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Evaluation of Scrab Conveyor Machine Performance at Pt Dharma Polimetal Tbk. Hyundai Plant Using The Six Sigma (Dmaic) Method

Avito Riza Yusuf [a,*], Ahmad Fikrie [a]

[a]*Department of Mechanical and Automotive Engineering, Universitas Negeri Yogyakarta, Indonesia*

**Corresponding author: avitoriza@gmail.com*

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ABSTRACT

This study aims to evaluate the performance of scrap conveyor machine in Stamping production line at PT Dharma Polimetal Tbk . Hyundai Plants. The main problem raised in this research is the high level of downtime on the conveyor machine, which negatively impacts the effectiveness of the production process and contributes to an increase in operational costs. Therefore, this research was conducted to identify the root causes of the problem and formulate applicable and sustainable improvement solutions. The method used in this research is the Six Sigma approach with DMAIC (Define, Measure, Analyze , Improve, Control) stages. Analysis is done by utilizing downtime data using Pareto Diagram and Fishbone tools to identify problem priorities. The Improve stage is carried out with corrective actions in the form of hopper redesign, installation of conveyor covers, and improvement of system wiring and automatic sensors to improve the reliability of the conveyor system. The results showed that corrective actions were able to significantly reduce the duration of downtime, especially in the bent chain plate problem, from 310 minutes to only 50 minutes in August 2024. This finding proves that the application of Six Sigma methods is effective in improving the operational efficiency and performance of scrap conveyor machines. Thus, this data-driven improvement strategy makes a real contribution to increasing the company's productivity and competitiveness.

1 Introduction

In the increasingly competitive context of modern industry, efficiency and effectiveness in production processes are crucial factors that determine a company's productivity and competitiveness. Production efficiency is not only related to the ability to produce high-quality products quickly, but also to the optimal management of production waste and residue. One of the systems that plays an important role in supporting material handling and waste management in manufacturing industries is the conveyor system. A conveyor is a mechanical system used to move materials or goods continuously from one location to another. In industrial applications, conveyors are widely used because they are considered more economical and efficient than heavy-duty transportation equipment such as trucks or other transport vehicles, especially under continuous production conditions [1].

PT Dharma Polimetal Tbk. Hyundai Plant is a manufacturing company that applies stamping production processes supported by machines and semi-automatic handling systems. In this production line, the scrap conveyor has an important function in transporting scrap material generated during the stamping process. If the scrap conveyor does not operate properly, scrap accumulation may occur and disrupt production continuity. Therefore, the reliability of the scrap conveyor system is essential to maintain smooth production flow, reduce production interruptions, and support operational efficiency.

Several types of conveyor systems are commonly used in industry, including belt conveyors, roller conveyors, chain conveyors, screw conveyors, pneumatic conveyors, bucket conveyors, and vibrating conveyors. Belt conveyors use flexible belts made of rubber, PVC, or metal to transport materials over pulleys, while roller conveyors use parallel rollers to move materials with flat surfaces. Chain conveyors use chains driven by sprockets to move heavy materials, and screw conveyors use rotating spiral blades to transport bulk materials. Pneumatic conveyors are used to move granular or powdered materials through pipes, while bucket conveyors and vibrating conveyors are commonly applied to transport bulk or granular materials. Each type of conveyor has different characteristics and applications depending on the material, load, and production requirements.

One of the main problems that often occurs in conveyor systems is downtime. Downtime refers to a period when a machine or system cannot operate as intended due to technical or non-technical factors. In the production process, downtime can reduce machine availability, disrupt production flow, decrease productivity, and increase operational costs. Therefore, downtime mitigation is necessary to maintain stable production performance. One approach that can be used to identify and reduce downtime is the Six Sigma method, which focuses on process improvement by reducing variation, defects, and operational inefficiencies [2], [3].

Six Sigma is a quality management methodology that emphasizes a data-driven approach to improve process performance and minimize defects. One of the important indicators used in Six Sigma is Defects Per Million Opportunities (DPMO), which is used to determine the number of defects in one million opportunities and to identify the sigma level of a process. The DPMO value can be calculated using the formula: DPMO = (Number of Defects / Number of Units × Opportunity per Unit) × 1,000,000. Through this calculation, process performance can be measured quantitatively and evaluated based on industrial quality-level standards [4].

The Six Sigma method is commonly implemented through the DMAIC approach, which consists of Define, Measure, Analyze, Improve, and Control. The Define stage is used to identify the main problem, while the Measure stage is used to collect and measure process performance data. The Analyze stage aims to determine the root causes of the problem using analytical tools such as Pareto diagrams and fishbone diagrams. The Improve stage focuses on implementing corrective actions, and the Control stage ensures that the improvements can be maintained in the long term [4], [5]. Based on this approach, this study aims to evaluate the performance of the scrap conveyor machine at PT Dharma Polimetal Tbk. Hyundai Plant, identify the main causes of downtime, and propose improvement strategies using the Six Sigma DMAIC method.

2 Method

Research design This designed as studies descriptive quantitative purposeful For evaluate in a way comprehensive performance machine scrap conveyor used at PT Dharma Polimetal Tbk ., especially in the line production at Hyundai Plant. The approach used in study This is method Six Sigma, with emphasis on five stages known systematic as DMAIC (Define, Measure, Analyze, Improve, Control). The following is a detailed explanation of each stage [4].

- Define : This first step aims to identify and formulate the main problems that have a significant impact on the performance of the scrap conveyor machine.
- Measure : At this stage, detailed data related to machine performance is collected and measured. The data analyzed includes machine failure rates, downtime frequency, production capacity, and other performance indicators.
- Analyze : The analysis stage aims to identify the main causes of problems that affect the performance of the scrap conveyor machine.
- Improvement : Based on the analysis results, improvement solutions are designed and implemented to enhance machine performance. These solutions are developed systematically and aim to address the identified causes of the problem.
- Control : The final step in the DMAIC process is to ensure that the improvements made can be maintained in the long term.

In this research, various data analysis tools and techniques were used to assist the information processing process, such as: Pareto Chart, this chart is used to identify the most common problems or those that have the greatest impact on machine performance. The Pareto principle, or 80/20 rule, helps focus attention on the few causes that contribute significantly to the problem, allowing for effective improvement efforts; Fishbone Diagram, This tool is used to explore and determine the main factors that cause problems in scrap conveyor machines. This diagram helps in classifying the causes of problems based on categories such as human, machine, method, material, environment, or other factors, so that the analysis can be carried out in a more in-depth and structured manner (Hakim & Augustlin, 2023) .

Using Validity and Reliability, specific steps were taken to ensure that the collected data had a high level of reliability and validity, so that it could be used as a basis for accurate analysis. Data validity was checked through a careful verification process, carried out using the data triangulation method. This triangulation involved comparing results obtained from several sources and data collection methods, namely data from field observations, data recorded in official documents or company documentation, and information obtained through interviews with relevant parties.

3 Result and discussion

3.1 Analysis of Conveyor Performance Data Before Repair

An evaluation of operational data for May 2024 revealed that the downtime caused by the scrap conveyor machine exceeded the company's tolerance threshold of 1%. This finding indicates the need for a comprehensive analysis to identify the root cause of the problem and formulate an appropriate improvement strategy.

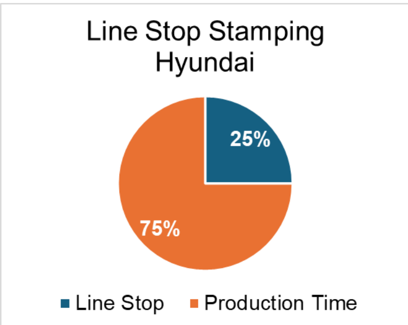

Figure 1. Percentage of Stamping Line Stop in May 2024

As step continued , done Defects Per Million Opportunities (DPMO) calculation for determine the sigma level, which works as indicator quantitative in measure production process performance in a way more accurate.

a. The DPMO calculation for the May 2024 line stop is as follows:
- Total production time: 14,531 minutes
- Line stop time: 3,623 minutes
- Percentage: 24.93%
- Target Line Stop: 1%

b. Based on the time data above (minutes), the following assumptions were used:
- Every minute is one unit of operational opportunity.
- Line stop time is considered the number of defects.
- Therefore:
- Number of units = 14,531 (total operating time)
- Number of defects = 3,623 (Line Stop)
- Opportunity per unit = 1 (because one minute is used as one unit)

Calculation

- DPMO = $\frac{\text{Number of Defects}}{\text{Number of Units x Opportunities per Unit}}$ x 1,000,000
- DPMO = (Number of defects / (Number of units x opportunities per unit)) x 1,000,000 $\frac{3{,}623}{14{,}531 \text{ X } 1}$ x 1,000,000
- DPMO = 249,326.2

Based on the Gaspersz DPMO conversion table, a DPMO value of 249,326 falls within a sigma level range of approximately 2.1-2.2.

It can be concluded that in the May 2024 period, the performance of the production system, especially that related to the scrap conveyor machine , has not been able to achieve the targeted operational efficiency standards.

3.2 Analysis With the Six Sigma Method

3.2.1 Define

From the results operational data collection , it is known that during May 2024 happened downtime on the line production 3,623 minutes of the total time available production , namely 14,531 minutes . If calculated in a way percentage , value downtime the reached 24.97%, which is far exceeding the tolerance limit the maximum that has been determined by the company , namely by 1%.

Table 1. Recapitulation of Stamping Downtime Data for June 2024

NO	PARAMETER	VARIABEL	DATE																															Total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
1	AV	Machine	0	140	15	0	0	220	0	0	0	120	0	0	0	0	65	35	0	0	0	0	0	0	0	57	0	0	83	0	0	0	0	735
2		Robot	0	60	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70
3		Dies	0	10	15	0	0	30	100	20	0	15	0	0	40	20	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	290
4	PE	Conveyor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	390	10	0	204	0	0	0	155	136	35	0	0	930
5		Dandori	0	120	40	0	0	130	120	180	0	110	0	0	60	80	60	100	50	0	0	90	90	40	0	0	0	0	131	0	0	0	0	1401
6		Delay Material	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7		Lain-lain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The table presents downtime data for June 2024 which illustrates distribution time stop production based on six category main , namely Machine , Robot , Dies , Conveyor , Dandori , and Delay Material . Based on results processing of the data , it is known that two categories contributor downtime the biggest is Dandori , who became the most dominant cause , as well as Conveyor showing contribution significant to total time stop production .

Referring to the findings mentioned , as well as consider position the writer who is below shade Maintenance Department , then focus analysis in study This will directed in a way specifically on the problem related downtime with machine conveyor . Approach This chosen as form contribution direct to duties and responsibilities answer Maintenance Department , which has role strategic in ensure machine availability at optimal level.

3.2.2 Measure

The findings in this section indicate that conveyor system issues significantly impact the smooth operation of the production process. To understand the extent of their impact on production performance, an in-depth analysis of the factors causing high conveyor downtime is necessary.

Calculation of DPMO line stop for June 2024 is known:

- Number of Defects: total downtime (assumed as defect) = 3.426
- Number of Units (opportunity occurs): total time available = 14,531 minutes (referring to previous data) in May)
- Opportunity per unit: assumed to be 1 (because 1 opportunity defects per minute)

Calculation

- $DPMO = \frac{\text{Number of Defects}}{\text{Number of Units x Opportunities per Unit}} X1.000.000$
- $DPMO = \frac{3.426}{14.531 \text{ X } 1} X1.000.000$
- DPMO = 235,715

Based on the Gaspersz DPMO conversion table, a DPMO value of 235,715 falls within a sigma level range of approximately 2.1. Although the process sigma level shows a value of 2.1, which is still within the average range of the manufacturing industry in Indonesia, this value does not yet reflect optimal performance standards.

3.2.3 Analyze

Based on direct observations on the stamping production line at Hyundai Plant, the conveyor machine, particularly the scrap conveyor, recorded the highest downtime compared with other main machines. This condition requires serious attention because the high frequency of machine failure directly affects the decline in production line availability and productivity. During direct observations, various problems were found that contributed to high downtime frequency, as reflected in the previous Pareto diagram. These problems were not only technical but also included procedural and operational aspects that affected overall machine performance.

The results of the analysis of the problems with the conveyor machine at Hall Hyundai are presented in a fishbone diagram.

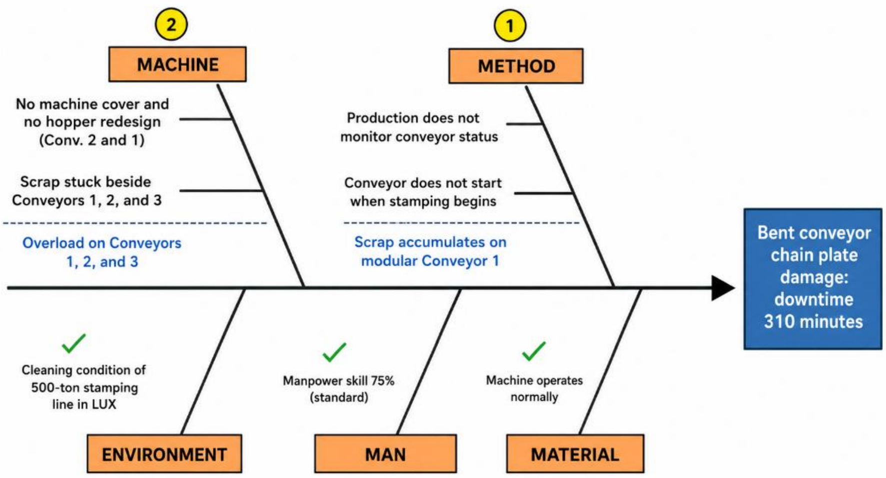

Figure 1. Fishbone diagram identifying the root causes of bent conveyor chain plate damage in the scrap conveyor system, which contributed to 310 minutes of downtime.

The figure presents a fishbone diagram as a visual representation of the cause-and-effect relationships of problems occurring in the conveyor machine. This diagram facilitates root-cause identification by grouping the causal factors into two main categories, namely machine factors and method factors.

3.2.4 Improve

The authors formulated several proposed improvements aimed at enhancing the system's overall performance and reliability. The proposed improvements include:

a. Cover Installation on Modular Conveyor Area
b. Hopper Redesign between Conveyor 2 and Conveyor 3
c. Hopper Design Improvement from Stamping Machine to Conveyor 1
d. Installation of Overload Alarm System on Conveyor

3.2.5 Control

The analysis results show that the most dominant failure was a bent chain plate, with a total disruption time of 310 minutes, accounting for approximately 69% of total downtime. Compared with previous repair data, the duration of failure due to bent chain plates decreased significantly from 310 minutes to 50 minutes. This indicates that the improvement actions implemented successfully reduced disruptions substantially. However, the increased proportion of disruptions due to scratched plates has become a new concern that needs to be followed up in continuous improvement efforts.

4 Conclusion

Based on the research and discussion, it can be concluded that the low performance of the scrap conveyor at PT Dharma Polimetal Tbk. Hyundai Plant was mainly caused by technical and operational factors, such as worn motors, bent chain plates, worn sprockets, lack of lubrication, irregular maintenance, and operational errors. The Six Sigma method using the DMAIC approach effectively identified the root causes of high downtime through Pareto and fishbone diagrams and supported structured improvements, including preventive maintenance, component replacement, and operator training. These improvements significantly reduced downtime, increased conveyor reliability, improved production efficiency, lowered operational costs, and supported the company’s productivity and competitiveness.

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Conflicts of Interest

The authors declare no conflict of interest.

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