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Critical Component Analysis Of Amc 36-800/Ma An Shan Lathe Using Failure Mode And Effect Analysis And Fault Tree Analysis Methods

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ABSTRACT

Maintenance emerges as a crucial intervention to ensure the sustained reliability of machinery. The AMC 36-800/MA AN SHAN lathe, a piece of equipment subject to extensive operational demands, frequently encounters breakdowns, thereby obstructing the seamless execution of maintenance activities for facilities. This investigation seeks to pinpoint the components responsible for the failures and malfunctions afflicting the lathe above. Employing the methodologies of Failure Mode and Effects Analysis (FMEA) and Fault Tree Analysis (FTA), this study successfully identifies the components at the epicentre of the machine's vulnerabilities. The analysis culminates in delineating critical components by calculating Risk Priority Numbers (RPN), unveiling a pivotal RPN value of 309.57. Moreover, it isolates two components whose failure modes surpass the critical RPN threshold: the Drive Motor and the Fixed Head. The genesis of these failures can be attributed to the escalating operational intensity, elevated engine temperatures, and a maintenance regimen that is both sporadically scheduled and suboptimal.

Keywords: Lathe AMC 36-800/Ma AN Shan, Failure mode, FMEA, FTA, RPN

Introduction

In the era of industrial development, facility maintenance activities or work support equipment are carried out. Machine maintenance is one of the factors that can affect the production process because the machine is a facility needed by a company in production [1]. Maintenance activities are carried out to repair or maintain equipment so that production activities can be carried out effectively and efficiently and produce quality products [2]. Maintenance activities can minimise costs or losses arising from damage to the machine [3]. The reliability of a machine depends on its period of use; the continuously used machine will continue to decrease its reliability [4].

One form of lathes maintenance is carrying out the lathe process AMC 36-800 / MA AN SHAN[5]. The wheel lathe process is carried out to minimise problems, namely the frequent careless operators in terms of safety. To maintain the condition of the lathe and make it usable, a scheduled maintenance and checking process must be carried out[6]. Lathes AMC 36-800/MA AN SHAN are performed using the help of lathes AMC 36-800/MA AN SHAN[7]. Therefore, it is necessary to prevent it by knowing the RPN value and the causes of existing failures[8]. Along with many problems with the wheels, the wheel lathe process is carried out continuously, which often causes the AMC 36-800 / MA AN SHAN lathe to be damaged[9]. Damage to the AMC 36-800/MA AN SHAN lathe significantly affects the facility's operation and can hinder maintenance. To prevent damage to the AMC 36-800 / MA AN SHAN lathe, maintenance on the AMC 36-800 / MA AN SHAN lathe One way to maintain a good machine is to identify the damage that occurs so that the machine's performance can be predicted. The production results obtained and the quality produced is good[10]. This study aims to identify and analyse AMC 36-800 / MA AN SHANlathe components to determine the components with the highest potential for failure and the causes of these failures[11]. To be able to identify damage or failure, one of them is done using the FMEA and FTA methods. FMEA is one method to evaluate the possibility of failure of a process, design, and system to make handling steps[12], [13].

The use of FMEA in maintenance can be said to be more actual because it looks at the history of damage and failure of an engine component[14]. Meanwhile, it is one of the methods used to analyse the root cause or cause of work accidents[15]. The use of FTA aims to identify each failure along with the root cause of the failure [16]. In one of the studies on failure analysis with the FMEA and FTA methods that have been carried out, FTA and FMEA are used for a comprehensive analysis of the top-level system so that it can be the right solution in dealing with problems that occur and from both methods can be made maintenance scheduling by differentiating behaviour according to the critical level of each machine component[17]. The results of this study are expected to minimise damage to the AMC 36-800 / MA AN SHAN lathe and can be a reference in making maintenance scheduling[18]. The purpose of choosing this method is to improve warehousing management.

Research Methods

This study analysed the failure mode and its effect on the PT's AMC 36-800/MA AN SHAN lathe machine. Swadaya Graha uses Failure Mode and Effect Analysis (FMEA) and Error Tree Analysis Method (FTA)[19]. This study identified critical components that frequently fail, particularly Drive Motors and Fixed Heads, attributing their malfunctions to high usage intensity, engine temperatures, and inadequate maintenance schedules. Using FMEA and FTA, the study pinpointed vulnerabilities in operating lathes and proposed practical recommendations for improvement, emphasising the need for regular and thorough maintenance checks by standard operating procedures to obtain the final RPN result of the multiplication between the three factors[20]. Through the FMEA method, the failure of a critical component on a machine or system can be known based on the RPN or Risk Priority Number. Meanwhile, the FTA method is used to find the root cause of failure in a system. The object of research taken in this study is the lathe component AMC 36-800 / MA AN SHAN. Lathe components of the AMC 36-800/MA AN SHAN lathe were identified and analysed for potential failures and their causes. The stages of research carried out are as follows:

Problem Formulation

This research begins by formulating the problems and conducting field and literature studies.

Data Collection

Data collection is carried out by observing the location directly and interviewing machine operators and divisions that perform maintenance. The data taken is in the form of data on machine damage, data on machine components and the impact that arises when the machine experiences a work failure.

FMEA

After collecting data and identifying critical components, the preparation of FMAE is arranged based on function, potential failure, and cause of failure. The use of FMEA is because FMEA has flexible procedures. After all, the goals of the organisation, processes, products, and customers in each company are different. In FMEA, the priority level of a failure can be determined by calculating the risk priority number (RPN). RPN calculation is determined by three factors, namely severity, occurrence, and detection. Failure using the FMEA method is aimed at improving engine performance. Defective products can be caused by machines, processes, materials, people, measurements, and the environment.

Critical Component Determination

From the calculation of the RPN that has been done, the critical components of the machine can be determined. RPN can be used as a basis for the selection of essential elements for carrying out component maintenance.

FTA

Fault Tree Analysis is a graphical model of parallel variations and combinations of faults arising from defining a problem. FTAs use tree diagrams to show the causes and effects of an event. After determining the critical components, an FTA is made to determine the cause of the failure [21].

Proposed Improvements

The analysis that has been done can provide proposals for further improvements or maintenance scheduling by the company.

Results and Discussion

The data collection method used in this study was directly observing the company under study. Before creating an FMEA table, it is necessary to identify the failures of each component. The inability of AMC 36-800/MA AN SHAN la the components can be identified in **Table 1.**

Table 1 Potential identification results

NO.	Component	Failure mode	Potential effects of failure
1.	Drive Motor	Electrical constellation	Low Colter (low quality) can cause a fire, so it cannot be used for turning.
2.	Fixed head	The transmission gear inside the gearbox jammed	The machine's speed and direction of rotation so unstable will result in the feeding of the workpiece is not solid/stable.
3.	Emergency Stop	Not working	Hazards during emergencies in operation resulting in work accidents
4.	Foot brake	It does not work when stepped on. The transmission gear inside the gearbox is stuck.	It can't stop the turning process scrolling and doesn't stop at a particular position.
5.	Gripper	Moving not simultaneously	difficult to set the workpiece to the flashlight
6.	Tailstock	Stuck when pushed	Drilling compression in the workpiece can not be done
7.	Handle	Break	I cannot adjust the speed, and the spindle speed is less stable.

Based on Table 1, 13 components have failure modes. Several effects can arise from the existing failure mode that can affect engine operation. After identifying engine component failures, an FMEA analysis will be performed, and the RPN will be calculated. Three factors, namely determine the calculation of RPN:

A. Severity

Severity is a parameter that measures the level of danger when the system is working and the impact it causes on the machine or the surrounding environment.

Table 2 The Value of Ad

Effect	Criterion	Rating
None	Unnoticed by the customer and does not affect the product or process	1
Very Mirror	Damage is likely to have minor consequences, but the chances of it happening are very small	2
Mirror	Crashes are minor glitches but do not cause performance degradation	3
Very Low	Damage can cause minor performance loss	4
Low	Damage affects product/process performance so that it can cause complaints	5
Moderate	Damage may cause partial failure of the product/process	6
Tall	Damage may cause partial failure of the product/process	7

High level	Damage causes the product/process to be inoperable or repairable	8
It's so high	Damage may lead to violation of government regulations	9
Very high	Damage may cause physical injury to users or workers	10

B. Occurrence

Occurance is a frequency value for the occurrence of failure mode in a component [14].

Table 3 Occurrence Value

Criterion	*Occurrence*	Rating
It is unlikely that a cause resulting in crash mode occurs	1 ln1.000.000	1
Damage is rare	1 ln20.000 1ln4.000	2 3
Damage is somewhat likely	1 ln1,000 1 ln400	4 5
Damage is very likely	1 ln80 1 ln40 1 ln20	6 7 8
Damage certainly occurred	1 ln8 1 ln2	9 10

C. Detection

Detection measures the ability to control failures that can occur at the workstation.

Table 4 Nilai Detection

Detection	Possible Detection by Control	Rating
A little impossible	Slight checks detect no damage	10
Quite a bit of a possibility	Not bad allows for checking to occur, detecting damage	9
Little Allow	It is less likely for checks to occur to detect damage	8
Very low	Dilution has a slight chance of detecting damage	7
Low	Checking for possible damage detection	6
Passable	Checking is likely to detect damage	5
High level	Checking is high enough to detect damage	4
Tall	There is a high probability of detecting damage	3
Very high	Checking can almost certainly detect damage	2
Almost certainly	Checking can detect damage	1

Risk Priority Number (Risk Priority Number) RPN is the last step in performing the FMEA method, where RPN has no meaning and value[22]. A mathematical product whose seriousness is seen from effects (Severity), the possibility of occurrence cause which results in failures related to effect (Occurrence), and the ability to detect and know failures before they occur to the unit (Detection). The following equation can show RPN:

$$RPN = S*O*D \quad (1)$$

A number used to identify risks seriously as a clue towards corrective action.

Table 5 Failure Mode and Effect Analysis

NO.	Component	Failure mode	Potential effects of failure	(S.O.D) S	Or	D	RPN
1.	Drive Motor	Electrical constellation	Low Colter (low quality) can cause a fire, so it cannot carry out the turning process	9	8	8	576
2.	Fixed head	The transmission gear inside the gearbox jammed	The speed and direction of rotation of the machine so unstable will result in the feeding of the workpiece is not solid/stable	8	8	9	576
3.	Emergency Stop	Not working	Hazards during emergencies in operation resulting in work accidents	9	6	7	378

4.	Khaki Rem	It does not work when stepped on. The transmission gear inside the gearbox is stuck	Can't stop the turning process scrolling and doesn't stop at a specific position	6	7	6	252
5.	Gripper	Moving not simultaneously	difficult to set the workpiece to the flashlight	5	7	7	245
6.	Tailstock	Stuck when pushed	Drilling compression in the workpiece can not be done	2	8	5	80
7.	Handle	Break	Cannot adjust the speed, and the spindle speed is less stable	3	4	5	60

Table 5 shows 7 failures that occur in AMC 35-800/Ma AN Shan lathes. Next, the determination of the critical value is carried out using the formula:

$$Critical\ Value\ RPN = \frac{\text{Total RPN Value}}{\text{Number of failures}} \quad (2)$$

After getting the RPN value and then calculating the critical value using the formula above, the critical value in this analysis is:
Critical Value RPN = 2.167 : 7
Critical Value RPN = 309.57
As a result of the critical value of RPN that has been calculated, the essential value of RPN is 309.57. After analysis, there were 2 failures above the critical value contained in 2 components, including the Drive Motor component and fixed head. The essential values of the elements can be seen in **Table 6**.

Table 6 Critical Components

Component	S	Or	D	RPN
Drive Motor	9	8	8	576
Fixed Head	8	8	9	576

To analyse the causes of failure, the FTA method is used with a top-down approach, which starts from the top-level event, which has been analysed based on risk priority, then looks for the cause of failure until the essential event from the most fundamental cause of failure[23]. Based on the RPN calculation results, four components have the highest critical values caused by several failure modes. The essential risks of these vital components are then identified using the FTA method. Identification using FTAs can be seen in **Figure 1**.

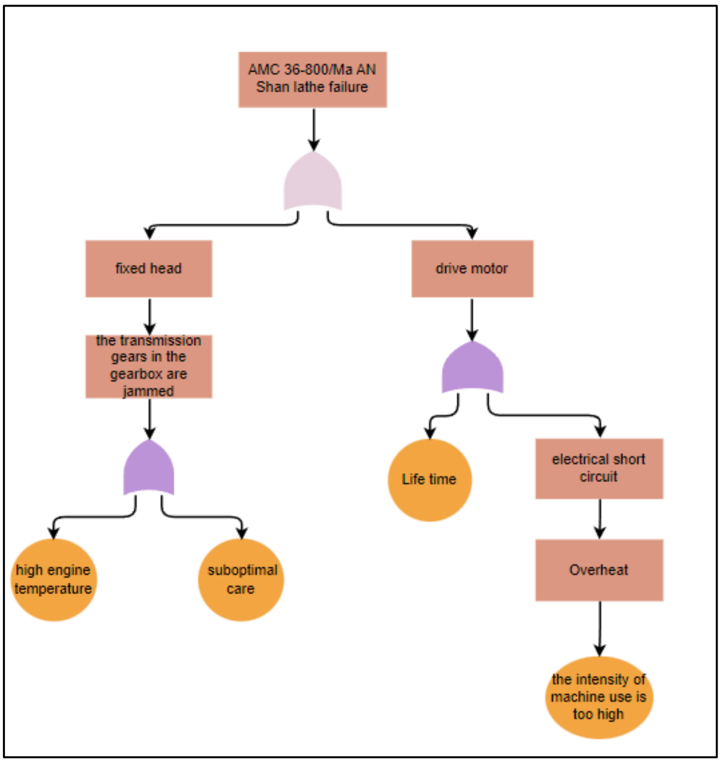

Figure 1. Fault Tree Analysis of AMC 35-800/Ma AN Shan Lathe Machine Failure.

From the results of the FTA analysis that has been carried out, the high intensity of machine use becomes the primary event or basis for failure initiation in every damage that occurs. Besides that, the lifetime of each component and suboptimal maintenance carried out are also the primary causes of failure on underfloor lathes. After the analysis of FMEA and FTA and the obtained results, suggestions can be taken that can be used for treatment policies[24]. Proposed improvements based on the results of RPN calculations can be seen in **Table 7.**

Table 7. Recommended activities

Component	**RPN**	***Recommended Action***
Drive Motor	576	Check the tightness of the cable/copper clamp to avoid a short circuit Replacing cable/copper when it is no longer suitable for use Removing dirt or insects that enter the Drive Motor Always pay attention to the working time of the engine so as not to work *overtime* to make the drive motor is not damaged
Fixed Head	576	Always pay attention to the feeding of the machined workpiece so as not to be too heavy pressure so as to make the gear not easily damaged. Pay more attention to gear care, so it is not easily damaged. If improvements are made, it is feared that the performance of these components will not be optimal. Check the current and rotation speed of the fixed head before performing turning work.

From **Table 7**, it can be concluded that the improvement recommendations from the analysis that have been carried out are periodic checking and maintenance by the guidebook[25]. Checking and maintenance must also be carried out in detail on all components.

Conclusion

Based on these results, conclusions can be drawn regarding identifying critical components that cause damage and proposed repairs to the AMC 35-800 / Ma AN Shan engine[26]. The conclusion obtained based on observations is that there are 7 critical components in the failure of the AMC 35-800 / Ma AN Shan engine. With the most considerable RPN value, namely the motor driving component, the cause of the cable/copper peeling with a value of 576, while with the same RPN value, the fixed Head component causes damage to the fixed Head system, causing the lathe work process is not optimal. The factors causing failure include the intensity of engine use that is too high, the high engine temperature, and the fact that maintenance carried out is less than optimal.

Proposed improvements based on these 2 critical components are to make SOPs according to turning quality standards, make theoretical and practical training for lathe operators, carry out regular maintenance, check the flow of lathes before turning work and every time before turning work, cleaning must be carried out on the premises and materials. Beyond research recommendations for routine inspection and maintenance, including predictive maintenance, this strategy can significantly improve machine reliability. Leveraging sensors and IoT technology to monitor critical conditions in real-time, components may predict failures before they occur, enabling preventive maintenance measures. The study highlights problems with operator error and suggests training for lathe operators. Extending on this, detailed training programs leading to certification for operators can be undertaken, ensuring higher standards in operational knowledge and safety practices, reducing the risk of machine breakdowns due to human error. Although the study provides solid results of recommendations for machine maintenance, a detailed cost-benefit analysis of the application of these recommendations versus the cost of machine downtime and repairs can strengthen the argument for practice Proactive maintenance. Conducting longitudinal studies to trace the implementation of recommended improvements and their impact over time provides valuable insights into the effectiveness of this strategy, reducing machine failure rates and maintenance costs. Inclusion of Technology Solutions: Exploring more integrations of advanced technology solutions, such as machine learning algorithms that can analyse historical data to predict future failures, may offer sophisticated approaches to minimise downtime and optimise schedule maintenance.

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