UNIVERSITI TEKNIKAL MALAYSIA MELAKA

IMPLEMENTATION OF PREVENTIVE MAINTENANCE PROGRAMME ON BAND SAW MACHINE IN MACHINING TECHNOLOGY LABORATORY

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Faculty of Mechanical and Manufacturing Engineering Technology

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Bachelor of Manufacturing Engineering Technology (BMIW) with Honours

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in fulfillment of the requirements for the degree of
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2024

DECLARATION

I declare that this Choose an item. entitled " Implementation Preventive Maintenance on Band Saw Machine in Machining Technology Laboratory" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : MARCEL ANAK MICHEAL

Date : 21.06.2023

APPROVAL

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

Signature : 

Supervisor Name : *Prof. Ts. Dr. Effendi Bin Mohamad*

Date : 21.06.2023

DEDICATION

To my beloved parents who are always supporting me,

Mr. Micheal Anak Ngtemang

Mdm. Betty Anak Bilong

And

To my Supervisor,

Prof. Ts. Dr. Effendi Bin Mohamad

Who always guide me and giving me advices,

To my families and dearest friends,

Who always support me in completing this task and encouraged me to keep me strong mentally, spritually and physically.

Thank you.

ABSTRACT

This case study is entitled as " Implementation of Preventive Maintenance Programme on Band Saw Machine in Machining Technology Laboratory". This case study discussed how implementation of preventive maintenance programme can improved maintenance activities in the laboratory and prevent the machine from the possibility of failure. The case study was conducted in Machining Technology Laboratory, FTK Campus and the selected area for this case study is band saw machine, RR 250-V and RR 180-B. The objectives of this study is to study the current maintenances practices on band saw machines, to improve the consistency and standardization of maintenance activities, and to proposed PM implementation on band saw machines. For this case study, topics such as Lean Manufacturing, Total Production Maintenance, Preventive Maintenance and Maintenance was studied to understand the relationship between these topics in term of maintenance practices. This case study was conducted through multiple stages. The stages of methodology used in this case study is problem identification using observation and interviews, study on band saw machines, fuguai mapping, PM activities implementation, and develop maintenance standards such as schedule, checklist, and procedure. Through all these method, this case study are expected to standardized the maintenance activties and enhance its consistency. By improving the maintenance standards, the possibility of band saw machine breakdown was reduced.

ABSTRAK

Tajuk kajian kes ini ialah "Pelaksanaan Program Penyelenggaraan Pencegahan ke atas Mesin Gergaji Pita di Makmal Teknologi Pemesinan". Kajian kes ini membincangkan bagaimana pelaksanaan program penyelenggaraan pencegahan dapat meningkatkan aktiviti penyelenggaraan di dalam makmal dan mencegah kemungkinan kerosakan mesin. Kajian kes ini dilakukan di Makmal Teknologi Pemesinan, Kampus FTK, dan kawasan terpilih untuk kajian ini adalah mesin gergaji pita, RR 250-V dan RR 180-B. Objektif kajian ini adalah untuk mengkaji amalan penyelenggaraan semasa pada mesin gergaji pita, meningkatkan konsistensi dan piawaian aktiviti penyelenggaraan, serta mencadangkan pelaksanaan penyelenggaraan pencegahan pada mesin gergaji pita. Dalam kajian kes ini, topik seperti Pengilangan Kecil, Penyelenggaraan Pengeluaran Menyeluruh, Penyelenggaraan Pencegahan, dan Penyelenggaraan dikaji untuk memahami hubung kait antara topik-topik ini dalam konteks amalan penyelenggaraan. Kajian kes ini dijalankan melalui beberapa peringkat. Peringkat metodologi yang digunakan dalam kajian ini ialah pengenalan masalah menggunakan pemerhatian dan temubual, kajian terhadap mesin gergaji pita, pemetaan fuguai, pelaksanaan aktiviti penyelenggaraan pencegahan, dan pembangunan piawaian penyelenggaraan seperti jadual, senarai semak, dan prosedur. Melalui semua kaedah ini, kajian kes ini dijangka dapat menyelaraskan aktiviti penyelenggaraan dan meningkatkan konsistensinya. Dengan meningkatkan piawaian penyelenggaraan, kemungkinan kerosakan mesin gergaji pita dapat dikurangkan.

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LIST OF SYMBOLS AND ABBREVIATIONS

mm	-	Milimeter
TPM	-	Total Production Maintenance
LM	-	Lean Manufacturing
PM	-	Preventive Maintenance
TBM	-	Time Based Maintenance
PDM	-	Predictive Maintenance
FFM	-	Failure Finding Maintenance
RBM	-	Risk-Based Maintenance

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CHAPTER 1

INTRODUCTION

1.1 Background

Machining technology are one of the important assets in the university laboratory due to its purpose for students learning session about machining operation in the industry in term of its function, mechanism, and capabilities. It is also used for the student and laboratory technician to perform machining operation during lab session. However, the machines are not for daily use like in industry. Due to this event, the machines in the laboratory are inconsistently maintained which may cause machine breakdown. Thus, to improve the maintenance practices, preventive maintenance activities were implemented on the machines in the laboratory.

Preventive maintenance is an action which is taken to enhance the condition of machines before it fail which are performed through maintenance and care activities. Through implementation of PM able to prevent unanticipated damage to the machines in the laboratory that will cost high amounts of university's expenses in repairing damaged machines. PM is a modified maintenance activities that origins from Autonomous Maintenance and its purposes to increase AM reliability. Thus, PM activities can be the tools that improve the condition of laboratory working conditions and enhance the efficiency of the machines.

1.2 Problem Statement

Band saw machines are one of the machining technologies in the UTeM laboratories which are used for materials preparation for laboratory sessions. The machines are supposedly to be consistently maintained to enhance their performance in material cutting operation. However, the maintenance activities were performed inconsistently. This problem is considered as inefficient maintenance practices and if it continuously happens, there a possibility of machine breakdown which could disrupt material preparation for laboratory sessions or projects. Besides, it will cost the UTeM expenses in hiring technical experts to fix the damaged machine.

Furthermore, the workstations are not well organized due to the lack of maintenance information such as maintenance operation instructions, schedule, parts information, and documentation. This information is important and need to be presented in the workstation area because the information will ease the maintenance activities conducted on band saw machine as it will help the laboratory technician to understand the proper procedures in performing maintenance activities such as inspection and cleaning. Besides, if the workstation lacks maintenance information such as schedule, it is difficult to track the history of maintenance activities performed.

Therefore, the implementation of PM activities is applied on band saw machines in the laboratory to improve and conduct standardization for maintenance activities. Through PM implementation, the risk of machine breakdown can be reduced, and it can enhance the performance of the machine when it operates.

1.3 Research Objective

There are three objectives in this case study. The objectives are as following:

i) To study the current maintenance activities on band saw machine.

ii) To improve the consistency and standardization of maintenance activities.

iii) To propose a preventive maintenance programme on band saw machines.

1.4 Scope of Research

The scope of this case study is to identify problems related to maintenance practices on band saw machines in Machining Technology Laboratory in UTeM Engineering Technology Campus. It is performed through assessing the current maintenance practices on band saw machines and perform data analysis. Afterwards, an improved and efficient solution is proposed for future maintenance activities using preventive maintenance activities.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Lean Manufacturing

According to ((Valamede and Akkari, 2020)), Lean Manufacturing is the strategy to reduce waste in industry such as human effort, manufacturing space, investments in tools, materials, cost, and engineering hours. It is considered as a method to reach the target in terms of output using less input.

The history of LM began when Sakichi Toyoda, Kiichiro Toyoda and Eiji Toyoda who are the member of the founding family of Toyota, applied the concepts they learnt from Ford Production System into Toyota Production System. Many years later, the concept was improvised by Taiichi Ohno who was one of the Toyota's manufacturing engineers.(Čiarnienė and Vienažindienė, 2012, p.2)

2.1.1 Principles and Tools

- Just in Time (JiT)

It is a tool obtain from Japanese manufacturing management philosophy which can be used to supply right and proper materials in proper quantity, time, position, sequence, and cost. Besides, it is also used to reduce the amount of waste and reworks during the manufacturing process.(Kootanaee et al., 2013)

- Kanban

It is a tool that enables the inventory are keep at the minimum rate at any time under the condition that the materials are not produced or moved until the customers show their interest in demanding it. Kanban also can be used to support the material tracking, process, and workstations.(Rose et al., 2011)

- Kaizen

It is a tool that is used to eliminate unnecessary work and waste systematically. Kaizen is performed through the process of problem analysis and solutions implementation with current real-time reassessment. Its target is to continuously improve quality of the work.(Prošić, 2011)

- Value Stream Mapping

Value Stream Mapping is a collection of ways to demonstrate the data flow and material flow during the work process which its purpose is to reduce waste by reorganize all sorts of waste in the value stream, Thus, this tool is classified as value-added actions and non-value-added actions.(Zahraee et al., 2014)

- Poka Yoke

It is a tool that purposed to save time and free the mind of the employees when conducting repetitive tasks. The method fundamentally to give respect for human liberties and intelligence.(Dudek-Burlikowska, 2009)

- Total Production Maintenance (TPM)

TPM is a tool that employs a newly defined concept for plant and equipment maintenance which its purpose is to significantly increase production while simultaneously boosting employee morale and job satisfaction.(Venkatesh, 2007)

- 5 S

It is a tool that can be used to organize the workplace to increase safety and efficiency simultaneously decrease the rate of product defects. Basically, 5S stands for Seiri, Seiton, Seiso, Seiketsu, and Shitsuke.(Singh et al., 2014)

2.1.2 Type of Waste

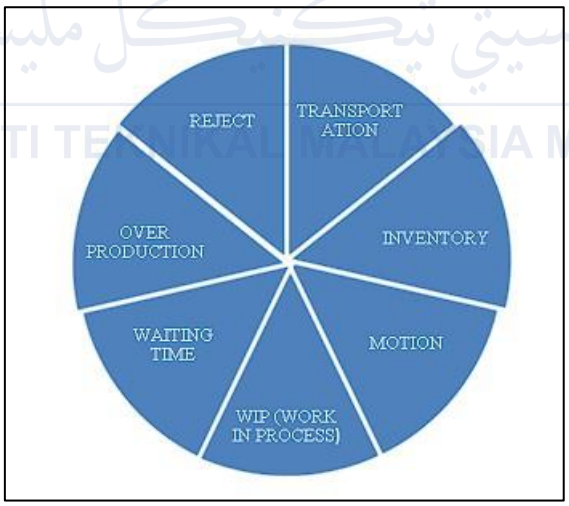

Figure 2.1 Type of Waste(El-Namrouty, 2013)

- Overproduction

Overproductions refer to the waste of production which happen due to the product that produce more than requirement. It leads to the increase in obsolescence risks and incorrect item production that cause an excessive work-in-progress inventories.(El-Namrouty, 2013)

- Defects

It refers to physical defects on the product manufactured which leads to material shortages, impede meeting schedules, create idle time at subsequent workstations, and lengthen production time.(El-Namrouty, 2013)

- Inventory

Inventory is a type of waste that refers to having excessive quantities of basic materials, work-in-process, and finished goods which result in increased cost in term of inventory financing, and storage. The rate of defect also increased due to the inventory waste.(El-Namrouty, 2013)

- Transportation

It is a waste that involves materials movement that does not contribute to the value of the product. The reason behind the waste is it lengthens production cycle times and makes inefficient use of labor and space.(El-Namrouty, 2013)

- Waiting

It is a waste that involves minor delays between unit processes when time is utilized inefficiently. Usually happen due to bottlenecks or ineffective production flow on the factory floor, employees, or machines that experience downtime.(El-Namrouty, 2013)

- Motion

It is a waste that involves any unnecessary physical motions or movement by employees that detract from their duties.(El-Namrouty, 2013)

- Over-processing

It is a waste that involves the work that was performed more than required. It occurs when the solutions are too complex even though the procedure to perform the task are straightforward.(El-Namrouty, 2013)

2.1.3 General Principles

a) Identify Customers and Specific Value

It is a principle that defines the value for a particular product or service from the perspective of the end consumer. Besides, it is a principle in acknowledging the portion of an organization total time and effort that adds value to the end consumer.(Čiarnienė and Vienažindienė, 2012)

b) Value Stream Analysis

It is a principle that involves the aggregation of processes and activities across all organizational components in delivering the product or service jointly. It also a comprehensive process that delivers value to the consumer.(Čiarnienė and Vienažindienė, 2012)

c) Create Flow by Eliminating Waste

It is principles that eliminate wastes to organize the process flowing efficiently through value-creating phases. This principle enables the product or service flow without interruption, diversion, or delay.(Čiarnienė and Vienažindienė, 2012)

d) Respond to Customer Pull

The principle is about comprehend the customer demand for the service and develop a process to meet their demand which means produce a product based on the desires of the customer.(Čiarnienė and Vienažindienė, 2012)

e) Pursue Perfection

It is a principle that focus on unceasing efforts to satisfy customer requirements an eliminate all process flaws that target perfection of the process flow.(Čiarnienė and Vienažindienė, 2012)

2.2 Introduction to Total Production Maintenance (TPM)

According to Ventakesh, Total Production Maintenance (TPM) is a maintenance programme that employs a newly defined concept for plant equipment maintenance. It is a programme that aims to significantly increase the production while at the same time enhance employee morale and job satisfaction. TPM emphasises maintenance as a necessary and indispensable aspect of the business.(Venkatesh, 2007)

TPM holds a philosophy of continuous improvement that applies a sense of ownership of the machine among the operators and their supervisors. It is because the organization able

to empower the maintenance management by allowing all operator to cooperate in achieving manufacturing efficiency.(Venkatesh, 2007

The origins of TPM were from Japan when the company named Nippondenso became the first company to implement plant-wide monitoring practices and develop the TPM. Due to the TPM implementation, Nippondenso was awarded the distinguished plant prize and become the first company to receive the TPM certification.(Venkatesh, 2007)

2.2.1 Major components

i) Education and Training

It is a component that supports the other TPM components by assuring that employees have the knowledge and skills to perform quality TPM related tasks. It also provides a standardised vocabulary and a precise comprehension of the TPM objectives.(Venkatesh, 2007)

ii) Autonomous Maintenance

AM is an action taken to eradicate accelerated equipment deterioration by cleaning, monitoring, data collection, and equipment condition documentation. In terms of manufacturing industry, AM aid in maintaining high machine dependability, low operational costs, and high production part quality.(Venkatesh, 2007)

iii) Preventive Maintenance

Preventive maintenance is a component that involves equipment servicing and in-depth inspection to detect and fix the condition of equipment that may lead to failure. PM also

aims to reduce the time requires for planned maintenance which capable of eliminating the need for unscheduled equipment repairs.(Venkatesh, 2007)

iv) Planning and Schedule

This component coordinates production schedules, preventive maintenance schedules, and other activities requiring equipment utilisation. It ensures that trained technicians with proper tools, equipment, parts, documents, and secure work instructions are coordinated with the availability of the equipment.(Venkatesh, 2007)

v) Reliability Engineering and Predictive Maintenance

Predictive Maintenance is a method for enhancing equipment effectiveness through identification and prioritization of chronic equipment problems. Meanwhile, reliability engineering is a component to analyses the root causes of problems and identifies the action and necessary resources. It enhances the reliability and maintainability of machines.(Venkatesh, 2007)

vi) Equipment Design and Start-Up Management

This component of TPM is accountable for integrating the knowledge acquired from maintaining existing equipment into the design of new equipment. It aims to achieve a rapid and reliable ramp-up to the designated production rate.(Venkatesh, 2007)

2.2.2 8 Pillars of TPM

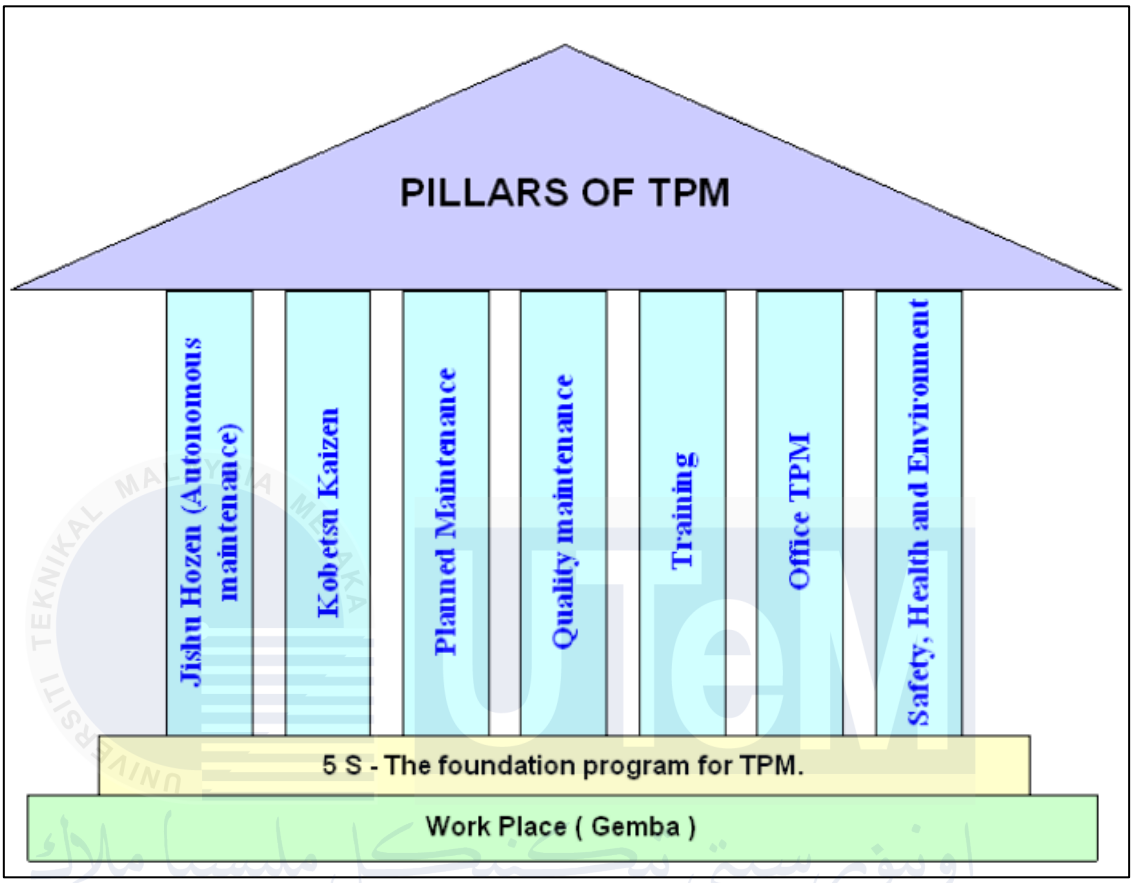

Figure 2.2 8 Pillar of TPM

Eight distinct activities, commonly referred to as the eight pillars of TPM. As suggested by JIPM, the eight-pillar methodology of TPM increases labor productivity by decreasing maintenance costs and production stoppages, thereby reducing downtimes. The followings are the 8 pillars of Total Production Maintenance (TPM):

i) 5 S

5S refers to a method in organizing, setting in order, cleaning, and standardizing a workplace which focuses on identifying problems that may go unnoticed.(Parikh and Mahamuni, 2015)

- Seiri – Sort Out
- Seiton - Organise
- Seiso - Shine
- Seiketsu - Standardisation
- Shitsuke – Self-discipline

ii) Autonomous Maintenance

The operator performs day-to-day duties to develop skills and ultimately mastery of the equipment, freeing up skilled maintenance personnel. Thus, they can devote more time to technical maintenance and other activities with added value. In this activity, operators are accountable for securing their equipment to prevent malfunctions. (Parikh and Mahamuni, 2015)

iii) Focused Maintenance (Kaizen)

Kaizen is the principle that underlying focused improvement which focuses on making incremental enhancements. Thus, this process to reduce losses in the workplace that impede plant efficiencies.(Parikh and Mahamuni, 2015)

iv) Planned Maintenance

This pillar prioritizes responsibility for increasing machine and plant availability by minimizing defects and failures. Besides, it also used for enhancing the quality of maintenance personnel.(Parikh and Mahamuni, 2015)

v) Quality Maintenance

This pillar purpose is to provide customer satisfaction through the utmost quality and error-free production. Furthermore, it assists in identifying the sections of the equipment that affect product quality. It also capable of eliminating current quality issues before it becomes potentially quality issues.(Parikh and Mahamuni, 2015)

vi) Education and Training

This pillar aims to develop employees into dynamic, multi-skilled work forces in which each member is enthusiastic about his work and performs all assigned tasks effectively and more independently.(Parikh and Mahamuni, 2015)

vii) Safety, Health, and Environmental Control

This pillar focuses on creating a secure workplace and environment without compromising the processes or procedures and it plays a crucial role in the ongoing development of all other pillars.(Parikh and Mahamuni, 2015)

viii) Office TPM

This pillar targets to increase the productivity and effectiveness of administrative functions by identifying and eliminating losses in office. The losses stated refers to the significant losses in administrative work such as cost and processing loss.(Parikh and Mahamuni, 2015)

2.3 Introduction to Preventive Maintenance

Preventive maintenance is a program that is essential to effective facility management because PM program enable the equipment to operate effectively, improved facility safety, and avoid high maintenance cost. PM can be defined as an action that is taken to enhance the condition of the equipment before failure. It consists of maintenance and care activities which are purposes to prevent any unpredictable damage on the equipment. Besides, it also helps to identify the conditions that may cause damage to the equipment.

Meanwhile, according to other sources, PM means scheduled maintenance activities which refers to studies that targeted the mitigation of errors impact on the machinery. It can be compared with the habit of being healthy within context of workout and nutrition. There are some advantages of PM to the organization such as increased the safety of production cycle, reduced downtime, reduced costs, decreased the number of repairing work, extend the useful life of the equipment and reduce the exposure of risk that may cost the equipment.

In the industrial company sector, PM was implemented on the facilities because it is an approach in minimize the maintenance cost while at the same time maximize the availability of the equipment, within a context in which a multitude of factors drive costs and penalise availability from multiple perspectives. It shows a significant impact on the company's cost savings.

2.3.1 Seven Elements of Preventive Maintenance

i) Inspection

This element aims to evaluate the serviceability of the equipment using a comparison on its physical, mechanical, electrical, and other aspects which able to predetermine the criteria of the equipment condition.(Taylor, 2006)

ii) Calibration

Calibration focuses on identifying and adjusting any inaccuracy in the equipment which being compared to the established standard value.(Taylor, 2006)

iii) Testing

Testing is an element that focuses on examine ascertains functionality of the equipment and perform detection on any possible mechanical or electrical deterioration.(Taylor, 2006)

iv) Adjustment

This element is about performing an adjustment to specified variable elements in the equipment. The purpose is to attain the optimal performance of the equipment.(Taylor, 2006)

v) Servicing

This element is related to performing basic maintenance activities such as lubricating, changing parts, and cleaning on the equipment at regular intervals which aims to prevent the occurrence of impending failures.(Taylor, 2006)

vi) Installation

Installation is mainly about replacing time-cycle or wear-degrade item of the equipment which purposes to maintain the specified tolerance level.(Taylor, 2006)

vii) Alignment

The element is about modifying the specified variable elements of a product to attain optimal performance.(Taylor, 2006)

2.3.2 Preventive Maintenance Program Development Method

i) Identify and select the area.

In this method, identification of key areas on the equipment is conducted and needs to be prioritize for initial phase for PM program. The objective is to achieve improvement in highly visible areas.(Taylor, 2006)

ii) Highlight the preventive maintenance requirement.

It is to define the requirements for PM programme which include schedule making for PM task. There were two categories of task in PM such as daily preventive maintenance inspections and periodic preventive maintenance assignments.(Taylor, 2006)

iii) Determine assignment frequency.

This process is about establishing the frequency of the task which depends on the familiarity of personnel on the equipment. Besides, this process also includes the process of examining the equipment records and condition.(Taylor, 2006)

iv) Prepare the preventive maintenance assignment.

The process focuses on preparing daily and periodic task for PM program which later needs to be approved.(Taylor, 2006)

v) Schedule the preventive maintenance assignment

This process aims to schedule the PM program in a span of time.(Taylor, 2006)

vi) Expand the preventive maintenance program as appropriate.

This method targets to expand the PM program to the other areas in the facility which require improvement. It will be conduct with the same method depend on the equipment implement.(Taylor, 2006)

2.3.3 Importance of Preventive Maintenance

i) Reduced Downtime

PM program capable of minimizing the number of interruptions on the operation which could save time and cost. Besides, the equipment can maintain properly and operate smoothly.(Ab-Samat et al., 2012)

ii) Increased Equipment efficiency and Performance

PM program helps to maintain the functionality of the machinery by using lesser energy and resources which could help reduce the cost of the company. Besides, the efficiency of the facility increased simultaneously extends the life cycle of the equipment.(Ab-Samat et al., 2012)

iii) Safer Working Conditions

It can enhance the quality and safety of the workstation environment by performing routine inspections which could uncover the potential hazards in the workstation that leads to accidents.(Ab-Samat et al., 2012)

iv) Improved Company Reputation

By implementing PM program, it able to keep the consistency in ensuring the safety of the employees when working in the facility. It will help to gain the positive reputation which is crucial.(Ab-Samat et al., 2012)

v) Reduced Cost

In implementing PM program, cost reduction can be seen in the following ways(Ab-Samat et al., 2012):

- It able to reduce the production downtime by resulting to lower number of machine breakdown.
- It conserves equipment which leads to longer life expectancy. It performed through premature replacement of machinery and equipment elimination.
- It increases the economical use of maintenance personnel through scheduled working basis simultaneously reduced the number of overtime costs.
- Due to repair operation routine, it circumvents more amount of large-scale machinery and equipment repair.
- Reduced the number of possible secondary failures through machinery and equipment repairing cost.

- The number of rejected product, rework, and scrap lower and it leads to better overall equipment condition.
- Improved safety and quality conditions.

2.3.4 Benefits of Preventive Maintenance

- Maintain the good condition of equipment to prevent costly problems.(Kumar Dey, 2021)
- The useful life of equipment capable to be extend.(Kumar Dey, 2021)
- System availability and reliability improved.(Kumar Dey, 2021)
- Reduce the number of system downtime.(Kumar Dey, 2021)
- Optimized the level of parts stocking.(Kumar Dey, 2021)
- Lower emergency breakdown in the facility.(Kumar Dey, 2021)
- Significantly lower the number of unplanned downtimes.(Kumar Dey, 2021)
- Able to detect minor problems before the bigger problems occur.(Kumar Dey, 2021)
- Improvement on customer service.(Kumar Dey, 2021)
- Inventory cost reduction through maintaining the availability of spare parts.(Kumar Dey, 2021)
- Maintenance and replacement costs reduces.(Kumar Dey, 2021)
- Overall productivity becomes higher.(Kumar Dey, 2021)

2.3.5 Type of Preventive Maintenance

i) Time-Base Maintenance

It is a maintenance action which is performed at a fixed interval which is scheduled. It focuses on restoring the efficiency and performance of the equipment and requires the replacement of items by referring to the item service life capability.(Kumar Dey, 2021)

ii) Predictive Maintenance

PDM is an action of predicting the probability of equipment failure and the activities of PDM is scheduled to prevent breakdown. The prediction is performed by analyzing and study the history of the equipment and its records such as downtime, defects, and performance.(Kumar Dey, 2021)

iii) Failure Finding Maintenance

FFM focuses on finding the potential hidden failures which is performed at regular times. If any failures were detected on the equipment, an immediate repairing work need to be performed to prevent major breakdown.(Kumar Dey, 2021)

iv) Condition-Based Maintenance

CBM is an action to monitor the actual equipment and further maintenance are required only if it is decided. CBM is perform through visual inspection, scheduled tests, or performance data. All the activities conducted based on the condition of the equipment.(Kumar Dey, 2021)

v) Risk-Based Maintenance

RBM is a type of maintenance which is performed on the equipment with the most risk during failure. It is because RBM target is to optimizes the risk of the failure and focus on economical use of maintenance resources.(Kumar Dey, 2021)

2.4 Maintenance

Maintenance is the task taken to maintain the performance of the equipment, which is crucial in increasing productivity. It is achieved through reducing equipment downtimes simultaneously improved the performance of the equipment. Maintenance considered as the practice that assist in keeping the operation of assets run continuously and stay efficient.(Pintelon and Parodi-Herz, 2008)

Some sources also define that maintenance as assignment conduct to maintain an asset to ensure the continuity of the equipment use and function. Besides, it also to keep the performance of the equipment more than the minimum level and prevent major fixing activities on the equipment.(Pintelon and Parodi-Herz, 2008)

Meanwhile, another source stated that the definition of maintenance is to maximize the availability and reliability of the assets and equipment to produce the desired quantity of the products. In addition, the products produce needs to follow the required quality specifications and it need to follow the desired time.(Pintelon and Parodi-Herz, 2008)

Basically, the purpose of maintenance in the industry is to increase the life span of the equipment or other assets. It also considers as an action taken to optimize equipment performance, decrease undesired downtime simultaneously increase the amount of production, and minimize cost.(Pintelon and Parodi-Herz, 2008)

2.4.1 Type of Maintenance

In term of maintenance, there were two main categories of maintenance. The categories are as followings:

- Preventive Maintenance

PM refers to an action taken to solve the problems in the equipment or assets before it happens which means it focuses on preventing the problem.

- Corrective Maintenance

It refers to maintenance task that is performed to resolves the problem to regain its optimal operational condition. It is also known as reactive maintenance, and it can be performed in two methods planned and unplanned. CM is performed if there were machine breakdown, identified issue on the machine or any possible fault on the machine.

2.5 Fuguai Mapping

Fuguai Mapping is a method to differentiate abnormalities detected on the focus area of machine which is performed using machine map. Meanwhile, Fuguai itself stands for contamination or abnormalities which translated from Japanese Word. Usually in Fuguai Mapping, the process covering five parts of the machine. The five parts is right view, left view, over-view, back view, and base. To perform Fuguai Mapping, a tool named F-Tag or Fuguai tag is used to identify and detect abnormalities on the machine.(Hasrulnizzam et al., 2008)

2.5.1 F-Tag

F-Tag or Fuguai Tag represent the big eyes which is used to detect and identify abnormalities. F-Tag can be differentiated into two types. It is red tag which is used to

represent abnormalities which need the high level of technical knowledge meanwhile yellow tag represent abnormalities which only need moderate level of technical knowledge and skills.(Hasrulnizzam et al., 2008.)

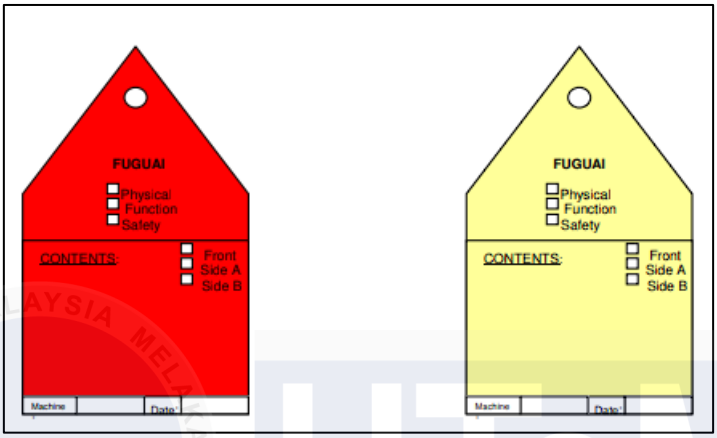

Figure 2.3 Example of F-Tag(Hasrulnizzam et al., n.d.)

2.6 Data Collection

It is a process of collecting and measuring required information on variables of interest which is performed through an established systematic method. The purpose is to obtained quality evidence which later to be analyze for producing credible response to the questions that have been presented. The data collected is important and must be accurate. It is because to maintain the integrity of the focused research.(Muhammad and Kabir, 2016)

2.6.1 Type of Data

Data collected can be divided into a few categories as followings:

- Quantitative Data

The nature of this type of data is numerical and computed mathematically which use a systematic standardized approach. Besides, it can be measured using different scales such as nominal scale, ordinal scale, interval scale and ratio scale.(Muhammad and Kabir, 2016)

- Qualitative Data

The data is mostly not in form of numerical and basically the data is presented in descriptive or nominal method which means writing form.(Muhammad and Kabir, 2016)

- Primary Data

Primary data is considered as authentic which means its validity is greater. It is data that obtain from firsthand-experience, and it must be data that are not modified.(Muhammad and Kabir, 2016)

- Secondary Data

It refers to the data that obtained from a source that already been published in any form such as information presented in literature review of the research.(Muhammad and Kabir, 2016)

2.7 Interviews

Based on some sources, interview refers to the technique in gathering data using verbal communications which is consider as conversation for gathering information. It basically used in survey designs and in exploratory and descriptive studies. In conducting interview in data gathering, there are few approaches which can be use such as unstructured or in-depth interviews, semi-structured interviews, structured or standardized interviews, face-to-face interviews, telephone interviews, or focus group interviews.(Fox, 2006)

2.8 Observation

Observation is a method of collecting data which is performed through visual judgement or evaluation. In data collection, it focuses on the selected area of the research and

information recording through evaluating the characteristics of the selected area.(Kumar, 2022)

2.9 Band Saw Machine

Band Saw Machine is a machine that purposes to perform material cutting. The type of material that usually uses this machine is bar stock, tubing, pipe, or any metal stock. If compared with the regular hand sawing method, it is significantly more reliable and efficient in term of its performance because it is designed to produce an accurate cut on rectangular or cylindrical shape material. Furthermore, this machine is built into two types of machines, horizontal band saw and vertical band saw. The difference between these two are the cutting position. Despite being slightly different, both type of machine is electric powered.(Toronto, 2006)

2.10 Summary

Lean Manufacturing is a methodology centered on boosting efficiency and minimizing wastage in production processes. Total Productive Maintenance (TPM) forms a critical part of this approach, aiming to optimize equipment efficiency by engaging all staff in maintenance activities. Within TPM, Preventive Maintenance assumes a key role, stressing regular checks and upkeep to avert machinery breakdowns. Maintenance, in this context, serves as the linchpin ensuring that machines and systems operate at their peak, aligning with the lean principles of efficiency and waste reduction. The interconnectedness of these concepts lies in their shared objective of augmenting productivity, curbing downtime, and optimizing resources in manufacturing, fostering a more efficient and resourceful production setting.

Besides, Fuguai Mapping is a proactive approach used to pinpoint and map potential risks within a workplace to bolster safety protocols. In healthcare, F-Tags serve as codes indicating regulatory gaps discovered during inspections. Observations and interviews are standard techniques employed to gather insights into work procedures and safety measures. Band saw machines, common in various industries, are power tools for material cutting. In workplace safety evaluations involving band saw machines, employing methodologies like Fuguai Mapping, F-Tags, observations, and interviews is vital. These methods aid in identifying, rectifying, and proactively averting potential hazards, ensuring compliance with safety standards.

CHAPTER 3

METHODOLOGY

3.1 Introduction

When implementing preventive maintenance program, there are methods to implement it. Implementation of preventive maintenance program is conducted through a few steps which later to be explain in other subtopics of methodology. Effectiveness means how successful the outcome produces from the implementation of the program on the selected machine and lab.

To achieve effectiveness of the program, the steps of implementation preventive maintenance need to be applied on both selected machine and lab. By implementing these steps, we can achieve the objectives of the study. When implementing preventive maintenance program, the common things that are involved in it is inspection and maintenance, record-keeping development, recommendation and adjustment.

The flow of the methodology in implementing preventive maintenance program on band saw machine and Machining Technology Laboratory begin with presenting the Flow chart and Gantt chart of the study. Flow chart briefly explain about how this research will be conducted. Meanwhile, Gantt chart explains how the research will be executed in span of specific time. Then, it proceeds with explanation of the steps in implementing preventive maintenance program. Limitation on proposed methodology also be stated in this chapter. Limitation means the constraints faced when performing methodology.

3.2 Research Design

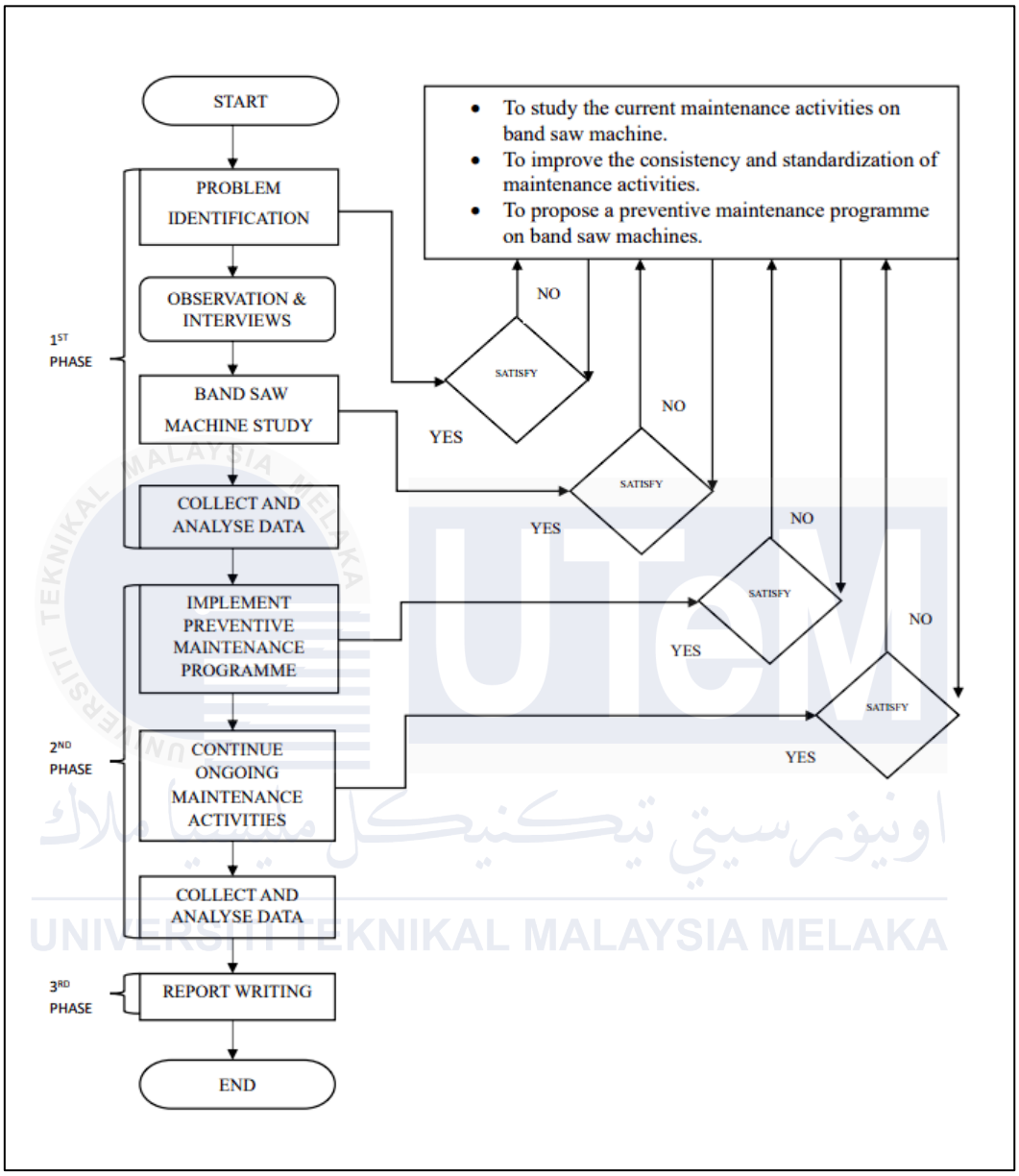

Figure 3.1 Flow Chart

3.3 Research Plan

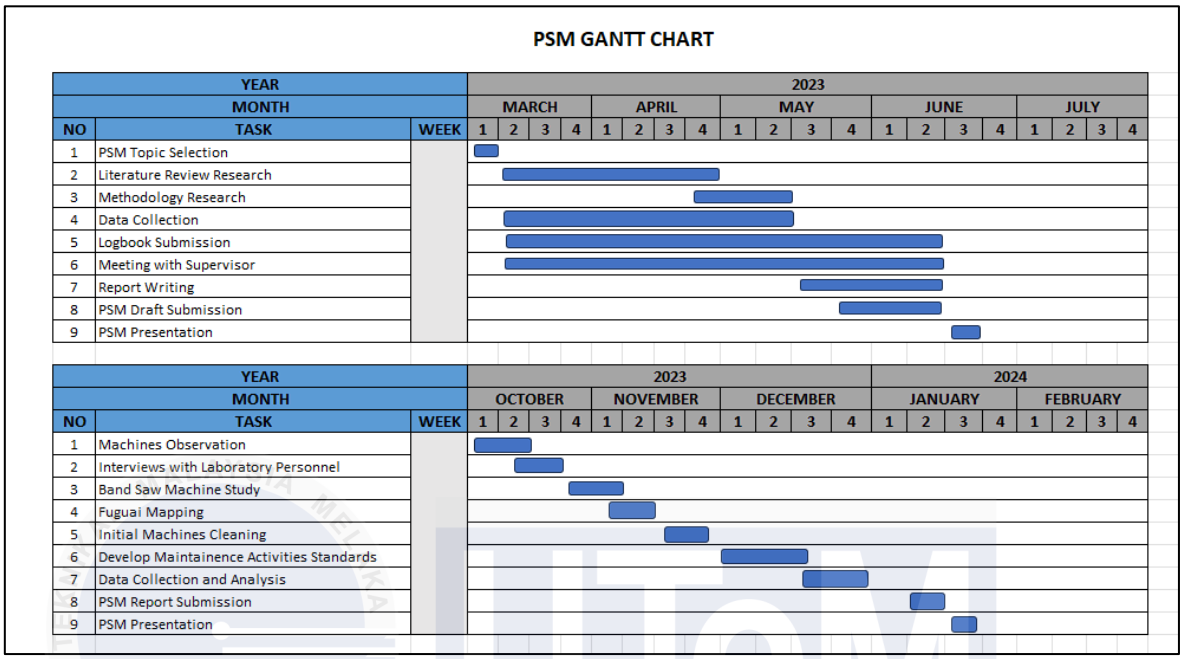

Figure 3.2 Gantt Chart

3.4 Observation

Observation is one of the methods in collecting primary data in problem identification. The purpose of observation is to evaluate the condition of band saw machines. Thus, from the evaluation, the band saw machines problem can be identified. The problems that need to be identified is the parts that contaminated with workpiece debris because it is considered as the factor that led to machine breakdown due to its capability of damaging machine. Besides, observation is used to identify the sources of contamination. Therefore, it can be eliminated to reduce the rate of contamination on band saw machines.

3.5 Semi Structured Interview

Semi structured interview is conducted to gather information related to the maintenance activities conduct on band saw machines such as the frequency of maintenance activities,

time spend on performing maintenance activities per machine and the standard of machine general housekeeping. It is conducted by asking several questions to the laboratory personnel through verbal communication. Then, the laboratory personnel answered and shared the information related to the questions given.

3.6 Study on Band Saw Machine

Before proceeding with the implementation of PM programme, the band saw machines in the Machining Laboratory are studied to gain understanding about the parts of the machine, specifications, operations procedure, and maintenance method. All this information is crucial to fully understand the band saw machine. Besides, it is able to help differentiate the difference between the band saw machines in Machining Technology Laboratory. This information is collected through study on band saw machine operation manual provided by the laboratory personnel.

3.7 Initial Cleaning

In implementing PM program, the first step performed is initial cleaning of band saw machine. It is conducted to detect any hidden defects on band saw machine. Hidden defects are the factors that could lead to machine breakdown means it is important to perform early detection of it. Besides, hidden defects could be the source of contamination on band saw machines which could continue contaminate the parts of the band saw machines. Initial cleaning is performed through inspection on band saw machines to identify contaminated parts. Later, cleaning is performed using proper tools prepared in the laboratory.

3.7.1 Fuguai Mapping

Fuguai mapping is an approach taken in performing in initial cleaning. It is purposed to indicate the parts that need to be clean or corrective action. As stated in literature review,

fuguai mapping is perform on the top, bottom, side, and base parts of the machine. Meanwhile, for this case study, fuguai mapping is conducted by placing only one F-Tag per machine. It is because the fuguai mapping in this case study is to indicate the condition of the machine in term of defects using the differences of F-Tag colour. The colours used for fuguai mapping is red, yellow, and green.

3.7.1.1 F-Tag

Figure 3.3 F-Tag

The meaning of each F-Tag color is explained in the following:

- Red F-Tag means the machine is broken and required high technical skills to solve it.
- Yellow F-Tag means the machine has a minor defect which could be solve independently.
- Green F-Tag means the machine has no defects and no action needs to be taken.

The contents of the tag explained in Table.

Table 3.1 F-Tag Explanation

No	Content	Description
1	Name	Name of the Machine
2	Equipment/Zone	Machine No and Zone Location
3	Reported by	The name of individual who tag the machine.
4	Defects	Explanation of Fuguai / Problem
5	Date	Date of F-Tag tagged
6	Corrective Action	Response to solve the defects identified.

3.8 Counter Measures to Source of Problems

This step is about an action taken to eliminate the source of contamination. In this step, the brainstorming of ideas needs to be performed to find a solution on method eliminate the source of contamination. The purpose it needs to be eliminated is to stop or reduce the contamination on band saw machine parts especially internal parts that related to the mechanism of band saw machine. If the parts are contaminated it could damage it and disrupt the operation of the band saw machine.

3.9 Develop Maintenance Activities Standards

Development of maintenance activities standards such as inspection, cleaning, lubricate, and adjustment are important because it helps to performed maintenance activities systematically. Besides, standardization of maintenance activities will enhance the consistency of maintenance activities in terms of time. In this step, development of maintenance activities is performed through the development of tools such as checklist, procedure, and schedule. All these tools are crucial in determining the effectiveness of PM implementation.

3.9.1 Develop Inspection and Cleaning Checklist

Checklist or check sheet for inspection and cleaning is developed to ensure that all the parts has been cleaned and inspected. It is also developed for maintenance activities documentation which could be the references.

3.9.2 Develop Maintenance Procedure

In this step, the procedure for performing maintenance is developed for maintenance activities because the procedure is used as a guideline in performing maintenance activities. Another purpose of developing procedure is to prevent mistakes in performing maintenance activities because it could cause defects on the machine if the maintenance is not properly performed.

3.9.3 Develop Schedule for Maintenance

Scheduled for maintenance is an important tool in performing maintenance because setting a duration of time for maintenance time improved the efficiency of maintenance activities. For this step, standardization of time to perform maintenance activities per machine is developed using a proper schedule. Besides, schedule for maintenance task also includes in the standardization of maintenance activities schedule.

3.10 Limitation of Proposed Methodology

a) Unexpected failures

Even if you have a thorough preventive maintenance program in place, there is still a chance that unexpected equipment failures or breakdowns can happen. Some issues may not be noticeable during routine inspections, and despite regular maintenance efforts, unforeseen situations or component failures can still occur.

b) Complexity and Technical Expertise

Certain equipment may require specialized technical knowledge and expertise for maintenance due to their complex requirements. This may involve seeking assistance from external service providers or ensuring access to skilled personnel. However, organizations that lack in-house expertise or face challenges in accessing external resources may encounter difficulties in acquiring and retaining the necessary skills and knowledge for proper maintenance tasks.

3.11 Summary

This chapter presents the proposed methodology to develop a new, effective and integrated approach in implementation preventive maintenance on band saw machine and Machining Technology Laboratory. The primary focus of the proposed methodology is to improve the maintenance practices applied on band saw machines and Machining Technology Laboratory. The methods proposed also intended to increase the lifespan of band saw machine and maintain the condition of the band saw machine to prevent machine breakdown. Besides, it is also purposely to create a safer environment for students and laboratory personnel who use Machining Technology Laboratory for lab activities or projects.

In general, the concept of implementing preventive maintenance on band saw machine and Machining Technology Laboratory is creating a more systematic workflow of the operation in the laboratory and more comprehensive maintenance practices on band saw machine. The preventive maintenance approach is applied to the maintenance practices on

band saw machines to enhance its performance and reliability. It is also applied to the workspace in the Machining Technology Laboratory. The next chapter shall now present the expected results from the study on implementation of preventive maintenance on Machining Technology Laboratory and band saw machine.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Observation

The observation was conducted on both machines and the condition of each part was differentiated into four categories such as clean, slightly contaminated, moderately contaminated, and highly contaminated. The contaminants of the machine are mostly workpiece debris such as metal.

- RR -250-V

Table 4.1 RR 250-V

No	Part	Condition
1	Saw Blade	Slightly contaminated
2	Band Wheel	Highly contaminated
3	Workpiece clamping mechanism	Moderately Contaminated
4	Cutting Distance Light Indicator	Clean
5	Operation Control Panel	Clean
6	Electrical Wiring and connection	Clean
7	Hydraulic Piping System	Slightly Contaminated
8	Coolant System & Piping	Slightly Contaminated
9	Machine Safety cover and guard	Slightly Contaminated
10	Whole Body	Slightly Contaminated

In Table 4.1, it shows the condition of each part related to machine RR 250-V during the observation. The condition of the machine parts was differentiated between four categories such as slightly contaminated, moderately contaminated, highly contaminated, and clean. Among 10 parts of the machine, there were 3 parts

clean, and 5 of them are slightly contaminated. Meanwhile, only one part each was moderately contaminated and highly contaminated.

- RR 180-B

Table 4.2 RR 180-B Condition

No	Part	Condition
1	Saw Blade	Slightly contaminated
2	Band Wheel	Highly contaminated
3	Workpiece clamping mechanism	Moderately Contaminated
4	Operation Control Panel	Clean
5	Electrical Wiring and connection	Clean
6	Hydraulic Piping System	Slightly Contaminated
7	Coolant System & Piping	Slightly Contaminated
8	Machine Safety cover and guard	Slightly Contaminated
9	Whole Body	Moderately Contaminated

By referring to Table 4.2, there were 9 parts on the machine. Among all the parts, there were only 2 of them were clean and another 4 were considered slightly contaminated. There were 2 parts that were moderately contaminated and only 1 was highly contaminated.

4.2 Semi-Structured Interviews

For interview sessions, there were 10 questions asked to the laboratory personnel related to the maintenance activities conducted in the laboratory. Besides, there were some questions related to the band saw machines used in the laboratory. The following list shows the questions given and their answers.

Figure 4.1 Interview with Laboratory Personnel

i) How many band saw machines are in this laboratory and what is the model of the band saw machine?

In this laboratory, there were two band saw machines used. Both machines were different models. The first one is PR 250-V and the second is PR 180-V. However, both machines are manufactured by the same manufacturer, which is GATE.

ii) In this laboratory, what do the common usages of the band saw machines?

Commonly band saw machines in the laboratory were used for cutting metals that are used for projects or laboratory activities.

iii) How frequently are the band saw machines in this laboratory used?

The average number of the band saw machines usage is about 4 times per week. It depends on the number of metals cutting operations required for material preparation.

iv) What kinds of maintenance activities were commonly performed on band saw machines?

Commonly for maintenance activities, we will perform inspection, cleaning, and lubricating on the machines. For lubricating, we used WD-40 spray lubrication for this task.

v) How frequently the maintenance activities were performed on the band saw machines?

The maintenance activities performed on band saw machines is about one time per month. However, the timing between latest maintenance activities and future maintenance are inconsistent because it depends on the condition of the machines.

vi) Do you have any record-keeping or documentation for maintenance activities conducted on band saw machines?

Yes, we did. We do have a record-keeping document such as checklist. Each time we perform maintenance activities, a checklist will be used for documentation purposes.

vii) Are maintenance procedures provided for conducting maintenance activities?

There was no procedure prepared for band saw machines maintenance. However, we do have its operation procedure provided in its workstation.

viii) Have there any band saw machines breakdown occur in the past?

Referring to the history of these both band saw machines, there was no breakdown happen before.

ix) Do band saw machines workstation general housekeeping performed?

Workstation housekeeping is a must, and it is performed every time after finishing metal cutting using these machines.

x) Do you have any information about the operation manual of these band saw machines?

For more information related to these band saw machines, it can be referred to the machine's operation manual. It contains information such as parts, specifications, safety and precautions, operation procedure, etc.

4.3 Band Saw Machine Data

There were two band saw machines in the Machining Technology Laboratory. Both machines are different in terms of their specifications. However, the parts are similar except for RR 250-V has more parts if compared with RR 180-B. All the parts, specifications and operation manual are stated below.

4.3.1 RR 250-V

Figure 4.2 RR 250-V Band Saw Machine

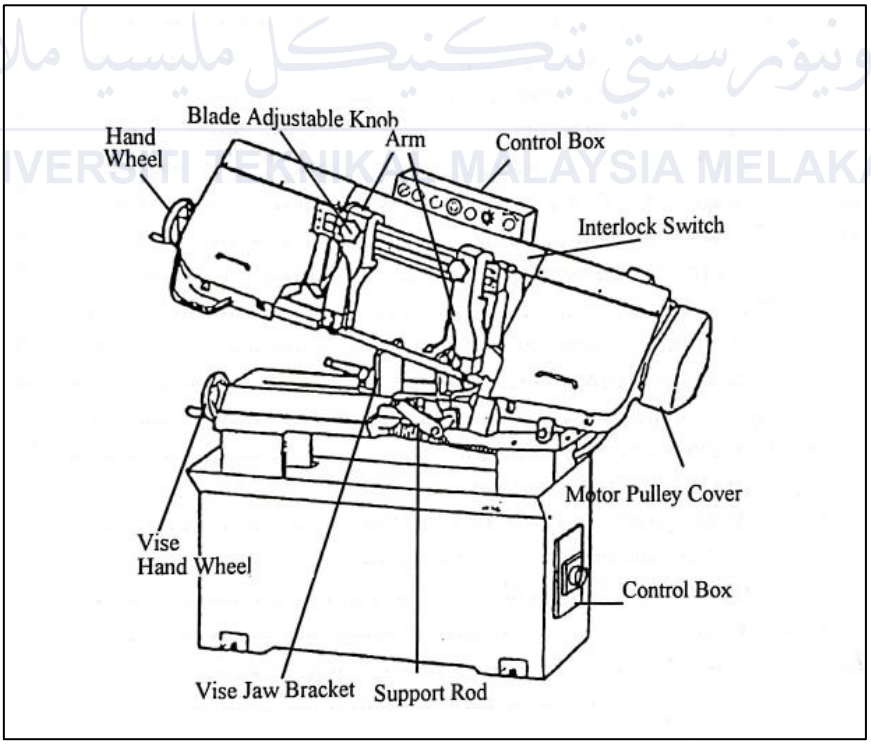

Figure 4.3 RR 250-V Parts

- Main Parts

No	Machine Parts	Quantity
1	Vise Hand Wheel	1
2	Blade Adjustable Knob	1
3	Arm	2
4	Control Box	1
5	Interlock Switch	1
6	Motor Pulley Cover	1
7	Band Wheel	2
8	Saw Blade	1
9	Coolant Pan	1
10	Coolant Piping	1
11	Coolant Tank	1
12	Vise Hand Wheel	1
13	Vise Jaw Bracket	1
14	Support Rod	1
15	Safety Cover	2

Figure 4.4 Main Parts

Based on Figure 4.4, there were 15 main parts of the machine (RR 250-V). Among all the parts, there were 3 different parts that have 2 components each attached to the machine. The part is Arm, Band Wheel, and Safety Cover. Meanwhile, the rest of the parts only have one component only.

- Specifications

Table 4.3 shows the specifications of the machine which includes the power of the machine, saw blade speed, blade size, dimension, packing and cutting capacity of the machine.

Table 4.3 Machine Specifications

Motor			2 HP	
Saw Blade Speed (for S model)			60Hz	35-60-88-115 MPM (114-196-288-377 FPM)
			50Hz	29-50-73-96 MPM (95-164-239-314 FPM)
Saw Blade Speed (for SV model)			60Hz	35~115 MPM (114~377 FPM)
			50Hz	29~96 MPM (95~314 FPM)
Blade Size (mm)			27 x 0.9 x 3090	
Dimension L × W × H (mm)			1720 x 620 x 1055	
Packing	N.W / G.W (kgs)		325 / 350	
	Measurement		1740 x 762 x 1143 mm	
Cutting Capacity	0°	○ (mm/inch)	250 / (10”)	
		□ (mm/inch)	127 x 468 (5 “x18 3/8”)	
	+ 45°	○ (mm/inch)	150 (6”)	
		□ (mm/inch)	175 x 239 (7 “x 9 3/8”)	

- Operation Procedure

The figures below show the machine operation procedure which explained the method of using the machine which includes hazards and safety precaution when using the machine.

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FAKULTI TEKNOLOGI KEJURUTERAAN	No Dokumen: JTKP/PK001/03	No Isu/ Tarikh: 1/9-10-2014
Tajuk: Band Saw RR250-V Machine Safe Operating Procedure	Disediakan: **Mohd Azimin**	Diluluskan: **En.Khahar bin Nordin**

The Band Saw Machine

A bandsaw is a power tool which uses a blade consisting of a continuous band of metal with teeth along one edge to cut various workpieces.

1 **HAZARDS :**

- High speed machinery with saw blade.
- Major damage to hands and finger.
- Hearing and eye damage.
- Trip hazards.

2 **PROTECTIVE EQUIPMENT AND EMERGENCY EQUIPMENT :**

- Eye protection ie safety glasses, goggles, visor.
- Safety boot and protective clothing.
- Hearing protection ie: ear muffs, ear plugs.
- Hair protection ie hair nets, if necessary.
- First aid equipment.

3 **BEFORE YOU START :**

- Ensure that the machine area is clean and free from off cuts.
- Ensure that the blade is correct type, is tensioned and tracks correctly.
- Ensure that table is square (at 90 degrees) to the blade.
- Ensure guides, thrust wheels and upper guide post is correctly adjusted.
- Ensure all guards are correctly positioned and secure.

1

Scanned with CamScanner

Figure 4.5 RR 250-V Operation Procedures

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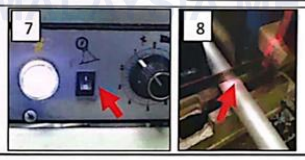
Tajuk: Band Saw RR250-V Machine Safe Operating Procedure	Disediakan: **Mohd Azimin**	Diluluskan: **En.Khahar bin Nordin**

4	**NEVER !!!** • Never attempt to remove off cuts from the table when saw is running. Stand on the right hand side of the band saw. • Never operate while under the influence of drugs, alcohol or medication. • Never wear gloves, neckties, jewelry or loose clothing.
5	**JOB STEPS :**

1. Switch 'ON' machine power supply. 2. Makesure the power light turning 'ON' .	
3. Makesure 'EMO' switch functioning .	
4. Manually lift up the top unit and put the workpiece into the vice. 5. Adjust the blade guide accordingly to the workpiece.	
6. Place the blade near to workpiece by bring down the top unit using cutting feeder feedrate controller. a) Cutting feeder On & Off switch. b) Cutting feeder variable speed controller.	
7. Turning on the red beam light switch. 8. Use red beam light as a guideline to set the cutting area.	

2

Figure 4.6 RR 250-V Operation Procedure

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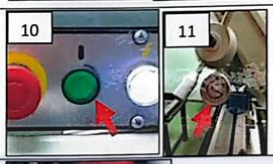
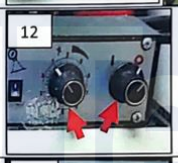
Tajuk: Band Saw RR250-V Machine Safe Operating Procedure	Disediakan: Mohd Azimin	Diluluskan: En.Khahar bin Nordin

9. Firmly clamp the workpiece. a) Turning the handle (CW) untill you feel the vice softly clamped the workpiece. b) Turn the lock handle to the left to firmly clamp the workpiece. *Workpiece not firmly clamp may damaged the workpiece and machine.*	
10. Press the bandsaw ON button to turn on the motor. 11. Check the bandsaw blade tension meter gauge. (18 to 22 KPSi) *Tension meter out of range may cause damaged on the machine.*	
12. Turn On the cutting feeder switch and adjusting the feeder feed rate to suitable speed accordingly to the workpiece material. *Unsuitable feedrate may cause damaged to the machine.*	
13. Turn ON the coolant system when the cutting process begin. *Turning on coolant pump with insuffient coolant level may damaged the coolant pump.*	
14. Adjust bandsaw motor speed to suitable cutting speed. (depend to the workpiece material) *Change speed only when the motor is running. DO NOT change speed when motor is stopped*	

3

Figure 4.7 RR 250-V Operation Procedure

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Tajuk: Band Saw RR250-V Machine Safe Operating Procedure	Disediakan: **Mohd Azimin**	Diluluskan: **En.Khahar bin Nordin**

	15. When workpiece completely cut, turn off the machine light switch as well as the feeder and coolant system . *Wait until rotating saw blade has completely stopped before handling work piece.*	
	16. Manually lift up the top unit. 17. Unclamp the workpiece and place back the balance of raw material to the appropriate place.	
	18. Manually flip up the bandsaw wheel guard cover and use brush to remove all cutting waste.	
	19. Perform overall cleanliness on the machine and machine area to keep the safety and lifespan of the machine.	
6	**WHEN YOU FINISH :** Always clean the area. There should be no cutting waste on the machine or floor. Use brush, regular broom, paper towels and provided cleaning solution. Place all tools used back in the appropriate place. Ensure to leave the machine area in a safe, clean and tidy state.	

Figure 4.8 RR 250-V Operation Procedure

4.3.2 PR 180 -V

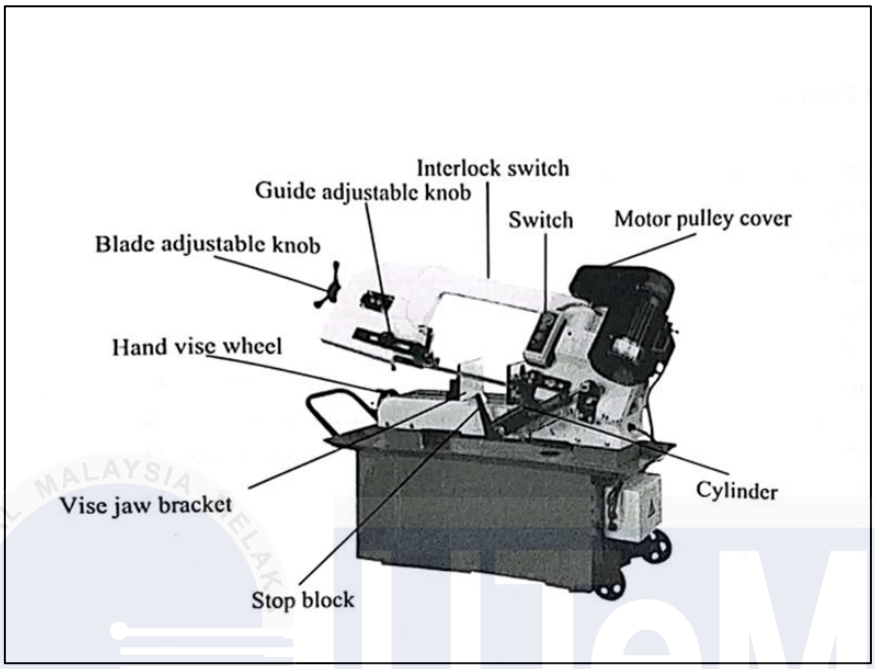


Figure 4.9 RR 180-B Parts

- Parts

Table 4.4 RR 180-B Parts

NO	Machine Parts	Quantity
1	Hand Wheel	1
2	Blade Adjustable Knob	1
3	Guide Adjustable Knob	2
4	Switch	1
5	Interlock Switch	1
6	Motor Pulley Cover	1
7	Band Wheel	2
8	Saw Blade	1
9	Coolant Pan	1
10	Coolant Piping	1
11	Coolant Tank	1
12	Vise Hand Wheel	1
13	Vise Jaw Bracket	1
14	Stop Block	1

Table 4.4 shows the main parts of the machine (RR-180-B). There were 14 parts in the machine and among two of them has two components each in term of quantity. The part is the Guide Adjustable Knob and Band Wheel. The rest of the parts have only one component only.

- Specifications

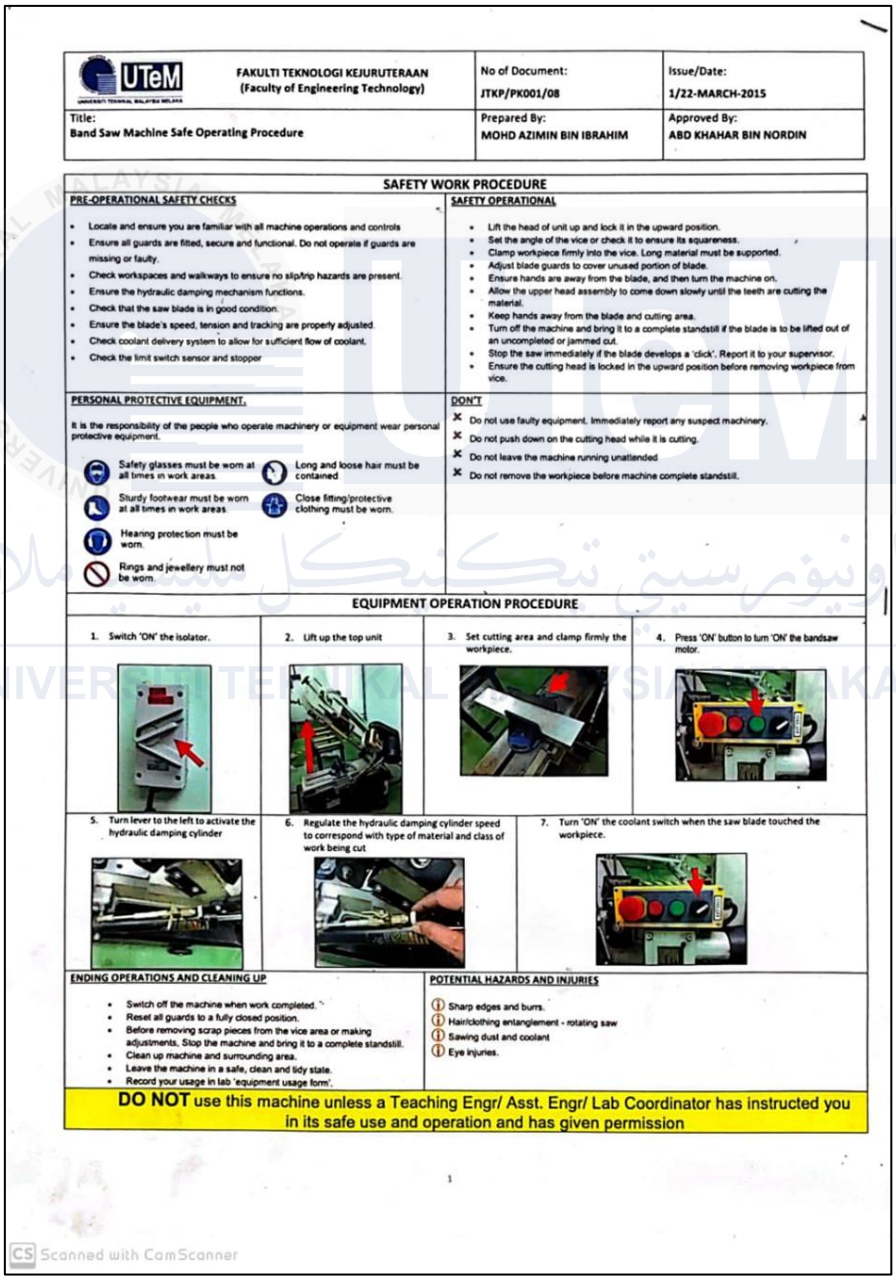
  The table below shows the specifications of the machine which includes the power of the machine, saw blade speed, blade size, dimension, packing measurement, net weight / gross weight, and working capacity of the machine. In terms of its power, it can be divided into two different power, 1 HP and 1.5 HP. Each motor has two different saw blade speed depending on the frequency.

Table 4.5 RR 180-B Specification

Motor		1HP		1.5 HP	
Saw Blade Speed (MPM)	919G (G9743)	60Hz	45 66 86	50Hz	38 55 72
	912B	60Hz	32 60 88 115	50Hz	26 50 73 95
Saw Blade Speed (FPM)	912G (G9743)	60Hz	148 216 282	50Hz	125 180 236
	912B	60Hz	105 196 288 377	50Hz	85 164 240 312
Blade Size (mm)		25 x 0.9 x 2655 mm (1"x0.035" x 104.5")			
Dimension L × W × H (mm)		1325 x 460 x 1080 (G) 1380 x 460 x 1050 (B)			
N.W / G.W (kgs)		170 / 200 (G) 160/185(B)			
Working Capacity		0°	○ mm	229(9")	
			□ mm	178x305(7"x12")	
		± 45°	○ mm	150(6")	
			□ mm	127x150(5"x6")	
Packing Measurement (mm) L x W x H		1450 x 660 x 1150(G) 1420 x 530 x 117(B)			
Noise		80 dB MAX			

- Operation Procedure

The figures below show the machine operation procedure which explained the method of using the machine which includes hazards and safety precaution when using the machine.



UTeM FAKULTI TEKNOLOGI KEJURUTERAAN (Faculty of Engineering Technology)	No of Document: JTKP/PK001/08	Issue/Date: 1/22-MARCH-2015
Title: Band Saw Machine Safe Operating Procedure	Prepared By: MOHD AZIMIN BIN IBRAHIM	Approved By: ABD KHAHAR BIN NORDIN

SAFETY WORK PROCEDURE

PRE-OPERATIONAL SAFETY CHECKS

- Locate and ensure you are familiar with all machine operations and controls
- Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.
- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Ensure the hydraulic damping mechanism functions.
- Check that the saw blade is in good condition.
- Ensure the blade's speed, tension and tracking are properly adjusted.
- Check coolant delivery system to allow for sufficient flow of coolant.
- Check the limit switch sensor and stopper

SAFETY OPERATIONAL

- Lift the head of unit up and lock it in the upward position.
- Set the angle of the vice or check it to ensure its squareness.
- Clamp workpiece firmly into the vice. Long material must be supported.
- Adjust blade guards to cover unused portion of blade.
- Ensure hands are away from the blade, and then turn the machine on.
- Allow the upper head assembly to come down slowly until the teeth are cutting the material.
- Keep hands away from the blade and cutting area.
- Turn off the machine and bring it to a complete standstill if the blade is to be lifted out of an uncompleted or jammed cut.
- Stop the saw immediately if the blade develops a 'click'. Report it to your supervisor.
- Ensure the cutting head is locked in the upward position before removing workpiece from vice.

PERSONAL PROTECTIVE EQUIPMENT.

It is the responsibility of the people who operate machinery or equipment wear personal protective equipment.

- Safety glasses must be worn at all times in work areas
- Long and loose hair must be contained
- Sturdy footwear must be worn at all times in work areas
- Close fitting/protective clothing must be worn.
- Hearing protection must be worn.
- Rings and jewellery must not be worn.

DON'T

- ✕ Do not use faulty equipment. Immediately report any suspect machinery.
- ✕ Do not push down on the cutting head while it is cutting.
- ✕ Do not leave the machine running unattended
- ✕ Do not remove the workpiece before machine complete standstill.

EQUIPMENT OPERATION PROCEDURE

1. Switch 'ON' the isolator.
2. Lift up the top unit
3. Set cutting area and clamp firmly the workpiece.
4. Press 'ON' button to turn 'ON' the bandsaw motor.
5. Turn lever to the left to activate the hydraulic damping cylinder
6. Regulate the hydraulic damping cylinder speed to correspond with type of material and class of work being cut
7. Turn 'ON' the coolant switch when the saw blade touched the workpiece.

ENDING OPERATIONS AND CLEANING UP

- Switch off the machine when work completed.
- Reset all guards to a fully closed position.
- Before removing scrap pieces from the vice area or making adjustments, Stop the machine and bring it to a complete standstill.
- Clean up machine and surrounding area.
- Leave the machine in a safe, clean and tidy state.
- Record your usage in lab 'equipment usage form'.

POTENTIAL HAZARDS AND INJURIES

- ⓘ Sharp edges and burrs.
- ⓘ Hair/clothing entanglement - rotating saw
- ⓘ Sawing dust and coolant
- ⓘ Eye injuries.

DO NOT use this machine unless a Teaching Engr/ Asst. Engr/ Lab Coordinator has instructed you in its safe use and operation and has given permission

1

Figure 4.10 RR 180-B Machine Operation Procedure

UTeM FAKULTI TEKNOLOGI KEJURUTERAAN (Faculty of Engineering Technology)	No of Document: JTKP/PK001/06	Issue/Date: 1/22-MARCH-2015
Title: Mitre Saw Safe Operating Procedure	Prepared By: MOHD AZIMIN BIN IBRAHIM	Approved By: ABD KHAHAR BIN NORDIN

SAFETY WORK PROCEDURE

PRE-OPERATIONAL SAFETY CHECKS

- Make sure that the machine or equipment is in good condition.
- Ensure you are familiar with all machine operations, controls, ON/OFF starter and Emergency Stop.
- Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.
- Check condition of saw blade – clean , blades sharp and not missing teeth etc.
- Check for cracks in the saw blade and report any you find.
- Remove adjusting keys and wrenches
- Keep the work area clean. Cluttered areas and benches invite accidents
- Reduce the risk of unintentional startup. Make sure saw switch is in OFF position before plugging in.

OPERATIONAL SAFETY CHECKS

- Only one person may operate this machine at any one
- Keep one hand on the trigger switch and handle and use the other hand to hold the stock against the fence.
- Keep hands out of the path of the blade.
- Ensure that the blade rotates in the correct direction.
- Allow motor to reach full speed before cutting
- Make sure an extra person is available to support long material when cutting
- Feed saw through at moderate rate

PERSONAL PROTECTIVE EQUIPMENT.

It is the responsibility of the people who operate machinery or equipment wear personal protective equipment.

- Safety glasses must be worn at all times in work areas.
- Sturdy footwear must be worn at all times in work areas
- Rings and jewellery must not be worn.
- Long and loose hair must be contained.
- Close fitting protective clothing must be worn.
- Hearing protection must be worn when using this machine.

DON'T

- ✕ Do not use faulty equipment. Immediately report any suspect machinery.
- ✕ Do not cut pieces smaller than 20 cm (8 in.) in length.
- ✕ Do not cut "free hand." The stock should lie solidly on the table against the fence.
- ✕ Do not reach around or behind the saw blade
- ✕ Do not take your hand away from the trigger switch and handle until the blade is fully covered by the lower blade guard.
- ✕ Do not overreach. Keep proper footing and balance at all times.
- ✕ Do not force the saw. The saw cuts better and more safely at the rate for which it was designed
- ✕ Do not leave the saw until it has stopped completely. Turn the power off and unplug the saw.
- ✕ Do not use electric tools in damp or wet locations.
- ✕ Do not operate electric tools near flammable liquids or in gaseous or explosive atmospheres. Sparks may ignite fumes.
- ✕ Do not cutting irregular stock, branches or wood with embedded nails or screws

EQUIPMENT OPERATION PROCEDURE

1. Plug in and switch 'ON' the equipment switch

2. Press down the holder and pull out the lock to release the top

3. Lock firmly the workpiece against the fence

4. Grip the trigger switch and press down the holder to start cutting the workpiece

ENDING OPERATIONS AND CLEANING UP

- Switch off the machine when work completed.
- Clean up all excessive cutting waste and dust immediately.
- Leave the machine in a safe, clean and tidy state.
- Record your usage in lab 'equipment usage form'.

POTENTIAL HAZARDS AND INJURIES

- ⓘ Hot metal.
- ⓘ Sparks.
- ⓘ Noise.
- ⓘ Sharp edges and burrs.
- ⓘ Hair/clothing getting caught in moving machine parts.
- ⓘ Kickback – work piece may catch or jam and be flung back violently
- ⓘ Eye injuries.
- ⓘ Airborne dust & splinters
- ⓘ Contact with blade at point of operation

DO NOT use this machine unless a Teaching Engr/ Asst. Engr/ Lab Coordinator has instructed you in its safe use and operation and has given permission

Figure 4.11 RR 180-B Machine Operation Procedure

4.4 Initial Cleaning

For initial cleaning, the results are shown in the table below.

Table 4.6 Initial Cleaning (Before & After)

Machines	Before	After
RR 250-V	 	 
RR 180-B	 	 

4.4.1 Fuguai Mapping

Figure 4.12 F-Tag tagged on band saw machines.

Table 4.7 Number of F-Tag before intial cleaning.

	Green	Yellow	Red
RR 250-V	0	1	0
RR 180-B	0	1	0

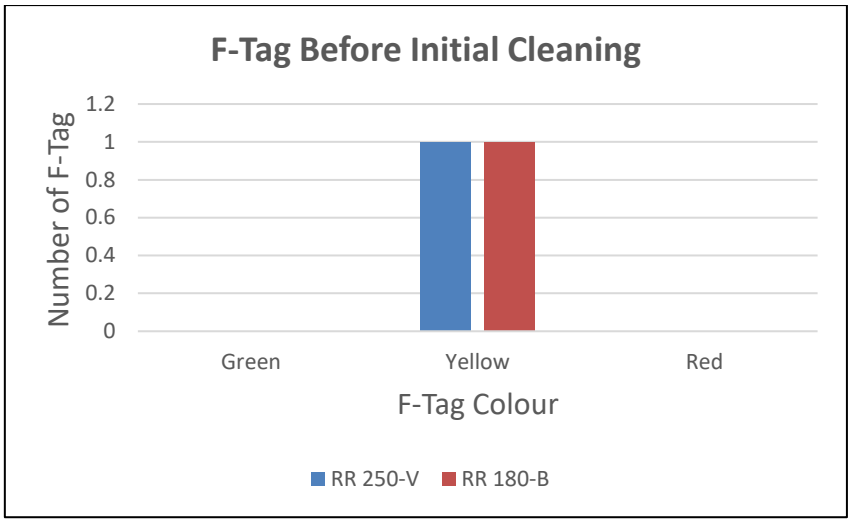


Figure 4.13 Bar Graph of F-Tag

Based on Table 4.5 and Figure 4.12, it shows that each machine was tagged with yellow F-Tag before initial cleaning. The data shows that each machine was tagged with 1 yellow tag per machine. It is because both machines were contaminated with workpiece debris which means it required to be cleaned.

4.5 Counter Measures to Sources of Contamination

Based on the results obtained from the initial cleaning phase, the source of contamination was from the cutting operation performed on both band saw machines. Due to the mechanism of the machines, approaches such as installing additional parts into the bandsaw machines were not able to be taken. However, it still can be eliminated through cleaning activities each time after using the machine.

4.6 Maintenance Activities Standards

The approach taken to set the standards for maintenance activities for band saw machines is by developing PM Checklist, maintenance schedule and procedures.

4.6.1 Weekly Preventive Maintenance Checklist

The purpose of preventive maintenance checklist is to record all the preventive maintenance activities conducted on the machines for documentation purposes and references. It contains the activities needed to perform and the parts of the machines. Besides, the machine model, date, week, and name of the operator are also included in the checklist. The purpose of the remarks in the checklist was to record the details of the problem identified when maintaining the machine. The details of the parts were stated in Table 4.6.

BANDSAW MACHINE CHECKLIST

MACHINE: Bandsaw Gate RR250-V #741		DATE:			WEEK			BY:	
No	Items	CHECK	CLEAN	LUBRICATE	TIGHTEN	ALIGN	CHANGE	REPAIR	REMARKS
1	Saw Blade								
2	Band Wheel								
3	Workpiece clamping mechanism								
4	Cutting distance light indicator								
5	Operation control panel								
6	Electrical wiring and connection								
7	Hydraulic piping system								
8	Coolant system & piping								
9	Machine safety cover and guard								
10	Whole Body General Housekeeping								

MACHINE: Bandsaw Gate RR180-B #742		DATE:			WEEK			BY:	
No	Items	CHECK	CLEAN	LUBRICATE	TIGHTEN	ALIGN	CHANGE	REPAIR	REMARKS
1	Saw Blade								
2	Band Wheel								
3	Workpiece clamping mechanism								
4	Operation control panel								
5	Electrical wiring and connection								
6	Hydraulic piping system								
7	Coolant system & piping								
8	Machine safety cover and guard								
9	Whole Body General Housekeeping								

Figure 4.14 Band Saw Machine PM Checklist

Table 4.8 Parts Explanation in PM Checklist

No	Parts in PM Checklist	RR 250-V	RR 180-B
		Parts	
1	Saw Blade	Saw Blade	Saw Blade
		Blade Adjustable Knob	Blade Adjustable Knob
2	Band Wheel	Band Wheel	Band Wheel
3	Workpiece Clamping Mechanism	Vise Hand Wheel	Vise Hand Wheel
		Vise Jaw Bracket	Vise Jaw Bracket
		Support Rod	Stop Block
4	Cutting Distance Light Indicator	Distance Light Indicator	-
5	Operation Control Manual	Control Box	Switch
6	Electrical Wiring System	Interlock Switch	Interlock Switch
		Motor Pully Cover	Motor Pulley Cover
7	Hydraulic Piping System	Hydraulic	Hydraulic
8	Coolant System & Piping	Coolant Pan	Coolant Pan
		Coolant Tank	Coolant Tank
		Coolant Piping	Coolant Piping
9	Machine Safety cover & Guard	Safety Cover	-
10	Whole Body General Housekeeping	Machine Workstation	Machine Workstation

4.6.2 Maintenance Procedures

Laboratory:	Machining Technology Lab	Zone	Zone D
Prepared by:	Marcel Anak Micheal	Approved by:	

BAND SAW MACHINE MAINTENANCE ACTIVITIES PROCEDURES

Safety and Precautions

- **Always wear safety shoes and laboratory jacket when performing maintenance.**
- **Disconnect the machine from power source before performing maintenance activities.**
- **Clean the workstation after performing cleaning.**
- **Keep the work are clean.**

Inspection Procedure	Info	
1. Check the condition of band saw machines. 2. Ensure each part of the machine stated in the followings list are checked. The list of part: • Vise Hand Wheel • Coolant Tank • Coolant Piping • Coolant Pan • Band Wheel • Saw Blade • Support Rod / Stop Block • Vise Jaw Bracket 3. Identify and differentiate the parts that require cleaning, adjustment, and lubricating. 4. Finally, tag the machine using F-Tag and fill in the information in the tag.	Inspection Time per machine	10 mins
	Total number of Machines	2
	F- Tag Information: • Green – No defects • Yellow – Minor defects • Red – Major Defects	

Cleaning and Lubrication Procedure		
1. Clean the parts that require cleaning using proper tools. 2. Remove all the contaminants from the parts. 3. Refill the coolant into the coolant tank. 4. Tighten the parts that loose. 5. Lubricate the parts that require lubrication. 6. Change the parts that require changing.	Time per machine	30 mins
	Total number of machines	2
	Maximum level of coolant	10 L
	Lubricant Type	WD-40
	Coolant Type	Tap Water

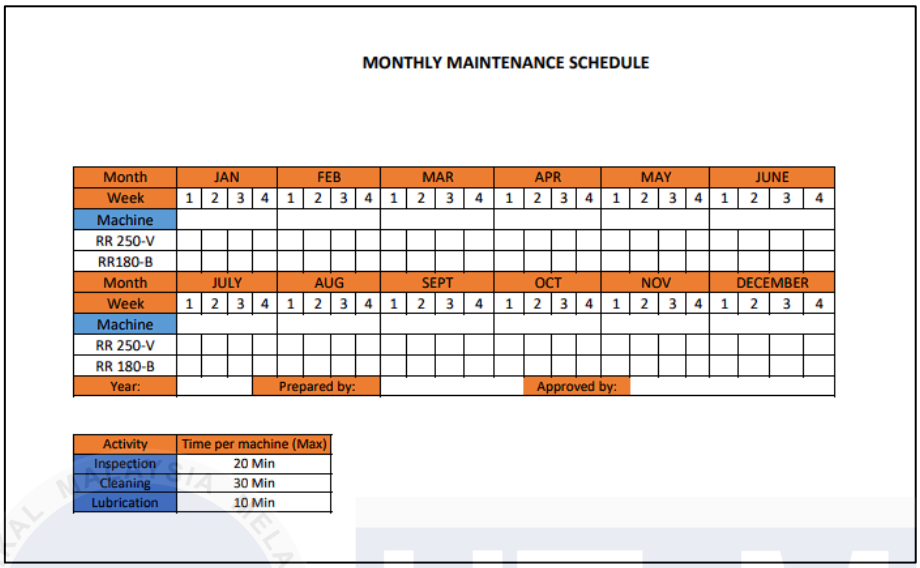
Reminder

- Tag the machines using the proper F-Tag Colour by referring to its condition.
- Record all the conducted task using checklist.

Figure 4.15 Maintenance Procedure

In Figure 4,14, it shows the procedure in performing inspection, cleaning, and lubrication process. Besides, safety and precautions were stated in the procedures including other information such as type of coolant, lubricant type, level of coolant, number of machine and time to perform task.

4.6.3 Monthly Maintenance Schedule



MONTHLY MAINTENANCE SCHEDULE

Month	JAN				FEB				MAR				APR				MAY				JUNE			
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Machine																								
RR 250-V																								
RR180-B																								
Month	JULY				AUG				SEPT				OCT				NOV				DECEMBER			
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Machine																								
RR 250-V																								
RR 180-B																								
Year:					Prepared by:								Approved by:											

Activity	Time per machine (Max)
Inspection	20 Min
Cleaning	30 Min
Lubrication	10 Min

Figure 4.16 Monthly Maintenance Schedule

Figure 4.15 shows the monthly maintenance schedule for preventive maintenance activities on the machine. The purpose of it is to track the consistency of PM activities conducted on both machines by weekly span of time. Besides, the time required to perform each activity such as inspection, cleaning and lubricating is also included in the schedule. It is to standardize the duration of PM activities performed for each machine.

4.7 Conclusion

As a conclusion, the implementation of preventive maintenance program is successful because through development of tools such as checklist, schedule, and procedure, the maintenance work conducted on band saw machine in laboratory standardized. Through standardization of maintenance activities on Band Saw Machine RR 250-V and RR 180-B, the maintenance task becomes more efficient and smoothens the workflow of maintenance on each machine. Thus, based on the results shown, the objective of thesis is achieved.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this case study, the advantages of implementing PM program on both band saw machines, RR 250-V and RR 180-D are studied. We can conclude that through implementation of PM program, the maintenance workflow for both band saw machines becomes more systematic. Besides, the development of maintenance schedule enhances the consistency of maintenance on both band saw machines. Development of PM Checklist and maintenance procedure document made the record-keeping activities for maintenance work become more effective.

Thus, through all the data obtained in this case study, the main objectives were achieved. Firstly, the objective to study the current maintenance practices on band saw was completed from the results of observation and semi-structured interviews. Secondly, the objective to improve and standardized maintenance activities on band saw machine achieved as well. It is shown through the development of maintenance practices standards such as checklist, schedule and procedure. Lastly, the objective to propose the implementation of PM program was also achieved as proposal was approved in PSM 1.

5.2 Recommendation

Preventive maintenance program needs to be continuously conducted on both band saw machines. It is because to prevent one or both machines from breakdown. If a breakdown happens, the process of material cutting operation will be delayed which means the required material for laboratory or projects can be obtained on time.

Lastly, the implementation of preventive maintenance should be conducted on all machines on FTK Campus because all the machines are important for educational purposes. Besides, if it is not implemented, the possibility of machine breakdown on campus is high because preventive action is not taken to maintain the efficiency of all machines.

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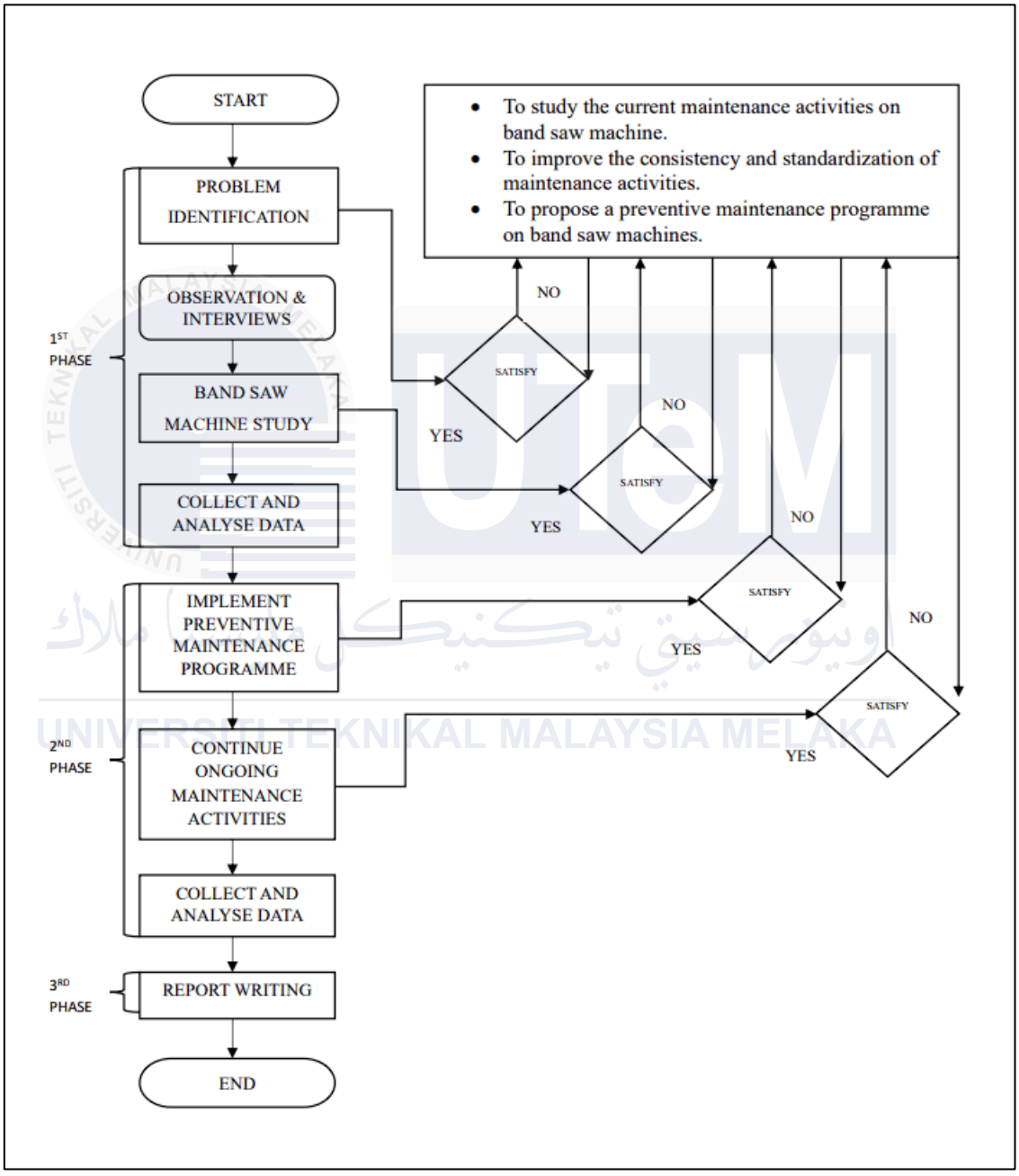
APPENDICES

APPENDIX A Flow Chart.



APPENDIX B Gantt Chart

PSM GANTT CHART

YEAR			2023																			
MONTH			MARCH				APRIL				MAY				JUNE				JULY			
NO	TASK	WEEK	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	PSM Topic Selection																					
2	Literature Review Research																					
3	Methodology Research																					
4	Data Collection																					
5	Logbook Submission																					
6	Meeting with Supervisor																					
7	Report Writing																					
8	PSM Draft Submission																					
9	PSM Presentation																					

YEAR			2023												2024							
MONTH			OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
NO	TASK	WEEK	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	Machines Observation																					
2	Interviews with Laboratory Personnel																					
3	Band Saw Machine Study																					
4	Fuguai Mapping																					
5	Initial Machines Cleaning																					
6	Develop Maintainence Activities Standards																					
7	Data Collection and Analysis																					
8	PSM Report Submission																					
9	PSM Presentation																					

BANDSAW MACHINE CHECKLIST

MACHINE: Bandsaw Gate RR250-V #741		DATE:			WEEK			BY:	
No	Items	CHECK	CLEAN	LUBRICATE	TIGHTEN	ALIGN	CHANGE	REPAIR	REMARKS
1	Saw Blade								
2	Band Wheel								
3	Workpiece clamping mechanism								
4	Cutting distance light indicator								
5	Operation control panel								
6	Electrical wiring and connection								
7	Hydraulic piping system								
8	Coolant system & piping								
9	Machine safety cover and guard								
10	Whole Body General Housekeeping								

MACHINE: Bandsaw Gate RR180-B #742		DATE:			WEEK			BY:	
No	Items	CHECK	CLEAN	LUBRICATE	TIGHTEN	ALIGN	CHANGE	REPAIR	REMARKS
1	Saw Blade								
2	Band Wheel								
3	Workpiece clamping mechanism								
4	Operation control panel								
5	Electrical wiring and connection								
6	Hydraulic piping system								
7	Coolant system & piping								
8	Machine safety cover and guard								
9	Whole Body General Housekeeping								

APPENDIX D Maintenance Procedure

Laboratory:	Machining Technology Lab	Zone	Zone D
Prepared by:	Marcel Anak Micheal	Approved by:	

BAND SAW MACHINE MAINTENANCE ACTIVITIES PROCEDURES

Safety and Precautions

- **Always wear safety shoes and laboratory jacket when performing maintenance.**
- **Disconnect the machine from power source before performing maintenance activities.**
- **Clean the workstation after performing cleaning.**
- **Keep the work are clean.**

Inspection Procedure	Info	
1. Check the condition of band saw machines. 2. Ensure each part of the machine stated in the followings list are checked. The list of part: • Vise Hand Wheel • Coolant Tank • Coolant Piping • Coolant Pan • Band Wheel • Saw Blade • Support Rod / Stop Block • Vise Jaw Bracket 3. Identify and differentiate the parts that require cleaning, adjustment, and lubricating. 4. Finally, tag the machine using F-Tag and fill in the information in the tag.	Inspection Time per machine	10 mins
	Total number of Machines	2
	F- Tag Information: • Green – No defects • Yellow – Minor defects • Red – Major Defects	

Cleaning and Lubrication Procedure		
1. Clean the parts that require cleaning using proper tools. 2. Remove all the contaminants from the parts. 3. Refill the coolant into the coolant tank. 4. Tighten the parts that loose. 5. Lubricate the parts that require lubrication. 6. Change the parts that require changing.	Time per machine	30 mins
	Total number of machines	2
	Maximum level of coolant	10 L
	Lubricant Type	WD-40
	Coolant Type	Tap Water

Reminder

- Tag the machines using the proper F-Tag Colour by referring to its condition.
- Record all the conducted task using checklist.

APPENDIX E Maintenance Schedule

MONTHLY MAINTENANCE SCHEDULE

Month	JAN				FEB				MAR				APR				MAY				JUNE			
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Machine																								
RR 250-V																								
RR180-B																								
Month	JULY				AUG				SEPT				OCT				NOV				DECEMBER			
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Machine																								
RR 250-V																								
RR 180-B																								
Year:					Prepared by:								Approved by:											

Activity	Time per machine (Max)
Inspection	20 Min
Cleaning	30 Min
Lubrication	10 Min

APPENDIX F F-TAG