International Journal of Computer and Information System (IJCIS)
Peer Reviewed – International Journal
Vol : Vol. 06, Issue 01, March 2025
e-ISSN : 2745-9659
https://ijcis.net/index.php/ijcis/index

Optimization of Hydraulic Pump Unit Control Communication with Seven Tools Method to Reduce Raw Mill Downtime In PT. Semen Gresik

[1]Zulfahmi Fauzan, [2]Erna Indriastiningsih,[3]Yunita Primasanti,[4]Bekti Nugrahadi
Faculty of Science, Technology and Health
Sahid University Surakarta
Surakarta, Indonesia
[1]fauzanzulfahmi@gmail.com, [2]ernaindriasti@usahidsolo.ac.id, [3]yunitaprimasanti@usahidsolo.ac.id, [4]Bekti.nugrahadi@usahidsolo.ac.id

Abstract *- The Indonesian cement industry faces challenges in improving operational efficiency amid increasing competition. One critical factor in cement production is the operational stability of the Raw Mill, which depends on the performance of the Hydraulic Pump Unit. This study aims to optimize control communication in the Hydraulic Pump Unit to reduce downtime in the Raw Mill area of PT. Semen Gresik. Using the Seven Tools method, the study identified communication disruptions as the primary cause of downtime. Key issues include unreliable remote I/O PLCs, high operating temperatures, excessive loops, poor grounding, and procedural errors. To address these problems, the study proposes replacing remote I/O PLCs, adding Junction Boxes, relocating PLCs to a control panel room, redesigning the network topology, switching from Ethernet to Profibus, improving grounding, conducting training, and updating maintenance standards. The implementation of these solutions successfully reduced Raw Mill downtime, improved production efficiency, and enhanced control system reliability by creating new operational standards. These findings highlight the importance of effective control communication in maintaining stable and efficient cement production operations.*

Keywords: *Downtime, Hydraulic Pump Unit, Optimization, Seven Tools*

I. INTRODUCTION

The cement industry in Indonesia has an important role in supporting economic growth, especially with the government's focus on infrastructure development. PT Semen Gresik, as one of the largest cement companies in Indonesia, has an important role in supporting national cement needs. In its operations, PT Semen Gresik relies on various equipment and machines, one of which is the Raw Mill, which functions to grind raw materials such as limestone, clay, silica sand, and iron sand into fine powder as the initial stage in cement production.

One of the crucial components that support the operational performance of the Raw Mill is the Hydraulic Pump Unit, which consists of three main subsystems: Hydraulic System to regulate roller pressure, Roller Lubrication System, and Gearbox Lubrication System. However, operational observations at PT Semen Gresik from November 2023 to January 2024 showed a significant increase in downtime at the Raw Mill, which was caused by a communication breakdown in the Hydraulic Pump Unit control system, thus hampering the production process.

Based on daily reports from the Crusher and Raw Mill sections at PT Semen Gresik's Rembang plant, communication disruptions in the Hydraulic Pump Unit control system caused 38 downtimes, with a total disruption time of 2,657 minutes. Excessive downtime not only reduces production efficiency, but also causes financial losses. In addition, the high frequency of downtime makes the Raw Mill experience frequent start/stop, which results in increased electricity consumption during start-up and accelerates mechanical wear on the equipment. Given these negative impacts, this study aims to identify the main causes of communication breakdowns, analyse the problems, and provide concrete solutions to reduce downtime in the Raw Mill at PT Semen Gresik.

To overcome communication breakdown in the Hydraulic Pump Unit control system, a structured troubleshooting and quality control approach is required. The Seven Tools method was chosen as the main approach in this research because it is effective in systematically identifying root causes and providing data-based solutions. Each tool in this method has specific functions, such as Pareto Diagrams to identify dominant problems, Fishbone Diagrams for root cause analysis, and Scatter Diagrams to examine relationships between variables. The application of the Seven Tools method allows for objective and data-driven analyses, so that the resulting solutions can be implemented on an ongoing basis.

The formulation of the problem in this study is what are the main causes of communication disorders in the

Hydraulic Pump Unit control system and what solutions can be applied to overcome these disorders.

This research aims to find the root cause of communication disorders, provide the best solution to overcome these problems, and establish operational standards for the Hydraulic Pump Unit control communication system so that similar disorders do not occur in the future.

Optimisation is the process of finding the best solution, not always the highest profit that can be achieved if the optimisation goal is to maximise profits, or not always the least cost that can be reduced if the optimisation goal is to minimise costs. [1]

Seven tools are tools used for quality control and are often used as problem-solving methods, so various production lines can apply this methodology for improvement. The techniques included are fishbone diagrams, pareto diagrams, check sheets, scatter diagrams, control charts, histograms, and flow charts. [2]

Cause and effect diagrams are used to identify and analyse processes or situations and reveal the possible causes of a problem or issue that occurs. This diagram is useful for separating causes from symptoms, focusing attention on relevant things, and can be applied to various types of problems. [3]

A Pareto diagram is a histogram that organises data from largest to smallest frequency. Pareto analysis is often used to analyse data collected through inspection sheets. This analysis is also easily applied to quality costs. [4] Pareto diagrams are useful in identifying key issues by applying the 80:20 comparison principle, which means 80% of improvements can be achieved by solving the 20% most important problems. [5]

Scatter diagram is a representation that shows the possible relationship (correlation) between a pair of variables. Although there is a relationship, it does not necessarily mean that one variable causes the other variable to arise. Scatter diagrams generally describe the relationship between two variables and indicate the degree of strength of that relationship, expressed as a coefficient. [6]

II. RESEARCH METHODS

The research method is the stage taken to solve a problem in research. This stage is arranged based on the background and objectives of the research with the support of relevant theories. Based on the methodology flowchart, there are several stages that need to be explained, starting from preliminary studies, problem formulation, to the conclusion stage.

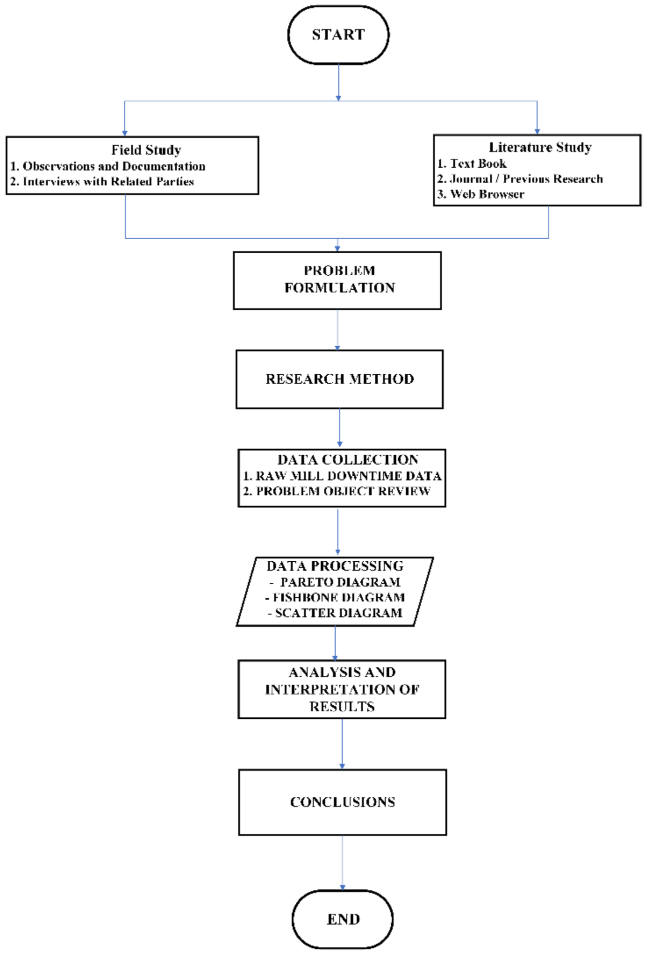

Figure 1. Research flowchart

1. Preliminary Study

The initial stage that will be carried out in this research is to formulate the problems that form the basis of this research, namely by conducting literature studies and field studies. These stages can be described into the following stages, namely:

a. Field Study

This stage is carried out by direct visits to the company PT Semen Gresik Rembang to gain an understanding of the actual conditions in the field. From this study, the researcher determines the factory area / department that will be used as the research location, determines the respondent, makes observations, site documentation and interviews the person in charge of the research area.

b. Literature Study

This stage is carried out by collecting and reviewing various existing sources of information, such as previous research published in reputable scientific journals, theories described in trusted literature books, and statistical data available on the internet. All these sources of information were selected based on

International Journal of Computer and Information System (IJCIS)
Peer Reviewed – International Journal
Vol : Vol. 06, Issue 01, March 2025
e-ISSN : 2745-9659
https://ijcis.net/index.php/ijcis/index

credibility, relevance to the research topic, and data currency.

2. Problem Formulation

The problem formulation stage comes from the results of the literature study and field study. Based on these two things, the problem formulation that has been described by the researcher is what is the root cause of the problem of communication breakdown in the Hydraulic Pump Unit in the Raw Mill unit and how to solve it.

3. Research Methods

At this stage, the researcher determines and chooses the method that is considered the most appropriate to solve the problem. Based on the results of problem identification, researchers decided to use the seven tools method as an approach in solving existing problems.

4. Data collection

At the data collection stage, it will be described what data is needed for the next stage, namely data processing. The instrument used in collecting data for this research is an interview which is one of the primary data collection techniques. Primary data, namely data sources that directly provide data to data collectors. [7]

Required data:

1. Raw mill downtime data.
2. Documentation of findings in the field.

5. Data processing

After identifying the problem and the collection that has been done by the author, the next step is to process the data. Based on the results of the literature study conducted by the author, methods proposed by previous studies with similar topics will be found. Here the author performs data processing using several methods in seven tools such as pareto diagrams, fishbone and scatter diagrams.

6. Analysis and Interpretation of Results

After the problem data is processed, the next step is to analyse the root cause of the problem. Furthermore, the best solution to the problem is sought and improvement planning is carried out. This analysis aims to examine and review the research results in depth in order to obtain a comprehensive understanding.

7. Conclusion

The last stage contains conclusions and suggestions based on the results of the analysis of the research which refers to the objectives that have been designed in the early stages of the research. This section also explains the impact on the company after the improvement solution is implemented, as well as suggestions given by the author to develop the research.

III. RESULT AND ANALYSIS

3.1 Downtime Data

In this study, the first data needed is downtime data that occurs in the research area, namely the raw mill area. Here the researchers made observations for 3 months. The research period starts from November 2023 to January 2024.

The data is processed using a pareto diagram to visualise the factors more clearly. The following is a pareto diagram view of the data:

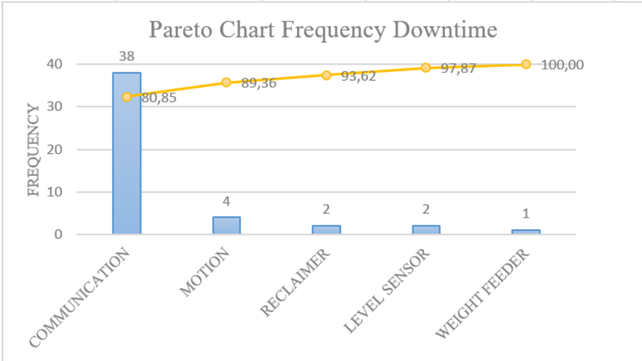

Figure 2. Pareto diagram of raw mill downtime

3.2Finding the Root Cause

After the researcher gets the Raw Mill downtime data and reviews the problem object, the next step is to find the root of the problem in the hydraulic pump unit control. Here the researcher analyses using several tools in the seven tools method.

In this study, analysis using fishbone diagrams was the first step taken by researchers to find the root causes of high downtime in the Raw Mill area. The following are several categories of causes that may contribute to the downtime problem in the Raw Mill, which can be mapped using the Fishbone Diagram.

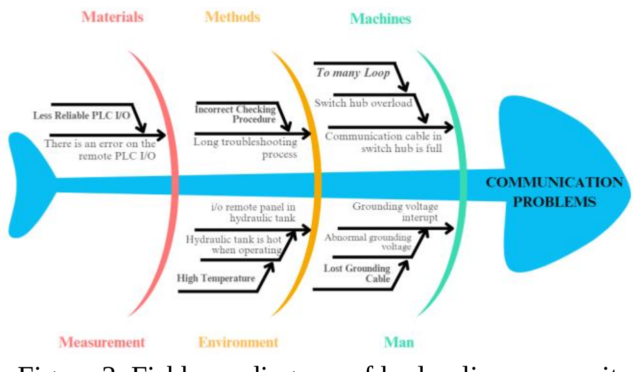

Figure 3. Fishbone diagram of hydraulic pump unit communication problem

Once the root causes have been identified using the fishbone diagram, the next step is to conduct a quantitative relationship analysis to validate or further explore the interrelationship between a particular causal variable and the observed outcome. This is where scatter diagrams are used to visualise the relationship between two variables. From the five root causes, researchers will conduct a correlation test to get the correlation coefficient value.

In one of the root causes, the researchers tested the correlation between the level of temperature rise compared to the frequency of downtime.

Table 1. Relationship between temperature rise and downtime frequency

Temperature	Downtime Frequency
25	0
30	0
35	0
40	1
45	2
50	2
55	2
60	3
65	4

From the data in the table above, it can be drawn into the Scatter diagram as in the picture below:

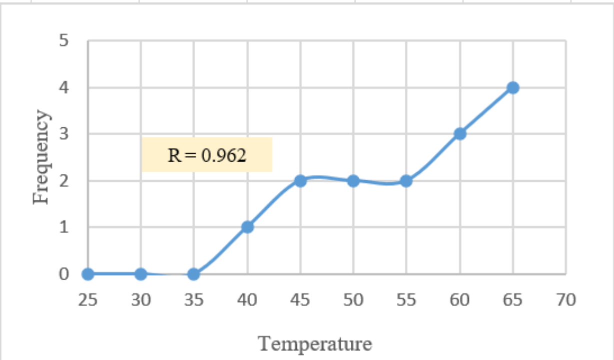

Figure 4 Relationship between temperature rise and downtime frequency

The diagram above shows the relationship between temperature and downtime frequency, with a correlation coefficient value of 0.962 which indicates a very strong positive relationship between the two variables. This value is obtained from the results of data formulation in the table using excel with the formula =CORREL(25:65;0:4). The higher the temperature, the higher the frequency of downtime that occurs. This pattern is clearly visible in the temperature range of 40°C to 65°C, where the frequency of downtime increases significantly. This data underscores the importance of temperature control to reduce the frequency of downtime and maintain equipment reliability.

3.3 Determine Solution

After the researcher gets the results of the root cause analysis, the next step taken by the researcher is to determine the right solution so that the root cause of the communication problem in the hydraulic pump control unit can be resolved and does not cause downtime problems in the future. Here the researchers carried out several stages of analysis in finding the final solution, such as listing alternative solutions, analysing alternative solutions and determining the final solution, and analysing the risks associated with the final solution chosen.

From each root cause of the problem, here the researcher makes several alternative solutions. To make it easier to understand, the researcher made it in the form of a table as follows:

Table 2. List of Alternative Solutions

No	Cause	Alternative Solution
1.	Less reliable PLC I/O	Replace the PLC I/O with another type according to the CPU brand.
		Replace the PLC I/O with new spare parts that are the same as those already installed.
2.	High Temperature	Installation of Exhaust Fan on the panel
		Relocation of the panel to the Local Control Panel room with Air Conditioner
3.	Too Many Loops	Addition of Ethernet Hub
		Change the communication protocol from Ethernet to Profibus
4.	Lost Grounding Cable	Installation of a new grounding cable
		Conduct routine inspections to check the quality of the grounding voltage
5.	Incorrect Checking Procedure	Sharing knowledge to each personnel
		Update the latest control drawing

After the researcher lists alternative solutions, the next step is to make a selection regarding alternative solutions. It aims to find which alternative solutions have a good probability value for immediate corrective action. Here the researchers made the selection using the weighting method using the standard of the Semen Gresik Innovation Convention which has assessment criteria in terms of cost, capability, processing time,

reliability and also the procurement of spare parts. Based on the results of the analysis, the final solution chosen is:
1. Replace the I/O PLC with another type.
2. Adding a Junction Box and relocating the Remote I/O PLC into the local control panel room.
3. Designing a more effective and efficient network topology and changing the communication protocol from ethernet to profibus.
4. Improving the grounding cable.
5. Sharing knowledge about the new controls and creating drawings and the latest maintenance standards.

3.4 Developing and Implementing Remediation

At this stage, the researcher plans in advance before starting the improvement phase. This aims to ensure that the solution can be implemented with proper monitoring so that the improvement goes according to plan. If later during the process of implementing improvements there are obstacles, then corrective action / risk mitigation will be taken immediately to overcome the problems that arise.

Developing an Improvement Plan is an important step in improving quality and operational performance. An improvement plan is created by determining the appropriate solution and to determine who is responsible for the implementation process. At this stage, an in-depth analysis of the previously identified root causes is conducted to determine the most effective solution.

The improvement plan includes the development of concrete steps that need to be taken, the determination of the necessary resources, the scheduling of the implementation time, and the assignment of responsibilities for each party involved. The goal is to ensure that all aspects that cause problems can be addressed with appropriate action, so that operational processes can run more efficiently and downtime or disruption can be minimised. Here the researcher uses the 5W+1H method in developing an improvement plan.

3.5 Implementation of Improvement

The improvement implementation stage is the step in which all previously developed improvement plans are systematically implemented in the field. At this stage, personnel who have been prepared with technical competence carry out repairs in accordance with established procedures and standards. This process includes initial checking, identification of damage, replacement of components or repair of problematic systems, and testing of repair results to ensure the system is running optimally again. During implementation, coordination between teams and documentation of each step is essential to ensure that repairs are carried out efficiently and thoroughly, and to prevent recurrence of problems in the future.

The repair implementation process consists of several stages, namely:
1. Mapping spare part requirements.
2. Designing a new control network topology.
3. Adding junction boxes and moving the remote I/O panel into the local control panel room.
4. The process of making new communication cable lines.
5. The process of replacing remote I/O spare parts.
6. System commissioning and trial process.

3.6 Comparative Analysis of Results

Based on data from the daily reports of the Crusher and Raw Mill operational sections for April - July 2024. No more communication problems were found in the hydraulic pump unit control system. So it can be said that the steps and improvement solutions carried out by researchers are appropriate.

Table 3. Comparison of Downtime Data Before and After Improvement

Downtime	Frequency (Times)		Duration (Minutes)	
	Before	After	Before	After
Communication on hydraulic pump unit control	38	0	2657	0

3.7 Positive Impact Analysis of PQCDSME Aspects

Each aspect of PQCDSME is a strategic element that is interrelated and contributes significantly to the success of the company's goals. Here, the researcher analyses the PQCDSME approach to ensure that improvements are not just focused on one dimension, such as productivity or cost, but include other aspects that support the sustainability and efficiency of the system as a whole.

1. Productivity (P)

Before:
Sub-optimal Raw Mill production resulting in kiln operations not being at full capacity due to depletion of silo levels.
After:
Raw mill production is optimised so that raw meal silo levels are maintained and kilns can be at full capacity.

International Journal of Computer and Information System (IJCIS)
Peer Reviewed – International Journal
Vol : Vol. 06, Issue 01, March 2025
e-ISSN : 2745-9659
https://ijcis.net/index.php/ijcis/index

2. Quality (Q)
Before:
Frequent interruptions in the communication control system of the hydraulic pump unit in the Raw Mill
After:
The quality of communication is maintained, allowing the Raw Mill to operate smoothly.
3. Cost (C)
Before:
- There are lost product losses due to less than optimal raw mill operations.
- High water usage in the Gas Conditioning Tower system when the Raw Mill is not operating.
- Raw Mill Heating Up costs using an air heater (341AH01).
- Potential losses due to spare part replacement due to the frequent start/stop pattern of Raw Mill operations.
- Electrical energy losses during initial start-up of equipment.

After:
- Potential lost product losses can be reduced.
- Reduce the use of raw water for the Gas Conditioning Tower system.
- Eliminate potential Raw Mill operating costs using air heaters that can consume up to 3000 litres of diesel per hour.
- Lower replacement part prices.
- Reduced electricity costs when starting equipment.

4. Delivery (D)
Before:
The product transfer process in the Raw Mill area is not optimal.
After:
Raw Meal production is more stable as there is no more start/stop of equipment.
5. Safety (S)
Before:
Increase the risk of occupational accidents, if the Raw Mill start-up uses Air Heater.
After:
The potential for occupational accidents is reduced because the system works optimally since the possibility of using Air Heater does not exist.
6. Morale (M)
Before:
Employees become bored due to repetitive trouble.
After:
Employee morale is better, because communication problems that previously occurred frequently have disappeared.
7. Environment (E)
Before:
Raw Mill often shuts down suddenly which causes air pollution because the Gas Conditioning Tower system must work optimally.
After:
Avoid air pollution as Raw Mill operation performance is maintained.

3.8 New Standards

New standards are needed to document the results of the repairs that have been carried out and also maintain the reliability of the repairs. Therefore, the researcher here created two kinds of standards that serve as a reference in maintaining the performance of the repair results.

a. Design Standard

Design standards are guidelines or rules used to ensure consistency, efficiency, and quality in creating a product or system. These standards cover various aspects, such as aesthetics, functionality, ergonomics, and sustainability. In the modern context, design standards also consider user-friendliness, accessibility, and technology compatibility.

The application of design standards aims to create results that fulfil user needs and comply with applicable regulations or industry norms. With design standards in place, the development process can be more focused, uniform, and produce globally reliable products.

The following is the standard design of the communication network topology as a result of the improvement in the hydraulic pump unit control.

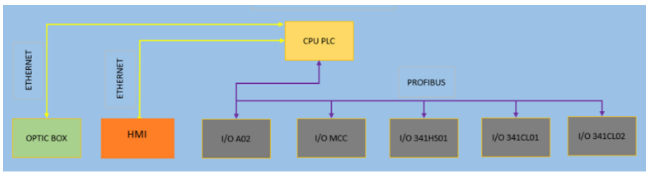

Figure 5. Improved communication network topology

b. Maintenance Standard

Maintenance standards are guidelines designed to ensure equipment, machinery or systems continue to operate optimally, safely and efficiently. These standards include preventive, predictive, and corrective maintenance procedures that aim to prevent sudden breakdowns, extend equipment life, and reduce operational downtime. Here the researcher has made maintenance standards in the form of work instructions documented in the standard document of PT Semen Gresik with the number IK/SG/MTC/50050289/024.

IV. CONCLUSION

Based on the results of data processing and analysis, conclusions were obtained to answer the research objectives. The conclusions in this study are as follows:

1. The root cause of communication problems in the Hydraulic Pump Unit control at the Raw Mill PT Semen Gresik is the remote I / O PLC is less reliable, high temperature, too many loops, missing grounding cables and incorrect checking procedures.
2. The solution to the communication problem in the Hydraulic Pump Unit control at the Raw Mill PT Semen Gresik is to replace the type of remote I / O PLC, add a Junction Box and relocate the Remote I / O PLC into the LCP room, design a more effective and efficient network topology and change the communication protocol from ethernet to profibus, repair grounding cables and share knowledge about new controls and make drawings and maintenance standards.
3. The standards made by researchers are in the form of design standards and also maintenance standards that have been documented in the form of work instructions.

REFERENCES

[1] Siringoringo, H., Linear Programming: Operations Research Techniques Series, 1st ed., F. Wiwiek Nurwiyati, Graha Ilmu, 2005.

[2] Gaspersz, V., Statistical process control: Application of statistical techniques in total business management, PT Gramedia Pustaka Utama, 1998.

[3] Tjiptono, F., Contemporary Management and Marketing Perspectives, 1st ed., Andi, 2000.

[4] Lindsay, James R. Evans, W. M. (2007). Introduction to Six Sigma: An Introduction to Six Sigma & Process Improvement. Fourth Edition. [Online]. Available: https://openlibrary.telkomuniversity.ac.id/pustaka/8428/pengantar-six-sigma-an-introduction-to-six-sigma-amp-process-improvement.html

[5] Yamit, Z., Product and service quality management, 5th ed., Ekonesia, 2010.

[6] Hunt, V. D., Managing for Quality: Integrating Quality and Business Strategy, Business One Irwin, 1993.

[7] Sugiyono, Qualitative Quantitative Research Methods and R&D., CV. Alfabeta, 2017.