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AMIRUL AIZAT BIN ADZMAN

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Autonomous Maintenance For Lathe Machine (Model: Optimum D-420)

Amirul Aizat Bin Adzman

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AMIRUL AIZAT BIN ADZMAN

A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this Choose an item. entitled " Autonomous Maintenance For Lathe Machine (Model: Optimum D-420)" 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	:	*AMIRUL AIZAT BIN ADZMAN*
Date	:	18 JAN 2022

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 : *PROFESSOR MADYA TS. DR. WAN HASRULNIZZAM BIN WAN MAHMOOD*

Date : 18/1/2022

DEDICATION

Alhamdulillah

Praise be to Allah for providing me with the strength, direction, and knowledge necessary to accomplish my research.

&

To my adoring parents and families, I want to express my gratitude for their unwavering support.

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To my supervisor, Professor Madya TS. DR. Wan Hasrulnizzam Bin Wan Mahmood for guiding and advising me throughout this project.

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To everyone who has helped me along the way

ABSTRACT

This project is performed based on analysis of autonomous maintenance for Lathe Machine (Model: Optimum D-420). Analysis of abnormalities for lathe machine is a way to detect fuguai or abnormalities that occurring on the lathe machine (Model: Optimum D-420). Therefore, autonomous maintenance like a flow of programme approach will help to prevent the lathe machine from breakdown by reacting faster and know how to do the maintenance personnel to prevent long-term breakdown. However, that will be affected the cost of sustain maintenance for the lathe machine. AM also represents for the user to understand and appreciate the function of the machine. Thus, the benefit of this approach is that it reduces maintenance costs and time by detecting and identifying which parts should be maintained and which maintenance actions should be performed. Although, the problem will occur if the machine cannot be used in the learning centre and it will impact all new users who want to learn on how to operate a lathe machine. The reason for the knowledge of autonomous maintenance and function of the lathe machine is to make sure to fulfill all the requirements that the user wants. From this research, the process of proposing best practices for eliminating fuguai as require in the basic AM programme by using fuguai tags or (F-tags). F-tags represent to place area where abnormalities are found on the lathe machine. Besides, the F-tags are divided into three categories such as physical, safety, and function of the problem description. It also states the machine type and the date of abnormalities. Lastly, autonomous maintenance is a preventive maintenance method that emphasizes the "man-machine" interaction in order to successfully conduct the following tasks such as cleaning, lubricating, and tightening. The approach supports the maintenance engineering team in implementing an autonomous maintenance strategy with their production assets in a precise way.

Keywords: Autonomous Maintenance (AM), *Fuguai*, Lathe machine, *Fuguai* tags (F-tags)

ABSTRAK

Projek ini dilakukan berdasarkan analisis penyelenggaraan autonomi untuk Mesin Larik (Model: Optimum D-420). Analisis keabnormalan bagi mesin pelarik adalah satu cara untuk mengesan fuguai atau keabnormalan yang berlaku pada mesin pelarik (Model: Optimum D-420). Oleh itu, penyelenggaraan autonomi seperti pendekatan aliran program akan membantu untuk mengelakkan mesin pelarik daripada rosak dengan bertindak balas lebih cepat dan mengetahui cara melakukan kakitangan penyelenggaraan untuk mengelakkan kerosakan jangka panjang. Walau bagaimanapun, itu akan menjejaskan kos penyelenggaraan berterusan untuk mesin pelarik. AM juga mewakili untuk pengguna memahami dan menghayati fungsi mesin tersebut. Oleh itu, faedah pendekatan ini ialah ia mengurangkan kos dan masa penyelenggaraan dengan mengesan dan mengenal pasti bahagian mana yang harus diselenggara dan tindakan penyelenggaraan yang harus dilakukan. Walaupun, masalah akan berlaku jika mesin tidak boleh digunakan di pusat pembelajaran dan ia akan memberi kesan kepada semua pengguna baharu yang ingin belajar tentang cara mengendalikan mesin pelarik. Sebab pengetahuan penyelenggaraan autonomi dan fungsi mesin pelarik adalah untuk memastikan untuk memenuhi semua keperluan yang dikehendaki pengguna. Daripada penyelidikan ini, proses mencadangkan amalan terbaik untuk menghapuskan fuguai seperti yang diperlukan dalam program AM asas dengan menggunakan tag fuguai atau (F-tag). F-tag mewakili untuk meletakkan kawasan di mana keabnormalan ditemui pada mesin pelarik. Selain itu, F-tags dibahagikan kepada tiga kategori seperti fizikal, keselamatan, dan fungsi huraian masalah. Ia juga menyatakan jenis mesin dan tarikh keabnormalan. Akhir sekali, penyelenggaraan autonomi ialah kaedah penyelenggaraan pencegahan yang menekankan interaksi "man-machine" untuk berjaya menjalankan tugas berikut seperti pembersihan, pelinciran dan pengetatan. Pendekatan ini menyokong pasukan kejuruteraan penyelenggaraan dalam melaksanakan strategi penyelenggaraan autonomi dengan aset pengeluaran mereka dengan cara yang tepat.

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Unfortunately, there were various challenges in coordinating the project's efforts, but I am grateful to Prof for his advice and constant supervision, as well as for supplying vital project information and help in completing the projects. His constant patience for guiding and providing priceless insights will forever be remembered. Also, thank you to my wonderful mother, Mrs Rasemah, who has always supported and prayed for my journey. My warmest appreciation goes to all my friends for all their help and assistance.

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AM	-	Autonomous Maintenance
Fuguai	-	Abnormalities
F-tags	-	*Fuguai* Tags
PM	-	Preventive Maintenance
KPI	-	Key Performance Indicator
SOP	-	Standard Operating Procedure

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Autonomous Maintenance (AM) is fundamental to the Japanese word, Jishu Hozen is a maintenance method in which machine operatives monitor, adjust, and conduct small maintenance routines on their machines continuously. This can be done more willingly than assigning a professional maintenance technician to undertake protection and maintenance regularly. It is one of the major contributions of the Japanese industry to industrial maintenance. AM programme plays a critical role in the maintenance of involves empowering plant students in conducting equipment checks and basic maintenance tasks that would normally be performed by an engineer with referring to (SOP) standard operating procedure (Y. Chen, 2021). AM also can develop the knowledge and ownership of the users to make them able to face more complex problems related to safety quality and productivity. According to S. Ferreira (2020), AM is one of the purposes to provide users of the lathe machine with knowledge and responsibility for basic maintenance tasks like cleaning, lubrication, and inspection. P. Guariente (2017) stated initial cleaning and inspection implement AM, and the user of the lathe machine must start cleaning and inspecting the machine for failures. Through cleaning, the user can inspect the machine to find *fuguai* on the machine.

In addition, it ensures that the machine is restored to its best performance by identifying and eliminating signs of *fuguai* machine function. Cleaning in hard-to-reach areas is important to discover hidden abnormalities in machine functions. After using the *fuguai* tag, the user can use the tag on the part that looks *fuguai*. Initial cleaning and inspection must be accompanied by the maintenance department. It represents a maintenance method in which machines and users can undertake basic maintenance tasks without maintenance personnel (N. Sihag, 2019). This pillar emphasizes the need for users to be educated and competent of doing simple maintenance tasks, allowing trained maintenance professionals to focus on higher-value activities and technical improvements.

Next, users are responsible for maintaining their machines to keep them in good condition. Then, AM programme calls for continuous equipment activity, flexible users to manage or repair other equipment, the elimination of source faults by active employee involvement, and the stepwise implementation of AM operations. Moreover, the effectiveness of AM is to aim at each step of equipment and human terms. The purpose of the AM's activity pillar as with others is focused on the elimination of losses. By cycling through continuous improvement, the optimal process conditions can be established for the exposure elimination and control of hidden defects. AM also increases the availability of high skill in task maintenance, reduction in labor cost, and reduction in unplanned maintenance.

At Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan (FTKMP), Universiti Teknikal Malaysia Melaka (UTeM) has a lot of machines that use variety types of lathe machine, such as Optimum D-420 and GH-1440W. It is important to apply for AM programme in the lathe machine since it can shorten user's task and work, plus it can identify the *fuguai* of the lathe machine. Students are the most useful of lathe machines at FTKMP, especially those who are new in UTEM and not familiar with AM and the machine. Because of that, they need to be educated on what is AM and how to eliminate *fuguai* for lathe machines by AM approach properly in their learning centre.

1.2 Problem Statement

This project will be more focusing on eliminating *fuguai* as require in AM programme for lathe machine (Model: Optimum D-420). The Optimum D-420 is one of the machines that regularly used in the laboratory of FTKMP in UTeM. The machine's operation may be harmed if the maintenance is not conducted properly and it might cause a lot of errors, plus the cost of sustain maintenance can be affected with a large amount of money. If the machine cannot be utilized, it will have an impact on all users who want to learn on how to operate a lathe machine. Most lathe machine users are individuals who are new to UTeM, which can be referring to new students. It is critical to apply proper maintenance on the lathe machine to have good quality and maintain the performance of the machine from time to time. AM is a concept that encourages or trains users to do daily routine maintenance tasks such as cleaning and inspecting (J. Alhilman, 2019). Hence, to avoid the machine becomes more problematic in the upcoming, (AM) should be applied. Different theories exist in the literature regarding maintenance management also constantly encountered with an effort to be identified as a less important aspect of complex organization management (Antosz, 2018) and reduce the number of accidents and increase the morale of the employees (Sharma, 2018).

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1.3 Project Objectives

The specific objectives of this project are:

a) To investigate the *fuguai*/abnormality for the lathe machine (Model: Optimum D-420).

b) To determine appropriate an AM programme for the lathe machining in the learning centre (Model: Optimum D-420).

c) To propose best practice for eliminating fuguai as require in the basic AM programme especially for lathe machining learning centre (Model: Optimum D-420).

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1.4 Scope of Project

The emphasis of this project is concentrating on the establishment of an AM programme that will be developed by the student and the user of the lathe machining (Model: Optimum D-420) learning centre at FTKMP. The model of the lathe machine that will be used for this project is Optimum D-420 since it is currently use in the learning centre machine of FTKMP in UTeM. This project is conducted under the guidance of a laboratory assistant that will propose to appropriate an AM, which are the development of safety for operations, the practice of inspection schedules, quick react of the problem for reducing the abnormalities and zero product defects, are addressed in this project. This project will take about a year to complete, started from March 2021. The data collection will acquire from primary and secondary sources. A detailed explanation about data collection will be found in Chapter 2 and Chapter 3.

1.5 Scope of Project

The importance of this study are as follows:

- To propose the well-maintained for the lathe machine in the learning centre of the UTeM (Model: Optimum D-420).
- Exposed the student to evaluate the best practice and detects an abnormality for the lathe machine (Model: Optimum D-420).
- Provide a safe and clean environment for the lathe machines in the learning centre of UTeM.
- Will be a reference for academic studies which is related to AM programme.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Autonomous Maintenance (AM) programmed require that every user of the lathe machine can react quickly inspect the fuguai to maintain their machines and equipment. According to Pinto et. al. (2020) stated that AM procedure and Preventive Maintenance (PM) plans have been developed with a well-defined schedule. For example, it will be responsible for simple tasks such as measuring pressure and tension, adjusting sensors, lubricating, and cleaning. In addition, technical training will prepare them to spot any changes and troubleshoot them quickly. In other words, users are encouraged to keep their assets in top condition. Similarly, J. Furman (2020) found that a step in AM is a preparation of employees, initial clean-up of measures, take countermeasures, fix tentative standards, general inspection, standardization, and autonomous management. There have been several published examples showing the impact of user and related maintenance in optimizing less time, response time, and efficiency.

In conventional maintenance programs, a machine or a section of equipment can run until it fails or achieves preventive maintenance (PM), and then maintenance is responsible for fixing it. The AM implementation is following the completion of this training programmed, which includes knowledge of basic analyst will work and normal daily maintenance (Yassin, 2020). So, it can also provide AM for requires system by users to do basic maintenance such as lubrication, safety inspections, fixture and cover protection tightening or securing, washing, and inspection to serve as first thing as maintenance workers in avoiding breakdowns and responding quickly if a specific failure has been observed using the "eyes and ears" of seeing and listening to the machine's motion, or rhythm. Since AM gives users a few responsibilities and special training as well as certain system modifications to make cleaning and maintenance will be easier. This would help the users get a greater understanding of how to handle and even improve the facilities of the lathe machine.

2.2 Autonomous Maintenance

In the new era of technology which is most organizations are investing a lot of money in hiring, training, and developing highly skilled maintenance teams to determine why critical assets fail and then perform renovations. Furthermore, AM also aims to free these technicians from performing low-skilled tasks such as inspection, lubrication, and minor adjustments. Among other things, AM brings four major benefits to the organization. Firstly, the biggest benefit is to reduce labor costs. This includes reducing the inefficiencies associated with travel time and waiting availability. Shrestha (2018) found that many companies around the world have been modernizing and using more and more technological resources to meet their customers and better manage the supply chain. It can be seeking to increase the competitiveness and the efficiency of deliveries and availability of products.

Then, AM also keeping the user always beware of the machine and a problem can be greatly reduced. Besides, another benefit of AM is that it increases the availability of highly skilled maintenance personnel, so they may be inclined to more critical needs. One study by Huang et. al. (2017) the tendency among manufacturers is to spend in the installation of high-quality machines, the hiring of high-skill personnel, or the use of advanced maintenance technologies in order to increase product quality and production effectiveness.

It also can conclude that management of maintenance includes both of ‘technical’ and ‘control’ aspects, which is AM the most staff-intensive maintenance department can handle critical issues without sacrificing routine maintenance. It also can increase the availability of highly skilled maintenance technology.

2.3 Concept of AM

The concept of AM needs to be fulfilled for a requirement to the body of workers for awareness about the role of the user manner in the production since the user does not takes the simplest makes use of the machine and need to more cares for the lathe machine. The study by Singh (2019) offers probably the most comprehensive empirical analysis of AM is a unique feature that is difficult to implement in practice because the users have the concept "I operate, you repair”. Conversely, Blanco (2020) argues that when the user is responsible for both the operation of the machine and its maintenance, the production will be increased. While the successful concept of AM execution can be depending on the systematic reduce the six big losses associated with the lathe machine and enhance their knowledge of operated the lathe machine. It will be the user's responsibility involves in maintenance or refurbishment of the full operating performance of the machinery and equipment since AM tasks include daily inspection, lubrication, replacement of parts, simple repairs, detection of abnormalities, and leakage check. As defined by JIPM, “Devising a planned maintenance system means raising output (no failures, no defects) and improving the quality of maintenance technicians by increasing plant availability (machine availability).

2.3.1 Stages Of AM

According to A. Acharya (2018), the first stage of AM is an initial cleaning. This stage will the removal of all types of dirt and chips, lubrication, control of loosened bolts, and fuguai detection. Next, elimination of pollution sources and difficult access areas. This will eliminate the contamination resources, preventing leaks, making sure to get entry to all system components, can facilitate cleaning and lubrication of coolant and hydraulic. After that, accomplish the initial cleaning, inspection, and greasing standards. This will develop the standards for operations of cleaning, lubrication, tightening free bolts, and practice of inspection schedules. Fourth, improving the user's technical skills. It will be accomplishing standardize machine operation and machine inspection to get rid of any abnormality. It initially brought requirements on the quality process aimed at reliability, high profit, minimum costs, zero number of human failure (defects), equipment failure, accident, and waste (Noohawn, 2016). Alongside, an autonomous inspection of the equipment. It can improve the standards for the preparation of manipulating sheets devoted to self-sustaining inspection and its implementation. Sixth, procedures, standards, and work rules. This stage will develop the standards and visualizations for upkeep (cleaning, lubrication, inspections, and tool control). Finally, autonomous equipment management. This final stage will establish the order of improvement activities and evaluate series of statistics on equipment failure frequency.

Once this pillar is implemented, this case has shown that the resulting actions will help maintenance to seek the best reliability of equipment and processes. Some reports of AM pillar implementation can be found in Vital et al. (2018), who presented a multi-criterion ordering of the pillars, and in Soltovski et al. (2018), who demonstrated the application of this pillar in industry, for highlighting its problems and benefits. However, its main contribution is to promote partnerships between production and maintenance departments to seek the best results. In addition, this pillar also improves quality safety and reducing losses through increased productivity.

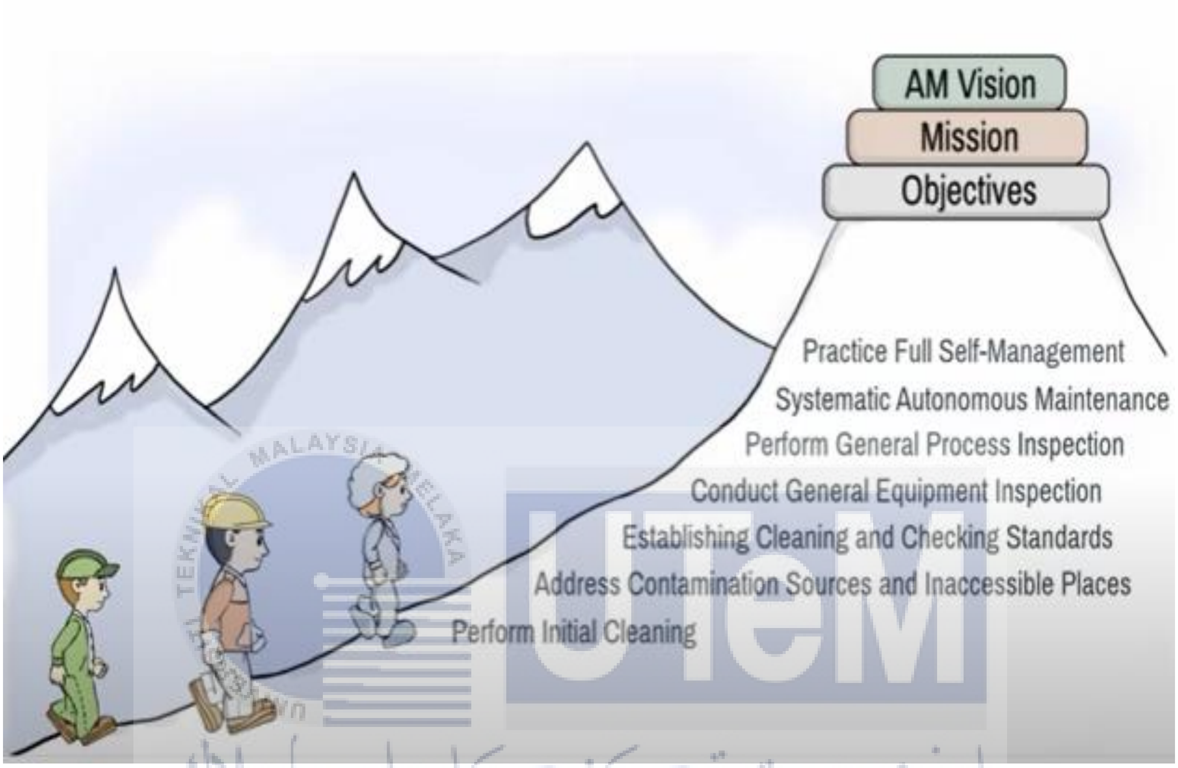


Figure 2.1 Example of AM implementation (Silva, 2017)

Silva (2017), to solve the above-mentioned in Figure 2.1 towards apply the improvement actions that were subsequently defined, selected the improvement tool of AM to optimize these processes and achieve the expected results. The implementation of AM includes seven stages.

2.4 *Fuguai* Tag (F-Tag)

Additional work by Gökhan Fidancı (2021) detailed the use of the "F-Tag" (*Fuguai* Tag) anomaly card application while conducting AM activities. Anomaly cards help user measures the level that reached in AM. *Fuguai* tag is attached to equipment where the problem is discovered. Kumar (2017), stated by identifying the *fuguai* for maintaining the machine neat and clean so that the abnormalities can be checked for its recurrence again. Therefore, it is the user's responsibility to clean the machine to prevent its stress from deteriorating.

2.5 Critical Review for *Fuguai* Elimination

This has been seen in the case of lacking cleaning on proposing inappropriate an AM programme for the lathe machining learning centre (Model: Optimum D-420). The problems caused have been shown by sources of failures. Hegab et al. (2017) proposed an algorithm for sustainability assessment of machining processes considering energy use, tool life, and surface roughness as performance systems of measurement. A case-study approach was applied to ensure eliminate that dust caught in rotating gearbox or sliding parts, hydraulic control system, and other parts causes wear, clogging, and resistance that leads to failures. Next, the sources of quality defects. It can be contamination of products due to accumulated dust. A major problem lathe machine with the experimental method are cleaning and the sources of speed reduction losses. Faced to this scenario, companies must continuously enhance their maintenance activities in order to survive in this workstation environment (Guariente, 2017). It was necessary to eliminate dirt increases with friction and vibration resistance of the lathe machine, which leads to reduced performance or idling and other speed reduction losses at the lathe machine. Moreover, dust and dirt make it difficult to detect *fuguai*, thus leading to neglect of the sources of forced deterioration.

2.6 Effect of *Fuguai*

The breakdown losses that occur throughout the lathe manufacturing process are listed here. For example, the type of losses occurs due to the failure of parts and causes the stop of production. The *fuguai* tag (F-tag) helps to measure all the processes contributing to the achievement of a maximum productivity of significant processes of the entire organization. In analyzing to eliminate or minimize loss causes, but on the other hand, it requires observance of the most possible objective method of its assessment (Hana, 2019). Next, set-up and adjustment losses. This sort of loss happens when a part lathe's manufacturing process is changed, such as when a tailstock is changed, the operating conditions are changed, different shifts are started, or the product is started to change. Then, minor stoppages losses by minor stoppage time occur due to jamming and machine idling. Furthermore, it can also affect speed losses while these losses are due to a reduction in the speed of the equipment. Fifth, a quality defect and rework losses. These losses are due to the defective product produced during the production process and therefore, rework must be done to remove the defects. Lastly, a process of yield losses. Such as, these losses are due to wasted raw material.

2.7 Lathe Machine (Model: Optimum D-420)

Refer to appendix A-1 the lathe machine (Model: Optimum D-420) has been selected for use in this project as a machine that will be exposed to an autonomous maintenance programme, as previously described. We demonstrate a lathe is a type of machining tool that is usually used to shape metal or wood. Therefore, the work-piece will rotated around a fixed cutting tool and the main purpose is to eliminate unnecessary material and leave a perfectly formed work-piece remaining. Next, lathe machines also used in metalworking, woodturning, metal spinning, thermal spraying, glass working, and parts reclamation. Furthermore, the main part of lathe machine are headstock, spindle, carriage, compound rest, cross slide, bed, tail-stock and feed rod. Equipment parts of lathe machine must be maintains to prevent the machine damage or under maintenance over a long period of time used. According to Turntech (2020) the process of lathe machine most common operations such as turning, facing, grooving, parting, threading, drilling, boring, knurling, and tapping.

2.8 Common Operations for Lathe Machine (Model: Optimum D-420)

The lathe is a flexible and vital machine to understand how to use. This machine spins a cylindrical item against a tool controlled by the user. The lathe is the predecessor to all machine tools. While the cutting tool is progressed along the line of a desired cut, the work is retained and rotated on its axis. One of the most versatile machine tools used in industry is the lathe. The lather may be used for turning, tapering, form turning, screw cutting, facing, dulling, drilling, spinning, grinding, and polishing with the right attachments. Cutting operations are carried out with a cutting tool that is fed either parallel or at right angles to the work axis. The cutting tool can also be fed at an angle, depending on the situation. For cutting taper and angles relative to the work axis. The tailstock of a lathe does not revolve. The spindle that holds the stock, on the other hand, revolves. The spindle may handle collets, centres, three jaw chucks, and other work-holding attachments. The tailstock can be used to store tools for drilling, threading, reaming, or cutting tapers. It may also support the end of the workpiece with a centre and be modified to accommodate varying workpiece lengths.

2.8.1 Facing Operation

Facing is the process of removing metal from a work item in order to make it flat. Facing is the process of rotating the work against a single point tool to flatten the end.

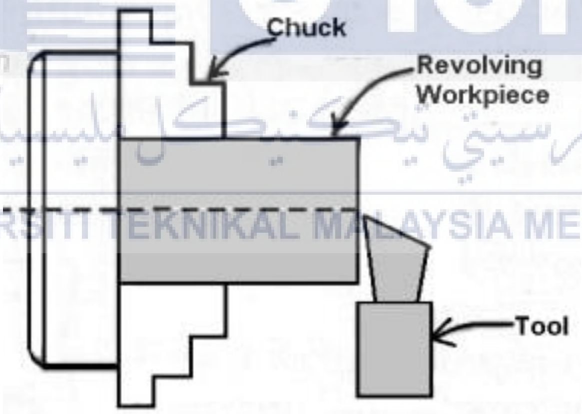


Figure 2.2 Facing Operation

2.8.2 Parting and Grooving Operation

The tool is pushed into or out of the work piece during a parting operation. The unsupported section will be cut with shallow charming leaves shaped cut and deep cut. To make the cut deeper, the cutting tool is taken out and moved to the side of the cut, preventing the tool from breaking.

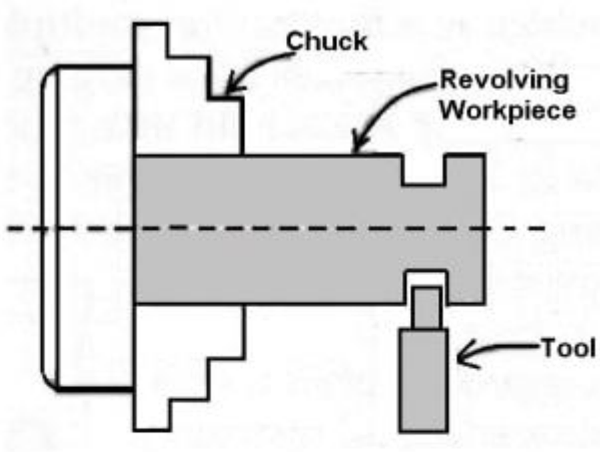


Figure 2.3 Parting Operation

2.8.3 Turning Operation

The process of removing metal from the outside diameter of a revolving cylindrical work piece is known as turning lathe machine operation. Its primary function is to lower the diameter of the work item. In general, turning operations are employed to produce base ball bats, candlestick holders, and other cylindrical items.

2.8.4 Drilling Operation

The drilling operation is the process of creating the first hole in a work item. It is subsequently subjected to further procedures such as boring and reaming. For this procedure, a drill bit is needed.

2.8.5 Boring Operation

Boring is used to expand the initial hole created by the drilling process or to convert a cylindrical hole to a tapper hole.

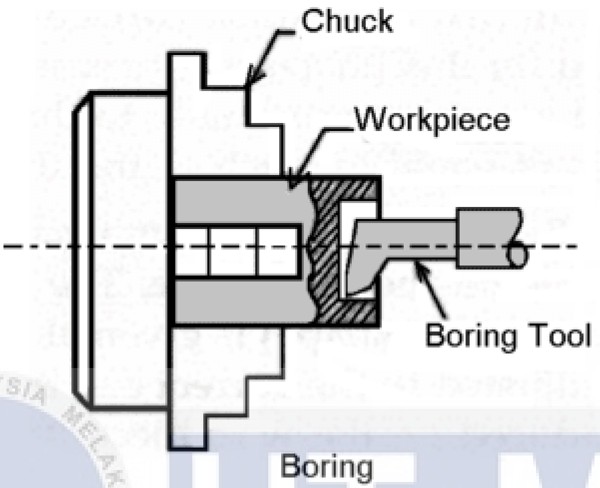


Figure 2.4 Boring Operation

2.8.6 Reaming Operation

The reaming operation on a Lathe Machine is used to finish the surface of a hole. Reaming is used to increase dimensional accuracy and tolerance while retaining a smoother interior finish. A reamer is inserted axially through the end of the work piece and enlarges the existing hole to the diameter of the tool. Reaming just eliminates a little quantity of material. It is frequently used after drilling to get a more precise diameter as well as a better interior finish.

2.8.7 Knurling Operation

Knurling is a popular industrial method that involves rolling a pattern of straight, angled, or intersecting lines into metal. The design is often a diamond-shaped (criss-cross) pattern carved or rolled into the metal. This pattern provides a greater grip for human hands or fingers on the knurled object than the original smooth metal surface.

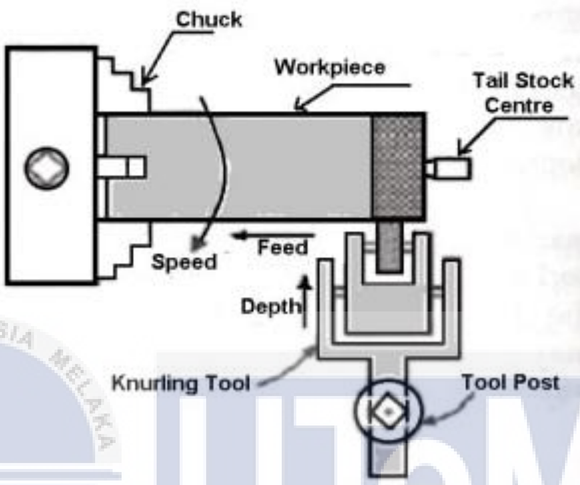


Figure 2.5 Knurling Operation

2.8.8 Spinning Operation

Metal spinning is the technique of shaping rings of metal over mandrels (also known as forms) while placed on a spinning lathe using levered force and other tools.

2.8.9 Threading Operation

Threading or thread cutting is a process that generates thread on a cylinder or cone by employing a single point cutting instrument. Thread is a helical structure used to transform force movement from rotational to linear.

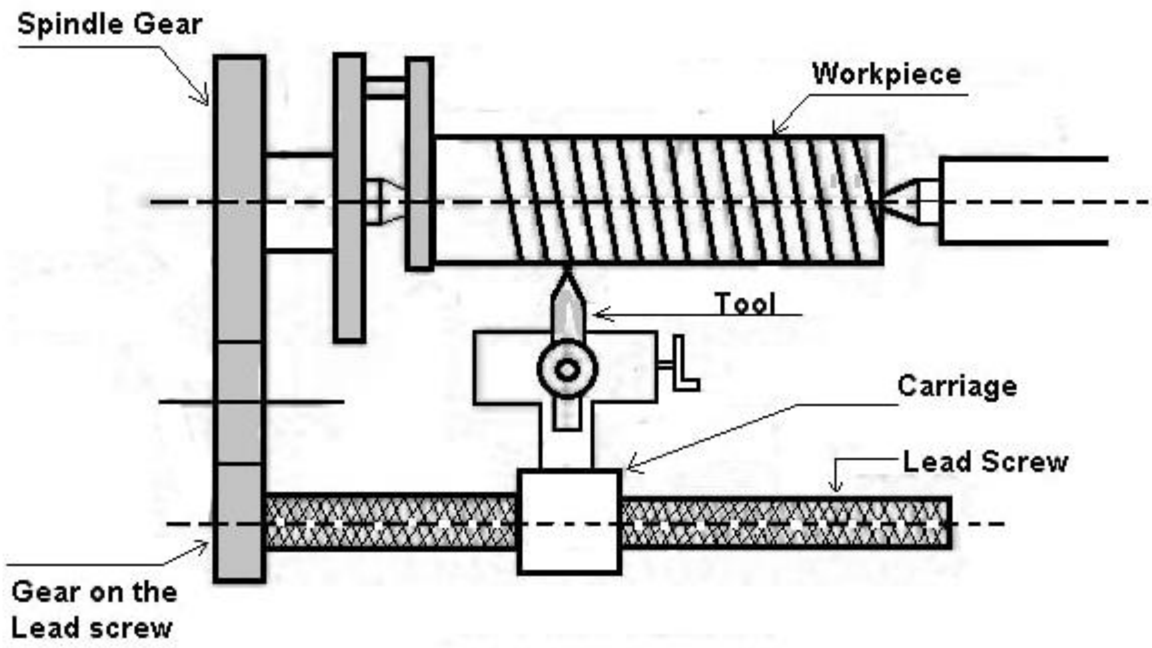


Figure 2.6 Threading Operation

2.8.10 Chamfering Operation

Only the cutting edge of a cylindrical form is employed in the chamfering process on a lathe machine to relieve tension on the work piece. Chamfering is a handy tool for deburring and is used in woodworking, glass cutting, architecture, and CAD.

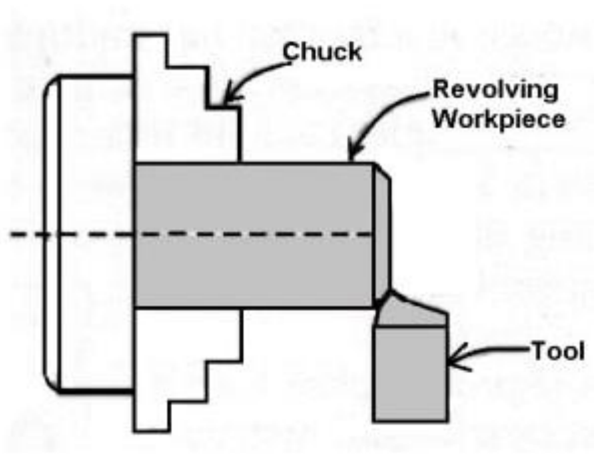


Figure 2.7 Chamfering Operation

2.9 Lathe Machine Cutting Tools

There are many different types of lathe tools that may be classed based on their materials, designs, and functions or applications.

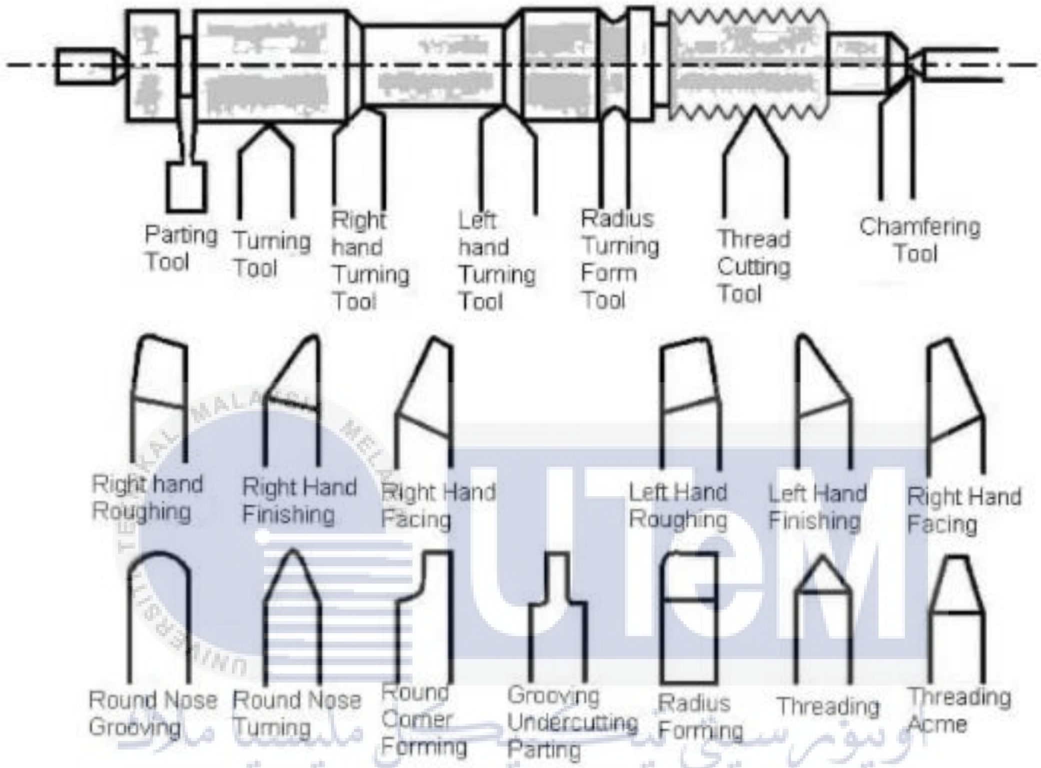


Figure 2.8 Type of Cutting Tools

2.9.1 Turning Tool

Turning tools are meant to remove materials from stock; a rough turning tool is used to remove the most material, while a finishing turning tool is used to achieve superior surface quality by removing only a tiny amount to make the item more precise.

2.9.2 Boring Bar

A boring bar is necessary when you wish to enlarge an existing hole. A boring bar can readily bore into an already drilled hole and widen its diameter. It can swiftly widen the hole and process it to the necessary size to fit additional components.

2.9.3 Chamfering Tool

A chamfer is a transitional edge between two sides of an item, and it is also a type of bevel. The chamfering tool is used to shape the component by creating a bevel or furrow. A chamfer can be used to smooth out sharp or potentially dangerous edges of a workpiece.

2.9.4 Knurling Tool

Knurling tools are used to manufacture knurled lathe parts by generating or pressing a pattern onto a circular portion, which is then utilised as a grip for a handle, and is also commonly formed on fasteners such as nuts. A knurling tool is made with a specific pattern in consideration.

2.9.5 Parting Tool

A parting tool is a narrow-bladed tool used in turning or planing or for splitting a piece in two. It is also defined as a tool used for cutting off parts from the main body of stock being machined.

2.10 Safety Precautions while Working on Lathe Machine

In fundamental, to avoid accidents and injuries when working on lathes, users should go over and acquaint themselves with the general safety precautions or recommendations (Ali Othman, 2019). Before starting the lathe, the user should always double-check that all the guards are in place. Following that, the user must always clamp the work and tools appropriately using the appropriate work size and tools for holding the device. Then, before making any measurements or regulations on the workpiece, make sure the lathe machine is free of tools and that the machine is stopped. Consumers should wear aprons or goggles that are correctly fitted to avoid chip particles encountering the human body, and goggles should also be worn to prevent chip particles from coming into contact with the eyes. Furthermore, when working on the lathe, the user should remove his or her tie, watch, and jewellery, and should not run the lathe unless he or she recognizes how to do so appropriately. As a result, inspect the workpiece and the chuck by hand on a regular schedule to determine there were no work hazards on any area of the lathe. Hazard is defined as the total of dangers and risks, while safety is defined as a judgement regarding how much risk is acceptable. Lathes are extremely convenient for cutting metal components, but if used incorrectly, it may be dangerous. The most common injuries caused by lathe accidents are broken fingers, wounds on the hands, and scorching debris in the eyes. Meanwhile, the user wants to stop the machine and remove the waste product using pliers, since the user should never remove waste product or chips by hand. Whereas if chuck has a fracture, do not use the machine since it will cause a lot of vibration.

3.0 Summary

This study is a preliminary study on autonomous maintenance for the Optimum D-420 lathe machine at Universiti Teknikal Malaysia Melaka (UTeM). This project focuses on the first three phases in regular Autonomous Maintenance operations, which are Initial Cleaning, *Fuguai* Countermeasures, and Problem-Solving Standardization. Moreover, failure to a production equipment might result in high production expenses. Hence, Autonomous Maintenance (AM) is one of the preventative maintenance solutions for reducing machine deterioration. The machine's *fuguai* were investigated in terms of safety, function, and physical characteristics according to F-tags. According to the findings, nasty *fuguai* occurred the most frequently, and those *fuguai* had the greatest impact on the machine's physical form. The majority of *fuguai* discovered over the project's period have been handled; nevertheless, a few *fuguai* remain unsolvable for various purpose explained in this report. Therefore, the goal of autonomous maintenance also to maintain a high level of cleanliness, optimum lubrication, and appropriate machine fastening. Consequently, conventional AM approach of initial cleaning, on either side, may increase the maintenance cost and time requirements (F. Trojan, 2017).

CHAPTER 3

METHODOLOGY

3.1 Design of the Project

The purpose of this designated project plan is to explore the objectives and attract explicitly the project output. This project must be followed a guideline to meet up the goals that have been set and determined by ensuring the effort puts to finalize this project. The first stage of designing this project would be the process of identifying the problem statement, the objectives, and the scope of the project. The project's objectives are mentioned to describe the project's purpose of providing solutions to the stated problem. While the process of identifying and documenting a list of specified project goals, deliverables, tasks, costs, and deadlines is known as the scope of the project. The next stage is to proceed with data collection methods. The data collection method involves in this project are primary and secondary data. The primary data consists of three methods, which are observation, *fuguai* investigation, and focused group discussion.

This data is usually obtained from the source itself. Meanwhile, the secondary data consists of internet resources and a machine manual. The internet resources would be the overview of the published articles and journals previously. The lathe machine's standard operation process, specifications, safety, and maintenance information is referring to the machine manual (Model: Optimum D-420). The first thing to do in the previous second stage is to collect the data and information for the AM, eliminate *Fuguai,* and the lathe machine information (Model: Optimum D-420). The data and information received are then combined to create an AM programmed for a lathe machine. The combined data is then evaluated and reviewed for the final draft version before being submitted for due report submission. The general methodology or design of the project is systematically planned and illustrated in the flow chart that is shown in Figure 3.1.

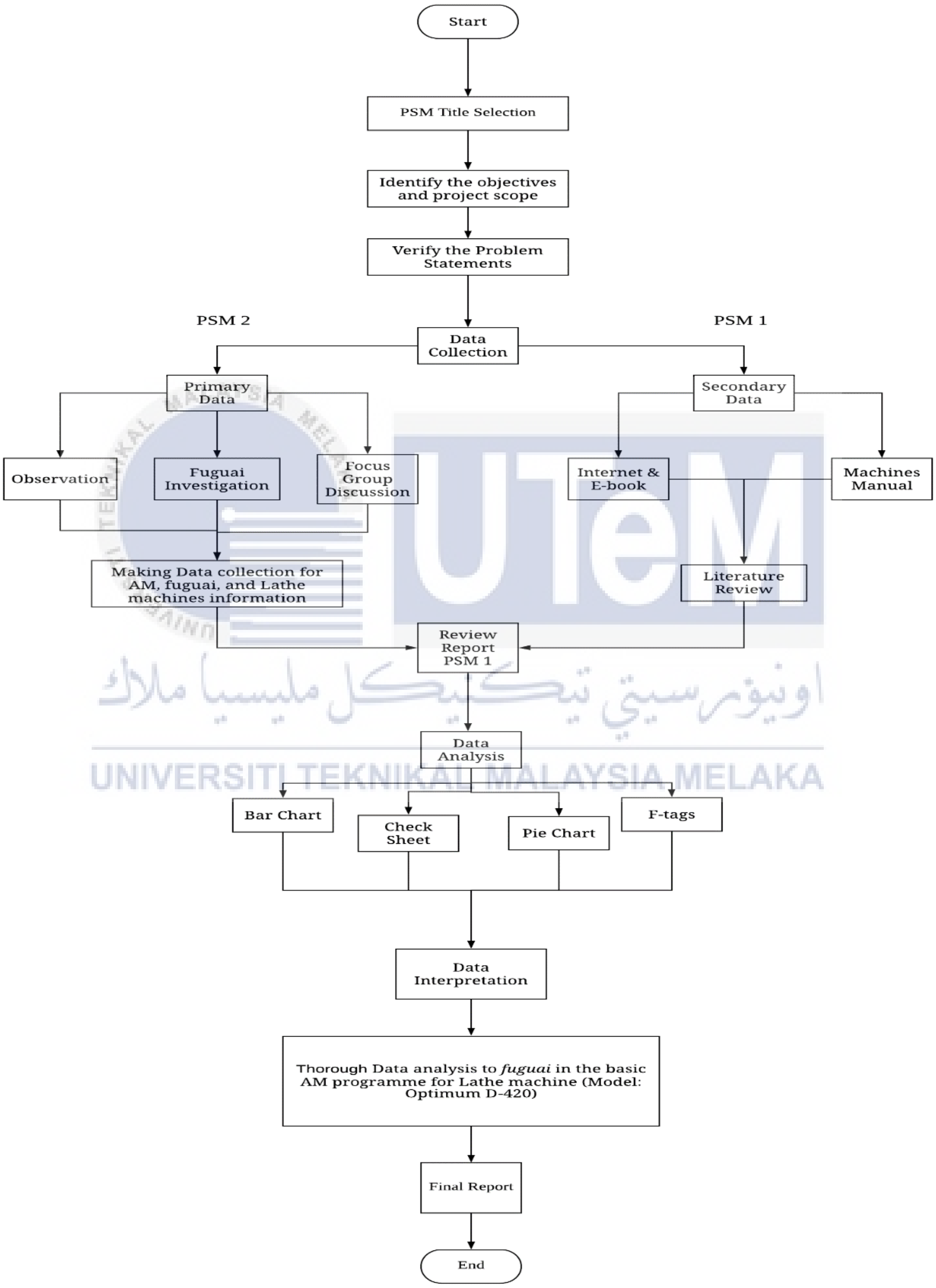


Figure 3.1 Project Flow Chart

Table 3.1 Gantt Chart of Design of the Project

	Activities Task	Status	Weeks														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PSM 1	Background Research on Topic	Plan															
		Actual															
	Problem Statement and Identify Objectives	Plan															
		Actual															
	Data Collection (Internet & Journal)	Plan															
		Actual															
	Report Writing of Literature Review	Plan															
		Actual															
	Design of Project Flow Chart	Plan															
		Actual															
	Research Methodology	Plan															
		Actual															
	Report Submissions and Presentation PSM 1	Plan															
		Actual															
PSM 2	Report Review	Plan															
		Actual															
	Collection Findings from Lathe Machine	Plan															
		Actual															
	Data Analysis	Plan															
		Actual															
	Establishment Of AM For Lathe Machining	Plan															
		Actual															
	Report Submissions and Presentation PSM 2	Plan															
		Actual															

3.2 Data Collection

This thesis present a primary and secondary data collection are the two types of data collection. There are three techniques and two techniques respectively, and both are used extensively in this project. This was done in order to collect sufficient and appropriate data to address the study's research objectives.

3.2.1 Primary Data

Primary data is information gathered directly from primary sources by researchers using methods such as observations and experiments. Primary data is usually acquired directly from the source or from the place where the data came from and is considered the greatest type of data in research. The primary data methods include observation, *fuguai* investigation, and focused group discussion.

3.2.1.1 Observation

Observation is a data collection method that relies heavily on eyesight. It suggests that the eyes, rather than the hearing of the voice, are used observation is defined as accurate watching and noting of phenomena as they occur in nature with regards to cause-and-effect relation according to Victor Ajayi (2017). In this project, observation is used to keep track of useful information for the lathe machine at the learning centre which can include the condition and the performance of the machine from time to time.

3.2.1.2 *Fuguai* Investigation

Fuguai investigation is the inspectation of abnormalities found on the lathe machine (Model: Optimum D-420). The abnormalities of the machines would be classified into three categories which are physical, function, and safety during the investigation. The *fuguai* tags are tagged on the parts of the machine which require improving data accuracy and ease of access will assist guide ongoing process maintenance activities to detect *fuguai* and propose appropriate an AM programme for the lathe machining learning centre to make improvements.

3.2.1.3 Focused Group Discussion

A focused group discussion is a useful technique to bring people together who have related backgrounds or experiences to talk about a certain issue. It can be used to evaluate the survey results that are just not statistically explainable and views on a specific topic.

Furthermore, there are five students selected and gathered for this AM topic but with different types of machines. The information that has been gathered can be very important to complete this report in this project.

3.2.2 Secondary Data

Data gathered by someone other than the primary user is referred to as secondary data. The existing results were analyzed and compiled to ensure the system effectiveness of the research. It is based on the review of literature in any research. The secondary data methods that were used for this project are internet resources and a machine manual to gather all the information of this project.

3.2.2.1 Internet Resources

The Internet resources method refers to AM and eliminates abnormalities for the lathe machine that uses this method to collect data from journals, articles, and ebooks. Most commonly, the internet has been used as the means for conducting this project, but e-mail has been used as well. Edwards (2018) concludes that objects of inquiring on the internet are diffuse enough that they challenge the utility of a case study framework, particularly considering recent methodologies for digital circulation. Thus, research methods commonly used in qualitative studies of online communication are identified.

3.2.2.2 Machine Manual

Data collection from the machine operation manual helping to have a better understanding of the lathe machine (Model: Optimum D-420). The machine user manual provides the standard operation procedure, specification, safety, and maintenance information regarding the lathe machine. The detail and knowledge are useful to provide a standard measure during the development of an AM programme.

3.2.3 Analytical Technique

A strategy or approach for analyzing a problem, situation, or fact is known as an analytical technique. Moreover, analytical method approaches are typically time and task-constrained to provide a specific problem. In this project, there are some graphs formed by a bar chart, pie chart, column chart, pareto chart and *fuguai* tags.

3.2.3.1 Bar Chart

The term bar chart refers to a graph or chart that represents categorical data as rectangular bars with heights or lengths proportional to the values it contains. Bar charts are advantageous for data collection to compare the type of *fuguai* for the lathe machine at the learning centre. An example of bar chart design, the performance types of *fuguai* vs *fuguai* frequency.

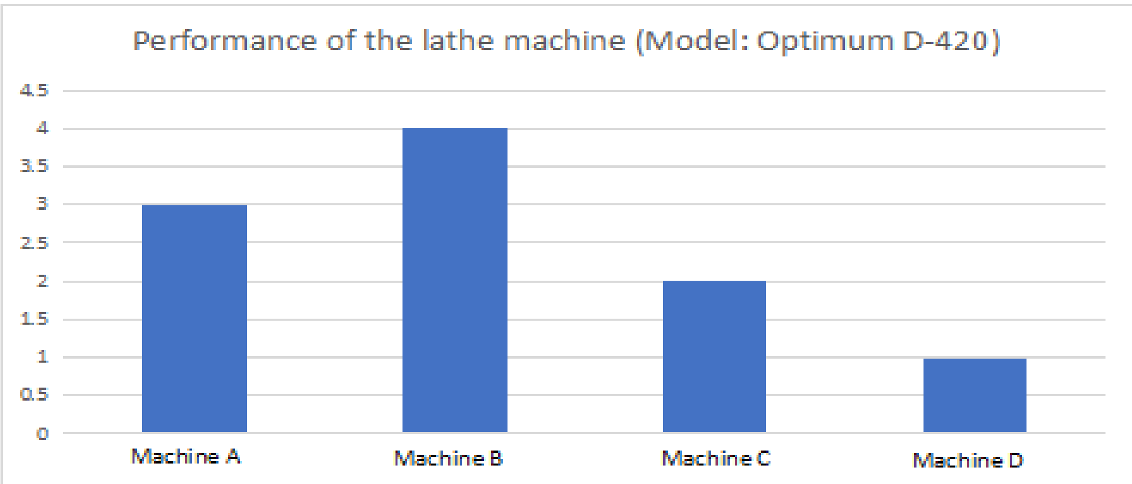


Figure 3.2 Example of Bar Chart

3.2.3.2 Pie Chart

A pie chart is a round diagram that illustrates the relationships between data sets. The arc length of each piece is equal to the number or the quantity it represents in a shape that resembles a slice of pie. In other words, a pie chart can only be utilized if the separate pieces add up to a meaningful total, and it is designed to show how each portion contributes to that whole. For this project, the pie chart is represented to analyze the percentages the type of *fuguai* at the lathe machine.

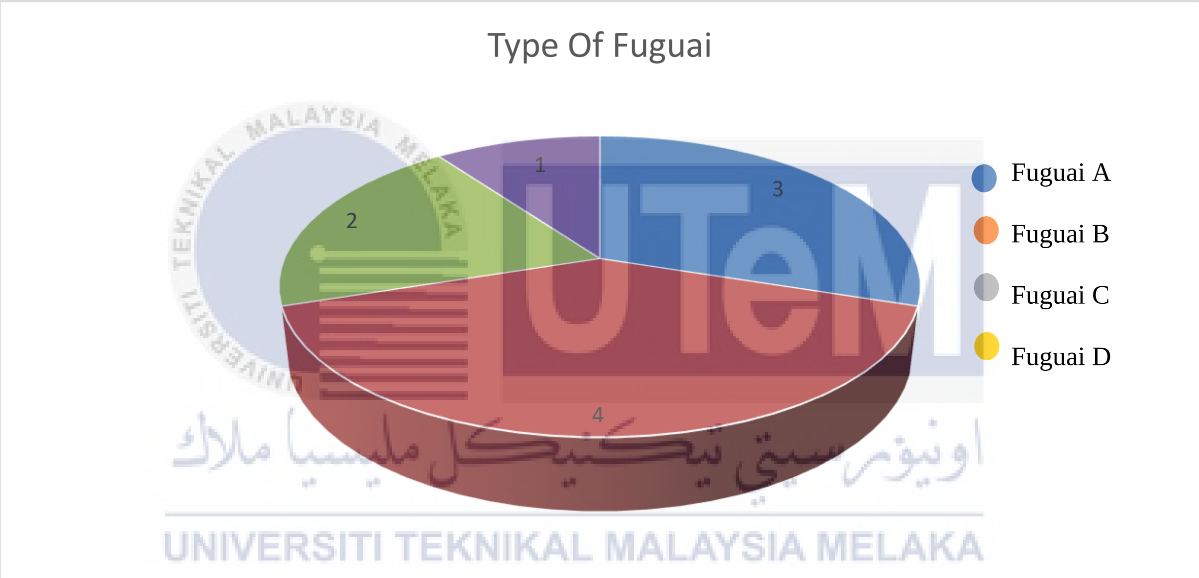


Figure 3.3 Example of Pie Chart

3.2.3.3 Column Chart

A column chart is a type of data visualisation in which each category is represented by a rectangle, the height of which is proportional to the numbers plotted. Vertical bar charts are another name for column charts. The height of the columns as measured by the y-axis represents values. On the x-axis, category labels are presented. Column charts are commonly used to compare numbers in different categories. Machine area vs fuguai classifications is an example of a column chart structure.

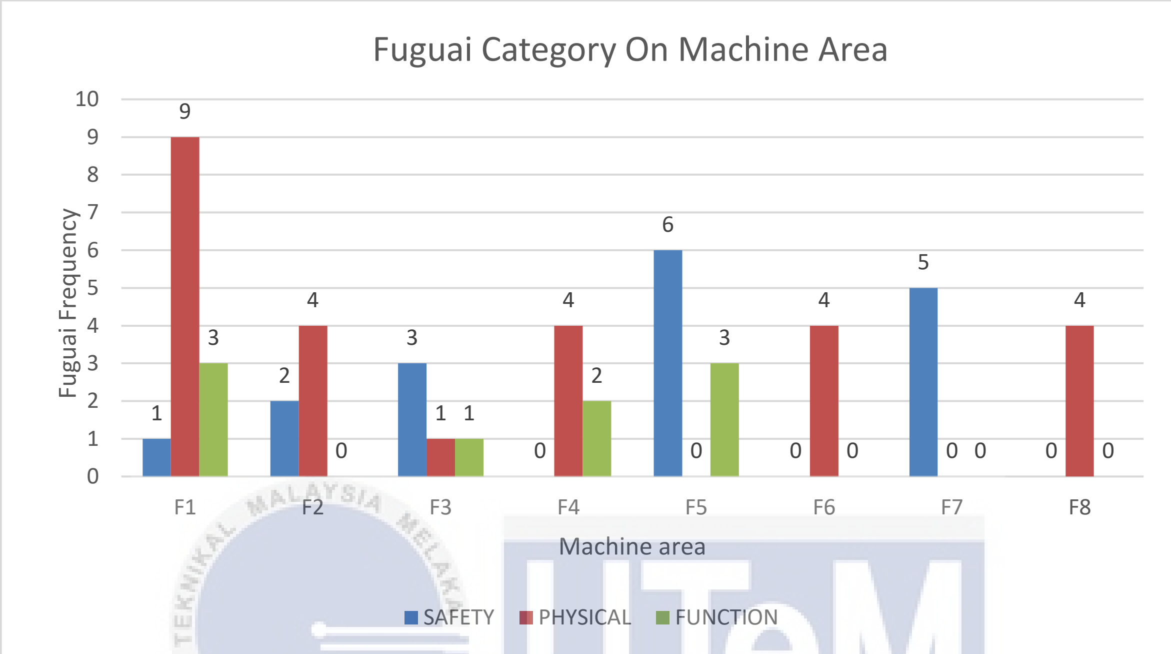


Figure 3.4 Example of Column Chart

3.2.3.4 Trend Chart

A Trend Chart are used to display data patterns over time. Because all processes differ, single point measurements can be deceptive. The trend chart is one of the most effective methods to present vast quantities of data in ways that allow for meaningful analysis. A line chart with time depicted on the X-axis and lines connecting the data points is a common trend chart. The horizontal (x) axis is used to indicate time, while the vertical (y) axis is used to represent the attribute under observation. A comparison of two F-tags is an example of trend chart construction.

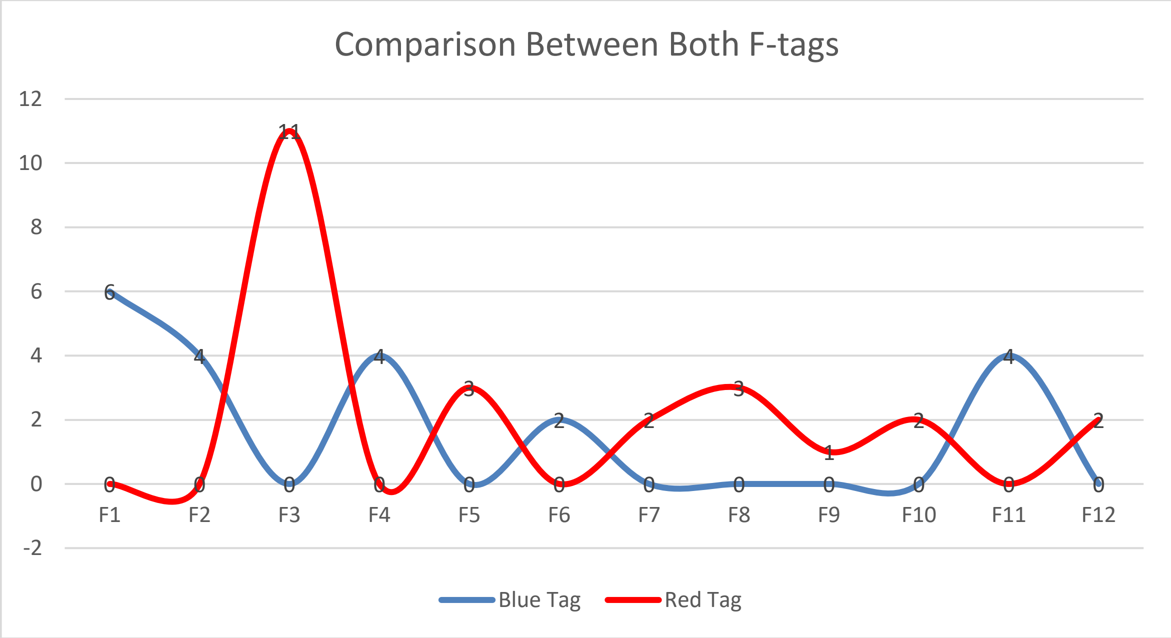


Figure 3.5 Example of Trend Chart

3.2.3.5 Pareto Chart

The Pareto chart is a graph that ranks analysis as the data categories are ranked in descending order from left to right. Problems, causes, and types of variances are all possible data classification. On the left are the vital few, and on the right are the useful ones. The horizontal scale is Fuguai types, Fuguai area, or Fuguai category, while the vertical scale is numbers and frequency.

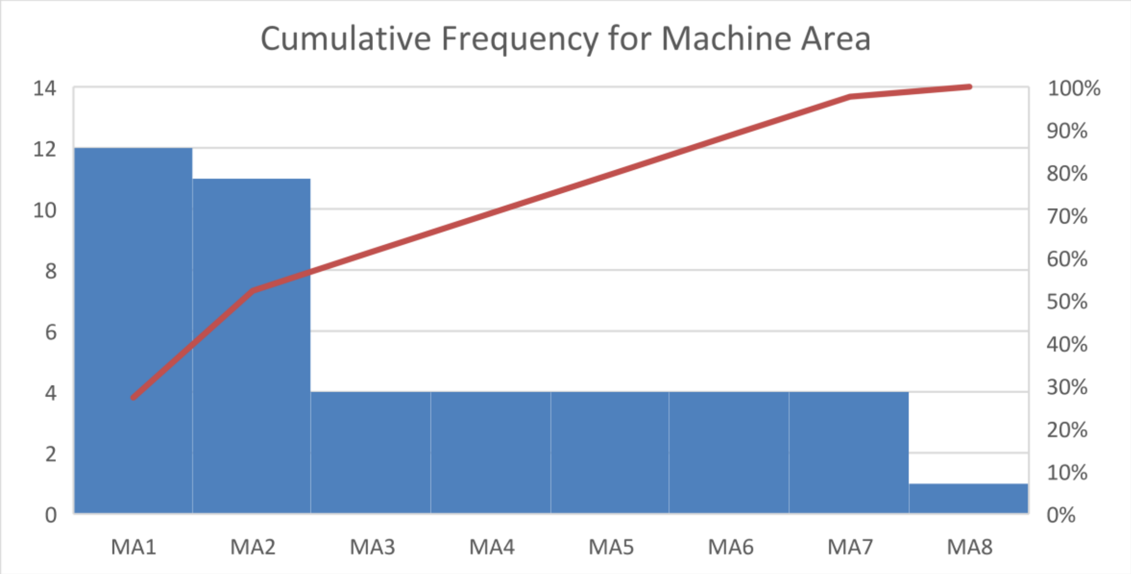


Figure 3.6 Example of Pareto Chart

3.2.3.6 *Fuguai* Tag

Fuguai tags (F-tags) are used for the tagging to identify an abnormality on the lathe machine at the learning centre during the initial cleaning stage. F-tags are also required for data collection which represents the safety, physical, and function to eliminate the *fuguai*. Therefore, it consists of two colors of F-tag such as red and blue tag that shown in Figure 3.5.

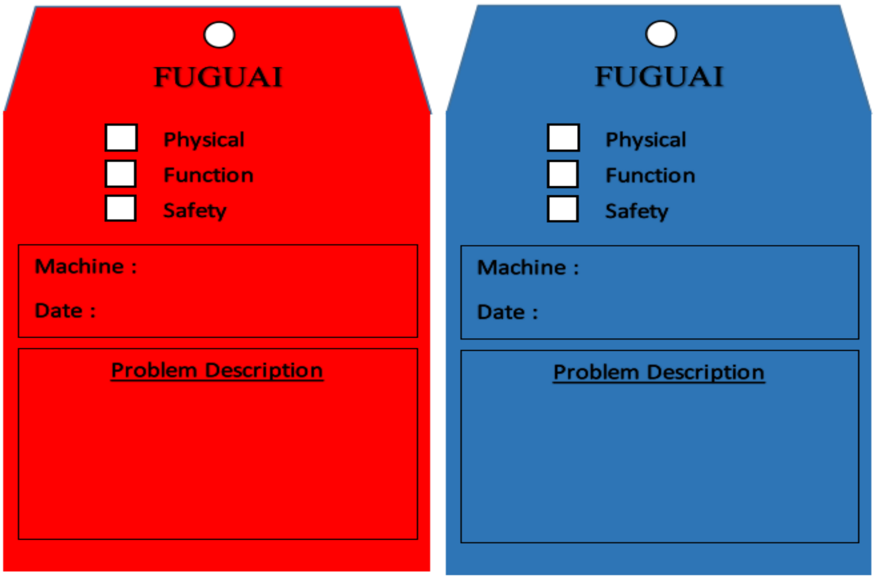


Figure 3.7 F-tags Colour Code

Red F-tags are used to detect *fuguai* with the machine by the superior machinist of the lathe machine while Blue F-tags represent any user that is required to fix *fuguai* on the lathe machine. Therefore, Red F-tags that are required by the superior machinist are ensured to handle and keep perform preventive maintenance occur during the process. Although, Blue F-tags is consistent with the appropriate initial cleaning for any user of the lathe machine at the learning centre. *Fuguai* tags shown on figure 3.4 provided and attached the multi-functions safety inspection checklist such as wear, leakage, corrosion, overheating, noise, and others else.

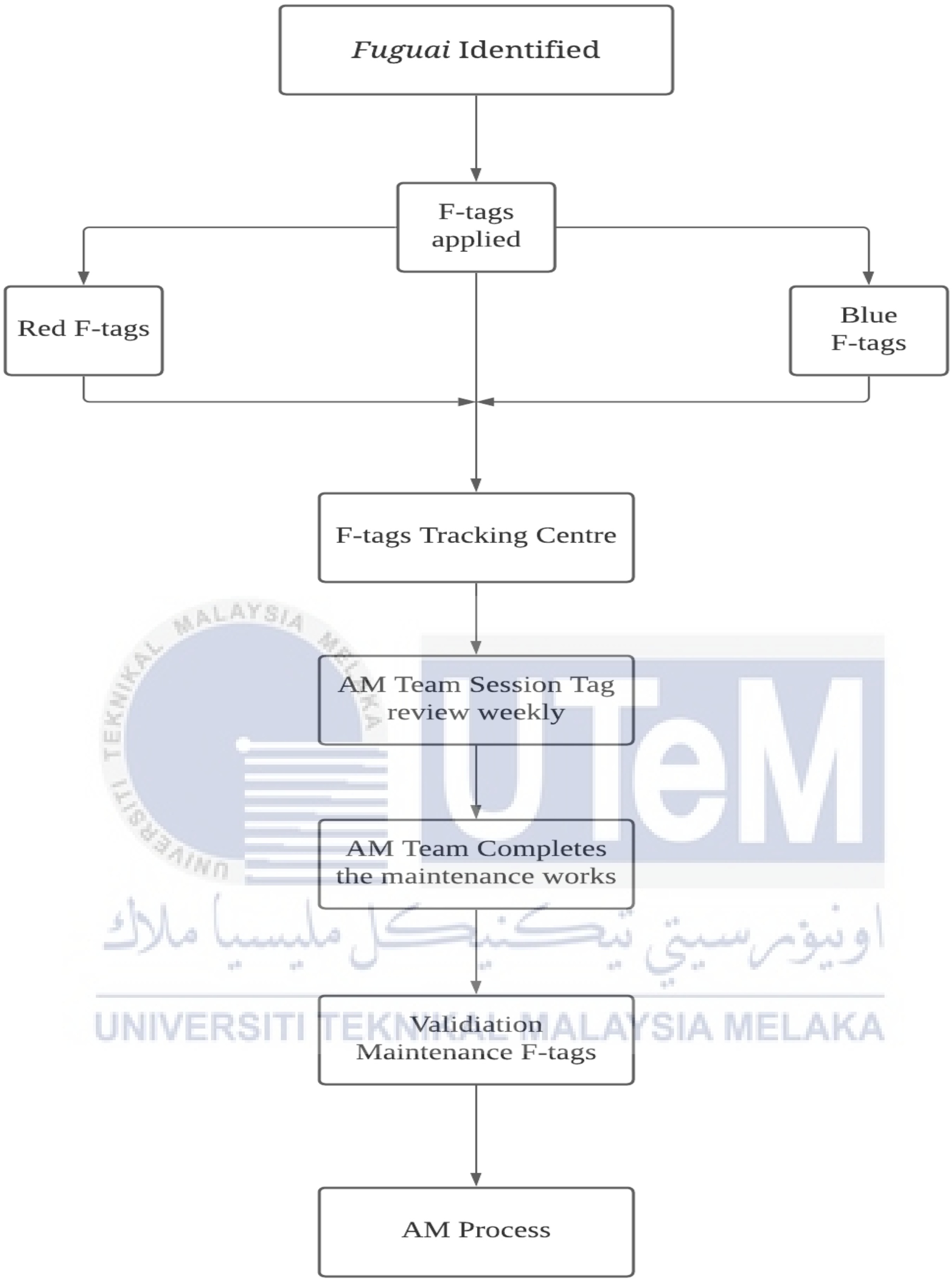


Figure 3.8 Flow Chart of F-tags

3.3 Summary

This chapter comprises the design of the project, the process of Flow chart, Gantt chart, data collection methods which are both primary and secondary data are gathered to consist of the data analysis of *fuguai* for the lathe machine in the learning centre (Model: Optimum D-420). The primary data represent by observation, *fuguai* investigation, and focused group discussion. Then, the secondary data consists of internet resources and a machine manual. Furthermore, the methods of analysis that I will use are bar chart, pie chart, trend chart, pareto chart, column chart and *fuguai* tags to support and approach the objectives. The systematic method of resolving a literature review by collecting data using various countermeasure methodologies, interpreting the data obtained and deriving conclusions from the research findings.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter represent to provide the findings of the project and discussions for the AM improvement of the Lathe Machine (Model: Optimum D-420). Gathered information will indeed be entered on a control chart in a relevant categorizing approach to be evaluated utilizing a variable method. The analysed data will also be described and analysed further for improved understanding and implementation. Morever, the *Fuguai* analysis and discussions for the lathe machine at the UTeM learning centre are covered in Chapter 4. The data gathered is organized into the given observation sheet. Then, the statistics also was reviewed with statistical graphics such as a bar chart, a pie chart, a column chart, a trend chart, and a pareto chart.

4.2 Initial Cleaning

The initial cleaning of the lathe machine is the first process in determining current condition (GY Lee, 2021). It is often carried out by all members of the manufacturing, maintenance, and engineering teams and requires thoroughly cleaning the machine and surroundings. The goal is to thoroughly restore the machines' performance by analyzing and removing any indicators of deterioration. Next, all the *fuguai*, such as minor defects, contamination sources, inaccessible areas, and quality defect sources, had to be investigated. Then, the contamination will be observed, such as dust, dirt, or grease, will be analyzed before cleaning. If any minor flaws occur, a lab assistant shall manage with these issues. All the following abnormalities or *fuguai* were documented in a tagging defect list known as *fuguai* tag, which had represented three categories: safety, physical, and functional. The *fuguai* tag contained the date of identification, a problem description of the *fuguai*, a name of machine, and the person in authority who was responsibility for the *fuguai*. Thus, *Fuguai* tags discovered were labelled with blue tags if they could be resolved by the operator, and red tags if they needed to be handled by a more skilled individual, such as a technician.

4.3 Mapping Of Lathe Machine

The mapping of the Lathe Machine (Model: Optimum D-420) is structured into eight areas of key sections to simply relate *fuguai* and its position determined. The eight main areas are as follows:

i. Headstock
ii. Lamp
iii. Tailstock
iv. Tool-post Guard
v. Carriage
vi. Bed Bridge
vii. Machine Body (Back View)
viii. Base Frame

Figures 4.1 and 4.2 below represent the eight main areas of a lathe machine through front view and back view respectively.

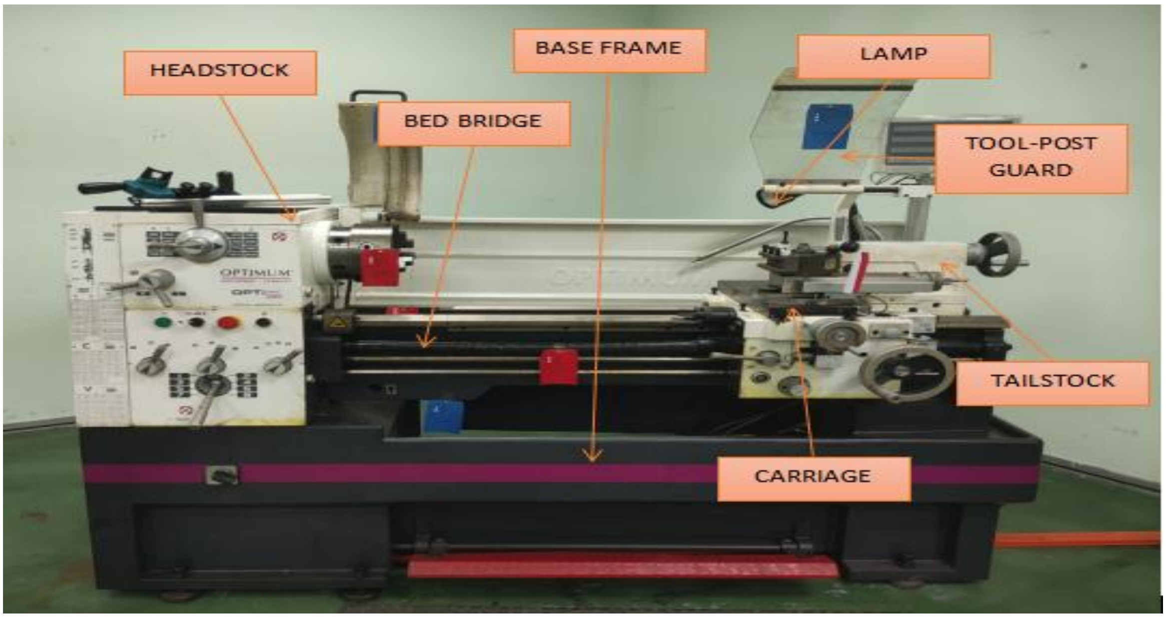


Figure 4.1 Front View of The Lathe Machine (Model: Optimum D=420)

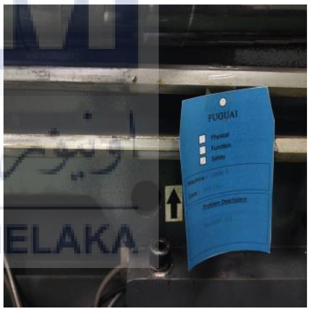
Figure 4.2 Back View of The Lathe Machine (Model: Optimum D-420)

Every *fuguai* discovered will be assigned to each of the eight areas. First of the area machine is headstock. The fixed support in a machine or power tool that supports and drives a spinning component is known as the headstock. A tool greased with oil, soap, or waxes drives the workpiece against the mandrel while the headstock turns and this major *fuguai* that be detect. Next, main area of lathe machine is lamp that provided to worklight with a high-intensity light source that illuminates the platform for the assistance of users. The third part is tailstock, which a lathe's adjustable or sliding head that contains the dead center. Typically, the complete tailstock is physically slid along its courses to the approximate spot where it will be required. It is then secured in place, and the tool attached to it is moved using a leadscrew to the precise location where it is required. Forth part is tool-post guard, which is one of the most prevalent ways for shielding lathe workers from rotating job. Fifth of the area machine, the carriage is in charge of directing the tool bit while it cuts or manipulates the workpiece. On the carriage area, that will figure out the second major *fuguai* of the lathe machine. For the sixth part area of the lathe machine is bed bridge. The turning diameter is increased to 590 mm by taking out the bed bridge. Bed bridge can be configured in a variety of ways, including box ways, v-ways, and dovetail ways, and they can be utilized with ball or roller bearings on various lathes. Next is machine back body that consist of the properly layout of coolant pipe and oil waste out pipe. A machine tool coolant system is a high-pressure coolant system used to keep your machine and machine tools cool. This is significant because it prevents machine tools from overheating and being damaged. Machine tool coolant systems are applicable to a wide range of machines and machine tools. For the eighth area that were to be observed is base frame. The base frame of the lathe is the most important structural component of the machine, which carry the carriage, tailstock, and other components such as steady rests and carriage stops. Therefore, on the base frame can determined the physical *fuguai* such as waste chips and misplacement part or hand-tool.

4.4 Types of *Fuguai*

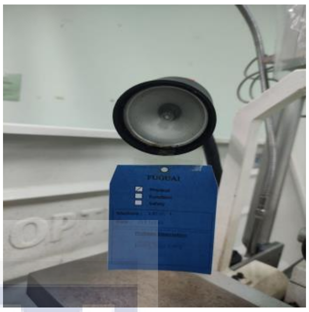
Fuguai seems to have a harmful effect on the machine, product, equipment, operator, and environmental elements. There are twelve *fuguai* that have been found on the Lathe Machine (Model: Optimum D-420) involving unclean oil, blurry tool-post guard, rusty parts, waste chip, stagnant oil, misplacement, gearbox problem, open liner, noise cross-slide, untidy coolant pipe, unclean glass lamp and chuck guard problem. Various varieties of *fuguai* were discovered throughout the *fuguai* mapping phase. These type of *fuguai* were also have been discovered to predict the future their major cause as be shown below on the Table 4.1.

Table 4.1 Types of *Fuguai* found on the Lathe Machine (Model: Optimum D-420)

No	Fuguai	Comments	Figures
1	Unclean Oil	• After operating the machine, oil that has not been thoroughly cleaned. As a result, dirt will accumulate on the student's attire, and there will be an increase in accident activity such as hand slipped.	 Figure 4.3 Unclean Oil
2	Blurry Tool-post Guard	• Does not do initial cleaning the tool-post guard after using the lathe machine. While operating the lathe machine, eyesight is blurred, and causing inconvenience to the other person who use it afterwards.	 Figure 4.4 Blurry Tool-post Guard

3	Rusty Parts	● Rust prevention is a crucial element when dealing with any form of machine tool. ● Rusty part and not cover the machine when it is not in use can cause the breakdown of the lathe machine	 Figure 4.5 Rusty Parts
4	Waste Chip	● Waste chip may become stuck in the lathe machine as well. The chuck will be ruined if the chip is not removed and clean regularly ● This encourages a safe working and also prevents fine chips from scrubbing the lathe parts' surface.	 Figure 4.6 Waste Chip
5	Stagnant Oil	● Long-standing oil reservoirs are not removed on a specified scheduled. ● Bacteria are frequently present when the oil becomes grey or black.	 Figure 4.7 Stagnant Oil
6	Misplacement	● Put the part of the lathe machine in the wrong placement. ● As a result, if the part is dropped from a high place, it will be shattered.	 Figure 4.8 Misplacement

7	Gearbox Problem	● The gearbox progress does not run so smoothly and efficiencies. ● The carriage is really not moving appropriately and the gear box that control the relative pace of the chuck and allow you to move the workpiece automatically with the power source.	 Figure 4.9 Gearbox Problem
8	Open Liner	● The open liner should be replaced with a neater and more recent type. ● Resulting in a situation which will get stuck on the surface of the lathe machine.	 Figure 4.10 Open Liner
9	Noise Cross-slide	● When using Lathe machines, the evaluation of that type of noise provides a handle that assists in the up-side motions of the tool post and compound rest have a vibration and does not run smoothly.	 Figure 4.11 Noise Cross-slide

10	Untidy Coolant pipe	● The coolant pipe is not inserted into the lathe bed neatly.	 Figure 4.12 Untidy Coolant Pipe
11	Unclean Glass Lamp	● This will reduce bright light while using the lathe machine. ● It also will cause dirt on the glass mirror of the lamp.	 Figure 4.13 Unclean Glass Lamp
12	Chuck Guard Problem	● Chuck guards are safety devices that protect individuals from excess shavings, shards, tool bits, and material chips that may come from operating machines and harm themselves.	 Figure 4.14 Chuck Guard Problem

4.5 *Fuguai* Analysis

Analysis has always been central to philosophical technique, although it has been interpreted and applied in a variety of ways. Perhaps, in a general sense, it might be characterized as a process of isolating or working back to what is more fundamental by which anything that was developed previously as given can be explained or constructed. The *fuguai* analysis consists of a classified based on machine area, f-tag distribution, *fuguai* category, and type. The data are collected and shown using the statistical graphs specified for this analysis, which are a bar chart, a pie chart, a trend chart, a column chart and a pareto chart. According to the data collecting strategy stated in the previous chapter, *fuguai* analysis is one of the approaches that will be mostly implemented for the results in this project.

4.5.1 Analysis Types of *Fuguai*

Table 4.2 illustrates the data obtained for *Fuguai* types for each lathe machines, and each *Fuguai* is specified previously in Figure 4.3 through Figure 4.14. The collected data will be evaluated and shown in statistical graphs as in a bar chart, a pie chart, and a trend chart.

Table 4.2 Lists of *Fuguai* for each Machines

Abbreviation	**Lists of *Fuguai***	**Lathe 1**	**Lathe 2**	**Lathe 3**	**Lathe 4**	**Total**
F1	Unclean Oil	2	1	1	1	5
F2	Blurry Tool-post Guard	1	1	1	1	4
F3	Rusty Parts	3	3	3	3	12
F4	Waste Chip	1	1	1	1	4
F5	Stagnant Oil	-	1	1	1	3
F6	Misplacement	1	1	-	-	2
F7	Gearbox Problem	-	-	1	1	2
F8	Open Liner	-	1	1	1	3
F9	Noise Cross-slide	-	-	1	-	1
F10	Untidy Coolant Pipe	1	-	-	1	2
F11	Unclean Glass Lamp	1	1	1	1	4
F12	Chuck Guard Problem	-	1	-	1	2

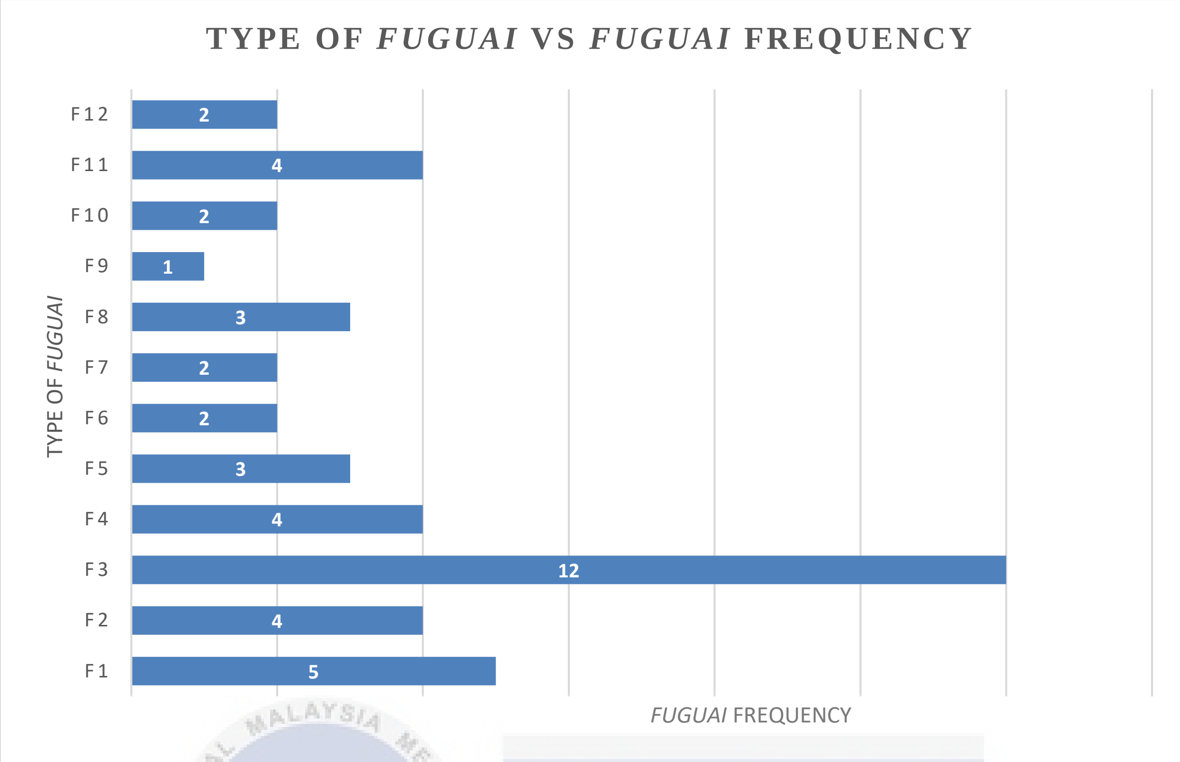


Figure 4.15 Bar Chart for Type of *Fuguai* Versus *Fuguai* Frequency

The bar chart indicates the total frequency of *fuguai* and the type of *fugua*i that be derived previously. From the bar chart analysis, the major *fuguai* is rusty parts (F3) on the lathe machine which is the highest value of *fuguai* frequency is 12 and followed by unclean oil (F1) which is 5 *fuguai* that can be found on the lathe machine. This is because of its frequent oxidation contact and a lack of consistent regular maintenance on machine parts. The frequency of 4 *fuguai* found which are belong to unclean glass lamp (F11), waste chip (F4) and blurry tool-post guard (F2). It also takes a lot of effort to keep it clean on a regular schedule.

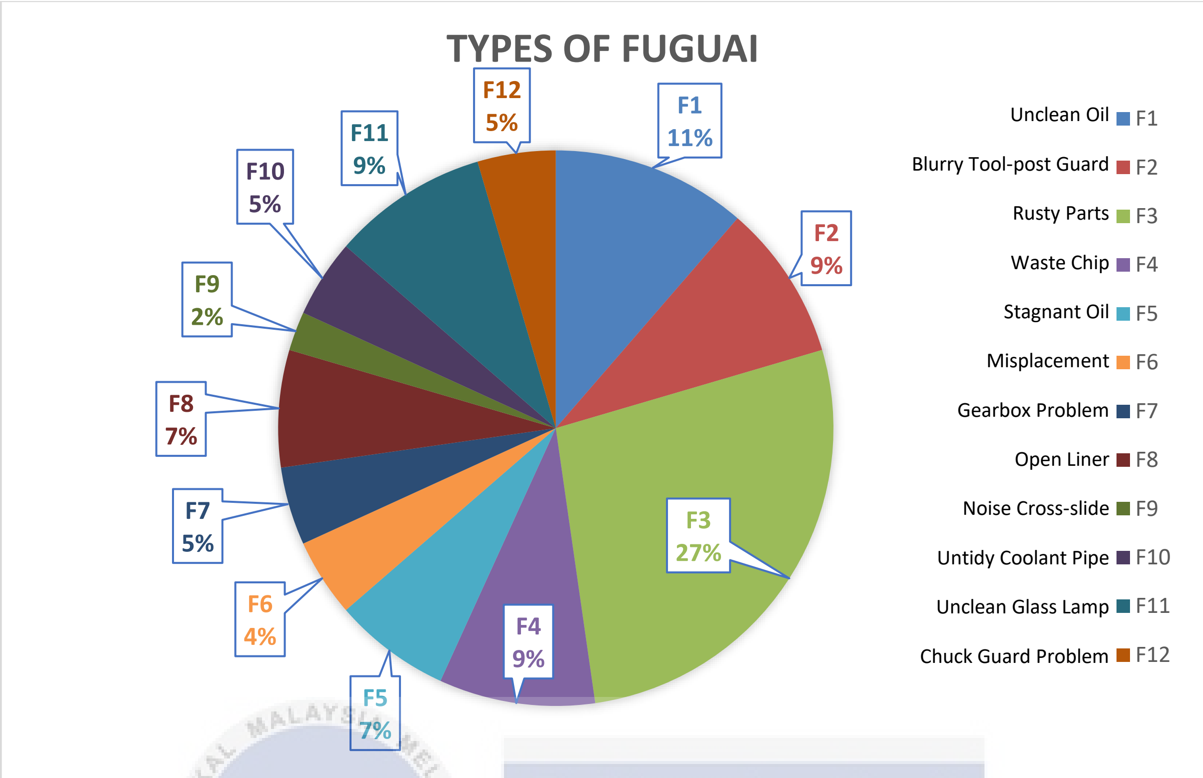


Figure 4.16 Pie Chart for Percentage Types of *Fuguai*

This pie chart provides information about the percentage types of fuguai on the lathe machine (Model: Optimum D-420). This pie chart is separated in twelve segments with the different percentage types of *fuguai*. The lowest percentage of 2% is belong to noise cross-slide (F9) and followed by the percentages of 4% which is (F6) misplacement of hand-tool on the machine. Next, the gearbox problem (F7), chuck guard problem (F12) and untidy coolant pipe (F10) consist same percentages of 5% among those *fuguai* that can find previously. It is because the performance of the lathe machine still in good condition.

4.5.2 Analysis of F-tags Distribution

Table 4.3 Comparison Between Both F-tags

List of *Fuguai*	F-tags colour	
	Blue	**Red**
Unclean Oil	6	0
Blurry Tool-post Guard	4	0
Rusty Parts	0	11
Waste Chip	4	0
Stagnant Oil	0	3
Misplacement	2	0
Gearbox Problem	0	2
Open Liner	0	3
Noise Cross-slide	0	1
Untidy Coolant Pipe	0	2
Unclean Glass Lamp	4	0
Chuck Guard Problem	0	2

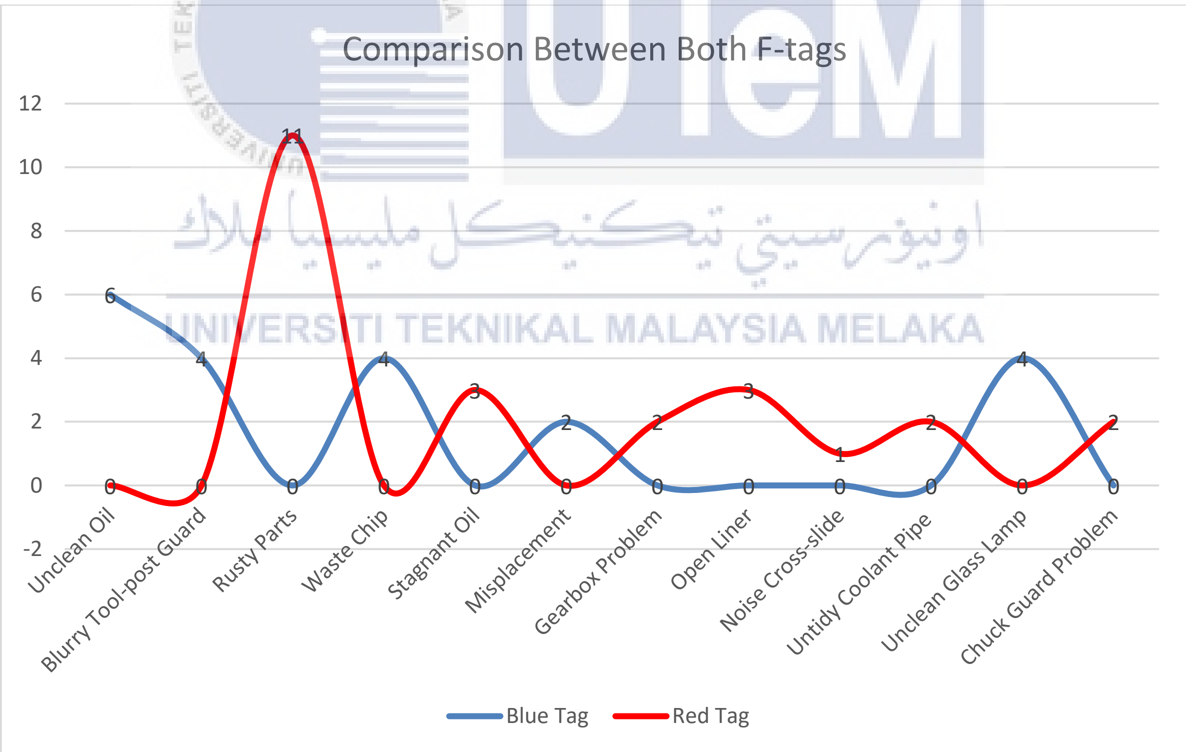


Figure 4.17 Trend Chart for F-tags Distribution

F-tag distribution is another excellent trend chart for displaying the collected data. Figure 4.17 depicts a comparison of both F-tags, which are blue and red tags. The graph will show the progress that has been made. As a result of success, the number of tags was going decreases. The highest value of red tags is rusty part (F3) that need to figure out by superior machinist to make a new part and keep the part of the machine performed occur during the process. *Fuguai* levels can be reduced by doing a final clean before to leaving the machine and clean the surrounding environment of the lathe machine. According to Table 4.3, there are only 20 blues marked *fuguai* and 24 reds labelled *fuguai*. The majority of the discovered *fuguai* are marked with red f-tags, indicating that the *fuguai* may be interpreted autonomously by the superior machinist of the lathe.

4.5.3 Analysis of Machine Area

Table 4.4 and Table 4.5 below illustrates the data were collected for the machine area among each Lathe Machine (Model: Optimum D-420). The data is collected using the specified statistical graphs, which are a column chart and a Pareto chart.

Table 4.4 Data Collected for Machine Area each Lathe Machine

Machine Area	Lathe 1	Lathe 2	Lathe 3	Lathe 4	Total
Headstock	4	3	2	3	12
Lamp	1	1	1	1	4
Tailstock	-	-	1	-	1
Tool-post Guard	1	1	1	1	4
Carriage	2	3	3	3	11
Bed Bridge	-	1	1	2	4
Machine Body (Back View)	1	1	1	1	4
Base Frame	1	1	1	1	4

Table 4.5 Cumulative Frequency for Machine Area

Machine Area	Frequency	Cumulative Frequency	Cumulative Percentage (%)
Headstock	12	12	27.27
Carriage	11	23	52.27
Lamp	4	27	61.36
Tool-post Guard	4	31	70.45
Bed Bridge	4	35	79.55
Machine Body (Back View)	4	39	88.64
Base Frame	4	43	97.73
Tailstock	1	44	100

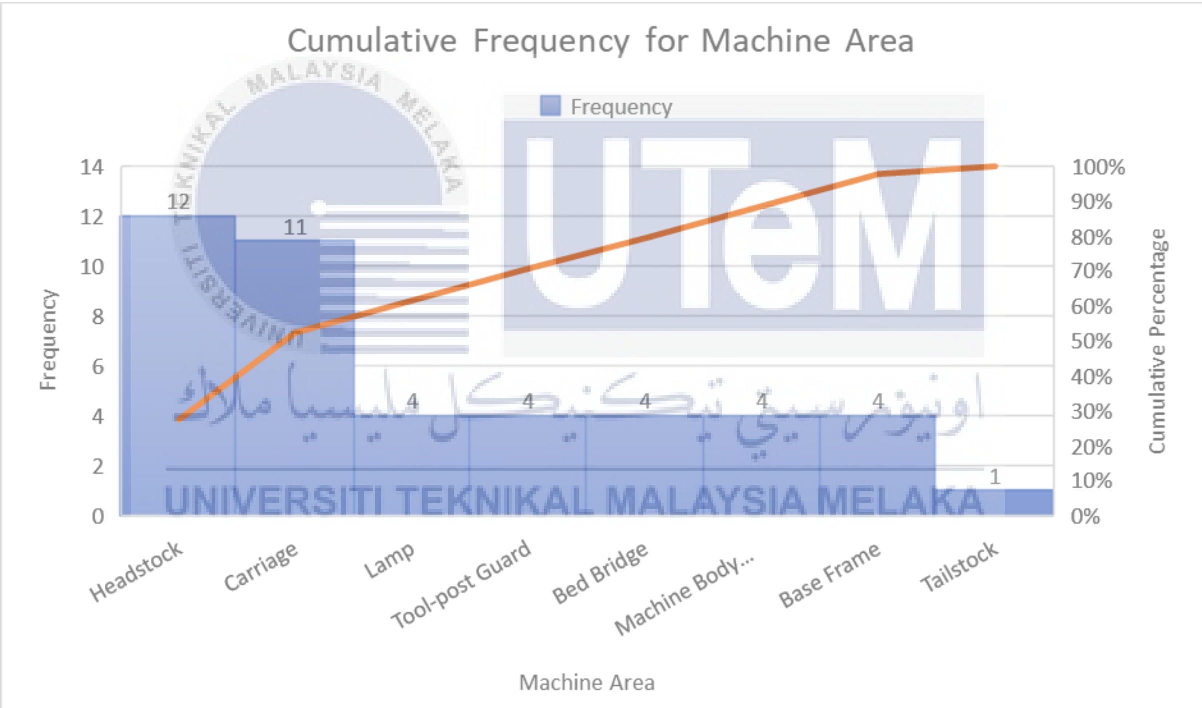


Figure 4.18 Pareto Chart for Machine Area

Fuguai on the machine area also can be analyzed by using a Pareto chart which is a statistics chart that lists the elements or effects of an issue in listed in order of frequency and cumulative significance. A histogram graphic is utilized inside the Pareto chart to classify the variables of *fuguai*. The major critical of machine area is a headstock which is frequency of 12 and the cumulative percentages of 27.27%. The minor critical of machine area is a tailstock which is frequency of 1 and the cumulative percentages of 100%. Therefore, the carriage also the second major of machine area which is frequency of 11 and the cumulative percentages of 52.27% and followed by lamp, tool-post guard, bed bridge, machine body (back view) and base frame are shared the same frequency of 4. Based on the Pareto chart, it assists in problem solving and leads in considerable improvements of the machine area.

4.5.3 Analysis of *Fuguai* Category

Table 4.6 Analysis of Machine Area based on *Fuguai* Category

Machine Area	*Fuguai* Category		
	Safety	Physical	Function
Headstock	1	9	3
Lamp	0	4	0
Tailstock	0	1	0
Tool-post Guard	0	4	0
Carriage	6	0	3
Bed Bridge	0	4	0
Machine Body (Back)	5	0	0
Base Frame	0	4	0

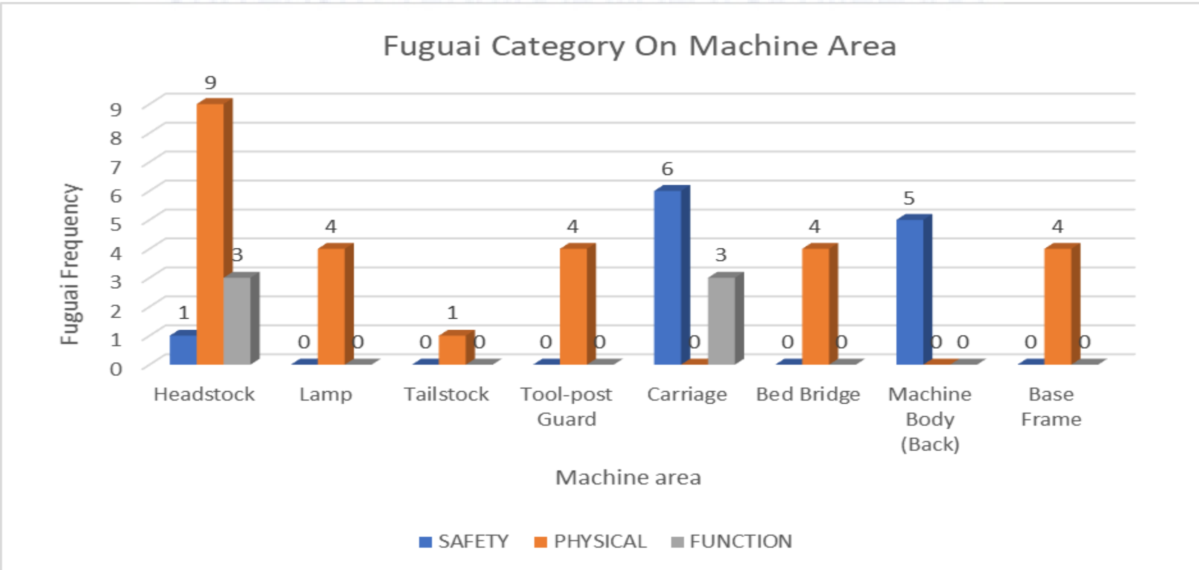


Figure 4.19 Column Chart for *Fuguai* Category on Machine Area

Figure 4.19 shows a column chart with the three *fuguai* category frequencies plotted against the area of frequency. According to the chart, functional *fuguai* were appears in the carriage area and headstock, whereas safety *fuguai* were appears in the headstock, carriage and the machine body (back view) areas. However, physical *fuguai* exist in every single phase developed because of the Lathe Machine's (Model: Optimum D-420) frequent *fuguai* defects. Although physical *fuguai* had the highest frequency of all, it is still relatively easy to fix by the average user of the lathe machinist.

4.6 *Fuguai* in Countermeasure Step and Discussion

Several *fuguai* were observed during countermeasure procedures. Every *fuguai* has a justification, and every failure has an explanation. Any *fuguai* instances discovered may be investigated to determine the actual cause and so prevent it from happening again in the future. Some *fuguai* have simple explanations, while others have complicated ones. The following discussion was on the study of the *fuguai* sources.

i. Frequently, dirty chuck guard was discovered *fuguai* contaminated with dust from cutting tools chips and other extraneous things. Chuck guards are often composed of a clear thermoplastic material, most frequently polycarbonate, which is corrosion resistant, resilient, shatterproof, and capable of withstanding continuous high impact. The actual cause of this *fuguai* is caused by the chuck turning during the machining process and without doing the first cleaning after using the lathe machine. As a solution, clean the dust on the surface of the chuck guard by using the dry cloth and a bottle of soap as shown on the appendix D.

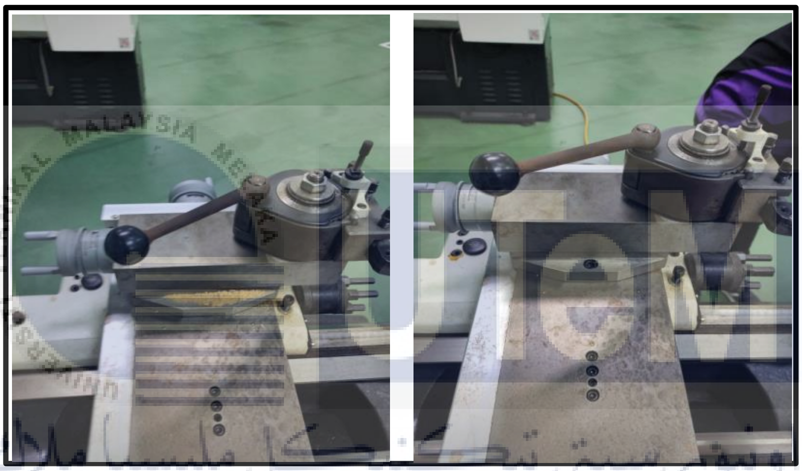
(a) (b) (c)

Figure 4.20 Before Cleaning Process (a), Equipment's Cleaning Process (b) and After Cleaning Process (c)

ii. Waste chip that consists of each the Lathe Machine (Model: Optimum D-420) also can be found and actual cause of *fuguai* sources. Machining is a major manufacturing operation and it involves a number of sustainability factors (such as tool life, usage of coolant and lubricant, waste chips and energy consumption) that have a big potential for environmental impact (S. Singh, 2017). Therefore, direct vacuuming of all waste chip from lathe machining can give cost savings, 100% efficiency, and time savings in machine tool maintenance. Using the vacuum specialized attachment kit, all waste chips may be reached, even the lathe's accessible areas to fix the *fuguai* as shown on appendix E.

(a) (b)

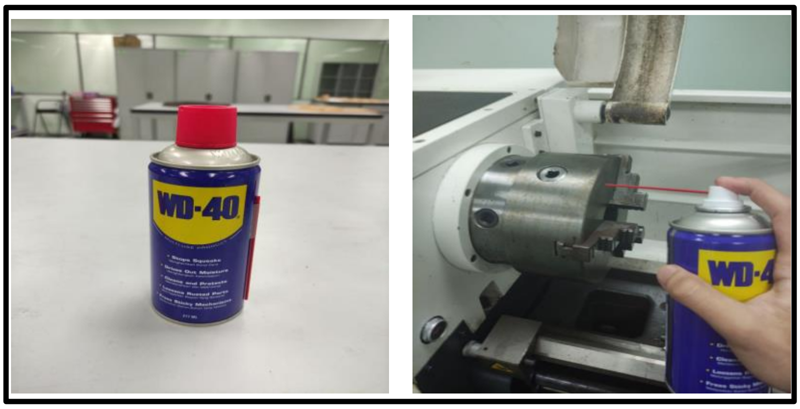
Figure 4.21 Tool-brush (a) and Vacuum (b)



(a) (b)

Figure 4.22 Before Cleaning Process (a) and After Cleaning Process (b)

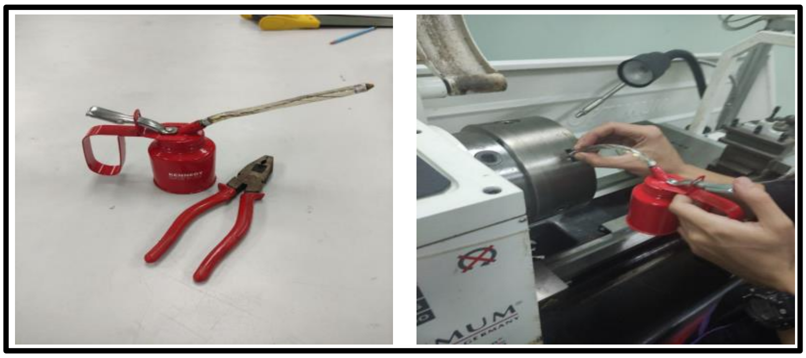
iii. Rusty parts were a major number of the *fuguai* that be found in this project. Rusty parts can be occurring when iron and oxygen react in the presence of water or moisture in the air. Another consideration is storing materials and parts in a high humidity environment without rust prevention. As a solution to fix these fuguai so that it does not happen once more in the upcoming by using WD-40 Specialist. Thus, WD-40 Rust Remover Soak dissolves rust rapidly and returns tools, equipment, and surfaces to bare metal without the need for chipping, scraping, or scrubbing.



(a) (b)

Figure 4.23 WD-40 Rust Remover Soak (a) and Rust Removal Process (b)

iv. Power chucks should be oiled at least once per eight hours of operation. A lubricant is a fluid that contributes to the reduction of friction between surfaces in mutual contact, hence decreasing the frictional heating as the surfaces move. It may also be used to transfer forces, convey foreign particles, or heat or cool the surfaces. When applying the oil, carefully pour it into a tiny cup and apply a little application to the chuck jaw's sliding surfaces as well as the screws.



(a) (b)

Figure 4.24 Equipment of Lubricant (a) and Lubricant Process (b)

v. As shown on the appendix F, regularly sanitize stagnant oil sumps and machinery. Remove any sludges and old machine coolant. Comers should be flushed out. It's pointless to put decent machine coolant into spore equipment. If required, modify sumps reservoir to facilitate cleaning by lining them forming rounded corners of the lathe machine.

(a) (b)

Figure 4.25 Before Cleaning Process (a) and After Cleaning Process (b)

Figure 4.26 Current Condition

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Finally, it may be concluded its significance is developing in the advanced manufacturing technology application stages. As a result, maintaining equipment is a critical duty in a production department. In general, the goal of maintenance is to minimize the *fuguai* impacts of breakdown and to optimize facility availability at the lowest possible cost. Its goal is to maximize the availability and efficiency of manufacturing equipment while keeping its operability at an affordable cost. Based on the findings in Chapter 4, the objectives of this project have been achieved. The *fuguai* that have been discovered were 12 types of *fuguai* which are unclean oil, blurry tool-post guard, rusty parts, waste chip, stagnant oil, misplacement, gearbox problem, open liner, noise cross-slide, untidy coolant pipe, unclean glass lamp and chuck guard problem on the Lathe Machine (Model: Optimum D-420) in the learning centre of the UTeM.

From all those listed *fuguai*, the most critical one is rusty parts which is consists of the highest percentage of 27% and found the *fuguai* frequency of 12. A physical *fuguai* is the highest of the F-tag types mentioned in the previous chapter. Furthermore, one of the important observations in the project was that the physical is a highly persistent sort of *fuguai* that influences each area of the machine. The most of the *fuguai* found on the machine have been eliminated. That just a small fraction of *fuguai* need further complex engineering knowledge to manage.

As the appropriate an AM programme for the lathe machine, it is countermeasure steps. The total result of *fuguai* discovered indicates that the lathe machine's greatest problem was *fuguai* that harmed its physical state at the machine area. The *fuguai* problem was discovered during the initial cleaning process. As a precautionary countermeasure steps, students, maintenance technicians, and lecturers were given informal discussions and explanations several times during visits. Consequently, the *fuguai* and F-tags physical inconsistencies have decreases reduced near the end of the project. Every stage in Autonomous Maintenance is crucial to achieving that all processes perform effectively. The most significant aspects of a basic AM to identify are fuguai, cause contamination, difficulty areas, and how people are participating throughout all processes. Additionally, AM must be implemented in an extremely systematic research approach. AM can indeed be successful even if there is continuous follow-up during implementation, inspection, and reinforcement.

All along the project, there few limitations which is necessary to set appropriate *fuguai* minimization standards as part of autonomous maintenance for the future reference of new or experienced users. The regulations for *fuguai* minimization are built depending on each *fuguai*. Depending on the methods and purpose for fuguai minimization, several ways are used to deal with many different fuguai types. Cleaning and inspection are undertaken on a daily and planned schedule for guarantee excellent maintenance, self-discipline, and the direct application of the operator's responsibility toward the equipment. Students and technicians use a thorough technique to restore the instrument to its original form while also identifying frequent defects. AM allows for advances in tool availability and performance, which are made feasible by its implementation. Consequently, the equipment will be able to continue working for a longer period of time. Therefore, *fuguai* are being analysed and evaluated as a preventative approach to enhance the machine's lifetime and performances.

Although not every fuguai have been fixed and *fuguai* characteristics of the laboratory lathe machines have been improved greatly.

5.2 Industrial Potential

Industry 4.0 is a new way of processing products. Companies' manufacturing processes have developed over time as manufacturers strive to get the most out of their equipment and manpower. What is Industry 4.0, how does it connect to maintenance, and how should organizations be considering about it today to be prepared for the future? Meanwhile, to do tentative standards are developed with the assistance of maintenance personnel, operators, certified engineers, and skilled fitters. Thus, technicians keep an eye on the system to ensure that all these *fuguai* do not reoccur and just one works in this area inspects the machine's systems, such as pneumatics, lubrication systems, fasteners, and so on, because then *fuguai* particular to the process may be quickly discovered, analysed, and handled. A check list is created so that untrained individuals may complete this very same operate autonomously using the check list. The goal of autonomous inspection is to apply visual, symptoms and reducing thoughtless errors. Therefore, the goal of AM is to assess the operator's role, enhance all tasks that are being performed, as well as improve maintenance and control of autonomous inspection with develop a system. Next, implement standards or virtual and physical control barriers in the workplace which these activities are performed will never fail due to development of *fuguai*. Additionally, AM activities not only aim to prevent breakdowns, but also to achieve zero failure and zero defects.

5.3 Recommendations

There have been several recommendations for further research into the deployment of an autonomous maintenance programme; continuous improvement never stopped. Workplace management and control are required to ensure success, and research on implementation for industrial application may be undertaken, as this study focuses mainly on personal machines for educational purposes. Moreover, the machine's actual utilization time should be verified to be parallel with the scheduled usage period. If this is not the case, the machine cannot be observed while students work on their machining projects. In order the cleaning schedules must be followed and there should be no leftovers. Meanwhile, the user should not abandon the cleaning processes and believing that the machine would be soiled or dirty again as soon as it is used. In addition, the determination of *fuguai* may be compared with machines that have the same processing type but use different specialized equipment. There is because no one standard audit check sheet or audit methodology that is recommended wherever. Thus, organizations and individuals may always have their own standards in terms of auditing procedure, based on how it operates. All this standardizing needs an audit to ensure sustainability and appropriateness.

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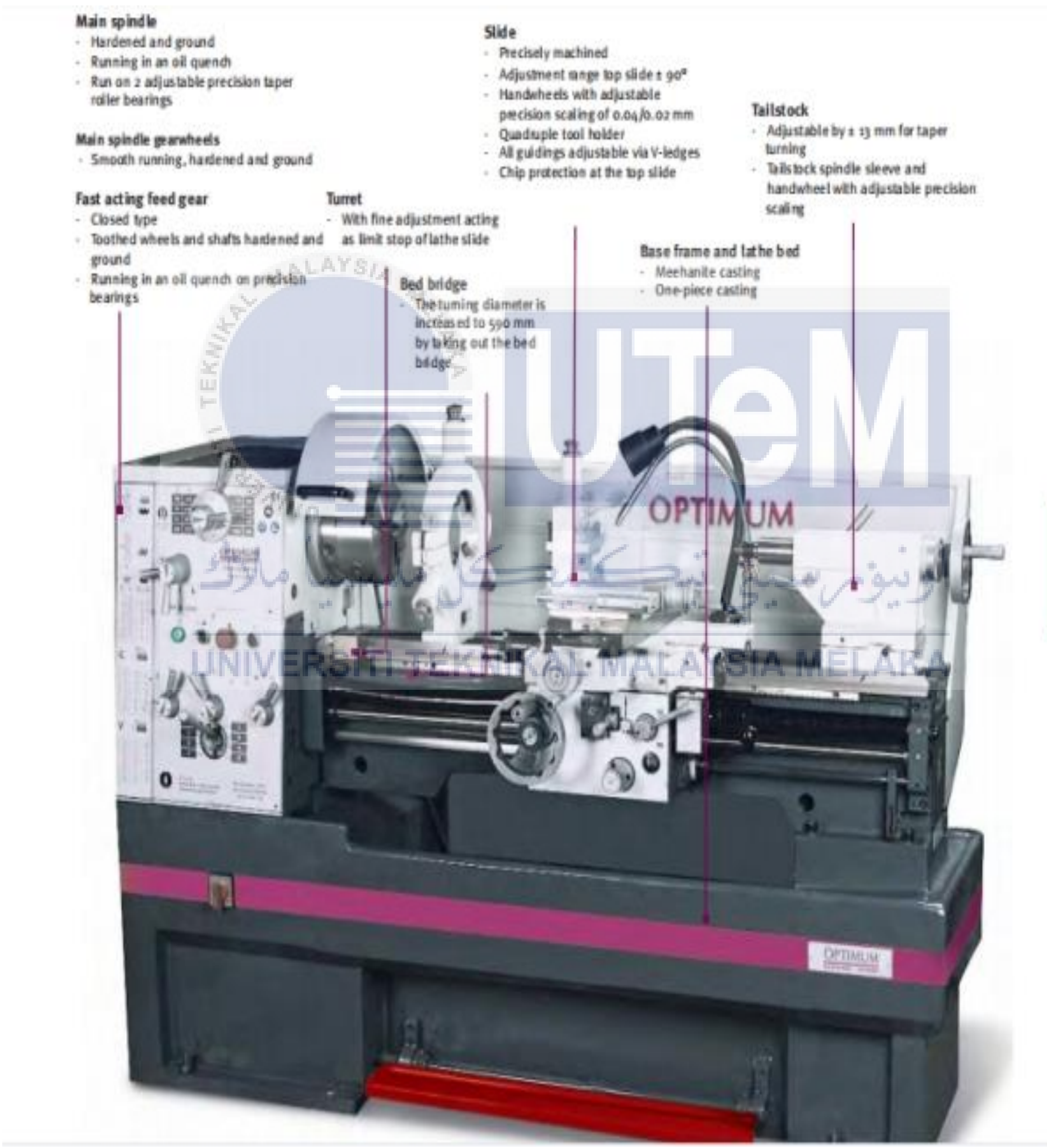
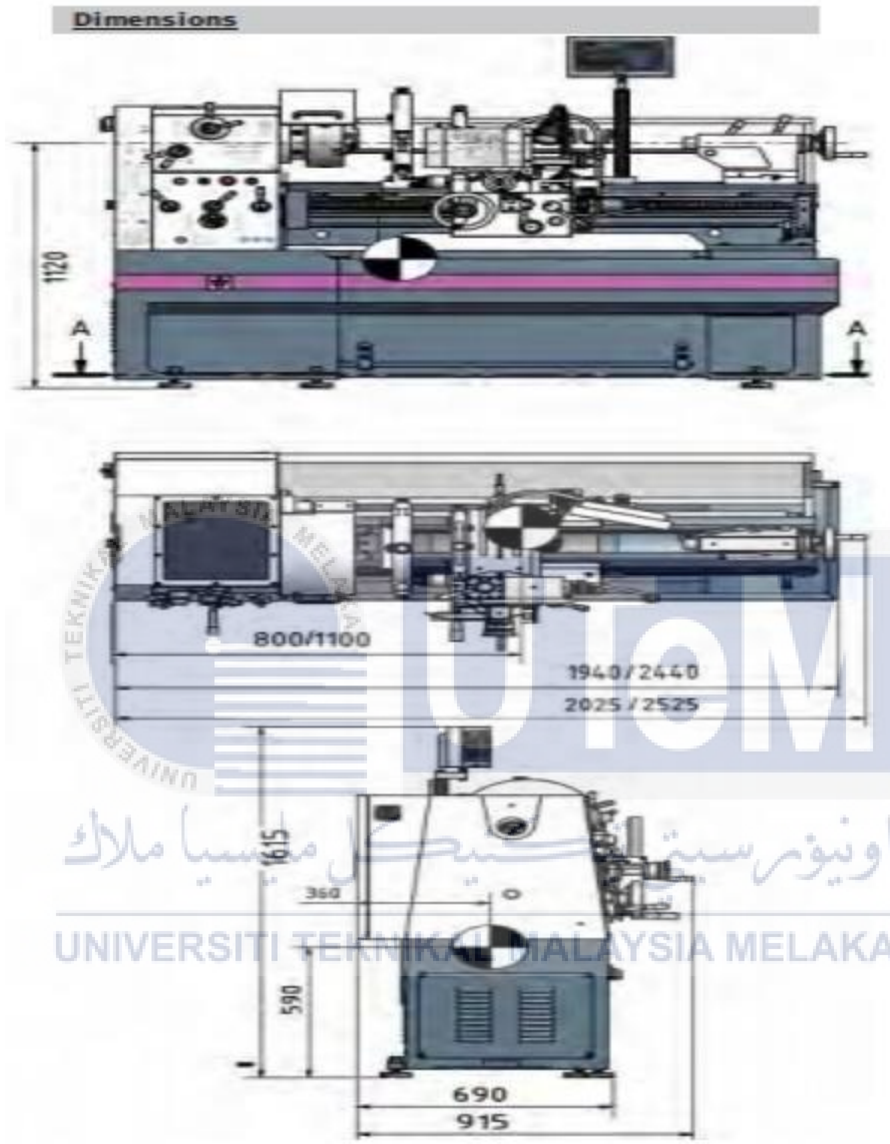
APPENDICES

APPENDIX A Lathe Machine (Model: Optimum D-420)



Appendix A-1 Lathe Machine (Model: Optimum D-420)

APPENDIX B Dimension Lathe Machine (Model: Optimum D-420)



Appendix B-1 Dimension Lathe Machine (Model: Optimum D-420)

APPENDIX C Specifications Lathe Machine (Model: Optimum D-420)

Model	D 420 x 1000	D 420 x 1500
Item No	340 1160	340 1165
€ plus VAT	8'690.00	9'790.00
Model	D 420 x 1000-DPA	D 420 x 1500-DPA
Item No	340 1160DPA	340 1165DPA
€ plus VAT	9'690.00	10'990.00
Performance features		
Electrical connection		
Motor power	4.5 kW 400 V ~50 Hz	
Coolant equipment	90 W	
Machine data		
Centre height	210 mm	
Centre width	1'000 mm	1'500 mm
Turning Ø over lathe bed	420 mm	
Turning Ø over cross slide	250 mm	
Turning Ø in the bed bridge	590 mm	
Length of bed bridge	260 mm	
Spindle speed	45 - 1'800 rpm	
Spindle speed Vario machines	10 - 1'800 rpm	
Number of steps	16 steps; for Vario infinitely variable	
Spindle taper	MT 6	
Spindle seat	Camlock ASA D1 - 6"	
Spindle hole	52 mm	
Bed width	250 mm	
Travel top slide	140 mm	
Travel cross slide	230 mm	
Tailstock seat	MT 4	
Tailstock - sleeve travel	120 mm	
Length infeed in the range of	0.05/1.7 mm/rev; 17 length infeeds	
Transverse feed in the range of	0.025/0.85 mm/rev; 17 transverse infeeds	
Pitch - metric in the range of	0.2/14 mm/rev; 39 pcs. thread pitches	
Pitch - inch in the range of	72 - 2 threads/1"; 45 pcs. thread pitches	
Trapezoid thread in the range of	8 - 44; 21 pcs. trapezoid thread	
Modular thread in the range of	0.3 - 3.5; 18 pcs. modular thread	
Quadruple tool holder		
Seat height (max.)	20 x 20 mm	
Dimensions		
Length	2'025 mm	2'525 mm
Width x Height	915 x 1'375 (DPA 1'615) mm	
Net weight	1'550 kg	1'800 kg
Vario retrofit only for	D 420 x 1000-DPA	D 420 x 1500-DPA
Item No	340 2941	340 2942
€ plus VAT	3'290.00	3'290.00

- Incl. Vario retrofit kit 400V
- Exchange digital position display DPA 2000 to DPA 2000S
- Incl. factory assembly

Appendix C-1 Specifications Lathe Machine (Model: Optimum D-420)

APPENDIX D Countermeasure *Fuguai* Report 1

PROPOSED BY	AMIRUL AIZAT BIN ADZMAN	LOCATION IMPLEMENTATION	LATHE MACHINE 2
FUGUAI NAME	UNCLEAN CHUCK GUARD	DATE IMPLEMENTATION	15/12/21

PROBLEM	COUNTERMEASURE	RESULT
Dust Chuck Guard the Lathe Machine.	Clean the dust on the surface of the chuck guard by using the dry cloth and a bottle of soap.	No more dust on the surface of the chuck guard.

BEFORE	AFTER
	

Appendix D-1 Countermeasure *Fuguai* Report 1

APPENDIX E Countermeasure *Fuguai* Report 2

PROPOSED BY	AMIRUL AIZAT BIN ADZMAN	LOCATION IMPLEMENTATION	LATHE MACHINE 2
FUGUAI NAME	WASTE CHIP	DATE IMPLEMENTATION	15/12/21

PROBLEM	COUNTERMEASURE	RESULT
Waste Chip on the surface of carriage's Lathe Machine.	Wipe out and direct vacuuming of all waste chip from lathe machining.	No more waste chip on the surface of the carriage's Lathe Machine.

BEFORE	AFTER
	

Appendix E-1 Countermeasure *Fuguai* Report 2

APPENDIX F Countermeasure *Fuguai* Report 3

<table>
<tr><td>PROPOSED BY</td><td>AMIRUL AIZAT BIN ADZMAN</td><td>LOCATION IMPLEMENTATION</td><td>LATHE MACHINE 2</td></tr>
<tr><td>FUGUAI NAME</td><td>STAGNANT OIL</td><td>DATE IMPLEMENTATION</td><td>15/12/21</td></tr>
<tr><td colspan="2">PROBLEM</td><td>COUNTERMEASURE</td><td>RESULT</td></tr>
<tr><td colspan="2">Stagnant oil on the reservoir of the Lathe Machine.</td><td>Sanitize stagnant oil sumps, remove any sludges and old machine coolant.</td><td>No more stagnant oil on the reservoir of the Lathe Machine.</td></tr>
<tr><td colspan="2">BEFORE</td><td colspan="2">AFTER</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Appendix F-1 Countermeasure *Fuguai* Report 3