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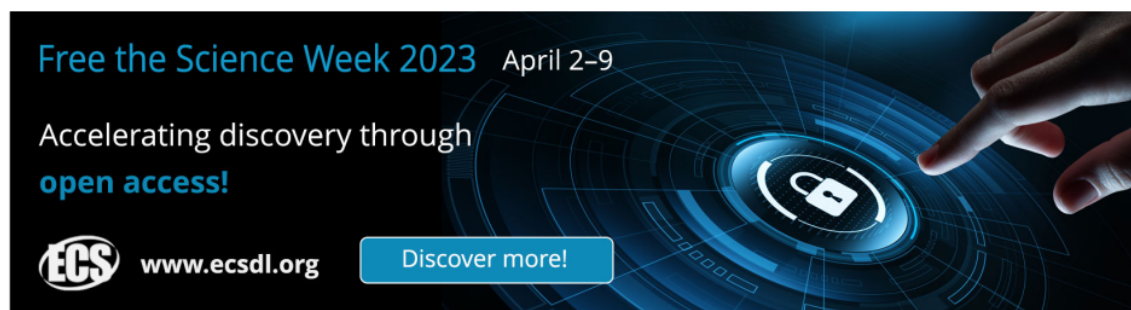# Evaluation of overall equipment effectivity in the cement manufacturing industry: a case study

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# Evaluation of overall equipment effectivity in the cement manufacturing industry: a case study

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**Abstract.** *Overall equipment effectiveness is one of the important tools to measure the productivity in the company. This research is based on a case study of cement manufacturing industry in Indonesia, especially in kiln machine. The research aims to investigate the six big losses. In addition, the calculation of availability components, performance efficiency, and quality rate are carried out. The fishbone diagram is also employed to identify the root cause of the problem deeply. The results show the biggest losses in the kiln machine are the reduced speed losses. Therefore, the availability component and the performance efficiency should be improved to increase the productivity and the efficiency in the shop floor. Some suggestions are presented such as make a better surveillance system, improve the planning of preventive maintenance machine, and replace the more sophisticated maintenance tools to facilitate maintaining the machine.*

*Keyworlds*: Kiln machine; cement industry; overall equipment effectiveness; six big losses.

## 1. Introduction

In this 21st century, the development of the industry is so significant so that it does not rule out the possibility of growth in Indonesia. Hence, the competition is very tight. Therefore, companies want to increase their productivity because productivity is essential for companies to obtain maximum success [1]. One of the examples of increasing productivity is to evaluate the performance of production facilities at companies [2]. Overall equipment effectiveness (OEE) is a quantitative metric that has been increasingly used in manufactorysystems for controlling and monitoring the productivity of production equipment, and also as an indicator anddriver of process and performance improvements. The OEE is a key performance measure in mass-production environments that consists of three important components which are availability, productivity and quality [3].

XYZ company is engaged in the cement manufacturing industry located on Cilacap, Indonesia. When it comes to production at XYZ company, it processes a homogenization of raw materials in the raw mill. After the raw materials are mixed, the raw materials pass through the combustion process in the kiln machine, then the combustion results from the kiln machine are cooled on the cooler machine. After the cold clinker cement is crushed in the finish mill machine, then the crushed cement dust is packed in the packaging machine, after which the finished cement is stored in a storage warehouse. The production process is carried out 24 hours non-stop, so that apart from the problem of the effectiveness of the machine or equipment. Therefore, without a willingness to maintain the right method at its kiln, it will produce less optimal production so that the targeted quantity will be less, and it will not be achieved as it is desired.

Overall equipment effectiveness (OEE) plays a crucial role in increasing productivity. effectiveness is the measure of doing it properly to the extent to which the requirements are fulfilled [4]. OEE is a

method used to implement total productive maintenance (TPM) to keep equipment in ideal condition by removing six big losses [5]. The OEE methodology is a proven approach to improve the overall performance of the equipment (rest time, lunch, scheduled maintenance, or periods in which nothing is produced [6].

Overall equipment effectiveness measures the gap between actual performance and the potential performance in the manufacturing. OEE includes three measuring metrics, such as availability, performance, and quality. It helps to measure the efficiency of the factory by categorizing the significant losses affecting the manufacturing process [7]. The primary purpose of overall equipment effectiveness (OEE) is to enhance and maintain equipment efficiency [8]. Most of the research involving OEE size is not only related to maintenance, but also for areas such as performance measurement and maintained productivity. The measure of OEE is carried out with attention to three critical things, the availability level, level of performance, and level of quality [9].

**Table 1.** Research Gap

| Researcher | Objective | Problem | Methodology | Conclusion |
|---|---|---|---|---|
| Swomnya and Chetan [6] | To evaluate the Losses occurred | OEE values are below world class standards | OEE and Six Big Losses | Implementation of OEE in manufacturing problems cannot be a short-term goal. However, it is a joint improvement program where higher OEE levels near world-class scores can be achieved by reducing six significant losses and implementing TPM tools |
| Prabowo et al [10] | Evaluate the implementation of 8 Pillar TPM and measure the effect on manufacturing performance in the form of Overall equipment effectiveness (OEE) and Waste | Only 6 out of the 8 pillars affect manufacturing performance | TPM and OEE | 74.3% of manufacturing performance variables can be explained/influenced by 8 Pillar TPM variables and the remaining 26.7% by other variables. |
| Sinaigar [11] | To determine and analyze each of the OEE values | Performance | TPM | The average OEE value of the kiln machine has met world-class results |
| Dawood and Abdullah [12] | To analyz the overall operating performance of the equipment | Performance and Quality | OEE | OEE values on all cement production machinery are below world-class standards |
| Proposed Research | To evaluate the OEE on kiln machine | Availability and Performance | OEE and Six Big Losses | OEE values on both machines are below world-class standards because they are caused by three losses, namely breakdown, idling stoppages, reduced speed. |

The difference between this research and previous research is analyzing the OEE value of the machine and exploring the losses that affect the engine's low effectiveness value.

## 2. Method

This methodology describes the stages that will be performed in the study. This method identifies the issue until the last conclusion is taken through the flow diagram in the display in Figure 1.
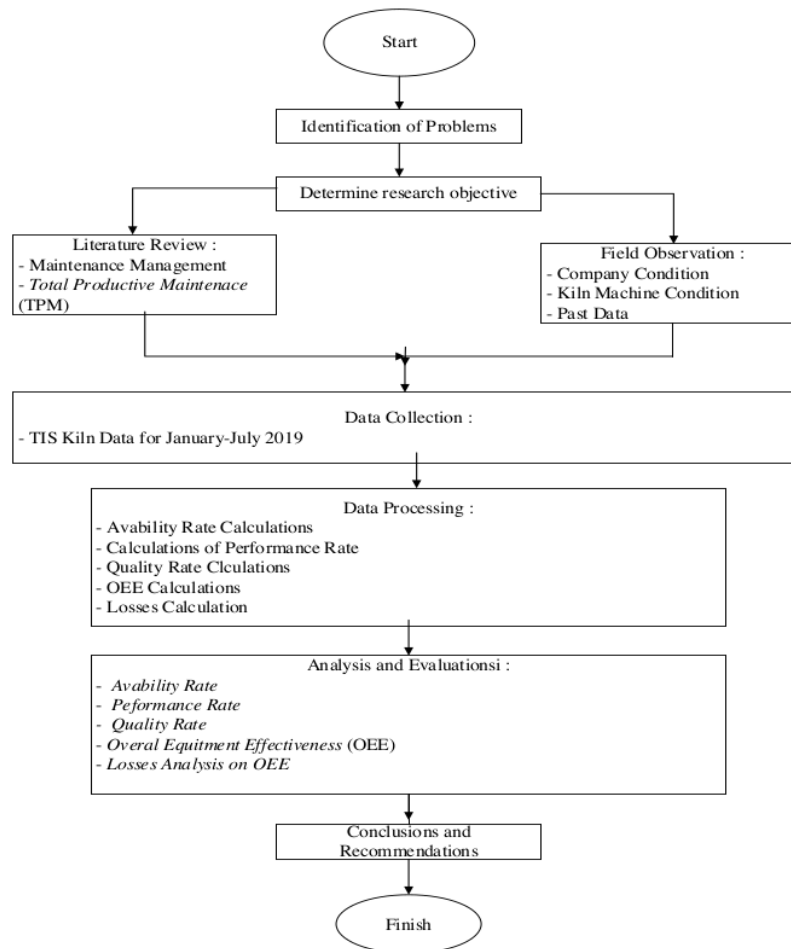


**Figure 1**. Flow Chart of research methods

These stages of research are the first Problem identification, identify the problem that occurs in the kiln machine, which is located at XYZ company can influence the effectiveness of kiln machine. Then research objectives, the purpose of this research is to know the value of overall equipment effectivity kiln machine and six big losses that influence the OEE kiln machine value. Then literature review, it studies the journals and related topics about the maintenance spells and total productive maintenance. Then field observations, it is conducted by observating at XYZ company to know field conditions, kiln machine conditions, and past data from the kiln machine. Then data collection, collecting previous data of kiln machines, which necessary to support the resolution to resolve the existing problems. Collecting data is done by observing the data from TIS kiln machine. Then data processing, data processing is done by calculating the value of availability, performance, quality, OEE, and losses in the kiln machine. Then analysis and evaluation, the result of its data processing depicts how the value of availability rate,

performance rate, quality rate, OEE, and evaluate whether the OEE value obtained from the kiln machine already meets the World class standard. The final step of this study is conclusions and suggestions, the final step of this study is to conclude from the research results which have been done on the kiln machine located in XYZ company. It also discussed suggestions for XYZ company to increase the OEE value and reduce the Six Big Losses on the kiln machine.

## 3. Results and Discussion

### 3.1 OEE calculations

The availability of June is low because in the same month in XYZ company has an annual Schedule maintenance engine, and the engine is experiencing a breakdown. The calculation of the availability value of kiln machine can be seen in Table 2.

**Table 2.** The result of availability kiln machine

| Month | Total Availability Time (h) | Planed Downtime (h) | Loading Time (h) | Downtime (h) | Operating Time (h) | Availability (%) |
|---|---|---|---|---|---|---|
| January | 744 | 0 | 744 | 62.3 | 681.7 | 91.63 |
| February | 672 | 0 | 672 | 168.7 | 503.3 | 74.90 |
| March | 744 | 0 | 744 | 189.7 | 554.3 | 74.50 |
| April | 720 | 0 | 720 | 320.5 | 399.5 | 55.49 |
| May | 744 | 0 | 744 | 31.2 | 712.8 | 95.81 |
| June | 720 | 414.25 | 305.75 | 193.6 | 112.15 | 36.68 |
| July | 744 | 0 | 744 | 67.7 | 676.3 | 90.90 |
| Average | 726.86 | 59.18 | 667.68 | 147.67 | 520.01 | 74.27 |

The average kiln machine availability is 74.27%, which means that the kiln machine availability is still below the world standard of 90%. It is because the machines are often damaged, and the supervision is less effective at XYZ company. The result of the performance value in kiln machine can be seen in Table 3.

**Table 3.** The result of kiln machine performance

| Month | Operating (h) | Total production (ton) | Cycle time (h) | Peformance % |
|---|---|---|---|---|
| January | 644.71 | 205421 | 0.0018 | 54.24 |
| February | 467.09 | 149331 | 0.0018 | 53.41 |
| March | 528.96 | 173202 | 0.0018 | 56.25 |
| April | 373.01 | 124102 | 0.0018 | 55.92 |
| May | 690.76 | 226336 | 0.0018 | 57.16 |
| June | 301.52 | 38643 | 0.0018 | 62.02 |
| July | 626.42 | 214346 | 0.0018 | 57.05 |
| Average | 518.92 | 162318.86 | 0.0018 | 56.58 |

The average performance of kiln machine is 56.58%, which means the performance of kiln machine is still very far below the world standard, namely 95%. It is due to machines that are often damaged and less effective machine maintenance at XYZ company. The result of the quality value in kiln machine can be seen in Table 4.

**Table 4.** The result of kiln machine quality

| Month | total production (ton) | The defect products (ton) | Quality % |
|---|---|---|---|
| January | 205421 | 0 | 100 |
| February | 149331 | 0 | 100 |
| March | 173202 | 0 | 100 |
| April | 124102 | 0 | 100 |
| May | 226336 | 0 | 100 |
| June | 38643 | 0 | 100 |
| July | 214346 | 0 | 100 |
| Average | 162318,86 | 0 | 100 |

Kiln machine quality gets an average of 100%, which means the quality of kiln machine is above the world standard, namely 99.9%. This is due to the absence of defects when the kiln machine was in production. After calculating the value of availability, performance, and quality then calculate the value OEE kiln machine. Calculation of the value of overall equipment effectivity for kiln machines can be seen in table 5.

**Table 5.** Calculation result of OEE kiln machine

| Month | Availability | Performance | Quality | OEE |
|---|---|---|---|---|
| January | 91.63 | 54.24 | 100 | 49.7 |
| Febuary | 74.9 | 53.41 | 100 | 40 |
| March | 74.5 | 56.25 | 100 | 41.9 |
| April | 55.49 | 55.92 | 100 | 31.02 |
| Mei | 95.81 | 57.16 | 100 | 54.76 |
| June | 36.68 | 62.02 | 100 | 22.75 |
| July | 90.9 | 57.05 | 100 | 51.86 |
| Average | 74.27 | 56.58 | 100 | 41.71 |

The average OEE value for kiln machines is 41.71%, which means that the OEE value for kiln machines is far below World standards. It is because there are three losses in the kiln machine, which significantly affect the effectiveness of the machine.

*3.2 Losses Calculation*

In the kiln machine, three losses cause the OEE value of the small kiln machine: breakdown losses, idling and stoppages minor, and reduced losses. The result of idling & mirror stoppages losses can be seen in the Table 6.

$$Idling\ and\ Minor\ Stoppages = \frac{Non\ Productive}{Loading\ Time}\ X\ 100\% \tag{1}$$

**Table 6.** The result of idling & miror stoppages losses kiln machine

| Month | Stop line | Loading time (h) | Idling & Mirror Stoppages (%) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| January | 0 | 744 | 0 |
| february | 0 | 672 | 0 |
| March | 180.8 | 744 | 24.3 |
| April | 0 | 720 | 0 |
| Mei | 4.93 | 744 | 0.66 |
| Juni | 0 | 305.75 | 0 |
| Juli | 0 | 744 | 0 |
| Average | 26.53 | 667.68 | 3.57 |

According to the table above, it can be noted that the average idling and minor stoppages of 3.57% of these losses have a relatively small value but also affect the amount of OEE. It is due to ineffective machine maintenance and supervision, so the performance value of the kiln machine is low. The result of the Reduced spees can be seen in Table 7.

$$Equipment\ Failure\ Losess = \frac{Total\ Breakdowns}{Loading\ Time} \ X\ 100\% \qquad (2)$$

**Table 7**. The result of reduced losses kiln machine

| Month | Operating (h) | Total production (ton) | Cycle time (h) | Loading time (h) | Reduced speed (%) |
|---|---|---|---|---|---|
| January | 681.7 | 205421 | 0.0018 | 744 | 41.93 |
| February | 503.3 | 149331 | 0.0018 | 672 | 34.90 |
| March | 554.3 | 173202 | 0.0018 | 744 | 32.60 |
| April | 399.5 | 124102 | 0.0018 | 720 | 24.46 |
| May | 712.8 | 226336 | 0.0018 | 744 | 41.05 |
| June | 112.15 | 38643 | 0.0018 | 305.75 | 13.93 |
| July | 676.3 | 214346 | 0.0018 | 744 | 39.04 |
| Average | 520.01 | 162318.8 | 0.0018 | 667.68 | 32.56 |

Based on the table, the average reduced losses are 32.56%, the losses are the most significant value so that the amount of OEE kiln machine under World Class. These losses are caused by a less effective or less stringent surveillance system so that the kiln machine's performance value is very low. The result of breakdown losess can be seen in table 8.

$$Recuded\ Speed = \frac{OT - (\ Cycletime\ x\ Processed\ Amount)}{Loading\ Time} \ X\ 100\%$$

**Table 8**. The result of breakdown losses kiln machine

| Month | Breakdown (h) | Loading time (h) | Breakdwon losses (%) |
|---|---|---|---|
| January | 62.3 | 744 | 8.37 |
| February | 168.7 | 672 | 25.10 |

| March   | 8.9    | 744    | 1.20  |
|---------|--------|--------|-------|
| April   | 320.5  | 720    | 44.51 |
| May     | 26.27  | 744    | 3.53  |
| June    | 193.6  | 305.75 | 63.32 |
| July    | 67.7   | 744    | 9.10  |
| Average |        |        | 22.16 |
|         | 121.14 | 667.68 |       |

Based on the above table can be known that the average breakdown losses of 22.16%, these losses occurred due to the preventive maintenance plan at XYZ company is still less effective, so the value availability kiln machine under standard world class. It is due to ineffective machine maintenance and supervision, so the performance value of the kiln machine is low.

According to the table above, it obtained the average value of the availability kiln machine amounting to 74.27% of the value, it has not fulfilled the world-class standards of 90%, in June, it has a very small performance, it is because of the machine usually experiencing a break down in this month. For the value of Performance kiln machine of 56.58%, The value has not fulfilled world-class standards, and for the quality value of the kiln machine amounting to 100% the value already meets world-class standards. Thus the value of availability and performance of the kiln machine is still less good because still under world-class standards, thus causing the value of OEE under world-class standards of > 85%. For quality, value has been good because it exceeds the world-class standards.

From research in the field, the factors that affect the value of availability are below the standard due to the breakdown loss can be seen in Table 6. It is because the ineffective preventive maintenance which makes the value availability below the World class standards. The factors that affect the value performance below the standard of world class caused by idling and minor stop losess can be seen in Table 7. The reduced speed losess can be seen in Table 8. The performance value of kiln machine is below the standard of World class because the poor supervision and poor maintenance machine.

Figure 2 is a graph comparison of OEE values obtained by the kiln machine and the World class standard, from the above image can be concluded that the amount of the OEE kiln machine does not meet the standard World class.
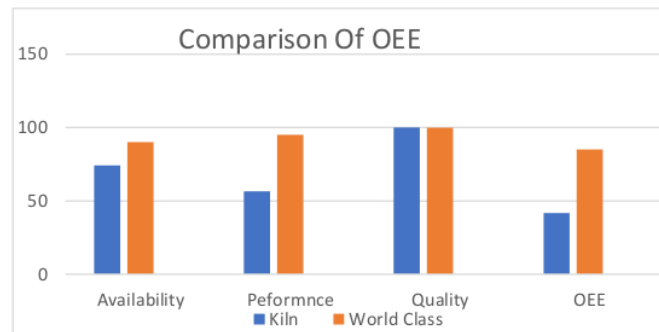


**Figure 2**. The comparison between real and the World class standard

### 3.3 Fishbone diagram
The fishbone diagram is employed to identify the problem of low OEE value, especially in kiln machine. It includes some factors, such as materials, machine, environment, and method.
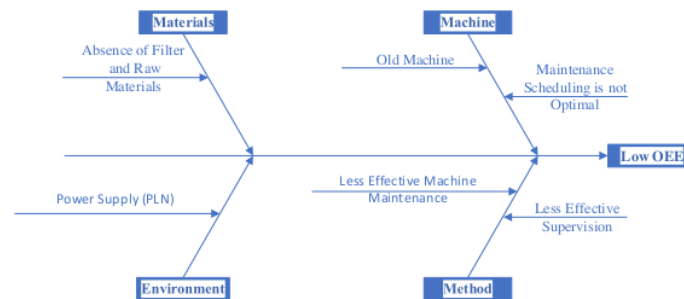
**Figure** 3. Fishbone diagram of kiln machine

The cause of the kiln's low OEE value is machine, one of the reasons for low OEE value is the machine is already old. It effects on the performance of that machine. In addition, the maintenance scheduling is very rare. It makes the condition become worse. Then method, another reason is the method employed in the production system. The controlling and monitoring that is conducted by the supervisor in the shop floor is poor. Next, there is no standard procedures in maintaining the machine. Then material, the raw materials such as sand and limestone that are from warehouse has no filtering procedures before entering into kiln machine. It makes some irons break the machine. In addition, the limestone are still in big size and there is no standardized size of limestone. It makes poor availability for that machine. Then environment, in the shop floor the electricity is easily down. It makes the machine break rapidly, and the machine's lifespan becomes short.

To overcome those problems, there are some suggestions in order to increase the OEE value while meeting the World Class standards. The supervisors should have effective and good surveillance system so that it helps on monitoring the performance of kiln machine. Then, the preventive maintenance planning should be improved in order to reduce the frequency of the kiln machine breakdown. Another suggestion is the sophisticated maintenance tools should be added in order to the machine maintenance becomes more effective and efficient.

## 4. Conclusion

This research is based on a case study in cement manufacturing industry in Cilacap, Indonesia. The research aims to investigate the six big losses. In addition, the calculation of availability components, performance efficiency, and quality rate are carried out. The fish bone diagram is also employed to identify the root cause of the problem deeply. The results show the value of availability 74.27%, the value of performance is 56.58%, and the value of quality is 100%, which means the component availability and performance are not meet the OEE world class standard, i.e. more than 85%. There are three losses that can cause low OEE values, such as reduced speed losses and idling and minor stops which affect the performance value of the kiln machine, and breakdown losses which affect the value availability of kiln machines. The fishbone diagram is employed to identify the root cause of the problem. Some suggestions are presented such as make a better surveillance system, improve the planning of preventive maintenance machine, and replace the more sophisticated maintenance tools to facilitate maintaining the machine.

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