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Research Article

IMPROVING THE PERFORMANCE OF 476 CUTTING MACHINES AT PT RACHMAT PERDANA ADHIMETAL DELTA PLANT WITH OVERALL EQUIPMENT EFFECTIVENESS (OEE)

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A B S T R A C T

PT Rachmat Perdana Adhimetal is one of the manufacturing industries engaged in manufacturing automotive and non-automotive components in the Delta industrial area, Cikarang, Bekasi Regency. In the implementation of the production process on the cutting line, the company experienced damage problems. Of the 8 available cutting machines, there is 1 machine, namely the 476 cutting machine which has the highest frequency of breakdown. To overcome these problems, data related to operating time, output and downtime are collected, followed by data processing using Overall Equipment Effectiveness (OEE) which can describe machine efficiency. The results of the data processing showed an OEE value of 68% from the standard value of 85%. Furthermore, an analysis was carried out with six major losses, the results showed that there were 2 largest losses, namely reduced speed losses with a value of 14.90% and breakdown losses with a value of 12.65%. Followed by a cause analysis using a causal diagram to find out the factors that affect the performance of machines and humans. To determine the priority of repairs made on the 476 mower, an analysis was carried out using Failure Mode and Effect Analysis (FMEA). Priority of repair based on the value of RPN 120 on the type of failure there is no wind pressure regulator with the repair of the installation of air speed regulator/faucet, the value of RPN 102 on the type of failure of maintenance staff does not understand the daily checksheet with the improvement of the socialization of the daily checksheet to the maintenance staff, the value of RPN 54 on the type of failure 1/3 of the wind pressure is divided into air sprayer and the value of RPN 21 on the type of failure the leader does not understand the SOP for moving materials at the beginning arrangements by improving the socialization of SOPs for moving materials at the beginning of the arrangement to the leader. The OEE value after the improvement showed a value of 77%, an increase of 9% from before the increase.

INTRODUCTION

In the era of increasingly rapid globalization, the manufacturing sector faces great challenges in maintaining competitiveness. Manufacturing companies must continue to adapt to technological and market developments, as well as innovate to improve operational efficiency. One effective way to achieve this goal is to optimize the performance of the machine, which is a key element in producing high-quality products with large volumes. PT Rachmat Perdana Adhimetal, as a company operating in the automotive and non-automotive sectors, faces various challenges in an effort to improve their production performance. One important aspect that requires special attention is the cutting process, which involves eight cutting machines in a single production line.

One of the machines of major concern is the 476 engine, which is used to process the cutting of pipe materials. Based on historical data, this machine is recorded to have the highest frequency of breakdowns compared to other machines. Between November 2022 and February 2023, there were 25 incidents of damage to 476 engines, much higher than the 12 incidents in other engines in the same period. This frequent damage results in production not reaching the set targets. Although the production target per shift is 7,000 pcs, only about 6,000-6,500 pcs has been achieved, which forces the company to work overtime to meet the shortage. The operational time per shift, which should have been 480 minutes, was also hampered by machine damage, reducing the effectiveness of production time.

However, until now, the company has not conducted a systematic evaluation of the performance of its cutting machines. Therefore, this study aims to implement the Overall Equipment Effectiveness (OEE) method to measure and analyze engine performance comprehensively. OEE combines three main factors: availability, performance, and quality, which allows the identification of the main causes of machine ineffectiveness in the production process (Sahril, 2019). The main purpose of this study is to evaluate the effectiveness of the existing maintenance system, as well as identify factors that affect machine performance, in the hope of formulating more appropriate solutions to improve the effectiveness of machines in supporting the achievement of production targets (Taufiq, 2022).

Once the OEE calculations are performed, a more in-depth analysis will use the concept of six major losses and a cause-and-effect diagram to dig into the root cause of the problem affecting the performance of the machine. Furthermore, the priority of remediation will be determined through Failure Mode and Effect Analysis (FMEA) taking into account the highest Risk Priority Number (RPN), which includes frequency, severity, and problem detection factors. With these measures, it is hoped that the company can reduce the risk of machine damage, improve production performance, and plan more focused and effective repairs to support operational sustainability.

This research is expected to make a significant contribution to PT Rachmat Perdana Adhimetal in increasing the effectiveness of cutting machines, which in turn will increase production capacity, reduce downtime, and achieve optimal production targets.

METHOD

Research conducted on PT. RPA is both quantitative and qualitative types. Production data obtained from the leader line of cutting machines and maintenance data obtained from section head maintenance were collected and processed in the period from November 2022 to February 2023. The research methodology is arranged systematically so that each stage has a close relationship between stages, with a systematic research methodology design, it is also hoped that the research to be carried out will be more directed to achieve the goals as expected in the formulation of goals. The methodology in this study is explained as follows:

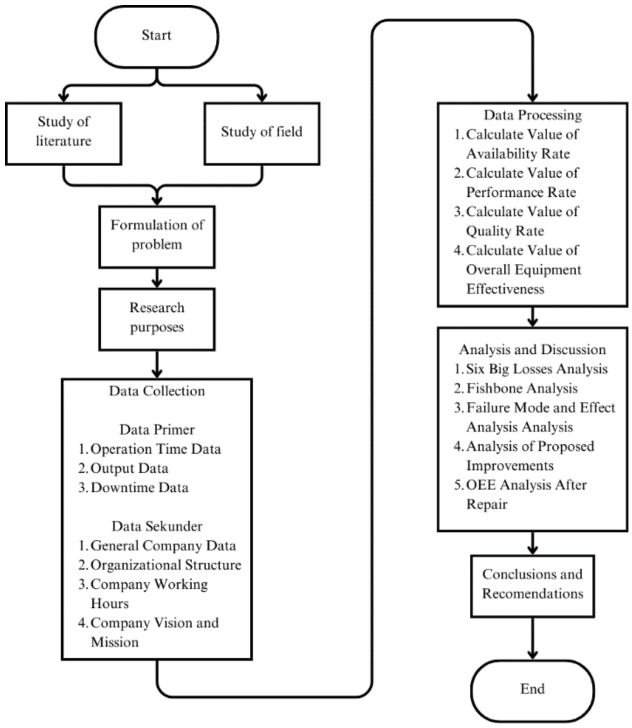

Figure 1 *Research Methodology*

The preparation stage, starting with conducting field research and literature research, is followed by compiling a formulation of the problem and research objectives.
Data collection stage, at this stage all data related to this research is collected, primary data starting from operation time, output, and downtime. Secondary data consists of general company data, organizational structure, company working hours and vision and mission.
The data collection and processing stage begins by calculating the value of availability, performance, and quality, after all factors are known to calculate OEE.
The analysis stage is sourced from the results of data collection and processing that has been carried out previously. This stage begins with an analysis with six major losses, followed by an analysis of cause and effect diagrams, Failure Mode and Effect Analysis (FMEA), analysis of proposed improvements and finally analysis for improvement.
The closing stage, compiling conclusions based on the results of the analysis and discussion that has been carried out.

RESULTS AND DISCUSSION

1. Calculating Overall Equipment Efficiency (OEE)

OEE is a comprehensive measure that identifies the level of performance of a machine/equipment as well as its theoretical efficiency (Adistiane, 2016). To be able to find out the OEE value, these factors must be calculated as follows:
The level of availability, a factor related to the availability of time that can be utilized for each machine or equipment

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operating activity, which is calculated based on the formula (1). The results of the calculation can be seen in table (1).

$$\frac{\text{Loading Time - Downtime}}{\text{Loading Time}} \text{ x } 100\% \quad (1)$$

Table 1 *Availability level*

November	Loading Time (min)	Downtime (minutes)	Availability level (%)
Week 1 Nov	4.811	488	89,86
Week 2 Nov	4.495	555	87,65
Week 3 Nov	4.735	575	87,86
Week 4 Nov	4.396	646	85,30
Sunday 5 Nov	1.570	175	88,85
Middle	**4.001**	**488**	**87,90**
December	Loading Time (min)	Downtime (minutes)	Availability rate (%)
Week 1 Dec	3.020	465	84,60
Sunday 2 Dec	3.815	645	83,09
Sunday 3 Dec	5.585	585	89,53
Sunday 4 Dec	4.280	465	89,14
Middle	**4.175**	**540**	**86,59**
January	Loading Time (min)	Downtime (minutes)	Availability rate (%)
Week 1 Jan	4.595	445	90,32
Week 2 Jan	5.212	530	89,83
Week 3 Jan	6.135	620	89,89
Week 4 Jan	5.420	560	89,67
Middle	**5.431**	**539**	**89,93**
February	Loading Time (min)	Downtime (minutes)	Availability rate (%)
Week 1 Feb	960	125	86,98
Week 2 Feb	4.648	1.190	74,40
Week 3 Feb	5.091	560	89,00
Week 4 Feb	3.715	510	86,27
Sunday 5 Feb	4.645	550	88,16
Middle	**3.812**	**587**	**84,96**

Performance level, a factor related to the ability of a machine or equipment to produce its products, which is calculated based on formula (2). The results of the calculation can be seen in table (2).

$$\frac{\text{Output x Ideal CT}}{\text{Operating Time}} \text{ x } 100\% \quad (2)$$

Table 2 *Performance Level*

November	Output (pcs)	Ideal Cycle Time (Minutes)	Operating Time (min)	Performance Rate (%)
Week 1 Nov	67.470	0,048	4.323	75,43
Week 2 Nov	61.841	0,048	3.940	75,86
Week 3 Nov	63.285	0,048	4.160	73,53
Week 4 Nov	61.266	0,048	3.750	78,97
Sunday 5 Nov	23.452	0,048	1.395	81,26
Middle	**55.463**	**0,048**	**3.341**	**77,01**
December	Output (pcs)	Ideal Cycle Time (Minutes)	Operating Time (min)	Performance Rate (%)
Week 1 Dec	43.595	0,048	2.555	82,47
Sunday 2 Dec	53.659	0,048	3.170	81,81
Sunday 3 Dec	82.520	0,048	5.000	79,77
Sunday 4 Dec	61.421	0,048	3.815	77,82
Middle	**60.299**	**0,048**	**3.635**	**80,47**
January	Output (pcs)	Ideal Cycle Time (Minutes)	Operating Time (min)	Performance Rate (%)
Week 1 Jan	62.135	0,048	4.150	72,37
Week 2 Jan	71.497	0,048	4.682	73,81
Week 3 Jan	89.009	0,048	5.515	78,01
Week 4 Jan	78.026	0,048	4.860	77,60
Middle	**60.299**	**0,048**	**4.802**	**75,44**
February	Output (pcs)	Ideal Cycle Time (Minutes)	Operating Time (min)	Performance Rate (%)
Week 1 Feb	12.952	0,048	835	74,97
Week 2 Feb	67.723	0,048	3.458	94,66
Week 3 Feb	72.510	0,048	4.531	77,35
Week 4 Feb	49.368	0,048	3.205	74,45
Sunday 5 Feb	67.898	0,048	4.095	80,14
Middle	**54.090**	**0,048**	**3.225**	**80,31**

Quality level, a factor that describes the ability of a machine or equipment to produce products in accordance with predetermined standards, which is calculated based on the formula (3). The results of the calculation can be seen in table (3).

$$\frac{\text{Output - Not Good}}{\text{Output}} \text{ x } 100\% \quad (3)$$

Table 3 *Quality Level*

November	Result (fruit)	Not Good (Pcs)	Quality level (%)
Week 1 Nov	67.470	100	99,85
Week 2 Nov	61.841	108	99,83
Week 3 Nov	63.285	78	99,88
Week 4 Nov	37.383	68	99,82
Sunday 5 Nov	23.452	34	99,86
Middle	**50.686**	**78**	**99,85**
December	Result (fruit)	Not Good (Pcs)	Quality level (%)
Week 1 Dec	43.595	61	99,86
Sunday 2 Dec	53.659	57	99,89
Sunday 3 Dec	82.520	110	99,87
Sunday 4 Dec	61.421	79	99,87
Middle	**60.299**	**77**	**99,87**
January	Result (fruit)	Not Good (Pcs)	Quality level (%)
Week 1 Jan	62.135	95	99,85
Week 2 Jan	71.497	87	99,88
Week 3 Jan	89.009	100	99,89
Week 4 Jan	78.026	109	99,86
Middle	**65.199**	**98**	**99,87**
February	Output (pcs)	Not Good (Pcs)	Quality level (%)
Week 1 Feb	12.952	21	99,84
Week 2 Feb	67.723	116	99,83
Week 3 Feb	72.510	292	99,60
Week 4 Feb	49.368	109	99,78
Sunday 5 Feb	67.898	72	99,89
Middle	**54.090**	**122**	**99,79**

Overall Equipment Effectiveness (OEE), a comprehensive measure that identifies the level of performance of a machine/equipment as well as its theoretical efficiency, which can be calculated based on the formula (4). The results of the calculation can be seen in table (4).

$$\text{Availability level x Performance level x Quality level} \quad (4)$$

Table 4 *OEE*

November	Availability rate (%)	Performance Rate (%)	Quality level (%)	OEE (%)
Week 1 Nov	0,90	0,75	0,999	67,68
Week 2 Nov	0,88	0,76	0,998	66,38
Week 3 Nov	0,88	0,74	0,999	64,52
Week 4 Nov	0,85	0,79	0,998	67,24
Sunday 5 Nov	0,89	0,81	0,999	72,09
Middle	**0,87**	**0,81**	**0,998**	**67,59**
December	Availability rate (%)	Performance Rate (%)	Quality level (%)	OEE (%)
Week 1 Dec	0,85	0,82	0,999	69,67
Sunday 2 Dec	0,83	0,82	0,999	67,91
Sunday 3 Dec	0,90	0,80	0,999	71,32
Sunday 4 Dec	0,89	0,78	0,999	69,27
Middle	**0,87**	**0,80**	**0,999**	**69,59**
January	Availability rate (%)	Performance Rate (%)	Quality level (%)	OEE (%)
Week 1 Jan	0,90	0,72	0,998	65,26
Week 2 Jan	0,90	0,74	0,999	66,22
Week 3 Jan	0,90	0,78	0,999	70,05
Week 4 Jan	0,90	0,78	0,999	69,48
Middle	**0,90**	**0,75**	**0,999**	**67,76**
February	Availability rate (%)	Performance Rate (%)	Quality level (%)	OEE (%)
Week 1 Feb	0,87	0,75	0,998	65,10
Week 2 Feb	0,74	0,95	0,998	70,30
Week 3 Feb	0,89	0,77	0,996	68,56
Week 4 Feb	0,86	0,74	0,998	64,09
Sunday 5 Feb	0,88	0,80	0,999	70,58
Middle	**0,85**	**0,80**	**0,998**	**68,09**

The results of the data processing that have been carried out show that the OEE value is 68%, the results have not reached the standard used by the company based on JIPM with a value of 85%. Therefore, it is necessary to conduct an analysis so that improvements can be made in accordance with the factors that affect engine performance, so that engine performance can increase.

2. Analysis of the Six Major Disadvantages

This analysis is to find out the factors that affect low OEE values. The six major losses include 6 types of loss factors that affect the efficiency of a machine or equipment (Denso, 2006) deep (Rahmah et al., 2021).

Breakdown loss, a loss that occurs due to damage to machinery or equipment during the production process, which can be calculated based on the formula (5). The results of the calculation can be seen in Table (5).

$$\frac{\text{Total Breakdown Time}}{\text{Loading Time}} \text{ x } 100\% \quad (5)$$

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Table 5 *Loss of Damage*

November	Downtime (minutes)	Loading Time (min)	Loss (%)
Week 1 Nov	488	4.811	10,14
Week 2 Nov	555	4.495	12,35
Week 3 Nov	575	4.735	12,14
Week 4 Nov	646	4.396	14,70
Sunday 5 Nov	175	1.570	11,15
Middle	**488**	**3.829**	**12,10**
December	Downtime (minutes)	Loading Time (min)	Loss (%)
Week 1 Dec	465	3.020	15,40
Sunday 2 Dec	645	3.815	16,91
Sunday 3 Dec	585	5.585	10,47
Sunday 4 Dec	465	4.280	10,86
Middle	**540**	**4.175**	**13,41**
January	Downtime (minutes)	Loading Time (min)	Loss (%)
Week 1 Jan	445	4.595	9,68
Week 2 Jan	530	5.212	10,17
Week 3 Jan	620	6.135	10,11
Week 4 Jan	560	5.420	10,33
Middle	**539**	**5.341**	**10,07**
February	Downtime (minutes)	Loading Time (min)	Loss (%)
Week 1 Feb	125	960	13,02
Week 2 Feb	1.190	4.648	25,60
Week 3 Feb	560	5.091	11,00
Week 4 Feb	510	3.715	13,73
Sunday 5 Feb	550	4.645	11,84
Middle	**587**	**3.812**	**15,04**

Losses of regulation & adjustment, losses incurred due to long regulatory activities, absence or change of production materials, or no operators, can be calculated based on formula (6). The results of the calculation can be seen in table (6).

$$\frac{\text{Set Up \& Adjustment Time}}{\text{Loading Time}} \times 100\% \qquad (6)$$

Table 6 *Loss Settings & Adjustments*

November	Knife & Chuck Setup (1)	Setup & Adjustment (Minutes)	Loading Time (min)	Loss (%)
Week 1 Nov	255	255	4.811	5,30
Week 2 Nov	285	285	4.495	6,34
Week 3 Nov	200	200	4.735	4,22
Week 4 Nov	210	210	4.396	4,78
Sunday 5 Nov	85	85	1.570	5,41
Middle	**207**	207	**4.001**	**5,21**
December	Knife & Chuck Setup	Setup & Adjustment (Minutes)	Loading Time (min)	Loss (%)
Week 1 Dec	90	90	3.020	2,98
Sunday 2 Dec	202	202	3.815	5,29
Sunday 3 Dec	200	200	5.585	3,58
Sunday 4 Dec	135	135	4.280	3,15
Middle	**157**	**157**	**4.175**	**3,75**
January	Knife & Chuck Setup	Setup & Adjustment (Minutes)	Loading Time (min)	Loss (%)
Week 1 Jan	270	270	4.595	5,88
Week 2 Jan	260	260	5.212	4,99
Week 3 Jan	290	290	6.135	4,73
Week 4 Jan	290	290	5.420	5,35
Middle	**278**	**278**	**5.341**	**5,24**
February	Knife & Chuck Setup	Setup & Adjustment (Minutes)	Loading Time (min)	Loss (%)
Week 1 Feb	70	70	960	7,29
Week 2 Feb	210	210	4.648	4,52
Week 3 Feb	261	261	5.091	5,13
Week 4 Feb	260	260	3.715	7,00
Sunday 5 Feb	310	310	4.645	6,67
Middle	**222**	**222**	**3.812**	**6,12**

Idling and stop loss are small, losses that occur due to a machine or equipment stopping for a moment and the idle time of the machine, which can be calculated based on the formula (7). The results of the calculation can be seen in table (7).

$$\frac{\text{Non Productive Time}}{\text{Loading Time}} \times 100\% \qquad (7)$$

Table 7 *Idle & Small Stop Loss*

November	5 R (1)	Briefing (2)	Idle & Small Stops (Minutes) (1+2)	Loading Time (min)	Loss (%)
Week 1 Nov	100	30	130	4.811	2,70
Week 2 Nov	90	85	175	4.495	3,89
Week 3 Nov	120	40	160	4.735	3,38
Week 4 Nov	130	51	181	4.396	4,12

Sunday 5 Nov	40	10	50	1.570	3,18
Middle	**96**	**43**	**139**	**4.001**	**3,46**

December	5 R (1)	Briefing (2)	Idle & Small Stops (Minutes)	Loading Time (min)	Loss (%)
Week 1 Dec	120	20	140	3.020	4,64
Sunday 2 Dec	260	100	360	3.815	9,44
Sunday 3 Dec	120	50	170	5.585	3,04
Sunday 4 Dec	80	80	160	4.280	3,74
Middle	**145**	**63**	**208**	**4.175**	**5,21**

January	5 R (1)	Briefing (2)	Idle & Small Stops (Minutes)	Loading Time (min)	Loss (%)
Week 1 Jan	90	55	145	4.595	3,16
Week 2 Jan	170	80	250	5.212	4,80
Week 3 Jan	100	50	150	6.135	2,44
Week 4 Jan	110	80	190	5.420	3,51
Middle	**118**	**66**	**184**	**5.341**	**3,48**

February	5 R (1)	Briefing (2)	Idle & Small Stops (Minutes)	Loading Time (min)	Loss (%)
Week 1 Feb	30	20	50	960	5,21
Week 2 Feb	100	50	150	4.648	3,23
Week 3 Feb	115	100	215	5.091	4,22
Week 4 Feb	80	40	120	3.715	3,23
Sunday 5 Feb	90	80	170	4.645	3,66
Middle	**83**	**58**	**141**	**3.812**	**3,91**

Reduce speed loss, a loss that occurs due to the actual speed of the machine or equipment below the set standard optimal speed, which can be calculated based on the formula (8). The results of the calculation can be seen in table (8).

$$\frac{\text{Operation Time} - (\text{Ideal CT x Output})}{\text{Loading Time}} \text{ x } 100\% \qquad (8)$$

Table 8 *Reduce Speed Loss*

November	Operating Time (min)	Output (pcs)	Ideal Cycle Time (Minutes)	Loading Time (min)	Loss (%)
Week 1	4.323	67.470	0,048	4.811	22,07
Week 2	3.940	61.841	0,048	4.495	21,16
Week 3	4.160	63.285	0,048	4.735	23,26
Week 4	3.750	61.266	0,048	4.396	17,94
Week 5	1.395	23.452	0,048	1.570	16,66
Middle	**3.341**	**55.463**	**0,048**	**3.829**	**16,51**

December	Operating Time (min)	Output (pcs)	Ideal Cycle Time (Minutes)	Loading Time (min)	Loss (%)
Week 1	2.555	43.595	0,048	3.020	14,83
Week 2	3.170	53.659	0,048	3.815	15,11
Week 3	5.000	82.520	0,048	5.585	18,11
Week 4	3.815	61.421	0,048	4.280	19,77
Middle	**3.635**	**60.299**	**0,048**	**4.175**	**17,26**

January	Operating Time (min)	Output (pcs)	Ideal Cycle Time (Minutes)	Loading Time (min)	Loss (%)
Week 1	4.150	62.135	0,048	4.595	24,96
Week 2	4.682	71.497	0,048	5.212	23,53
Week 3	5.515	89.009	0,048	6.135	19,77
Week 4	4.860	78.026	0,048	5.420	20,09
Middle	**4.157**	**75.167**	**0,048**	**5.341**	**9,81**

February	Operating Time (min)	Output (pcs)	Ideal Cycle Time (Minutes)	Loading Time (min)	Loss (%)
Week 1	835	12.952	0,048	960	21,77
Week 2	3.458	67.723	0,048	4.648	3,97
Week 3	4.531	72.510	0,048	5.091	20,16
Week 4	3.205	49.368	0,048	3.715	22,04
Week 5	4.095	67.898	0,048	4.645	17,51
Middle	**3.225**	**54.090**	**0,048**	**3.812**	**16,01**

Process defect loss, loss that occurs due to output defect during the production process, which can be calculated based on formula (9). The results of the calculation can be seen in table (9).

$$\frac{\text{Ideal CT x Not Good}}{\text{Loading Time}} \text{ x } 100\% \qquad (9)$$

Table 9 *Losses of Process Defects*

November	Ideal Cycle Time (Minutes)	Not Good (Pcs)	Loading Time (min)	Loss (%)
Week 1 Nov	0,048	100	4.811	0,10
Week 2 Nov	0,048	108	4.495	0,12
Week 3 Nov	0,048	78	4.735	0,08
Week 4 Nov	0,048	68	4.396	0,07
Sunday 5 Nov	0,048	34	1.570	0,10
Middle	**0,048**	**78**	**3.829**	**0,09**

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December	Ideal Cycle Time (Minutes)	Not Good (Pcs)	Loading Time (min)	Loss (%)
Week 1 Dec	0,048	61	3.020	0,10
Sunday 2 Dec	0,048	57	3.815	0,07
Sunday 3 Dec	0,048	110	5.585	0,10
Sunday 4 Dec	0,048	79	4.280	0,09
Middle	**0,048**	**77**	**4.175**	**0,09**
January	Ideal Cycle Time (Minutes)	Not Good (Pcs)	Loading Time (min)	Loss (%)
Week 1 Jan	0,048	95	4.595	0,10
Week 2 Jan	0,048	87	5.212	0,08
Week 3 Jan	0,048	100	6.135	0,08
Week 4 Jan	0,048	40	5.420	0,04
Middle	**0,048**	**81**	**5.341**	**0,07**
February	Ideal Cycle Time (Minutes)	Not Good (Pcs)	Loading Time (min)	Loss (%)
Week 1 Feb	0,048	21	960	0,11
Week 2 Feb	0,048	116	4.648	0,12
Week 3 Feb	0,048	292	5.091	0,28
Week 4 Feb	0,048	109	3.715	0,14
Sunday 5 Feb	0,048	72	4.645	0,07
Middle	**0,048**	**122**	**3.812**	**0,15**

Reduce yield loss, losses caused by unstable output, abnormal machinery and improper processes resulting in defects during the initial process, which can be calculated based on the formula (10). The results of the calculation can be seen in table (10).

$$\frac{\text{Ideal CT x Reduce Yield}}{\text{Loading Time}} \text{ x } 100\% \quad (10)$$

Table 10 *Reducing Yield Loss*

November	Ideal Cycle Time (Minutes)	Bad Setup (pcs)	Loading Time (min)	Loss (%)
Week 1 Nov	0,048	10	4.811	0,01
Week 2 Nov	0,048	10	4.495	0,01
Week 3 Nov	0,048	10	4.735	0,01
Week 4 Nov	0,048	10	4.396	0,01
Sunday 5 Nov	0,048	4	1.570	0,01
Middle	**0,048**	**9**	**3.829**	**0,01**
December	Ideal Cycle Time (Minutes)	Bad Setup (pcs)	Loading Time (min)	Loss (%)
Week 1 Dec	0,048	8	3.020	0,01
Sunday 2 Dec	0,048	10	3.815	0,01
Sunday 3 Dec	0,048	12	5.585	0,01
Sunday 4 Dec	0,048	8	4.280	0,01
Middle	**0,048**	**10**	**4.175**	**0,01**
January	Ideal Cycle Time (Minutes)	Bad Setup (pcs)	Loading Time (min)	Loss (%)
Week 1 Jan	0,048	10	4.595	0,01
Week 2 Jan	0,048	10	5.212	0,01
Week 3 Jan	0,048	12	6.135	0,01
Week 4 Jan	0,048	10	5.420	0,01
Middle	**0,048**	**11**	**5.341**	**0,01**
February	Ideal Cycle Time (Minutes)	Bad Setup (pcs)	Loading Time (min)	Loss (%)
Week 1 Feb	0,048	2	960	0,01
Week 2 Feb	0,048	10	4.648	0,01
Week 3 Feb	0,048	10	5.091	0,01
Week 4 Feb	0,048	8	3.715	0,01
Sunday 5 Feb	0,048	10	4.645	0,01
Middle	**0,048**	**8**	**3.812**	**0,01**

Table 11 *Average of Six Major Losses*

Damage Loss (%)	Adjustment Settings & Losses (%)	Idling Stop & Small Stop Loss (%)	Reduce Speed Loss (%)	Process Defect Loss (%)	Reducing Yield Loss (%)
12,65	5,08	3,85	14,90	0,1	0,01

The 2 biggest losses came from a decrease in speed of 14.90% and a damage loss of 12.65%. The results of this analysis are in accordance with the results of OEE calculations that have not reached the standard. Reducing speed loss causes the resulting output to not reach the target, resulting in low performance values in OEE. Meanwhile, breakdown loss causes the availability time of the heavy equipment to operate is not optimal because of the time lost when the machine cannot operate due to damage, so the availability value in OEE is also low.

3. Causal Diagram Analysis

These diagrams can depict lines and symbols that show the relationship between the cause and effect of a problem. This diagram is used to find out the consequences of a problem so that corrective action can be taken (Susanti, 2011). The two biggest failures affect the OEE factor, the decrease in the speed of loss affects the performance of the rate and the breakdown loss affects the Availability Rate, as the results of the analysis that has been carried out using the Six Big Loss.

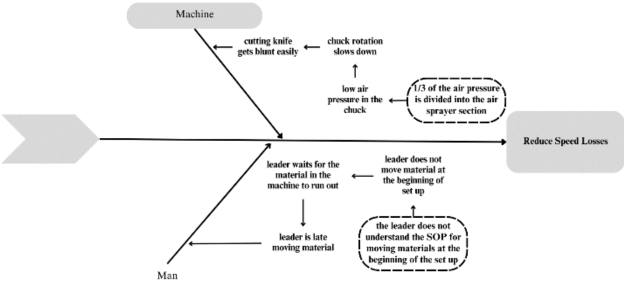

Figure 2 *Fish Bone Diagram Reduces Speed Loss*

The machine, cutting 476 uses a cutting blade to process the pipe material. A good product can be produced with high chuck rotation, which comes from high wind pressure. The cutting blade is easy to blunt when the chuck rotation is low. Low wind pressure causes the cutting process to take longer than when the wind pressure is high. The cause of low air pressure is because 1/3 of the air pressure is divided into air atomizers, so the air pressure entering the chuck is not optimal.

Human, 476 cutting machine processes pipe material. The material from the raw material area must be transferred to the barfeeder by the leader. Often the machine has to stop because it is waiting for the material to be moved by the leader, when the machine stops it can take more than 10 minutes. The leader moves the material when it is about to run out. If the material is moved at the beginning of the setting time, then the machine does not need to wait for the leader. This happened because the leadership did not understand the SOP for moving materials at the beginning of the arrangement properly.

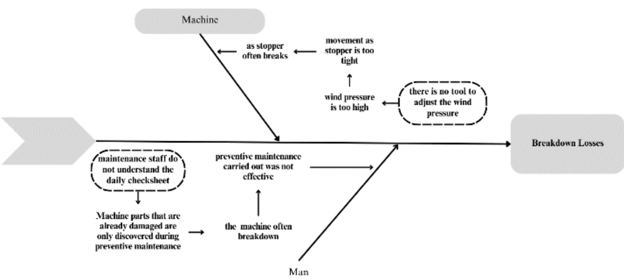

Figure 3 *Fish Bone Diagram Damage Loss*

Machine, The cutting machine has an important part called the stopper axle, the function of this component is as a material barrier shaft so that it can be cut according to the predetermined size. The stop axle requires wind pressure to operate. The high wind pressure causes the axle to move too fast and then break. The mower does not have a tool to adjust the height and low pressure of the incoming air.

Human, Preventive maintenance carried out is not effective because the 476 cutting machine has a high frequency of damage. This damage was only known when preventive maintenance was carried out, so the machine was damaged because it was not repaired immediately. This happens because maintenance staff do not understand the daily checksheet to know the damage as early as possible.

4. Failure Mode and Effects Analysis (FMEA)

Table 12 *Failure Modes and Effects Analysis*

Six Major Losses	Types of Failure	Effects of Failure	Severity	Causes of Failure	Examination	Control	Detection	RPN
Reduce Speed Loss	1/3 of the wind pressure is divided into parts of the air atomizer	Not a good product	2	Wind pressure is not maximum	9	Automatically shuts off the airflow of the air atomizer part	3	54
	The leadership did not understand the SOP for moving materials at the beginning of the arrangement	The production process does not run	3	Leaders don't understand SOPs	9	Socialization of material transfer to the machine at the beginning of each setup	1	27
Damage Loss	No air pressure regulator	Engine Breakdown	5	The air pressure for the stopper shaft is too high	8	Adjust the pressure using the air speed regulator	3	120
	Maintenance staff do not understand the daily inspection sheet	Causes an average downtime of 10-30 minutes	4	Preventive maintenance checks performed in many missed parts	8	Socialization of daily checksheets	3	102

5. Analysis After Improvement

Once the proposed improvements are implemented, here is the data from the OEE calculation from July to August 2023:

Table 13 *OEE After Repair*

July	Output (pcs)	Ideal Cycle Time	Operating Time (min)	Performance Ratio (%)

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		(Minutes)		
Sunday 1 July	84.910	0,048	4.875	84,18
Sunday 2 July	77.338	0,048	4.431	84,36
Sunday 3 July	63.446	0,048	3.630	84,48
Sunday 4 July	78.029	0,048	4.490	84,00
Middle	**75.931**	**0,048**	**4.357**	**84,25**
August	Output (pcs)	Ideal Cycle Time (Minutes)	Operating Time (min)	Performance Ratio (%)
Sunday 1 August	77.984	0,048	4.487	84,00
Sunday 2 August	77.538	0,048	4.420	84,79
Sunday 3 August	77.431	0,048	4.440	84,29
Sunday 4 August	78.026	0,048	4.540	83,07
Sunday 5 August	78.225	0,048	4.491	84,18
Middle	**77.841**	**0,048**	**4.476**	**84,07**

Next, see a comparison of OEE before and after the upgrade.

Table 14 *Comparison of OEE Before and After Repairs*

	Standard (%)	Before Repair (%)	After the Repair (%)
Availability level	90	87	91
Performance level	85	78	84
Quality level	99	99	99
OEE	**85**	**68**	**77**

The OEE value increased by 9% from 68% before the increase to 77%. The availability value has increased by 4% from before the increase, this result shows that the availability has reached the standard of 90%.

CONCLUSION

The 476 mower initially had a low Overall Equipment Effectiveness (OEE) value of 68% from November 2022 to February 2023. This is because the level of performance and availability has not reached the standard, namely 78% and 87%. However, the quality level of the machine is in accordance with the standard with a value of 99%. The analysis of the six major losses shows that the decrease in speed loss and damage loss are the main causes of these low values, 14.90% and 12.65%, respectively.

Factors affecting the effectiveness of the machine include problems with irregular air pressure systems, lack of understanding of daily inspection sheets by maintenance staff, and lack of understanding of SOPs for moving materials early in the set-up.

Various improvements have been made based on the Failure Mode and Effect Analysis (FMEA), including the installation of air speed regulators to regulate wind pressure and the socialization of daily checksheets and SOPs for material disposal. After these improvements were made, the OEE value increased from 68% to 77% from July 2023 to August 2023. However, this value still does not reach the standard target of 85%, because the engine performance level has only reached 84%.

In conclusion, although there has been an increase in OEE values after proper improvements, further efforts are still needed to achieve the expected standards, especially in improving the performance level of the engine to reach the target of 85%. In the next research, the method that has been applied can be used not only on 1 machine, and can be combined with other methods, according to the problems that occur in the future.

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