OPEN ACCESS

Saudi Journal of Business and Management Studies
Abbreviated Key Title: Saudi J Bus Manag Stud
ISSN 2415-6663 (Print) |ISSN 2415-6671 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com/sjbms

Original Research Article

Overall Equipment Effectiveness Improvement on Cutting Machine by Minimizing Six Big Losses

Rosalendro Eddy Nugroho[1*], Syifa Khoirudin[2]

[1]Lecturer of Master Manajemen, Mercu Buana University, Jakarta, Indonesia
[2]Student of Master Manajemen, Mercu Buana University, Jakarta, Indonesia

DOI: 10.36348/sjbms.2020.v05i01.011 | **Received:** 20.01.2020 | **Accepted:** 27.01.2020 | **Published:** 29.01.2020

***Corresponding author:** Rosalendro Eddy Nugroho

Abstract

This study aims to analyze the achievement of Overall Equipment Effectiveness on the cutting machine by minimizing the Six Big Losses that occur on the cutting machine. The research data are monthly data for the period January 2017 to June 2018. The sampling method used was purposive sampling. From a population of 18 carline areas with a total of 148 cutting machine units, 3 carline areas with the lowest OEE achievement as a sample. The analytical method used in the study is the analysis of OEE calculations and six big losses with a fishbone diagram analysis. The results showed the cause of the OEE value not yet achieved in the Toyota Bfree carline was the low Performance Efficiency results of 72.56% and the high Equipment Failure losses of 94.57%. In the Toyota Hiace carline is the low Performance Efficiency results of 69.25% and the high Equipment Failure losses of 88.70%. On the Toyota Vitz carline is the low availability of 76.81% and the high Equipment Failure losses of 87.01%. With suggestions for improvements given to increase the value of OEE companies based on factors Man, Machine, Method, Material, and Environment.

Keywords: Cutting Machines, Fishbone Diagrams, Overall Equipment Effectiveness, Six Big Losses.

INTRODUCTION

The industrial sector has always tried to minimize their operational cost and maximize their asset usage. The efficiency of production and industrial effectivity depends on the effectivity of tools that are being used. In short, Overall Equipment Effectiveness (OEE) is basically seen to calculate performance efficiency [1].

In order to determine what causes the result of the below standard OEE score, we will use the Six Big Losses calculation. Six Big Losses are six points that decrease the effectivity of a standard machine that must be avoided by a company [2].

XYZ manufacture company was established in 1989 at Indonesia. XYZ Manufacture Company occupied the automotive manufacture sector that produced vehicle components, especially wiring harness for cars. There are a few steps in every production, such as pre assy, final assy, inspection, and finish goods. Cutting machines holds an important part in the production process. Cutting machines must produce wire with cutting length and quality which suited the standard quality that the company prescribed. Below is the OEE data of cutting machines between the period of 2017 and January – June 2018:

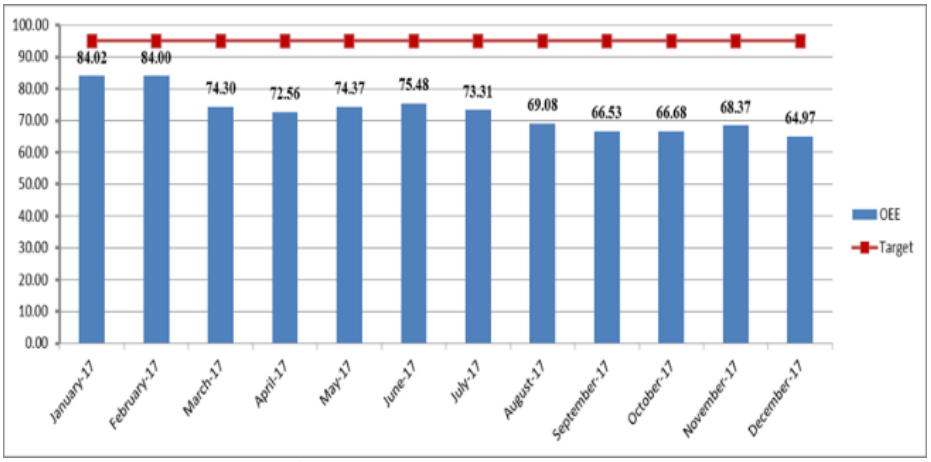

Fig-1: XYZ Manufacture Company's cutting machine OEE scores in 2017
Source: Maintenance Department (2017)

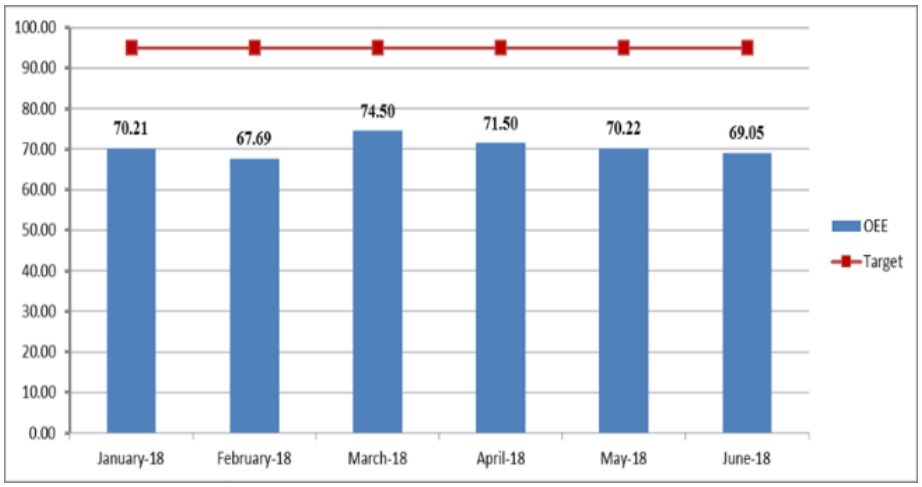

Fig-2: XYZ Manufacture Company's cutting machine OEE scores in January-June 2018
Source: Maintenance Department (2018)

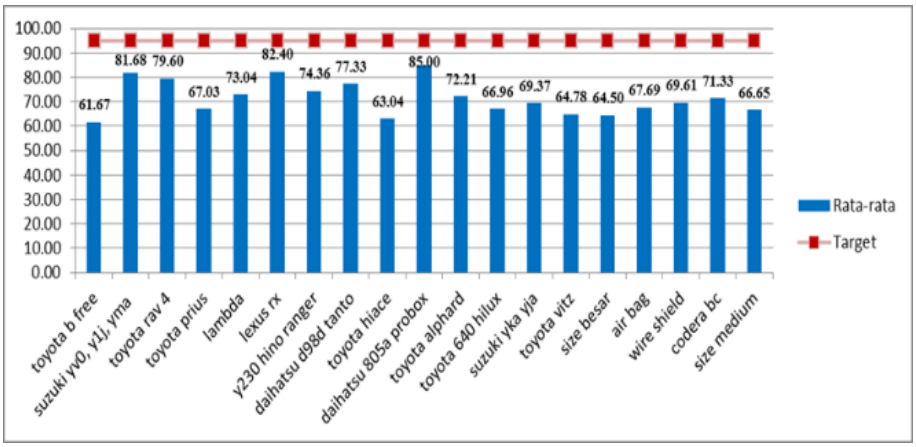

Fig-3: OEE score of each carline production in January 2017 – June 2018

OEE score achievement per carline in January 2017 – June 2018 shows the lowest 3 OEE score achievement on cutting machine are carline Toyota B Free with 61,67%, carline Toyota Hiace with 63,04%, and carline Toyota Vitz with 64,78%.

REVIEW OF LITERATURE

Total Productive Maintenance (TPM) is a management principle to increase the productivity and production efficiency of a company by effectively using machines [3]. The concept of Total Productive Maintenance is used to maintain the best equipment to avoid unexpected damage, speed loss, and quality defects [4].

Overall Equipment Effectiveness (OEE) is really valuable for accounting and identifying the sources of deficiency in a production. OEE is also very crucial for performance optimization of the current capacity, halt a big investment, decrease overtime expenses, variability reduction process, operator performance improvement, and reduce changeover time [5]. In Eng and Choi's research, [6] concluded that OEE is an important metric that provides information about the root causes of lost time and production. OEE is also a tool that can help a company to optimize performance without large investments.

According to Nakajima Vice Chairman of the Japan Institute of Plant Mintenance in the research Nurfaizah, *et al*. [7] The Six Big Losses are six major losses incurred, which are part of TPM's actions to eliminate these six losses. The six major losses can be calculated in OEE calculations. According to Nakajima in the study of Alvira *et al*. [2] activities and actions undertaken not only focus on preventing damage to the machine / equipment and minimizing machine / equipment downtime.

Fishbone Diagram (also known as Ishikawa Diagram or Cause-and-Effect Diagram) is a graphic technique to show the causes of some events or phenomena. Specifically, fish bone diagrams (shaped similar to fish skeletons) are a tool commonly used for cause and effect analysis to identify complex interactions from the cause of a particular problem or event [8].

RESEARCH METHODOLOGY

In this research, the writer uses a quantitative research method in a form of a case study where the research was done by using data and information from a problem to come up with thorough comprehension that will be used to solve the current problem. On the other hand, the descriptive model will be used as the research design. Descriptive design is used to describe the result of processing and analyzing each of the variables in the research.

Population and Sample

The population in this research is the whole cutting machine on every carline of PT. EDS Manufacturing Indonesia in a total of 18 carline areas which consist of 148 units of cutting machines. Samples in this research are the three lowest carlines area in the OEE score, which are: carline Toyota B Free, carline Toyota Hiace, and carline Toyota Vitz.

Collecting Data Method

Data collection methods used in this study are combining two methods, there are primary data collection methods and secondary data.

Primary data is data obtained from its main source by conducting field studies directly to companies or observatives. Data needed to help the analysis process using fishbone diagrams, interviewing operators who operate machines related to man factors and methods, as well as making observations to companies related to machine, materials, and environment factors.

Secondary data is data in the form of company documentation, which is related to maintenance report data, engineering reports related to cutting machines, as well as relevant studies in writing this thesis, as for the study sources such as journals, books, and others.

Data Analysis Method

OEE Score Achievement Analysis:

Calculation of the OEE score comes from 3 calculation indicators as shown below [9]

$$\text{Availability} = \frac{\text{Loading time} - \text{Downtime}}{\text{Loading time}} \times 100\% \quad (1)$$

$$\text{Performance Efficiency} = \frac{\text{Actual Production} \times \text{Ideal Cycle Time}}{\text{Operation Time}} \times 100\% \quad (2)$$

$$\text{Quality rate} = \frac{\text{Actual Production} - \text{Total Defect}}{\text{Actual Production}} \times 100\% \quad (3)$$

To acquire the OEE score we must apply the calculation below:

$$\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality} \quad (4)$$

Six Big Losses Score Achievement Analysis

The loss that can cause a decrease in the effectiveness value is known as the six big losses. The six big losses are as follows: [10]

Equipment failure (Losses because of inoperable tools)

$$= \frac{Total\ Breakdown\ Time}{Loading\ Time} \times 100\% \quad (5)$$

Set-up and adjustment (Losses because of installation and adjustment)

$$= \frac{Total\ Set\ Up\ and\ Adjustment\ Time}{Loading\ Time} \times 100\% \quad (6)$$

Idling and minor stoppages (Losses because of idling on production or minor stoppage)

$$= \frac{Non\ Productive\ Time\ at\ Set\ Up\ and\ Adjustment\ Time}{Loading\ Time} \times 100\% \quad (7)$$

Reduced speed (Losses because of the decreasing of speed)

$$= \frac{Operating\ Time - (Theoritical\ Cycle\ Time \times Processed\ Amount)}{Loading\ Time} \times 100\% \quad (8)$$

Process defect (Losses because of defect product and/or because reprocess work of the product)

$$= \frac{Theoritical\ Cycle\ Time \times Rework}{Loading\ Time} \times 100\% \quad (9)$$

Reduced yield losses (Losses because of early production process until achieving stable product)

$$= \frac{Theoritical\ Cycle\ Time \times Scrap}{Loading\ Time} \times 100\% \quad (10)$$

RESULTS AND DISCUSSION

To get the result from the research, calculation on the 3 carlines with the lowest OEE score, which are carline Toyota B Free, carline Toyota Hiace, and carline Toyota Vitz, must be done. Each of the carlines was calculated by looking at the OEE variables. Then, the factor with the lowest percentage is held as a focus to analyze the cause of the low score achievement of OEE on the cutting machine. Next, calculate the variables of the Six Big Losses. After that, the factor with the highest percentage becomes the focus to analyze the cause of the low score achievement of OEE on the cutting machine. Lastly, the result of the analysis of the OEE and Six Big Losses are calculated with the Fishbone diagram.

OEE Calculation Results

OEE calculation of the cutting machine was done on the period of January 2017 – June 2017. The calculation based on 3 OEE variables, which are Availability, Performance Efficiency, and Quality Rate, was dealt with the formula that has been mentioned in the data analysis method. Here are the calculation results of the OEE variable for carline Toyota B Free, Toyota Hiace, and Toyota Vitz on the period of January 2017 – June 2018:

Table-1: OEE Result Carline Toyota BFree

No	Month	Availability	Performance Efficiency	Quality Rate	OEE
1	Jan 17	91.20%	83.91%	100%	76.52%
2	Feb 17	88.48%	85.94%	100%	76.05%
3	Mar 17	94.68%	84.57%	100%	80.07%
4	Apr 17	92.73%	91.39%	100%	84.75%
5	May 17	87.18%	88.12%	100%	76.82%
6	Jun 17	90.14%	76.80%	100%	69.23%
7	Jul 17	83.87%	65.81%	100%	55.20%
8	Aug 17	86.20%	72.62%	100%	62.59%
9	Sep 17	78.45%	74.31%	100%	58.29%
10	Okt 17	76.69%	67.96%	100%	52.12%
11	Nov 17	74.31%	69.24%	100%	51.45%
12	Dec 17	81.21%	61.12%	100%	49.64%
13	Jan 18	76.64%	64.98%	100%	49.80%
14	Feb 18	81.11%	70.70%	100%	57.34%
15	Mar 18	88.46%	70.39%	100%	62.27%
16	Apr 18	86.36%	65.19%	100%	56.30%
17	May 18	81.04%	59.71%	100%	48.39%
18	Jun 18	81.01%	53.39%	100%	43.25%
Average		84.43%	72.56%	100%	61.67%

Source: Self elaborated

Table-2: OEE Result Carline Toyota Hiace

No	Month	Availability	Performance Efficiency	Quality Rate	OEE
1	Jan 17	89%	69.88%	100%	62.52%
2	Feb 17	92%	73.04%	100%	67.30%
3	Mar 17	92%	72.12%	100%	66.41%
4	Apr 17	94%	69.92%	100%	65.40%
5	May 17	92%	73.71%	100%	67.47%
6	Jun 17	92%	74.56%	100%	68.74%
7	Jul 17	89%	66.53%	100%	59.47%
8	Aug 17	75%	58.97%	100%	44.31%
9	Sep 17	87%	63.87%	100%	55.48%
10	Okt 17	87%	62.40%	100%	54.36%
11	Nov 17	88%	57.52%	100%	50.62%
12	Dec 17	89%	62.99%	100%	55.87%
13	Jan 18	87%	68.47%	100%	59.68%
14	Feb 18	83%	69.77%	100%	58.05%
15	Mar 18	93%	77.22%	100%	71.83%
16	Apr 18	92%	79.39%	100%	73.06%
17	May 18	86%	72.80%	100%	62.52%
18	Jun 18	89%	73.33%	100%	65.21%
Average		89%	69.25%	100%	61.57%

Source: Self elaborated

Table-3: OEE Result Carline Toyota Vitz

No	Month	Availability	Performance Efficiency	Quality Rate	OEE
1	Jan 17	82.72%	96.49%	100%	79.82%
2	Feb 17	78.81%	96.39%	100%	75.97%
3	Mar 17	78.72%	90.86%	100%	71.53%
4	Apr 17	92.29%	83.56%	100%	77.12%
5	May 17	71.04%	88.31%	100%	62.73%
6	Jun 17	70.03%	93.44%	100%	65.44%
7	Jul 17	81.00%	90.62%	100%	73.40%
8	Aug 17	87.83%	88.14%	100%	77.41%
9	Sep 17	68.59%	76.79%	100%	52.67%
10	Okt 17	76.47%	80.15%	100%	61.29%
11	Nov 17	75.44%	77.11%	100%	58.18%
12	Dec 17	78.75%	73.60%	100%	57.96%
13	Jan 18	75.46%	84.27%	100%	63.60%
14	Feb 18	71.09%	98.58%	100%	70.08%
15	Mar 18	76.85%	80.20%	100%	61.64%
16	Apr 18	66.71%	76.60%	100%	51.10%
17	May 18	80.29%	73.58%	100%	59.08%
18	Jun 18	70.48%	71.34%	100%	50.28%
Average		76.81%	84.45%	100%	64.96%

Source: Self elaborated

According to the results, the OEE score on the cutting machine of the three carlines has not met the standard of those that the company had set up, which is 95%. By looking at the result, a more thorough analysis should be done to find a solution to fix the OEE score achievement of the company. Based on the result of the OEE calculations above, in order to find the source of the problem for the low achievement on the OEE score on the three carlines, Pareto diagram was used such as below:

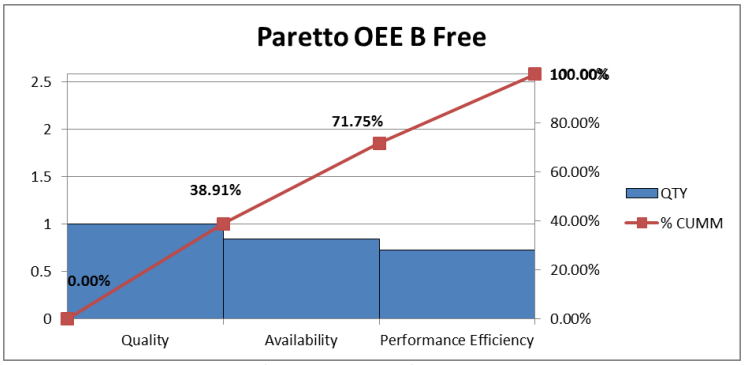

Fig-4: Diagram of OEE Toyota Bfree's Paretto Calculation

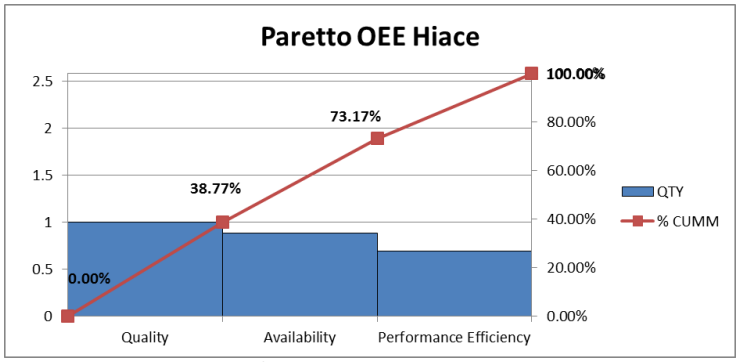

Fig-5: Diagram of OEE Toyota Hiace's Paretto Calculation

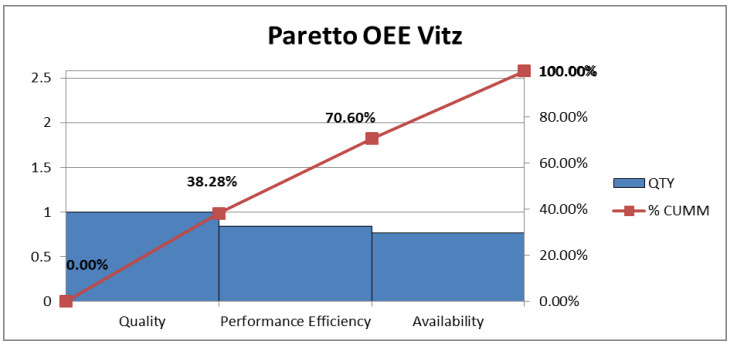

Fig-6: Diagram of OEE Toyota Vitz's Paretto Calculation

Through the Paretto diagram, we found that the lowest score from the OEE calculation on carline Toyota B Free and Toyota Hiace are the scores from Performance Efficiency. On the other hand, the carline Toyota Vitz score is from the Availability. Next, the lowest achievement is set as a focus to fix the OEE score achievement on the three carlines through analyzing the scores with the Fishbone diagram and give the solution to fix the OEE score achievement on carline B Free that is applicable for the company.

Six Big Losses Calculation Results

The Six Big Losses calculation on the cutting machine was done on the period of January 2017 – June 2017. The calculation was based on six variables of Six Big Losses, which are Equipment Failure, Reduced Speed, Set Up & Adjustment, Idling Minor & Stoppage, Process Defect, Reduced Yield Losses, by using the formula mentioned on analysis data method. Below are the calculation results on Six Big Losses variables on carline Toyota B Free, Toyota Hiace, and Toyota Vitz on the period of January 2017 – June 2018:

Table-4: Six Big Losses Result Carline Toyota Bfree

No	Six Big Losess	Percentage (%)	Cummulative Percentage (%)
1	Equipment Failure	70.70%	70.70%
2	Set Up & Adjustment	17.04%	87.74%
3	Idling Minor & Stoppages	10.39%	98.13%
4	Reduced Speed	1.87%	100.00%
5	Process Defect	0.00%	100.00%
6	Reduced Yield Losess	0.00%	100.00%

Source: Self elaborated

Table-5: Six Big Losses Result Carline Toyota Hiace

No	Six Big Losess	Percentage (%)	Cummulative Percentage (%)
1	Equipment Failure	63.18%	63.18%
2	Set Up & Adjustment	19.30%	82.48%
3	Idling Minor & Stoppages	13.60%	96.08%
4	Reduced Speed	3.92%	100.00%
5	Process Defect	0.00%	100.00%
6	Reduced Yield Losess	0.00%	100.00%

Source: Self elaborated

Table-6: Six Big Losses Result Carline Toyota Vitz

No	Six Big Losess	Percentage (%)	Cummulative Percentage (%)
1	Equipment Failure	80.86%	80.86%
2	Set Up & Adjustment	10.97%	91.82%
3	Idling Minor & Stoppages	7.53%	99.35%
4	Reduced Speed	0.65%	100.00%
5	Process Defect	0.00%	100.00%
6	Reduced Yield Losess	0.00%	100.00%

Source: Self elaborated

From the Six Big Losses calculation above, the losses that were found on the three carlines can be analyzed to fix the main problem to minimize the losses that happened. As to how to find the main problem on the low achievement on the OEE score on the three carlines, Paretto Diagram was used such as below:

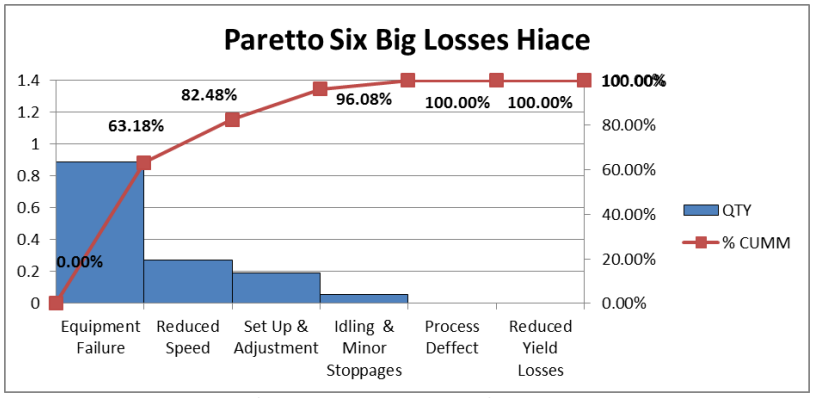

Fig-7: Diagram of Six Big Losses Toyota Bfree's Paretto Calculation

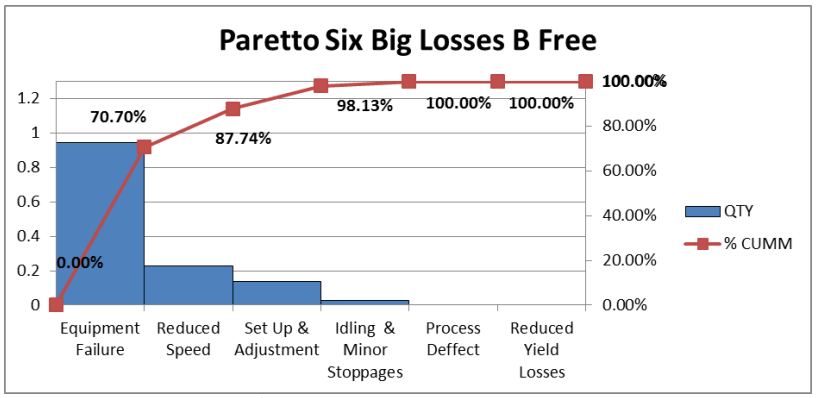

Fig-8: Diagram of Six Big Losses Toyota Hiace's Paretto Calculation

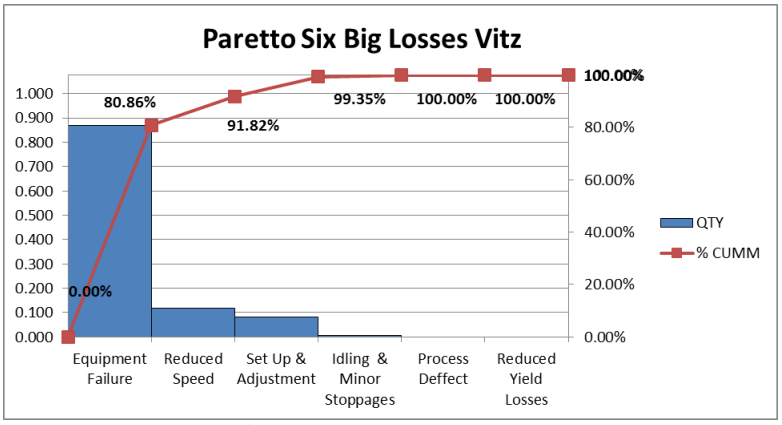

Fig-9: Diagram of Six Big Losses Toyota Vitz's Paretto Calculation

Through the *Paretto* Diagram, we found that the lowest score on the Six Big Losses calculation on the three *carlines* is the score of Equipment Failure. Next, those scores are held as a focus to fix the OEE score achievement on the three carlines by analyze it using the *Fishbone* Diagram and then finding the solution to fix the OEE score achievement of *carline* Toyota B Free which is applicable for the company.

Cause – Effect Diagram (Fishbone Diagram) OEE calculation result

According to Paretto Diagram, the result of the Overall Equipment Effectiveness calculation can figure out the main problem from the three carline. The lowest result from the OEE calculations becomes the main focus on the problem and analysed further with Fishbone Diagram method such as below:

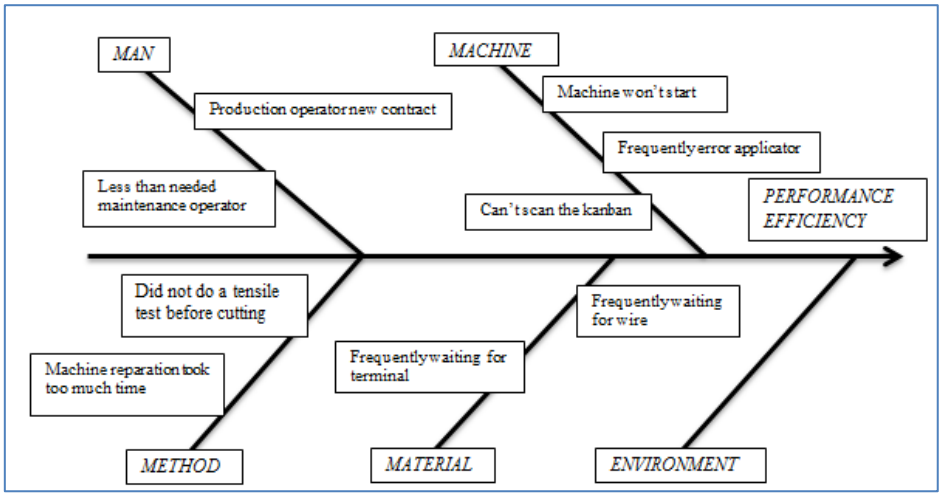

Fig-10: Fishbone Diagram Performance Efficiency Carline Toyota Bfree

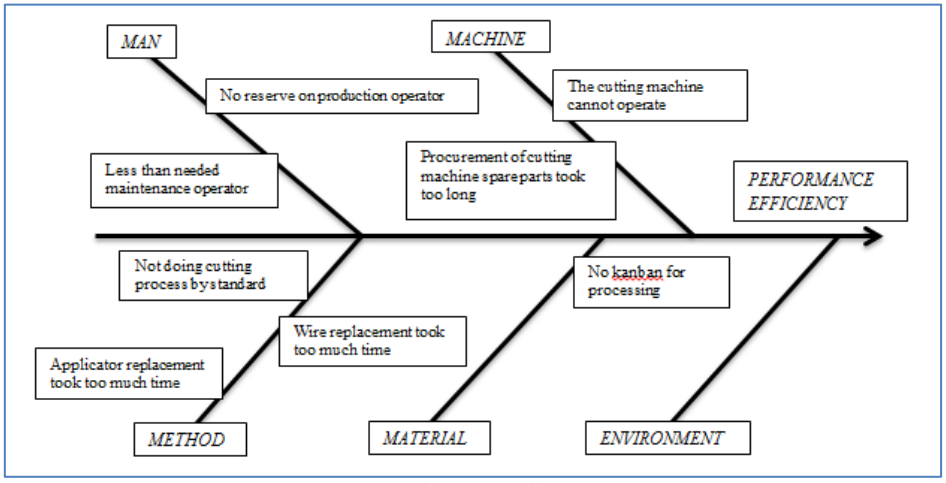

Fig-11: Fishbone Diagram Performance Efficiency Carline Toyota Hiace

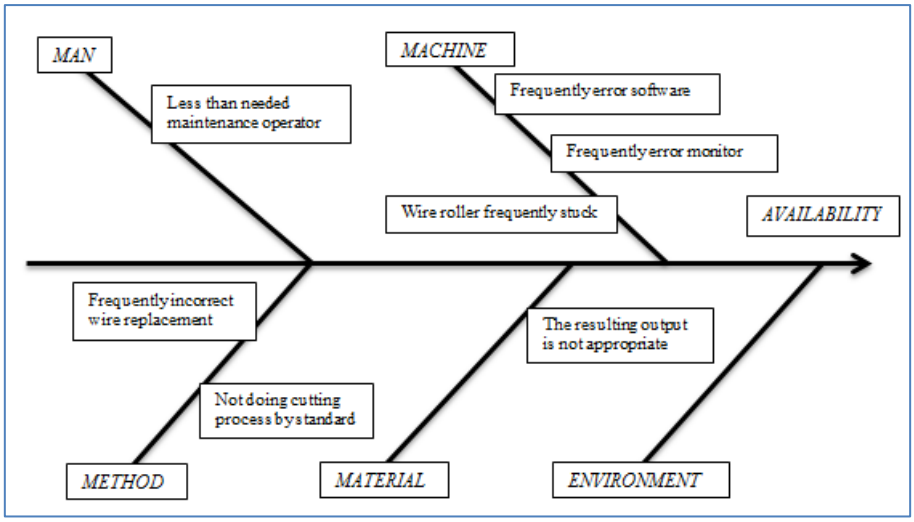

Fig-12: Fishbone Diagram Performance Efficiency Carline Toyota Vitz

Cause – Effect Diagram (Fishbone Diagram) calculation result of Six Big Losses

According to Paretto Diagram, the result of the Six Big Losses calculation can figure out the main problem from the three carlines. The lowest result from the Six Big Losses calculations becomes the main focus on the problem and analysed further with Fishbone Diagram method such as below:

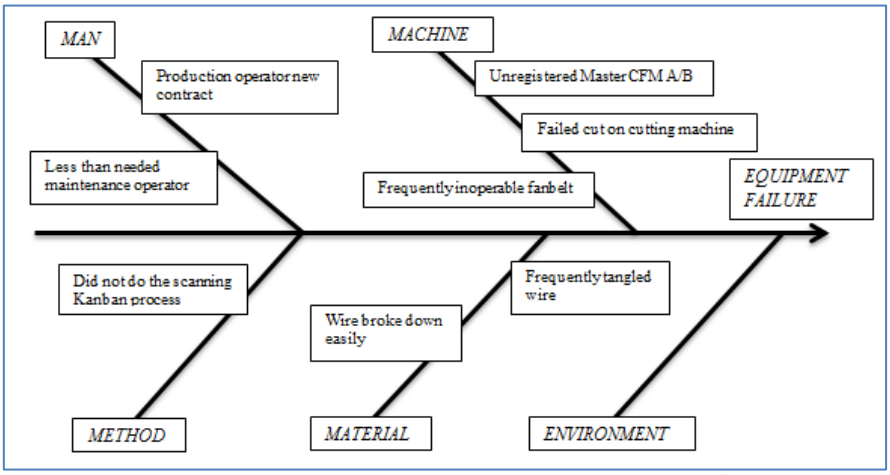

Fig-13: Fishbone Diagram Equipment Failure Carline Toyota Bfree

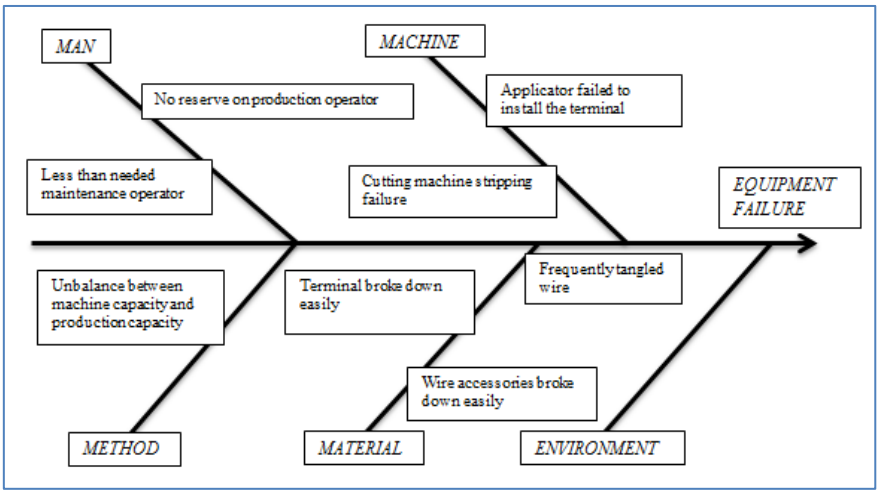

Fig-14: Fishbone Diagram Equipment Failure Carline Toyota Hiace

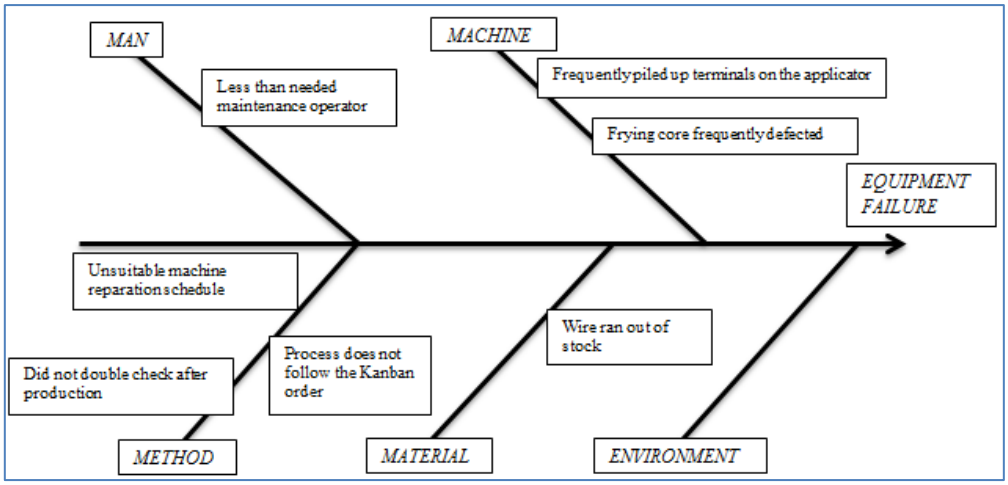

Fig-15: Fishbone Diagram Equipment Failure Carline Toyota Vitz

Problem Solving

The solution for this problem can be found by doing an extensive analysis on the main problem using the Fishbone Diagram with why – why analysis method until we found the suitable solution to do an accurate restoration such as the table below:

Table-7: Solution of Oee and Six Big Losses Problems Carline Toyota BFree

Overall Equipment Effectiveness				
Man	**Why 1**	**Why 2**	**Why 3**	**Corrective Solution**
Production operator new contract	Previous operator's contract expired at the same time	The company did not being cautious about the operator's contract term		The company must cautiously register the operator's contract term so that it will not clash against the new contact
Less than needed maintenance operator	1 maintenance operator per 3 carlines	The company's efficiency policy		Maintenance operator procurement must be suited for the chances of machine breaking down
Machine	Why 1	Why 2	Why 3	Corrective Solution
The machine will not start	Machine operation failure	Lack of annual machine checking	Annual machine checking not operating optimally	Create a schedule on annual machine checking on the cutting machine
Frequently error applicator	Terminal not connected to the circuit	Damage on dice applicator		Register the maximum use of the dice so that it will not break down before it is replaced
Cannot scan the kanban	New Kanban is not recorded yet	Kanban is outdated	PPIC Department has not informed the Production Department about the new kanban	Teamwork and communication must be increased to avoid outdated kanban
	Barcode scanner cannot scan the kanban	Barcode scanner breaks		Replacement for the broken barcode scanner
Method	Why 1	Why 2	Why 3	Corrective Solution
Did not do a tensile test before cutting process	Operator lack the knowledge about tensile test	Lack of information about the importance of tensile test		Socialization about the importance of tensile test to the operator in training
Machine reparation took too long	Lack of maintenance operator			Adjusting the amount of maintenance operator to the *carlines*
	Lack of understanding of machine damages	Insufficiency training/retraining time for the operator		Training/retraining the maintenance operator on the cutting machine intensively

Material	Why 1	Why 2	Why 3	Corrective Solution
Frequently waiting for the wire	Did not update the wire stock	Did not monitor the wire stock periodically		The company must monitor and register the stock of wire to ask for new stock before the wire runs out
Frequently waiting for the terminal	Deliver the wrong type of terminal	Did not see the terminal code before delivery		The company must be thorough before delivering the terminal
Environment	Why 1	Why 2	Why 3	Corrective Solution
No need for improvement because there is not a factor that affects the OEE score.				
Six Big Losses				
Man	Why 1	Why 2	Why 3	Corrective Solution
Production Operator new contract	Previous operator's contract expired at the same time	The company did not being cautious about operator's contract term		The company must cautiously register the operator's contract term so that it will not clash against the new contact
Less than needed maintenance operator	1 maintenance operator per 3 carlines	Company's efficiency policy		Maintenance operator procurement must be suited for the chances of machine breaking down
Machine	Why 1	Why 2	Why 3	Corrective Solution
Unregistered Master CFM A/B	Outdated on the new type of defect	Unregistered Master CFM A/B program by the maintenance operator		The company must update on the new type of defect on the Master CFM A/B
Failed cut on the cutting machine	Inoperable blade on the cutting machine	Blade is already on the maximum usage capacity	Unregistered maximum usage of the blade on cutting machine	The company must register the maximum usage of the blade to find a replacement before the blade reaches the maximum usage capacity
Frequently inoperable fanbelt	Fanbelt stuck	Lack of lubrication		The company must regularly check the fanbelt physically
Method	Why 1	Why 2	Why 3	Corrective Solution
The cutting process did not scan the kanban	Did not do the cutting process by the standard	The operator wants to do the cutting process quicker		Supervising by the line leader and retraining of the importance on the scanning Kanban before the cutting process
Material	Why 1	Why 2	Why 3	Corrective Solution
Frequently tangled wire	A lot of small and long wire dimension	Consumer specification		Specific handling on the long and small wire, starts with the rolling the wire to the distribution
	The rolling process from the big roll to the bobbin is not well-kept	The rolling process was rash		The rolling process to the bobbin wire must be done carefully and precisely
Wire broke down easily	Thin protective skin on the wire	Consumer specification and the distributor's quality		The company must ask the consumer does changing the wire is necessary or not, if not, specific handling is required on the easily broke down wire
Environment	Why 1	Why 2	Why 3	Corrective Solution
No need for improvement because there is not a factor that affects the OEE score.				

Source: Self elaborated

Table-8: Solution of Oee and Six Big Losses Problems Carline Toyota Hiace

Overall Equipment Effectiveness				
Man	**Why 1**	**Why 2**	**Why 3**	**Corrective Solution**
No reserve on the production operator	A lot of operator does not come up at the same time	The company's policy on leave permission and furlough		The company must regulate on the policy of leave permission and furlough
Less than needed maintenance operator	1 maintenance operator per 3 carlines	Company's efficiency policy		Maintenance operator procurement must be suited for the chances of machine breaking down
Machine	Why 1	Why 2	Why 3	Corrective Solution
The cutting machine cannot operate	Frequent error on machine operation	Lack of annual machine checking	Production operator and maintenance operator are careless about cutting machines condition	Socialization to production operator and maintenance operator to start paying attention to the cutting machine condition and regularly check on the cutting machine
Spare part replacement took too much time	Spare part ran out of stock	Machine spare parts were not registered		The company must register all the spare parts needed by the cutting machine
	Spare part delivery took too long	Spare parts were imported from Japan		The company must order the spare part according to the necessity and must be done before replacement
Method	Why 1	Why 2	Why 3	Corrective Solution
Cutting process does not follow the standard procedure	Work was done by a recitation	The operator wants to do the cutting process quicker	Meeting the target of cutting output	In the training process, there must be socialization about the importance of procedure and fit quality and quantity
Wire replacement took too much time	Wires were not placed on the corresponding storage	MPC Operator did not do a thorough job on storing the wire		Line Leader must supervise and guide the storing process to ensure wires were stored appropriately
Applicator replacement took too much time	Applicators were not placed on the corresponding storage	Production Operator did not do a thorough job on storing the applicators after use		Line Leader must supervise and guide the storing process to ensure applicators were stored appropriately after use
Material	Why 1	Why 2	Why 3	Corrective Solution
No kanban to process	A lot of kanbans are missing	Slip inside the circuit store or stolen	Lack of supervising and registering the actual quantity of kanban	The company must supervise and register the actual quantity of kanban
	New type of process kanban	PPIC lateness on delivering kanban	PPIC did not communicate with Production about the kanban change	PPIC must communicate if there is a change in process kanban
Environtment	Why 1	Why 2	Why 3	Corrective Solution
No need for improvement because there is not a factor that affects the OEE score.				
Six Big Losses				
Man	Why 1	Why 2	Why 3	Corrective Solution
No reserve on the production operator	A lot of operator does not come up at the same time	The company's policy on leave permission and furlough		The company must regulate on the policy of leave permission and furlough
Less than needed maintenance operator	1 maintenance operator per 3 carlines	Company's efficiency policy		Maintenance operator procurement must be suited for the chances of machine breaking down
Machine	Why 1	Why 2	Why 3	Corrective Solution
Applicator failed to install the terminal	Dice on the applicator not working properly	Dice has reached maximum usage	Not communicating about dice applicator replacement before the dice reached maximum usage capacity	The company should replace the dice applicator before it reached the maximum usage capacity
	Damage on the applicator	Applicator usage capacity		The company should apply specific handling to prolong the usage of the applicator. If it already reached its' maximum usage capacity, the company should buy the replacement immediately

Cutting machine stripping failure	Cutting machine stripping blade now working properly	Stripping blade already reached its' maximum usage capacity	Registering censor on cutting machine stripping blade not functioning	The company should replace the registering censor in cutting machine stripping blade so replacement would happen before it reached maximum usage capacity
Method	Why 1	Why 2	Why 3	Corrective Solution
Unbalance between machine capacity and production capacity	Increasing cutting output target on the machine	Increased kanban quantity	Consumer order increased	Changing the method on the kanban quantity with increasing the amount of kanbans that are circulating
Material	Why 1	Why 2	Why 3	Corrective Solution
Frequently tangled wire	A lot of small and long wire dimension	Consumer specification		Specific handling on the long and small wire, starts with the rolling the wire to the distribution
	Rolling process from the big roll to the bobbin is not well-kept	The rolling process was rash		The rolling process to the bobbin wire must be done carefully and precisely
Terminal broke down easily	Frequently banned up/down on the circuit terminal	Circuit leveling process after cutting process was not done on the provided space		On training, the company should socialize about doing the circuit leveling process on the provided space
Wire accessories broke down easily	Circuit rubber seal is thin and easily tear off	Consumer specification		Circuit rubber seal installation process should be done separately from the cutting machine for the easily broke down rubber seal
Environment	Why 1	Why 2	Why 3	Corrective Solution
No need for improvement because there is not a factor that affects the OEE score.				

Source: Self elaborated

Table-9: Solution of Oee and Six Big Losses Problems Carline Toyota Vitz

Overall Equipment Effectiveness				
Man	**Why 1**	**Why 2**	**Why 3**	**Corrective Solution**
Less than needed maintenance operator	1 maintenance operator per 3 carlines	Company's efficiency policy		Maintenance operator procurement must be suited for the chances of machine breaking down
Machine	Why 1	Why 2	Why 3	Corrective Solution
Frequently error software	Cutting machine software is unrecognized when operated	Software got virus		Prevention should be done by doing a check-up regularly and installing antivirus on the software
Frequently error monitor	Monitor turns off by itself frequently when operating the cutting machine	Monitor is worn out		Replacing monitor that has been worn out
Wire roller frequently stuck	Wire not working properly when processing	Roller insert surface is sluggish	Lack of lubrication on roller insert wire	Cutting operator must lubricate the roller insert wire periodically
Method	Why 1	Why 2	Why 3	Corrective Solution
Frequently incorrect wire replacement	Cutting operator use the wrong wire type	Wires were not stored in the corresponding wire storage	Wires were wrongly stored in the distribution process	Wire storing process must follow the corresponding storage instead of placing it with the same color
Not doing cutting process by standard	Work was done by a recitation	The operator wants to do the cutting process quicker	Meeting the target of cutting output	In the training process, there must be socialization about the importance of procedure and a fit quality and quantity

Material	Why 1	Why 2	Why 3	Corrective Solution
The resulting output is not appropriate	Kanbans were uneven with the expected output	Lack of kanban to process	Kanban updates were late	The company must adjust the amount of Kanbans in production with the expected output
Environtment	Why 1	Why 2	Why 3	Corrective Solution
No need for improvement because there is not a factor that affects the OEE score.				
Six Big Losses				
Man	Why 1	Why 2	Why 3	Corrective Solution
Less than needed maintenance operator	1 maintenance operator per 3 carlines	Company's efficiency policy		Maintenance operator procurement must be suited for the chances of machine breaking down
Machine	Why 1	Why 2	Why 3	Corrective Solution
Frequently piled up terminals on the applicator	There was a mistake when setting the terminal in the applicator	Use the wrong type of terminal	Did not pay attention to the terminal's code in use	Operator must pay attention to the terminal's code when picking up the terminal to use with suitable applicator
		Terminals were not set correctly	The setting was done in a rash	The operator must set the terminal thoroughly and as the procedure
	Broken applicator	Applicators were not checked regularly and were not taken care of		The company must prevent it by taking care of the applicator regularly and make a replacement when it breaks
Frying core frequently defected	Defect passed through after the cutting process	Defect was not seen by Master CFM A/B	Master CFM A/B error or broken	Prevention by checking the Master CFM A/B regularly and make reparation if it breaks
Method	Why 1	Why 2	Why 3	Corrective Solution
Machine reparation scheduling does not suit the schedule	Maintenance operator did not repair the machine on schedule	Reparation schedule clash with other carlines	Maintenance operator are limited	Machine reparation schedule should not clash with other carlines and adjustment should be made with the maintenance operator available
Process did not follow the kanban	Process was done manually and did not follow the program	Operator accessing the cutting program without permission	Cutting process with the same type of wire was done simultaneously	Maintenance operator should lock the cutting program so the work order will not be altered by the cutting operator and supervised by the line leader
Did not double-check after production	Consider the cutting output was already as standard	Rushing to the next process		Supervising by line leader so ensure operator double-check after every cutting process
Material	Why 1	Why 2	Why 3	Corrective Solution
Wire ran out of stock	Wires delivery to the production was late	Wire is not available on the wire store	The required wire was used on another carline	Wire resupply must be suited for each carline
			Wire supply delivery was late to restock	The company must register the wire stock thoroughly and reorder before it ran out of stock
Environment	Why 1	Why 2	Why 3	Corrective Solution
No need for improvement because there is not a factor that affects the OEE score.				

Source: Self elaborated

CONCLUSSIONS

The conclusions that can be drawn from this study are:

1. The dominant factor for the low achievement of the OEE score on carline Toyoto Bfree is the Performance Efficiency of 72.56%. The dominant factor for the low achievement of the OEE score on carline Toyota Hiace is the Performance Efficiency of 69.25. The dominant factor for the low achievement of the OEE score on carline Toyota Vitz is the Availability of 84.45%.

2. Based on the calculation of Six Big Losses on carline Toyota Bfree, carline Toyota Hiace, and carline Toyota Vitz the losses factor that frequently happened is the Equipment Failure.

Advice

1. The company need to consider about the worker recruitment system with a contract system, prepare the reserve operator for each carline to anticipate the absent of operator, also adjusting the amount of maintenance operator for carline production needs.
2. Do prevention on damaging the cutting machine by a precise scheduled machine handling and also take care of the machine accordingly with the schedule, do a repair on the machine accurately supported by maintenance operator's ability with spare part procurement so that spare part substitution will not slow down and damaging the cutting process.
3. Training and retraining system for the operators to understand and operate the job according to the procedure and company standard, better oversight by the line leader and supervisor, also make improvement to ease the operator's work process.
4. A ripe production preparation, material distribution process according to the cutting needs, and good communication between department and consumer about the choice of material being used.

REFERENCES

1. Nallusamy, S., & Majumdar, G. (2017). Improvement of Overall Effectiveness Equipment using Total Productive Maintenance in the Manufacturing Industry. *International Journal of Performability Teknik*, *13*(2), 173–188.
2. Alvira, D. (2015). Proposed Improvement of Overall Equipment Effectiveness (OEE) on Manual Tapping Machines by Minimizing Six Big Losses. *Jurnal Online Institut Teknologi Nasional*, *03*(03), 240–251.
3. Subiyanto. (2014). Analysis of the Effectiveness of Sugar Machine Machinery/ Tools Using the Overall Equipments Effectiveness Method. *Jurnal Teknik Industri*, *16*(1), 41–50. https://doi.org/10.9744/jti.16.1.41-50.
4. Kumar, T. V., Parthasarathi, M., Manojkumar, S., & Selvaprakash, S. (2016). Lean Six Sigma Approach to Improve Overall Equipment Effectiveness Performance: A Case Study in the Indian Small Manufacturing Firm. International Journal for Innovative Research in Multidisciplinary Field, *2*(12), 122–129.
5. Esmaeel. (2018). Understanding of Business Performance from the Perspective of Manufacturing Strategies: Fit Manufacturing and Overall Equipment Effectiveness. Procedia Manufacturing, 22, 998–1006. https://doi.org/10.1016/j.promfg.2018.03.142.
6. Eng, C. K., & Choi, N. K. (2016). Relationship between Overall Equipment Effectiveness, Throughput and Production Part Cost in Semiconductor Manufacturing Industry. *IEEE IEEM*, 75–79.
7. Nurfaizah, U., Adianto, R. H., & Prassetiyo, H. (2014). Design of Implementation of Total Productive Maintenance (TPM) in the Press Part II of PT. XYZ. *Jurnal Online Institut Teknologi Nasional*, *01*(01), 340–353.
8. Coccia, M. (2017). The Fishbone Diagram to Identify, Systematize and Analyze The Sources of General Purpose Technologies. *Journal of Social and Administrative Sciences*, *4*(4), 291–303. https://doi.org/10.1453/jsas.v4i4.1518.
9. Sagita, I. (2017). Performance Improvement of E5 Punching Machine and E150 Bending Production of Pix Panel Products with Overall Equipment Effectiveness (OEE) Method (Case Study of PT Schneider Indonesia-Pulogadung Plant).
10. Siddiq, M., Atmaji, F. T. D., & Alhilman, J. (2018). Proposed Implementation of Total Productive Maintenance (TPM) to Increase Machine Effectiveness by Using the Overall Equipment Effectiveness (OEE) method at PT Sanbe Farma Cimareme Unit III Large Volume Parenteral Plant. *E-Proceeding of Engineering*, *5*(2), 2982–2990.