Identifying Project Delays in the Engineering Division of a Manufacturing Company: Using the Fishbone Diagram and Root Cause Approach

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ABSTRACT

Project delays are a common challenge in project management, especially in the engineering sector of the manufacturing industry. This study aims to identify the root causes of delays in production machinery procurement projects within the Engineering Division at PT XYZ, focusing on internal processes that affect project completion. The study uses Fishbone Diagram and Root Cause Analysis (RCA), which are effective tools to systematically uncover complex causal factors. The research is descriptive qualitative in nature, based on secondary data from 27 Project Status Reports (PSRs) from February 2022 to December 2023, categorized into six factors: Man, Machine, Method, Material, Measurement, and Environment. Fishbone analysis and 5 Whys were used to determine dominant and root causes. Finding show that delays are primarily caused by Method (25.4%), Machine (22.8%), and Man (21.1%) factors. Root causes include the lack of standardized design processes, limited machine precision for new design requirements, and delays in management decision-making due to incomplete technical information and multitasking among designers. To mitigate delays in future projects, PT XYZ is advised to establish a cross-functional planning team from the early stages, develop consistent SOPs for design, approval, and validation, and implement better human resource allocation through integrated project scheduling. These steps are expected to enhance project efficiency and accelerate technical decision-making processes.

1. INTRODUCTION

One of the main challenges in engineering project management is project delays, especially in the complex and dynamic environment of the manufacturing industry. Projects involving technological system development, machine modifications, and infrastructure modernization often face time lags that impact cost efficiency, implementation quality, and operational sustainability. This phenomenon of procurement delays is not unique to one or two companies, but is a common problem across the manufacturing industry. Fatmaria[1] stated that the absence of an integrated information system and weak vendor control systems were crucial factors causing delays.[2] Kurniawan and Mulyono [3]emphasized the importance of risk-based procurement and vendor performance monitoring to anticipate supply constraints. stated that delays in improvement projects in the industrial sector can be significantly reduced through systematic approaches such as simulation and critical path mapping. Furthermore, Viles et al.[4] Research has identified that over 70% of delays in construction and engineering projects stem from implementation issues, administrative problems, and lack of coordination between departments. The reality on the ground shows that delays in component procurement remain a significant problem, directly impacting productivity declines, increased production costs, and the potential loss of customer trust. A study by Makhmudah et al.[5] examined procurement delays in manufacturing companies by examining 226 cases and using a combination of Fishbone Diagrams and the 5 Whys model. The results revealed root causes such as lack of internal coordination, unintegrated information systems, and the characteristics of make-to-order suppliers. Another study on "The role of standardization at the interface of product and process development" emphasized that without formal standardization in the early design phase, integration between design and production processes is suboptimal, increasing the risk of time and quality deviations [6]. This finding aligns with PTXYZ's situation, which does not yet have a formal internal policy for the design process.

In this study, project delay is defined as a condition where the actual completion of finishing project exceeds the time planned in the initial baseline schedule. Delay indicators are identified through records in the Project Status Report (PSR), including time deviations in the design, procurement, installation and also commissioning phases. Projects at PT XYZ are carried out by the Engineering Division, with the Production Division acting as the customer and end user of the machinery. Therefore, delays in project completion will directly impact production operations. Based on PSR data, the average delay is 75 days, with some reaching 180 days. The company bears additional costs such as overtime, extended project team working hours, and storage costs due to components being stored in warehouses at risk of damage or obsolescence. Furthermore, these delays hamper planned production capacity increases, resulting in lost revenue opportunities. Non-technical consequences also occur, namely the damage to the Engineering Division's reputation in the eyes of the Production Division, which is considered incapable of meeting targets professionally and on time..

Root Cause Analysis (RCA) is an analytical framework or an analytical process used to identify the root cause of a problem, so that appropriate and sustainable corrective actions can be taken. In this study, RCA was used to analyze project delays based on company data obtained from the Project Status Report (PSR) document, not through brainstorming techniques. One of the tools in RCA used is a fishbone diagram that functions to group the causes of delays into six main categories: Man, Machine, Method, Material, Measurement and Environment. After the cause category is identified, the analysis is continued with the 5 Why method to explore more deeply the dominant cause until the most fundamental root cause is found. With this approach, a systematic analysis will be based on real data to support more accurate and targeted improvement recommendations.[7]

Fishbone diagram was introduced by Kaoru Ishikawa in 1985 which is also known as cause-and-effect diagram or Ishikawa diagram is an analytical tool used to identify, organize, and visualize various causes that may contribute to a particular problem or effect. [8]This diagram is called fishbone because its shape resembles a fishbone, with the fish head representing the main problem and the fishbone representing the cause category. This tool is used when identifying possible causes for a problem when the team is having difficulty finding the root of a problem [9]. The procedure for making a fishbone diagram is 1) Determine the problem and write it on the right side of the diagram as the head of the fish, 2) Identify the main categories of causes and draw them as horizontal line branches, 3) Write down the causes in each category, 4) Once the diagram is complete, use it to analyze the causes and plan corrective actions or subsequent analysis.

The 5 Whys method is a root cause analysis (RCA) technique developed by Sakichi Toyoda. This technique involves repeatedly asking the question "why?" to a problem until the root cause is found. This is usually done five times, but can be more or less depending on the complexity of the problem. The function of this method is to trace cause-and-effect relationships logically and systematically, while the goal is to identify the true root cause, not just the surface symptoms. This method is done by sequentially tracing each answer to the previous question and is often used in conjunction with other tools such as fishbone diagrams to direct the analysis focus on the dominant cause [9].

In this study, to find the main causes of project delays, fishbone diagrams were used to identify and group causes, while 5 Whys was used to explore one cause in more depth to find the root cause. By combining fishbone diagrams and the 5 Whys method, it was possible to map the factors causing delays from both internal and external sides of the company, as well as provide a rational basis for formulating solutions[10]. This diagram is effective in identifying cause-and-effect relationships in complex systems, including manufacturing projects that involve many functions and resources. Fishbone diagrams can also help teams visualize causes hierarchically to facilitate the diagnosis process.

Literature study of the application of fishbone diagram and 5 Why method as part of RCA is used to identify the root causes of delays, including lack of internal coordination, information systems that are not yet integrated and the characteristics of suppliers who are not ready to stock goods. [5]Other studies state that the application of fishbone diagram and 5 Why method has an impact on improving product quality, both direct impacts in the form of decreasing defect rates and indirect impacts, namely increasing morale from all parts to work together to find solutions to product quality problems that occur [11].

This research was conducted at a manufacturing company in the Engineering Division at PT XYZ which recorded 20 cases of project completion delays out of a total of 24 projects worked on from February 2022 to December 2023. The three main factors with the highest frequency of delays, namely Method, Man and Machine, contributed more than 69.3% of the total causes of project delays. The purpose of the research is to conduct an in-depth analysis of component procurement delays using the Root Cause Analysis method, identify the root causes from various causal dimensions and develop applicable improvement strategies that can be implemented by the company to increase the effectiveness and efficiency of overall project implementation. The urgency of this research lies in the high level of delays in machine procurement projects in the manufacturing industry, particularly at PT XYZ, where 20 out of 24 projects (83%) experienced delays. These delays not only impact operational schedules but also directly affect productivity, costs and customer trust. The implication of this research is the systematic identification of dominant delay factors and their root causes, which can serve as a strategic basis for management to develop mitigation policies and improve project processes comprehensively and sustainably. This study involved respondents in the root cause validation stage through semi-structured interviews with four key project stakeholders: two Project Leaders, one PPIC people and one Engineering Designer. These interviews served as triangulation to confirm the findings of the PSR documentation and deepen the 5 Whys process as part of the Root Cause Analysis .

Although previous literature provides an overview of the causes of project delays, most studies still focus on civil construction, apparel or public sector projects. In-depth studies based on internal project documentation in the manufacturing sector, especially through an integrated RCA and fishbone diagram approach, are still limited. In this study, the main causes of delays include inaccurate initial design planning, late design approval, and lack of experience and knowledge of design personnel. Therefore, this study aims to identify the root causes of project delays by analyzing PSR data using the Fishbone Diagram and RCA approaches with the data source being the Project Status Report (PSR) documentation in the Engineering Division of PT XYZ.

2. METHOD

This research uses a qualitative descriptive method with a company document approach and Root Cause Analysis (RCA). The primary data source comes from 27 document of Project Status Report (PSR) for the production machinery project in the Engineering Division of PT XYZ. The data was from project within February 2022 to December 2023. The data in the PSR includes records of project constraints, coordination meeting results and work progress. This data was then classified into Fishbone Diagram categories 5M+1E: Man, Machine, Method, Material, Measurement, Environment and further analyzed using the 5 Whys technique to identify the root causes of the three dominant categories. To strengthen the results of the document analysis and ensure the validity of the identified causes, semi-structured interviews were conducted with four key respondents directly involved in the project process: two Project Leaders as they have full responsibility for project management and decision-making; one person from PPIC (Production Planning and Inventory Control) as they play a role in scheduling and component procurement and one Engineering Designer as they are responsible for creating engineering drawings and design documents as the main input for the project. Respondent selection criteria were determined based on their strategic role in the project cycle, direct involvement in the problem being analyzed and access to the technical and managerial information necessary to accurately identify root causes. This selection also considered cross-functional representation (engineering, managerial and operational) to ensure comprehensive triangulation of data .

2.1 Analysis Stage

The analysis was conducted through two main stages: classification of the factors causing delays using a fishbone diagram approach and Root Cause Analysis (RCA) of three dominant categories using the 5 Whys technique. The research flow was carried out according to the flowchart in Fig. 2 below.

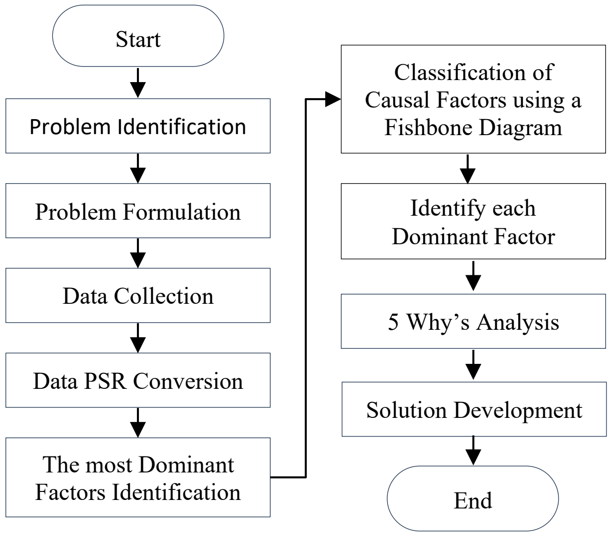

Fig. 1 Root Cause Analysis Research Flow for Project Delays

2.2 Data collection technique

The research data was obtained from 27 Project Status Report (PSR) documents prepared by PPIC personnel and Project Leaders during project activities between February 2022 and December 2023.

2.3 Convert PSR notes to Fishbone categories

The Project Status Report (PSR) document used in this study contains narrative notes on project progress and obstacles, written periodically based on the results of technical coordination meetings. In order to be analyzed systematically, the raw data in the PSR was first converted into a structured form using the Fishbone Diagram (Ishikawa) approach. The conversion steps are (1) Identifying the problem statement, by understanding the context of each sentence, especially whether it leads to obstacles to project delays or not. (2) Grouping into Fishbone categories, each sentence is entered based on the cause category in the fishbone. An example of the notes in the PSR document file is shown in Fig. 2.

6. REPLACEMENT OF MTR FOX 2T+10T
- Procurement process, estimate: 10/07/2002

7. PORTABLE FEEDING LINE C33
- Procurement delivery: 4-6 Months (delay from OEM)
- Start predesign in mid-April 2022 due to manpower working on the project Sub Filling Tank

8. REPLACEMENT OF CNV BLND EX-SILO
- Procurement delivery: 4-6 Months (delay from OEM)
- 2 units of conveyor will make by the workshop (full of tasks)

Fig. 2 Example contents of the Project Status Report file

The actual conversion method of PSR records is as follows:

- "Procurement delivery: 4-6 Months", is included in the Material category.
- "Start Predesign in mid of April 2025 due to manpower working on the Sub Filling Tank project", is included in the Man category, namely due to limited personnel so that there must be a reschedule due to the full workload.

This kind of conversion was carried out for all relevant records in the 27 PSR documents and the results of this classification were then tabulated to calculate the frequency per category in tables 2 up to 4. For each grouping, only 3 dominant causes were written as samples.

2.4 Project Status Report (PSR)

Project Status Report (PSR) is a periodic report containing information about project progress. Its purpose is to provide a brief overview of the schedule, costs, risks and important issues to all parties involved in the project. [12]. The PSR document contains meeting minutes, technical constraints, procurement status, implementation chronology, emails, discussions and management decisions that are routinely documented during project implementation. The PSR document is a relevant data source because it is actual, reflects real conditions in the field and records chronologically the project dynamics and important decisions that impact the schedule. The analysis process is carried out using the Root Cause Analysis (RCA) method with Fishbone Diagram tools and the 5 Why's technique.

2.5 Fishbone Diagram

A fishbone diagram, or Ishikawa diagram, is a tool used to identify the root causes of problems in a system. It is used to show the structure of relationships between causes that represent dominant causes, thus visually aiding problem understanding. [8] The concept of a fishbone diagram is a diagram that resembles a fishbone, consisting of a head and bones. The head represents the main problem whose cause is being investigated, with several spines representing the cause categories.

2.6 Root Cause Analysis (RCA) uses the 5 Why's technique

The three categories with the highest frequency are method, machine and man, were further analyzed using the 5 Whys technique to further explore the root causes of the problems until their underlying source was identified. The results are presented in the form of narrative descriptions and cause-and-effect diagrams

2.7 Data Validity and Credibility

To maintain the validity of the results, the coding process was carried out through internal triangulation by cross-validating the contents of the PSR document with information from personnel including the Project Leader, Engineer Designer and PPIC who were directly involved in the project using structured interviews. Through this approach, it is hoped that the analysis results will be able to fully describe the structure of the causes of project delays carried out by the Engineering Division and become a strong basis for developing improvement strategies. The purpose is to ensure that the causes of delays identified through documentation analysis align with actual experiences in the field. Triangulation was conducted in two stages: 1) Content validation: Findings from the PSR documentation were compared with respondents' answers to questions designed based on the Fishbone analysis and the 5 Whys analysis. 2) Logical validation: The researcher reanalyzed the alignment between the identified causes and the cause-and-effect sequence in the 5 Whys and confirmed by relevant respondents, ensuring that the root causes were explored rationally and accurately. With this triangulation approach, the research has a strong foundation of internal validity because it confirms the documentation findings with field data obtained directly from competent project actors.

2.8 Data collection

From the project data carried out by the Engineering division of PT XYZ from 2022 to 2023, there were a total of 24 projects, of which 20 projects (83%) experienced delays and 4 projects (17%) were completed according to the specified schedule.

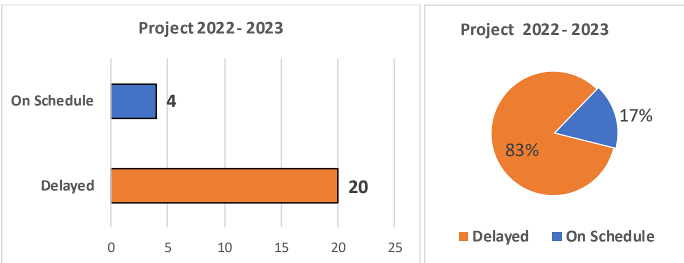

Fig. 3 Number of Projects at PT XYZ during 2022-2023

The data source for this study was collected from Project Status Reports (PSRs) that were created and documented periodically and compiled using Microsoft Word. The PSRs contain notes on the results of coordination meetings that cover technical discussions, implementation strategies, issues encountered, work progress, and managerial decisions. This document was compiled by personnel from the PPIC (Production Planning and Inventory Control) department based on coordination meetings held routinely every two weeks. These meetings involved cross-functional personnel involved in the project, including project leaders, designers, procurement, PPIC, workshops, and managers. This data is qualitative in nature and will later be grouped according to categories. Table 1 to table 3.

Table 1. Grouping of data categories Method and Machine

No.	Method (29 causes)	No.	Machine (26 causes)
1	There is no standardization of the design process.	1	The main engine is being used for another project.
2	Image revisions were not well communicated.	2	Components were not tested before being sent to site.
3	There is no definite timeline for user approval.	3	System integration has not been done in the workshop.
4	Undocumented test method.	4	There was a deviation during the component integration test.
5	The design does not take into account actual field conditions.	5	Components damaged upon receipt at site.
6	Installation method has not been created before procurement	6	Spare part replacement takes a long time.
7	Workflow between departments is not yet organized	7	Local spare parts do not meet specifications.
8	Users were not involved during the initial planning phase.	8	Delayed delivery of spare parts from vendor.
9	Approval is done verbally, not in writing.	9	OEM items cannot be converted to local yet.
10	Design changed after order was placed.	10	There is no preventive maintenance schedule.

Table 2. Grouping of Man and Material category data

No.	Man (24 causes)	No.	Material (21 causes)
1	Design approval, specifications, or management decisions have not been given.	1	PR/PO is still pending due to revisions, slow approval, vendor backlog.
2	PIC has not followed up on the work, has not been determined, or is overloaded.	2	Large items are still being manufactured.
3	Cross-divisional coordination is not yet effective.	3	Modular components not yet included.
4	User requests come in late or change after the final design.	4	Small components are incomplete.
5	Commissioning and execution scheduling has not been clearly determined.	5	Housing materials and protection systems are not yet available.
6	Supervision by the PIC is not comprehensive.	6	Incomplete components of a system.
7	The handover process was carried out partially.	7	Material returned due to mismatch.
8	There is no agreement on cross-functional testing methods.	8	Revised drawing has not been sent to the vendor.
9	PIC has not yet supervised vendors and procurement.	9	Overseas vendor approval not yet completed.
10	Project leader does not actively update project status.	10	New components have not been included in the procurement list.
11	Schedule changes were not promptly communicated to the team.	11	The goods were sent in stages and were not complete.

Table 3. Grouping of Environment and Measurement category data

No.	Environment (8 causes)	No.	Measurement (6 causes)
1	The project location was affected by light flooding.	1	There is no project baseline schedule.
2	Power outage in the work area.	2	Progress monitoring is only done manually.
3	Access road to the location is closed.	3	There is no weekly evaluation benchmark.
4	Logistical constraints due to extreme weather.	4	Design revisions are not recorded in tracking.
5	Water supply is hampered by other utility projects.	5	There is no measuring tool for design quality.
6	The working environment is too narrow for heavy equipment.	6	Performance evaluation is based only on feeling.

3. RESULTS AND DISCUSSION

Classification of causal factors of delay using Fishbone Diagram. All findings and information from the PSR are grouped into six causal categories based on the 5M+1E category approach. Table 4.

Table 4. Grouping problems based on 5M+1E categories

Factor	Information
Man	Factors related to the ability, work capacity, and responsibilities of the PIC
Machine	There are technical problems with manufacturing equipment and machines.
Method	Inconsistency or absence of work procedures and designs
Material	Availability, suitability and delivery of components/materials
Measurement	Limitations of measuring instruments or quality testing methods
Environment	External constraints such as weather, location access, infrastructure disruptions

Identify dominant frequency factors. Each category is calculated based on its frequency of occurrence across 27 PSR documents to determine the dominant factor. The classification results are used to select priority categories for further analysis.

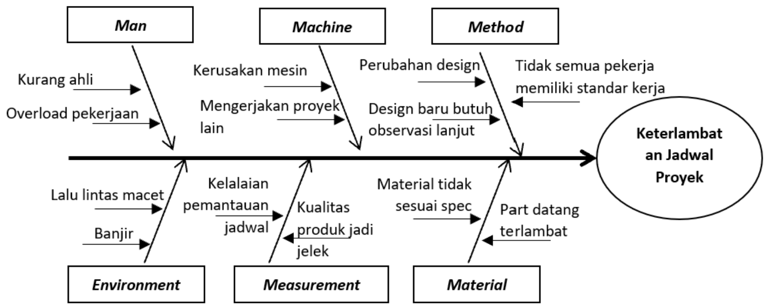

Fig. 3. Fishbone Diagram with Main Problem is Project Schedule Delay

3.1 Analysis of dominant categories of causes of delays

The proportion of causes of delay was calculated to determine the contribution of each category to the causes of project delays. The results in Table 5 show the frequency and percentage contribution of each cause category.

Table 4. Proportion of delays in each category

Category	Frequency	Percentage (%)	% Accumulative
1. Method	29	25.4%	25.4%
2. Machine	26	22.8%	48.2%
3. Man	24	21.1%	69.3%
4. Material	21	18.4%	87.7%
5. Environment	8	7.0%	94.7%
6. Measurement	6	5.3%	100.0%
Total	**114**	**100**	

Based on the table above, there are three categories that contributed 79 incidents (69.3%) of the 114 causes. This shows that the root causes of project delays predominantly come from the Method (25.4%), Machine (22.8%) and Man (21.1%). This analysis is then visualized in a Pareto diagram (Fig. 6) which shows the cumulative distribution of cause frequencies, that the top three categories (Method, Machine and Man) already cover more than 60% of the total causes, according to the Pareto

80/20 principle, namely that most impacts are caused by a small number of main causes. These three categories are causes that have a large or critical influence on project delays.

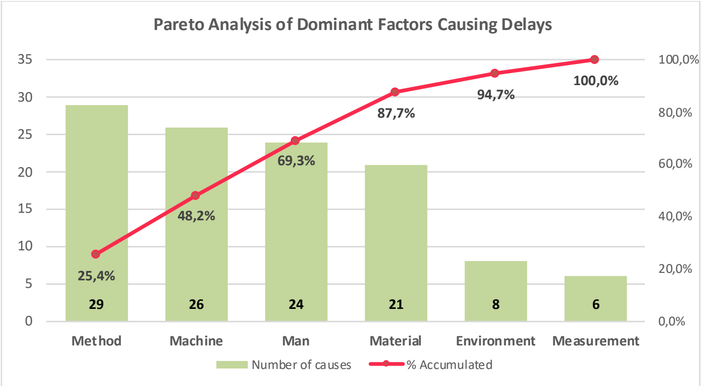

Fig. 4. Pareto analysis of factors causing delays

Applying the Pareto principle allows management to focus on developing more targeted and efficient improvement strategies for mitigation in subsequent projects. Companies can reduce the risk of project delays by focusing improvements on these three factors, rather than a blanket approach across all categories. Therefore, subsequent mitigation steps will be directed at these three main categories using the RCA approach and 5 Whys analysis.

3.2 Fishbone diagram of domiannt cause categories

After conducting a Pareto analysis of the six main categories of delay causes (Man, Machine, Method, Material, Measurement, and Environment), three dominant cause categories were obtained that had the largest contribution to the delay in the production machine procurement project at PT XYZ, namely Method, Machine, and Man. To dig deeper into the root causes of these three dominant factors, a visual analysis was conducted using a Fishbone Diagram. Its function is to group the causal factors into six main categories. Each category in each dominant factor is filled with causes based on the reading results from the Project Status Report (PSR) data. Next, for each dominant factor, 3 categories with the largest number of causes were selected, then further analyzed using the 5 Why's Analysis approach to find the most fundamental root cause.

For the Method factor, after visualizing it in a Fishbone Diagram (Fig. 6), there are five main cause categories that contain the majority of issues. Therefore, these five categories are the focus of the 5 Whys analysis.

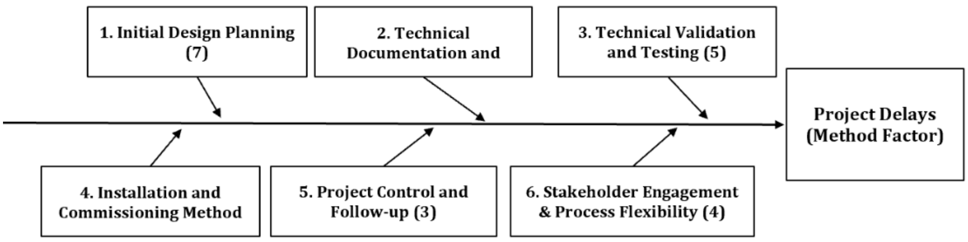

Fig. 5. Fishbone Diagram Causes of Delays Method category

Table 5. Factors Causing Delays in the Method Category

METHOD	Number of causes	%	% Accumulative
1. Initial Design	7	24%	24%
2. Technical Documentation and Communication	6	21%	45%
3. Technical Validation and Testing	5	17%	62%
4. Installation and Commissioning Methods	4	14%	76%
5. Project Control and Follow-up	3	10%	86%
6. Stakeholder Engagement & Process Flexibility	4	14%	100%

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Total	**29**	**100%**	

After conducting a Pareto analysis for the Method factor, three dominant factors were obtained with a cumulative % of 62%. (Fig. 7).

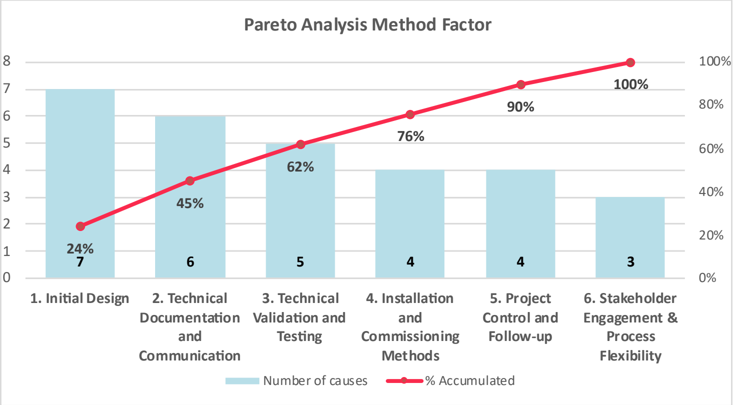

Fig.6 Pareto analysis of dominant causes in the Method factor

Factors were the second most dominant factor contributing to delays in the machine procurement project at PT XYZ. Using a fishbone diagram, it was found that these delays were closely related to two main categories: machine and equipment readiness, technical constraints, and material quality (Fig. 8).

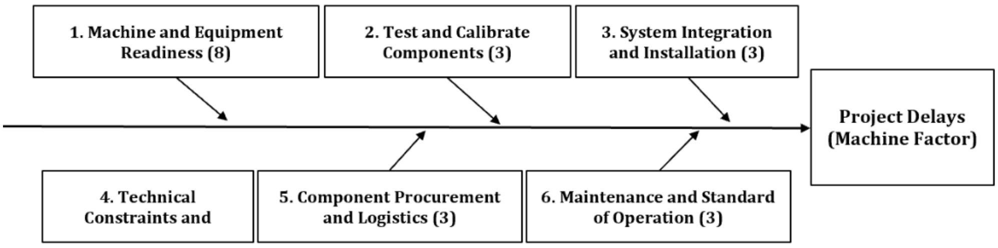

Fig.7 Fishbone Diagram of Delay Causes from Machine Factors

Table 6. Factors Causing Delays in the Machine Category

MACHINE	**Number of causes**	**%**	**% Accumulative**
1. Machine and Equipment Readiness	8	31%	31%
2. Technical Constraints and Material Quality	6	23%	54%
3. Component Testing and Calibration	3	12%	65%
4. System Integration and Installation	3	12%	77%
5. Component Procurement and Logistics	3	12%	88%
6. Maintenance and Operating Standards	3	12%	100%
Total	**26**	**100%**	

After conducting a Pareto analysis for the Machine factor, two dominant factors were obtained with a cumulative % of 54%. (Fig. 9).

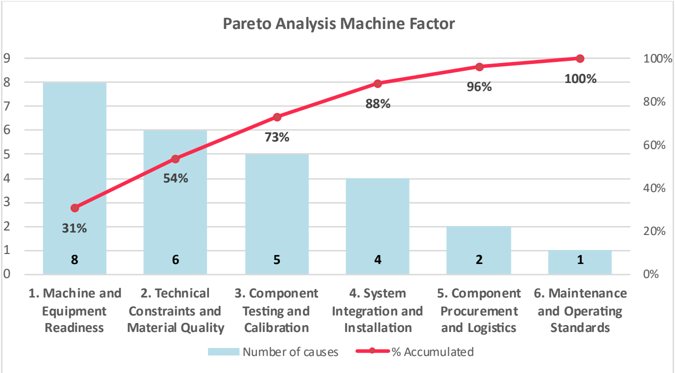

Fig. 8. Pareto analysis of dominant causes of the Machine factor

The third dominant factor is Man. Using a fishbone diagram, it was found that this delay is closely related to two main categories: the role and responsibility of the PIC and team coordination and communication (Fig. 10).

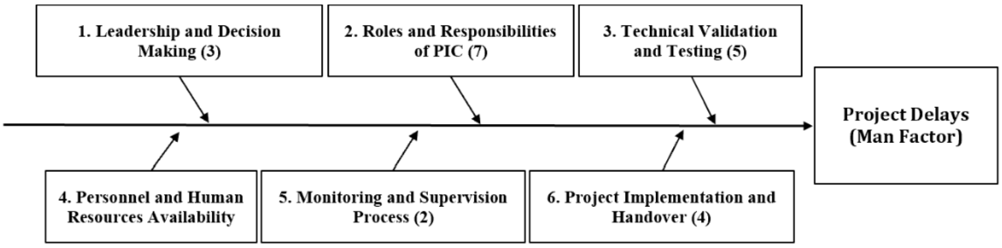

Fig. 9. Fishbone Diagram of Causes of Delays from Man Factors

Table 7. Factors Causing Delays in the Man Category

MAN	**Number of causes**	**%**	**% Accumulative**
1. Roles and Responsibilities of PIC	7	29%	29%
2. Team Coordination and Communication	5	21%	50%
3. Project Implementation and Handover	4	17%	67%
4. Personnel and HR Availability	3	13%	79%
5. Leadership and Decision Making	3	13%	92%
6. Monitoring and Supervision Process	2	8%	100%
Total	**24**	**100%**	

After conducting a Pareto analysis for the Man factor, two dominant factors were obtained with a cumulative % of 50%. (Fig. 11).

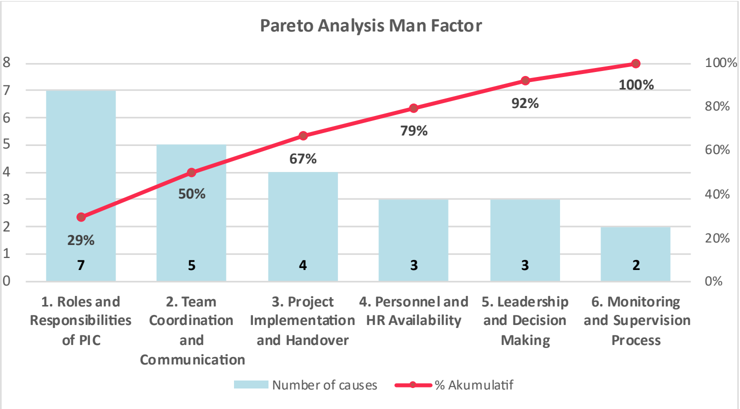

Fig. 10. Pareto analysis of dominant causes of Man factors

3.3 The Interview process is a stage in the 5 Why's Root Cause Analysis

In order to explore the root causes of project delays identified through Pareto analysis and Fishbone Diagram, a 5 Whys analysis was conducted on the dominant cause categories, namely Method, Machine, and Man. This analysis process was not only carried out deductively from project documentation data, namely the Project Status Report, but also further validated using semi-structured interviews with parties directly involved in the project. Semi-structured interviews were chosen as the data mining method because they provide flexibility in exploring information more deeply based on the flow of the interviewee's answers while still having a directed question framework. The main purpose of conducting this interview was as a triangulation effort to confirm and complement secondary data obtained from the PSR documentation. Data triangulation is a technique to test the validity of information by comparing it from various sources or methods.

The personnel who served as sources in this interview process were two Project Leaders, who were responsible for the overall project management, one person from PPIC (Production Planning and Inventory Control), who managed the procurement and logistics flow of project components and one Engineering Designer, who was involved in the design process and technical planning of the project. Each source was given questions tailored to their responsibilities and roles in the project. The results of this interview were then synthesized to answer the question "why" repeatedly (five times or until the main root cause was found) for each finding in three dominant categories. For each problem, the causal factors are shown in table 9. By using the 5 Why's technique, the results obtained were:

1. In the Method category, it was found that project delays were often caused by a lack of standardization in the design planning process. Using the 5 Whys technique, the root cause was traced and it was discovered that this irregularity stems from the lack of clear guidelines or policies regarding the design process, which is caused by management not yet realizing the importance of standardization. The focus is directed more at achieving the final project result than ensuring the process stages run systematically. This occurs due to meeting tight deadlines, which ultimately indicates a lack of thorough planning from the project's inception. Another problem in this category also arises from delays in design approval, which is apparently caused by documents from the design team not being available in time. This occurs because the designer is simultaneously handling other projects. This irregular scheduling is rooted in the lack of a priority system and integrated communication between the involved divisions, resulting in workload conflicts and delays in the managerial decision-making process.
2. In the Machine category, the root cause of the problem stems from components that do not meet design specifications, particularly in terms of manufacturing precision. A 5 Whys analysis revealed that this discrepancy was caused by manufacturing machines that were unable to meet the tolerances required by the new design. This high-precision design exceeded the technical capabilities of the company's existing machines. However, new, more precise machines were not purchased because the frequency of such needs was relatively low, making the investment in new equipment economically unfeasible. Thus, the root cause was the limited capabilities of the machines to cope with the increasing complexity of the design.
3. In the Man category, it was found that one of the main causes of delays was the inability to approve designs or management decisions in a timely manner. The 5 Whys technique revealed

that incomplete technical information was due to unavailability of documents from the design team, as the designer was working on other projects. This parallel workload created an excessive workload and resulted in delays in document delivery. This occurred because the design was highly complex and required longer time to complete. Therefore, this problem stemmed from suboptimal human resource allocation and an inefficiently distributed workload for the design team.

Table 8. Problems in each dominant factor

No	Dominant causal factors	Problems
1	Method	1. Initial design planning. 2. Technical Documentation and Communication. 3. Technical validation and testing.
2	Machine	1. Machine and Equipment Readiness. 2. Technical Constraints and Material Quality.
3	Man	1. Roles and Responsibilities of PIC. 2. Team Coordination and Communication.

The 5 Why's technique was carried out through semi-structured interviews with three main project actors, namely the Project Leader, Engineer Designer and PPIC person. Obtained the following results.

A. Category: Method

1. Initial design planning

Problem: Projects do not always have a standardized design process.
Why's 1: Why don't projects always have a standardized design process?
Because there are no clear guidelines or policies regarding the design process.
Why's 2: Why are there no clear guidelines or policies?
Because management has not considered it a priority.
Why's 3: Why hasn't management considered it a priority?
Because they focus more on the end result than the process.
Why's 4: Why focus more on the end result than the process?
Because there is pressure to meet project deadlines.
Why's 5: Why is there pressure to meet project deadlines?
Due to lack of proper planning at the start of the project.

2. Technical Documentation and Communication.

Problem: Design approval was not given in a timely manner
Why's 1: Why wasn't it delivered on time?
Due to pending management decisions
Why's 2: Why is the decision delayed?
Because the documents from the design team are not yet available
Why's 3: Why isn't the document available yet?
Because I'm working on another project.
Why's 4: Why handle other project work?
Because there is no clear priority system.
Why's 5: Why isn't there a clear priority system yet?
Because there is no integrated communication and scheduling mechanism.

B. Category: Machine

Technical Constraints and Material Quality.
Problem: Components do not match the design.
Why's 1: Why do components not fit the design?
Because the manufacturing results cannot be the precision required by the design.
Why's 2: Why are manufacturing results not precise?
Because the manufacturing machines are not capable of producing tolerances according to the new design.
Why's 3: Why are manufacturing machines unable to meet new designs?
Because the expected design exceeds the machine's capabilities.
Why's 4: Why not use a machine that fits the design needs?
Because the type of machine owned has a maximum tolerance limit.
Why's 5: Why isn't the machine type replaced with a more precise one?

Because the need for high precision designs is rare, it is not economical to buy a new machine.

C. Category: Man.
Problem: Design approval, specifications or management decisions have not been provided in a timely manner.
Why's 1: Why hasn't approval been given on time?
Due to delayed management decisions.
Why's 2: Why are management decisions delayed?
Because the required technical information is incomplete.
Why's 3: Why is the technical information incomplete?
Because the design team has not submitted supporting documents (drawings, working system)
Why's 4: Why hasn't the design team submitted the supporting documents?
Because I'm working on another project.
Why's 5: Why work on other projects at the same time?
Due to the difficulty of the design, it takes longer to complete.

4. CONCLUSIONS

This study shows that delays in the production machine procurement project at PT XYZ are predominantly caused by three main categories: Method (25.4%), Machine (22.8%) and Man (21.1%). The results of the 5 Whys analysis identified the following root causes:

1. In the Method category, the root of the problem is the lack of standardization of the design process, which stems from the absence of internal policies and weak initial project planning.
2. In the Machine category, the root of the problem is the component's incompatibility with the design, due to the limited capability of the manufacturing machine to meet the precision standards of the new design.
3. In the Man category, the root of the problem lies in delays in management decision-making, which is caused by incomplete technical information due to the workload of designers handling several projects simultaneously.

The Results was in line with Nancy R. Tague's [9] that explainn in The Quality Toolbox. The use of Fishbone Diagram and Root Cause Analysis effectively highlights systemic problems such as lack of standard procedures, inadequate machine capability and poor resource coordination. In the Method category, the absence of standardized design processes and unclear internal policies led to inconsistent planning and delayed approvals, confirming Tague's classification of "inadequate procedures" as a common root cause. Machine-related delays stemmed from the mismatch between the required design precision and the technical limits of existing equipment, illustrating what Tague defines as "equipment capability mismatch." Meanwhile, delays in the Man category occurred due to designers handling multiple projects simultaneously, resulting in incomplete technical documentation and late decision-making—conditions that Tague associates with overextended human resources and lack of cross-functional coordination.

Suggestions for companies to minimize the possibility of delays in future projects, PT XYZ should form a planning team involving various functions from the early stages. This team should discuss together and be responsible for designing and preparing the project schedule. In addition, the company is also advised to establish consistent standard operating procedures (SOPs) related to the design process, approval, and technical validation across all projects. Human resource allocation management should also be improved with a comprehensive scheduling system for all projects. It is hoped that with these steps, the company can improve the efficiency of project implementation while accelerating the technical decision-making process that has been a factor causing delays.

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