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# *Improving Machine Efficiency at PT PID Ongkowidjojo:*
## *OEE and FMEA Analysis Leading to Significant Gains in Primary Stage 3*

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**Abstract.** This study aims to enhance equipment effectiveness in the primary cigarette manufacturing process at PT. PID Ongkowidjojo, focusing on Stage 3, a critical production phase with significant downtime due to equipment failures. Using Overall Equipment Effectiveness (OEE) and Failure Mode and Effects Analysis (FMEA), the research identified nine key failure modes affecting interconnected machines. Based on these findings, targeted improvements were implemented, including scheduled maintenance, real-time monitoring, periodic cleaning, and spare parts inventory management. As a result, the OEE value increased from 50.52% to 56.57%, driven by improvements in Availability (71.07% to 79.22%) and Quality Rate (92% to 93.36%), despite a slight decline in Performance Rate (77.20% to 76.25%). This study highlights the importance of integrating OEE and FMEA methodologies to reduce downtime and address equipment inefficiencies. By tackling the Six Big Losses, particularly equipment failures, this approach offers actionable insights for maintaining operational efficiency and fostering continuous improvement in manufacturing systems.

**Keywords:** Cigarette primary processing; Equipment effectiveness; Failure Mode and Effect Analysis (FMEA); Six big losses; Overall Equipment Effectiveness (OEE)

## 1. Introduction

The effectiveness of equipment or machinery is critical in ensuring the smooth operation of production processes. In manufacturing industries, three primary factors often disrupt production: machinery, environment, and human factors, which are interconnected and can influence each other (Triwardani et al., 2017). Addressing these factors is essential to maintaining production efficiency and meeting operational goals.

In the cigarette manufacturing process, production is divided into two key stages: the primary and secondary processes. The primary process involves blending tobacco and cloves into a mixture ready for rolling, serving as the foundation of cigarette production. This stage is crucial as it determines the flavor and quality of the final product (Kurniarso & Azwir, 2014). Inefficiencies or delays in the primary process can disrupt the entire production cycle, emphasizing the need for optimized machine performance.

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Downtime is a critical metric for evaluating machine effectiveness, as non-operational machines result in wasted production time (Exor, 2013). Downtime is categorized into two types: setup and adjustment downtime, which occurs during machine configuration changes, and equipment failure, caused by mechanical breakdowns (Nurwulan & Fikri, 2020). Addressing downtime is essential to improving machine availability and overall production efficiency. Table 1 presents the data on equipment failure time for the primary process.

**Table 1** Data on Equipment Failure in the Primary Process

| Primary Process | April | May | June | Total |
|---|---|---|---|---|
| Stage 1 | 0 | 0 | 0 | 0 |
| Stage 2 | 0 | 2.210 | 1.930 | 4.140 |
| Stage 3 | 2.570 | 4.920 | 2.405 | 9.895 |
| Clove | 1.301 | 2.485 | 2.610 | 6.396 |
| Total Equipment Failure Time | | | | 20.431 |

Source: Processed Data

Between April and June 2023, the primary cigarette manufacturing process at PT. PID Ongkowidjojo experienced significant downtime, totaling 20,431 minutes. Among the stages, Stage 3 recorded the highest equipment failure time at 9,895 minutes, surpassing Stages 1 and 2. As Stage 3 is the initial stage of the primary process, frequent equipment failures here disrupt downstream production activities and highlight low machine effectiveness.

To address this issue, the study applies Overall Equipment Effectiveness (OEE) and Failure Mode and Effects Analysis (FMEA) methodologies. OEE is a widely recognized tool for evaluating and enhancing machine performance to meet world-class standards (Saw Shu Zhen et al., 2024). Meanwhile, FMEA is a systematic approach to identifying and mitigating potential failure modes, as demonstrated in prior studies (Fadhlullah et al., 2024; Pramono et al., 2024). By integrating these methods, this research aims to reduce equipment downtime, improve machine performance, and provide actionable insights for optimizing the primary cigarette manufacturing process.

## 2. Methods

The methods to be used to improve the machine effectiveness in Stage 3 of the primary process at PT PID Ongkowidjojo are the Overall Equipment Effectiveness (OEE) and Failure Modes and Effect Analysis (FMEA) methods. The OEE method is employed to measure machine effectiveness based on the factors of Availability, Performance Rate, and Quality Rate, which together yield the OEE value. The OEE value will be analyzed based on the Six Big Losses that have the most significant impact. The most influential factors among the Six Big Losses will be analyzed using the FMEA method, which is expected to minimize downtime in Stage 3 and enhance overall machine effectiveness.

### *2.1 Overall Equipment Effectivess (OEE)*

Overall Equipment Effectiveness (OEE) is a tool used to identify the potential within equipment as well as to identify and track losses (Stamatis, 2010). OEE can be utilized to enhance the effectiveness of machinery or equipment, as well as to empower operators to perform routine activities that also boost productivity and responsibility (Nakajima, 1988). OEE is widely accepted as a tool to measure and evaluate the productivity of production processes.

OEE is divided into three measurement metrics: Availability, Performance, and Quality. The calculation of OEE is done by multiplying the values of equipment availability, work performance, and product quality rate (Pranowo, 2019), as shown in Equation 1.

$$OEE(\%) = Availability \times Performance\ rate \times Quality\ rate \tag{1}$$

#### 2.1.1. Six Big Losses

The Six Big Losses reduce equipment or machinery performance and are categorized into downtime, speed, and defect losses. Downtime losses include breakdowns (unplanned stoppages due to equipment failure) and setup/adjustment time. Speed losses cover idling and minor stoppages (short production halts) and reduced speed (operating below capacity). Defect losses involve defects in process (production of defective items) and reduced yield (producing fewer good products from raw materials) (Alriva et al., 2015).

### 2.1.2 Availability

Availability measures the time a machine is available for operation. It is influenced by equipment failure and setup and adjustment losses from the Six Big Losses, meaning it directly impacts downtime losses.

$$Availability = \frac{Loading\ time - Downtime\ Losses}{Loading\ Time} \times 100\% \quad (2)$$

### 2.1.3 Performance Rate

The performance rate describes the ability of a machine or equipment to produce goods. It is affected by idling and minor stoppage losses and reduced speed, which are two factors from the Six Big Losses.

$$Performance\ Rate = \frac{Processed\ Amount \times Ideal\ Cycletime}{Operating\ time} \times 100\% \quad (3)$$

### 2.1.4 Quality Rate

The quality rate represents the machine's ability to produce products that meet standards. It is influenced by two types of losses: defects in process and reduced yield (Ariyah, 2022).

$$Quality\ Rate = \frac{Processed\ Amount - Number\ of\ defect}{Processed\ Amount} \times 100\% \quad (4)$$

### *2.2 Failure Mode and Effect Analysis (FMEA)*

Failure Mode and Effects Analysis (FMEA) is utilized as a tool for identifying and eliminating potential failures or damages. The identification of these failures encompasses mechanisms, impacts, likelihoods, prevention strategies, and methods for detection (Nurkertamanda and Wulandari, 2009). The application of FMEA is employed to analyze manufacturing and assembly processes, as well as product design prior to mass production (Wawolumaja and Muis, 2013). To facilitate the FMEA process, a worksheet in the form of a table is utilized. Within it, there is a list of failure modes of the process under analysis, a list of impacts from losses should they occur, S-scale value, O-scale value, D-scale value, calculated RPN value, RPN value category, and preventive actions (Alijoyo, 2017).

## 3. Results and Discussion

In Figure 1, the tobacco processing process is depicted at stage 3 of the primary process at PT PID Ongkowidjojo. This stage involves several machines: Slicer, Conditioning, Trasher 1, Separator 1, Trasher 2, Separator 2, RC4, Dryer, SILO, interconnected by a conveyor. Tobacco is initially processed through the slicer machine for cutting, then transferred to the conditioning machine for humidification. After humidification, the tobacco undergoes disintegration and separation of Non-Tobacco Related Materials (NTRM) from the tobacco by the trasher and separator machines. The subsequent process involves shredding by the RC4 machine. Once shredded, the tobacco is moved to the dryer machine for drying. Finally, the tobacco is sent to the SILO for blending before being packed into bags and stored. Processed tobacco from stage 3 continues to stage 1 for further refinement processes.

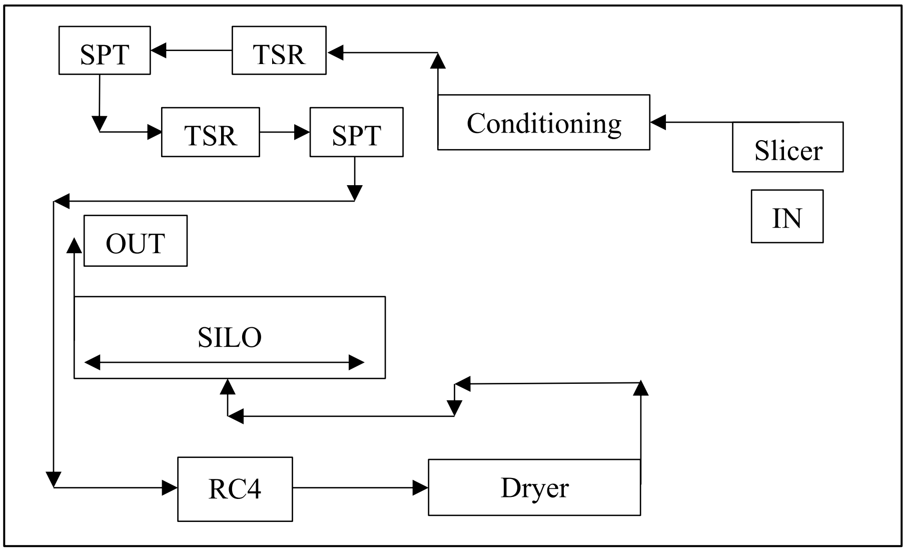


**Figure 1** Stage 3 of Tobacco Processing

The tobacco processing stage 3 consists of nine interconnected machines. Therefore, if any one machine experiences a malfunction and stops, it will result in a complete shutdown of all machines. Hence, the machine uptime data collected represents the entirety of stage 3. Table 2 presents the calculation of Overall Equipment Effectiveness (OEE) data before improvement from April to October 2023.

**Table 2** The Average OEE Values Before The Improvements

| Months | Availability | Performance Rate | Quality Rate | Nilai OEE |
|---|---|---|---|---|
| April | 70.74% | 78.16% | 93.03% | 51.44% |
| May | 71.54% | 78.64% | 92.81% | 52.21% |
| June | 68.96% | 74.45% | 88.19% | 45.28% |
| July | 70.55% | 74.94% | 90.93% | 48.08% |
| August | 73.85% | 79.08% | 92.36% | 53.93% |
| September | 70.92% | 78.09% | 93.19% | 51.61% |
| October | 70.91% | 77.06% | 93.50% | 51.09% |
| Average | 71.07% | 77.20% | 92.00% | 50.52% |

The average OEE value for stage 3 from April to October 2023 was 50.52%, with an Availability value of 71.07%, Performance Rate of 77.20%, and Quality Rate of 92.00%. Among the three ratios comprising the OEE, the Availability ratio had the lowest average, at 71.07%. This ratio is influenced by two aspects within the Six Big Losses framework: equipment failure and setup and adjustment. A comparison of these two types of losses is presented below, along with loading time data from April 2023:

$$Equipment\ Failure\ Losses = \frac{Equipment\ Failure\ Time}{Loading\ Time} \times 100\% \quad (5)$$

$$= \frac{2570}{13860} \times 100\%$$

$$= 18.54\%$$

$$Set\ up\ and\ Adjustment = \frac{Set\ up\ and\ Adjustment}{Loading\ Time} \times 100\% \quad (6)$$

$$= \frac{1485}{13860} \times 100\%$$

$$= 10.71\%$$

Based on the above ratio calculations, Equipment failure accounts for the highest loading time, totaling 18.54%. This indicates that 18.54% of the loading time is spent on machine repairs. This figure is higher compared to the time allocated for setup and adjustment, which stands at 10.71%. Therefore, it can be concluded that the Six Big Losses factor most significantly impacting Overall Equipment Effectiveness (OEE) is equipment failure.

Equipment failure occurs when machines break down, halting production entirely. The causes of equipment failure for each machine in stage 3 will be detailed in the Failure Mode and Effects Analysis (FMEA). This FMEA focuses on failure modes that could occur in each machine within stage 3, where each machine represents a tobacco processing process. The FMEA data is based on direct observations in stage 3 and interviews with two experienced machine supervisors and operators.

The FMEA for the tobacco processing machines identifies several potential failures, including malfunctioning limit switches, worn-out or broken knives, hydraulic system issues, incorrect conditioning settings, and electrical supply disturbances. These failures can cause significant operational disruptions, such as ineffective cutting or shredding of tobacco, machine downtime, and improper moisture levels in the tobacco. The analysis highlights the need for regular inspections, timely maintenance, and the availability of spare parts to mitigate these risks. Recommended actions include scheduling regular machine checks, cleaning key areas, lubricating bearings, and conducting inspections by mechanical and electrical teams to ensure optimal machine performance and minimize downtime.

Out of these suggestions aimed at reducing downtime, four were implemented in stage 3 of the primary process at PT PID Ongkowidjojo: regular machine checks, periodic machine cleaning, continuous monitoring during operation, and repairs conducted by vendors. Following the implementation in stage 3, a new OEE value measurement was conducted. Table 3 presents the calculated OEE values from November to January 2024.

**Table 3** The Average OEE Values After The Improvements

| Months | Availability | Performance Rate | Quality Rate | OEE |
|---|---|---|---|---|
| November | 79.47% | 76.44% | 94.03% | 57.12% |
| December | 77.41% | 75.47% | 92.63% | 54.61% |
| January 2024 | 80.78% | 76.83% | 93.42% | 57.97% |
| Average | 79.22% | 76.25% | 93.36% | 56.57% |

The average OEE value before improvements was 50.52%, and after the improvements, it increased to 56.57%. The average Availability ratio improved from 71.07% to 79.22%, while the Performance Rate decreased from 77.20% to 76.25%, and the Quality Rate increased from 92% to 93.36%. Based on these comparisons, it can be concluded that the research successfully increased the average Overall Equipment Effectiveness.

The proposals that had the highest impact on improving OEE were regular machine checks and periodic thorough machine cleaning. Previously, machines in stage 3 were only checked when they malfunctioned and required repairs. With the implementation of regular machine checks, operators now inspect machines before use. If any machine issues are detected, repairs can be conducted on the same day or scheduled for weekends. During this implementation, the average downtime decreased compared to before. Furthermore, weekly maintenance also contributed to better operation of the machines in stage 3, thereby increasing machine effectiveness.

## 4. Conclusions

The study initially identified a low Overall Equipment Effectiveness (OEE) of 50.52% from April to October 2023, primarily due to equipment failure, a key factor among the Six Big Losses. Using Failure Mode and Effect Analysis (FMEA) at stage 3, recommendations were developed, including regular inspections, scheduled repairs, continuous monitoring, thorough cleaning, periodic electrical checks, and maintaining spare parts. Implementation focused on proactive scheduling of repairs based on real-time observations before production, managed by stage 3 supervisors with the mechanical division.

Following these interventions, OEE for November 2023 to January 2024 increased significantly to 56.57%, alongside improvements in availability (79.22%), performance (76.25%), and quality (93.36%) metrics. This underscores the effectiveness of the implemented strategies in enhancing primary stage 3 processes. Continuous evaluation is crucial to sustain and further improve these gains.

Future research at PT PID Ongkowidjojo should prioritize ongoing maintenance of stage 3 machinery, expanding FMEA application beyond the Six Big Losses to improve OEE, and conducting thorough OEE assessments across all sections to optimize process efficiency. These efforts are essential for enhancing operational effectiveness and productivity in the organization.These recommendations aim to guide future research and support ongoing efforts in improving manufacturing efficiency through effective maintenance and process optimization strategies.

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