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Implementation of PDCA and Seven Tools to Handle Obstacles in the KCl Screw Material Machine at PT Petrokimia Gresik

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ABSTRACT

This study applies the Plan-Do-Check-Act (PDCA) method and the Seven Tools of Quality Control to address jamming issues in the screw machine handling KCl at PT Petrokimia Gresik. Frequent jams caused by wires and cement slurry led to downtime and production losses. PDCA was chosen for its systematic approach to problem-solving. In the Plan phase, check sheets and Pareto analysis identified wires (75%) and cement slurry (25%) as primary causes. The Do phase implemented modifications, including installing a handhole for cleaning and a drain to remove coarse materials. The Check phase showed zero jams and downtime in December 2023, a significant improvement from previous monthly downtime of up to 2 hours. The Act phase standardized these changes into operating procedures and included operator training to enhance raw material supervision. Results showed improved operational efficiency by an average of 1.5 hours monthly and eliminated downtime. This highlights the value of structured methodologies and teamwork between maintenance and operations. Future recommendations include using PDCA and Seven Tools as standard approaches for problem-solving across various machines and processes at PT Petrokimia Gresik.

INTRODUCTION

The Indonesian fertilizer industry plays a vital role in supporting the agricultural sector, particularly in efforts to achieve food self-sufficiency (Famela et al., 2023). PT Petrokimia Gresik is one of the leading companies in this field. With increasing production demands and the need for efficiency, where the production capacity of PT Pupuk Indonesia in 2024 reaches 14 million tons (Ambarwati, 2024). The company must ensure that its production processes run smoothly without obstacles that could reduce productivity.

PT Petrokimia Gresik is a state-owned enterprise (SOE) under the Indonesian Ministry of Industry and Trade and is a member of PT Pupuk Indonesia Holding Company (PIHC) (Huda, 2023). PT Petrokimia Gresik is engaged in the production of fertilizers, chemicals, as well as construction and engineering services. The name Petrokimia comes from the words "Petroleum Chemical," abbreviated as "Petrochemical," which are chemicals made from petroleum and natural gas (Kusumawati, 2022). PT Petrokimia Gresik is the most complete fertilizer producer in Indonesia, producing various fertilizers such as Urea, ZA, SP-36, ZK, NPK Phonska, NPK Kebomas, and

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organic fertilizer Petroganik. PT Petrokimia Gresik also produces non-fertilizer products, including: Sulfuric Acid, Phosphoric Acid, Ammonia, Alf3, Dry Ice, Aluminum Fluoride, Cement Retarder, and others (Rahmawati, 2023).

One of the common problems faced by PT Petrokimia Gresik is operational obstacles in the screw conveyor machine used to convey KCl (potassium chloride) raw materials, an important component in fertilizer production. The screw conveyor machine functions to convey raw materials from one process to another (Sudarso & Suhradi Rachmat, 2020). However, this machine often jams due to the presence of foreign objects. This obstruction causes downtime, a condition where the machine stops operating temporarily (Hidayat et al., 2020). *This downtime has a significant impact on the company's productivity, as every production stoppage reduces the amount of daily output that can be achieved* (Mochamad Saefullah et al., 2024). For example, during the period from August to November 2023, the screw machine jammed several times, causing the production of KCl fertilizer to decrease from the standard 27 tons to 24.75 to 26.44 tons per day.

One method that has proven effective in managing and improving industrial processes is the PDCA (Plan-Do-Check-Act) cycle. PDCA is a continuous improvement cycle or a continuous cycle like a circle that has no end (Muzamil & Nuruddin, 2023). This method helps companies identify problems, test solutions, and monitor and adjust actions based on the results obtained. The PDCA (Plan-Do-Check-Act) cycle, also known as the Deming cycle or Shewhart cycle, is a quality management approach used for continuous improvement in various industrial processes (Gunawan et al., 2024). Introduced by W. Edwards Deming, it adapted Walter Shewhart's earlier concepts (Syaputra et al., 2021). PDCA is designed as a repetitive cycle enabling organizations to continually enhance their performance by conducting thorough planning, implementing actions, examining results, and then taking corrective actions based on evaluation results (Syafrizal, 2023).

According to Deming, the PDCA cycle provides a systematic framework for identifying and resolving issues, ultimately improving productivity and quality at every process stage (Hartati et al., 2024). Each phase in this cycle has a specific role (Fadhli Syadzali Kusuma & Fahriza Nurul Azizah, 2024) The Plan phase involves identifying problems, collecting data, and setting improvement goals. Next, in the Do phase, the planned solutions or improvements are implemented. The Check phase focuses on monitoring and evaluating the implementation results to ensure that the desired improvements have been achieved. Finally, the Act phase determines whether the improvement should be adopted as a new standard; if successful, the solution is standardized, while unsuccessful attempts prompt a repetition of the cycle with necessary adjustments.

In addition to PDCA, quality management tools such as the Seven Tools have been widely applied in efforts to improve quality and solve production problems. The Seven Tools are statistical tools used to improve quality and address problems that arise in the manufacturing process (Neilam, 2021). Tools such as check sheets, Pareto charts, and fishbone diagrams are very effective in detecting the frequency of problems, identifying root causes, and analyzing cause-and-effect relationships in a production process (Maulana, n.d.). *The Seven Tools of Quality Control are a set of tools developed by Kaoru Ishikawa to assist companies in solving quality problems and improving production processes* (Sumpena, 2021). These seven tools are often referred to as "basic tools" for quality management due to their ease of use in various production and problem-solving situations.

According to Ishikawa, the Seven Tools of Quality Control provide essential methods for analyzing and improving processes (Rozi & Nugroho, 2022). These tools include the Check Sheet, which simplifies data collection and tracks production quantities and defects over a specific period (Rozzaqi Rachmanda et al., 2024). The Pareto Chart is a graph used to identify the primary root causes of a problem (Absa & Suseno, 2022). . The Fishbone Diagram classifies factors to pinpoint potential problem causes, making it a valuable tool in analysis (Purwaningsih et al., 2024). The Control Chart monitors process performance over time, highlighting variations that may require

intervention (Rizal & Khoiroh, 2023). A Histogram visually represents data distribution, aiding in understanding variations and trends in production processes (Elfaladonna et al., 2024).The Scatter diagram identifies possible relationships between two variables by analyzing observed changes (Ibnu Tsabit & Hartini, 2019). Lastly, the Flowchart provides a graphical representation of a process's sequential flow, making it easier to visualize and optimize operations (Halimatussya'diyah Purba & Yahfizham Yahfizham, 2023)

The application of these Seven Tools has proven effective in manufacturing industries and has been widely used in various countries. Previous research examples demonstrate how these tools can be used to analyze the defect rate of Donggala songket-patterned sarong products (Iqbal et al., 2020).

This research aims to implement the PDCA method and Seven Tools in handling obstacles in the KCl screw material machine at PT Petrokimia Gresik. By identifying the root causes of the problem, this research is expected to provide a comprehensive solution to reduce downtime and improve production efficiency at the company.

RESEARCH METHODS

This research employed a quantitative method using a case study approach at PT Petrokimia Gresik. The Plan-Do-Check-Act (PDCA) method and the Seven Tools of Quality Control were applied to identify and address obstacles in the screw machine used in the KCl material handling process.

In addition to PDCA, alternative methodologies like DMAIC from Six Sigma and Root Cause Analysis (RCA) were considered. While DMAIC offers a structured quantitative approach and RCA emphasizes identifying root causes comprehensively (Knop, 2022), PDCA was chosen for its simplicity and practicality in addressing the immediate needs of the production process.

The research was conducted in the ZK Fertilizer Production Department of PT Petrokimia Gresik, East Java, Indonesia. The research period was from August to November 2023, coinciding with the data collection period for production and analysis of operational obstacles in the screw machine.

This research was conducted in four main stages following the PDCA method:

a. Plan
   Problem identification was conducted using check sheets and production logbook reports. Collected data included the frequency of occurrences, downtime duration, and lost production tonnage. This data was obtained from daily production records and machine failure reports from August to November 2023.
   A Pareto chart was used to identify the primary causes of operational disruptions, and a fishbone diagram was employed to map out various contributing factors, including machine technical issues, work environment, raw materials, and human factors.
b. Do
   Based on the analysis results, improvements were made, and solutions were developed to address the previously identified problems. Modifications are made to machine parts that often experience problems, such as repairing mechanisms currently used to increase operational efficiency or replacing components that are often damaged or less efficient with components that are stronger and more suitable.
c. Check
   After the machine modifications, the screw machine's performance was monitored for several weeks. Data on downtime, production losses, and tonnage produced were remeasured and compared to pre-modification data. The effectiveness of the modifications was analyzed using a

Pareto chart to determine if the frequency of jams decreased and a check sheet to monitor daily results.

d. Act

Based on the evaluation results, additional steps were taken to ensure continuous improvement. If the results from the Check phase showed significant improvement, the modification would be adopted as a new operating standard in the plant. Preventive procedures were also implemented to avoid similar jams in the future, including regular inspection and maintenance procedures for the screw machine.

RESULTS AND DISCUSSION

This research applied the PDCA method and Seven Tools to analyze and address obstacles in the screw machine handling KCl material at PT Petrokimia Gresik. The research results were divided into several stages according to the PDCA cycle and supported by data analysis using Python.

Plan

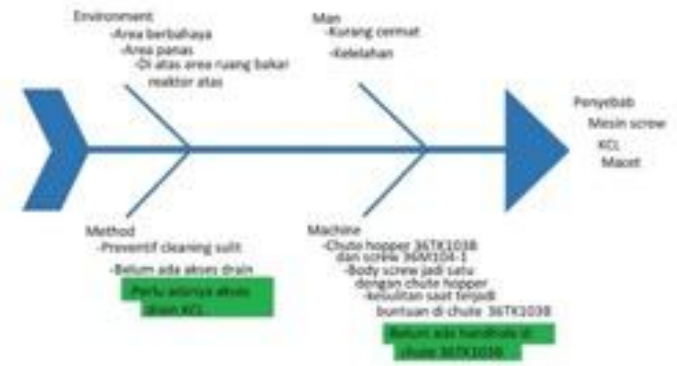
At this stage, problem identification analysis was conducted using check sheets. The analysis using check sheets revealed operational problems such as:

Table 1. Frequency of Screw Machine Jams (August - November 2023)

Date	Cause	Number of Findings	Duration of Time
2/08/2023	Cement slurry	1	2 Hours
9/09/2023	Wire	1	2 Hours
4/10/2023	Wire	1	30 Minutes
7/11/2023	Wire	1	30 Minutes

These obstacles resulted in an average screw machine downtime of 1 to 2 hours per occurrence, with a frequency of once per month. This data was then depicted and analyzed in the following Pareto chart and fishbone diagram:

Picture 1. Pareto Diagram of Screw Machine Jam Frequency

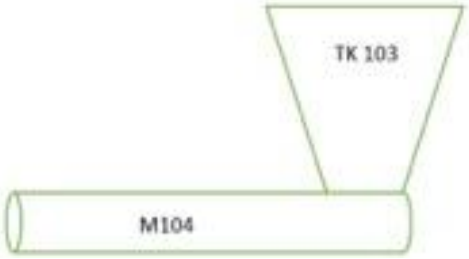


Picture 2. Fishbone Diagram Identifying Causes of Jams

From this analysis, it was found that the most significant obstacle in the screw machine was caused by foreign objects entering the machine, such as cement slurry and wire. This caused the machine to jam at least once a month during the period from August to November 2023, with an average downtime duration of 1 to 2 hours per occurrence. Based on Pareto analysis, the most frequent type of obstacle was due to wire. Out of the total 4 occurrences of obstacles, 3 of them (75%) were caused by wire, while 1 occurrence (25%) was caused by cement slurry. However, in terms of downtime, obstacles caused by cement slurry and wire had almost equal durations, with each obstacle causing downtime of up to 2 hours in a single occurrence.

Do

The solution implemented in this phase involved a modification to the screw machine. The original screw machine configuration looked like this:



Picture 3. Screw Machine Before Modification

Where the KCl hopper (item TK 103) was directly above the KCl screw (item M-104). A modification was made to change the configuration to this:

Picture 4. Screw Machine After Modification

A handhole was added to the machine body to facilitate operator cleaning of foreign objects causing jams. Additionally, a drain access for coarse KCl raw material was added to make it easier to empty the machine in case of jams.

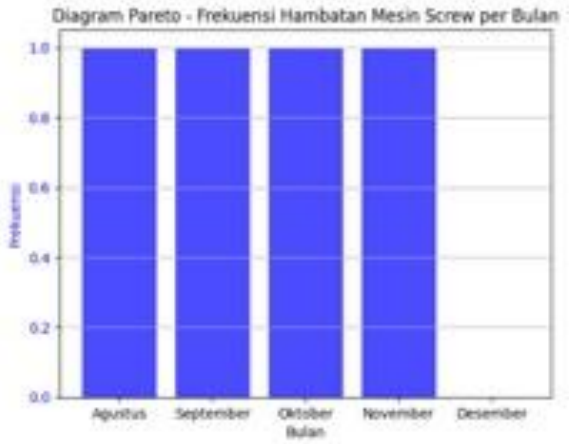
Check

Operational data after the modification implementation showed significant results. In December 2023, no screw machine jams were recorded, with downtime reduced to zero hours. This can be seen in the following table:

Table 2. Jam Frequency Data After Modification

Month	Jam Frequency	Downtime Duration (hours)
August 2023	1 kali	2 hours
September 2023	1 kali	2 hours
October 2023	1 kali	0.5 hours
November 2023	1 kali	0.5 hours
December 2023	0 kali	0 hours

When visualized in a Pareto chart, the results look like this:



Gambar 5. Pareto Chart of Jam Frequency After Modification

The diagram shows that after the modification, the jam frequency decreased to zero in December. This indicates the effectiveness of the modification and shows that the screw machine is now operating more efficiently. The evaluation results show that the implemented solution, including the addition of the handhole and KCl drain access, had a positive impact on machine performance. The maintenance team also provided additional training to operators to improve their supervision of raw materials entering the machine, preventing potential future problems.

Act

Based on the evaluation results demonstrating the success of the screw machine modification in reducing jam frequency, several follow-up actions have been taken to ensure continuous improvement and increased operational efficiency at PT Petrokimia Gresik.

a. The modification implemented, namely the addition of the handhole and KCl drain access, has been adopted as a new operating standard for the screw machine.
b. To improve supervision of raw materials entering the machine, additional training has been provided to all operators.

c. The maintenance team will conduct regular monitoring of the screw machine's performance and record any future jam occurrences.
d. If any jams are detected after the implementation of the modification, corrective actions will be taken immediately based on data analysis.
e. Regular reports on the screw machine's performance and operator feedback will be collected to evaluate the effectiveness of the modifications and training implemented.

CONCLUSION

This research successfully applied the PDCA method and the Seven Tools of Quality Control to address jamming issues in the screw machine used for KCl material handling at PT Petrokimia Gresik. The systematic approach identified wire and cement slurry as the primary causes of jams, leading to effective modifications such as installing a handhole for cleaning and improving maintenance procedures. As a result, machine jams were eliminated by December 2023, significantly enhancing operational efficiency.

The study also highlighted the importance of operator training and updated operating standards to ensure sustainable improvements. By adopting the PDCA method and Seven Tools, the company not only resolved technical obstacles but also established a framework for continuous improvement. These methods can be implemented as standard procedures for managing similar processes across various machines and production lines. This research emphasizes the value of a structured quality management approach and collaboration between maintenance teams and operators. Regular monitoring, evaluation, and the exploration of these methods for other production processes are recommended to maintain and expand the achieved results.

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