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# Overall Equipment Effectiveness (OEE) Measurement Analysis for Optimizing Smelter Machinery

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***Abstract:*** *This study aims to evaluate the causes of the low performance of smelter machines, determining improvement proposals so that engine performance can be improved. This study uses a quantitative descriptive approach with the Overall Equipment Efectivness (OEE) value analysis method. The results of OEE values are analyzed using the six big losses method so that loss factors can be found and analysis of root causes of performance using fishbone diagrams and then making recommendations for improvements that can be done using whys analysis. Based on the results of the study, the average value of OEE (Overall Equipment Effectiveness) of the smelter machine for the period January 2017 to December 2017 is still below the Standard World Class Manufacturing. The low OEE value is caused by the high value of losses that occur. Losses are derived from performance efficiency, namely Reduced Speed Losses caused by unstable input smelters, and Availability, which is a breakdown caused by the length of fire brick smelter replacement. While corrective steps can be taken by installing some additional equipment and improving methods on production machinery, periodic checking of machines, replacement of materials, arranging production plans and the handover between shift employees.*

***Keywords:*** *smelter machine, Overall Equipment Effectiveness (OEE), six big losses.*

## I. INTRODUCTION

The prospect of the national ceramic industry in the long run is quite good in line with the growing domestic market growth, especially for ceramic tile types because it is supported by growth in property and housing development. Indonesia has also succeeded in dominating the Southeast Asian market for the quality of ceramics. With the size of the domestic market and the existence of trade cooperation in the ASEAN Economic Community, this has triggered intense competition in the domestic ceramic industry in Indonesia.

One of the ceramics factories that has been operating, PT. Angsa Daya (IKAD). To fulfill the raw material for making ceramics, PT. Angsa Daya (IKAD) has a special subsidiary to supply one of the raw materials for making ceramics, namely PT. ITA Smaltindo. Products manufactured by PT. ITA Smaltindo is a frit. The main production machine is a smelter.

The target to be achieved by PT. ITA Smaltindo is product accuracy, number of products and delivery. This is because PT. ITA Smaltindo only supplies frits to PT. Angsa Daya (IKAD), if the product cannot be shipped on schedule, then the frit product will only become a settled product.

In the production process, there are demands to produce products with good quality and timely production. This allows the machine to operate in a higher operating time and a decrease in frit production occurs where the engine has a breakdown. One concept that can be used to measure the effectiveness of production is the Overal Equipment Effectiveness (OEE) method (Stamatis, 2010). The concept used to improve quality and efficiency is to use TPM (Total Production Maintenance).

By using TPM tools that aim to improve efficiency by increasing engine performance by setting aside six big losess on the machine it can increase productivity in line with expectations (Suharjo, 2016).

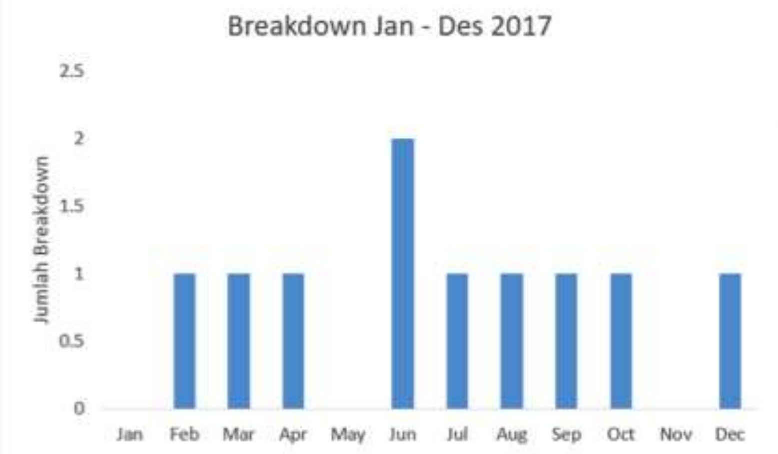


**Fig. 1. Breakdown 2017**

## II. LITERATURE REVIEW

**Manufacturing Maintenance System,** The traditional maintenance perception is to repair damaged equipment components. So that maintenance activities become limited to reactive tasks for repair or replacement of equipment components. Thus, this approach is better known as reactive maintenance, damage maintenance or corrective maintenance (Ahuja and Kahamba (2008).

**Total Production Maintenance (TPM)**, Total Productive Maintenance (TPM) is a maintenance activity that includes all elements of the company that aim to create a critical mass in the industrial environment in order to achieve zero breakdown, zero defect, and zero accident (Kurniawan, 2013).

**Overall Equipment Effectiveness (OEE)**, Overall Equipment Efficiency (OEE) is a method that is able to evaluate the production process to the level of quality of existing products. By using the OEE method, companies can make improvements in the part that is not appropriate because this method can calculate the Availability, Performance and Quality Yield values which are important factors of OEE so that it can be known the factors causing the low OEE values (Simanungkalit, 2016).

**Six Big Losses,** There are six equipment losses that cause the low performance of the six big losses equipment as follows (Saiful, 2014):

1. Equipment failure / breakdown losses, categorized as time losses due to decreased productivity and quality losses due to defects.
2. Set-up / adjustment time losses, is the result of downtime and defects that occur when the production of the last item and equipment is determined as a prerequisite for other items.
3. Idling and minor stop losses, occur when production is interrupted by a temporary malfunction or a machine that is stopping.
4. Reduced speed losses, is the difference between design speed and actual operating speed.
5. Reduced yield, is a loss that occurs during the initial stages of production when the engine starts up to reach stable conditions.
6. Quality defects and rework, are losses in quality caused by malfunctioning production equipment.

## III. RESEARCH METHODOLOGY

This research refers to the background and is oriented towards the interests of the company and refers to the formulation of the problem. The first step is to focus on eliminating large losses, then analyze with a fish bone diagram, and make corrective steps proposed to be carried out after the results of OEE calculations are known, six big losses and find the root of the problem using cause and effect analysis (Nusraningrum, 2018).

**Populasion and Sample**, The population of this research is the smelter machine located at PT. Ita Smaltindo is as many as 2 machines, while the sample taken is a type of saturated sample in which all populations become the sample under study.

**TABLE 1. RESEARCH VARIABLES**

| Variabel | Dimension | Indicator | Data Type | Data Source |
|---|---|---|---|---|
| *Overall Equipment Effectiveness* (OEE) | Availability | 1. Loading Time<br>2. Operation Time | Sekunder<br>Sekunder | Daily report *Maintenance*<br>Daily report *Maintenance* |
| | Performance | 1. Real Capacity<br>2. Target Capacity | Sekunder<br><br>Primer | Daily report *Production* |
| | Quality | 1. Reject/Rework | Primer | |

**Method of Collecting Data,** Primary data collection is done through interviews and documentation. Interviews were conducted with operators, maintenance personnel and section heads of frit production sections.

**Methode of Data Analysis**

$$Availability = \frac{Loading\ time - Downtime}{Loading\ Tima}\ x\ 100$$

$$Performance\ efficiency = \frac{Processed\ amount\ x\ thoritical\ cycle\ time}{Operating\ time}\ x\ 100$$

$$Quality\ Product = \frac{Processed\ amount - Defect\ amount}{Processed\ amount}\ x\ 100$$

$$OEE = Availability\ rate\ x\ Performance\ rate\ x\ Quality\ rate$$

The results of O EE values were analyzed using the six six big losses method so that loss factors can be found and the root cause analysis of performance using a fishbone diagram and then making recommendations for improvements that can be made (Nusraningrum, 2018)

## IV. RESULT AND ANALYSIS

Overall Equipment Effectiveness is a measurement of the overall effectiveness of the equipment to evaluate how much performance is achieved. OEE is an indicator of productivity performance based on a certain level of expected performance. Overall Equipment Effectiveness (OEE) value is influenced by three factors, namely Availability, Performance and Quality. According to world standards, the ideal of OEE value is Availability of 90.0%, Performance of 95.0%, Quality of 99.9% and Overall Equipment Effectiveness (OEE) of 85.0%.

Based on Table 2. Discriminant Validity, it can be concluded that each indicator on the research variable has a cross-loading value on the variable that it forms greater than the cross-loading value on other variables. Based on the results obtained it can be stated that the indicators used in this study have good discriminant validity in preparing their respective variables.

**TABLE 2. OEE SMELTER CK2 AND CK3 PT. ITA SMALTINDO 2017**

| Machines | Month | Loading Time (Hour) | Operational Time (Hour) | Production Result (Ton) | Production Rework (Ton) |
|---|---|---|---|---|---|
| CK 2 | Jan | 744 | 600 | 301553 | 2523 |
| | Feb | 672 | 600 | 307000 | 738 |
| | Mar | 744 | 600 | 301365 | 1506 |
| | Apr | 720 | 600 | 300786 | 734 |
| | May | 744 | 0 | 0 | 0 |
| | Jun | 720 | 0 | 0 | 0 |
| | Jul | 744 | 624 | 313314 | 0 |
| | Aug | 744 | 624 | 313609 | 0 |
| | Sep | 720 | 600 | 299809 | 0 |
| | Oct | 744 | 624 | 313841 | 482 |
| | Nov | 720 | 576 | 289775 | 653 |
| | Dec | 744 | 600 | 301083 | 338 |
| CK 3 | Jan | 744 | 600 | 226253 | 724 |
| | Feb | 672 | 576 | 230800 | 748 |
| | Mar | 744 | 600 | 225701 | 811 |
| | Apr | 720 | 600 | 225742 | 506 |
| | May | 744 | 576 | 217083 | 534 |
| | Jun | 720 | 624 | 235120 | 847 |
| | Jul | 744 | 576 | 217652 | 409 |
| | Aug | 744 | 624 | 235115 | 307 |
| | Sep | 720 | 0 | 0 | 0 |
| | Oct | 744 | 0 | 0 | 0 |
| | Nov | 720 | 624 | 235092 | 365 |
| | Dec | 744 | 624 | 234659 | 540 |

Furthermore, after the data is collected, a smelter machine OEE value is calculated with the availability, performance and quality rate values so that the OEE values are as follows:

**TABLE 3. OEE SMELTER CK2 AND CK3 PT ITA SMALTINDO 2017**

| Machines | Month | Availability | Performance | Quality | OEE | AV OEE |
|---|---|---|---|---|---|---|
| CK 2 | Jan | 80.65% | 94.29% | 99.16% | 75.41% | 65.09% |
| | Feb | 89.29% | 96.00% | 99.76% | 85.51% | |
| | Mar | 80.65% | 94.24% | 99.50% | 75.62% | |
| | Apr | 83.33% | 94.05% | 99.76% | 78.19% | |
| | May | 0.00% | 0.00% | 0.00% | 0.00% | |
| | Jun | 0.00% | 0.00% | 0.00% | 0.00% | |
| | Jul | 83.87% | 94.20% | 100.00% | 79.01% | |
| | Aug | 83.87% | 94.29% | 100.00% | 79.08% | |
| | Sep | 83.33% | 93.75% | 100.00% | 78.12% | |
| | Oct | 83.87% | 94.36% | 99.85% | 79.02% | |
| | Nov | 80.00% | 94.39% | 99.77% | 75.34% | |
| | Dec | 80.65% | 94.15% | 99.89% | 75.84% | |
| CK 3 | Jan | 80.65% | 95.47% | 99.68% | 76.74% | 65.83% |
| | Feb | 85.71% | 100.00% | 99.68% | 85.44% | |
| | Mar | 80.65% | 95.23% | 99.64% | 76.52% | |
| | Apr | 83.33% | 95.25% | 99.78% | 79.20% | |
| | May | 77.42% | 95.41% | 99.75% | 73.69% | |
| | Jun | 86.67% | 95.39% | 99.64% | 82.37% | |
| | Jul | 77.42% | 95.66% | 99.81% | 73.92% | |
| | Aug | 83.87% | 95.39% | 99.87% | 79.90% | |
| | Sep | 0.00% | 0.00% | 0.00% | 0.00% | |
| | Oct | 0.00% | 0.00% | 0.00% | 0.00% | |
| | Nov | 86.67% | 95.38% | 99.84% | 82.53% | |
| | Dec | 83.87% | 95.20% | 99.77% | 79.66% | |

Based on the calculations that have been done, the average OEE value for the CK 2 smelter is 65.09% and for the CK 3 smelter is 65.83%. This value is still far from the OEE ideal standard value of 85%. From these data it can be seen that the effectiveness of the smelter machine as a whole still needs evaluation to be improved in an effort to increase engine effectiveness.

**Calculation of Six Big Losses**, The calculation of losses in this study is used to find out what are the loss factors of the six big losses factor, which results in a non-maximum percentage of OEE (Overall Equipment Effectiveness) on the smelter. So, from the results of this calculation can also be determined factors that are the top priority to be corrected. OEE analysis six big losses that cause production equipment to not operate normally. Of the 6 main losses grouped into 3 namely downtime losses, speed losses, quality losses. Following are the grouping of six big losses, which include:

**TABLE 4. PERCENTAGE SIX BIG LOSSES 2017**

| No | Six Big Loss | CK 2 | CK 3 |
|---|---|---|---|
| 1 | Breakdown losses | 0.219% | 0.219% |
| 2 | Setup & Adjusment Losses | 0.108% | 0.114% |
| 3 | Idle & Minor stoppages | 0.000% | 0.000% |
| 4 | Reduce Speed Losses | 5.490% | 3.150% |
| 5 | Rework Losses | 0.150% | 0.170% |
| 6 | Scrap Losses | 0.000% | 0.000% |

**Analysis of OEE's Relationship with Losses,** The relationship between OEE and losses has an inverse relationship. This means that if the OEE value of a production process is low, it will produce a value for high six big losses. Vice versa. To see more clearly the Six Big Losses that affect the effectiveness of the smelter, a Time Losses calculation will be performed on each of the factors in the Six Big Losses.

**TABLE 5. SORTING PERCENTAGE OF FACTOR SIX BIG LOSSES FOR CK2 AND CK3 SMELTER MECHINES 2017**

| No | Six Big Loss | CK 2 | | | CK 3 | | |
|---|---|---|---|---|---|---|---|
| | | Total Time Loss | Persentase (%) | Persentase Komulatif (%) | Total Time Loss | Persentase (%) | Persentase Komulatif (%) |
| 1 | Reduce Speed Losses | 5707.57 | 99.26% | 99.26% | 5780.30 | 99.25% | 99.25% |
| 2 | Breakdown losses | 20.00 | 0.35% | 99.61% | 19.00 | 0.33% | 99.58% |
| 3 | Rework Losses | 13.09 | 0.23% | 99.83% | 14.67 | 0.25% | 99.83% |
| 4 | Setup & Adjusment Losses | 9.50 | 0.17% | 100.00% | 10.00 | 0.17% | 100.00% |
| 5 | Idle & Minor stoppages | 0.00 | 0.00% | 100.00% | 0.00 | 0.00% | 100.00% |
| 6 | Scrap Losses | 0 | 0.00% | 100.00% | 0 | 0.00% | 100.00% |
| | Total | 5750.16 | 100.00% | | 5823.97 | 100.00% | |

From the data it can be concluded that Reduce Speed Losses is the highest loss experienced by CK 2 and CK 3 smelters in a year which is 5707.57 hours or 99.26% for CK 2 and 5780.30 hours or 99.25% smelters for CK smelters 3. Followed losses the others, for the CK 2 smelter are: Breakdown Losses (20 hours / 0.35%), Rework Losses (13.09 hours / 0.23%), Setup and Adjustment Losses (13.09 hours / 0.17%). As for the CK 3 smelter, namely: Breakdown Losses (19 hours / 0.33%), Rework Losses (14.67 hours / 0.25%), Setup and Adjustment Losses (10 hours / 0.17%).

The results of sorting the percentage of the six big losses factor will be illustrated by a pareto diagram so that the sequence of the six factors that affect the effectiveness of the smelter is clearly seen. In this diagram illustrates that the biggest percentage is six big losses in the Reduce speed losses category. Pareto diagrams for each smelter can be seen in Figures 2.

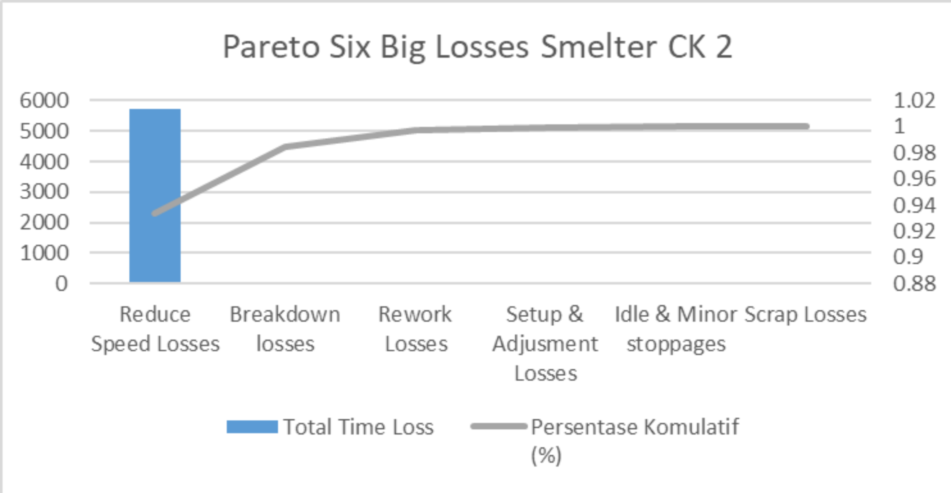


**FIG. 2. PARETO SIX BIG LOSSES SMELTER CK2 2017**

The Pareto diagram shows that the sequence of losses from the largest to the smallest are reduced speed losses, breakdown losses, rework losses, set up & adjustment losses, idle & minor stoppages and scrap losses. Based on the results of the calculation of losses found that there are 2 types of dominant losses, namely reduced speed losses and breakdown losses. The next stage is to find the root cause of the emergence of these losses. The search for root causes is done with the help of tools namely fishbone diagrams or cause-effect diagrams. Following analysis of these losses.

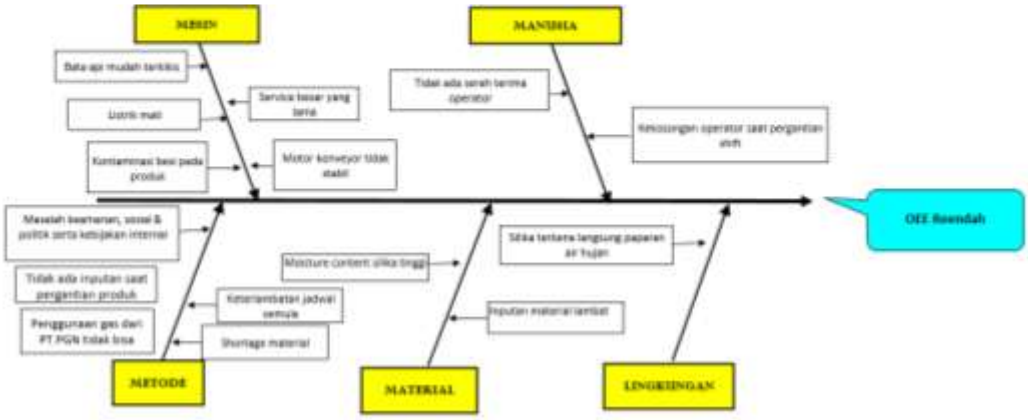


**FIG. 3. FISHBONE DIAGRAM**

Based on the results of brainstorming through the FGD, the losses that occur that cause a low OEE value are:

**Machine,** Refractory brick in the smelter will eventually erode due to high temperatures. If the refractory brick is eroded, it will eventually run out and penetrate into the metal wall (the outer portion of the smelter) and will cause iron contamination on the frit. Besides the electric motor drive conveyor problems or unstable speed, it will affect the amount of input entering the smelter.

**Humans,** Operators on the current shift do not meet the shift operators afterwards, so as to avoid the risk of production, the input of raw materials is stopped to avoid trouble in the absence of personnel, and will be reactivated when the personnel stand by at the position of the production machine.

**Method,** When changing product types, it should not be mixed with each other, to avoid these problems, the smelter does not input as long as the previous product has not been finished, while the gas from PT. PGN cannot be stopped. Besides material shortage for imported materials.

**Material,** The main raw material for making frit is silica which is directly taken from nature. Silica itself has water content that depends on the weather and natural conditions. When the water content is high, it takes longer for the drying process.

**Environment**, Silica raw material which greatly influences its water content on the weather.

After an analysis of the causes of the problem is carried out, a proposed improvement can be made which can later increase the OEE value. Here are the proposed improvements:

1. Human: Present 15 minutes before the shift time (handover).
2. Machine: The replacement of fire brick with good quality so that it does not wear out quickly, periodically check the electric motor and conveyor support, and install automatic gensets.
3. Material: Storage in a closed warehouse so that the silica moisture content is not high.
4. Method: Manage production plans by looking at the customer's production stock and implementing a safety system for raw material stock.

## V. Conclusion

After the previous discussions in this study, a conclusion can be drawn, is :

1. The average value of OEE (Overall Equipment Effectiveness) turning machines for the period January 2017 to December 2017 is 65.09% for CK 2 smelters and 65.83% for CK smelters 3. The results are still below the World Class Manufacturing Standard. Therefore, there needs to be an effort to improve OEE values.
2. The low value of OEE is caused by the high value of losses that occur on the machine.
    a. The largest loss that occurs is the category of losses from the performance efficiency factor, namely Reduced Speed Losses or losses caused by the decrease in speed at the engine operation from the speed determined by the company. This is because smelter input is unstable.
    b. The second largest loss is the losses category from the availability factor, namely breakdown. Losses are caused by the length of replacement of smelter fire bricks.
3. Improvement efforts to increase the value of OEE on these machines are:
    a. Human: Present 15 minutes before the shift time (handover).
    b. Machine: The replacement of fire brick with good quality so that it does not wear out quickly, periodically check the electric motor and conveyor support, and install automatic gensets.
    c. Material: Storage in a closed warehouse so that the silica moisture content is not high.
4. Method: Manage production plans by looking at the customer's production stock and implementing a safety system for raw material stock.

Suggestion:

1. For Company
    a. Follow-up actions to keep repairs carried out must be included in the SOP.
    b. Conducting machine performance evaluation using either the OEE method or others in order to maintain or increase productivity levels.
    c. More tidying up the manual recording of machine performance and machine production results
2. For Next Researcher
    a. Perform OEE measurements in the 'Before and After Improvement' phase.

b. There is further research into the proposed improvement using other methods that can be applied directly.

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