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Total Productive Maintenance (TPM) Implementation to Improve Machine Efficiency

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ABSTRACT

The company focuses on producing quality products by implementing the Toyota Production System, known as TPS. The current constraint is the absence of maintenance on the Leak Test, thereby reducing production profits caused by high engine damage. This also causes the average repair time for the Leak Test Model 4L45W engine to be above the repair target set by the company, where the company targets an average repair time per month of 12 minutes. For this reason, corrective steps are needed so that the production process runs smoothly according to operational standards. This step involves proposing the implementation of Total Productive Maintenance (TPM). It is known that the average Overall Equipment Effectiveness (OEE) Leak Test machine in June–August was 60.09%. The Japan Institute of Plant Maintenance (JIPM) stipulates that if the OEE value is equal to 60%, it indicates that there is a lot of room for improvement. After implementing Total Productive Maintenance (TPM) on the Leak Test in September, the OEE value rose to 94.33%, and the average monthly repair time met the company's target of 9.2 minutes. This greatly affects the cost of production due to lower production costs due to overtime. This indicates improvement, and the first step in the proposed implementation of the Total Productive Maintenance Machine Leak Test model 4L45W is said to be successful.

Key Words: Overall Equipment Effectiveness, Mean time to Repair. Productive Maintenance, Toyota Production System.

1. INTRODUCTION

The development of the industrial world is increasingly rapid, resulting in increased competition in the industrial world, so companies are competing to improve efficiency. Modern manufacturing requires organizations that want to succeed and achieve world-class manufacturing to have adequate maintenance and efficiency. Underlies all parts of the organization to continue to make improvements. The consequences of the company's inability to provide satisfaction to consumers in the form of products that meet specifications and the accuracy of delivery of goods will result in the switch of regular customers and not the addition of new customers [1].

The amount of production, quality of production, and maintenance of machinery in a production process are interrelated issues; traditionally, the three problems are separate. Each has its own needs to grow and develop, even though, factually, there is dependence on each other. The modern production process prefers to combine to obtain optimal results [2].

This partner company is engaged in automotive manufacturing and Air Cleaner assembly production for four-wheeled vehicle customers. The problem today is the machine's high downtime or damage to the machine in production, so it requires a repair time that the company has targeted for a maximum of 12 minutes. However, machine repairs exceed the company's target time, and machine maintenance carried out by the maintenance department has not been efficient, so machine damage often occurs during production. Waste activities in the production process are still high, so waste minimization is needed to increase production output. Below is Table 1 of engine damage frequency data from 2021 and 2022.

Table 1. Machine Breakdown Frequency

Engine Breakdown		*Leak Fault*	*Cylinder Fault*	Sensor Fault	Other	Total
CY 2021	June	4	2	1		**7**
	July	6	3	2	1	**12**
	August	7	6	2		**14**
	September	2		2		**4**
	October	1	1	1	2	**5**
	November	2	-	-	-	**2**
	December	1	1	1	1	**4**
CY 2022	January	4	2	3	1	**10**
	Februaryy	1	1	2	-	**4**
	March	4	2	1	1	**8**
	April	5	1	1	1	**8**
	May	4	2	2	1	**9**
	June	5	2	2	1	**10**
	July	5	3	2	1	**11**
	August	7	4	2	-	**13**
Total		**58**	**30**	**24**	**10**	**121**

Based on Table 1, The high frequency of engine damage can be seen in the Leak Test machine. From June 2021 to August 2022, the Leak Test machine was damaged 58 times. Therefore, it is necessary to find solutions and solve problems, starting with calculating the current OEE value and applying the Total Productive Maintenance method and waste minimization in the production process.

To improve machine efficiency, this study will use a Lean manufacturing approach, resulting in a decrease in machine damage by applying Total Productive Maintenance. [3].

2. LITERATURE SURVEY

2.1 Basic Lean Concepts

Use There exists a persistent endeavour to eradicate inefficiencies and enhance the value-added aspects of products (both goods and services) in order to deliver optimal customer value. The objective of the lean approach is to achieve ongoing enhancements in Customer Value by continuously improving the ratio of value to waste [4]. The Lean methodology encompasses five fundamental principles.

1. Identify the value of products (goods and services) based on the customer's perspective, where customers want superior-quality products with competitive prices and timely delivery.
2. Identify the value stream process mapping for each product. Eliminate non-value-added waste from all activities throughout The Value Stream.
3. Organize materials, information, and products to flow smoothly and efficiently throughout the Value Stream process using the Pull system.
4. Continuous improvement tools and techniques for excellence and continual improvement

2.2 Pillar of TPM

A strong foundation and solid pillars are expected when applying the TPM method to a manufacturing company. The foundation of TPM is 5S, while the primary pillars of TPM consist of 8 pillars or are generally considered to use 8 pillars of TPM [5]. The eight pillars of TPM are focused on aggressive and preventive techniques to increase the reliability of machinery and production equipment. Here are the 8 pillars of TPM according to Shirose (1995):

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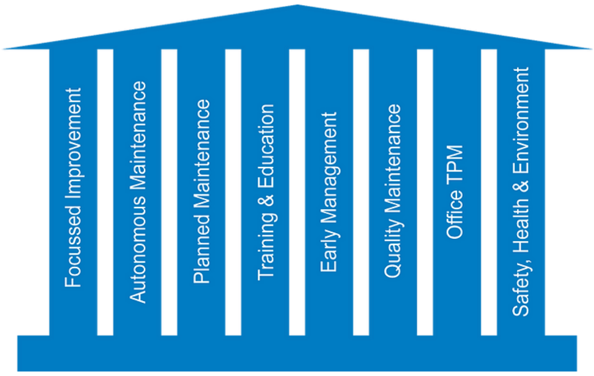

Figure 1. Pillar of TPM

1. **Autonomous maintenance /Jishu Hozen**
   Autonomous maintenance, or Jishu Hozen, assigns operators routine maintenance tasks such as machine cleaning and knowledge of their equipment. With the autonomous maintenance pillar, producers can ensure that production machinery or equipment is clean and well-lubricated and identify potential breakdowns before major damage occurs.
2. **Planned Maintenance**
   The planned maintenance pillar schedules maintenance tasks based on the extent of damage that has occurred and the estimated damage level. Planned maintenance can reduce sudden breakdowns and better manage the amount of damage.
3. **Quality Maintenance**
   The quality maintenance pillar addresses quality issues by enabling production equipment or machinery to detect and prevent errors during production. This ability to detect errors makes the manufacturing process more reliable for the first time when manufacturing products to specifications. The ability to detect errors reduces product failure rates and production costs.
4. **Focused Improvement / Kobetsu Kaizen**
   Form a working group to proactively identify problematic machines/equipment and propose solutions or suggestions for improvement. Working groups to implement focused improvements can also bring in talented employees to support the company's performance in achieving its goals.
5. **Early Equipment Management**
   Initial equipment management is a pillar of TPM, using learnings from previous repair and maintenance activities to help new machines achieve optimal performance. The purpose of this pillar is for the new production machine or system to achieve optimal performance in the shortest possible time.
6. **Training and Education**
   This training and education pillar is needed to bridge the knowledge gap in implementing TPM. If we do not know the tools and machines we use, we can damage our equipment, reduce labour productivity, and ultimately negatively impact the business. With sufficient training, operators' ability to perform basic maintenance activities, training engineers to perform preventive maintenance, and improving the ability to analyse damage to machinery or equipment can be improved. Manager-level training can also improve managers' ability to mentor and coach employees in the use of TPM.
7. **Safety, Health and Environment**
   Workers must be able to work and carry out their duties in a safe and healthy environment. Within this pillar, the company is committed to providing a safe and healthy environment without harm. This pillar aims to achieve the goal of an "accident-free" workplace.
8. **TPM in Administration**
   The next pillar of TPM is to spread the concept of TPM into the administrative function. The purpose of this TPM in the Administration pillar is to ensure that all parties in the organization (company) have the same concept and perception, including administrative staff (purchasing, planning, and finance).

TPM reduces machine and equipment losses by increasing the availability ratio, performance efficiency, and rate of quality products [6] TPM can eliminate six big losses, which is the focus of TPM. The objective of TPM is to eliminate or minimize all losses related to the manufacturing system to improve OEE [1]

2.3 Overall Equipment Effectiveness

OEE is a comprehensive indicator of machine/equipment productivity and theoretical performance [7]. These measurements are critical to finding areas where machine/equipment productivity or efficiency needs to be improved and can also reveal areas of breakdown on the production line.

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The purpose of overall equipment effectiveness (OEE) is as a maintenance system performance instrument. With the help of these tools, we can consider the availability of machines or plants, production efficiency, and the quality of machine or plant performance.[8]

Using OEE as a performance indicator takes a certain amount of time. Examples: shifts, daily, weekly, monthly, or yearly [9]. OEE measurement is used more effectively in production plants.

Overall Equipment Effectiveness (OEE) benefits include: [6]

- Determine the starting point of the company’s equipment or machinery. identify bottleneck events in equipment or machines.
- Identify true productivity losses.
- Prioritizing efforts to improve OEE and increase productivity.

The mathematical formula of Overall Equipment Effectiveness (OEE) is formulated as follows:

$$\boldsymbol{OEE} = \frac{Availability \times Performance\ Efficiency \times Rate\ of\ Quality\ Product}{Total\ Leading\ Time} \times 100\% \quad (1)$$

Three measurable factors affecting machine productivity and effectiveness are product availability, power efficiency, and quality. The operating conditions of the machine or production line are not accurately represented if they are based on the calculation of one element alone. [10]

1. **Availability**

   Availability is a comparison of actual and planned time. This parameter considers the operational readiness level of existing and used equipment. Low availability reflects simple and basic availability calculations that inadequate, or maintenance availability (Almeanazel, 2010) is:

$$\boldsymbol{Availability} = \frac{Total\ Loading\ Time - Total\ Down\ Time}{Total\ Loading\ Time} \times 100\% \quad (2)$$

   Loading time is the time available per day or per month minus the planned downtime of the machine.

   Loading time = Total availability – planned downtime

   - Planned downtime is the time machine downtime for maintenance (Scheduled Maintenance) or other management activities. Operation time results from measuring loading time with machine downtime (non-operation time). In other words, operation time is the available operating time (Availability Time) after the machine downtime is removed from the total planned availability time.
   - Machine downtime is the processing time that the machine should use, but due to disruption to the machine/equipment (equipment failures), resulting in no output being produced.

2. **Performance Efficiency**

   Performance efficiency is the result of multiplying the operating and net operating speeds, or product production, by the ideal cycle time and the ratio of time available for processing (operating time). Net uptime is the ratio of the number of products processed (processing volume) multiplied by cycle time and uptime. Net uptime helps calculate losses caused by minor interruptions and slower production speeds. According to Almeanazel (2010), there are three essential factors needed to calculate performance efficiency.

   Ideal cycle time

   - Processed amount
   - Operation time

   Performance efficiency can be calculated as follows :

$$\boldsymbol{Performance\ Efficiency} = \frac{Total\ Product \times Ideal\ Cycle\ Time}{Loading\ Time} \times 100\% \quad (3)$$

3. **Rate of quality Product**

   The rate of quality products is the ratio of the number of better products to the total number of products processed. Therefore, the percentage of high-quality products results from the calculations of two factors. [10]

   - Processed amount
   - Defect amount

There are four ways to assess OEE scores, namely:

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1. If OEE = 100%, production is considered perfect: producing only without defects, working in Fast performance, and with no downtime
2. If OEE = 85% - 99%, production is considered world-class for many companies. This score is a suitable score for long-term goals.
3. If OEE = 60% - 84%, production is reasonable but shows a large room for Improvement.
4. If OEE = <60%, production is considered to have a low score but, in most cases, can be quickly improvised through direct measurement

2.4 Conceptual Framework

The rationale of this research can be described in the process flow of the framework below:

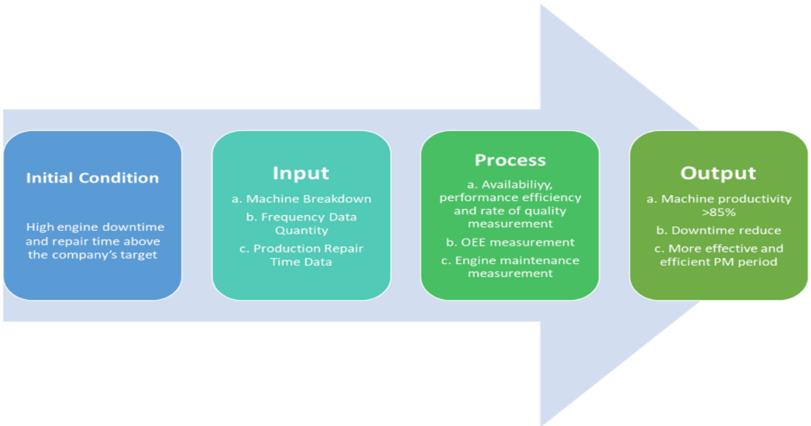

Figure 2. Cenceptual Framework

3. OBJECTIVE OF THE STUDY

Based on the background and problem formulation discussed previously, the main objective of this study was to find factors that contribute to machine wear and tear, to increase overall equipment effectiveness (OEE) after repairs, and to strengthen the concept of total productive maintenance (TPM).

4. METHODS

4.1 Research Design

In carrying out research, a research design is needed to assist in determining research steps. The forms of systematic stages in this research design are:

- Conduct field observations to see the process of machine performance in production activities.
- We are collecting the required data on the object of research.
- Analyze by calculating the OEE value and applying the eight pillars of TPM by minimizing waste.

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4.2 Research Stage

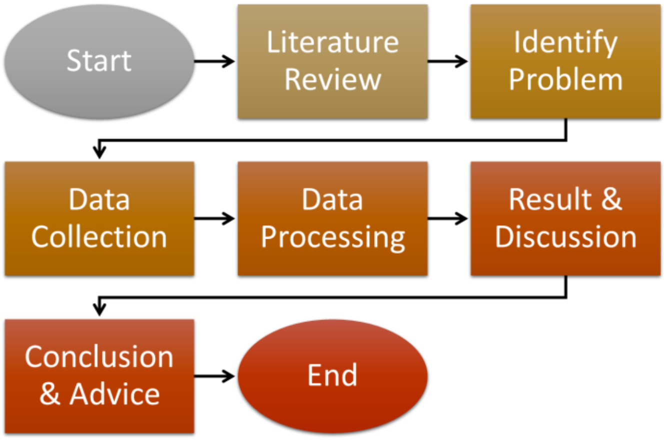

Figure 3. Research Stage

1. Identify research problems and objectives. Identify the process flow until the product reaches the consumer.
   The first stage to make improvements is to identify problems as a reference. These characteristics can be described with an Output Process Input Diagram (IPO). This IPO diagram aims to see what factors affect the output process / what targets are desired from the process, which we then analyze further for the problem point.
2. Calculating OEE values and OEE value analysis
   At this stage is the calculation stage to calculate the most effective engine failure rate and then make it a top priority in solving the problem. In this stage, observations are made with damage data and the length of repair time. The stages in the OEE value analysis focus on machine maintenance in the concept of the 8-pillar TPM theory.
3. Waste Minimization
   At this stage, waste minimization is carried out in every production activity to reduce machine damage.
4. Proposed Improvement and Implementation of TPM
   Propose corrective measures to improve machine efficiency and minimize waste. At this stage, improvements are made by making proposals for applying TPM and improving the lean concept with autonomous maintenance on the production floor. [11]
   At this stage of improvement, what needs to be done is put emphasis on machine maintenance schedules, problem-solving, implementing machine maintenance schedule plans, and the application of lean manufacturing science in controlling waste reduction. As for this stage, the application of research is carried out according to the research diagram below.

5. Data Collection and Processing

Define abbreviations and acronyms the first time they are used in the text Metal Matrix Composite (MMC). Do not use abbreviations in the title and abstract unless they are unavoidable.

5.1 Data Collection

This 4L45W Leak test machine is one of the machines in the flow of the Air Cleaner product assembly process for 4-wheeled vehicles with the red three-diamond logo. Air Cleaner products are car parts that filter dust and other dirt and can provide clean air for the engine to maintain performance and extend engine life. The following is a picture of the Air Cleaner model 4L45W.

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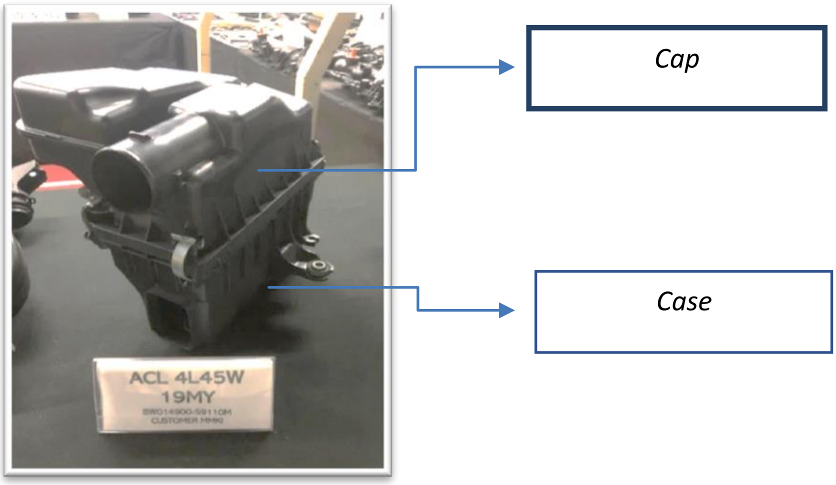

Figure 4. Products Air Cleaner Model 4L45W

Every Part (Cap) of Model 4L45W must be checked for leakage by vacuum/vacuum to empty the air chamber in the product with pressure and ratio adjusted parameters in the engine. In the Leak Test Process, if the goods meet the requirements of the predetermined standards (no leakage), the machine will automatically mark the product so that it can be continued in the following process; this is a production safety procedure so that no part immediately continues the assembly process without checking for leaks.

Products that pass the Leak Test process have results between -3,000 to 10,000 ml/minute. If the Leak Test process results are okay, the monitor will display the words Pass in green. Furthermore, if the Leak Test process is flawed, the monitor will display red with different information for each process. It could be an Up Limit if the result value is above the limit and Low Limit if the process results are below the limit. The damages that usually occur and interfere with the course of production are as in table 4.1 below.

Table 2. Machine Demage Type Leak Test Model 4L45W

No.	Machine Damage Leak Test	Cause
1.	*Leak Fault*	Air Picker leaking, Air Picker dirty, Air Picker position does not fit in position should be
		Shaft Cylinder broken, Clamp Cylinder pressure is less, Clamp Cylinder does not fit in the position it should be
		Less Cylinder *Clamp Pressure*
		Dirty Rubber Base , reduced reliability of Rubber Base
2.	*Cylinder Fault*	Sensor position Changes
		Air Picker *wind pressure* is too big
		Cylinder Stamp moved
		Cylinder *position* does not fit the product
3.	*Sensor Fault*	Sensor light intensity is not up to standard, Sensor shifted.
4.	Other	*Electric, Mechanic, Pneumatic*

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Production report data used from the period of June-August 2022 is used to see production planning and also working hours every day. Because the line used to produce Air Cleaner is a multi-product line, the leak test machine is only operated some days.

Table 3. Operating Time of Leak Test machine model 4L45W

Month	Number of Working Days	Production Target	Actual Production	Total Defective Products	Total Effective Working Hours (Minutes)	Total Man-Hours Spent (Minutes)
June	25	4302	4302	0	2151	2654
July	23	4464	4464	0	2232	2756
August	25	4392	4384	8	2192	2759

5.2. Data Processing

Based on data that has been recapitulated from the company to determine the damage machines that make the highest downtime using downtime data in the June-August 2022 period. Here is a recap of the total downtime data seen in table 4.3 below:

Table 4. Machine Downtime Leak test Based on Cumulative Frequency Calculation

Types of Damage	June		July		August	
	Frequency Cumulative	Downtime	Frequency Cumulative	Downtime	Frequency Cumulative	Downtime
Leak Fault	5	450	4	464	6	481
Sensor Fault	2	25	3	25	3	28
Cylinder Fault	2	18	3	22	4	58
Other	1	10	1	13	0	0
Total	**10**	**503**	**11**	**524**	**13**	**567**

Based on the data processing results in Table 4.3 above, it can be concluded that the frequency of damage events and downtime of the 4L45W model Leak Test machine is increasing. And the highest type of damage is Leak Fault. From the analysis in the field, several factors of Leak Fault can be seen in Table 4.4 below:

Table 5. Causes of Leak Fault Machine Leak Fault Machine Leak Test Model 4L45W

Types of Damage	Root Cause	Cause	Action
Leak fault	Air picker	Silinder bocor, Life Time Dirty Rubber air picker	Replace cylinder air picker Cleaning
	Cylinder position does not fit	Shaft Cylinder patah/ Life Time	Weld Shaft, adjust position cylinder air picker
	The clamp pressure on the product is less	Life time	Change clamp and cylinder unit
	Rubber base leak	Life time	Change rubber base

In Table 4.4 above, the leading causes of leak faults are classified into four items: analyzed the causes of leak faults because the reliability of the parts used has decreased.

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6. RESULT AND DISCUSSION

6.1 Evaluation of TPM Implementation

Production data starts with damage that began to last a long time in June until after the start of periodic maintenance in September. After analysis, many engine parts take time to be replaced because of their lifetime. Therefore, the author proposes normalizing the machine by first making its schedule, as in the table below.

Table 6. Leak Test Machine Part Replacement Schedule

ACTIVITY	P/A	2022																PIC
		June				July				August				September				
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Order Sparepart Base Rubber	Plan																	Maintenance Sparepart
	Act																	
Order Sparepart Clamp 1, 2, 3	Plan																	Maintenance Sparepart
	Act																	
Order Sparepart Cylinder Air Picker	Plan																	Maintenance Sparepart
	Act																	
Install Rubber	Plan																	Maintenance Machine
	Act																	
Install Clamp 1, 2, 3	Plan																	Maintenance Machine
	Act																	
Install Cylinder Air Picker	Plan																	Maintenance Machine
	Act																	

schedule above shows that much damage started in early June, and the spare parts that must be replaced can only be replaced in the third week of August. Never doing maintenance also affects the availability of spare parts, so there is a very long loading in terms of changing spare parts.

The proposed Leak Test Machine Part Change Schedule is implementing Focus improvement on the TPM pillar as one of the efforts to achieve the conditions on the leak test machine before the implementation of periodic maintenance.

The next step is the implementation of Autonomous Maintenance (AM). In the fourth week of August, training/socialization was made for operators who run machines to carry out independent maintenance. It aimed to direct operators to feel responsible for their machines by conducting regular cleaning and inspection. A Maintenance Check Sheet is made so machine operators can conduct daily inspections by referring to the Check Sheet. The following is picture 5, the Daily Check Sheet of the 4L45W Leak Test machine.

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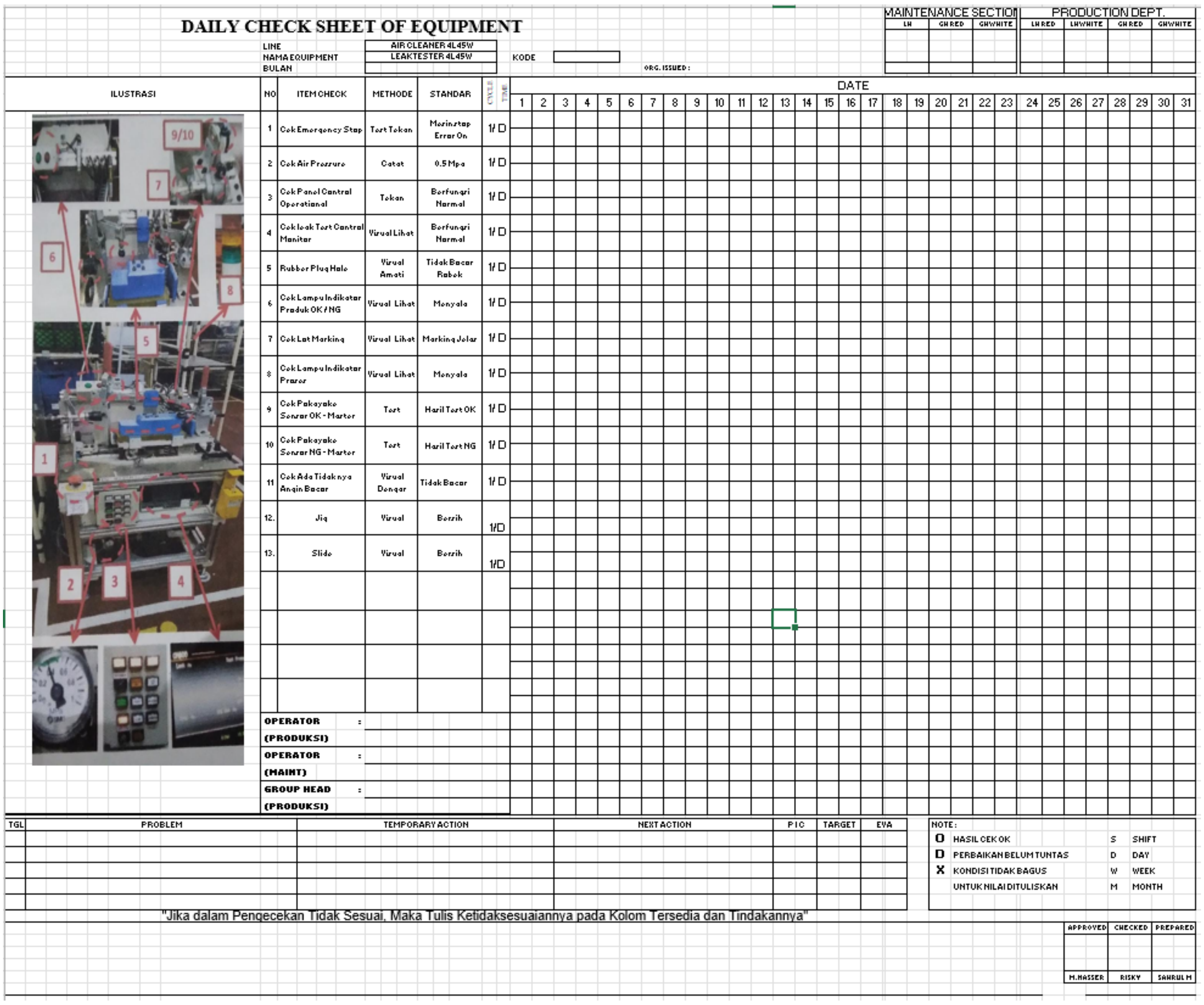


DAILY CHECK SHEET OF EQUIPMENT

LINE: AIR CLEANER 4L45W
NAMA EQUIPMENT: LEAKTESTER 4L45W
BULAN:
KODE:
ORG. ISSUED:

MAINTENANCE SECTION: LH | GH RED | GH WHITE
PRODUCTION DEPT.: LH RED | LH WHITE | GH RED | GH WHITE

ILUSTRASI	NO	ITEM CHECK	METHODE	STANDAR	CYCLE TIME	DATE 1–31
	1	Cek Emergency Stop	Test Tekan	Mesin stop Error On	1/ D	
	2	Cek Air Pressure	Catat	0.5 Mpa	1/ D	
	3	Cek Panel Control Operational	Tekan	Berfungsi Normal	1/ D	
	4	Cek leak Test Control Monitor	Visual Lihat	Berfungsi Normal	1/ D	
	5	Rubber Plug Hole	Visual Amati	Tidak Bocor Robek	1/ D	
	6	Cek Lampu Indikator Produk OK / NG	Visual Lihat	Menyala	1/ D	
	7	Cek Lot Marking	Visual Lihat	Marking Jelas	1/ D	
	8	Cek Lampu Indikator Proses	Visual Lihat	Menyala	1/ D	
	9	Cek Pokayoke Sensor OK - Master	Test	Hasil Test OK	1/ D	
	10	Cek Pokayoke Sensor NG - Master	Test	Hasil Test NG	1/ D	
	11	Cek Ada Tidaknya Angin Bocor	Visual Dengar	Tidak Bocor	1/ D	
	12.	Jig	Visual	Bersih	1/D	
	13.	Slide	Visual	Bersih	1/D	

OPERATOR (PRODUKSI) :
OPERATOR (MAINT) :
GROUP HEAD (PRODUKSI) :

TGL	PROBLEM	TEMPORARY ACTION	NEXT ACTION	PIC	TARGET	EVA

NOTE:
O HASIL CEK OK — S SHIFT
D PERBAIKAN BELUM TUNTAS — D DAY
X KONDISI TIDAK BAGUS — W WEEK
UNTUK NILAI DITULISKAN — M MONTH

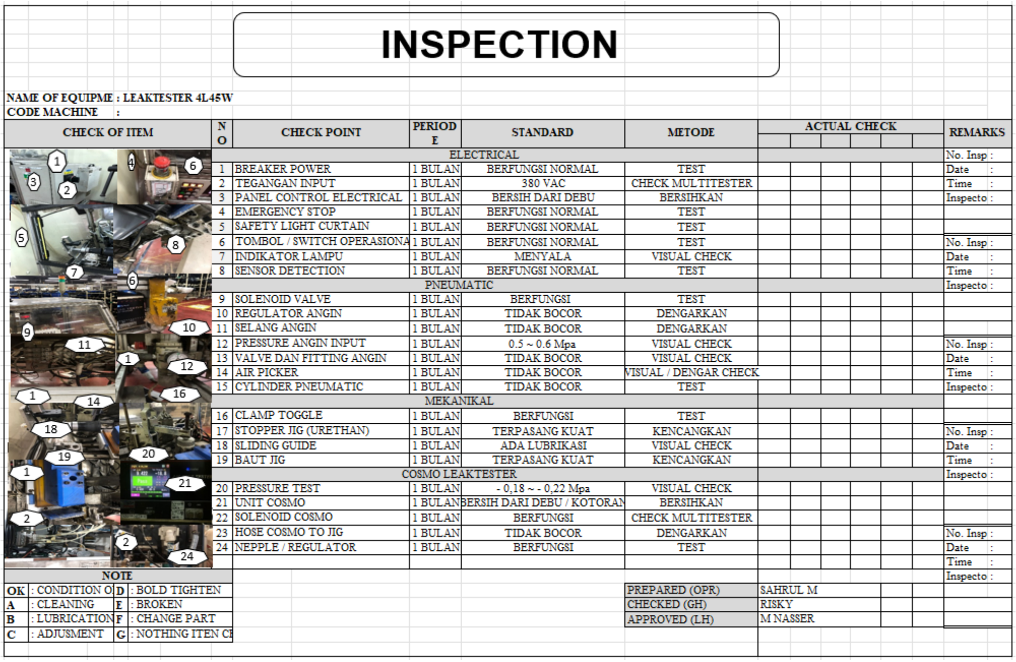
"Jika dalam Pengecekan Tidak Sesuai, Maka Tulis Ketidaksesuaiannya pada Kolom Tersedia dan Tindakannya"

APPROVED	CHECKED	PREPARED
M.NASSER	RISKY	SAHRUL M

Figure 5. Check sheet

The check sheet above is made in the same format as other machines, filled daily by the production operator of the Leak test machine, and there is a recheck by the maintenance operator.

Next, schedule maintenance tasks based on the level of damage that has occurred and the predicted level. Establish planned maintenance items by making a monthly maintenance schedule as below.



INSPECTION

NAME OF EQUIPME : LEAKTESTER 4L45W
CODE MACHINE :

CHECK OF ITEM	NO	CHECK POINT	PERIODE	STANDARD	METODE	ACTUAL CHECK	REMARKS
		ELECTRICAL					No. Insp :
	1	BREAKER POWER	1 BULAN	BERFUNGSI NORMAL	TEST		Date :
	2	TEGANGAN INPUT	1 BULAN	380 VAC	CHECK MULTITESTER		Time :
	3	PANEL CONTROL ELECTRICAL	1 BULAN	BERSIH DARI DEBU	BERSIHKAN		Inspecto :
	4	EMERGENCY STOP	1 BULAN	BERFUNGSI NORMAL	TEST		
	5	SAFETY LIGHT CURTAIN	1 BULAN	BERFUNGSI NORMAL	TEST		
	6	TOMBOL / SWITCH OPERASIONA	1 BULAN	BERFUNGSI NORMAL	TEST		No. Insp :
	7	INDIKATOR LAMPU	1 BULAN	MENYALA	VISUAL CHECK		Date :
	8	SENSOR DETECTION	1 BULAN	BERFUNGSI NORMAL	TEST		Time :
		PNEUMATIC					Inspecto :
	9	SOLENOID VALVE	1 BULAN	BERFUNGSI	TEST		
	10	REGULATOR ANGIN	1 BULAN	TIDAK BOCOR	DENGARKAN		
	11	SELANG ANGIN	1 BULAN	TIDAK BOCOR	DENGARKAN		
	12	PRESSURE ANGIN INPUT	1 BULAN	0.5 ~ 0.6 Mpa	VISUAL CHECK		No. Insp :
	13	VALVE DAN FITTING ANGIN	1 BULAN	TIDAK BOCOR	VISUAL CHECK		Date :
	14	AIR PICKER	1 BULAN	TIDAK BOCOR	VISUAL / DENGAR CHECK		Time :
	15	CYLINDER PNEUMATIC	1 BULAN	TIDAK BOCOR	TEST		Inspecto :
		MEKANIKAL					
	16	CLAMP TOGGLE	1 BULAN	BERFUNGSI	TEST		
	17	STOPPER JIG (URETHAN)	1 BULAN	TERPASANG KUAT	KENCANGKAN		No. Insp :
	18	SLIDING GUIDE	1 BULAN	ADA LUBRIKASI	VISUAL CHECK		Date :
	19	BAUT JIG	1 BULAN	TERPASANG KUAT	KENCANGKAN		Time :
		COSMO LEAKTESTER					Inspecto :
	20	PRESSURE TEST	1 BULAN	- 0,18 ~ - 0,22 Mpa	VISUAL CHECK		
	21	UNIT COSMO	1 BULAN	BERSIH DARI DEBU / KOTORAN	BERSIHKAN		
	22	SOLENOID COSMO	1 BULAN	BERFUNGSI	CHECK MULTITESTER		
	23	HOSE COSMO TO JIG	1 BULAN	TIDAK BOCOR	DENGARKAN		No. Insp :
	24	NEPPLE / REGULATOR	1 BULAN	BERFUNGSI	TEST		Date :
							Time :
							Inspecto :

NOTE			
OK	: CONDITION O	D	: BOLD TIGHTEN
A	: CLEANING	E	: BROKEN
B	: LUBRICATION	F	: CHANGE PART
C	: ADJUSMENT	G	: NOTHING ITEN CI

PREPARED (OPR)	SAHRUL M
CHECKED (GH)	RISKY
APPROVED (LH)	M NASSER

Figure 6. Inspection check sheet

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The check sheet above is made in the same format as other machines, but the check items are different. The maintenance operator does Monthly Check Sheet.

6.2. Analysis After Repair Machine Leak Test

After each month, the Overall Equipment Effectiveness (OEE) value is calculated. The data is presented in the table below.

Table 7. OEE Value by month

Month	*Availability*	Performance Efficiency	Rate Of *Quality*	OEE
June	76,61%	81,04%	100%	62,08%
July	76,52%	80,98%	100%	61,96%
August	74,13%	79,59%	99,81%	58,89%
September	97,09%	97,16%	100%	94,33%

If depicted in graphic form, the OEE comparison from June-September is as shown in the figure below.

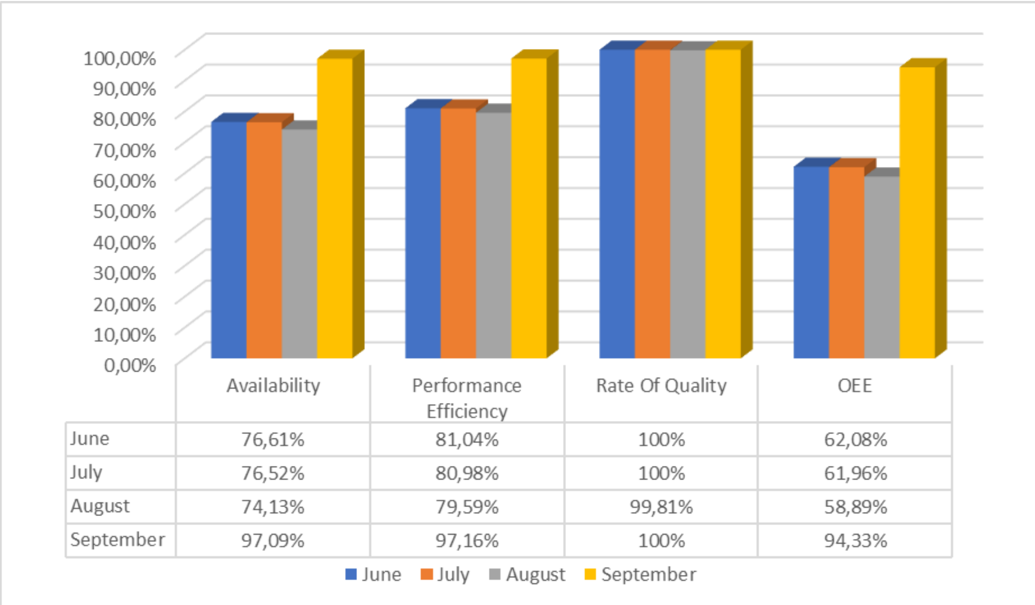

Figure 7. OEE Value by Month Graph

It is known that the Average OEE Value in June-August was 60.09%. The Japan Institute of Plant Maintenance (JIPM) has set benchmark standards widely practiced worldwide, where OEE equal to 60% of production is considered reasonable but shows a large room for improvement. Then in September, the OEE value rose to 94.33%, indicating the improvement of standardization and the implementation of treatment proposals said to be successful.

Data Calculation of the average time to repair or Mean Time To Repair (MTTR) is seen in the table below.

Table 8. MTTR table

	June	July	August	**September**
Downtime	503	524	567	**55**
Breakdown	10	11	13	**6**
MTTR	50,3	47,6	43,6	**9,2**
LTTR	255	268	210	**17**

With the normalization of the machine and the start of proposed maintenance on the Leak Test machine, downtime can be minimized, and the MTTR target can be achieved in September.

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6.3. Discussion

In this research, a discussion is made about calculating OEE values on the 4L45W model Leak test machine, carried out from June to August 2022. After analysis, it is known from the calculation results from June to August that the average OEE value was 60.97%, where the Availability Rate value was 75.75%, the performance rate was 80.54%, and the Quality rate was 99.94%. With an OEE value of 60.97%, it is reasonable according to JIPM but shows a large gap to improve. The downtime is relatively extended compared to the operating time making the repair time beyond the target. Because there is no maintenance, making the machine is unmonitored, and the spare parts it uses are not available in the company, so after the decline to the failure of the piece, the handling is more extended when damage occurs. Then the author proposes maintenance on the Leak test engine model 4L45W by normalizing the engine and replacing critical parts seen from the injury. After submitting Autonomous Maintenance, socialization was made to operators who run machines so that they can carry out independent maintenance. It aimed to direct operators to have a sense of responsibility for their devices by referring to the proposed Check Sheet.

Furthermore, the author proposes to make monthly maintenance of the Leak test machine run by PIC Maintenance with a proposed preventive Check Sheet. In September, after the normalization of the engine and the proposed maintenance had started, the OEE value was recalculated with a result of 94.33%, and the average repair time target was achieved at 9.2 minutes, indicating that the repair/normalization and maintenance are going well and successfully.

7. CONCLUSION AND SUGGESTION

7.1. Conclusion

From the analysis and discussion that has been carried out, it can be concluded. The main factor that caused sudden damage when the Leak test machine was operated was the lack of engine maintenance. The worst damage is the Leak Fault caused by the reliability of already inefficient parts (lifetime). Devices that have never been maintained also affect the availability of spare parts, making loading part replacements very long.

The calculation of OEE values from 62.08%, 61.96%, and 58.98% in June-August increased to 94.33% in September after the normalization of machines and the implementation of periodic maintenance.

Improvement and initial steps Evaluation of the Application of Total Productive Maintenance of the 4L45W model Leak Test machine is successful. The average target of repair time can be achieved from 50.3 minutes, 47.6 minutes and 43.6 minutes in June-August to 9.2 minutes in September, dramatically affecting the cost down / lowering production costs due to overtime to pursue of production targets hampered due to very long repairs.

7.2. Suggestions

For companies, the author advises not to take maintenance problems lightly. Even though the machine is small and only in the subline, it is still equipment/devices we use daily; it will have a significant effect sooner or later. Then the author suggests that companies significantly create training/seminars for operators to build awareness and improve capabilities.

For researchers, further research is needed to examine and analyse other factors that affect the decrease in availability, performance, and quality in increasing OEE value. And if, from the beginning, the company has never implemented TPM, the author suggests that future research emphasize the preparation stage for implementing TPM.

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