

ANALYSIS OF PROJECT CONSTRUCTION DELAY USING FISHBONE DIAGRAM AT PT. REKAYASA INDUSTRI

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Abstract. *This research focuses on finding the root problem of the construction delay that happened in several tasks at PT Rekayasa Industri's CGPX project. The project was planned to start on June 27th, 2011 and planned to be finished on April 8th, 2013. However, the actual project was finished almost one year later than the planned finished date (March 20th, 2014), despite the fact that the project started on time. The project delays will be analyzed through systematical methodology to find root cause that makes the project finished late using Ishikawa Diagram, then the result will be presented using "5M" criteria. Finally, the best solution will be given as a feedback to the company to improve future project. The result shows that the most powerful delay is caused by human error. The recommendation given to the company is to increase the ability of workers to reduce the delays in these aspects. Way to increase the ability is by doing training, hire more professional person, recruit the third party, or give penalty if the drawing is late.*

Keyword: *Project management, fishbone diagram, project delay, root cause analysis*

Introduction

The knowledge of project management is very important because many projects in business are deemed unsuccessful because lacking of knowledge in project management. Project management also can make our project more effective and efficient, which will lead to have maximal result. Project management is increasingly important for the company. It is also a critical for the success of the company. Thus, the project managers must create a well-planned project that lead company to get maximal result through limited source in the project. Project management requires project manager who has three characteristics, which are knowledge, performance, and personal. In general, projects have a time limit (deadline), it means the project must be finished before or right at the predetermined time. In fact, many projects finished after the deadline. There are many factors that make it happened, and if the symptom had happened the company should held an evaluation to know which process is failed.

This paper will specifically discuss about delays in PT Rekayasa Industri's projects. PT Rekayasa Industri was established based on Regulation of the Government of the Republic of Indonesia Number 7 Year 1981 concerning Capital Participation of the Republic of Indonesia in the Establishment of State-Owned Enterprises Engaging in the Industrial Planning, Engineering and Construction Businesses, State Gazette of the Republic of Indonesia Number 41 Year 1987. The company mentioned "On Schedule" as one of their advantage and stated that they have strong project management abilities and global supply chain for fast procurement. The projects themselves are called Dayung Compression (DC-1) & Central Grissik Plant Debottleneck Project (CGPX). They are part of the "Corridor Block PSC (Production Sharing Contract)" located in the Southern part of Sumatra, Indonesia, in an area between Palembang

and Jambi. The scope of work of the project is EPC. Contract value of the project is \$ 138.000.000. The project is considered as a trigger for pushing local company to use local components in oil and gas industry while the local component in this project reach 55%. It is also will bring 1000 thousand workers in the peak schedule.

Main outcome of this paper is to know the root problem of the construction delay that happen in several tasks and to give the feedback to the company. The feedback is expected to help the company to face the problem in the present and repeating in the future if the problem happened again. The feedback also can be used in the same sector, manufacturing and construction project.

Literature Review

Project Management Concepts

Project is an action to accomplish a specific objective by doing a unique set of interrelated task and effective utilization of resources that available (Gido & P. Clements, 2006). According to PMBOK Guide, it said "project management is the application of knowledge, skills, tools, and technique to project activities to meet the project requirements.". Project management typically including in identifying the requirements and addressing the stakeholders need and concern to make a project plan.

Project Life Cycle

A project life cycle is a collection of generally sequential and sometimes overlapping project phases whose name and number are determined by the management and control needs of the organization and organizations involved in the project, the nature of the project itself, and its area of application (Project Management Institute, 2008).

Every project has a beginning, a middle period where there are organizing and preparing, and a closing. A standard project typically has the following five major phases : initiation, planning, executing, monitoring, and closing. Taken together, these phases represent the path a project takes from the beginning to its end and are generally referred to as the project life cycle. The life cycle provides the basic framework for managing the project, regardless of the specific work involved.

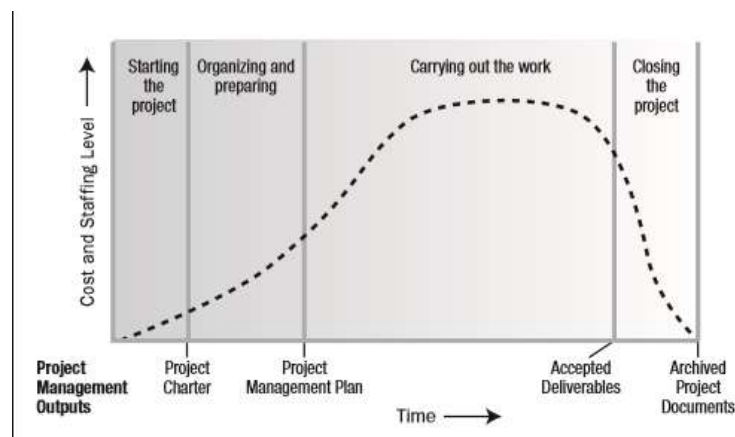


Figure 2.1 Project Life Cycle

EPC Work

EPC stand for engineering, procurement, and construction. EPC is a prominent form of contracting agreement in the construction industry (EPC Engineer, 2014). The contractor and engineer will design

the whole project in detail, procure all the materials and equipment that needed within the project, and doing a construction and deliver it to the clients or owner. The company that delivers EPC Project, which is the PT Rekayasa Industri is called as EPC Contractor.

Ishikawa Diagram

Ishikawa Diagram is well known as Fishbone Diagram. It gets name from its form, which is in the shape of skeleton of a fish. It was devised by Professor Kaoru Ishikawa, who pioneered quality management process in the Kawasaki Shipyards in the 1960s. The fishbone diagram is also well known as cause – effect diagram. It helps to show the correlations between an effect and its multiple happening causes. Fishbone diagram shows the possible causes of a specific event or a problem. It is also illustrate the possible causes of a particular problem by sorting and relating each causes using a classification scheme. In general, it is a analysis of the impact that cause a particular outcome observed phenomena.

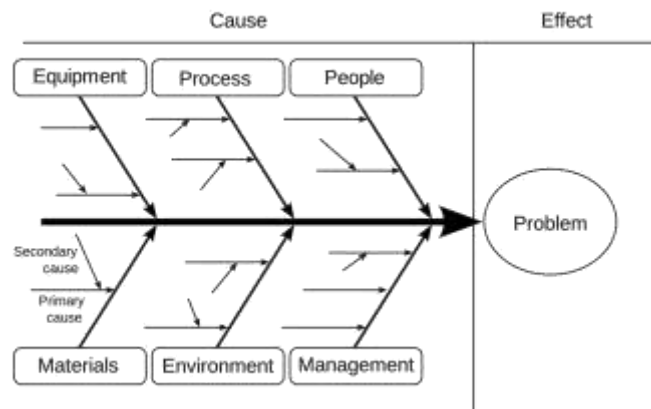


Figure 2.2 Fishbone Diagram

Fishbone diagram has a wide range of applications in the processes of quality assurance processes of all functions of the company. The structure provided by the diagram helps team members think in a very systematic way. Several benefits of constructing a fishbone diagram are that it is very helpful to determine the root causes of a problem using a structured approach and will make a study easier because the researcher can identifies areas where data should be collected. Fishbone diagram has multiple function that can be applied in manufacturing, sales process, and marketing aspects. Each category has different characteristics. The fishbone diagram that used in this research is manufacturing type while the most popular content in manufacturing is "5Ms" ; methods, machines, materials, measurements and man (Usmani, 2014).

Pareto Chart

A pareto chart, also known as a pareto diagram, is a particular sort of histogram, requested by recurrence of event. It indicates what number of defects were created by sort or class of identified cause. Rank ordering is utilized to focus corrective actions. The project team ought to address the causes making the greatest number of defects first. Pareto charts are theoretically identified with Pareto's law, which holds that a generally little number of causes will commonly deliver a greater part of the issues or defects. This is commonly alluded to as the 80/20 principle, where 80% of the issues are due to 20% of the causes. Pareto diagram can likewise be utilized to summarize different kind of information for 80/20 analyses. (Project Management Institute, 2008).

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Project Schedule

Project schedule is a planned dates for performing the tasks and the planned dates for meeting schedule milestones (Project Management Institute, 2008). Project schedule should have a planned start date and planned finish date for each tasks.

Project Delay

A project can be said delays if it is finished after the time that has been determined before like written in the contract. The schedule is increasing and have large impact to the parties that get involved in the project such as contractor and owner. The delayed project can dispute for each parties. It will make the contractor spend more money in variable cost such as paying the labor, transportation cost, etc. Even the contractor can pay a penalty if this written in the contract. And the owner will have an impact such as less income because the facilities can not be used in planned time. The project management has an active role to make the project success. Scheduling a project is needed to make the project can finished on time.

Methodology

Research Design

In order to solve the problem, researcher uses five systematical methodology steps. Each method and step will be explained in detail which each step has its own objective and mutual purpose. Starting from the objective identification, literature study, data collection and research, data analysis, and conclusion. As seen in the diagram below.

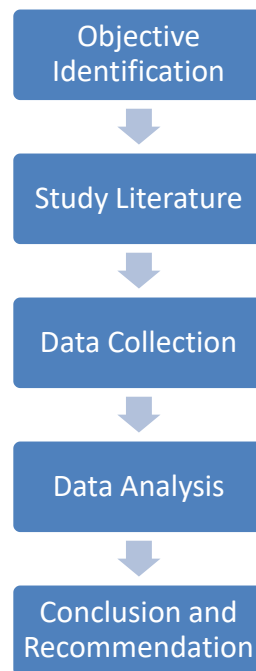


Figure 3.1 Research Design

This research use qualitative method. Qualitative method is needed because the objective of this research is to know the classification of actions. Qualitative method because data that need to collect and analyze need a qualitative analysis method. The character of the problem need the qualitative method. The method that researcher use is non ethnographic. It means the data collection referring to

unstructural interview, researcher did not directly participate in the activity to collect the data which means researcher just meet the informant to collect the data (Afrizal, 2014).

Data Collection Method

1. Primary Data

Primary data is data that collected directly from the first hand person and collected systematically from source of origin by researcher. In this research, primary data is collected by doing interview to the project officer.

2. Secondary Data

Secondary data is data that collected not from the first hand person. It means secondary data is collected from source that has been published before. For this research, secondary data is collected from the internet, historical data, book literature, and documents from the company. Reseacher use secondary data as a main data to formulate this research. From the company, researcher has a project Gantt Chart, projecct description, and company profile that collected from the officer.

1. Data Analysis

Qualitative data analysis is reduce data, serve data, and make a conclusion (Miles & Huberman, 1994). This chapter also explain deeply how should the data analyzed in qualitative research. There are three steps in analyzing data; data codification, serving the data, and conclusion (Miles & Huberman, 1994).

Codification means data that already gathered need to be named, so the output is all data will get a classification. The classification is needed to separate the not important data from the important one, which means all data that already gathered are not all important. Researcher need to split the data to two type; the important and not important. For the data that not important, it is also not necessary to use it while the important data is needed to make this research complete. After the data has been classified, the next step is serving the data. When the data has been separated, the data is ready to serve. It is a forward analysis where the researcher serve what already found. It is very recommended to use matrix or diagram to shows the research result because the picture shows much more than a narrative. Narrative also not recommend because it is less effective than matrix or diagram.

From the data that have been served, researcher can have a conclusion based on it. It is the interpretation of the researchers on the findings of a data. It is important to recheck the codification and serving the data steps after the conclusion has been made to make sure there is no mistake when the conclusion made. Repeating those three steps will make researcher have a valid conclusion will lead the research has a good result. For this research, researcher use the document from the company as main data, which are a bar chart. The bar chart consist of complete task as mentioned in Chapter II which called Project Schedule Network Diagram. This bar chart shows from the beginning of the project till the end in very deep.

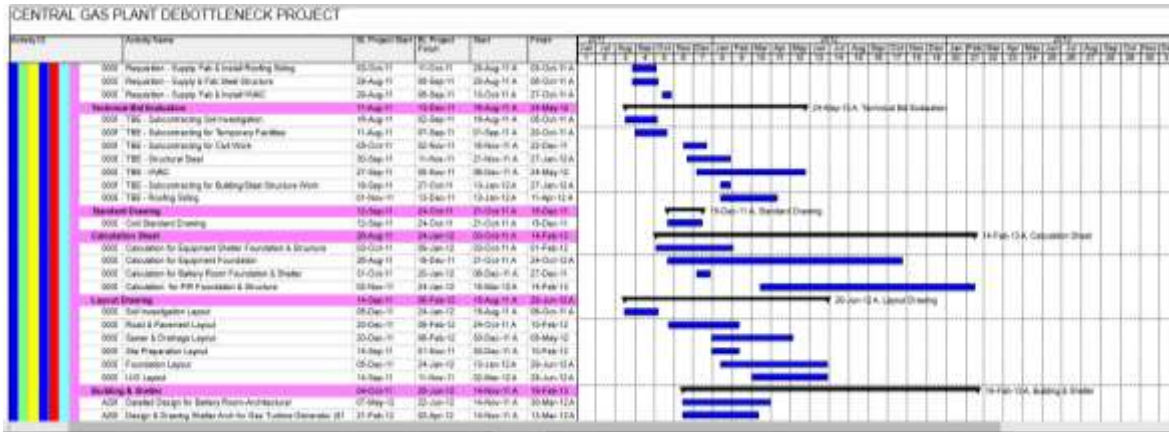


Figure 4.1 Bar Chart

As mentioned before, all data that have been collected need to separate to choose which the important data and not important data because it is not possible to process all data because its complexity and large number of tasks. The original bar chart has 13 level, means it is very deep and complete enough to show the project task from the beginning till end and how deep is the project. Every single task can be seen in the bar chart. It has 33 pages in PDF Format See Appendix A. Because of its complexity, researcher shows the preview in the figure above about the bar chart that has company given to the researcher.

From the bar chart, researcher need to simplify the bar chart to make easier in making the analysis. To make it simple, researcher has convert the original bar chart to the table to make it easy to read. It reduce the original bar chart which has 13 level to 1 level to simplify the bar chart and make the data analysis easier. It is become a 1 level after researcher separate the important data from not important data and resulting in this table as shown below. The important data that researcher use is the activity in the sixth level. Because in this level the activity is deep enough to represent the whole activities in the project. While, the upper level is not deep because only few activities can be showed. The lower level also has too many activities that cannot be done in the limited time of research.

Table 1 List of Tasks

Tasks Name	
Project Management	Piping
Construction & Fabrication Management	Instruments & Control Systems
Information Technology	Electrical
Project Control Management	Subcontracting Soil Investigation
Civil / Structural Engineering	Subcontracting for Temporary Facilities
Piping Engineering	Sucontracting for Civil Work
Mechanical Engineering	Subcontracting for Piping Work
Electrical Engineering	Subcontracting Mechanical Work
Intrument Engineering	Subcontracting for Electrical Work
Process Engineering	Subcontracting for Intrument Work
H&E / Fire and Safety Engineering	Carbon Steel Shop Fabrication
Company Supply Equipment	Stainless Steel Shop Fabrication
Filters	Fabrication Support
Separators	Painting
Instrument Air System	Temporary Facility

Regen Gas Compressor	Permanent Work
Package Unit Membrane	Amine System
Package Unit WHB	Glycol Regen System
Package Unit TOX	Intrument Air
Package Unit Glycol	Flare System
Vessels/Reactors (Contractor)	CO ₂ Analyzer
Treated Gas Coolers	Membrane Skids
Miscellaneous Equipment	Civil
Electrical Equipment	

In the tabel above, there are 47 tasks that available in the level 6 of a bar chart which is the Tosca column. Researcher use those tasks as a task category reference because it is deep enough in the project task. Not all tasks above has a targeted completion date, it means this kind of task cannot be analyzed because researcher cannot compare the targeted and actual completion date since there is no data provided. All project task in the table above will shown in the table below including the targeted completion data and actual completion date for comparison to show how far the task finished late and have a big impact to the whole project.

Table 2 Level 6 Tasks and Date

Tasks	Targeted Completion Date	Actual Completion Date
Project Management	13-Oct-11	30-Dec-11
Construction & Fabrication Management	10-Apr-12	2-Jan-12
Information Technology	18-Jul-11	18-Jul-11
Project Control Management	25-Aug-11	25-Aug-11
Civil / Structural Engineering	25-Jun-12	28-Feb-13
Piping Engineering	18-Jun-12	15-Apr-13
Mechanical Engineering	28-May-12	20-Mar-13
Electrical Engineering	30-Apr-12	13-Feb-13
Instrument Engineering	23-Jul-12	3-Apr-13
Process Engineering	11-Jan-12	30-Jan-13
HSE / Fire and Safety Engineering	24-Feb-12	10-Oct-12
Company Supply Equipment	17-May-12	27-Jul-12
Filters	21-Jul-12	25-Nov-12
Separators	25-Sep-12	9-Nov-12
Intrument Air System	26-Aug-12	1-Aug-13
Regen Gas Compressor	15-Oct-12	19-Jan-13
Package Unit Membrane	29-Oct-12	2-May-13
Package Unit WHB	1-Oct-12	28-Jun-13
Package Unit TOX	17-Sep-12	29-Jul-13
Package Unit Glycol	9-Jul-12	11-Jan-13
Vessels / Reactors (Contractor)	25-Sep-12	9-Dec-12
Treated Gas Coolers	N/A	3-Apr-13
Miscellaneous Equipment	17-Oct-12	22-Mar-13

Electrical Equipment	8-Oct-12	1-Feb-13
Civil	14-Jun-12	19-Jun-13
Piping	31-Aug-12	17-Apr-13
Instruments & Control Systems	16-Oct-12	1-Aug-13
Electrical	21-Oct-12	1-Apr-13
Subcontracting Soil Investigation	15-Aug-11	28-Oct-11
Subcontracting for Temporary Facilities	26-Sep-11	25-Nov-11
Subcontracting for Civil Work	22-Nov-11	9-Feb-12
Subcontracting for Piping Work	27-Feb-12	18-May-12
Subcontracting Mechanical Work	14-May-12	30-May-12
Subcontracting for Electrical Work	24-Apr-12	12-Apr-12
Subcontracting for Instrument Work	7-May-12	12-Apr-12

Table 3 Level 6 Tasks and Date (Cont.)

Carbon Steel Shop Fabrication	N/A	9-Apr-13
Stainless Steel Shop Fabrication	N/A	1-Apr-13
Fabrication Support	N/A	23-Apr-13
Painting	N/A	10-Jun-13
Temporary Facility	23-Jan-12	27-Oct-12
Permanent Work	22-Feb-12	15-Dec-13
Amine System	N/A	11-Dec-13
Glycol Regen System	N/A	10-Dec-13
Instrument Air	N/A	13-Oct-13
Flare System	N/A	27-Oct-13
CO ₂ Analyzer	N/A	26-Oct-13
Membrane Skids	N/A	9-Dec-13

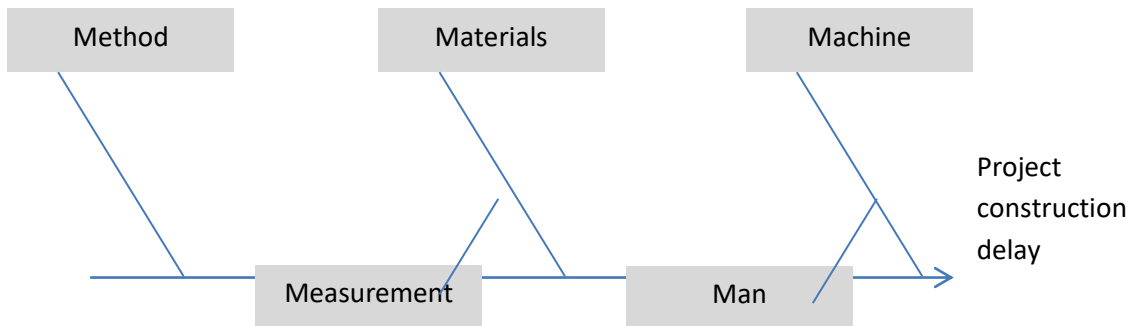
From the table above, there are several task that finished on time. There are also several task that do not have estimated finished time which can not be analyzed. So, researcher need to separate the task which are late from the on time task. Therefore, the result will shows the tasks, which have a delay from the targeted date. The late finished task will shown below including the reason why they are late. The reason comes by doing an analysis from the deeper level of task which are level 7 to level 13. After researcher found the reason why those tasks finished late than researcher can categorized each reasons above and convert it to the fishbone diagram to know the root cause of the delay of the project. Researcher need to determine for each cause and categorized it into "5Ms" of fishbone which already explained in chapter II. The "5Ms" are man, method, machine, measurement and materials. This "5Ms" is the common method that used in manufacturing process in making the fishbone diagrams because it is complete enough as a representative of aspect within the project.

It is important to convert it to the fishbone according to the title of the research.

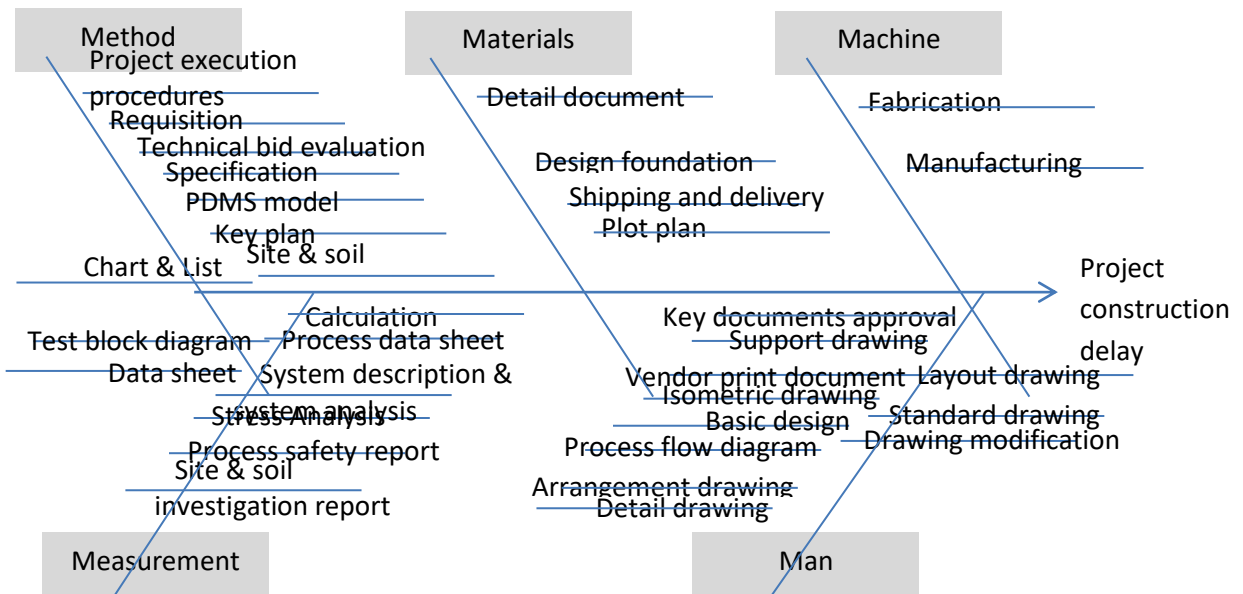
1. Draw a line and write down the problem.



2. Identify the main cause of the problem. For this research, there are "5Ms" that researcher used, which are method, man, materials, machine, and measurement.



3. Identify the reasons behind the main causes to know specifically the reason why the problem can happen.



Each category of the fishbone diagram above has a root cause that make the project finished late. To make the it easier to read, researcher convert it to the several category based on "5Ms" category which can be see below for each category.

Table 4 Causes of Delay for Each Category

Factors	Cause
1. Machine	<ul style="list-style-type: none"> a. Late in fabrication some materials b. Late in manufacturing some materials
2. Materials	<ul style="list-style-type: none"> a. Detail document does not provided on time b. Late in making plot plan c. Late in making design foundation d. Materials not provided on predetermined time
3. Method	<ul style="list-style-type: none"> a. Project execution procedures cannot be used on time b. Requisition for some items delayed c. Technical bid evaluation did not match the requirement d. Specification for some items delayed to made e. PDMS model for piping late for 1 year f. Key plan for piping is late g. Site mobilization is late h. Chart & list not available on time
4. Measurement	<ul style="list-style-type: none"> a. Process data sheet cannot be provided b. Process safety report is late c. Data sheet delay d. Test block diagram cannot be provided on time e. Calculation late f. Site & soil investigation not reported on time g. System description and analysis take long time h. Stress analysis for piping is late
5. Man	<ul style="list-style-type: none"> a. Key document approval b. Piping support drawing c. Vendor print document d. Isometric drawing e. Basic design f. Process flow diagram g. Layout drawing h. Drawing modification i. Standard drawing j. Detail drawing k. Piping arrangement

1. From the table above, there are several reasons why the problem happens as a result of those causes. However, the reasons above are not detail. For details, the explanation for each cause will explain below to make understood the readers. Machine
 - a. Manufacturing is the process using several devices to create something. Using a raw materials brought together to create something new. Manufacturing viewed as a vast piece of industry. The objective of manufacturing is to create lot of devices (DF, 2010). There are carbon steel pipe, stainless steel pipe, main instrument cable, instrument cable tray, field instrument, control systems, control valves, flame & gas detector, cable tray, and cable that cannot manufactured on time. This is because the devices or

equipment to create those material not ready. This delay caused by three factors occurring sequentially, inquiry take long time, commercial bid evaluation by vendors did not match the requirement, and purchasing orders not complete because the details not performed.

Fabrication for materials is late. This includes the design of devices. Fabrication can likewise include the making of a machine that will be utilized as a part of the manufactured item. The objective is creating one device that can work properly (DF, 2010). Materials that are late in fabrications are polishing filters, instrument air receiver, regeneration gas compressor, thermal oxidizer, glycol regeneration, amine contractor, fire fighting system, switchgear, piperack, structure steel, building, shelters, and U/G piping. Those lateness make a quite significant delay to the project.

2. Material

- a. Detail document is a document containing all the requirements needed to create a certain product. It is a written document to allow people to understand what a product should do or product function. For instrument engineering, it is a specific branch of electrical and electronic engineering and it manages estimation, control and automation of procedures. In scientific terms, instrumentation is defined as the craftsmanship and science of measurement and control of procedure variables inside a production, or manufacturing area (The Project Definition, 2015). The production of detail document is late for 15 months from the planned date caused by the measurement in instrument engineering took long time.
- b. A plot plan is an architecture, engineering, and/or landscape engineering architecture plan drawing—diagram, which demonstrates the piping structure and layout, utility runs, equipment layout, and different developments of a current or proposed project site at a characterized scale (Wikipedia, 2016). It means the execution for plot plan in piping engineering is late for 9 months for whichever reasons that already explained above.
- c. The function of a design foundation is to keep the vibration levels and dynamic displacement of the isolation system within acceptable limits. If the design foundation designed incorrectly, it is extremely difficult to correct once installed (Fabreeka). Design foundation for all materials that needed in structural engineering is late. It was actually plan to finish in January 2012, but this task finished in February 2013. The delay in design foundation caused by the project team takes this task carefully to prevent the failure in designing.

3. Method

- a. In project execution procedures contractor shall prepare, develop, and implement complete project control procedures for general management, project management, and overhead. The procedures need to be clear and concise in comply with the plan (KLM Technology Group, 2011). This task is late for 2.5 months. This task performed in the early of the project that makes the whole project delayed because of this task. This task is late caused by the project team consider many variable that exist in the project.
- b. Requisition prepared by the contractor if the scope of vendor consists of supply. Once the vendors meets the criteria that contractor made, then vendors can dispatch of the materials as the final activity of vendors (Faiz, 2015). Requisition is late in almost happens in all tasks. However, the significant happen in instrument engineering, which take 15 months of delay, from December 2011 to March 2013. The analyzer, pressure

instrument, level instrument, temperature instrument, and flame & gas detector are the causes that requisition in instrument engineering finished late.

- c. In general, there will be a technical bid evaluation if the items have requisition. Important materials require multidiscipline review and vendor clarification meetings to make sure the specification that contractor request has match with the vendors (Faiz, 2015). Technical bid evaluation delay significantly happen in civil engineering for HVAC, instrument engineering for instrument bulk material, flow instrument, temperature instrument, flame & gas detector, flange, pressure instrument, analyzer, and level instrument. Delay in these tasks also makes a significant effect to the project. The delay caused by the technical bid evaluation itself is a process that requires contractors and vendors should have meetings in many times, because technical bid evaluation is the last step before the vendors deliver the material to the contractor.
- d. Specifications means minimum detail requirement for instrumentations. It likewise gives standard that might be applied to instrument keeping in mind the end goal to have uniform detail for certain instrument all through the plant (Rajender, 2012). Making the specification in the process engineering is late for 4 months caused by the actual situations that happen cannot predict by the project team.
- e. Plant Design Management System is an adjustable, multi-client and multi-discipline, engineer controlled configuration software bundle for building, design and construction project in offshore and onshore. It is the most efficient and most reliable software modeling, oil, gas and petrochemical industries. This software contains word, program design, and management of a site to the maximum extent. PDMS model in piping engineering late for 1 year from April 2012 to April 2013 caused by the making of 60% PDMS model takes long time than usual and affecting the make of 90% PDMS model.
- f. The key plan is a little "map" in a drawing that shows the area of an assembly, a cast unit, or a part in the model. The key plan contains the model matrix and the assembly, cast unit, or part shown in the included drawing view (Tekla User Assistance, 2014). The key plan is delay in piping engineering late for 7 months caused by when drawing this, the project team found the reasons that researcher does not know.
- g. Site mobilization should comprise of acquiring all required insurance, bonds and permits; preliminary work and operations necessary for the movement of staff, hardware, supplies, and incidentals to the project site. This task is late for 7 months because in the process the project team get a trouble in the movement.
- h. In the making chart and list in the process engineering, the project team found a trouble that makes this task late for 13 months since the targeted completion date.

4. Measurement

- a. Process data sheet describes the fundamental data that needed in specific engineering discipline such as mechanical, structural, piping, control systems, and electrical areas. Process data sheet includes the approximate geometry, size, and number. It is usually includes a simple diagram (The Project Definition, 2015). In process data sheet, delay caused by all materials in process engineering do not finished on time although those tasks start at predetermined time.
- b. Process Safety is a disciplined framework for dealing with the integrity of operating systems and procedures taking care of risky substances by applying great design standards, engineering, and working practices. Processing the safety report in safety engineering took time 10 months longer than it should whereas this tasks started 1 month earlier than planned date.

- c. All activities that include data sheet cannot finish on time. Data sheet activities that available in piping engineering, mechanical engineering, electrical engineering, instrument engineering, and process engineering respectively delay for 16 months, 10 months, 3 months, 15 months, and 10 months.
 - d. A block diagram is a diagram of a framework in which the vital parts or function are spoken to by blocks connected by lines that demonstrate the connections of the blocks. It is heavily used in engineering (Wikipedia, 2016). The piping engineering is delay caused by testing the block diagram finished 10 months after planned date.
 - e. Calculation sheet for equipment shelter foundation, equipment foundation, and P/R foundation late about for 1 year, in civil / structural engineering.
 - f. Soil investigation & report task reported 6 months after predetermined time. This task is delay caused by the project team get a trouble in the process.
 - g. System description and system analysis for electrical engineering is late for 14 months, caused by the project team get a trouble in the process.
 - h. Piping stress analysis delayed for 3 months and makes piping engineering cannot finish on time because of the project team get a trouble in the process.
5. Man
- a. Contract mobilization should comprise of acquiring all required insurance, bonds and permits; preliminary work and operations necessary for the movement of staff, hardware, supplies, and incidentals to the project site. This task is delayed for 5 months because of key document approval.
 - b. Special pipe support drawing was delayed for 14 months since predetermined time because of the project team get a trouble in the process.
 - c. Vendor print document tasks consists of vendor data review for thermal oxidizer package, waste heat boiler, amine contractor, membrane skid, TSA, inst. air receiver, glycol regeneration package, polishing filter. This task is late for 10 months.
 - d. Isometric drawing does not to scale but should show all material to represent a 2D view of 3D piping system. Piping length and important datum identifying the pipe location are included in isometric drawing. Isometric drawing is delay in cpx piping drawing 8 months after predetermined time.
 - e. Basic design in process engineering also late for 15 months.
 - f. A Process Flow Diagram (PFD) demonstrates process streams and fluid flows or transfer system through equipment and associated lines incorporates system conditions, components of fluid, flow rates, and a short hardware specification. PFD is produced by examination and count of the chemical and physical characteristics of materials utilized by a process simulation program (The Project Definition, 2015). Making the process flow diagram takes 6 months delay in the process engineering caused by process simulation program had a trouble.
 - g. A layout drawing delineates design improvement requirements. It is like a point of detail, assembly, or installation drawing, aside from that it presents pictorial, notational, or dimensional data to the degree important to convey the design solution used as a part of planning other engineering drawings (Gaston, 2006). Layout drawing is late because drawing in civil engineering delayed for 4 months.
 - h. A Modification Drawing portrays changes to items after they have been conveyed. At the point when required for control purposes, a modification drawing might require re-identification of the adjusted items. F&G drawing modification also contribute to the project delay. This task delayed for 3 months caused by the safety engineering.

- i. There are standard drawing activities in several engineering category. Standard Drawings define the materials, set out standard construction details and provide general design data. In civil engineering, electrical engineering, and instrument engineering contribute delay respectively 2 months, 5 months, and 1 month.
- j. A Detailed drawing is to build up all required construction drawings for the construction, and point by point bill of materials for bulk material procurement. The Detailed drawing is restricted to confirming design basis however creating all construction drawings after incorporating vendor data (The Project Definition, 2015). A detailed drawing is delay caused by making detail drawing in electrical delayed for 9 months and making detail drawing in instrument engineering delayed for 9 months.
- k. Usually 3DCAD used in piping arrangement drawing. Either isometric drawing or orthographic or a combination both of the two (The Project Definition, 2015). The level of difficulty is quite high and makes the making of arrangement drawing become late for 9 months.

After knowing the factors that affecting the project delay at PT Rekayasa Industri, the next step is determine the potentials factors and determine the dominant cause from the problem. The potential factor can be known by making the pareto chart. The pareto chart will show what factors that has most problem. Pareto chart consists of "5Ms" category of fishbone and amount of caused of delay for each category. The pareto chart data will gathered from the table below, the table consists of amount of cause for each category and percentage.

Table 5 Percentage and Amount of Causes

	Amount of Cause	Cumulative of cause	Percentage	Cumulative %
Man	11	11	33%	33%
Measurement	8	19	24%	58%
Method	8	27	24%	82%
Materials	4	31	12%	94%
Machine	2	33	6%	100.0%

The table above used as references to make a pareto chart. Amount of cause obtained by calculating the factors for each category. The percentage obtained by divide amount of cause with total amount of cause. Then, the table above can be explained in the pareto chart below.

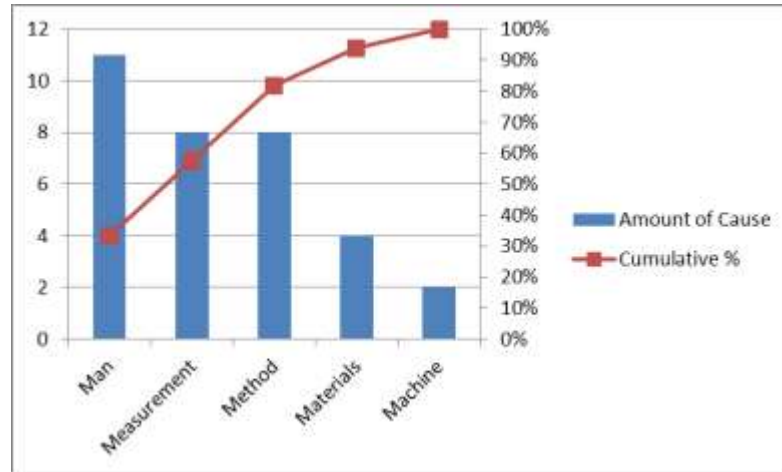


Figure 4.2 Pareto Chart

The pareto chart above show that the most potential and dominant factors is “Man”. “Man” is the highest cause of the delay of the project with 33.3%, following by measurement, method, material, and machine with 24%, 21%, 15%, and 6% respectively. According to pareto chart theory, the first 80% means the causes of the problem. In this case, the first 80% of delay caused by man, measurement, and method and means these three category needs an improvement.

After knowing the factors that affecting the project delay at PT Rekayasa Industri, the next step is determine the potentials factors and determine the dominant cause from the problem. The potential factor can be known by making the pareto chart. The pareto chart will show what factors that has most problem. Pareto chart consists of “5Ms” category of fishbone and amount of caused of delay for each category. The pareto chart data will gathered from the table below, the table consists of amount of cause for each category and percentage.

Table 6 Percentage and Amount of Causes

	Amount of Cause	Cumulative of cause	Percentage	Cumulative %
Man	11	11	33%	33%
Measurement	8	19	24%	58%
Method	8	27	24%	82%
Materials	4	31	12%	94%
Machine	2	33	6%	100.0%

The table above used as references to make a pareto chart. Amount of cause obtained by calculating the factors for each category. The percentage obtained by divide amount of cause with total amount of cause. Then, the table above can be explained in the pareto chart below.

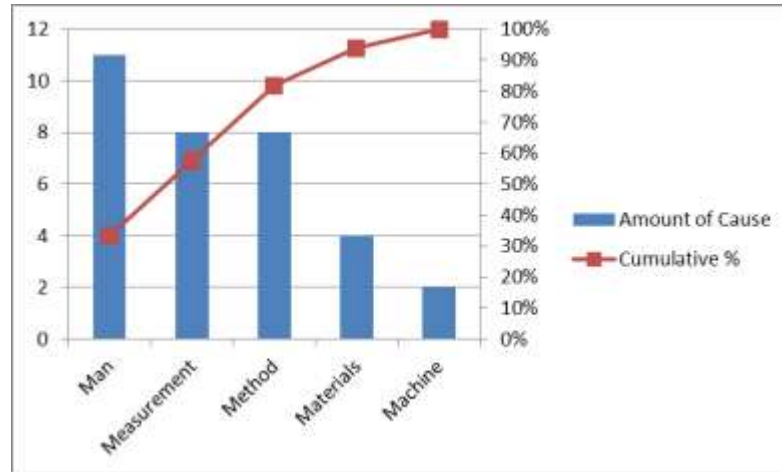


Figure 4.3 Pareto Chart

The Pareto chart above shows that the most potential and dominant factor is "Man". "Man" is the highest cause of the delay of the project with 33.3%, followed by measurement, method, material, and machine with 24%, 21%, 15%, and 6% respectively. According to Pareto chart theory, the first 80% means the causes of the problem. In this case, the first 80% of delay is caused by man, measurement, and method, and means these three categories need an improvement.

Conclusion and Recommendation

Conclusion

The three categories that reach 80% of minimum as mentioned in Pareto chart theory need an improvement. Man, method, and measurement are the factors that can be controlled by humans. Unlike the environment, those three factors can be controlled to reduce the delay in a project. As a proven and trusted company, PT Rekayasa Industri has many clients and customers around Indonesia. However, delays in the project still become a problem that happens without anything that can stop it. The most realistic way is to reduce the delay rather than omit the delay. The improvement in those three categories would lead the company to have a better result. It will improve the effectiveness and efficiency of each activity in order to result in an optimal result.

Recommendation

The improvement that can be researched will be explained below for each category.

1. Man

PT Rekayasa Industri was founded in the 1980s and it has been 30 years since the company began. 30 years of experience makes the company mature in every aspect and already faced any kind of situations. Therefore, actually there is still a problem that happens until these days, which is human resource. As mentioned in chapter II, one of the causes that make a project delay is human. Lack of discipline, lack of motivation, low expertise, and miss communication among the workers can make a project delay.

The feedbacks that can be researched to give to the company are :

- a. Control and monitoring for each task that should be performed strictly to increase the discipline of workers.
- b. Increase the working knowledge of workers through several ways such as training, guidance by supervisor, and reward and punishment system to increase the motivation of workers.

- c. SOP must be clear and concise to reduce the miss communication among the workers. It is important to make all levels of workers have same understanding when doing a job or tasks.
 - d. More tight recruitment process to make sure all workers that work at company has high credibility.
2. Measurement

One of cause of project delay is measurement as mentioned in chapter II. Evaluation, control, and inspection are the activities in the measurement category. In this project, it is described in 8 tasks. Data sheet, process safety report, diagram test block, calculation sheet, soil investigation & report, electrical system analysis, and piping stress analysis are activities that make delay to the project.

Feedbacks that researcher can give to the company are :

 - a. Report should be written faster than usual to reduce time when make it. It can be done by training the workers or even by reading the literature about how to make report fast.
 - b. Analysis also need a fast handling to make another execution plan when the defect or failure known on equipment or instruments.
3. Method

PT Rekayasa Industri known as a company that has proven project management skills. It indicates this company has updated methodology. In reality, there are still delays in several activities in this category. There are execution procedures, requisition, technical bid evaluation, site mobilization, and chart & list. In order to reduce the delay, feedbacks that researcher can give to the company are :

 - a. Controlling the activities can help reduce the delay of its activities significantly.
 - b. SOP takes important rules in methodology. Because it contains many things that manage everything needed such as schedule, person in charge, and the task description itself. So, if the SOP clear and concise, it will reduce the delay of the activities.