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Effectivity analysis of raw mill 4R1 and 4R2 using Overall Equipment Effectivity (OEE) Method and Six Big Losses in Indarung IV Plant of PT Semen Padang

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Effectivity analysis of raw mill 4R1 and 4R2 using Overall Equipment Effectivity (OEE) Method and Six Big Losses in Indarung IV Plant of PT Semen Padang

Abstract. Machine is one of the important things in industry today. For a company that produces products in a great value, it is impossible for company to employ a human for the production process. Similar to humans, machines also have limitations in their use. PT Semen Padang is the first cement producer in Indonesia which currently has 5 factories. Indarung IV Plant has a production capacity of 1,620,000 tons per year. During operation to produce raw mix, Raw Mill also suffers from interference that hinders operation of Raw Mill itself. Based on that condition, the problems that will identified in this research are measuring effectiveness of Raw Mill 4R1 and 4R2 using Overall Equipment Effectiveness (OEE) method and determine factors that affect the effectiveness of Raw Mill 4R1 and 4R2 using Six Big Losses method. The result of this research is the effectivity of the Raw Mill 4R1 and 4R2 that is equal to 60% and 72%. The value of OEE is still below the International Company standard of 85% or more. Based on the six losses that occur on the machine, the most losses cause the Raw Mill 4R1 and 4R2 engine to lose its effectiveness is Breakdown Losses.

1. Introduction

Machine is one of the important things in the industry today [1]. For a company that produces products in a big number, it is impossible for the company to employ a human for the production process. Especially for products that require a complicated process, it would be difficult to be done by humans and takes a long time. Therefore, the machine is used as a tool to facilitate the production process for the company. Similar to humans, machines also have limitations in their use [2]–[5]. If the machine is constantly being used in without good maintenance, the machine will quickly break down and can't be used. This conditions will certainly affect productivity of company [6], safety performance of company [7], and the results of products produced by the company. If one of the machines is damaged or not operating, then this may interfere the operation of other machines. Consequently, the production process will be disrupted.

PT Semen Padang is the first cement producer in Indonesia which currently has 5 factories that are still actively operating. PT Semen Padang has a production capacity of 10,400,000 tons per year. It is impossible for PT Semen Padang to make a production with such huge value without the help of a production machine. Therefore, each factory from PT Semen Padang is equipped with production machinery such as Raw Mill, Kiln, and Cement Mill. One of the factories in PT Semen Padang is Indarung IV Factory. Indarung IV has a production capacity of 1,620,000 tons per year. Like other factories, Indarung IV is also equipped with production machine, one of them is Raw Mill. Raw mill is a machine that serves to grind raw materials into raw mix. There are two Raw Mill machines in Indarung IV. Raw Mill is the first machine to use in the cement production process. During operation to produce raw mix, Raw Mills also suffer from interference that hinders operation of Raw Mill itself. Based on existing data, there are many disruptions that occur that cause Raw Mill to stop operating.

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Details of disruptions happen in Raw Mill 4R1 in 2015 can be seen on **Table 1** and Raw Mill 4R2 can be seen on **Table 2.**

Table 1. Disruptions in Raw Mill 4R1

Disruptions	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kiln stop	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Clogged Material	✓					✓	✓	✓	✓		✓	
Disruption of Power Distribution					✓		✓	✓	✓		✓	✓
PMC		✓		✓	✓	✓		✓	✓		✓	✓
Electric Equipment Checking	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓
Mechanic Equipment Repair				✓	✓	✓	✓	✓	✓	✓	✓	
Blocking in Inlet Mill ✓												
Mechanics Equipment Changing			✓	✓	✓	✓		✓	✓		✓	
Mill Vibration is Maximum	✓	✓		✓	✓	✓		✓	✓	✓	✓	
Avoiding WBP										✓		
Fan Repairing								✓				
Critical Raw Material								✓				✓
Electric Equipment Repairing					✓	✓						
Mechanic Equipment Checking			✓	✓	✓	✓	✓	✓		✓		
Mill Checking							✓					
Transportation Equipment Repairing	✓				✓		✓	✓	✓	✓		
Raw Mix Silo is Full								✓				
PLN off			✓		✓	✓		✓				
Instrument Equipment Checking	✓	✓	✓	✓	✓		✓	✓		✓		
Blocked on Transportation Equipment			✓	✓	✓		✓		✓			
Electric Equipment Checking												✓
TOTAL TIME (hr)	98:39	175:30	92:12	94:50	144:30	158:23	352:29	114:02	95:09	102:34	128:48	116:24

Table 2. Disruptions in Raw Mill 4R2

Disruptions	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kiln stop	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PMC	✓	✓		✓				✓			✓	✓
Disruption of Power Distribution		✓		✓	✓		✓	✓	✓		✓	✓
Electric Equipment Checking	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓
Clogged Material	✓			✓	✓	✓	✓		✓		✓	✓
Limited Power									✓	✓	✓	
Mechanic Equipment Repair	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mechanic Equipment Checking	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mill Checking											✓	✓
Blocked on Transportation Equipment			✓	✓	✓	✓		✓	✓	✓	✓	
Laboratory Requested											✓	
Critical Raw Material			✓					✓				✓
Blocking in Inlet Mill		✓										
Transportation Equipment Changing									✓			
PLN off			✓	✓		✓						
Raw Mix Silo is Full								✓	✓			✓
Electric Equipment Repairing								✓				
Transportation Equipment Repairing	✓		✓	✓		✓			✓			
Mechanics Equipment Changing	✓				✓	✓	✓		✓	✓		
Mill Repairing	✓		✓									
Avoiding WBP										✓		
Electric Equipment Changing						✓						✓
Mill Vibration is Maximum						✓				✓		
Instrument Equipment Checking		✓	✓	✓	✓	✓		✓	✓	✓		✓
Decreasing Kiln Speed												✓
TOTAL TIME (hr)	191:42	257:49	103:41	131:31	117:25	155:33	372:33	209:12	224:01	231:43	117:05	228:50

Based on the disruptions above, we can see the disruptions cause the machine didn't working as long as the available time. There is difference between the planned operating time with the actual operating time. This difference will affect the effectiveness of the Raw Mills and after that we need to know what if the effectiveness affects the cement production in PT Semen Padang. After that, from those disruptions we need to know which one of that disruptions that make the machine stop working.

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Therefore, it's needed to calculated the effectiveness of the Raw Mills using Overall Equipment Effectivity (OEE) method. Most researchers used OEE method to identify critical indicator in maintenance area, performance management, and productivity improvement [8]–[14]. OEE offers a means of controlling the whole production process by analyzing results from the totality of events. More often than not, production inefficiencies and stoppages are blamed on equipment failure. However, this is not always the case. The production cycle involves a multiplicity of influences and a combination of any of these can trigger a production stop. OEE will provide information on the root cause of production inefficiency and thus lead to a targeted resolution, concentrating effort where it has the greatest impact.

To analyze the factors that caused the Raw Mills loss the effectiveness using Six Big Losses method [15]–[17]. Six Big Losses is useful for determining effective value. Six Big Losses provides more details about the loss of engine effectiveness. In addition to getting more information, Six Big Losses can also provide a foundation for more effective action. The benefits gained from implementing Six Big Losses is to provide additional information that aligns with and extends OEE and facilitates the identification of effective preventive measures for equipment-based losses.

2. Methods

The research methodology is the stages of research that must be determined first that serve as a direction in the analysis and problem solving. Literature study is first stages that used to help understanding the theory related to the research so that it will support the researcher in solving the problem. The literature study needed is about Overall Equipment Effectiveness (OEE) method and Six Big Losses Method.

Next stage is preliminary stage. This stage is the preliminary stage in the research is to observe directly the production process at the factory. This is done to see the real condition of the factory that is guided by the field supervisor, Mr. Achiarman. Interview has also been done with the employee in Production Planning and Control Bureau. Interview was used to know about cement production process with Mr. Fauzan and Mrs. Isil. Based on the preliminary survey, it is determined that the problems will be studied. In this study the problem is focused on the Raw Mill 4R1 and 4R2 in Indarung IV factory. The problems that exist on this machine are the number of disturbances that cause engine operation is disrupted.

Primary data is data got from interview. The primary data that used in this report is cement production process and how the production machine works. The secondary data that used in this report is daily report of Raw Mill 4R1 and 4R2 in 2015, production planning of Indarung IV Plant, and actual production of Indarung IV Plant of PT Semen Padang. After the required data is collected then the next step is to perform data processing Overall Equipment Effectiveness (OEE). To find OEE, calculate the availability, performance efficiency, and quality rate of the Raw Mill 4R1 and 4R2. After that, find the cause of the decreasing of the effectivity of the machine using Six Big Losses Method. Calculating the 6 losses may cause the decreasing of the effectiveness.

3. Result and Discussion

The process used to calculate effectivity of Raw Mill is Overall Equipment Effectivity (OEE). The following is an example of the availability of January 2015 availability for Raw Mill 4R1 :

$$\text{Availability} = \frac{\text{Operation Time}}{\text{Loading Time}} \times 100\%$$

$$= \frac{\text{Loading Time - Downtime}}{\text{Loading Time}} \times 100\%$$

$$= \frac{505.7 - 145.07}{505.7} \times 100\%$$
$$= 71\%$$

The following is an example of the Performance Rate of January 2015 availability for Raw Mill 4R1 :

$$\text{Performance Rate} = \frac{\text{Operating Speed Rate}}{\text{Net Operating Rate}} \times 100\%$$
$$= \frac{\text{4R1 Production} \times \text{Idle Cycle Time}}{\text{Operation Time}} \times 100\%$$
$$= \frac{74730 \times 0.0044}{360.60} \times 100\%$$
$$= 92\%$$

The following is an example of the Quality Rate of January 2015 availability for Raw Mill 4R1 :

$$\text{Quality Rate} = \frac{\text{Processed Amount-Defect Amount}}{\text{Processed Amount}} \times 100\%$$
$$= \frac{74370 - 0}{74370} \times 100\%$$
$$= 100\%$$

The following is an example of the OEE of January 2015 availability for Raw Mill 4R1 :

$$\text{OEE} = \text{Availability x PR x QR}$$
$$= 71\% \text{ x } 92\% \text{ x } 100\%$$
$$= 65\%$$

The results of OEE calculation of Raw Mill 4R1 and 4R2 in 2015 can be seen on **Table 3.**

Table 3. OEE of Raw Mill 4R1 (a) and 4R2 (b) in 2015

(a)

Month	Availability	Performance Efficiency	Quality Rate	OEE
January	71%	92%	100%	65%
February	40%	95%	100%	38%
March	84%	100%	100%	84%
April	76%	98%	100%	75%
May	79%	100%	100%	79%
June	71%	100%	100%	71%
July	3%	100%	100%	3%
August	52%	93%	100%	48%
September	58%	100%	100%	58%
October	58%	100%	100%	58%
November	81%	96%	100%	78%
December	60%	99%	100%	59%

(b)

Month	Availability	Performance Efficiency	Quality Rate	OEE
January	85%	100%	100%	85%
February	65%	99%	100%	65%
March	86%	100%	100%	86%
April	84%	98%	100%	82%
May	80%	92%	100%	74%
June	71%	99%	100%	71%
July	9%	100%	100%	9%
August	84%	85%	100%	72%
September	85%	97%	100%	82%
October	82%	100%	100%	82%
November	79%	96%	100%	76%
December	79%	100%	100%	79%

After the calculation of the availability of Raw Mill 4R1 in Indarung IV in 2015, it can be seen that the availability of Raw Mill 4R1 is still below international company standard with 90% or more standard. While the availability of Raw Mill 4R1 in 2015 is only 61%. For the availability of Raw Mill 4R2 also still under International company standard only 74%.

Based on the calculation of Performance Efficiency from Raw Mill 4R1, the average Performance Efficiency of Raw Mill 4R1 is 97.76%. While Performance Efficiency of Raw Mill 4R2, the average Performance Efficiency of Raw Mill 4R1 is 97.26%. This Efficiency performance has exceeded the international standard limits of 95% or more. Although the average Performance Efficiency Raw Mill 4R1 of 2015 has exceeded the standard limit, there are several months that Performance Efficiency is still below the standard of January (92%) and August (93%). Performance Efficiency Raw Mill 4R2 of 2015 has also exceeded the standard limit, but there are several months that its Performance Efficiency is still below the standard of May (92%) and August (85%).

For the Quality Rate of Raw Mill 4R1 and 4R2 in Indarung IV in 2015, it can be seen that the Quality Rate Raw Mill 4R1 and 4R2 has exceeded the International Company's standard of 100% while the International Company's standard is 99% or more. After the calculation of the Quality Rate of Raw Mill 4R1 and 4R2 in Indarung IV in 2015, it can be seen that the Quality Rate Raw Mill 4R1 and 4R2 has exceeded the International Company's standard of 100% while the International Company's standard is 99% or more. This is because PT Semen Padang mixed back the cement that the quality is bad with good quality cement so that there's no damaged goods in PT Semen Padang.

After calculating Availability, Performance Efficiency, and Quality Rate, obtained OEE value from Raw Mill 4R1 and 4R2 that is equal to 60% and 72%. The value of OEE is still below the International Company standard of 85% or more. For the OEE value per month, the Raw Mill 4R1 of its OEE value does not exceed OEE standard values. The highest OEE value of Raw Mill 4R1 is 79% in May. Then for Raw Mill 4R2 there are 2 months that its OEE value exceeds the standard that is January (85%) and March (86%)

When compared to the OEE value of each machine in Indarung IV, the 4R1 and 4R2 engines whose OEE values are still below the standard OEE values. As for Kiln and Cement Mill machine its OEE value has exceeded the standard OEE value of 85% for Kiln, 88% for Cement Mill 4Z1, and 87% for Cement Mill 4Z1.

The following is an example of breakdown losses calculation for the period of January 2015:

$$\text{Breakdown} = \frac{\textit{Breakdown Time}}{\textit{Loading Time}} \times 100\% = \frac{88.25}{505.67} \times 100\% = 17.45\%$$

The following is an example of setup and adjustment time calculation for the period of January 2015:

$$\text{Setup} = \frac{\textit{Total Set up and adjustment}}{\textit{Loading Time}} \times 100\% = \frac{56.82}{505.67} \times 100\% = 11.24\%$$

The following is an example of Idling Minor Stoppages calculation for the period of January 2015:

$$\text{Idling} = \frac{\textit{Non Productive Time}}{\textit{Loading Time}} \text{x } 100\% = \frac{0}{505.67} \times 100\% = 0\%$$

The following is an example of Reduced Speed Loss calculation for the period of January 2015:

$$\text{Reduced} = \frac{\text{TPH Aktual}}{\text{TPH Standard}} \times 100\%$$

$$= \frac{\text{OperTIme} - (IdleCycleTIme \; x \; 4R1Prod)}{505.67} \times 100\%$$
$$= \frac{360 - (0.0044 \; x \; 74370)}{505.67} \times 100\%$$
$$= 6.02\%$$

The following is an example of Rework Loss calculation for the period of January 2015:

Rework Loss $= \frac{\text{Rework Time}}{\text{Loading Time}} \times 100\%$
$$= \frac{0}{505.67} \times 100\%$$
$$= 0\%$$

The following is an example of Yield Loss calculation for the period of January 2015:

Yield Loss $= \frac{\text{Yield Time}}{\text{Loading Time}} \times 100\%$
$$= \frac{0}{505.67} \times 100\%$$
$$= 0\%$$

The comparation between the factors of Six Big Losses can be seen on **Table 4** and **Table 5.**

Table 4. Percentage of Six Big Losses Raw Mill 4R1

Six Big Losses	Total Time Loss	Persentase
Breakdown Loss	1532,45	67,08%
Setup and Adjustment Loss	674,28	29,51%
Idling Minor Stoppage	0,00	0,00%
Reduced Speed Loss	77,94	3,41%
Rework Loss	0,00	0,00%
Scrap Loss	0,00	0,00%
Total	2284,68	

Table 5. Percentage of Six Big Losses Raw Mill 4R2

Six Big Losses	Total Time Loss	Persentase
Breakdown Loss	1228,40	53,77%
Setup and Adjustment Loss	307,80	13,47%
Idling Minor Stoppage	0,00	0,00%
Reduced Speed Loss	117,53	5,14%
Rework Loss	0,00	0,00%
Scrap Loss	0,00	0,00%
Total	1653,73	

From the six losses that occur on the machine, the most losses cause the Raw Mill 4R1 and 4R2 engine to lose its effectiveness is Breakdown Losses. Things that cause breakdown losses include machine break and power cut off. this machine break can be caused due to interference from other equipment or because of material entering raw mill. The cause of breakdown losses can be seen of **Figure 1.**

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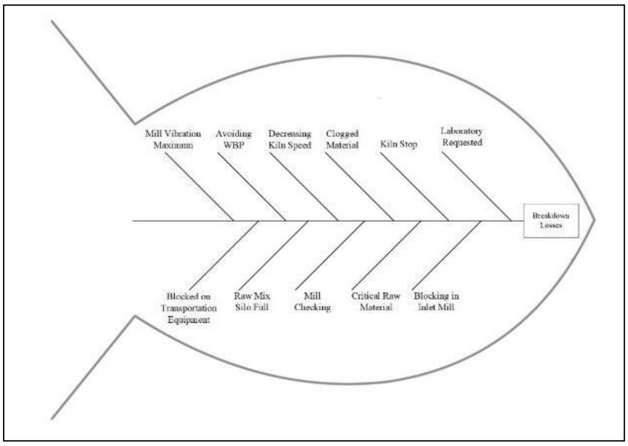

Figure 1. Fishbone Diagram of Breakdown Losses

The next losses that cause the decreasing of Raw Mills effectivity is setup and adjustment losses. The cause of setup and adjustment losses can be seen on **Figure 2**

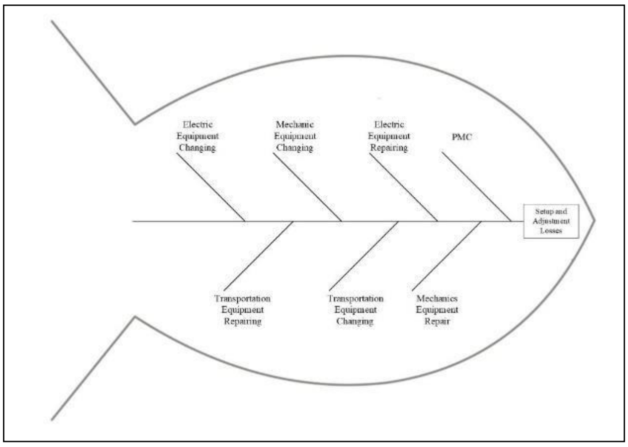

Figure 2. Fishbone Diagram of Setup and Adjustment Losses

Idling minor stoppage, rework losses, and scrap losses doesn't affect the decreasing of Raw Mills effectivity because Idling minor stoppage it causes by activity of cleaning machine. But PT Semen Padang didn't clean the machine because the size of the machine is big and PT Semen Padang just do maintenance to the machine. Rework losses and scrap losses doesn't affect the decreasing of Raw Mills effectivity because it causes by the reject product. PT Semen Padang didn't have reject product because PT Semen Padang mix the bad quality product with the good quality product.

4. Conclusion

This research has measured effectivity values and six big losses of Raw Mill 4R1 and 4R2. It is found that the effectiveness values of Raw Mill 4R1 and 4R2 are 60% and 70%. The value of this effectiveness is still below the standard value according to JIPM that is 85% or more. The biggest disruption caused the loss of engine effectiveness Raw Mill 4R1 and 4R2 is Breakdown losses that is due to machine break and power cut off.

5. Acknowledgment

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3. Effectivity analysis of raw mill 4R1 and 4R2 using Overall Equipment Effectivity (OEE) Method and Six Big Losses in Indarung IV Plant of PT Semen Padang

by Prima Fithri

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1. Introduction

Machine is one of the important things in the industry today [1]. For a company that produces products in a big number, it is impossible for the company to employ a human for the production process. Especially for products that require a complicated process, it would be difficult to be done by humans and takes a long time. Therefore, the machine is used as a tool to facilitate the production process for the company. Similar to humans, machines also have limitations in their use [2]–[5]. If the machine is constantly being used in without good maintenance, the machine will quickly break down and can't be used. This conditions will certainly affect productivity of company [6], safety performance of company [7], and the results of products produced by the company. If one of the machines is damaged or not operating, then this may interfere the operation of other machines. Consequently, the production process will be disrupted.

PT Semen Padang is the first cement producer in Indonesia which currently has 5 factories that are still actively operating. PT Semen Padang has a production capacity of 10,400,000 tons per year. It is impossible for PT Semen Padang to make a production with such huge value without the help of a production machine. Therefore, each factory from PT Semen Padang is equipped with production machinery such as Raw Mill, Kiln, and Cement Mill. One of the factories in PT Semen Padang is Indarung IV Factory. Indarung IV has a production capacity of 1,620,000 tons per year. Like other factories, Indarung IV is also equipped with production machine, one of them is Raw Mill. Raw mill is a machine that serves to grind raw materials into raw mix. There are two Raw Mill machines in Indarung IV. Raw Mill is the first machine to use in the cement production process. During operation to produce raw mix, Raw Mills also suffer from interference that hinders operation of Raw Mill itself. Based on existing data, there are many disruptions that occur that cause Raw Mill to stop operating.

Details of disruptions happen in Raw Mill 4R1 in 2015 can be seen on **Table 1** and Raw Mill 4R2 can be seen on **Table 2.**

Table 1. Disruptions in Raw Mill 4R1

Disruptions	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kiln stop	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Clogged Material	✓					✓	✓	✓	✓		✓	
Disruption of Power Distribution					✓		✓	✓	✓		✓	✓
PMC		✓		✓	✓	✓		✓	✓		✓	✓
Electric Equipment Checking	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓
Mechanic Equipment Repair				✓	✓	✓	✓	✓	✓	✓	✓	
Blocking in Inlet Mill ✓												
Mechanics Equipment Changing			✓	✓	✓	✓		✓	✓		✓	
Mill Vibration is Maximum	✓	✓		✓	✓	✓		✓	✓	✓	✓	
Avoiding WBP										✓		
Fan Repairing								✓				
Critical Raw Material								✓				✓
Electric Equipment Repairing					✓	✓						
Mechanic Equipment Checking			✓	✓	✓	✓	✓	✓		✓		
Mill Checking							✓					
Transportation Equipment Repairing	✓				✓		✓	✓	✓	✓		
Raw Mix Silo is Full								✓				
PLN off			✓		✓	✓		✓				
Instrument Equipment Checking	✓	✓	✓	✓	✓		✓	✓		✓		
Blocked on Transportation Equipment			✓	✓	✓		✓		✓			
Electric Equipment Checking												✓
TOTAL TIME (hr)	98:39	175:30	92:12	94:50	144:30	158:23	352:29	114:02	95:09	102:34	128:48	116:24

Table 2. Disruptions in Raw Mill 4R2

Disruptions	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kiln stop	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PMC	✓	✓		✓				✓			✓	✓
Disruption of Power Distribution		✓		✓	✓		✓	✓	✓		✓	✓
Electric Equipment Checking	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓
Clogged Material	✓			✓	✓	✓	✓		✓		✓	✓
Limited Power									✓	✓	✓	
Mechanic Equipment Repair	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mechanic Equipment Checking	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mill Checking											✓	✓
Blocked on Transportation Equipment			✓	✓	✓	✓		✓	✓	✓	✓	
Laboratory Requested											✓	
Critical Raw Material			✓					✓				✓
Blocking in Inlet Mill		✓										
Transportation Equipment Changing									✓			
PLN off			✓	✓		✓						
Raw Mix Silo is Full								✓	✓			✓
Electric Equipment Repairing								✓				
Transportation Equipment Repairing	✓		✓	✓		✓			✓			
Mechanics Equipment Changing	✓				✓	✓	✓		✓	✓		
Mill Repairing	✓		✓									
Avoiding WBP										✓		
Electric Equipment Changing						✓						✓
Mill Vibration is Maximum						✓				✓		
Instrument Equipment Checking		✓	✓	✓	✓	✓		✓	✓	✓		✓
Decreasing Kiln Speed												✓
TOTAL TIME (hr)	191:42	257:49	103:41	131:31	117:25	155:33	372:33	209:12	224:01	231:43	117:05	228:50

Based on the disruptions above, we can see the disruptions cause the machine didn't working as long as the available time. There is difference between the planned operating time with the actual operating time. This difference will affect the effectiveness of the Raw Mills and after that we need to know what if the effectiveness affects the cement production in PT Semen Padang. After that, from those disruptions we need to know which one of that disruptions that make the machine stop working.

Therefore, it's needed to calculated the effectiveness of the Raw Mills using Overall Equipment Effectivity (OEE) method. Most researchers used OEE method to identify critical indicator in maintenance area, performance management, and productivity improvement [8]–[14]. OEE offers a means of controlling the whole production process by analyzing results from the totality of events. More often than not, production inefficiencies and stoppages are blamed on equipment failure. However, this is not always the case. The production cycle involves a multiplicity of influences and a combination of any of these can trigger a production stop. OEE will provide information on the root cause of production inefficiency and thus lead to a targeted resolution, concentrating effort where it has the greatest impact.

To analyze the factors that caused the Raw Mills loss the effectiveness using Six Big Losses method [15]–[17]. Six Big Losses is useful for determining effective value. Six Big Losses provides more details about the loss of engine effectiveness. In addition to getting more information, Six Big Losses can also provide a foundation for more effective action. The benefits gained from implementing Six Big Losses is to provide additional information that aligns with and extends OEE and facilitates the identification of effective preventive measures for equipment-based losses.

2. Methods

The research methodology is the stages of research that must be determined first that serve as a direction in the analysis and problem solving. Literature study is first stages that used to help understanding the theory related to the research so that it will support the researcher in solving the problem. The literature study needed is about Overall Equipment Effectiveness (OEE) method and Six Big Losses Method.

Next stage is preliminary stage. This stage is the preliminary stage in the research is to observe directly the production process at the factory. This is done to see the real condition of the factory that is guided by the field supervisor, Mr. Achiarman. Interview has also been done with the employee in Production Planning and Control Bureau. Interview was used to know about cement production process with Mr. Fauzan and Mrs. Isil. Based on the preliminary survey, it is determined that the problems will be studied. In this study the problem is focused on the Raw Mill 4R1 and 4R2 in Indarung IV factory. The problems that exist on this machine are the number of disturbances that cause engine operation is disrupted.

Primary data is data got from interview. The primary data that used in this report is cement production process and how the production machine works. The secondary data that used in this report is daily report of Raw Mill 4R1 and 4R2 in 2015, production planning of Indarung IV Plant, and actual production of Indarung IV Plant of PT Semen Padang. After the required data is collected then the next step is to perform data processing Overall Equipment Effectiveness (OEE). To find OEE, calculate the availability, performance efficiency, and quality rate of the Raw Mill 4R1 and 4R2. After that, find the cause of the decreasing of the effectivity of the machine using Six Big Losses Method. Calculating the 6 losses may cause the decreasing of the effectiveness.

3. Result and Discussion

The process used to calculate effectivity of Raw Mill is Overall Equipment Effectivity (OEE). The following is an example of the availability of January 2015 availability for Raw Mill 4R1 :

$$\text{Availability} = \frac{\text{Operation Time}}{\text{Loading Time}} \times 100\%$$

$$= \frac{\text{Loading Time - Downtime}}{\text{Loading Time}} \times 100\%$$

$$= \frac{505.7 - 145.07}{505.7} \times 100\%$$
$$= 71\%$$

The following is an example of the Performance Rate of January 2015 availability for Raw Mill 4R1 :

$$\text{Performance Rate} = \frac{\text{Operating Speed Rate}}{\text{Net Operating Rate}} \times 100\%$$
$$= \frac{\text{4R1 Production} \times \text{Idle Cycle Time}}{\text{Operation Time}} \times 100\%$$
$$= \frac{74730 \times 0.0044}{360.60} \times 100\%$$
$$= 92\%$$

The following is an example of the Quality Rate of January 2015 availability for Raw Mill 4R1 :

$$\text{Quality Rate} = \frac{\text{Processed Amount-Defect Amount}}{\text{Processed Amount}} \times 100\%$$
$$= \frac{74370 - 0}{74370} \times 100\%$$
$$= 100\%$$

The following is an example of the OEE of January 2015 availability for Raw Mill 4R1 :

OEE = Availability x PR x QR
= 71% x 92% x 100%
= 65%

The results of OEE calculation of Raw Mill 4R1 and 4R2 in 2015 can be seen on **Table 3.**

Table 3. OEE of Raw Mill 4R1 (a) and 4R2 (b) in 2015

(a)

Month	Availability	Performance Efficiency	Quality Rate	OEE
January	71%	92%	100%	65%
February	40%	95%	100%	38%
March	84%	100%	100%	84%
April	76%	98%	100%	75%
May	79%	100%	100%	79%
June	71%	100%	100%	71%
July	3%	100%	100%	3%
August	52%	93%	100%	48%
September	58%	100%	100%	58%
October	58%	100%	100%	58%
November	81%	96%	100%	78%
December	60%	99%	100%	59%

(b)

Month	Availability	Performance Efficiency	Quality Rate	OEE
January	85%	100%	100%	85%
February	65%	99%	100%	65%
March	86%	100%	100%	86%
April	84%	98%	100%	82%
May	80%	92%	100%	74%
June	71%	99%	100%	71%
July	9%	100%	100%	9%
August	84%	85%	100%	72%
September	85%	97%	100%	82%
October	82%	100%	100%	82%
November	79%	96%	100%	76%
December	79%	100%	100%	79%

After the calculation of the availability of Raw Mill 4R1 in Indarung IV in 2015, it can be seen that the availability of Raw Mill 4R1 is still below international company standard with 90% or more standard. While the availability of Raw Mill 4R1 in 2015 is only 61%. For the availability of Raw Mill 4R2 also still under International company standard only 74%.

Based on the calculation of Performance Efficiency from Raw Mill 4R1, the average Performance Efficiency of Raw Mill 4R1 is 97.76%. While Performance Efficiency of Raw Mill 4R2, the average Performance Efficiency of Raw Mill 4R1 is 97.26%. This Efficiency performance has exceeded the international standard limits of 95% or more. Although the average Performance Efficiency Raw Mill 4R1 of 2015 has exceeded the standard limit, there are several months that Performance Efficiency is still below the standard of January (92%) and August (93%). Performance Efficiency Raw Mill 4R2 of 2015 has also exceeded the standard limit, but there are several months that its Performance Efficiency is still below the standard of May (92%) and August (85%).

For the Quality Rate of Raw Mill 4R1 and 4R2 in Indarung IV in 2015, it can be seen that the Quality Rate Raw Mill 4R1 and 4R2 has exceeded the International Company's standard of 100% while the International Company's standard is 99% or more. After the calculation of the Quality Rate of Raw Mill 4R1 and 4R2 in Indarung IV in 2015, it can be seen that the Quality Rate Raw Mill 4R1 and 4R2 has exceeded the International Company's standard of 100% while the International Company's standard is 99% or more. This is because PT Semen Padang mixed back the cement that the quality is bad with good quality cement so that there's no damaged goods in PT Semen Padang.

After calculating Availability, Performance Efficiency, and Quality Rate, obtained OEE value from Raw Mill 4R1 and 4R2 that is equal to 60% and 72%. The value of OEE is still below the International Company standard of 85% or more. For the OEE value per month, the Raw Mill 4R1 of its OEE value does not exceed OEE standard values. The highest OEE value of Raw Mill 4R1 is 79% in May. Then for Raw Mill 4R2 there are 2 months that its OEE value exceeds the standard that is January (85%) and March (86%)

When compared to the OEE value of each machine in Indarung IV, the 4R1 and 4R2 engines whose OEE values are still below the standard OEE values. As for Kiln and Cement Mill machine its OEE value has exceeded the standard OEE value of 85% for Kiln, 88% for Cement Mill 4Z1, and 87% for Cement Mill 4Z1.

The following is an example of breakdown losses calculation for the period of January 2015:

$$\text{Breakdown} = \frac{\textit{Breakdown Time}}{\textit{Loading Time}} \times 100\% = \frac{88.25}{505.67} \times 100\% = 17.45\%$$

The following is an example of setup and adjustment time calculation for the period of January 2015:

$$\text{Setup} = \frac{\textit{Total Set up and adjustment}}{\textit{Loading Time}} \times 100\% = \frac{56.82}{505.67} \times 100\% = 11.24\%$$

The following is an example of Idling Minor Stoppages calculation for the period of January 2015:

$$\text{Idling} = \frac{\textit{Non Productive Time}}{\textit{Loading Time}} \text{x } 100\% = \frac{0}{505.67} \times 100\% = 0\%$$

The following is an example of Reduced Speed Loss calculation for the period of January 2015:

$$\text{Reduced} = \frac{\text{TPH Aktual}}{\text{TPH Standard}} \times 100\%$$

$$= \frac{\text{OperTIme} - (IdleCycleTIme\ x\ 4R1Prod)}{505.67} \times 100\%$$
$$= \frac{360 - (0.0044\ x\ 74370)}{505.67} \times 100\%$$
$$= 6.02\%$$

The following is an example of Rework Loss calculation for the period of January 2015:

Rework Loss $= \frac{\text{Rework Time}}{\text{Loading Time}} \times 100\%$
$$= \frac{0}{505.67} \times 100\%$$
$$= 0\%$$

The following is an example of Yield Loss calculation for the period of January 2015:

Yield Loss $= \frac{\text{Yield Time}}{\text{Loading Time}} \times 100\%$
$$= \frac{0}{505.67} \times 100\%$$
$$= 0\%$$

The comparation between the factors of Six Big Losses can be seen on **Table 4** and **Table 5.**

Table 4. Percentage of Six Big Losses Raw Mill 4R1

Six Big Losses	Total Time Loss	Persentase
Breakdown Loss	1532,45	67,08%
Setup and Adjustment Loss	674,28	29,51%
Idling Minor Stoppage	0,00	0,00%
Reduced Speed Loss	77,94	3,41%
Rework Loss	0,00	0,00%
Scrap Loss	0,00	0,00%
Total	2284,68	

Table 5. Percentage of Six Big Losses Raw Mill 4R2

Six Big Losses	Total Time Loss	Persentase
Breakdown Loss	1228,40	53,77%
Setup and Adjustment Loss	307,80	13,47%
Idling Minor Stoppage	0,00	0,00%
Reduced Speed Loss	117,53	5,14%
Rework Loss	0,00	0,00%
Scrap Loss	0,00	0,00%
Total	1653,73	

From the six losses that occur on the machine, the most losses cause the Raw Mill 4R1 and 4R2 engine to lose its effectiveness is Breakdown Losses. Things that cause breakdown losses include machine break and power cut off. this machine break can be caused due to interference from other equipment or because of material entering raw mill. The cause of breakdown losses can be seen of **Figure 1.**

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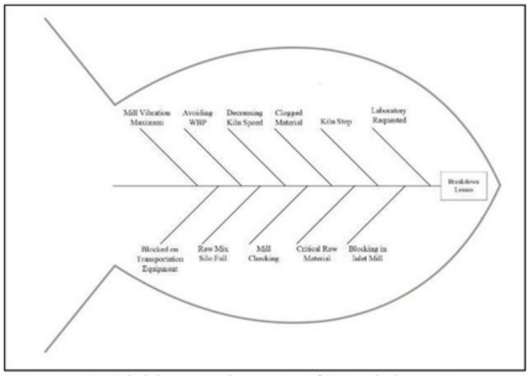

Figure 1. Fishbone Diagram of Breakdown Losses

The next losses that cause the decreasing of Raw Mills effectivity is setup and adjustment losses. The cause of setup and adjustment losses can be seen on **Figure 2**

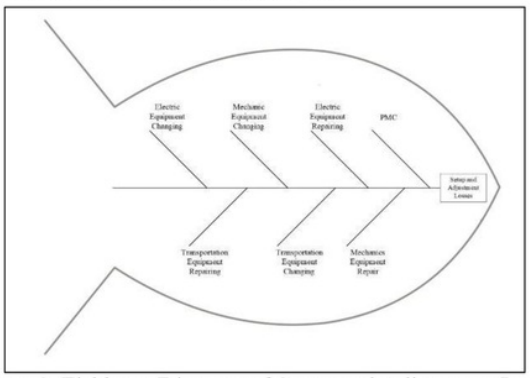

Figure 2. Fishbone Diagram of Setup and Adjustment Losses

Idling minor stoppage, rework losses, and scrap losses doesn't affect the decreasing of Raw Mills effectivity because Idling minor stoppage it causes by activity of cleaning machine. But PT Semen Padang didn't clean the machine because the size of the machine is big and PT Semen Padang just do maintenance to the machine. Rework losses and scrap losses doesn't affect the decreasing of Raw Mills effectivity because it causes by the reject product. PT Semen Padang didn't have reject product because PT Semen Padang mix the bad quality product with the good quality product.

4. Conclusion

This research has measured effectivity values and six big losses of Raw Mill 4R1 and 4R2. It is found that the effectiveness values of Raw Mill 4R1 and 4R2 are 60% and 70%. The value of this effectiveness is still below the standard value according to JIPM that is 85% or more. The biggest disruption caused the loss of engine effectiveness Raw Mill 4R1 and 4R2 is Breakdown losses that is due to machine break and power cut off.

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No.	Komponen yang dinilai	Nilai Maksimum *Prosiding* Internasional ☑	Nilai Maksimum *Prosiding* Nasional ☐	Nilai Akhir Yang Diperoleh (NA)
a	Kelengkapan unsur isi paper (10%)	3		3
b.	Ruang lingkup dan kedalaman pembahasan (30%)	9		9
c.	Kecukupan dan kemutahiran data/informasi dan metodologi (30%)	9		8
d.	Kelengkapan unsur dan kualitas terbitan/buku (30%)	9		9
	Total = (100%)	30		29
	Nilai Pengusul (NA X BP*)** = ...29..... X ..0,6.. = 17.4			

Catatan Penilaian Paper oleh Reviewer (wajib ada) :
Similarity index 14% Prosiding bereputasi scimago/SJR.
Pembahasan belum memadai

Padang, 21 Februari 2020
Reviewer 1 / 2 **

Alizar Hasan
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Bidang Ilmu : TEKNIK INDUSTRI
Jabatan/Pangkat : GB / Pembina Utama Madya

* Dinilai oleh dua Reviewer secara terpisah
** Coret yang tidak perlu
*** Bobot Peran (BP) : Sendiri = 1; Penulis Pertama = 0,6; Anggota = 0,4 dibagi jumlah anggota