

Analysis of Effectiveness of Cut Size Line Machines Based on Total Productive Maintenance (TPM) and Analytical Hierarchy Process (AHP) - A Case Study

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ABSTRACT

This research aims to analyze the implementation of Total Productive Maintenance (TPM) using Overall Equipment Effectiveness (OEE) and Analytical Hierarchy Process (AHP) approaches to increase the OEE value on cut-size line machines in the finishing department in PT. X. The research methodology was carried out by calculating OEE and significant loss values, analyzing Pareto and Fishbone diagrams, and using the AHP as a decision-making method. Then, the recommendations for implementing focused and autonomous maintenance in the case study company. The research results revealed that the significant influencing factor for the OEE value was engine speed, which causes performance efficiency to decrease so that the OEE value also decreases. The OEE value in 2021 is 74%. The improvement plan by applying the TPM and AHP methods will be expected to increase the performance efficiency of the machine via OEE value from 74% in 2021 to 79% for the coming year 2023/2024.

KEYWORDS: *Total Productive Maintenance (TPM), Overall Equipment Effectiveness (OEE), Analytical Hierarchy Process (AHP), Cut size line machine.*

1.0 INTRODUCTION

PT. X is a high-quality private business in the paper-making industry. The Finishing Department is one of several departments in PT. X. The Finishing Department's tools and

processes include using jumbo rolls (larger rolls), which have more significant cut and folio sizes. The Finishing Department has two conversions: Converting machine line I has seven cut-size lines, and Converting II has three and five folio-size lines. PT. X in the maintenance process needs to continue innovating to improve the performance of cut-size line machines. In practice, the improvement efforts often need to touch the real root of the problem. For this reason, a method that can express problems is needed to improve equipment performance optimally. One method of measuring machine performance and effectiveness is Overall Equipment Effectiveness (OEE). This measurement method consists of three main factors that are interconnected, namely Availability, Performance and Quality. This method is the central part of the maintenance system, namely Total Productive Maintenance (TPM) [1].

Total Productive Maintenance (TPM) is part of Lean Manufacturing. TPM in Lean Manufacturing is one of the maintenance process developments that increase effectiveness in the workplace, produce consistent products, and eliminate or reduce waste. The TPM is expected to produce zero work accidents, equipment damage, and product failures [2]. TPM in PT. X in the finishing department has not run optimally and has yet to achieve the company's targets. According to data from PT. X, the average OEE value obtained in 2020 of 71% and in 2021 of 74% [Table 1], while the world-class OEE target and the company's target was 85% [3],[4]. Based on the OEE values for the last two years, there are differences in the OEE values and the company target values.

Handling and process analysis, which are still low in the paper processing process, affect the effectiveness of the machine in achieving output and production quality levels. It can be seen from the results of the OEE values for 2020 and 2021 that the maintenance process is already underway, but the process in the field still needs to be effective. It has yet to reach the world-class target. In the finishing department, PT. X strives to reduce downtime in the paper processing process until it reaches the maximum stage in increasing OEE and increasing product quality to reduce losses [5]. Apart from that, the level of operator awareness and concern regarding machine

effectiveness and how to measure machine performance in production still needs to be higher. Machine standardization has yet to be realized, so machine conditions are not producing optimally. Machine maintenance regarding cleaning and preventive maintenance has yet to be carried out optimally. Corrective action is needed to improve the level of effectiveness of machines in production. After obtaining corrective action, the AHP approach may help make decisions about selecting the best priority and recommendations from TPM data processing. Therefore, this paper proposes to conduct research using the TPM method to provide input on the problems faced through analysis of OEE calculations, identify the root cause of the problem, and get several AHP recommendations to increase the OEE value on the machine.

Table 1: OEE value data for 2020 and 2021

All CS 2020	OEE Actual (%)	OEE Target (%)	All CS 2021	OEE Actual (%)	OEE Target (%)
January	74	85	January	69	85
February	72	85	February	72	85
March	69	85	March	70	85
April	70	85	April	72	85
May	69	85	May	76	85
June	67	85	June	74	85
July	72	85	July	72	85
August	72	85	August	76	85
September	70	85	September	73	85
October	70	85	October	70	85
November	71	85	November	70	85
December	76	85	December	76	85
Average	71	85	Average	74	85

2.0 METHOD

This paper adopted the quantitative descriptive approach. Based on the background description, the problem formulation was found by increasing the effectiveness of the cut-size line machine in the Finishing Department in PT. X by analyzing the implementation of TPM and using the AHP method for decision making as well as recommendations for the TPM pillar, namely focused maintenance, autonomous maintenance and planned maintenance to improve the effectiveness of the cut-size line machine. According to data from PT. X [Table 1], the average OEE value obtained in 2020 was 71%; in 2021, it was 74%, while the world-class OEE target and the company's target was 85%. The effectiveness of the cut-size line machine still needs to be up to standard. In order to increase the effectiveness of the cut-size line machine, it was necessary to identify the cause of the problem.

The data was collected in the case study as follows:

1) Machine effectiveness data

The TPM in companies has become a measuring tool for continuous improvement [6-9]. The implementation of TPM in manufacturing companies is measured using the Overall Equipment Effectiveness (OEE) tool [6-9]. The OEE value calculation is divided into three variables: availability, performance efficiency and quality rate. The calculations for these three variables are as follows [10],[11]:

a. Availability

Availability is a ratio that describes the utilization of time available for machine/equipment operating activities. The availability is the ratio of operation time, by eliminating equipment downtime, to loading time.

b. Performance Efficiency

Performance Efficiency is a ratio that describes the ability of equipment to produce goods. This ratio is the result of the processed amount and theoretical cycle time.

c. Quality Rate

Quality Rate is a ratio that describes the ability of equipment to produce products that comply with standards. Rate Quality compares the value of the number of better products to the total number of products processed.

d. Overall Equipment Effectiveness (OEE)

The assessment related to OEE for machines following global standards is 90% for the availability rate, 95% for the performance rate, 99% for the quality rate and 85% for the OEE value of equipment.

1. Determining the Percentage of Machine Losses

To achieve the OEE in the case study company, the first step was to eliminate the main losses (six significant losses). Six significant losses are generally divided into three main categories based on the loss aspect, namely downtime losses, speed losses and defect losses [12],[13] that can be seen in Figure 1.

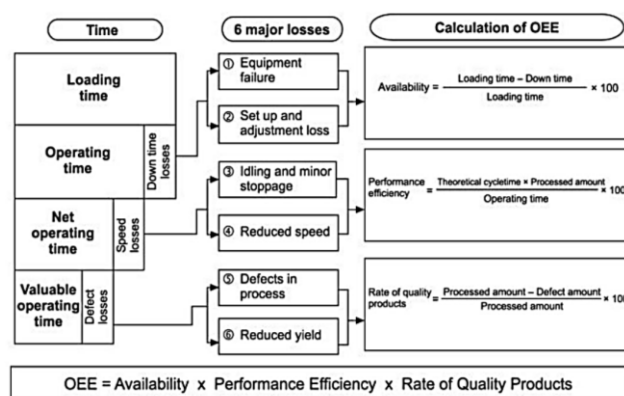


Figure 1: The OEE measurement based on six big losses [13]

2. Determining the Cumulative Percentage of Machine Losses

The cumulative percentage of the identified machine losses is determined. Implementing a Pareto diagram is a way of sorting or classifying data from left to right according to highest to lowest ranking order. It can also identify the most critical problems affecting quality improvement efforts and guide in allocating limited resources to solve problems [14],[15] in the process of maintenance innovation and calculating the six main losses (six significant losses) using Pareto tools, to complement the sources of losses that have been obtained in cumulative percentages and the most prioritized losses using the Pareto diagram and in this paper applied the Fishbone Diagram to explain the root cause of priority losses encountered.

3. Determining the Root of Machine Problems

This research finds the root cause in identifying the main problems obtained by the Pareto diagram. This research used the fishbone diagram tool to get the root source of the

problem. The cause-and-effect diagram or fishbone diagram is a way of identifying possible causes of a problem, helping solve a problem, and focusing on the leading root cause of the problem [16-19]. The root of the problem in Fishbone analysis can be used for the OEE step process. In the final step to obtain specific and targeted problem-solving, this research recommends the solution targets using the Analytical Hierarchy Process (AHP) methodology.

4. Determining Problem Priority Scale Using the AHP Method Solving problems using the AHP method [20-25] is a way to produce alternatives or recommendations in conducting research and develop them into TPM recommendations. Recommendations from the AHP results were a decision-making step to improve problems in the company. With the recommendations from the AHP, results can improve and increase effectiveness within the company. Thus, the priority scale obtained from the AHP method has been produced, and the following AHP recommendations can be applied for the long-term maintenance process on cut-size line machines in the finishing department in PT. X.

5. Recommendations for the 3 Pillars of TPM

The TPM calculation was obtained, and the AHP priority scale and recommendations were produced. So, the next focus was to implement and recommend the three pillars of maintenance innovation solutions. It was developed from the results of the TPM method in identifying losses and AHP from the priority scale and recommendations obtained. These three pillars were Focused Maintenance, Autonomous Maintenance, and Planned Maintenance.

3.0 RESULTS AND DISCUSSION

3.1 The OEE Improvement Result Analysis

1. Overall Equipment Effectiveness (OEE)

Figure 2 shows the size of cutting machines in 2020; the average availability is 95.3% (world-class 90%), and performance efficiency is 78.5% (world-class 95%). The difference between the world-class numbers is 16.44%, and the quality rate is 94.9 % (world-class is 99.9%). The difference in world-class figures is 5.08%. The average size of the line-cutting machine in 2021 is Availability 96.6% (world-class 90%). Performance Efficiency is 79.8% (world-class 95%), the difference between the world-class numbers is 15.02%, and the Quality Rate is 95.8 % (world-class 99.9%), the difference in world-class numbers is 4.09%.

2. Big Losses

- a. Equipment Failure

Equipment failure: this loss occurs because the equipment is damaged, cannot be used and requires repair or replacement. This loss is measured by how long it takes for damage to occur until repairs are completed. In Figure 3, for equipment failure, it can be seen that the machine performance experienced losses in cut size lines 1 – 10.

- b. Setup and adjustment failure

Setup and adjustment losses were losses due to machine setup time and adjustment time, as well as time wasted due to machine tools' activities that differentiate the output produced according to desires. In Figure 4, for equipment failure, it can be seen that the machine performance experienced losses in cut size lines 1 – 10.

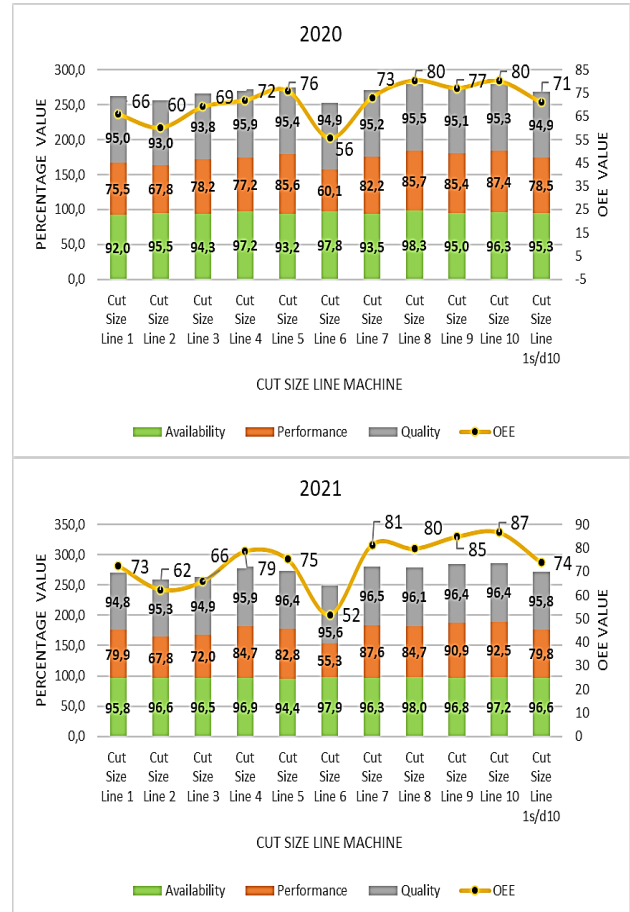


Figure 2: Average OEE for cut size line machines 2020 and 2021

- c. Reduced Speed

Reduced speed losses were the losses from the engine operating below the engine's ideal speed. Adjust to the data obtained at the research location in calculating reduced speed losses. In Figure 5, for equipment failure, it can be seen that the machine performance experienced losses in cut size lines 1 – 10.

- d. Defect in Process

Defects in process, losses resulting from the produced being a defective product resulting in material losses, reducing the amount of production, increasing production waste, and rework costs. In Figure 6, it can be seen that the machine performance experienced losses in cut size lines 1 – 10.

From Figure 7, it can be seen that the losses have decreased; however, among the four loss factors, the value of the loss factor for the reduced speed losses factor is still much greater than the other factors. The Pareto diagram is employed to ascertain the factor that occurred in the dominant factors as the basis of the problem. The Pareto diagram chart was used to identify the most critical problems that must be resolved immediately. After the Pareto diagram chart is obtained, it can be analyzed that the losses that will be corrected are more critical than other losses. The percentage of significant loss factors for cut-size line machines 1 – 10 in 2020 is shown in Table 2 and Figure 8.

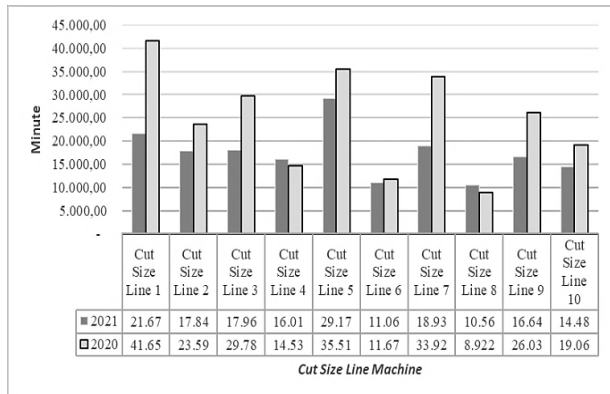


Figure 3: Average equipment failure cut size line machines 2020 and 2021

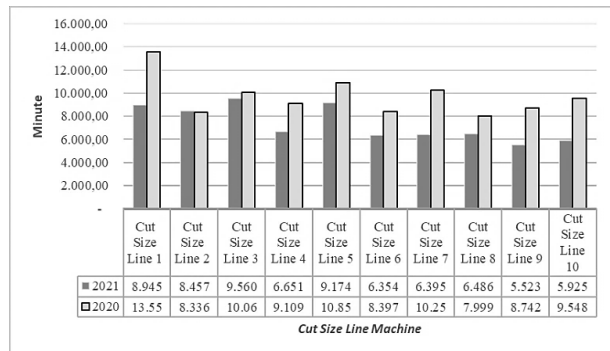


Figure 4: Average setup and adjustment losses cut size line machines 2020 and 2021

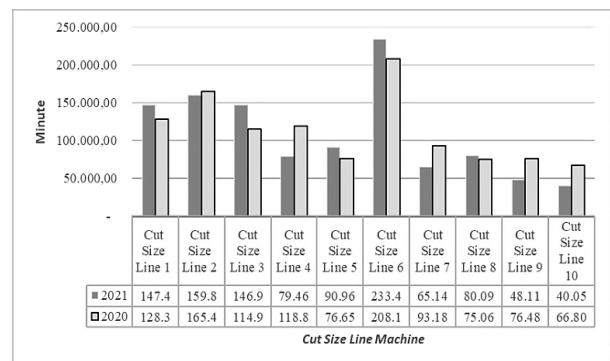


Figure 5: Average reduced speed losses cut size line machines 2020 and 2021

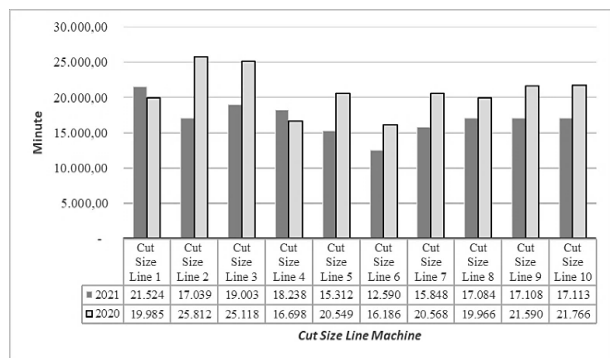


Figure 6: Average defect in process cut size line machine 2020 and 2021

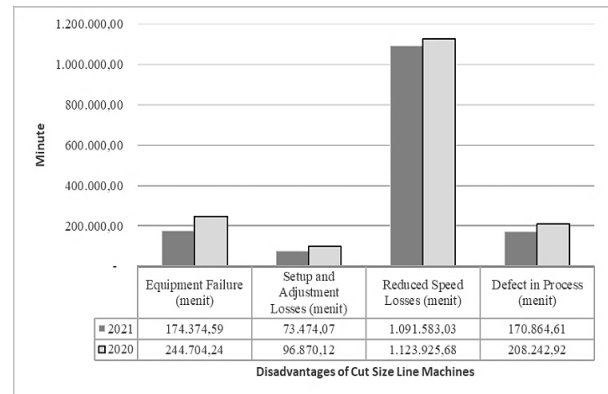


Figure 7: Average results of search data for big losses in 2020 and 2021

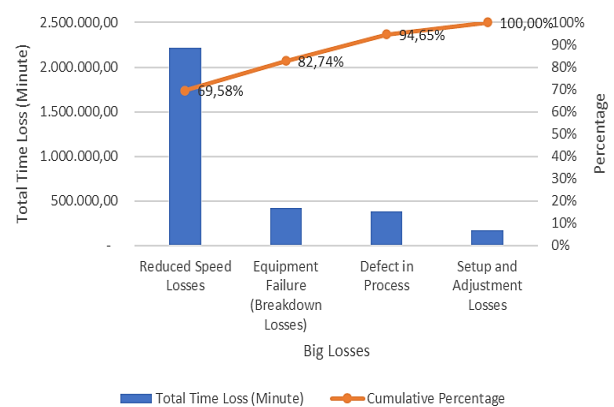


Figure 8: Pareto Big Losses Diagram for Cut Size Line Machines 1 – 10 in 2020

Table 2: Percentage of big losses factors for cut size line machines 1 – 10 in 2020 and 2021

Big Losses Factor	Total Time loss (minutes)	Percentage (%)	Cumulative Percentage (%)
Reduced Speed Losses	2,215,508.71	69.58%	69.58%
Equipment Failure	419,078.83	13.16%	82.74%
Defect in Process	379,107.53	11.91%	94.65%
Setup and Adjustment Losses	170,344.19	5.35%	100.00%
Total	3,184,039.26	100%	

Reduced speed losses occupy the number 1 position with total time losses (minutes) of 2,215,508.71 minutes, a percentage of 69.58%. Furthermore, equipment failure occupies the number 2 position with total time losses (minutes) of 419,078.83 minutes, a percentage of 13.16%. Furthermore, defects in process occupy the number 3 position with total time losses (minutes) of 379,107.53 minutes with a percentage of 11.91%. Furthermore, setup and adjustment losses occupy position number 4 with a total time loss (minutes) of 170,344.19 minutes, a percentage of 5.35%.

1. Losses Analysis

a. Reduced Speed Losses

Table 3 and Table 4 show the factors influencing losses on cut-size line machines. Overall, it can reduce the effectiveness of cut-size line machines, which have never reached global standards, namely 85%. The critical factor is then connected to the following method: Analytical Hierarchy Process (AHP) to obtain a priority scale in solving loss problems on cut-size line machines.

Table 3: Critical factors and reduced speed losses solutions

Section	Problem
Machine	Clutch Gears Transmission belt Transmission belt Tension Pressure Nip Roller Pressure Nip Roller
Material	Roll bouncing Roll bouncing
Man Power	New operator
Environment	Paper / damp paper

b. Equipment Failure

Table 4: The critical problems of equipment failure

Machine	Section	Problem
CS3	CSW line 1	The wrapper is loose, the wrapper is torn, and the wrapper is not aligned.
CS5	Cross Belt	Diagonal cross belt and frame support gripper damaged.
CS3	CSW	Bottom side welding edge.
CS1	Cross cutter	Cross jam paper cutter.
CS1	SCW 1	CSD conveyors out of position.
S8	Back stand	Damaged spindle gearbox.
CS9	Back stand	The right rack tooth is broken.
CS9	Palletizer	Elevator chain pall #9 is broken.
CS5	CSW Line 2	Universal joint broken.
CS2	CSW – 2	Edge welding.
CS8	CSW	Edge welding.
CS10	Palletizer	Pallet lift error.
CS3	CSW Line 2	Roller conveyor lift bolt damaged.
CS4	CSW	Wrap misalignment
CS3	CSW Line 2	The roller conveyor lift bolt is damaged.
CS3	CSW Line 1	Suction pump belt does not run.
CS9	Cartomizer-2	Bad side fold wrapper.
CS6	CSW	Bad side fold wrapper.
CS3	Overlapping	Flight conveyor clutch damage
CS2	Line 2	nip roller stuck.
CS3	Line 1	Edge weld bottom sheet.
CS10	Cross cutter	Bad cutting.
CS1	Back stand	Broken drive shaft.
CS3	Back stand	The gear shaft is damaged.
CS3	Cross Cutter	Furry corners.
CS7	Palletizer	Pallet lift error to lock.
CS1	Back stand	Broken drive shaft.
CS3	Back stand	The gear shaft is damaged.

2. Analytical Hierarchy Process

a. Reduced Speed Losses

The reduced speed losses criteria in Table 5 showed the percentages of problem-solving for Manpower, Material, Environment and Machine. It can be seen in Table 5 that Manpower has the highest percentage of 45%, followed by Material, which has a percentage value of 38%. Next, after determining ranks one and 2 of reduced speed losses, each alternative solution was explained in Table 6 and Table 7.

Table 5: Criteria that influence reduced speed losses

No	Influencing Criteria Reduced Speed Losses	Percentage
1	Manpower	45%
2	Material	38%
3	Environment	9%
4	Machine	8%

Table 6: Solutions and alternatives to the man power

No	Alternatives That Affect Man Power Reduced Speed Losses	Percentage
1	Create a training schedule.	30%
2	Create an equipment check schedule (operator schedules equipment inspection).	26%
3	Using good and durable materials (applying to operators must have quality in work and be easy to adapt).	23%
4	Follow SOP/Instructions in working to adjust equipment.	17%
5	Replacing new equipment (balance between old operators and new operators so that there is regeneration in the workplace).	3%

The solutions and alternatives for the manpower criteria were obtained from ranks 1, 2, and 3. The alternative rank 1 was to make a training schedule with a percentage of 30%. Alternative rank 2 was the operator scheduling equipment inspections with a percentage of 26%. Alternative rank three was applied to operators who must have quality in work and be easy to adapt, with a percentage of 23%.

Table 7: Solutions and alternatives for material

No	Alternatives Affecting Material Reduced Speed Losses	Percentage
1	Using good and durable materials.	35%
2	Make an equipment checking schedule (create a material checking schedule for equipment).	26%
3	Follow SOP/instructions in working to adjust equipment (materials).	15%
4	Replacing new equipment (using new materials if the materials cannot be recycled).	13%
5	Make a training schedule (make a material training schedule for equipment so that it has a long life).	11%

The solutions and alternatives for the material criteria revealed that the first alternative was to use excellent and durable materials with a percentage of 35%. Alternative

ranking 2 was to create a material checking schedule for equipment with a percentage of 26%.

b. Equipment Failure

Table 8: Criteria that influence equipment failure

No	Influencing Criteria Equipment Failure	Percentage
1	Cross Cutter	35.2%
2	Overlapping	19.4%
3	Palletizer	15.3%
4	Cartoonizer	9.8%
5	Cross Belt	9.1%
6	Cut size wrapping	7.1%
7	Back stand	4.0%

Table 8 depicted the equipment failure criteria, those taken to be a source of problem-solving of rank 1, rank 2, and rank 3, namely cross cutter, overlapping and palletizer, respectively. It can be seen in Table 8 that the cross cutter has a percentage of 35.2%, overlapping has a percentage value of 19.4%, and palletizer has a percentage value of 15.3%. Then, the Equipment Failure (Breakdown Losses) for an alternative solution can be seen in Table 9, Table 10, and 11.

Table 9: Solutions and alternatives to the cross cutter

No	Alternatives That Affect Cross Cutter Equipment Failure	Percentage
1	Clean tools and equipment on the machine from dust and dirt	44.0%
2	Check and adjust equipment on tools according to standards	27.0%
3	Carry out repairs and modify equipment or tools on machines according to standards	19.0%
4	Replacing equipment on the machine	10.0%

The solutions and alternatives for the cross-cutter criteria obtained results from rank 1 and 2. Alternative rank one was cleaning the tools and equipment on the machine from dust and dirt, with a percentage of 44%. Alternative rank two is checking and adjusting equipment on tools according to standards, with a percentage of 27%.

Table 10: Solutions and alternatives to the overlapping

No	alternatives that affect Overlapping Equipment Failure	Percentage
1	Clean tools and equipment on the machine from dust and dirt.	37.0%
2	Check and adjust equipment on tools according to standards.	24.0%
3	Replacing equipment on the machine.	22.0%
4	Carry out repairs and modify equipment or tools on machines according to standard.	17.0%

The results obtained were ranked 1, 2, and 3 in the solutions and alternatives for the overlapping criteria. Alternative rank one was cleaning the tools and equipment on the machine from dust and dirt, with a percentage of 37%. Alternative rank two was checking and adjusting equipment on tools according to standards, with a percentage of 24%. Alternative rank three was replacing equipment on the machine with a percentage of 22%.

Table 11: Solutions and alternatives to palletizer

No	Alternatives That Influence Palletizer Equipment Failure	Percentage
1	Check and adjust equipment on tools according to standards.	40.0%
2	Carry out repairs and modify equipment or tools on machines according to standards.	26.0%
3	Replacing equipment on the machine.	22.0%
4	Clean tools and equipment on the machine from dust and dirt	12.0%

In the solutions and alternatives to the palletizer criteria, the results obtained were ranked 1, 2, and 3. Alternative ranked 1 was to check and adjust the equipment on the tool according to standards with a percentage of 40%. Alternative rank 2 was to carry out repairs and modify equipment or tools on machines according to standards with a percentage of 26%. Alternative rank three was replacing equipment on the machine with a percentage of 22%.

The average OEE value in 2020 was 71%, and the average OEE value in 2021 was 74%. The average for world-class companies was 85%. From availability and quality rate data, it reached world-class targets. Meanwhile, performance efficiency was still far from the world-class average. Based on the data collected at the research location, four significant losses can be identified: equipment failure, setup and adjustment losses, reduced speed losses and defects in process. The significant loss factors have been arranged from highest to lowest, then continue to add them up and look for the cumulative percentage to get a Pareto diagram chart. A chart was used to identify the most critical problems that must be resolved immediately. Once the Pareto diagram chart was obtained, it can be analyzed that the losses to be corrected.

A significant loss factor for cut size line machines 1 to 10 in 2020 and 2021 is reduced speed losses occupying the number 1 position with total time losses (minutes) of 2,215,508.71 minutes with a percentage of 69.58%. The equipment failure occupies the number 2 position with total time losses (minutes) of 419,078.83 minutes, a percentage of 13.16%. The defects in process occupy the number 3 position with total time losses (minutes) of 379,107.53 minutes with a percentage of 11.91%. Next, setup and adjustment losses occupy position number 4 with total time losses (minutes) of 170,344.19 minutes, a percentage of 5.35%. In this case, researchers will look for solutions and alternatives using Fishbone diagrams and the Analytical Hierarchy Process to reduce these losses. On cut size line machines 1 to 10 in 2020 and 2021, looking at the OEE value, calculation of significant losses and Pareto diagram, the ranking results for numbers 1 and 2 of the four significant losses in this research case are reduced speed losses and equipment failure.

The results of the fishbone diagram in the case of reduced speed losses found four problems, namely machine, material, workforce and environment. In the case of equipment failure (breakdown losses), there were seven problems, namely cut size wrapping, cross belt, cross cutter, back stand, palletizer, cartoonizer, and overlapping. From the 2 cases analyzed, eight solutions were obtained for reduced speed losses, and 30 solutions to equipment failure were found for each problem.

The correlation between performance efficiency and the final result of the analytical hierarchy process is a solution or alternative to problems on the cut size machine lines 1 to 10.

The average performance efficiency value per year can increase by recommendations from the results of the analytical hierarchy process and why-why analysis, namely as follows:

Reduced Speed Losses (Man Power)

Make a training schedule for employees according to their respective fields. It is hoped that once every three months, training will be made, such as learning methods about TPM and preventive maintenance on cut-size line machines.

Operators make a schedule for checking or inspecting equipment on cut-size line machines. Due to conditions in the field, operators rarely conduct integrated inspections, only looking at conditions in the field and providing reports via smartphone group communication if problems occur. By making recommendations, it is hoped that operators, staff, and top management in the finishing department can make the equipment inspection schedule more integrated.

Applying that operators must have quality in their work and be easy to adapt, this means that in field conditions, many operators and shifters still work with a less productive work culture, usually in the afternoon and evening work shifts. It seems that they work only with the routine daily activities they do.

Reduced Speed Losses (Materials)

Using excellent and durable materials for each material on the cut size line machine, namely in conditions in the field; if damage occurs in one part of the production process, the machine still uses poor materials, but looking at the condition of the damage in the field that occurs. Usually, if the damage occurs is relatively high, suitable materials are used.

Make a daily, weekly and monthly material checking schedule for cut-size machine equipment. Operators rarely carry out integrated material inspections in the field, only looking at conditions in the field and providing reports via smartphone group communication if there is a problem with one of the materials in the machine components. By making recommendations, it is hoped that operators, staff, and top management in the finishing department can make the equipment material inspection schedule more integrated.

Following the SOP/Instructions in working to adjust materials means that in the field conditions, the operator or shifter has carried out the instructions according to the SOP directions and the direction of the shift head and top management.

Equipment Failure (Cross-Cutter)

Clean the tools and equipment on the machine from dust and dirt on the cross-cutter machine parts.

Check and adjust the equipment on the tool according to the standards for the cross-cutter machine.

If a jam occurs in the paper cutting path, replace

components and adjust their position.

If cutting the paper results in a bad cut, adjust the knife and replace the cross-cutter block.

If the corners of the paper become hairy, adjust the position of the cutting knife and replace the component.

Equipment Failure (Overlapping)

Clean tools and equipment on the overlapping machine from dust and dirt.

Check and adjust equipment on tools according to standards on overlapping machines.

If the paddle shaft is damaged, replace the component with a new Paddle shaft; if the old component can still be repaired, then carry out repairs.

Equipment Failure (Palletizer)

Check and adjust equipment on tools according to standards during the production process in the palletizer machine section.

Carry out repairs and modify equipment or tools on the palletizer machine by standards or SOP for the palletizer machine.

If the elevator chain pall is damaged, the power man on duty must replace the elevator chain pall.

If the roller conveyor lift bolt is damaged, the roller conveyor must be forced open.

If there is an error or damage to the pallet lift to lock the pallet lifter, and the reposition sensor part becomes stuck, the mechanical team opens and cleans the area.

The recommendations may increase performance efficiency, specifically on speed issues for cut-size line machines. Based on the input and processing of OEE values, significant loss data, Pareto diagrams, and fishbone diagrams, the AHP method is expected to increase the speed of the cut-size line machine. Increasing the speed can increase the performance efficiency value and maximize the value of the OEE to increase the effectiveness of the cut-size line machine.

3.2 Adaptation of the TPM Pillar Concept Focused Maintenance

Speed in a production system is critical to support the performance of a machine. Increase the average speed value for the cut size line machines 1 – 10 by five reams/minutes for the coming year, from January to December. Increasing the machine speed for cut size line 1 – 10 by five reams/minute at the performance efficiency value for 2023/2024 will achieve the OEE value of 79%. The scenario to increase machine speed for the cut size line is depicted in Table 12.

Table 12: The OEE values for the coming year 2023/2024
January – December

ALL CUT SIZE	UoM	Year 2023/2024												YTD
		Jan- 21	Feb- 21	Mar- 21	Apr- 21	May- 21	Jun- 21	Jul- 21	Aug- 21	Sep- 21	Oct- 21	Nov- 21	Dec- 21	
Availability	%	95,76	96,31	96,65	97,00	95,93	97,12	96,43	96,99	96,38	96,92	96,81	97,33	96,64
Performance	%	84,89	86,32	86,74	88,43	86,12	82,94	83,07	85,33	83,63	83,07	84,33	84,71	84,96
Efficiency	%	96,09	95,91	96,20	95,70	95,70	95,74	95,55	95,89	95,92	95,71	95,69	95,64	95,81
Quality Rate	%	78	80	81	82	79	77	77	79	77	77	78	79	79
MTD OEE	%	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00
OEE Target	%													

Autonomous Maintenance

To increase the performance efficiency of the cut size line 1 to 10 machines, relative to the speed of the machine, the following analysis is carried out: (a) develop operator skills to have more knowledge and skills so that operators can detect symptoms of decreased speed before damage occurs, (b) creating an orderly workplace to performance efficiency from normal conditions can be detected quickly. To implement autonomous maintenance so that performance efficiency can be increased and produce speeds that comply with standards on cut size line 1 – 10 machines. The following seven steps are recommended:

Step 1 : Cleaning or initial inspection.

Step 2 : Prevention of sources of contamination and places that are difficult to clean.

Step 3 : Development of cleaning and lubrication standards

Step 4 : Thorough inspection.

Step 5 : Carry out autonomous maintenance and continuous improvement activities.

A summary of steps recommended when applied to increase the speed of Performance Efficiency for cut size line 1 – 10 machines is as follows:

- Able to differentiate between normal and abnormal speed conditions on cut size line 1 – 10 machines.
- Understand how to maintain optimal speed conditions and efficiency for cut size line 1 – 10 machines.
- Understand how to respond to engine speed quickly and responsively to find engine speed conditions that do not comply with standards.

4.0 CONCLUSION

The effectiveness of the cut-size line machine is influenced by three main OEE parameters: Availability, Performance Efficiency and Rate Quality. In 2020, availability is 95.28% (world-class 90%), performance efficiency is 78.56% (world-class 95%), and quality rate is 94.82% (world-class 99.9%). In 2021, availability is 96.64% (world-class 90%), performance efficiency is 79.98% (world-class 95%), and quality rate is 95.81% (world-class 99.9%). Average Availability and Quality Rate data reaches world-class targets. Meanwhile, Performance Efficiency is still far from the world-class average. The higher the loss value, the lower the effectiveness of using the cut-size line machine, which is displayed as an OEE value. Based on calculations and data analysis, four significant losses can be identified: equipment failure setup and adjustment losses, reduced speed losses, and defects in the process. From the results of the analysis, the performance efficiency value is still far from the world-class average due to the speed of the cut-size line machine still being needed to be optimal. Based on the results of the fishbone analysis, the speed problem from reduced speed losses includes manpower (new operators), low knowledge, and no training for machine speed cases.

In the AHP decision-making analysis, they resulted in critical losses, namely reduced speed losses and equipment failure. Reduced speed losses have 2 points, namely workforce and material. Equipment failure has 3 points: cross cutter, overlapping, and palletizer. The workforce recommended developing a training and inspection schedule and implementing quality and adaptable work. The material

criteria recommendation was to use sound, long-lasting materials and create a schedule for checking materials on equipment. The cutter and overlapping recommendation to clean and check the equipment for dust and dirt and adjust the equipment according to standards. Palletizer recommended adjusting equipment according to standards and modifying and replacing equipment on machines according to standards.

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