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Implementation of Lean Manufacturing for Improvement of Gas Pipe Product Quality with Six Sigma Approach and Value Stream Mapping in Oil and Gas

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ABSTRACT

A company in the oil and gas manufacturing industry produces gas pipe products using the Polyethylene model. During the period of January to June 2020, the company experienced a defect rate of 2% in the total production. This research utilized a descriptive method to analyze the production process in order to identify and eliminate the rejected products. The objective of this study was to achieve a decrease in defects below 2%. By applying the Six Sigma (DMAIC) method and conducting calculations and analysis, an improvement proposal was developed to address the defects found during the Radiography Test. The proposed solution involves providing specialized training for workers, implementing clear procedures and methods for work, and conducting training sessions to enhance operator skills and understanding of Standard Operating Procedures (SOPs). As a result of the proposed improvements, a comparison of cycle times was conducted. Prior to the implementation of the improvements, the cycle time was 390 minutes. However, after the implementation, the cycle time reduced significantly to approximately 245 minutes. Overall, the proposed improvements aim to reduce the defect rate below 2% and optimize the production process for gas pipe products with the Polyethylene model in the oil and gas manufacturing company.

Key Words: Gas Pipe line, Lean, Manufacturing, Product Quality.

1. INTRODUCTION

The development of the industrial world today is increasingly rapidly making competition more competitive, especially in the manufacturing industry which requires companies to continue to produce quality products in order to be able to compete with other companies in the same field. Of course, quality is very important for the company, therefore the company must be able to maintain and improve the quality of its products. Products that have good quality will be able to meet the expectations and desires of consumers to continue to use these products. Quality control in the company is very necessary, to still be able to attract consumer interest the company must control the quality of its products properly. Product quality control is an activity that must be carried out from the early stages of the process starting from raw materials to finished products and until the stage of distribution to the hands of consumers. Quality itself is the overall characteristics of a product or service that is able to give satisfaction to customers or consumers (1-15). To reduce product defects and increase productivity, companies need to implement lean six sigma. Lean Six Sigma is a business philosophy, a systemic and systematic approach to identify and eliminate waste or non-value added activities through radical continuous improvement to achieve six sigma levels of performance (16-22). A product can be said to be of good quality if it can meet the needs and desires of consumers or can be accepted by consumers as the desired specification limit, and a good process will be provided by the manufacturer as a quality standard that has been set by the company. Quality standards include raw materials, production processes and finished products. (23-38).

This Oil and Gas Manufacturing Company was initially involved as an Indonesian supplier in the oil and gas industry. In the field of gas metering systems, PPS finds its market dominance by partnering with RMG Regel +

Messtechnik GmbH, Europe's leading gas processing equipment manufacturer. This Oil and Gas Manufacturing Company is a project based organization company engaged in construction, engineering, procurement & project (EPC).

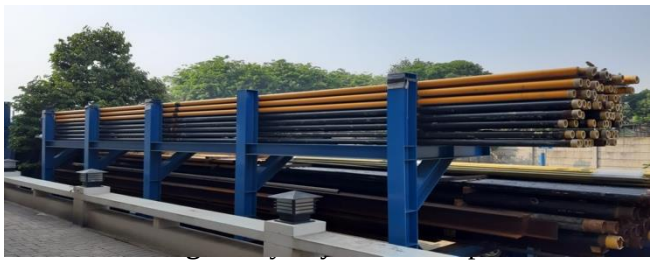

Fig 1. The Product

Companies engaged in manufacturing oil and gas that produce gas pipe products in the production process, there are still many gas pipe products that have defects. The following table 1 contains data on the percentage of defects in gas pipe products produced by oil and gas companies that occurred in the period June - November 2021.

Table 1. Production Data and Defect Model of gas pipes

Gas Pipe Model	Total Production (Jun–Nov2021)	Number of Defective Products (Jun-Nov 2021)	Percentage (%)
Spiral Welding	561	45	8,0
SMLS	478	42	8,7
Niple	403	27	6,6
Polyethylene	604	61	10,1

Based on table 1, the gas pipeline model with the highest number of production and number of defects in the period Jun – Nov 2021 is the Polyethylene gas pipeline model. So the company must be able to meet these quality standards. Of course, the company has its own defect target of 2% per month. The company certainly carries out quality control to prevent defects from occurring, but in the process of producing gas pipes, the Polyethylene model often experiences defects due to the large amount of production. The following is an image of 2 graphs of the percentage of total production and total defects of the Polyethylene gas pipe model in the period Jun-Nov 2021 with a total production of 604 units and a total number of product defects 61 units with a percentage of 10.1%.

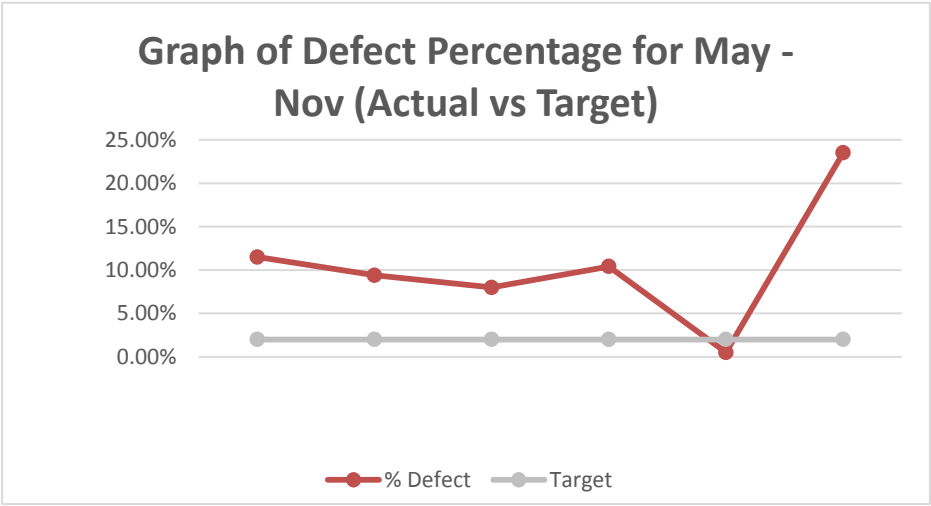

Fig 2 Graph of Percentage of Total Production and Total Defect

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Table 2. Data on Total Production and Data on Number of Defective Products of gas pipes

No.	Month	Production Quantity (Units)	Number of Defective Products (NG)	Percentage ((%)
1	Jun	78	9	11.5%
2	Jul	138	13	9.4%
3	August	224	18	8%
4	Sept	143	15	10.4%
5	Oct	4	2	50%
6	Nov	17	4	23.5%

Based on Table 2 the number of monthly production is not fixed and it can be seen that the highest number of defects in the Polyethylene model gas pipe product occurred in March of 18 units, still higher than the predetermined target. Overall this indicates that there is a quality problem. Therefore, companies should prioritize better quality control to reduce cost losses from defects that occur and increase profits for the company. From the problems that occur in Oil and Gas Manufacturing Companies, this company needs to implement lean six sigma in order to reduce defects in the Polyethylene Gas Pipeline product so that losses can be avoided. In this research, the author uses the lean six sigma method with the DMAIC (Define, Measure, Analyze, Improve and Control) and VSM (Value Stream Mapping) approach as a case study of Oil and Gas Manufacturing Companies.

2. RESEARCH METHOD

The stages carried out in processing and analyzing data in this study are as follows:

1. Identification of Product Manufacturing Process

Understanding the process of making a Polyethylene Gas Pipe product from the initial raw material to the finished product is the first step taken in this research.

2. Data Collection

In this study, data collection was carried out, the data needed in this study included total production data and product defect data.

In this study, the method used by the author to improve the quality of the Polyethylene Gas Pipe product using the Six Sigma and VSM method approaches, namely:

a) Define, Measure, Analysis, Improve and Control (DMAIC)

1) Define

At the define stage, problem identification is carried out, starting with defining the type of defect that often occurs in Polyethylene Gas Pipe products using CTQ (Critical To Quality) tools to find out what kind of product is in accordance with the established standards and what the customer wants.

2) Measure

The Measure stage is the stage of measuring the Sigma level, DPMO (Defect Per Millio Opportunities) and Yield value to determine the probability of a product that is not defective in the Polyethylene Gas Pipe production process.

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3) Analyze

At this stage, an analysis will be carried out which is the most likely cause of the defect. Beginning with finding the most dominant defect in the Polyethylene Gas Pipeline product using a Pareto diagram, after obtaining the most dominant defect, problem solving is then made by conducting an analysis to determine the cause of the problem that occurs using a fishbone diagram.

4) Improve

After analyzing in the previous stage, namely by giving a questionnaire to the production supervisor and Quality Control Leader who is the person who is responsible and knows all the activities and problems that exist in the Polyethylene model Gas Pipe production activity, by asking questions related to the results of the cause. defects in fishbone diagrams to determine severity, occurrence and detection so that they can find out the largest RPN value. Then then make a repair plan using 5W + 1H tools which will describe the improvements to be made.

5) Control

This stage is the last stage which aims to control the existing process so that problems that arise in the old process cannot be repeated. At the control stage, it is only in the form of proposals to be implemented by the company in the future.

b) Value Stream Mapping

Value stream mapping is a map that summarizes or describes the production process starting from the supply of materials, the production process until the product is in the hands of the customer. Because VSM helps in finding waste in the production process. The following is a description of creating a Value Stream Mapping.

1. Create a Future State Map

The future state map is obtained from the results of reducing waste on the current state map. However, future state mapping still refers to the initial mapping or current state.figure title and number.

3. RESULT

Define (D)

At this stage the tools used are CTQ (Critical To Quality) tools using CTQ and then an analysis is carried out to find out what the customer wants for the quality of the Polyethylene Gas Pipe product.

a) Identification of CTQ (Critical To Quality)

To use this tool, it is necessary to know what defects occur in the product. In the Polyethylene Gas Pipe product, there are 3 types of defects, namely Ultrasonic Flaw Detector, Radiography Test, and Welding.

The following in table 3 below is the CTQ identification on the Polyethylene model Gas Pipe product:

Table 3. CTQ of Polyethylene Gas Pipe Products

CTQ	INFORMATION	TARGET
Ultrasonic Flaw Detector	No Detection Of Ultrasonic In Pipes	Always Detected Ultrasonic In Pipes
Radiography Test	Disadvantages of Radiation in Pipes	Radiation on Surface and Subsurface Can Be Detected Quickly
Welding	Pipe Leak	Not leaking

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Measure (M)

At this stage, it is used to calculate the sigma value by calculating the DPMO (Defect per Million Opportunity) value and calculating the probability of the product not having a defect (Yield).

This stage has an important role to be able to improve the quality of a product, because after the results of the calculations are obtained it will be known performance of the company at this time as a consideration for analysis and improvement in the future.

a. Sigma Level

Based on the calculation results, it can be seen that the average sigma level of the Polyethylene Gas Pipe product model based on production and defect data for the January 2020 - June 2020 period is 1.57. Where for the average DPMO value is 3145 per one million opportunity with a probability of a product that does not experience a defect of 83.71%. In this stage it is useful to measure the company's performance and get the following results:

Table 4. DPMO Results

No.	Period	Total Order	Total Defect	DPU	DPO	DPMO	Yield%	Sigma
1	January	78	9	0,115	0,038	38400	89,13%	3,27
2	February	138	13	0,094	0,031	31000	91,02%	3,37
3	March	224	18	0,08	0,026	26000	92,31%	3,44
4	April	143	15	0,104	0,034	34000	90,12%	3,33
5	May	4	2	0,5	0,17	170000	60,65%	2,45
6	June	17	4	0,235	0,078	78000	79,05%	2,92
Average		50	5	0,094	0,031	31450	83,71%	1,57

Analyze (A)

At the Analyze (A) stage, an analysis will be carried out to find out what causes the current problems so that repairs can be made quickly and precisely, for this stage the tools used, namely the Pareto Diagram, serves to determine the most dominant type of defect in Gas Pipe products. Polyethylene models. So that improvements can be focused on the type of defect found.

In addition, Fishbone Diagram tools are used to be able to find the causes of the defect.

a. Pareto chart

Pareto diagram is a tool used to find the cause of a problem or damage to a product by getting the highest damage data and to be able to focus repairs on the most dominant problem. In the Polyethylene Gas Pipe product, there are 3 types of defects that occur such as Ultrasonic Flaw Detector, Radiography Test, and Welding, but in the Pareto diagram analysis used there is 1 defect, the largest is the defect in the Radiography Test. After obtaining the dominant defect, it can be seen in table 4.8 above with the percentage of Radiography Test defects of 51%. Next, focus on repairing the Radiography Test defects because the Radiography Test is the defect with the highest percentage.

b. Fishbone Diagram

After the results obtained from the analysis with the Pareto diagram of the type of defect with the largest percentage, namely the type of defect Radiography Test with a percentage of 51%, then further analysis is carried out to determine

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the cause of the Radiography Test defect by using the Fishbone Diagram. The following are the results of the analysis carried out using the Fishbone Diagram in Figure 4.8 as follows:

1. Personnel Factor

Personnel factor is a factor which is usually caused by workers who are pursuing targets so they do not pay attention to the quality produced. The causes caused by the personnel factor are as follows:

a) Operators do not carry out procedures with SOPs

b) Operators are not careful in checking

2. Machines factor

Machines factor is an equipment used to produce a product from raw materials to finished products, on machines that are not maintained properly will make the production process of the product hampered and can even make the quality decrease, therefore the machine factor can cause defects, among others :

a) Finishing and surface roughness affect the inspection result

b) Difficulty inspecting thin objects

c) Checking tools are relatively expensive

3. Materials factor

Materials factor is a raw material to form a product, so if the material used is not good or not according to company standards, the quality of the product produced will decrease. The following are the results of the analysis with Fishbone Diagram of the causes of Radiography Test defects including:

a) Checking tools do not match the material

b) Material requires reference standard

4. Factor Methods

Factor Methods is a way to carry out a process that has been set according to the standard or SOP from the company, if the SOP is not executed properly it will reduce the quality of a product. The following causes the defect from the method factor:

a) SOP system that has not run optimally

b) Lack of accuracy in material checking

5. Environmental Factor

Environmental factors are an important part of a production process, good environmental conditions will make a production process run well, on the contrary if the environment is not good and uncomfortable will cause a decrease in the quality of the production, therefore environmental factors can cause defects such as :

a) Poor lighting

b) Dusty

c) Less spacious place

6. Factor Measurements

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The Measurements factor is a measurement in a process of a tool in advance in order to avoid things that are not desirable to a production process on the pipe, therefore the measurement factor can cause defects such as:

a) The checking tool requires a trial and error process first.

Improve (I)

The next stage is Improve which aims to propose improvements to overcome problems that occur such as Radiography Test by making improvements through 5W + 1H and through VSM (Future State Mapping).

Table 5. Future State Mapping Result

Activity	Cycle Time	
	Before (Minutes)	After (Minutes)
Marking	60	30
Cutting	30	15
Ultrasonic Flaw	60	30
Welding	90	60
Radiography Test	60	50
Painting	90	60
Total	390	245

Control (C)

Control phase is a proposal for companies that are used as research which is the last stage of the DMAIC method which contains proposals or recommendations in order to eliminate waste and reduce defects. At this Control stage, a Check sheet and SOP are made.

4. CONCLUSION

To summarize the findings of the analysis conducted on the Polyethylene Gas Pipeline product in the Oil and Gas Manufacturing Company, the following conclusions can be drawn:

1. The Pareto diagrams revealed that the most significant types of defects affecting the quality of the Polyethylene Gas Pipe product are Radiography Test defects with a percentage of 51%, followed by Ultrasonic Flow Detector defects with 28%, and Welding defects with 21%.

2. The fishbone diagram analysis identified various causes for the Radiography Test defects, including non-compliance with SOPs, lack of carefulness in checking, difficulty in inspecting thin objects, mismatched checking tools, suboptimal SOP system, lack of accuracy in material inspection, inadequate lighting, dusty environment, insufficient space, and the need for trial and error in using the checking tool.

3. Applying the Six Sigma (DMAIC) method, the proposed improvement to address the Radiography Test defects involves providing specialized training for workers to ensure adherence to proper procedures and methods, as well as conducting training sessions to enhance operator skills and understanding of SOPs. After implementing these improvements, the comparison of cycle times showed a reduction from 390 minutes to approximately 245 minutes.

In conclusion, the analysis identified the key defects in the Polyethylene Gas Pipeline product, determined the causes of Radiography Test defects, and proposed improvements to address these issues. Implementing these improvements can help reduce defects and enhance the overall quality of the product in the Oil and Gas Manufacturing Company.

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