IMPLEMENTATION OF PREVENTIVE MAINTENANCE ON MILLING MACHINE AT UTeM MACHINING TECHNOLOGY LABORATORY

AMIR NAJMI BIN MHD NAZERI

BACHELOR OF MANUFACTURING ENGINEERING TECHNOLOGY WITH HONOURS

2024

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Industrial and Manufacturing Engineering Technology

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AMIR NAJMI BIN MHD NAZERI

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

Faculty of Industrial and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2024

DECLARATION

I declare that this Choose an item. entitled “ Implementation of Preventive Maintenance on Milling Machine at UteM Machining Technology Laboratory ” is the result of my own research except as cited in the references.

Signature :

Name : AMIR NAJMI BIN MHD NAZERI

Date : 10th January 2024

APPROVAL

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

Signature	:	
Supervisor Name	:	Professor Ts. Dr. Effendi Bin Mohamad
Date	:	10th January 2024

DEDICATION

To my beloved parents

Mhd Nazeri Bin Mhd Saman and Che Raziah Binti Che Omar, that

Always support, patience and sacrifices shared to me.

To my honoured supervisor

Professor Ts. Dr. Effendi Bin Mohamad

And all UteM lecturers.

Lastly, I would like to thank all people which contributes to my Bachelor Degree Project

for their comments and suggestions, and to my all friends that help me too.

ABSTRACT

Total preventive maintenance (TPM) is a lean manufacturing technique that focus on the improvement of the equipment reliability and condition. Prevention of machine breakdowns is the main issue that related to the preventive maintenance (PM). PM is among several tools of the TPM beside Kaizen, 5S and so on. PM is an important strategy used by many sectors and industries to fix irregularities and incidents before they arise, maintaining optimal operating efficiency and reliability. Healthcare is one the sector that use PM strategy in their daily management. The objective of this research is to study the current milling machine condition, to analyse the maintenance issues relate to milling machine and to propose preventive maintenance into milling machine. The first step is to know the condition of the machine by go through the checklist existed and interview the personal that supervise the laboratory. Next, doing the early cleaning and eliminate the source of contamination that will congest the machine and by the time will affect the machine ability to do the operation. Lastly, form the data collected, the implementation of the fuguai tag and schedule checklist will help the prevention of the machine breakdowns. This study is focus within the Machining Technology Laboratory at Universiti Teknikal Malaysia Melaka (UTeM). The primary area of study is on the milling machine. The main method to execute this study is by know the current machine condition, analyse the step of the preventive maintenance, and find the solution in getting the high reliability of the machine. By implementing all three methods, there are 3 machines that having a breakdown, 4 need are regular maintenance and remaining eight machine that are on the good condition. This machine been tagged with three different colours of the fuguai tag that differentiate by the degree of their condition. The checklist also will help the personal to do the schedule and regular maintenance activities in this laboratory. This will help the personal in charge to detect any early sign of breakdowns and to know which machine need to be prioritise first. As conclusion, this method helps the machine from getting worst and having an issue that will affect the reliability of itself.

ABSTRAK

Penyelenggaraan secara menyeluruh adalah pembuatan bersandar yang memberi tumpuan dalam menambah baik keupayaan sesuatu mesin. Pencegahan mesin daripada rosak adalah tumpuan utama dalam penyelengaraan pencegahan. Penyelenggaraan pencegahan adalah salah satu alat penyelenggaraan secara menyeluruh di samping Kaizen, 5S dan banyak lagi. Penyelenggaraan pencegahan adalah langkah yang penting dalam pelbagai sektor dan industri untuk membaik pulih sebarang masalah dan kemalangan sebelum bertambah teruk, dan mengekalkan kebolehan mesin pada tahap tertinggi. Sektor kesihatan adalah salah satu contoh sektor yang menggunakan penyelenggaraan pencegahan di dalam pengurusan mereka. Tujuan penyelidikan ini adalah untuk mengkaji keberadaan mesin pengisar, untuk menganalisis isu yang berkait dengan mesin pengisar dan mengamalkan penyelenggaraan pencegahan terhadap mesin pengisar. Langkah pertama untuk mengenal pasti keadaan mesin adalah melalui senarai semak yang tersedia dan menemu bual individu yang menjaga makmal itu. Seterusnya, melakukan pembersihan awal dan menyikirkan sumber masalah mesin dari masa ke masa yang akan menggangu kebolehan mesin itu untuk beroperasi. Akhir sekali, dari maklumat terkumpul, penggunaan tandaan fuguai and senarai semak akan membantu mencegah mesin daripada rosak. Kajian ini tertumpu dalam Makmal Teknologi Permesinan di Universiti Teknikal Malaysia Melaka. Kawasan utama kajian ini adalah terhadap mesin pengisar. Langkah utama dalam menjalankan kajian ini adalah dengan mengetahui keadaan semasa mesin, menganalisa langkah pencegahan and mencari solusi dalam mengekalkan kebolehan mesin untuk beroperasi. Dengan mengamalkan ketiga tiga langkah ini, terdapat tiga mesin yang rosak, empat yang memerlukan perhatian dan lapan lagi mesin dalam keadaan yang bagus. Mesin ini dilabel dengan tiga label yang berbeza yang dibezakan dengan tahap keadaan mesin itu. Senarai semak juga membantu individu yang terlibat untuk melakukan pencegahan secara berjadual dan kerap di dalam makmal. Ini akan membantu individu bertugas untuk mengenal pasti tanda-tanda keroskan dan mesin mana yang harus diutamakan. Konklusinya,langkah ini membantu mesin daripada bertambah teruk dan mengalami isu yang akan menggangu ketahanannya.

ACKNOWLEDGEMENTS

I am immensely grateful to the following individuals and organizations for their invaluable support and assistance throughout the conclusion of my bachelor's degree assignment: Prior to anything else, I'd like to thank my superior, Professor Ts. Dr. Effendi bin Mohamad, for his guidance, encouragement, and unwavering support. Their insight and expertise were instrumental in determining the direction of this endeavor. I am exceedingly grateful for their dedication and determination. The FTKIP faculty at Universiti Teknikal Malaysia Melaka (UTeM) provided me with invaluable instruction and direction.

Their passion for their respective fields of study has inspired me and increased my understanding of the topic. I am grateful to my coworkers and acquaintances for their mutual support and for cultivating a collaborative environment in which we were able to share ideas and assist one another throughout the duration of the project. Their friendship and support have increased the value of this journey. I appreciate the assistance of the Perpustakaan Laman Hikmah staff in locating relevant research materials and resources. Their promptness and willingness to help have been extraordinarily beneficial. I am indebted to the participants who volunteered their time and helped collect data for this study. This research would have been impossible without their participation.

Finally, I would like to express my gratitude to my family for their unwavering love, tolerance, and support. Their unwavering confidence and support have motivated and inspired me throughout my academic career. Everyone who contributed to the completion of this bachelor's degree project has my deepest gratitude. Your encouragement and support have been invaluable, and I am privileged to have worked with such extraordinary people.

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LIST OF SYMBOLS AND ABBREVIATIONS

BMIW	-	BACHELOR ENGINEERING TECHNOLOGY MANUFACTURING
PM	-	PREVENTIVE MAINTENANCE
QR	-	QUICK RESPONSE
TPS	-	TOYOTA PRODUCTION SYSTEM
LMS	-	LEAN MANUFACTURING SYSTEM
VSM	-	VISUAL STREAM MAPPING
SMED	-	SINGLE MINUTE EXCHANGE
JIT	-	JUST IN TIME
TPM	-	TOTAL PREVENTIVE MAINTENANCE
LM	-	LEAN MANUFACTURING

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter wrote the background of the problem statement and objectives to be achieved through the study. This chapter also provides a structure of the report that will describe generally chapter division and related content.

1.2 Backgorund of study

Total Productive Maintenance (TPM) is a lean manufacturing technique that concentrates on improving the overall equipment effectiveness of a machine which is used for production (Suryaprakash et al., 2019). The TPM framework emphasizes the importance of machine availability, emphasizing the need for continuous and efficient operation. TPM attempts to reduce downtime and increase the amount of time machines are available for usage or operation. Equipment inspections, precise measurements, partial or total overhauls at predetermined intervals, oil changes, lubrication, and other daily tasks fall under this category. Workers also keep track of equipment breakdown so they may replace, or fix worn out parts before problems develop. An important operating issue is maintenance. PM costs must be kept to a minimum while costly failures and overhauls are avoided. This should take into account the issue of choosing the frequency of PM interventions, where the ideal frequency reduces the cost of both PM and the negative effects of deterioration, such as failures or overhauls. The majority of the present work makes the assumption that preventative maintenance returns the system to an ideal condition. However, in practice upkeep is frequently not ideal.

In the literature, several maintenance impacts have been investigated, from maintenance that returns the system to a perfect state to maintenance that worsens the status of the system (Wang and Pham, 2006). Therefore, creating maintenance guidelines that take into account unsatisfactory maintenance is a crucial research issue. According to the condition of the machine or its characteristics, maintenance is optimized under the condition-based maintenance policy (Alaswad and Xiang, 2017). Recent techniques to predictive maintenance, which decide on the right maintenance treatments by learning a prediction model from data (Swanson, 2001), are particularly pertinent to our work.

A popular strategy is to use the machine's features to anticipate its health and perform maintenance only when a degradation threshold is achieved. This is accomplished by keeping track of the machine's health and utilizing a data-driven model to foretell when a failure is likely to occur. An intervention can be planned to prevent failure when the perceived risk is too great, such as when it exceeds a degradation threshold. The disadvantage of condition-based techniques is that they merely forecast the asset's deterioration and do not take PM's influence on this depreciation into account.

The best time to do maintenance and address the deterioration may not coincide with the period when the deterioration threshold is achieved, and PM is planned. In a perfect world, maintenance would take place when it would be most beneficial to reduce the likelihood of the asset failing rather than right before it does. To this purpose, it is crucial to calculate the asset's risk rate as a result of a specific PM frequency, and this is precisely what our method does.

1.3 Problem Statement

Preventive Maintenance (PM) is an important strategy used by many sectors and industries to fix irregularities and incidents before they arise, maintaining optimal operating efficiency and reliability. Aside from the manufacturing industry, the healthcare sector is a notable example of an industry that places a strong focus on the PM approach, employing methodologies such as 5S and Kaizen to improve the management and care of equipment and facilities.

Among the lean tools adopted and used in the service industry, particularly healthcare, the 5S and Kaizen are among the most well-known and widely used, as proposed in a study by (Emerson G,2012). The 5S acronym is derived from the Japanese terms seiri, seiton, seiso, seiketsu, and shitsuke. Since 2008, countries such as Australia, Canada, Germany, the Netherlands, New Zealand, the United Kingdom of Great Britain and Northern Ireland, and the United States of America have been involved in high 5S projects. Meanwhile, Kaizen is a Japanese word that means "change for the better," and it refers to a philosophy or set of practices that focuses on the continual improvement of processes in manufacturing, engineering, and business management. Kaizen strives to eliminate waste by improving standardized activities and processes.

The goal of this effort is to provide a solution for prescribing an asset's PM frequency in order to reduce the expenses associated with overhauls, failures, and PM. The two sorts of events that planned PM seeks to avoid are overhauls and failures. The first type, called overhauls, involves extensive, unscheduled maintenance activities during which significant portions of the equipment must be replaced. The second, unexpected machine breakdowns, requires immediate maintenance since the equipment must be shut down while corrective maintenance is performed.

Assigning various PM frequencies to a group of (similar) machines and comparing the results would be the ideal way to estimate maintenance impacts in a randomized controlled experiment (Rubin, 1974). However, in reality, this strategy may be impractically expensive, impractical, or even unethical (for instance, when taking into account hospital life support systems). It would typically be difficult to randomly assign different PM frequencies to different machines in maintenance since doing so could put the machines' minimal service levels at risk. When randomized controlled trials cannot be performed, historical observational data of machines and their upkeep must be used to determine the effects of various PM frequencies.

1.4 Research Objective

To achieve the research aim, three research objectives were formulated, which include:

i) To study the current milling machine condition

ii) To analyse the maintenance issues relate to miiling machine

iii) To propose preventive maintenance into the milling machine

1.5 Scope of Project

This research is specifically dedicated to exploring the practical application of Preventive Maintenance (PM) within the Machining Technology Laboratory at Universiti Teknikal Malaysia Melaka (UTeM). The Machining Technology Laboratory, among various laboratories, has been identified as a focal point for investigation. The primary objective of incorporating PM in this laboratory is to optimize the operational efficiency and longevity of machining equipment, ensuring a reliable and well-maintained environment for student use.

The focus of this study will centre on the milling machine as the designated area of implementation within the laboratory. The milling machine is a critical component of the machining processes taught to students at UTeM. Implementing PM in this context aims to proactively monitor, assess, and address potential issues in the milling machine's functionality. By doing so, it ensures that the machine remains in optimal operating condition, minimizing unplanned downtime and enhancing the overall learning experience for students.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Lean manufacturing has been perfected by Toyota Production System (TPS) and a huge number of companies in developed countries followed suit for their performance improvements. However, it takes human dedication and perseverance to combine various tools and processes into a system-whole. The outcomes are frequently quite amusing.

Today, every factory aims to cut production costs without sacrificing quality and wants to do so as quickly as feasible. A well-designed lean manufacturing system (LMS) combines a number of techniques for getting rid of wastes that are frequently present on shop floors to achieve these objectives. Users may recognize and understand value from both the producer's and consumer's points of view thanks to lean manufacturing. In order to identify waste and minimize or eliminate it, it includes looking at the flow of information or materials required to make a certain product or a group of products. (Zhou B,2016). Any form of production floor can use LMS. It is both a process and a philosophy. Value stream mapping (VSM), one-point lessons (OPL), single minute exchange of dies (SMED), 5S, kaizen, just-in-time inventory (JIT), and kanban are just a few of the adaptable tools and methods used in its applied process. These have been widely employed in a variety of production contexts. Lean manufacturing is a soft technology that takes into account computing, qualitative, and quantitative methods to show a commitment to ongoing improvement. Thus, a lean system can be used in both the industrial and service sectors. (M. Shahin, 2020).

Lean manufacturing has been widely applied in several industries, as said, and it has its roots in the Toyota Production System (TPS).(Diego Fernando and Rivera Cadavid, 2007). They do so because it provides a chance to obtain a competitive advantage. It's an integrated system where an organization puts all of its ingenuity and effort into maximizing the elements that matter to the customer. Businesses who effectively implemented LMS saw improvements in lead time, customer satisfaction, work-in- process, productivity, and delivery time.

Implementing lean manufacturing critically depends on a number of key principles. Toyota Motor Company in Japan pioneered the first application of lean manufacturing as "only-on- time" in the name of a just-in-time (JIT) management concept in the early 1970s. (Nasrfard et al., 2023). It was incredibly successful in reducing waste and inventory. (Noori H, 1995). Waste is defined in TPS to include every stage of production and assembly. The success of Toyota quickly became known worldwide, and lean manufacturing techniques were applied outside of American boundaries as well. However, "The Machine that Changed the World" (Womack, 1992) is where the concept of lean was originally introduced.

Lean manufacturing is a process that uses less of everything to produce goods and services of the same quality as the traditional method. (Wolf, 1991) Lean emphasizes pull demand rather than typical market push, resulting in productivity that considers quality in all aspects and is as quick with less expensive cost by increasing the efficiency of the process. (Antony J, 2011). Thus, the most talked-about topic right now in emerging nations is lean manufacturing.(Rahman et al., 2013). Lean thinking can be thought of as the customer value discoverer's tool. It can be used in a wide range of industries, from manufacturing to services, large-scale production to low-volume production, and labor-based industries to tech giants. (Bhamu J, 2014).

The implementation of lean concepts throughout the entire supply chain system has received good attention in the process industries over the past ten years in an effort to increase competitiveness in the modern market (Melton, 2005). Lean's basic principle is the ability to adjust any motivating element, minimize waste, and ensure the quality of the produced good or service (Motwani J, 2003). It is renowned for minimizing wastes and nonvalue-added tasks while utilizing the fewest resources possible (Nasrfard et al., 2023). Because there will always be significant differences in personnel management, floor plan, machine types, and process information flow, choosing to implement lean manufacturing can be challenging (Detty B, 2000). Lean has eventually received a lot of attention in recent academic studies (Pettersen J, 2009) and has emerged as a paradigm for manufacturing firms (Kumar et al., 2022).

2.2 Lean Manufacturing Principles

Short development cycles and progressively decreasing batch sizes are characteristics of assembly work, despite the fact that the number of product categories and model types is still increasing. Prior to these requirements, there is constant demand to reduce production lead times, which makes the mix challenging for all producers—even the most innovative ones. The capacity to respond fast calls for the use of production systems that can be reconfigured and expanded as needed on the fly as well as advancements in assembly techniques without the need for an initial output outdated expenditure (Aly W, 2014).

Lean manufacturing is a method that mainly relies on adaptability and flexibility. An excellent place to start for firms looking to reevaluate their current production methods is the organization of the workplace. Since they reduce the need for large capital expenditures on specific machinery up until the point of complete automation, lean techniques are also worthwhile to research. Lean manufacturing is in reality a significant shift from the infamous computerized factory of recent years. The expression "less is better" A wide-ranging, startlingly uncluttered environment that is precisely matched to the requirements of the environment maker results from manufacturing policy. In contrast to batch production for inventory, goods are created in response to the specifications of the client one at a time. The target is to only generate the amount used not more than that.

The quantity of parts produced, the ability to modify the methods, the suitability for handling different components, and the full utilization of personnel, services, and floor space. Therefore, hand assembly cells are better than automated ones due to their inherent adaptability. The lean work cell and the components that make up a lean work cell must meet this maximum required flexibility. Admittedly, there are other ways to solve production-related problems outside the lean approach. However, it does offer a degree of adaptability that makes it a suitable choice for more complicated assembly goods.

Table 1 Lean principles

Lean principles	Explanation
Continuous flow	A U-shaped work cell is created using the lean work cell. Each subprocess has connections to the following in order of technique. And a worker within the U is required to transport the workpiece or one-piece assembly to the following workstation (Diego Fernando and Rivera Cadavid, 2007)
Simplicity	Valuable floor space can be saved by correctly sizing workstations machines, and the implementation of uniform machine bases or workstations for all processes, while tempting for the sake of conformity and standardization, should be avoided (Morteza G,2018)
Workplace organization	Using a specific ideal holder for each instrument with an integrated tool holder mechanism. If holders can be readily added to or removed from a workstation, this increases the workstation's adaptability and improves its value in a lean manufacturing process (Jerry K,2003)
Parts presentation	Every part should be provided to each workstation from outside the work cell. The lean work-cell's streamlined design is suited to the usage of gravity feed conveyers or bins.
Reconfigurability	A correctly constructed lean work cell must be simple to reconfigure. In reality, the ability to change the process and move quickly from one good item to another is essential. The faster the switch, the less manufacturing time is lost. Strong quick-change fixtures make switching possible in a couple of seconds (Leskova A,2013)

2.2.1 Lean Manufacturing Tools

Choosing the right LM tools saves time and may improve efficiency by reducing or eliminating waste and boosting performance metrics. It also assists companies in achieving long-term success by avoiding negative environmental consequences and saving money, water, energy, and raw resources. Furthermore, it promotes the health and safety of communities, employees, and consumers in the industrial industries. However, not every LM tool produces the same results, and not every firm may benefit from them.

2.2.1.1 Total Preventive Maintenance (TPM)

TPM is a maintenance strategy that increases equipment efficiency, prevents failures, and encourages autonomous maintenance by operators through regular operations involving the entire workforce (Bhadury, 2000). According to (Singh et al., 2020), TPM includes a potent organised method to changing employees' mindsets, which then results in a noticeable change in the workplace culture of an organisation.

2.2.1.2 Just in Time (JIT)

JIT manufacturing is the main production method used to improve production competitiveness by reducing inventory and lead times. Implementing just-in-time manufacturing poses several challenges, including effective, frequent, and real-time information sharing and communication among different functional departments, as well as responsive action for adjusting the production plan in response to a constantly changing manufacturing situation.

2.2.1.3 Kaizen

The underlying organizational idea, known as Kaizen, is to enhance the amount of work that adds value and reduce waste through continuous improvement. The secret to ongoing change is making modest adjustments and never-ending efforts. The biggest benefits of using kaizen are increased productivity, quality, and efficiency as well as cheaper costs, the elimination of waste, workplace safety, etc (Peng et al., 2022).

2.2.1.4 Kanban

In order to implement customer pull manufacturing, kanban is a technology that encourages a continuous material flow with waste-free procedures while keeping a pre-defined inventory level to guarantee continuous material supply (Plakhotnik and Lauwers, 2012).Different Kanban cards are made in response to a specific client demand to indicate necessary manufacturing operations and to start the replenishment of raw materials, inventory, dies, etc.

2.2.1.5 5S

Sort, Set in Order, Shine, Standardize, and Sustain are the five terms that make up the "5S" approach of office organization. These words all start with the letter S. These five elements outline how to keep the new arrangement and store objects. Employees talk about standardization while making choices, which will help everyone understand how things are done. Each employee will feel invested in the process by doing this. 5S goals are:

- To lower waste
- To enhance variant
- To increase productivity

Table 2 5S

Sort	In the work area, everything was organised. They began by classifying what is necessary for production and what is not. Those that are unnecessary for the workspace or have no use must be eliminated right away.
Set in order	The location of each item is covered in the set. Each object should be put such that it is easily accessible to all people and that everyone is aware of its location. Colour coding and product labelling were two techniques used to help all personnel recognise the goods.
Shine	Every day, the work area should be maintained physically clean. Employees should also inspect the workspace to ensure that everything is arranged correctly; if something is misplaced, it may be fixed right away.
Standardized	Worker should follow the given process or instructions and not divert in some other way
Sustain	Make a habit of 4 step early and improve them.

2.2.1.6 Visual Stream Mapping (VSM)

VSM is a method of analysis that allows all of a process's knowledge flows to be specified and visualized in a synthetic manner. The employment of standardized symbols and a definition that, while not complete, must stay at a macroscopic stage is likely to be an unreal and visual aspect. Many bits of understanding are common in flow mapping:

I. Mutual representation of fundamental and information flows.

II. In addition to the other pure development stages, the trips and stock phases are included.

III. The identification of significant volume statistics for each phase.

IV. The cumulative time line is calculated by supplying the processing times and the periods between operations.

V. Recognizing the difficulties.

Any organization embarking on a lean journey must conduct value stream mapping (Suryaprakash et al., 2019). The value streaming mapping is a crucial tool for process planning, execution, and improvement. The flow diagram that VSM generates is utilized by organizations to record each process. By using lean technologies, it is possible to decrease the process bottlenecks that VSM highlights. A future state value stream mapping was then created.

VSM's goal is to identify any non-value-added operations that customers are unwilling to pay for. the present situation VSM offers current process analysis for data such as client demand, process cycle times, working hours, planned downtimes, inventory information, uptime duration, and availability.

2.2.1.7 Poka Yoke

Techniques that assist operators in avoiding errors in their work that result from selecting the incorrect part, omitting a part, installing a part incorrectly, etc. A device with physical forms that prevent pieces from being installed in any orientation other than the proper orientation is an example of error proofing.

2.2.1.8 5 Why

Sakichi Toyoda would have created the "five whys" Lean system. It is one of the important ways Toyota use to tackle challenges. The aim is to assess the problem before determining the root reason or causes, rather than stopping at the initial source of a problem.

2.3 Types of waste in manufacturing

Lean manufacturing seeks to eliminate waste from the production process. Before clearing, it is crucial to determine the eight waste. Waste is any unnecessary procedure that lowers the value of the product and that the consumer does not want to pay for. Waste is the least expensive action or activity that does not increase the cost of the product. The first seven forms of garbage, known as Muda (Pingyu Y, 2010) in Japan, were named by Taiichi Ohno. Taiichi Ohno defined seven different categories of waste: transportation, inventory, movement, waiting, overproduction, overprocessing, and defects.

2.3.1 Overproduction

Overproduction occurs when an industry product produces more than is required, affecting the overall system. Manufacturing items in advance or in excess of demand wastes money, time, and space, resulting in a loss to the manufacturer.

2.3.2 Waiting

According to some findings, almost 99% of a product's manufacturing time is spent waiting. This involves waiting for a job, planning, ordering, machine accessories, email, and so forth. When one process waits to begin while another finishes, time is lost, and the process becomes ineffective, disrupting the smooth and continuous flow of operation.

2.3.3 Transportation

It is a waste of time and money to transport things from one workplace to another. This involves moving tools, machine components, and machine accessories from one location to another. These are non-value-added operations that are expensive. In addition, excessive movement causes fatigue, wear and tear of product and equipment (Hariyani et al., 2023).

2.3.4 Overprocessing

It is described as going above and beyond what the consumer wants. In brief, produce more than is required. It produces more waste in terms of labor, materials, personnel, and assets. Always, produce product per requirement and try to reduce the unnecessary operations and manufactured quantities where it is required (Chahal V, 2017)

2.3.5 Inventory waste

Inventory waste is inventory that is sitting around unused and waiting to be used. The most crucial thing to understand is that inventory might be in the form of completed items as well as raw materials.

2.3.6 Defect

To remove flaws in the manufacturing process, lean manufacturing employs a number of processes. They function as industrial rules, resulting in poor quality and consumer dissatisfaction as well as a decrease in market value and reliability, resulting in decreased sales and price of the product. The flaw should not arise again and again. Due to defective product or material it will loss of money and defective will not be reused (Dixit A, 2017).

2.3.7 Movement

Waste of motion refers to any movement of people or equipment that does not add value to a product or service. Workplace planning should be done in such a way that motion waste is minimized. Some of the sources of motion waste are poor workstation layout, poor method design transferring parts from one hand to another, large batch sizes and reorientation of materials. Tool place material is place near machinery in well-organized manner (Chahal V, 2017).

2.4 Total Preventive Maintenance (TPM)

TPM is one of the most significant because it assists businesses in reducing waste, such as breakdowns and unscheduled work, and it stimulates the formulation of production plans that avoid machine overload. TPM may also be characterized as a method for rapidly improving production processes via employee participation and empowerment. In today's volatile and uncertain global business climate, well-managed organizations aspire to increase their capabilities by running economically; in other words, TPM is a tool that, when properly applied, may assist firms in achieving this goal.

Reactive maintenance, preventive maintenance, predictive maintenance, and proactive maintenance are the three types of maintenance mentioned in TPM (Nakajima. S, 1988). Reactive maintenance, often known as firefighting, is maintenance carried out in the wake of an equipment failure. Preventive maintenance is defined as maintenance carried out at regular intervals over time, whereas predictive maintenance is defined as maintenance carried out in response to monitored equipment conditions. Proactive maintenance is maintenance carried out in response to root cause failure investigation.

TPM addresses six different waste categories, which are referred to as losses because they show equipment efficiency that has been lost. These six major losses are divided into three categories: speed losses, defect losses, and downtime losses. Losses due to speed, defects, and downtime, on the other hand, result in performance and quality losses, respectively. Equipment failures, setup and adjustment errors, idle time and minor shutdowns, reduced speed operation, scrap and rework errors, and start-up losses are the six major losses. The seventh loss, cutting blade losses, is explained by modern TPM.

Implementing TPM means working towards a vision of the ideal manufacturing environment, a situation in which there are zero breakdowns, faults, abnormalities, and accidents. Continuous improvement, involving everyone in the organization—from the operators to the top management is the only way to reach this ideal state. It makes sense to concentrate on this gap and seek out solutions if there is one between the current procedure and the ideal condition. To increase the efficiency of the machine, TPM focuses on the machine's six major losses, or gaps. One can improve the proper things and target the losses they wish to stop by using a number that counts the six biggest losses.

Additionally, the output of the machine allows us to determine what else might have come out and where efficiency was lost. A straightforward yet effective measurement technique is provided by overall equipment effectiveness (Braglia M, 2008) to provide insight into what is actually taking place. OEE is the result of three rates: availability rate, performance rate, and quality rate. The availability rate compares the actual running time of the equipment to the potential running time; the performance rate compares the actual running time to the potential running time at the equipment's designed speed; and the quality rate is the ratio of the number of high-quality products produced to the total number of products produced.

TPM essentially consists of five fundamental components (Singh et al., 2020). They are Maintenance Prevention, Small Group Kaizen Activities, Operator Self-Maintenance, Conduct Planned Maintenance, and Education and Training.

The steps in putting TPM into practice are as follows: choose the pilot area, get the equipment back in top operational condition, start measuring OEE, deal with major losses, adopt proactive maintenance methods and sustain improvement. Everyone in the organization, from top management to operators, must participate in the implementation of TPM.

2.4.1 8 pillars of TPM

The eight pillars of TPM is a system for maximizing production effectiveness and efficiency. The concept of Total Productive Maintenance (TPM) is based on the Eight Pillars, which create a systematic approach to maximizing production effectiveness and efficiency in a manufacturing setting. These pillars are intended to establish a holistic and proactive maintenance culture and serve as the guiding principles for implementing TPM methods. The first pillar, Autonomous Maintenance, promotes operators to take ownership of everyday tasks such as cleaning, lubricating, and basic maintenance, allowing them to directly contribute to machine reliability. The second pillar, Focused Improvement, is targeted efforts to address and eliminate losses in the manufacturing process, developing an attitude of continuous improvement.

The third pillar, Planned Maintenance, emphasizes scheduled maintenance efforts to prevent unexpected breakdowns and maximize equipment performance. The fourth pillar, Quality Maintenance, combines quality management with maintenance techniques to ensure that manufacturing processes continually fulfill quality standards. The fifth pillar, Training and Education, emphasizes the necessity of developing a trained and informed workforce to enable personnel to more successfully operate and maintain machines.

Early Equipment Management, the sixth pillar, focuses on including maintenance issues early in the design phase of new equipment, with the goal of improving total equipment effectiveness from the start. Office TPM, the seventh pillar, extends TPM principles beyond the work floor to administrative and support operations, encouraging a holistic approach to efficiency. Finally, the eighth pillar, Safety, Health, and Environment (SHE) Management, incorporates safety and environmental considerations into TPM procedures, assuring a comprehensive approach to production that prioritizes both employee and environmental well-being. These Eight Pillars, when combined, form an organized and interconnected framework that enables firms to optimize production processes, reduce downtime, and improve overall operational effectiveness and efficiency.

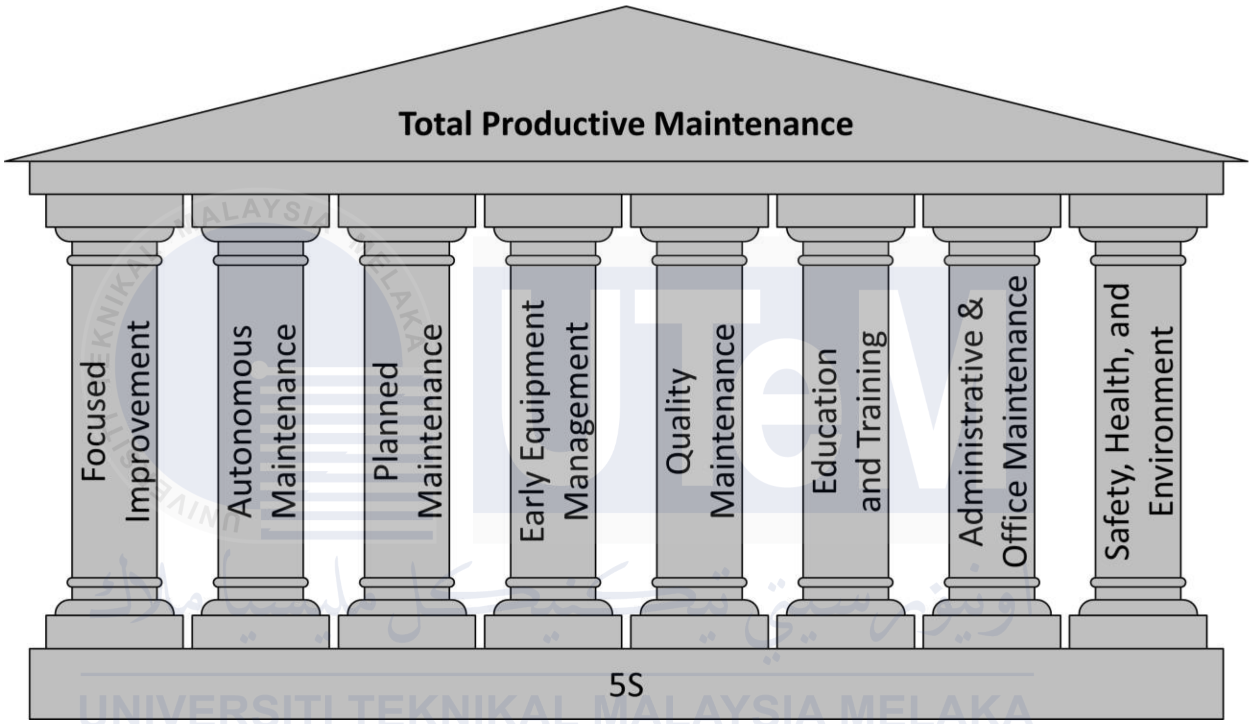


Figure 1 TPM pillars

2.5 Preventive maintenance (PM)

Preventive maintenance (PM) is described as a series of operations conducted at specific points in a planning horizon to extend the life cycle of equipment, keep it in good operating order, and boost overall system dependability and availability. These operations are part of maintenance programs and are designed to reduce the risk of unplanned equipment downtime. Inspection, cleaning, lubrication, adjustment, alignment, and component replacement for machines and tools in a manufacturing process are all part of PM.

These jobs are critical in any manufacturing process because they keep equipment running at the required long-term standards. Furthermore, PM has a beneficial influence on cost, quality, and delivery performance since it reduces quality expenses by maintaining equipment in good working order through regular maintenance programs that ensure a high proportion of compliant goods.

There have been studies that show the relevance of PM in production systems. An connection between the cost of PM and better machinery reliability, as well as a strategy to link PM program activities with batch size for production lines in order to minimize time wasted due to maintenance stoppages. Product quality is not the responsibility of a single department, but preventative maintenance, calibration, and changes in machinery and equipment are necessary to ensure goods meet client criteria.All of the above show the significance of PM as a work culture emphasis for machinery conservation, which has industrial and academic appeal.

2.6 Fuguai Mapping

PM is a crucial aspect of ensuring the efficient and reliable operation of machinery and equipment. In the context of fuguai tagging, where "fuguai" translates to contamination or abnormalities in Japanese, a specialized approach known as fuguai mapping is employed. Fuguai mapping is a sophisticated machine mapping technique designed to identify and differentiate areas of abnormalities within a selected machine. This proactive strategy allows maintenance teams to focus their attention on specific regions or components that may be prone to issues, enabling them to address potential problems before they escalate.

By utilizing advanced technologies, fuguai mapping creates a detailed and precise map of the machine, highlighting areas that deviate from the norm. This targeted approach not only enhances the effectiveness of preventive maintenance but also minimizes downtime, increases operational efficiency, and prolongs the lifespan of the equipment. In essence, fuguai tagging through mapping empowers maintenance teams to stay ahead of potential issues, fostering a proactive and comprehensive maintenance strategy.

2.7 Milling Machine

Milling is a process in which material is removed by a rotated cutting tool (Plakhotnik and Lauwers, 2012). The terminology for cutting instruments in English, such as mill cutter, mill, and milling tool, are closely related to the name of the procedure. These phrases may also include additional adjectives that describe the mill cutter's shape, although they all generally relate to rotary cutters with flutes and sharp edges. There are many types of milling operations, which can be distinguished into three groups according to the orientation of a tool relative to a workpiece. The simplest method is three axis milling, where a cutter's orientation in relation to a workpiece always stays the same. The second technique is referred to as 3 + 2 milling, also termed indexed milling or multi-sided milling. A cutter may be supposed to carry out a series of three axis milling operations while the operations are associated with different tool orientations during 3 + 2 milling.

Figure 2 Milling machine parts

2.7.1 Milling Machine Parts

Table 3 Miiling machine parts

Parts	Function
Base	Lowermost part to support the machine
Column	Ribbed inside and houses all the driving instruments for the shaft and table feed
Knee	House the feed system of the table and various control to work it.
Power feed mechanism	Use to control the longitudinal, transverse and vertical feeds
Saddle	Support the table and providing the motion in the X and Y axes by means of lead screw.
Table	Present on the top of the saddle and moved along X axes. Contains several T slot for the mounting of work piece or clamping jig and fixtures
Spindle	Hollow shaft that is use to hold and drives the cutting tools. The face of spindle that lies near to the table has an internal taper machined on it.
Over arm	Slides on top of the column
Arbor	Has an oil reservoir that lubricates the bearing surfaces. Prevent the spring of outer end of the arbor during cutting operations. Also help in aligning the outer end of the arbor with spindle.
Ram	Processing head is connected can be situated ahead and in reverse along the slide route on the highest point of the section.

2.7.2 Type of milling cutter

Table 4 Type of milling cutter

Type of cutters	Attributes or function
Plain cutters	To cut with the side only. Have straight or helical teeth.
End mill	Also known as HSS cutting tolls with three or more flutes.
Face mill	Consists of a butter body that is designed to hold multiple disposable carbide or ceramic tips.
Hollow mills	Use in screw machines. Cutting teeth are available inside of the surfaces.
Face slotting	Generally two fluted cutters that are designed to cut on their end as well as the flutes.
Double or equal angle cutter	Have V- shaped teeth with both conical surfaces at an angle to their end faces.

2.7.3 Method of milling

2.7.3.1 Up milling

iv) Conventional milling is another name for up milling.

v) The cutter rotates in the opposite direction to the feed motion during an up milling operation.

vi) The feed motion will go in a rightward direction if the cutter spins in a clockwise orientation.

vii) The chip thickness is thinnest at the start of the cut and thickest at the finish.

viii) Slicing power varies from zero to the highest value.

2.7.3.2 Down milling

ix) Another name is climb milling.

x) When down milling, the work piece is cut in a clockwise direction from right to left by the cutter.

xi) The chip thickness is greatest at the beginning of the cut and lowest at the conclusion.

xii) Less friction is involved, which results in less heat being produced on the cutter and work piece's contact surface.

2.8 Journal comparison

Table 5 Journal comparison

No	Title	Finding	Notable features	Reference
1	Understanding Learning Intention Complexities in Lean Manufacturing Training for Innovation on the Production Floor	Lean manufacturing introduction	TPS history	(García Márquez and Segovia Ramirez, 2020)
2	Sustainability metrics and a hybrid decision making model for selecting lean manufacturing tools	Lean manufacturing tools	VSM	(Naeemah and Wong, 2023)
3	Implementing lean manufacturing for improvement of operational performance in a labelling and packaging plant	Kanban tools	Manufacturing management	(Habib et al., 2023)
4	Lean manufacturing techniques and its implementation	Lean manufacturing functions	Two pillars of lean manufacturing	(Hines P,2013)
5	Improvement of warehouse logistic based on the introduction of lean manufacturing principles	Reduction of maintenance costs	Issues associated with the development of Coca Cola in Russia	(Prasanth N,2016)

			optimization program	
6	The role of Managerial Commitment and TPM Implementation Strategies in Productivity Benefits	Prevention of machine overload	Current industrial scenarios that involves many waste and lack of operator skills	(Pettersen, 2009)
7	Machine Learning Framework for Predictive Maintenance	Predictive maintenance explanation	Artificial intelligent involvement in manufacturing	(Hassan S, 2018)
8	Optimizing the preventive maintenance frequency with casual machine learning	Background study of the report	PM to avoid asset overhauls and failures.	(Rosmaini Ahmad, 2012)
9	Improvement of overall equipment effectiveness of machining centre using TPM	TPM explanation	Overall Equipment Effectiveness	(Braglia M, 2008)
10	Machine Learning Framework for Predictive Maintenance in Milling	Importance of operators skill and knowledge	IoT and machine learning methods	(Badshah S, 2018)

11	Real time integrated production scheduling and maintenance-planning in a flexible job shop with machine deterioration and condition-based maintenance	Importance of planning and scheduling	Increasing limits on rescheduling times will increase cost saving	(Huimin Ma, 2015)
12	Analysing the frictional properties of micro dimpled surface created by milling machine under lubricated condition	Importance of lubrication	More dimples creates from milling machines capable of friction reduction	(Peric S,2012)

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the research clearly defines the method use to conduct for study. This methodology and overall process will be discussed by using methodology flow chart process that includes related methods.

3.2 Process planning

Some literature reviews that related to this study have been through. They are found from several sources such as journals, reference books from library, and the internet. Besides, the process of gaining information using collected data has been performed by group discussion, interview, and brainstorming. Next, the steps made during the implementation of this project are placed in the process flow chart as follows:

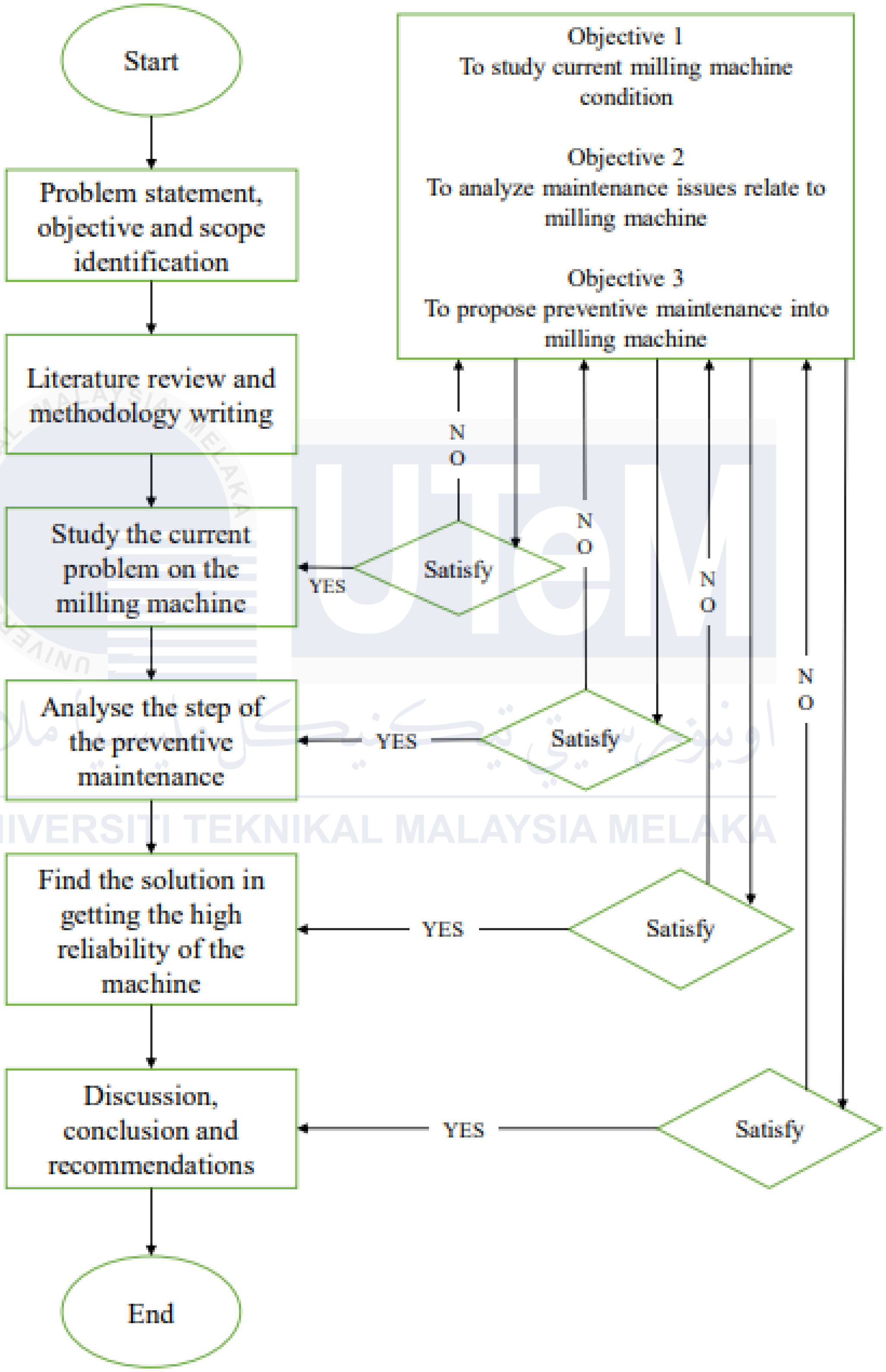


Figure 3 Process flowchart

3.3 Planning and scheduling

A fundamental problem with real-time scheduling systems is the rescheduling time, sometimes referred to as the response time and reaction time. However, the relevant study did not sufficiently address this issue. Due to the additional duties like technical and administrative work that must be completed after each rescheduling replanning procedure, introducing time restrictions to the rescheduling process is vital in practice (Ghaleb M, 2020). The time limit is dependent on a number of production system variables, including flexibility, the typical components processing time, and the length of the shortest event, according to (Harmonosky M, 1991)

Planning a proper scheduling is good for an institution to do their task properly. They can plan what to do before, after and by the time they do their job. Because of uncertainty in machine condition, the planning of maintenance is good for the time management issues. Uses of machine need to be optimize, so the condition and reliability of the machine is the main focus.

Planning and schedule are based on the data collected and analyze. The data is based on the observation and number that they obtain before. After the data is obtained and analyze, operator can setup the proper planning and scheduling to maintain the machine reliability and availability.

3.4 Initial cleaning

The technician should prioritize cleaning as the first step. The equipment can be physically touched and moved to reveal any abnormalities. People utilize their senses to identify things that are loose or vibrating, wearing, misaligned, deflecting, making unusual noises, being overheated, and having oil leaks. Cleaning will disclose countless minor anomalies in any workshop. Many of them will be the kind that, when used alone or in combination, might cause serious malfunctions or other losses if not caught in time.

Large surprises can occasionally be found after cleaning, such as a damaged frame that had been covered by dirt, a lubrication inlet that had also been covered by dirt, or switches that have become so grimy that they are no longer functional. Equipment and quality issues are sometimes the result of poor cleaning.

The goals for this are to ensure elimination of causes of deterioration such as dust and dirt and at the same time can prevent the worsen situation. Also, technician can improve the quality of inspection and repairs and reduce time required to do next cleaning.

Two place that are always become the problem that is power drawbar and speed plate problems. Power toolbar is a part that always expose to the friction. Initial cleaning of the surround area of the parts is a must to ensure any dirt that will congest the part and problem become more complicated.

Figure 4 Breakdowns machine

Figure above show the machine that have a breakdowns issue. Power drawbar located between the head and the spindle. The location is not easily reach and it need the operator to open the motor. When the motor is disassembled, the power drawbar can be seen and pull out. The lubrication and cleaning of the power drawbar is crucial to prevent the misalign of the spindle and the tool attach. Early cleaning can help power drawbar run smoothly and safe. This can help the technician to use the machine effectively before doing their job.

Figure 5 Power drawbar

3.4.1 Eliminates sources of contamination and inaccessible areas

If the machine is not regularly inspect and clean, there will be a lot of contamination that will causes a lot of problems. By this way, technician will controlling the sources of the any situation early. This will improve accessibility of areas that are hard to reach and clean. The lubrication work also become easier with the early detection and work of prevention. This also will reduce the cleaning time of the machine parts.

The focus is on the reliability and the condition of the machine. When the causes is prevent, the condition of the machine will be in good terms by eliminating the dirt, leakage and grime from adhering the machine.

Figure 6 Worktable

The figure above show the table of the work, operator need to ensure the table is not full of debris that can stop them from doing their job. This table is the example of the one part that need cleaning operation every single time before and after use it.

Figure 7 Head components

Figure above show the spindle and the power drawbar part. It need lubrication and cleaning in schedule. The part inside it need regular lubrication. This will help the operator make the changing of tools and the tool bit with ease. The up and down of the power drawbar and the exchange of the tool bits will become easy with the early inspection to prevent the sources of the incoming problems.

3.5 Develop cleaning, lubrication, and inspection standard.

Technician should have a proper standard to be followed. The standard will ease their work by implementing the same procedure all the time. The standard is include their understanding in specific lubricant need to be used, measure the lubricant consumption, measure the amount of lubricant used per application, clearly label all the lubricant label, and list all the difficulties occur systematically.

With the standard they will get used to the functions of every parts of the machine checked. The inspection work will be faster than the period given to them by time to time. This will teach them the importance of the daily cleaning. This will became their routine at work and can bring the benefit to their daily life.

Power drawbar is the parts that always need a cleaning and lubrication due to friction between the spindle and the motor and the toolhead. Any contamination between the area will affect the efficiency of the up and down of the drawbar. The level of lubrication in the reservoir also need to be checked depends on the weekly or monthly uses. By applying the standard, their routine on checking the condition of the parts will become easier and inline.

They also need to ensure the power drawbar head and tail need to lubricate when needed. Construct a standard for lubrication of the parts is needed to ensure the breakdowns in the future. So, construct one standard that include cleaning, lubrication and inspection that will be follow by any person that will be assign. Daily cleaning is a must to ensure clean environment. Weekly inspection also is a must by analyze the data collected in QR code that will be assign by student every time used the machine.

Controlling friction becomes a crucial task for any sector since friction leads to wear and failure of mechanical components (Peric S, 2012). To reduce friction and wear, techniques including using the right lubricants between mating pairs (Duradji V, 2016) and surface modification (Adamovic D, 2015) are applied. This show that lubrication also need to be done in time to prevent wear of parts when it expose to friction every single time. All task mentioned above will be deliver with the good standard.

3.5.1 Conduct general inspection skills training

To understand the machine itself, technician must learn about the basic system of the machine they work with. They need to know the parts to how to handle the parts. This will obtain with the proper training. (Emiliano Traini, 2019) Using a rotating tool that has multiple cutting blades, known as a cutter, to remove material from a workpiece's surface is termed milling. To do this, it is necessary to define a number of cutting parameters that have an impact on the job's duration, the quality and accuracy of the finished surface, the tool's life, and the cost of manufacturing. This knowledge is one of the parts that should have a proper training to ensure the quality of product and the reliability of the machine.

Operator must know the subsystem of the machine, hydraulic, pneumatic and the fundamentals of the machine and that should be highlighted. With the proper training of the machine, person related will know the problem occur, can detect any abnormalities and predict the incoming problems that will occur. This will happen with knowledge and the proper training of the machine.

Any parts that need lubrication is easily detected with sound they produced. The level of lubrication of the motor control up and down of the power drawbar need to be easily maintain. The transparent or see- thru reservoir need to be use to make the inspection more clear. They should take care of the reservoir from the any leakage or dirt that will cover and make the surround area full of dirt and oil. This will ensure the motor get enough supply of the oil and the part easily recognize.

3.5.2 Provide information for user

Information is crucial in this moment. It is crucial for all people to know the data and information that can help them prepared for the future. Laboratory should be a place that full of data and information for the user. The technician in charge, the schedule for the laboratory uses, the machine in there and state of the machine. Machine state should be the main consent for the user before they use it. The condition is rely on the response from the technician to take a good care of the machine. Prevent the breakdowns of the is better than the real time maintenance that will cost a lot of time and energy for the user from below to the top management.

Tehnician work with the machine everyday. It is their responsible and care that should been eye every single time. Good care of the machine will achieve high percent of the machine availability. The quality of product came from the well manage and controlled machine. The great input in learning is based on the availability of the machine. People assigned should be alerted with the condition of the machine. They can provide more informative things to the user that will help them track the abnormalities of the machine and this will prevent the machine breakdowns before broken. The QR code provided in the machine can be better with a lot more information.

Figure 8 QR code

There are QR code provided for the user to fill the details. Name, time, date and purpose of the machine uses need to be fill. It great to collect the data of the user and the information of it. But, it need further and useful information like the state of the machine after use. This will prevent the incoming problems. Any operator need to report any abnormalities of the machine by the time they use it. This will alert the technician assigned to do their job. Early detection is the best. So, the QR code need to be update to ensure the inspection work can be detected early and clear.

Figure 9 QR content

The figure above show the existing QR code details that should be fill in. There are not enough details for the operator to know the state of the machine after the laboratory uses. So, for the complete details, the state of the machine should be added. This will help the student to report directly to the system and at the same time will alert the technician about the whereabouts of the machine. QR code is better than paper documentation. This will benefit in the term of documentation, reference and history of problem. By this documentation, they can forecast the problem that may be happen in future.

3.6 Organise and manage the workplace.

Effectiveness, quality of product, and great safety will came from the organize and proper workplace. Proper and well manage workplace ease the work in front. The moment person can help themselves with the tidiness and well manage environment, the greater result they can obtain. The quality of product also can be guarantee. The people working around will be safe and far from danger. Bad environment of working will affect the person delivery. The quality of work will worsen and this will affect the reliability of the machine.

But the machine should be in a good term first. At this point, any unnecessary item should be eliminated. The layout of the laboratory also is important to ensure the flow of the operator and the product flow runs smooth. The specific place for the specific item also can help organize the place.

Technicians also can applying visual control to the machine they operated. For example, applying marks to the parts that need lot of focus and their time. By applying different marks to every level, parts of the machine, it will be easily recognize the parts and any abnormalities occur. This will restore the machine from any breakdowns or causes that may affect the function. Applying the creative and innovation method such as numbering to the parts, instruction label and thermotape gauge and transparent cover or parts for oil and lubricant especially.

Technician assign should take care of the good workplace. They will provided their care to the student that will use and learn the machine and their applications. Well organized laboratory will help the student do well in their session and this will prevent some environment that will cause misbehave or unsatisfied heart to heart.

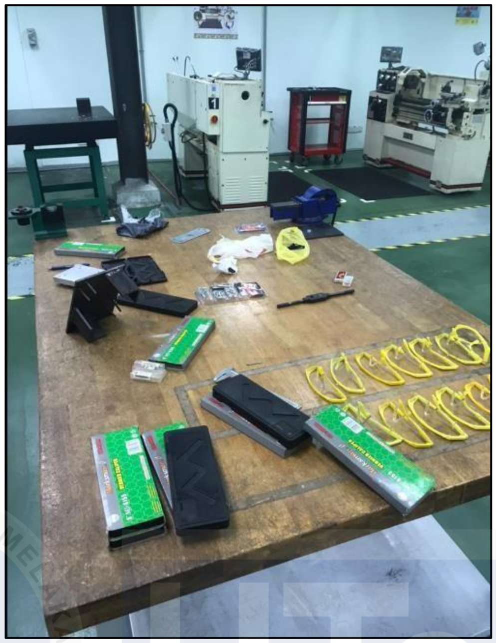


Figure 10 Messy workplace

The figure above show the work station in the laboratory. As can be seen, the marking of the table should be replaced with the new one. Item will be organized on the workstation and will make the environment more lively. The environment will be the first expectation for the student about the laboratory and the technician itself. This will help student to learn in such proper and comfort environment.

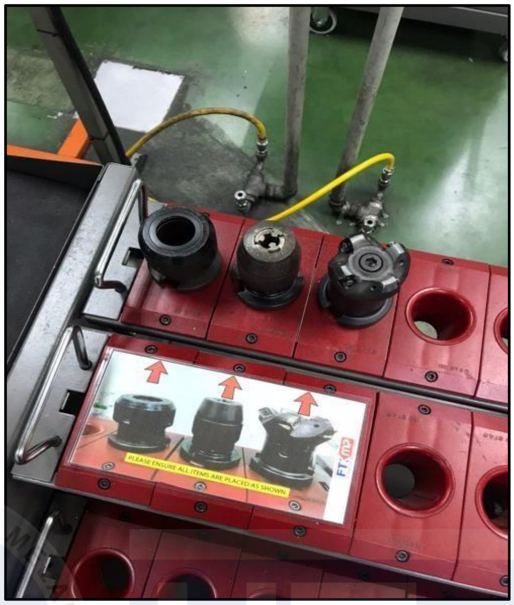


Figure 11 Trolley labelling

This is one good example of the SOP that will help both sides. Student will keep the laboratory in good shape and technician will not worried about the whereabouts of the parts. But, the machine itself been neglected. The only tagging or labelling on the machine is the amount of the machine exist in the laboratory. They can improvised by tagging the part of the machine by classifying the parts with the person that can be access. The student, the technician and both of them. This can prevent the misconduct of machine by the student. This also will aware the student that some parts are not for them to use without technician supervise. So, it will help the breakdowns of the machine form the student and technician just focus in maintain the machine condition by the machine aging only.

3.7 Fuguai

Preventive maintenance is a crucial aspect of ensuring the efficient and reliable operation of machinery and equipment. In the context of fuguai tagging, where "fuguai" translates to contamination or abnormalities in Japanese, a specialized approach known as fuguai mapping is employed. Fuguai tagging is a sophisticated machine mapping technique designed to identify and differentiate areas of abnormalities within a selected machine. This proactive strategy allows maintenance teams to focus their attention on specific regions or components that may be prone to issues, enabling them to address potential problems before they escalate.

By utilizing advanced technologies, fuguai tagging creates a detailed and precise map of the machine, highlighting areas that deviate from the norm. This targeted approach not only enhances the effectiveness of preventive maintenance but also minimizes downtime, increases operational efficiency, and prolongs the lifespan of the equipment. In essence, fuguai tagging through mapping empowers maintenance teams to stay ahead of potential issues, fostering a proactive and comprehensive maintenance strategy.

3.7.1 Fuguai benefit

There are benefits when implementing the fuguai tagging in context of maintenance and management in laboratory.

a) Fuguai tagging employs a visual categorizations system using different colors to represent various machine conditions. This visual approach allows for quick and easy identifications of a machine status, helping rapid decision making and response.

b) Fuguai tagging supports a proactive approach to maintenance. By categorizing machines based on their condition, it enables preventive measures to be taken before issues escalate. This proactive strategy helps prevent unexpected breakdowns and enhances overall equipment reliability.

c) Fuguai tagging allows for the monitoring of machine performance trends. By analysing the frequency and types of tags applied to each machine, maintenance personal can identify patterns, optimize preventive maintenance schedules, and make informed decisions about equipment replacement.

d) Fuguai tagging contributes to cost savings. It helps avoid costly emergencies repair, reduces downtime, and extend the lifespan of machinery. In the long run, this optimization of maintenance practise contributes to a more cost-effective operation.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, the result will be shown based on the implementation of the PM to milling machine in the laboratory. The right methodologies been implemented to increase the reliability of the machine to operate in order to provide their function as a tool in the learning process.

4.2 To study the current milling machine problem

The laboratory has been selected as the main location for the implementation of PM measures in response to new requirements resulting from a prior pandemic. Among the different machinery housed in the machining technology lab, such as lathes and band saws, milling machines have received special attention. The lab is equipped with fifteen milling machines, of which one is strategically positioned to serve as the main subject of study for PM procedures. Given their vital role in machining processes, this decision stems from the need to assure the best functionality of these critical machines.

Among the 15 milling machines, a comprehensive assessment has revealed that three are currently experiencing issues, necessitating prompt attention and remediation. Concurrently, the remaining twelve machines have been deemed to be in good working condition and are considered ready for operation. The difference emphasizes the importance of proactive maintenance procedures, as they allow for detection and solution of possible problems before they worsen, limit inconveniences in the lab's operations.

Furthermore, the milling machine area is being observed for reasons other than mechanical functionality. The cleanliness of the surroundings surrounding each milling machine is being closely monitored, with special attention paid to any potential sources of contamination. This general approach to maintenance recognizes the close relationship of machine performance and environmental conditions, recognizing that a clean workspace is critical not only for the longevity of the equipment but also for avoiding any unintended consequences related to hygiene and safety.

4.2.1 Machine problem

During the recent visit to the laboratory, the primary concerns that surfaced in the realm of milling machine functionality were centered on challenges related to the power drawbar and spindle speed. The power drawbar, a critical component facilitating tool changes in the milling machines, exhibited issues indicative of mechanical malfunctions. These problems might be attributed to worn-out components or potential misalignment within the drawbar assembly, compromising its overall effectiveness and reliability.

Further analysis uncovered another aspect of the problem, as insufficient lubrication of the drawbar mechanism was discovered. Inadequate lubrication not only increases the possibility of premature wear and tear, but also introduces friction into the system, reducing the smooth operation of the power drawbar. The double problem of mechanical faults and insufficient lubrication contributes to a deterioration in milling machine performance, potentially reducing machining precision and efficiency.

In contrast, another set of difficulties arose during the latest laboratory visit, especially spindle speed abnormalities in the milling machines. These inconsistencies point to potential motor-related issues, such as overheating or mechanical breakdowns, which could jeopardize the spindle's level and precise performance. The milling machine's control system was also examined, indicating flaws that might be linked to a variety of variables such as malfunctioning sensors, wiring issues, or complications inside the speed control unit.

The complexity of spindle speed inconsistencies gets worse by the possibility of belt or gear drive system failures. Wear and pressure irregularities in these components may contribute to spindle speed fluctuations, producing inconsistencies in machining processes. The discovery of these multiple issues emphasizes the crucial need of carrying out a thorough maintenance plan.

The prompt resolution of these highlighted difficulties is critical to maintaining the best functioning of the laboratory's milling equipment. Proactive maintenance that addresses both power drawbar and spindle speed concerns not only restores the machines to peak performance but also contributes to their longevity, assuring a reliable and precise machining environment in the machining technology lab.

Figure 12 Breakdown machine

The power drawbar, located at the top of the milling machine, plays an important part in the tool-changing process for two specific machines, notably Machine Numbers 2 and 11. Fundamentally, the power drawbar serves as the control mechanism that governs the drawbar's opening and closing motions, allowing for the seamless loosening and tightening of tools throughout operations. The power drawbar, as the vital component responsible for holding cutting tools in place, is critical to the overall precision and efficiency of machining processes.

Machines 2, 11, and 13 in the laboratory are currently dealing with spindle troubles, which present two particular problems: spindle speed irregularities and a broken spindle plate. The consequences of these issues go beyond mechanical considerations, affecting essential areas of machining operations. The fractured spindle plate stands out as a particularly significant concern, influencing the cutting process's speed, tool-to-workpiece alignment, and the general capacity to start machining processes properly.

4.2.2 Unstructured observation

A conversation with Cik Hisham, the person in charge of managing the laboratory, revealed important insights into the tedious care and constant monitoring required to ensure the proper operation of the machines in the machining technology lab. Cik Hisham elaborated on the extensive checklist used for routine milling machine checking and maintenance, offering insight on every single strategy used to improve their reliability.

Cik Hisham underlined the importance of a systematic checklist, precisely prepared to cover many essential features of milling machines throughout our talk. A detailed assessment of mechanical components, including as spindle bearings, cutting tools, and lubrication systems, is included in the checklist to ensure their integrity and performance.

Figure 13 Interview

4.3 To analyse the maintenance issues relate to miiling machine

The early cleaning component of the PM program involves regular and systematic removal of debris, dust, and any accumulated contaminants from the milling machines. This preventive measure serves to prevent the build-up of materials that could potentially interfere with the proper functioning of machine components. By addressing cleanliness as a proactive step, the lab minimizes the risk of abrasion, wear, or damage to critical parts, thus contributing to the overall longevity and reliability of the milling machines.

Simultaneously, the PM program places a strong emphasis on the elimination of sources of contamination in the milling machine area. This involves a detailed inspection of the surroundings to identify and mitigate factors that may compromise the machines' performance. It includes addressing issues such as spillages, improper storage of materials, or any other potential sources of particulate matter or foreign substances that could adversely affect the machines. By systematically eliminating these sources, the lab takes a preventative stance against contamination-related problems, reinforcing the reliability of the milling machines.

4.3.1 Early cleaning and prevention of contamination

Implementing early cleaning methods and proactively preventing contamination emerge as critical methods for sustaining milling machine operation in the machining technology lab. The methodical approach starts with a concentrated attention on the milling machine table, which is recognized as a vital surface where precision machining operations take place. The table is thoroughly cleaned using a systematic cleaning tool combining towels, steel brushes, and brooms to remove any residues or particles that may impact machining accuracy. This early action not only assures a clean working surface, but it also reduces the danger of contamination, which could compromise the quality of machined components.

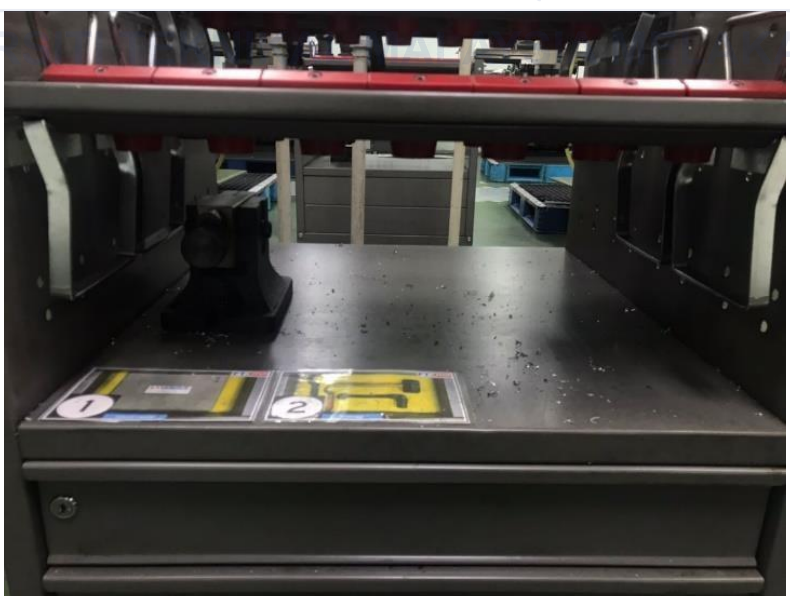


Figure 14 Dirty trolley

The figure illustrates the tool storage table in a state of disarray and disorder, portraying an improper and messy environment. Such conditions pose a significant threat to the quality of work within the machining technology lab. The chaotic arrangement not only hampers the accessibility of tools for the operators but also presents a tangible risk of injury, with the potential for operators to be harmed or cut while attempting to retrieve tools for machine use.

Figure 15 Good condition trolley

This is the state of the workstations after they have been cleaned. The cleaning process used a steel brush and a towel to successfully remove metal chips from the workstations. This will keep the operator safe and allow them to concentrate on operating and cleaning the equipment. In essence, the initial state of disarray on the tool storage table acts as a catalyst for a chain reaction of concerns that go beyond plain aesthetics. The risk of operator injury and consequent disregard for cleaning procedures set the stage for a progressive reduction in machine reliability and the overall efficiency of the machining technology lab. Addressing the immediate disorder in the tool storage area becomes critical not only for visual tidiness, but also for establishing a safe, orderly, and productive working environment.

Figure 16 Messy base

This part of machine is designated as a debris collector area during the machining and post machining. The cleaning part of this machine is done weekly by the lab assistant. The idea is to reduce the cleaning task of this part machine to one time per week from everyday cleaning because of laboratory schedule. Its not the main concern but it must be clean regularly to avoid any congestion that will be damage the pathway of the debris from the table.

Figure 17 Cleaning work

The cleaning of the table is important because it hold the jig that hold the workpiece. The congestion at jig part will affect the ability of the clamping. The condition and state of the workpiece also will affect the quality of the cutting that control by the spindle. It can prevent the damage of the spindle that will affect if the position of the jig and workpiece not aligned.

Figure 18 Result of cleaning

4.3.2 Prevention activities

Prevention activites or prevention maintenance involves taking proactive measures to eliminate or reduce the causes of equipment failures and breakdowns. There are some activities that can be go through by the maintenance personnel that is identifying and addressing root causes of equipment deterioration, implementing design improvements to enhance equipment reliability and analyzing failure data to develop strategies for preventing recurrent issues.

Power draw bar issues and broken spindle plates are two of the most typical milling machine breakdowns. Recognizing these failures requires a knowledge of their usual performances as well as possible basic causes. The power draw bar issue is frequently characterized by difficulty in tool shifting, with the draw bar failing to correctly release or attach the tool. This problem can be caused by several circumstances, including insufficient lubrication, component wear and tear, or misalignment. Regular inspections and monitoring of tool change operations might help in the early detection of power draw bar issues.

A broken spindle plate in a milling machine, on the other hand, is a more serious issue that can result in significant downtime. This failure is frequently visible when the spindle plate, which is responsible for holding and rotating the cutting tool, fractures or breaks completely. Overloading the machine beyond its capability, poor handling of cutting tools, or insufficient maintenance are all potential reasons of spindle plate failure. Understanding the milling machine's load capacity, maintaining with manufacturer's tooling recommendations, and performing frequent checks for indicators of wear or damage on the spindle plate can all help to prevent such major breakdowns.

In both circumstances, user practices are important. The frequency and degree of these breakdowns can be impacted by factors such as machine usage number, following to particular operating procedures, and maintenance practice efficiency. Regular operator training on appropriate operation, routine inspection techniques, and the importance of following to manufacturer specifications for lubrication and maintenance can all help to detect problems and prevent breakdowns in milling machines.

4.4 To propose preventive maintenance into the milling machine

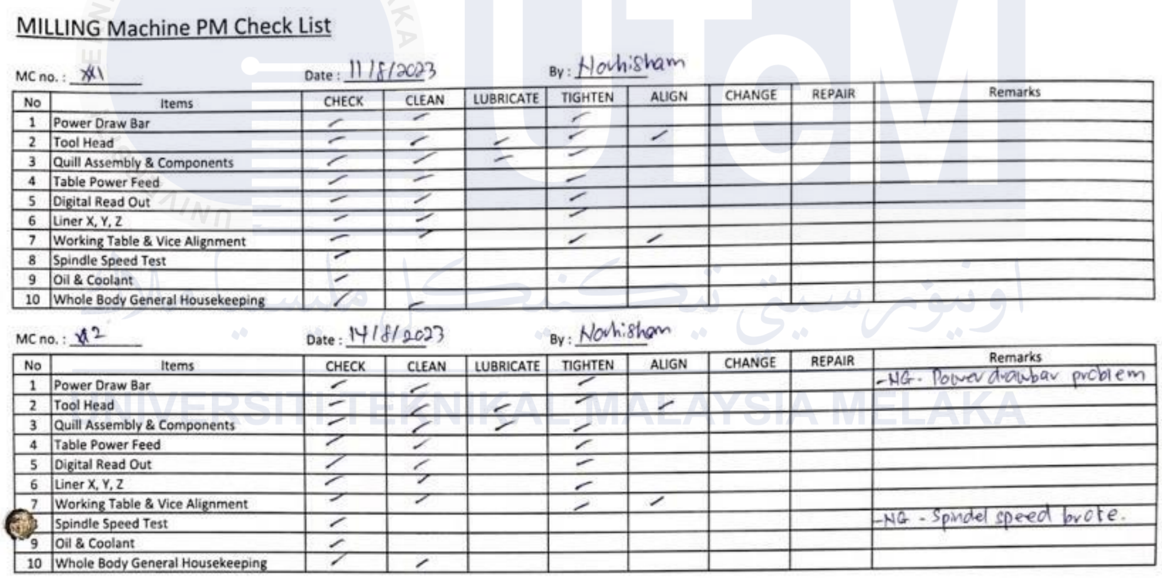
The checklist proves to be an invaluable tool in systematically detecting and addressing abnormalities that may arise over time, specifically focusing on critical elements such as power draw bar and tool head spindle speed tests. The checklist encompasses a comprehensive evaluation of the designated areas, emphasizing key factors such as cleanliness, lubrication, alignment, and identification of components requiring repair. By methodically assessing each aspect, the checklist enables a focused and efficient approach to maintenance tasks. lubrication schedules, timely replacement of the wear parts

The checklist serves as a guide for maintenance personnel, allowing them to systematically evaluate and document the condition of each area related to power draw bar and tool head spindle speed tests for example. Specific attention is given to areas requiring lubrication, alignment adjustments, and cleaning. This focused approach ensures that maintenance efforts are targeted where they are most needed, optimizing the efficiency of the overall maintenance process.

Following the checklist assessment, a final categorization is performed based on the observed conditions. The machines are tagged with color-coded indicators – green for well-maintained and optimal condition, yellow for areas requiring attention and potential issues, and red for components or areas demanding immediate repair or replacement. This tagging system streamlines the communication of maintenance priorities, enabling quick visual identification of the status of each machine.

The power draw bar, a critical component in milling machines, is examined using checklist to find any irregularities that may affect performance. Checklist method also detects tool head abnormalities such as misalignments or wear, ensuring precision and accuracy in machining processes. Checklist focuses on the spindle speed test, methodically examining the rotational speed for any deviations that may indicate potential concerns with the machine's performance.

Furthermore, during checklist, the oil and coolant systems, which are essential for controlling the temperature and lubrication within the milling machine, are thoroughly examined. Any contaminants or anomalies in these systems are identified in order to avoid negative impacts on the machinery. Another critical component is the working table, which is examined to ensure a smooth and solid surface for machining processes. Checklist contributes to proactive milling machine maintenance by revealing potential issues in these critical regions, hence improving the equipment's overall reliability and lifespan.



MILLING Machine PM Check List

MC no. : X1 Date : 11/8/2023 By : Norhisham

No	Items	CHECK	CLEAN	LUBRICATE	TIGHTEN	ALIGN	CHANGE	REPAIR	Remarks
1	Power Draw Bar	✓	✓		✓				
2	Tool Head	✓	✓	✓	✓	✓			
3	Quill Assembly & Components	✓	✓	✓	✓				
4	Table Power Feed	✓	✓		✓				
5	Digital Read Out	✓	✓		✓				
6	Liner X, Y, Z	✓	✓		✓				
7	Working Table & Vice Alignment	✓	✓		✓	✓			
8	Spindle Speed Test	✓							
9	Oil & Coolant	✓							
10	Whole Body General Housekeeping	✓	✓						

MC no. : X2 Date : 14/8/2023 By : Norhisham

No	Items	CHECK	CLEAN	LUBRICATE	TIGHTEN	ALIGN	CHANGE	REPAIR	Remarks
1	Power Draw Bar	✓	✓		✓				-NG- Power drawbar problem
2	Tool Head	✓	✓	✓	✓	✓			
3	Quill Assembly & Components	✓	✓	✓	✓				
4	Table Power Feed	✓	✓		✓				
5	Digital Read Out	✓	✓		✓				
6	Liner X, Y, Z	✓	✓		✓				
7	Working Table & Vice Alignment	✓	✓		✓	✓			
8	Spindle Speed Test	✓							-NG - Spindel speed brote.
9	Oil & Coolant	✓							
10	Whole Body General Housekeeping	✓	✓						

Figure 19 Old checklist

Monthly Inspection										
Machine Number	Power Draw Bar	Tool Head	Quill Assembly	Table Power Feed	Digital Read Out	Linear X, Y, Z	Working Table & Vice	Spindle Speed Test	Oil & Coolant	Whole Body General Housekeeping
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
Checked by:					**Date:**		**Approved by:**			
						Remarks				

Figure 20 Monthly checklist

Table 6 Machine explanation

Machine parts	Explanation
Power Draw Bar	Begin by inspecting the power drawbar, which allows for quick tool changes. Check for signs of wear or damage and make sure it runs smoothly. A properly working power drawbar is essential for smooth machining processes.
Tool head	Inspect the tool head for proper alignment and signs of wear on the spindle and bearings. Misalignments or wear can cause

	machining inaccuracies, making regular checks necessary for precision.
Quill assembly	Examine the quill assembly for correct engagement and smooth movement. Any irregularities in the depth control during milling operations may have an impact on the overall machining precision.
Table power feed	Examine the milling table's power feed system. Check that it moves smoothly along the specified axes (X, Y, and Z). Check for unexpected noises or resistance, as these may indicate hidden issues.
Digital read out	Examine the digital readout system for proper measurement display. Inaccuracies in the DRO can cause machining errors, hence it is critical to test its precision on a frequent basis.
Linear X, Y, Z	Examine the linear motion systems along the X, Y, and Z axes in detail. Ensure that the slides and paths are well-lubricated and debris-free to ensure smooth movement and prevent premature wear.
Working table & vice	Check the stability and alignment of the working table and vice. Precision milling requires a solid and well-aligned setup, and any deviations might lead to inaccuracies in the machined pieces.
Spindle speed test	Perform a spindle speed test to ensure that the milling machine performs within the speed range indicated. Differences can have an impact on the quality of machined

	surfaces, thus regular checks are essential for reliable outcomes.
Oil & coolant	Examine the oil and coolant levels to ensure they are within the approved limits. Proper lubrication and cooling are required to avoid overheating and reduce friction in moving parts.
Whole body general housekeeping	Perform a thorough visual inspection of the milling machine. Examine the machine's structural components for loose bolts, collected debris, or signs of wear. A clean and well-maintained machine is less likely to fail.

Weekly Inspection				
Zone:	Machine number:		Date:	
Task	Week 1	Week 2	Week 3	Week 4
Lubrication				
Alignment of Jig				
Spindle bearing				
Remarks				

Figure 21 Weekly checklist

Certain critical areas of a weekly inspection for milling machines require prioritized attention to ensure sustained operational excellence. First and foremost, adequate lubrication is critical. Lubricating key components such as slides, channels, and bearings on a regular basis reduces friction and wear, extending the life of these critical elements. Adequate lubrication also contributes to the milling machine's overall efficiency by providing smooth and accessible movement along the various axes.

Second, during weekly inspections, the alignment of the jig should be carefully considered. The appropriate alignment of the jig is critical for ensuring machining accuracy and precision. Misalignments in the final product can have an impact on the quality and uniformity of machined parts. By prioritizing jig alignment on a weekly basis, technicians may solve any possible faults quickly, ensuring the milling process's accuracy.

Finally, during weekly inspections, a thorough check of spindle bearings is required. Spindle bearings are critical to milling machine functionality, and any flaws in their performance can have a domino impact on the entire machining process. Technicians can detect early signs of wear, potential misalignments, or other concerns by inspecting the spindle bearings on a regular basis, allowing for timely interventions to prevent more serious complications.

Daily cleaning and Inspection							
Zone:		Machine number:			Date:		
Task	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Tool trolley							
Worktable							
Quill Components							
T- slot							
Digital Read Out							
Linear X, Y, Z							
Vice							
Base							
Remarks:							

Figure 22 Daily checklist

Daily inspections of milling machines are critical for ensuring optimal performance and avoiding potential problems that could disrupt machining processes. During these daily checkups, it is critical to concentrate on important areas for proper equipment care. Close attention is required to ensure that tools are organized, accessible, and in good shape, supporting efficient production and minimizing downtime.

The worktable, as a crucial component, necessitates regular inspection to guarantee cleanliness, stability, and proper alignment. Any abnormalities in the state of the worktable can have a direct impact on the precision of machining processes, making it critical to solve faults as soon as possible.

Daily inspections should also focus the quill components, ensuring that they are functional and aligned. The smooth operation of the quill is vital for obtaining precise drilling and milling depths, therefore regular checks are required to ensure machining precision.

T-slot checks are critical for assuring a safe and sturdy workpiece fixture on the machine. Any imperfections in the T-slot can affect the placement of the workpiece, potentially resulting in inaccuracies in the machined parts.

A critical component in giving real-time measurement feedback during machining processes is the digital readout system. Daily inspections on the digital display aid in ensuring its correctness, allowing operators to notice and fix any problems as soon as possible.

The linear motion systems along the X, Y, and Z axes are critical to milling machine movement. Daily inspections of key components, such as slides and ways, ensure that they are well-lubricated, free of dirt, and run smoothly, all of which contribute to overall machine efficiency.

The vice and base, which are crucial for anchoring workpieces during machining, must be checked daily to ensure their stability and alignment. A stable and properly oriented vice is critical for precision in milling operations, highlighting the importance of routine inspections.

Finally, daily inspections of milling machines, with a focus on the tool trolley, worktable, quill components, T-slot, digital readout, linear X, Y, Z, vice, and base, are essential for the equipment's reliability over time and precision. This proactive method aids in the early discovery of possible problems, allowing for timely maintenance and assuring consistent high-quality machining output.

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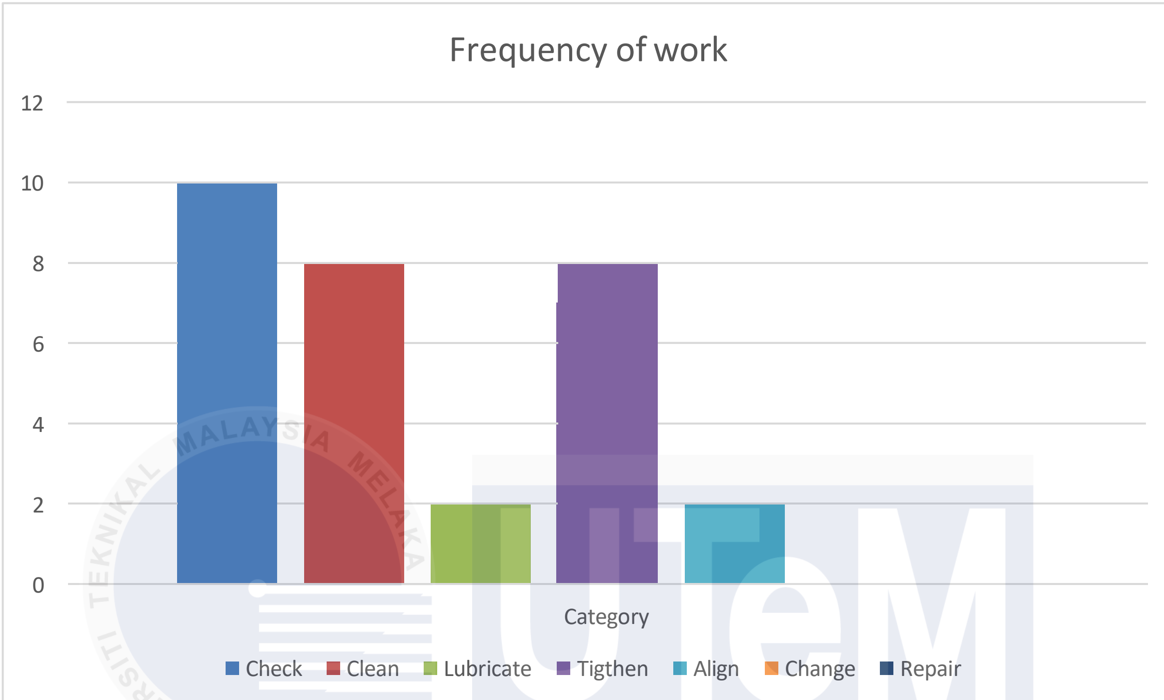

Figure 23 Frequency of work

The full inspection of the machining machinery indicated positive results in the maintenance checklist. All ten important components were thoroughly examined, ensuring an accurate assessment of their operating reliability. Following that, eight of these components were thoroughly cleaned to remove any accumulated debris or pollutants. The tool head and quill components, which are critical for precision and functionality, were selectively lubricated to improve their performance.

Furthermore, seven components, including the power draw bar and working table, were tightened to ensure their stability and avoid any operational concerns. Furthermore, alignment operations were given careful attention, with both the tool head and working table undergoing precision alignment to improve accuracy and performance.

4.5 Fuguai tagging

The implementation of the "fuguai" tagging system involves a practical and visual approach to communicating the condition of each machine within the machining laboratory. Through the printing and hanging of distinctive "fuguai" tags on respective machines, a clear and immediate signal is provided to all laboratory users, indicating the operational status of each machine.

Fuguai is a Japanese word means contamination or abnormalities. Fuguai mapping is machine map used to differentiate abnormalities focus on area on the selected area, notably in the context of milling machines. The Fuguai mapping process entails an in-depth assessment of numerous key areas within the milling machine to detect and identify irregularities, assuring the equipment's effective and safe operation.

Figure 24 Fuguai tag

Fuguai mapping, employing advanced machine mapping technology, serves as a valuable tool in differentiating abnormal focus areas on selected machines. The Fuguai tag itself encapsulates key information such as the name of the inspector, the date of assessment, the specific equipment or zone under scrutiny, and details regarding the detected defect.

When preventative maintenance measures are implemented, alert reporting becomes critical. Maintenance personnel must document their identity, the date of maintenance, and a detailed summary of the corrective steps conducted. This methodical approach not only improves traceability and accountability, but it also helps to a safer and more efficient industrial environment by identifying abnormalities before they cause major operational interruptions.

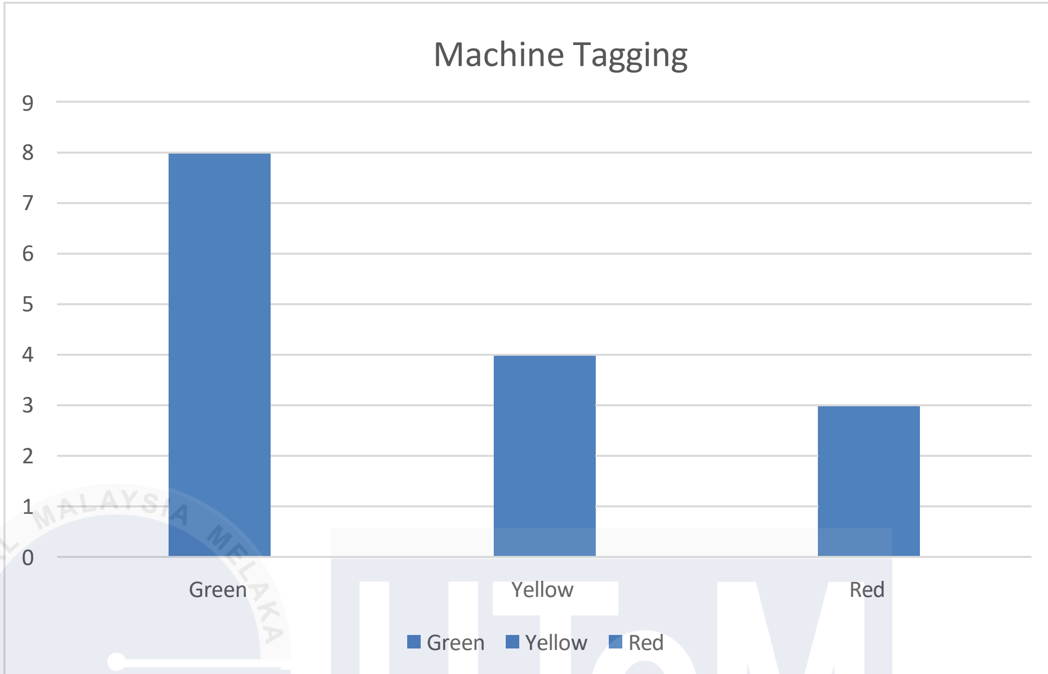

Figure 25 Fuguai analysis

Conversely, the three machines marked with red fuguai tags demand immediate attention, signaling the need for repair and maintenance. These machines, specifically encountering challenges related to power drawbar and spindle plate issues, require prompt intervention to restore their optimal performance. Due to the complexity of the problems identified and the current lack of competency in the laboratory's designated personnel, UTeM is actively seeking a qualified external client to address and resolve these issues effectively.

The assessment using the "fuguai" tagging system has categorized the eight machines with green tags, indicating that they are in good operational condition and ready for use. This signifies that these machines have passed the checklist evaluation and are currently free from critical issues, ensuring their reliability and functionality for various tasks within the laboratory. Also, the remaining four machine need to undergo some lubrication or checking it be classified under yellow tagging.

Figure 26 Yello tag machine

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Figure 27 Red tag machine

Figure 28 Green tag machine

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, our initial goal of researching modern milling machine challenges was achieved through a comprehensive method. The checklist assessment and in-depth discussions with the laboratory technician gave useful information into the milling machines' current state. As a result, a complete list was prepared, revealing that three of the 15 machines are currently out of commission. The remaining twelve machines, on the other hand, are judged to be in good condition, stressing the need of doing daily inspections to ensure their dependability for end-users. This methodical approach has proven to be incredibly effective, providing precise and extensive information about the general status of the machines and highlighting specific issues faced by each, laying the groundwork for informed decision-making and proactive maintenance measures.

The second objective of this study involves a detailed analysis of maintenance issues related to milling machines, particularly in the context of preparing for the implementation of Fuguai tagging. Prior to the introduction of Fuguai tagging, a crucial step is ensuring the cleanliness of the machines and the elimination of potential sources of contamination. This preliminary step is essential to create an optimal working environment and to enhance the effectiveness of subsequent maintenance measures. By addressing cleanliness and eliminating potential contaminants, the milling machines are better poised for the implementation of Fuguai tagging, enabling a more focused and efficient approach to maintenance practices. This proactive method not only improves overall equipment reliability, but it also lays the groundwork for the successful integration of systematic tagging for continuous maintenance management.

The study's main objective is to provide a preventive maintenance method for milling machines. The collaborative implantation of two major methodologies: the thorough checklist and the fuguai tagging system, is planned as effectively preventing machine faults. These complementary techniques are critical in empowering individuals to confront possible difficulties and avoid uncertain breakdowns. The Fuguai tagging system employs a dynamic classification mechanism, with different colors (red, yellow, and green) representing different machine states. This classification corresponds to the level of care required, which ranges from complete repairs allocated to specific workers to basic routine procedures like lubrication, cleaning, and daily inspections. The system provides operators with quick visual indications, speeding decision-making and accelerating critical actions to maintain the condition of the machine.

The checklist approach is a precise and methodical tool for technicians that complements the Fuguai tagging system. This method provides for a thorough analysis of each machine component, allowing for a more targeted approach to preventative maintenance. Technicians walk through the checklist in a systematic manner, ensuring that every part is carefully inspected. This not only improves the efficiency of maintenance routines, but it also gives an organized framework for addressing possible concerns before they become major problems.

In conclusion, the proposed preventative maintenance technique combines the advantages of the Fuguai tagging system and the detailed checklist approach. They provide a comprehensive and proactive solution to protect milling machines from malfunctions by emphasizing a planned and informed approach to maintenance operations. This integrated method not only improves the equipment's longevity and reliability, but it also creates a proactive maintenance culture inside the operational framework.

5.2 Recommendations

The advice to incorporate the Fuguai tagging system and checklist into the laboratory ecology is a very effective method of preventing machine faults. However, in order for these strategies to be implemented successfully, the institution must spend in technician training. Sending professionals for comprehensive training gives them the skills and information they need to monitor, address, and actively participate in the repair and maintenance operations.

By placing technicians in extensive training programs, the institution not only improves their technical skills but also promotes a sense of ownership and responsibility for milling machine maintenance. Involving technicians throughout the maintenance process also promotes a culture of accountability and expertise within the institution. It guarantees that the people in charge of the machinery are completely prepared to deal with any problems that may develop, promoting a more efficient and sustainable maintenance environment.

To summarize, while implements the Fuguai tagging system and checklist is a strong preventive maintenance approach, the institution's commitment to technician training is critical for the smooth integration and long-term effectiveness of these measures. This investment in training benefits not only the technicians, but also the general dependability and longevity of the milling machines in the laboratory ecosystem.

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Appendices

Gantt chart for FYP 1

Implementation of Preventive Maintenance on Milling Machine At UTeM Technology Machining Laboratory								
Task	2023				2023-2024			
	March	April	May	June	October	November	December	January
Choose title of the project and briefing about the project	■							
Chapter 1 : Introduction	■	■						
Chapter 2 : Literature Review		■	■					
Chapter 3 : Methodology		■	■	■				
Slide preparation for FYP 1				■				
Presentation of FYP 1				■				
Submission of report FYP 1				■				
Chapter 4 : Result					■	■	■	■
Chapter 5 : Conclusion and Recommendation							■	■
Presentation of FYP 2								■
Completion of report FYP 2					■	■	■	■
Submission of full report								■

Gantt chart for FYP 1 and 2

Implementation of Preventive Maintenance on Milling Machine At Technology Machining Laboratory																
Activities	March				April				May				June			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Title selection	■															
Registration FYP title to committee	■															
Endorsement of FYP tittle		■														
Chapter 1 : Introduction			■	■												
Problem statement				■												
Objectives and Scopes				■												
Chapter 2 : Literature Review					■	■	■	■	■	■	■	■	■	■		
Chapter 3 : Methodology						■	■	■	■	■	■	■	■	■	■	
Report writing		■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Report editing													■	■	■	
Submission of logbook to Supervisor																■
Slide presentation for FYP 1																■
Presentation for FYP 1																■
Last submission of report 1																■