CHAPTER I
INTRODUCTION

This chapter includes the background, problem formulation, objectives, scope of study, assumptions of study, and the outline of this research.

1.1 Background

Maintenance is defined as all activities that are necessary to maintain a component or machine throughout its life cycle, or to restore it to a state in which it can perform its required function. Maintenance is essential, as it directly impacts the production capacity of the machines used in the manufacturing process (Rakyta et al., 2024). Maintenance is also a discipline that must be adapted to the specific operations or organization it serves, since similar problems may require different approaches (Higgins et al., 2002).

In today's industrial environment, companies are required not only to achieve high production output but also to maintain cost efficiency and operational reliability. Unplanned downtime has been identified as a major challenge in industrial operations, as it reduces production capacity by up to 20% and causes significant financial losses (Cristian et al., 2025). According to the research conducted by Susilo & Widjajati (2025), the implementation of maintenance strategies can minimize total maintenance costs by up to 41.55%. Furthermore, research conducted by Afdal & Linarti (2023) demonstrated that the appropriate maintenance was able to enhance the reliability level of the machine by 44.63% based on optimal preventive maintenance interval analysis. However, maintenance activities may temporarily interrupt the production process and result in economic losses. Kusmono et al.(2024) found that inadequate maintenance management led to a production opportunity loss of USD 1,706,574.20, with unplanned shutdowns contributing 92.49% of the total.

Maintenance consists of two types: planned maintenance and unplanned maintenance. Planned maintenance involves routine and scheduled activities, whereas unplanned maintenance occurs randomly and must be considered as a stochastic process (Wijaya, 2024). Both types of maintenance share a common characteristic, even for the same asset, the maintenance activities vary over time. This variation arises from the complexity and scope of each maintenance task.

PT Semen Padang, the first cement factory in Indonesia and Southeast Asia, established on March 18th, 1910. The company operates with an annual cement production capacity reaching millions of tons (Arzaq et al., 2024). In addition to cement production, PT Semen Padang also manages non-cement products under the Non-Cement Production Unit. This unit manages various non-cement product productions, one of which is split stone.

The raw material for split stone is basalt rock obtained from Bukit Karang Putih. Basalt rock has high density and strength, and is resistant to weathering, making it suitable for use as a construction material for buildings, roads, bridges, and also as aggregates (Sopan et al., 2024). PT Semen Padang manufactures split stone in four different sizes: 0-10 mm, 10-20 mm, 20-30 mm, and 30-50 mm. The 0-10 mm size is used for construction, the 10-20 mm size is for casting, the 20-30 mm size is suitable for highway construction, and the 30-50 mm size is typically used as ballast for railway tracks. **Figure 1.1** presents the illustration of the split stone product.

Figure 1.1 Split Stone
(Source: https://www.semenpadang.co.id/id/produk/non-semen/)

The production of split stone involves numerous machines, such as the Hopper, Vibrating Feeder, Jaw Crusher, Cone Crushers 01 and 02, Belt Conveyors U01, U02, U03, U04, U05, U06, U07, U10, and the Vibrating Screen. The production process begins with raw materials being fed into the Hopper, then transferred to the Jaw Crusher via the Vibrating Feeder, where the material is broken down into medium-sized pieces. The output from the Jaw Crusher is conveyed to Cone Crusher 01 through Belt Conveyor U01 for further reduction. The crushed material is then sent to a Vibrating Screen via Belt Conveyor U02 to be separated based on size. Stones sized 0–10 mm are transferred through Belt Conveyor U03 to stockpile stone sized 0-10 mm for construction purposes, 10–20 mm stones via Belt Conveyor U04 to stockpile stone sized 10-20 mm for casting, 20–30 mm stones via Belt Conveyor U05 to stockpile stone sized 20-30 mm for highway construction, and 30–50 mm stones are sent back to Cone Crusher 02 for further reduction through Belt Conveyor U10. The Cone Crusher 02 processes these larger stones to produce smaller sizes, which are then sent back to the Vibrating Screen via Belt Conveyors U07 and U02 for further screening. Any stones larger than 50 mm are directed to Cone Crusher 01 through Belt Conveyor U07. This ensures that the desired sizes and quality of split stone products, 0–10 mm, 10–20 mm, and 20–30 mm, are achieved for different construction applications. **Figure 1.2** illustrates the flowchart of the crushed stone production process.

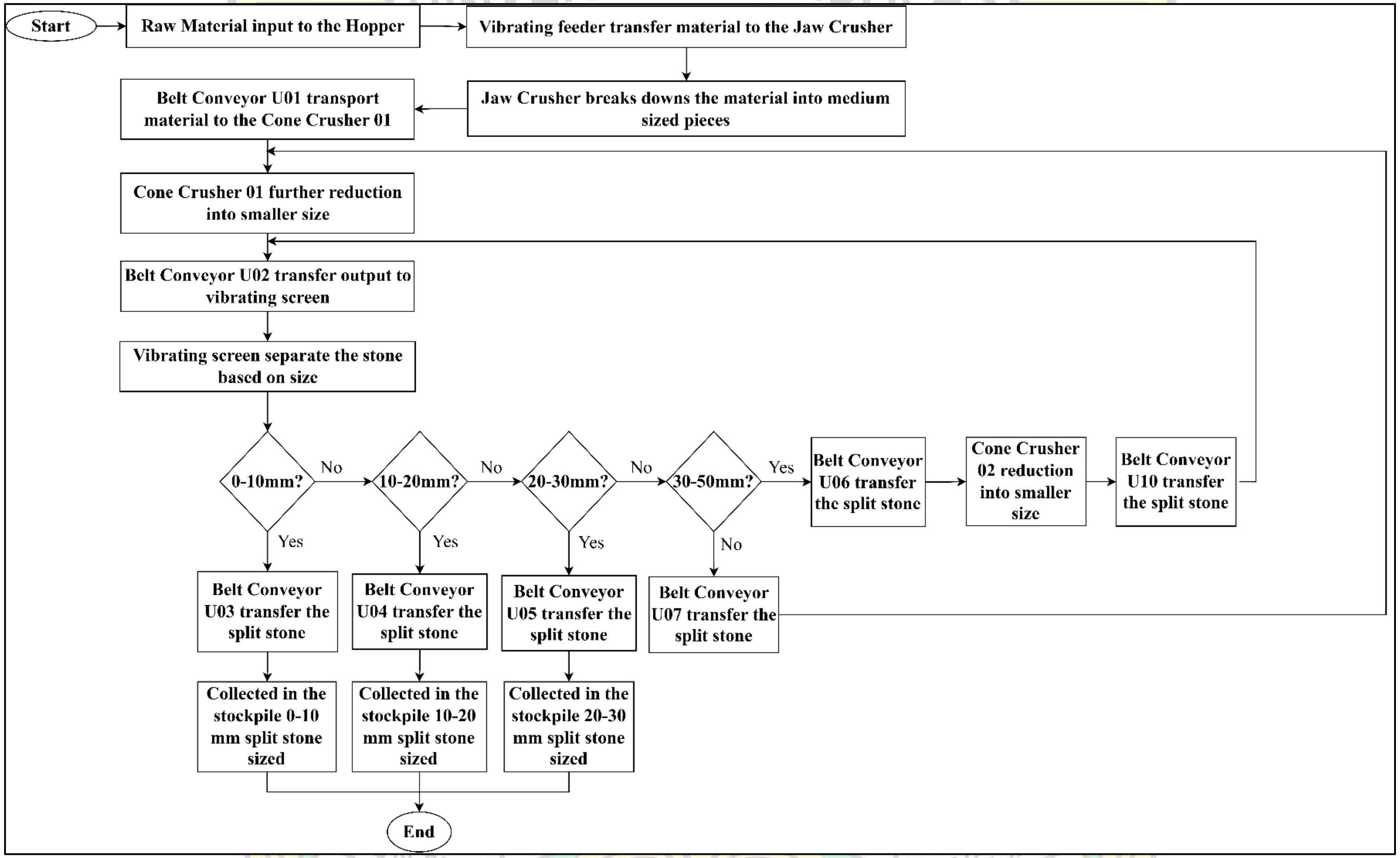

Figure 1.2 The Production Process of Split Stone.

The layout of the split stone production floor can be seen in **Figure 1.3** below.

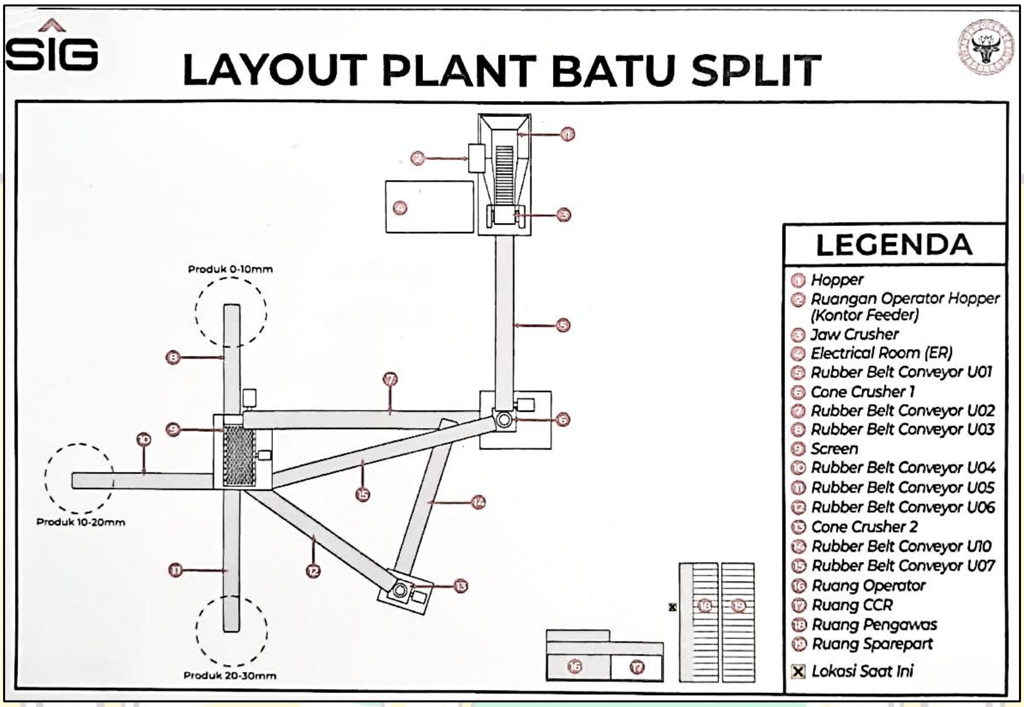

Figure 1.3 Split Stone Production Floor Layout

Proper maintenance planning is important because the split stone production process relies on a series of interconnected machines. The next stage depends on the previous one, no stage can be skipped or bypassed. Therefore, the process can not proceed if any stage experiences a disruption. When any machine stops functioning, it will halt the entire production line until maintenance is carried out.

The split stone plant operates five days a week, from Monday to Friday, with working hours from 8 AM to 6 PM, including an hour break, resulting in an ideal operational time of 9 hours per day or around 45 hours per week. The monthly production target is set at 10.000 tons. However, the actual production of split stone does not always meet the target. **Figure 1.4** illustrates the comparison of target and actual split stone production from October 2023 to October 2025.

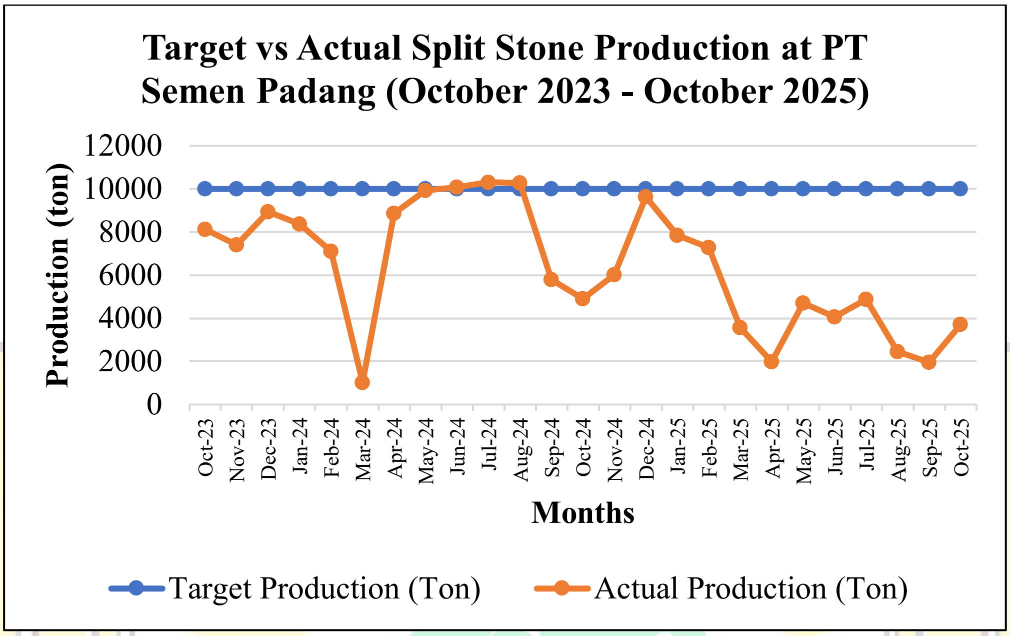

Figure 1.4 Target vs Actual Split Stone Production at PT Semen Padang (October 2023- October 2025)

Based on **Figure 1.4**, the production target was consistently at 10.000 tons per month, while the actual production showed significant fluctuations. Only for the period of May 2024 to August 2024, the actual production was relatively close to the target. Identification of this problem required systematic data collection covering the period from October 2023 to October 2025. The collected data include production records, machine operating hours, and downtime records. The data were processed and presented in the form of operating time allocation graphs and proportional distribution charts.

Figure 1.5 shows the distribution of available operating hours into productive, planned delay, breakdown, and non-breakdown delay in the Split Stone Plant from October 2023 to October 2025.

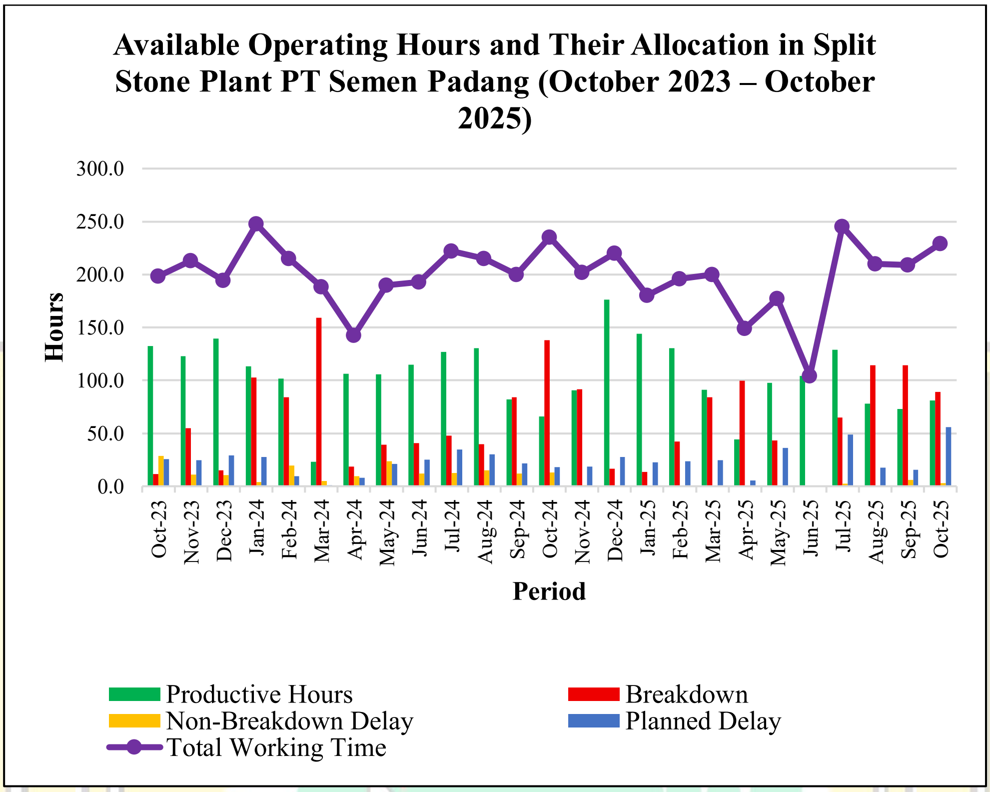

Figure 1.5 Available Operating Hours and Their Allocation in Split Stone Plant PT Semen Padang (October 2023–October 2025)

Based on **Figure 1.5**, the total working time represents the total operating hours in the Split Stone Plant. The total working time shown in the graph corresponds to the plant's operating schedule, which operates from 8:00 AM to 6:00 PM, with an additional overtime period of up to three hours per day and occasional overtime on Saturdays. The total working time in the Split Stone Plant is divided into four categories: productive hours, non-breakdown delay, breakdown, and planned delay. Productive hours represent the time when the machines are actively operating and producing output. Planned delay refers to scheduled stoppages of production activities, such as safety talks and break time. Non-breakdown delay refers to delays that occur due to factors other than machine failures, such as waiting for materials, materials overflow, and waiting for loading. Breakdown indicates the time lost due to unexpected machine failure or a mechanical problem that interrupts production.

Observation results show that machine breakdowns occurred almost every month during the study period. Downtime is defined as the period when the machine is unable to operate due to breakdowns or maintenance activities. The average recorded breakdown duration during the observation period was approximately 66.67 hours per month. The highest breakdown duration occurred in March 2024, reaching 159.3 hours, while the lowest was observed in October 2023, with only 12.7 hours. **Figure 1.6** presents a comparison of the time distribution throughout the observation period, categorized into productive hours, non-breakdown delays, breakdown delays, and planned delays.

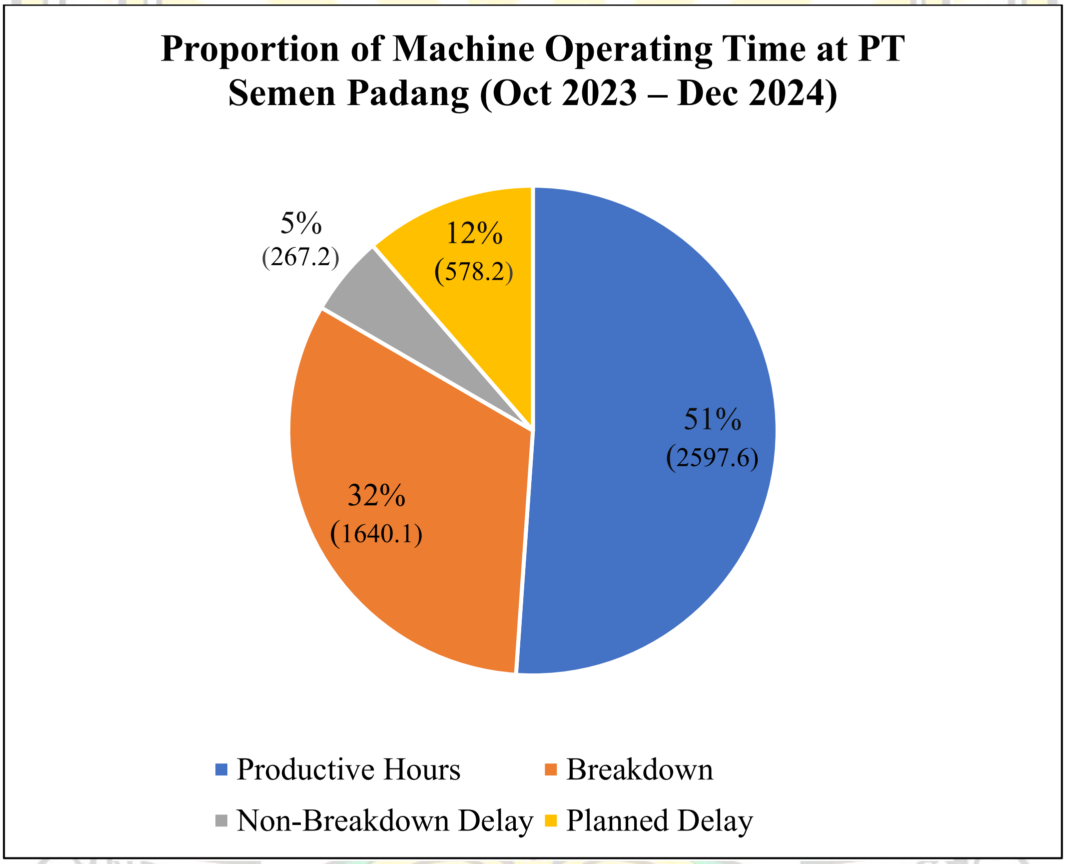

Figure 1.6 Proportion of Total Working Time Allocation at Split Stone Plant PT Semen Padang (October 2023– October 2025)

Based on **Figure 1.6**, the productive hours account for only 51%, while breakdown hours still represent a significant portion at 32%. This indicates that the machine's operating performance has not yet reached the ideal condition, where availability should be up to 90% (NS.Nakajima, 1988). The large gap between the current performance and the target (39%) suggests the presence of significant issues that limit operational efficiency and require further investigation and corrective action.

Currently, PT Semen Padang implements both corrective and preventive maintenance strategies in the Split Stone Plant. Corrective maintenance refers to maintenance activities carried out after a failure occurs. Preventive maintenance is scheduled once a week and is scheduled at the end of each workweek to determine the maintenance plan for the following week. The tasks carried out include lubrication of the Jaw Crusher bearings, inspection and cleaning of the Cone Crusher 01, Cone Crusher 02, Belt Conveyor, Hopper, and Vibrating Feeder, as well as lubrication of Vibrating Screen bearings no 1 and 2. Although these activities are carried out once a week, the maintenance does not have a fixed day or a consistent interval. Preventive maintenance scheduling is adjusted according to production demand rather than determined through analytical evaluation of failure patterns.

However, despite these maintenance activities, the current maintenance policy still needs improvement, as the percentage of breakdown time remains high at 32%. This condition indicates that current maintenance practices have not been fully effective in reducing unexpected equipment failures and improving availability. In order to identify the machines that contribute most significantly to downtime, a further analysis was conducted using breakdown data recorded from October 2023 to October 2025. The analysis focuses specifically on downtime caused by mechanical failures that required maintenance activities. Downtime resulting from external or non-mechanical factors, such as electrical disturbances, overload trips, or operational interruptions, was excluded to ensure that the evaluation concentrates on failures directly related to mechanical reliability and maintenance performance. **Figure 1.7** presents the total downtime for each machine to identify which machines contributed the most to the overall downtime recorded from October 2023 to October 2025.

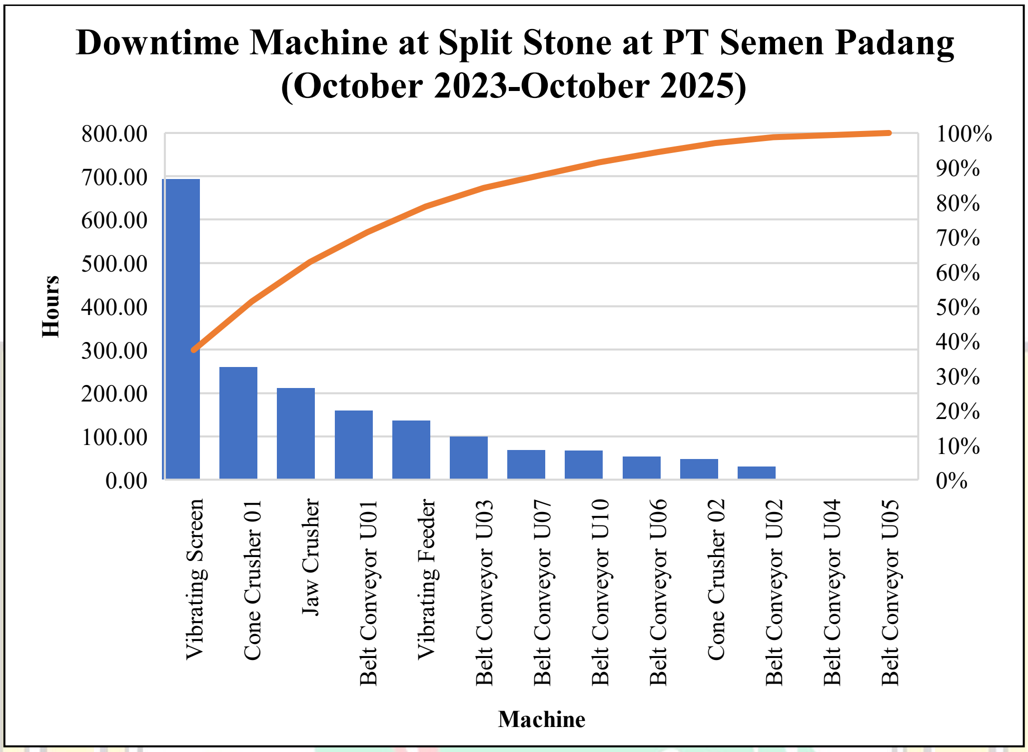

Figure 1.7 Machine Downtime at Split Stone PT Semen Padang 2024

Based on **Figure 1.7**, the Pareto analysis indicates that downtime is highly concentrated in a limited number of machines. The cumulative percentage shows that these five machines account for approximately 79% of total downtime during the observation period. One of these machines is the Vibrating Feeder.

The Vibrating Feeder is a vibrating machine used to transfer material from the Hopper to the Jaw crusher. The Vibrating Feeder used in this system is of type ZSW-490×110, with dimensions of approximately 1.1 m x 4.9 m, and operates at a maximum speed of around 0.63 m/s. The appearance of the Vibrating Feeder is shown in **Figure 1. 8**.

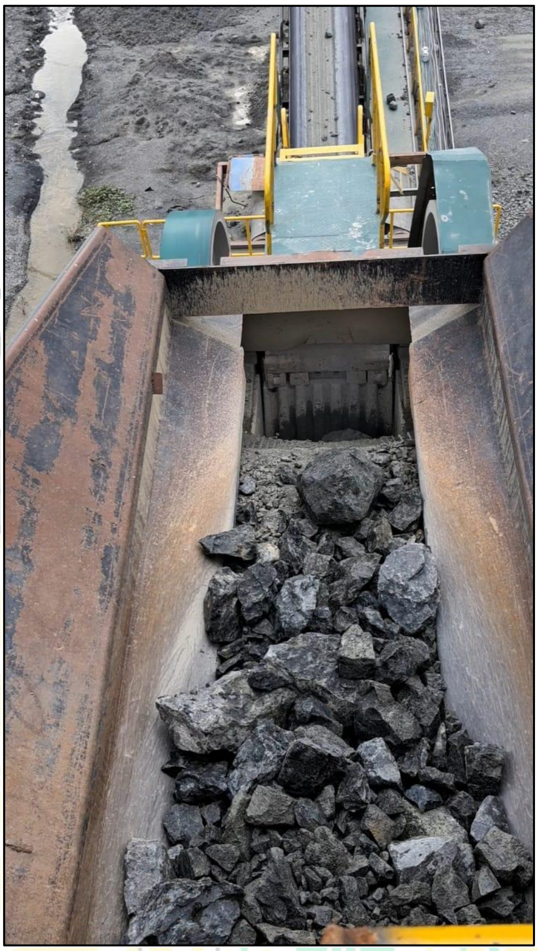

Figure 1.8 Vibrating Feeder at Split Stone Plant

A more detailed analysis of downtime in the Vibrating Feeder was conducted at the component level. Historical data were classified based on the components that experienced failure. **Table 1.1** presents the components with their total accumulated downtime and frequency of occurrence.

Table 1.1 Downtime and Failure Frequency of Vibrating Feeder Components

Vibrating Feeder	Downtime (Hours)	Frequency
Bolt V-belt	3.25	1
Gear Mounting Bolt	9.50	1
Gearbox	22.00	2
Motor	0.50	1
Motor Cable	1.00	2
Motor Mount	1.75	2
Motor Mounting Bolt	9.00	9
Plate	2.97	3
Shaft	45.75	2
V-belt	38.25	20

Table 1.1 shows that the shaft records the highest accumulated downtime among all components. However, the shaft experienced only two major failure events, each requiring a long repair duration. Meanwhile, the V-belt records the second-highest accumulated downtime and has the highest frequency of failure. Damage to the V-belt can directly cause the machine to stop operating, as the V-belt functions in transmitting torque from the motor to the driven components. Since the machine operates as an interconnected system, failure of the V-belt can interrupt the overall production process. The V-belt component used in the Vibrating Feeder is illustrated in **Figure 1.9**.

Figure 1.9 V-belt of The Vibrating Feeder

The V-belt used on this machine is a Mitsuboshi C-100 V-Belt. In actual operating conditions, the V-belt frequently experiences failures, such as slipping and snapping, due to excessive heat and high friction loads. These conditions accelerate material degradation and reduce the belt's effective performance. However, according to the information provided by Mitsuboshi, the life expectancy depends on the user's actual operating conditions, so it can not be determined precisely (Mitsuboshi, 2024).

In addition, the machine is relatively large and consists of multiple interconnected machines, making failure identification more complex. When a breakdown occurs, technicians cannot immediately determine which component is damaged. A diagnostic inspection must first be carried out to isolate and identify the source of failure before corrective action can begin. The V-belt is installed in the lower section of the machine and is not directly visible during normal operation, which further complicates the inspection process. Based on an interview with company technicians, V-belt failure may also contribute to gearbox damage. When one or two belts in a multi-belt system break, and the machine continues to operate, the remaining belts are subjected to higher loads, leading to load imbalance and increased vibration. In addition, under this condition, the Vibrating Feeder can still operate but at a reduced speed, resulting in less effective material flow. These abnormal operating conditions may transmit excessive stress to the gearbox, which includes components such as the shaft and bearings. Over time, this condition may accelerate wear of the gearbox components. Maintenance activities involving gearbox components generally require longer downtime, sometimes taking a full day or more.

Despite the critical role of the V-belt, current maintenance practices remain largely time-based or reactive. Optimal replacement age for the V-belt based on reliability has not been determined and probabilistic failure behaviour is not considered. As with similar high-downtime equipment, increasing the frequency of preventive replacement of the V-belt can initially increase downtime due to scheduled maintenance, but it reduces downtime caused by unexpected failures. This trade-off highlights the need to determine the optimal timing for V-belt preventive maintenance to minimize total downtime.

1.2 Problem Formulation

The research problem in this study is to determine the preventive replacement age for the V-belt in the Vibrating Feeder in order to reduce downtime, so the productive time can be increased, as well as production output.

1.3 Objectives

This study aims to determine the preventive replacement age for the V-belt in the Vibrating Feeder to reduce total downtime.

1.4 Scope of Study

The limitations of this research are as follows:

1. The study focuses on the V-belt component of the Vibrating Feeder in the production line.
2. The data used in this study consists of historical records from October 2023 to October 2025.

1.5 Assumption of The Study

The assumption used in this study is that the V-belt on Vibrating Feeder returns to a condition as good as new after replacement.

1.6 Outline of Study

The outline of this final project report is as follows:

CHAPTER I INTRODUCTION

This chapter explains the background of the study, the problem formulation, the objectives to be achieved in the research, the scope and assumptions used, as well as the outline of this research report.

CHAPTER II LITERATURE REVIEW

This chapter contains explanations of the theories related to the research topic.

CHAPTER III RESEARCH METHODOLOGY

This chapter describes the stages carried out in conducting the research including: the objects of study, method selection, collecting data, processing data, discussion, and conclusion.

CHAPTER IV RESULT AND DISCUSSION

This chapter presents the data processing and analyses the results to determine the appropriate preventive maintenance plan for the V-belt of the Vibrating Feeder.

CHAPTER V CONCLUSION

This chapter contains the conclusion obtained from the research and provide suggestions for future studies.