The Overall Equipment Effectiveness (OEE) analysis in minimizing the Six Big Losses: An effort to green manufacturing in a wood processing company

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Abstract. A company needs an appropriate maintenance management system to conduct production process effectively and efficiently. However in reality, the maintenance actions that have been taken result in losses because employees who carry out maintenance actions do not know with certainty the factors causing damage to the machine. This study was conducted to measure the level of effectiveness and analyze the factors that cause the low effectiveness of NC-Router machines. The aim is to provide recommendations for improvements in the maintenance so that six big losses can be reduced. The method used for this research was the Overall Equipment Effectiveness (OEE), which focuses on measuring the effectiveness level to prevent the loss of production time caused by breakdown on the machine. After OEE has been implemented, the overall equipment effectiveness on NC-Router machines at PT. Maruki International Indonesia, a wood processing company, for twenty periods production was 61%. The main factors causing the low OEE value on the machine were the reduce speed factor of 61.21%, as well as the idle and minor stoppages of 31.03%.

1. Introduction
The level of effectiveness of the equipment that is available on the average manufacturing industry is about half of the actual capability of the machine [1]. The main problem in engine maintenance is known as the Six Big Losses [2]. Six Big Losses are six categories of losses that must be avoided by every company because those losses can reduce the level of effectiveness of machines. Six Big Losses are usually categorized into three main categories based on aspects of their losses, namely downtime, speed losses, and defects [3].

Performance measurement methods that are widely used by companies, which can overcome the above problems, are the Overall Equipment Effectiveness (OEE) [4][5]. This method is a major part of the Total Productive Maintenance (TPM) maintenance system that is widely applied by Japanese companies. TPM itself is a philosophy from Japan that aims to maximize the effectiveness of each facility owned by the industry [6]. TPM is applied by analyzing the problems that occur in each equipment and machine using the OEE calculation method. Therefore, OEE can be regarded as a comprehensive measure that identifies the level of machine/equipment productivity from performance in theory. This measurement is
critical to know which areas need to be increased productivity or efficiency of the machine/equipment. In addition, OEE can also show the bottleneck area contained in a production process. OEE is also a measuring tool to evaluate and improve the right way to ensure increased productivity of the use of machinery/equipment.

OEE seeks to identify lost production and other indirect and hidden costs that have a significant contribution to the total cost of production. These losses are formulated as a function of a number of mainly related components, namely: availability, performance, and quality. OEE reliability with its ability to measure the effectiveness of the total (complete, inclusive, whole) of the performance of equipment in carrying out a work that has been planned, and measured from the actual data related to the availability, performance efficiency, and quality of a product. Information from OEE is used to identify and classify the causes of the low performance of equipment.

OEE solutions can help producers obtain world-recognized status. To be able to utilize the OEE method as a measurement system to monitor and improve process efficiency, a company must design a specific OEE size system that starts from identifying the causes of loss, setting targets for each OEE factor and determining the scale of priorities in achieving OEE World-Class [7]. The OEE World-Class value is 85%, with the composition of the availability element at 90%, performance element at 95%, and quality element at 99.9% [8].

Two tools generally used to help in determining the OEE value. First is Fishbone Diagrams or also known as cause-effect diagrams, that help to show the relationship between effects on various possible causes. It also illustrates the possible causes of a problem by highlighting and linking causes based on classification [9]. In general, the goal is to analyze the impact that causes a phenomenon to occur. The cause and effect diagram method is used as a supporting method to describe the causal factors that result in the low effectiveness of the machine being studied based on the 4 M's category: Machine, Method, Material, And Manpower.

The second tool is Failure mode and effect analysis (FMEA). FMEA is an analysis technique that combines the technology and experience of a person in identifying possible failures of a product or process and planning to be eliminated [5]. FMEA is used to identify failure modes, failure modes included in defects or failures in the design, conditions outside the specification limits, or changes in the product that interfere with product functionality.

PT Maruki Internasional Indonesia (MII) is a wood processing company. One of the main machines used for their production process is the NC-Router machine, which used to create the thread on the wood surface. Based on observations, it appears that preventive maintenance activities at this company are still lacking. As a result, the factors that are at the root of the problem of the occurrence of six big losses in the production process are left untouched. This study aimed to measure the level of effectiveness and analyze the factors that cause the low effectiveness of NC-Router machines.

2. Methods
This study used 20 periods’ production data from December 2018 – January 2019 at MII. The methods used for data collecting process are interview, documentary study, discussion, and brainstorming.

3. Result and discussion

3.1. Overall Equipment Effectiveness (OEE)
The data of working time NC-Router machine during 20 production periods are presented in table 1.
Table 1. The working time data of NC-Router machine

| Period | Working Days | Planned Production (pcs) | Planned Downtime (minutes) | Breakdown time (minutes) | Failure Equipment(s) | Set Up & Adjustment |
|--------|--------------|--------------------------|----------------------------|--------------------------|----------------------|----------------------|
| Period 1 | 3            | 18                       | 180                        | 0                        | 100                  |                      |
| Period 2 | 3            | 16                       | 180                        | 10                       | 100                  |                      |
| Period 3 | 4            | 30                       | 240                        | 0                        | 150                  |                      |
| Period 4 | 2            | 10                       | 120                        | 0                        | 100                  |                      |
| Period 5 | 2            | 6                        | 120                        | 0                        | 100                  |                      |
| Period 6 | 3            | 24                       | 180                        | 0                        | 100                  |                      |
| Period 7 | 3            | 20                       | 180                        | 10                       | 150                  |                      |
| Period 8 | 3            | 16                       | 180                        | 0                        | 50                   |                      |
| Period 9 | 3            | 20                       | 180                        | 0                        | 50                   |                      |
| Period 10 | 4            | 38                       | 240                        | 0                        | 150                  |                      |
| Period 11 | 2            | 20                       | 120                        | 0                        | 100                  |                      |
| Period 12 | 3            | 38                       | 180                        | 0                        | 200                  |                      |
| Period 13 | 2            | 20                       | 120                        | 0                        | 100                  |                      |
| Period 14 | 3            | 20                       | 180                        | 0                        | 50                   |                      |
| Period 15 | 3            | 16                       | 180                        | 15                       | 100                  |                      |
| Period 16 | 3            | 28                       | 180                        | 0                        | 100                  |                      |
| Period 17 | 3            | 20                       | 180                        | 15                       | 100                  |                      |
| Period 18 | 3            | 28                       | 180                        | 0                        | 150                  |                      |
| Period 19 | 3            | 16                       | 180                        | 0                        | 50                   |                      |
| Period 20 | 3            | 36                       | 180                        | 10                       | 100                  |                      |

Working days shows the number of days in a certain period for finishing the planned production in NC-Router machine, where one working day equal to nine working hours. Planned downtime shows the stop time of the machine, while breakdown time shows when the machine abruptly stops from the operation because of the defect or adjustment time. The production amounts of NC-Router machine during 20 periods are presented in table 2.

Table 2. The production data of NC-Router machine

| Period | Planned Production (pcs) | Broken (pcs) | Product Amount (pcs) |
|--------|---------------------------|--------------|----------------------|
|        | Scrap & Rework | Startup Losses |                       |
| Period 1 | 18             | 0             | 0                    | 18                    |
| Period 2 | 16             | 0             | 0                    | 16                    |
| Period 3 | 30             | 0             | 0                    | 30                    |
| Period 4 | 10             | 0             | 0                    | 10                    |
| Period 5 | 6              | 0             | 0                    | 6                     |
| Period 6 | 24             | 0             | 0                    | 24                    |
| Period 7 | 20             | 0             | 0                    | 20                    |
| Period 8 | 16             | 0             | 0                    | 16                    |
| Period 9 | 20             | 0             | 0                    | 20                    |
| Period 10 | 38             | 0             | 0                    | 38                    |
| Period 11 | 20             | 0             | 0                    | 20                    |
| Period 12 | 38             | 0             | 0                    | 38                    |
| Period 13 | 20             | 0             | 0                    | 20                    |
| Period 14 | 3              | 0             | 0                    | 3                     |
| Period 15 | 16             | 0             | 0                    | 16                    |
| Period 16 | 28             | 0             | 0                    | 28                    |
| Period 17 | 20             | 0             | 0                    | 20                    |
| Period 18 | 28             | 0             | 0                    | 28                    |
| Period 19 | 16             | 0             | 0                    | 16                    |
| Period 20 | 36             | 0             | 0                    | 36                    |
The OEE calculation of NC-Router machine during 20 periods is presented in table 3.

| Period   | Availability Rate (%) | Performance Rate (%) | Quality Rate (%) | OEE (%) |
|----------|------------------------|-----------------------|------------------|---------|
| Period 1 | 93%                    | 54%                   | 100%             | 50%     |
| Period 2 | 92%                    | 48%                   | 100%             | 44%     |
| Period 3 | 92%                    | 68%                   | 100%             | 63%     |
| Period 4 | 90%                    | 47%                   | 100%             | 42%     |
| Period 5 | 90%                    | 28%                   | 100%             | 25%     |
| Period 6 | 93%                    | 72%                   | 100%             | 67%     |
| Period 7 | 89%                    | 63%                   | 100%             | 56%     |
| Period 8 | 97%                    | 46%                   | 100%             | 44%     |
| Period 9 | 97%                    | 58%                   | 100%             | 56%     |
| Period 10| 92%                    | 86%                   | 100%             | 79%     |
| Period 11| 90%                    | 93%                   | 100%             | 83%     |
| Period 12| 86%                    | 94%                   | 100%             | 81%     |
| Period 13| 90%                    | 93%                   | 100%             | 83%     |
| Period 14| 97%                    | 58%                   | 100%             | 56%     |
| Period 15| 92%                    | 48%                   | 100%             | 44%     |
| Period 16| 93%                    | 84%                   | 100%             | 78%     |
| Period 17| 92%                    | 60%                   | 100%             | 56%     |
| Period 18| 90%                    | 87%                   | 100%             | 78%     |
| Period 19| 97%                    | 46%                   | 100%             | 44%     |
| Period 20| 92%                    | 93%                   | 100%             | 86%     |
| Average  | 92%                    | 66%                   | 100%             | 61%     |

The recapitulation of the time losses averages ratio during 20 periods of production is presented in table 4.

| Losses Type | Six Big Losses       | Time Losses (%) | Cumulative |
|-------------|----------------------|-----------------|------------|
| Availability Ratio | Equipment Failure     | 0.22%           | 1%         |
|              | Set Up & Adjustment  | 7.54%           | 9%         |
| Speed Losses | Idle & Minor Stoppages | 31.03%         | 43%        |
|              | Reduce Speed         | 61.21%          | 96%        |
| Quality Losses | Scrap & Rework     | 0%              | 98%        |
|              | Startup Losses       | 0%              | 100%       |

3.2. The Fish Bone Diagram

Base on the six big losses calculation, there were two potential factors of the loss: Time losses at NC-Router machine and divided by reducing speed, and idle and minor stoppages. Both diagrams for those two potential factors of the loss are presented in figure 1 and 2.
Figure 1. The Ishikawa diagram of reducing speed losses on NC-Router machine

Figure 2. The Ishikawa diagram of idle and minor stoppages on NC-Router machine
3.3. Failure Mode and Effect Analysis (FMEA)

The rank of Risk Priority Number (RPN) based on the cause of failure presented in table 5. The highest RPN value from each factor must be analyzed to determine the suggested improvement.

Table 5. The Risk Priority Number rank based on the cause of failure

| Failure Category | Cause of Failure           | RPN |
|------------------|----------------------------|-----|
| Machine          | Machine abruptly stop      | 112 |
|                  | Electricity interruption   | 112 |
|                  | Machine idle              | 84  |
|                  | Unclean working station    | 70  |
|                  | **Total**                 | **378** |
| Material         | Unavailable material       | 210 |
|                  | Set-up process re-do      | 70  |
|                  | Material damaged          | 28  |
|                  | Inappropriate material specification | 14 |
|                  | **Total**                 | **308** |
| Manpower         | Prolonged working hours   | 112 |
|                  | Prolonged working period  | 63  |
|                  | The operator not available| 63  |
|                  | Loss focus of the manpower | 56 |
|                  | **Total**                 | **294** |

4. Conclusion

After OEE had been implemented, the overall equipment effectiveness on NC-Router machines at MII, a wood processing company, for twenty periods production was 61%. The main factors causing the low OEE value on the machine were the reduce speed factor of 61.21%, as well as the idle and minor stoppages of 31.03%. From the Ishikawa Diagram, the main problems in NC-Router machines at MII such as machine abruptly stop, electricity interruption, unavailable material, and prolonged working hours must be analyze deeply to determine the proper suggested improvement.

References

[1] Muchiri P and Pintelon L 2008 Performance measurement using overall equipment effectiveness (OEE): literature review and practical application discussion *Int. J. Prod. Res.* 46 3517–35
[2] Badiger A S and Gandhinathan R 2008 A proposal: evaluation of OEE and impact of six big losses on equipment earning capacity *Int. J. Process Manag. Benchmarking* 2 234–48
[3] Sowmya K and Chetan N 2016 A review on effective utilization of resources using overall equipment effectiveness by reducing six big losses *Int. J. Sci. Res. Sci. Eng. Technol.* 2 2394–4099
[4] Dal B, Tugwell P and Greatbanks R 2000 Overall equipment effectiveness as a measure of operational improvement—a practical analysis *Int. J. Oper. Prod. Manag.* 20 1488–502
[5] Stamatis D H 2017 *The OEE primer: understanding overall equipment effectiveness, reliability, and maintainability* (New York: CRC Press)
[6] Nakajima S 1989 *TPM development program: implementing total productive maintenance*
(Productivity press Cambridge, MA)

[7] Krzysztof K 2018 The Impact of Performance Improvement Achieved by the Closing Machine up to the Level of World-Class OEE on the Results of the Production Process Terotechnology: 10th Conference on Terotechnology vol 5 (Materials Research Forum LLC) p 117

[8] Willmott P and McCarthy D 2000 TPM-A Route to World Class Performance: A Route to World Class Performance (Elsevier)

[9] Ilie G and Ciocoiu C N 2010 Application of fishbone diagram to determine the risk of an event with multiple causes Manag. Res. Pract. 2 1–20