Analysis of Raw Mill Machines Maintenance in Cement Industry

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Abstract. Cement processing plan is a state-owned enterprise engaged in the cement industry. The problem that this factory has is such as frequent damage to the engine. The machines used in cement production at the factory include raw mill machines, kiln machines, and cement mill machines. The more often a machine is damaged, the average time between failures of a machine is lower. So that it can cause the production process is hampered. In this study, the engine studied was the Raw Mill machine at plant. The raw mill machine functions as a main material grinder in the initial milling process such as limestone, silica stone, clay, and iron sand to become raw mix. To find out the frequency of damage to the machine or the time interval between damage to the tool (MTBF) and the length of time used to repair the tool (MTTR), the Total Productive Maintenance (TPM) method is used to perform maintenance by optimizing the effectiveness of the equipment and reducing / eliminating sudden damage (breakdown) by first identifying and then the cause of the problem is identified using fish bone analysis and Failure Mode and Effect Analysis (FMEA).

Keywords: Maintenance, Mean Time Between Failure (MTBF), Mean Time To Repair (MTTR), Fault Mode and Effect Analysis (FMEA).

1. Introduction
In an effort to increase competitiveness with the other companies, the cement processing company must compete to apply management practices that lead to achieve efficiency and effectiveness of the company. One of the company's objective is to improve the effectiveness of machinery/equipment through equipment maintenance.

Maintenance is all activities related to maintaining a machine/equipment so that it is in a ready condition to operate, and if there is damage it is endeavored that the machine/equipment can be returned to a good condition. The role of new maintenance felt when the system starts to experience disruption or cannot be operated again. [1]

Maintenance activities are usually carried out according to a schedule determined by the company. Maintenance activities have been carried out at the cement processing company. However, at sometime there are still engine failures that occur. This condition certainly disrupt the production process. Maintenance activities that disrupt the production process will increase downtime. Downtime in a production system means loss of production time. Loss of production time can be caused by equipment breakdown due to damage and the time required to set up and adjust the damaged equipment. Maintenance activities will also affect the Mean Time Between Failure (MTBF) and the length of Mean Time To Repair (MTTR). The effectiveness of MTBF and MTTR in optimal conditions can be seen from the level of availability of the tool / machine. To optimize the performance of tools/machines, a good concept is needed, namely Total Productive Maintenance (TPM). Based on this, the author conclude the title of Analysis of Maintenance Raw Mill Machines in Cement Processing Company.
2. Research Methodology

2.1. Total Productive Maintenance (TPM)
Total Productive Maintenance (TPM) is a maintenance program that includes the latest concept definitions to maintain equipment and one of them can also be used by calculating performance maintenance. Performance consists of 3 parts, namely: [3]

1. Reliability
   *Reliability* is the possibility that the equipment can operate under normal conditions properly. [7] MTBF (Mean Time Between Failures) which is the time estimation between an improvement and subsequent failure (damage) of a component, machine, process or product. [6] MTBF this is formulated as the quotient of the total operating time of the machine divided by the number/ frequency of failures. Operation of the machine due to breakdown. The following is a calculation from MTBF:
   \[
   \text{MTBF} = \frac{\text{Total Operation Time}}{\text{Breakdown Frequency}}
   \] (1)

2. Maintainability
   *Maintainability* is a business and costs to carry out maintenance (maintenance). A measure of maintainability is *Mean Time To Repair* (MTTR), the increase of MTTR identifies the decrease of maintainability. [8] Dimana *Mean Time To Repair* (MTTR) is the average time the repaired machine when a failure occurs. [9] The following is an calculation from MTTR:
   \[
   \text{MTTR} = \frac{\text{Breakdown Time}}{\text{Breakdown Frequency}}
   \] (2)

3. Availability
   *Availability* is the time percentage of the machine is used. Availability (A) is calculated using the formula:[10]
   \[
   A = \frac{\text{Total Operation Time}}{\text{Leading Time}} \times 100\%
   \] (3)

2.2. Overall Equipment Effectiveness (OEE)
Overall Equipment Effectiveness (OEE) the overall effectiveness of the facility obtained by calculating the Availability, Performance, Efficiency, dan Rate of Quality Product. [2]

   OEE = Availability \times Performance \times Quality

   The following is an explanation of three ratios to measure machine effectiveness.

1. Availability
   *Availability* is the probability of a system operating at a time or in a certain interval. [11] The following is the calculation of Availability:
   \[
   \text{Availability} = \frac{\text{standby time} + \text{operational time}}{\text{Calendar time}} \times 100\%
   \] (4)

2. Performance
   Performance in OEE calculation is the number of machine products produced in the time available. The following is a calculation of performance.
   \[
   \text{Performance} = \frac{\text{Production Total/Operational Time}}{\text{Design Production Capacity}} \times 100\%
   \] (5)

   *Design Production Capacity* Raw mill (Indarung VI) = 18000 tpd (ton per day)

3. Quality
   *Quality* in this OEE is the number of machines of good products successfully produced compared to the total number of machines of products produced. Quality of cement production is calculated of 100%

2.3. Failure Mode and Effect Analysis (FMEA)
FMEA is a systematic method of identifying and preventing problems that occur in products and processes. [5]
3. Result and Discussion

3.1. Data Collection

Data collection of MTBF, MTRR, and OEE of Raw Mill Machine is the following below.

1. Operational Data

| Table 1. Operational Data of Raw Mill Machine |
|------------------------------------------------|
| Period | Operational Time (Days) | Total Operational Time (Hours) |
| 1      | 16,8                    | 403,3                        |
| 2      | 13,5                    | 324,6                        |
| 3      | 24,5                    | 587,0                        |
| 4      | 21,6                    | 519,4                        |
| 5      | 23,6                    | 567,5                        |
| 6      | 20,8                    | 498,8                        |
| 7      | 24,9                    | 597,9                        |
| 8      | 21,4                    | 513,8                        |
| 9      | 16,8                    | 402,7                        |
| 10     | 24,2                    | 581,8                        |
| 11     | 21,0                    | 504,4                        |
| 12     | 20,8                    | 499,0                        |
| Total  | 250                     | 6000,20                      |
| Average| 20,83                   | 500,02                       |

2. Data of breakdown time

| Table 2. Breakdown Time Data of Raw Mill Machine |
|------------------------------------------------|
| Period | Operational Time (Days) | Total Operational Time (Hours) |
| 1      | 1,20                    | 29,87                         |
| 2      | 2,90                    | 69,32                         |
| 3      | 2,10                    | 50,22                         |
| 4      | 6,5                     | 155,67                        |
| 5      | 4,0                     | 95,45                         |
| 6      | 4,6                     | 110,72                        |
| 7      | -                       | 0,00                          |
| 8      | 4,9                     | 116,57                        |
| 9      | 2,5                     | 60,37                         |
| 10     | 3,7                     | 87,70                         |
| 11     | 5,1                     | 122,67                        |
| 12     | 2,5                     | 59,67                         |
| Total  | 33,80                   | 808,82                        |
| Average| 3,64                    | 79,85                         |

3. Data of breakdown frequency

| Table 3. Breakdown Frequency Data of Raw Mill Machine |
|-----------------------------------------------------|
| Period | Frequency of breakdown stop |
| 1      | 42,0                         |
| 2      | 25,0                         |
4. Data **Loading Time**

**Table 4. Loading Time Data of Raw Mill Machine**

| Period | Standby Time (Days) | Total of Standby Time (Hours) |
|--------|---------------------|-------------------------------|
| 1      | 11,9                | 286,6                         |
| 2      | 11,2                | 268,1                         |
| 3      | 1,4                 | 34,4                          |
| 4      | 0,4                 | 9,8                           |
| 5      | 1,1                 | 25,7                          |
| 6      | 0,5                 | 11,3                          |
| 7      | 6,0                 | 144,5                         |
| 8      | 0,4                 | 10,7                          |
| 9      | 7,9                 | 190,0                         |
| 10     | 0,8                 | 18,3                          |
| 11     | 1,8                 | 42,5                          |
| 12     | 4,0                 | 96,5                          |
| Total  | 47,40               | 1138,40                       |
| Average| 3,95                | 94,87                         |

5. Data of Cement Production

**Table 5. Cement Production Data of Raw Mill Machine**

| Period | Production (Ton) |
|--------|-----------------|
| 1      | 245.718         |
| 2      | 212.485         |
| 3      | 405.304         |
| 4      | 396.998         |
| 5      | 416.437         |
| 6      | 376.047         |
| 7      | 328.490         |
| 8      | 382.792         |
3.2. Data Processing

The following is a recapitulation of Mean Time Between Failure (MTBF), Mean Time To Repair (MTTR), and Overall Equipment Effectiveness (OEE).

| MTBF | 8.42 Hours |
|------|------------|
| MTTR | 1.35 Hours |
| Availability | 81% |
| Performance | 83% |
| Quality (set by company) | 100% |
| OEE (overall equipment effectiveness) | 76% |

The following is the cause of the raw mill machine experiencing a breakdown.

| No. | Problems          | Description                        | Improvement          | Frequency | Duration (hours) |
|-----|-------------------|------------------------------------|----------------------|-----------|-----------------|
| 1   | Max Vibration     | Vibration crosses the threshold    | 190                  | 179:53    |
| 2   | Chain reclaimer   | The reclaimer chain broke          | Replacement of a broken reclaimer chain | 24        | 43:08           |
| 3   | Belt runtime      | Appear alarm runtime in belt       | Check and reset again | 19        | 18:00           |
| 4   | 6R1J04 trip      | Appear of alarm high current       | Check and reset again | 15        | 4:44            |

3.3 Fault Mode and Effect Analysis (FMEA)

| Part/Process Function & specification | Potential failure mode | Potential effect of failure | Potential Causes/ Mechanism failure | Occ | Det | RPN | Recommended Action |
|--------------------------------------|------------------------|-----------------------------|-------------------------------------|-----|-----|-----|-------------------|
| Man                                  | Lack of concentration | Machine stop due to maximum vibration | Operators do not focus when there are parameters change | 7   | 4   | 112 | Workers must be more focused when operating the machine |
| Machine                              | Gate used to sort     | Machine stop due to maximum vibration | Material enters and gets stuck between the gates | 8   | 7   | 56  | More often to check the machine parts |
| Material                             | There is a strange object in raw material object such as metal in the material above the table | Machine stop due to maximum vibration | Loose Raw Mill body plates or metal detection sensors do not detect strange objects | 8   | 6   | 240 | More often to do a machine inspection |

Table 6. Recapitulation of MTBF, MTTR and OEE

Table 7. Cause of the Raw Mill Machine Experiencing a Breakdown

Table 8. Problem Resolution Priority Value in Raw Mill Machines.
The hardness of mining material is not homogeneous. Take material samples for testing in the laboratory. Test the material hardness. More improvement in material testing.

| Material        | Machine stop due to maximum vibration | The hardness of mining material is not homogeneous | Take material samples for testing in the laboratory | Test the material hardness | More improvement in material testing |
|-----------------|---------------------------------------|-----------------------------------------------|-----------------------------------------------|---------------------------|--------------------------------------|
| Hard material   | 6                                     | 3                                             | 4                                             | 72                        | 72                                   |
| Hanging clay    | 7                                     | 7                                             | 2                                             | 98                        | 98                                   |

| Method of Operational Control | Bed material under ideal (operational ideal 50 mm) | Machine stop due to maximum vibration | Water injection is given to the material which causes dry material so the roller pressure must be harder | Adjust the injection of water injection | Do control of water injection | More improvement in controlling water injection |
|-------------------------------|---------------------------------------------------|---------------------------------------|-------------------------------------------------|--------------------------------------|-------------------------------|---------------------------------------------|
|                               | 8                                                 | 8                                     | 6                                              | 1                                   | 48                            | 48                                          |

4. Conclusion
From the data processing and analysis that has been done, the following conclusions can be conclude:

1. The value of the MTBF unit of Raw Mill is 8.42 hours. With the achievement of a target about 4% of the target set by the company of 250 hours, the MTTR value of the Raw Mill unit in 2018 was 1.35 hours, and the value of the Overall Equipment Effectiveness (OEE) unit of the Raw Mill was 76%. This achievement has reached the target set by the company by 75%.

2. The biggest cause of damage to the raw mill machine is the maximum vibration problem with a frequency of 190 times with a duration of 179.53 hours.

3. Based on the results of the FMEA, it was found that the biggest factors causing maximum vibrations in Raw Mill machines were material, human, and machine factors that were part of the process.

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