools Not Available	Setup delays, inefficiency	7	Poor tool management	4	Tool inventory checks	5	140	Implement tool management system, ensure tool availability

4.3.5 Propose Solutions

The proposed solution is aimed at increasing machine effectiveness, reducing waste, reducing production costs, and increasing machine capabilities. In this method, the engineering division and the production division must maintain a good relationship because to achieve a more effective production process. In this problem, recommendations are given based on calculations and analyses that have been carried out. From the calculation and analysis, it is found that the losses that must be minimized and handled are speed losses and setup and adjustment losses. This treatment proposal is carried out to reduce the risk of failure caused by dominant problems that have been identified using FMEA in Table 4.21 and Table 4.22.

A) Operator Training

The labour factor warrants significant attention because humans play a crucial role in the work system, contributing unique characteristics and abilities that can greatly impact the success of efforts to enhance the effectiveness of the Packaging Machine. Addressing the operator's training is a proposed solution to resolve the issue of waiting for maintenance to repair the machine. In this project, the primary root cause of delays in maintenance repairs is the operator's lack of knowledge in handling machine failures. To improve machine effectiveness, it is proposed to provide comprehensive training to operators, conducted by technicians, to equip them with the necessary skills and knowledge to manage machine failures effectively.

In implementing operators' training, training materials will be given on how to handle failures that apply at Automatic Blister Packaging Machine. The purpose of the given training program is to improve operator skills and provide training to overcome machine failures. This application solution can reduce the length of the breakdown period because operators can overcome breakdown problems on the machine. In addition, it can reduce the occurrence of errors made by repairs on the machine. To saving the costs, the training presented by the maintenance team can be filled in. The additional maintenance team understands this machine more. Figure 4.23 shows the checklist of the operator's training that consists of the flow chart of the program, procedure, and who is responsible for handle the task. The material recommendations that can be presented to the operator are:

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OPERATOR TRAINING

Automatic Blister Packaging Machine

Date:		Assigned Operator:	
Start Time:		Employee No:	

Flow Chart	Procedure	Responsibility	Doc./Ref
Operator	New operators are required to go through training to enhance their skills.	Line Leader	
Introduction to Machine	Technician shows the machine and also the introduction of components in Automatic Blister	Maintenance Department Line Leader	Machine Procedure
Introduction to Process Flow	Technician shows a process flow of the machine • Remind the operator of the safety precaution. • Crucial steps. • Tools involve	Maintenance Department	Training Manual
Training to Recognize abnormal behaviour of the machine	Technician shows how to recognize the abnormal situation of the machine from sound performance or vibration.	Maintenance Department	Training Manual
Training on How to Handle Minor Breakdown	Technician shows how to handle minor operator that happen in machine.	Maintenance Department	Training Manual

Figure 4.18: Operator Training Form

B) Standard Operating Procedure

Standard Operating Procedures (SOPs) are crucial documents that provide clear, consistent, and detailed instructions for performing routine tasks within organizations. By outlining step-by-step procedures, SOPs ensure tasks are completed uniformly, reducing errors, improving efficiency, and maintaining compliance with regulations. They serve as essential tools for training new employees, facilitating smooth operations, and enabling continuous improvement through regular updates and refinements to procedures based on evolving best practices and organizational needs. During this project, it is found that the operator has a difficulty to read current SOP since most of the operator that handle the machine are foreigner. To counter that problem, a SOP with figure is proposed to ensure that the SOP is effective for the operator. Figure 4.19 shows the new SOP proposed for Automatic Blister Machine.

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STANDARD OPERATING PROCEDURE

Automatic Blister Packaging Machine

Date:		Assigned Operator:	
Start Time:		Employee No:	

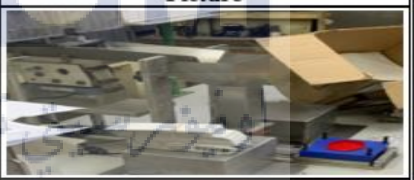
No.	Step	Action	Description	Picture
	Box Placement	Place the plastic box into the mold	Ensure the box is securely positioned within the mold to prevent misalignment.	
	Filling Alignment	Align mold with filler	Adjust the position so the filler can accurately fill the box.	
	Box Ejection	Push the filled box out of the mold	Carefully eject the box to avoid spilling or damaging the contents.	
	Needle Arrangement	Ensure the needle is filled neatly	Inspect the filled box to confirm that the contents are arranged correctly. Use the part in a circle to arrange the needle.	

Figure 4.19: Automatic Blister SOP

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

This chapter will discuss the conclusions of the entire research and recommendations. Furthermore, this chapter discusses all the objectives of this study that were determined at the beginning. As stated before, every objective has been achieved by implementing the OEE approach. Solutions are proposed to enhance machine effectiveness.

5.1 Conclusions

Objective 1 has been achieved which to study the current process flow of the packaging machine. This objective is completed by doing direct research on the company. Furthermore, the machine involved in this research is an Automatic Blister machine which only a few operators have experienced handling. It is also known that the technicians for this machine are limited which results in a delay to production. As a result, the maintenance process will prolong and affect the production. In addition, this machine is also the only machine available to pack straight pins needles.

Objective 2 of this research is to implement Overall Equipment Effectiveness at the machine involved which is the Automatic Blister Packaging Machine. The implementation is done by collecting data in the first place. After that, the data is processed to perform the OEE on the Automatic Blister Packaging Machine. Before the OEE can be calculated, three parameter values which are availability, performance, and quality need to be calculated first. Once the value of the three parameters is known, the OEE calculation is done.

From the OEE calculation performed, it is obtained that the average value of the calculation of the OEE of the Automatic Blister Packaging Machine is 79.64%. According to the OEE value standard that has been determined, the OEE value of Automatic Blister Packaging Machine falls into the medium category, where the value ranges from a percentage of 60% to 84%. In this category, the value of machinery in production work is considered reasonable and still has room for improvement to make production can reach world-class with an OEE value of 85%.

The third objectives of this research are to analyze the cause that contributes to low effectiveness and propose a solution. OEE for Automatic Blister Packaging Machine has not achieved the stand OEE which OEE for Automatic Blister Packaging Machine is 79.64%, and the OEE stand is 85%. The calculation and analysis of the six big losses performed to obtain the largest and most significant losses on the MCB Packaging Machine are Speed Losses of 48.15% and Setup and Adjustment Losses, which accounted for 39.16%.

In the fishbone diagram analysis with the problem of speed losses that arise, it is found that the factors that the speed losses are high because of inefficient handling method by the operator. The operator did not follow the Standard Operating Procedure due to a lack of understanding of the SOP. Operator like to perform the job according to their comfortable way which resulting in problem while performing the job. Operator age also affects the speed where older operators face a problem related to health which is back pain due to repeatedly doing awkward movements.

The factors are operators' lack of knowledge on how to handle minor problems on the machine. Not only that, there is no standard operating procedure if there is a failure on the Automatic Blister Packaging Machine and fewer technicians became another factor that contributed to this loss. Operators have zero knowledge of how to handle minor problems since the line leader only allows technician to handle them.

The first solution to propose to reduce both losses is operator training. It is very important for the operator to be involved in training, especially for the new operator. This solution involves maintenance department and line leader to train the operator so they will follow the right Standard Operating Procedure. Furthermore, the operator needs to be train on how to handle minor problem which do not require technician to handle it. By doing this, waiting time for the technician can be eliminated and prevent production from stopping for a long time.

The second solution proposed is providing an effective Standard Operating Procedure (SOP) for the operator. It is found that most of the operators face a problem where they are unable to understand the SOP since they have difficulties reading in other languages. So, by providing a better SOP, will make it easier to read and understand the SOP. plus, putting a figure in the SOP will ensure the process is followed correctly. They also can use figures in the SOP to check whether they perform the correct way or not. So, if the operator can read and understand the SOP correctly, many problems such as missing process steps can be avoided.

5.2 Recommendations

After conducting this project, there are some suggestions that are expected to be useful to the research company. It is hoped that this suggestion can attract attention to conduct research on OEE in the future. Here are some suggestions from this study:

a) Provide proper training to new operators to ensure they follow the correct SOP.
b) Train the operator to handle minor problems on the machine if the company does not plan to increase technicians in the future.
c) Update the Preventive Maintenance sheet for the packaging machine since some parts of the machine are no longer working to avoid confusion while checking the machine.
d) In the future, maintenance issues on the machine can be considered in terms of maintenance cost

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APPENDICES

Appendix **A**

No	Project Description	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
1	Brief on PSM															
2	Supervisor selection and PSM registration															
3	Literature review research															
4	Specifying research method															
5	Online meeting with company															
6	Visiting the company															
7	Find the problem															
8	Identify objective															
9	Project methodology															
10	Report progress															
11	Logbook submission															
12	Presentation															
13	Report format discussion															
14	Report preparation															
15	Submission report															

Appendix **B**

No	Project Description	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
1	Study machine flow process															
2	Six big losses analysis															
3	Critical problem identification															
4	FMEA approach															
5	Implement solution															
6	OEE evaluation															
7	Report progress to the supervisor															
8	Company presentation															
9	Project presentation															
10	PSM report draft															
11	Final report															
12	Logbook															

Appendix **C**

Prym CONSUMER MALAYSIA	LAPORAN OPERASI HARIAN	Type of Product:

Nama Operator	:	Item	:	Tarikh	:
		Kuantiti per carton	:	Shift	:
Mesin	:	Kuantiti per loose	:	Remarks	:

Masa		Target	Output	Reject	Catatan
Dari (AM / PM)	Hingga (AM / PM)				
7.00	8.00				
8.01	9.00				
9.01	10.00				
10.01	11.00				
11.01	12.00				
12.01	1.00				
1.01	2.00				
2.01	3.00				
3.01	4.00				
4.01	5.00				
5.01	6.00				
6.01	7.00				
7.01	8.00				

Pencapaian Harian			
Jumlah carton		carton	Disediakan Operator
Jumlah loose		loose	
Jumlah output		pieces	
Jumlah reject/ rework		pieces	
Jumlah scrap		pieces	Diperiksa
Jumlah masa operasi		jam/min	
Jumlah masa berhenti		jam/min	
Productivity		%	

Appendix **D**

PRYM CONSUMER MALAYSIA SDN BHD

OPERATOR TRAINING

Automatic Blister Packaging Machine

Date:		Assigned Operator:	
Start Time:		Employee No:	

Flow Chart	Procedure	Responsibility	Doc./Ref
Operator	New operators are required to go through training to enhance their skills.	Line Leader	
Introduction to Machine	Technician shows the machine and also the introduction of components in Automatic Blister	Maintenance Department Line Leader	Machine Procedure
Introduction to Process Flow	Technician shows a process flow of the machine • Remind the operator of the safety precaution. • Crucial steps. • Tools involve	Maintenance Department	Training Manual
Training to Recognize abnormal behaviour of the machine	Technician shows how to recognize the abnormal situation of the machine from sound performance or vibration.	Maintenance Department	Training Manual
Training on How to Handle Minor Breakdown	Technician shows how to handle minor operator that happen in machine.	Maintenance Department	Training Manual

Prepared by: Norhisyam bin Isa

Date: 11/3/2024

Appendix **E**

PRYM CONSUMER MALAYSIA SDN BHD

STANDARD OPERATING PROCEDURE

Automatic Blister Packaging Machine

Date:		Assigned Operator:	
Start Time:		Employee No:	

No.	Step	Action	Description	Picture
	Box Placement	Place the plastic box into the mold	Ensure the box is securely positioned within the mold to prevent misalignment.	
	Filling Alignment	Align mold with filler	Adjust the position so the filler can accurately fill the box.	
	Box Ejection	Push the filled box out of the mold	Carefully eject the box to avoid spilling or damaging the contents.	
	Needle Arrangement	Ensure the needle is filled neatly	Inspect the filled box to confirm that the contents are arranged correctly. Use the part in a circle to arrange the needle.	

Prepared by: Norhisyam bin Isa

Date: 11/3/2024