SIX SIGMA METHODOLOGY TO IDENTIFY THE MAJOR FACTORS CAUSING DEFECTS IN PIPE MANUFACTURING PROCESS

CE 1.1 INTRODUCTION

I have done my bachelors in industrial engineering from [redacted]. Also, I took training for professional development in "Professional trends in Industrial Engineering" in [redacted] and [redacted]. In my academic course of "management of engineering projects" which I pursued in my last semester, I did a project which opted "Six Sigma methodology to identify the major factors causing defects of pipes" in a mat production industry [redacted] The duration of the project was [redacted]. This was linked with my curriculum courses of "Management of Engineering Projects" which I completed [redacted]

BACKGROUND

CE 1.2.1

As an industrial engineer, it was my responsibility to identify the root cause of the problem faced by the [redacted] industry and provide solutions to improve the process of daily production of pipes. To accomplish this, I started analyzing the current process and gathering data on the defects and waste generated during production.

The data analysis revealed that one type of defect, known as the Dori defect, was causing more waste than any other defect. I determined that the root cause of the problem was the machine settings on the extrusion line, which were not optimized for the process. To address this issue, I decided to conduct a design of experiment analysis and Pareto analysis using fractional factorial design to determine the optimal machine settings that would produce fewer defects. After gathering data and conducting an analysis of the Dori defect, I created an optimization plot that showed the high, current, and low machine settings. The new settings identified by the plot were optimal and would reduce the Dori defect significantly.

CE 1.2.2

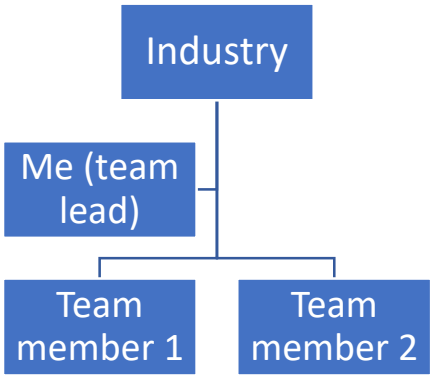
I devised the following methodology to execute my project:

- Facility/Industry Overview
- Problem Formulation
- Defining Objectives
- Literature Review
- Implementing the Six Sigma approach

- Define Phase
- Measure Phase
- Analyze Phase
- Improvement
- Control Phase

CE 1.2.3

In this data research and optimization project, I followed the industrial engineering guidelines and fulfilled my responsibilities, including managing and submitting all required documentation to the industry on a weekly basis. Initially, I created a comprehensive project strategy that included the necessary criteria and instructions to achieve our objectives. To keep the industry informed of our team's progress and the project's status, I prepared weekly progress reports. These reports facilitated ongoing feedback and adjustments to ensure the project stayed on track. As the team lead, I was responsible for the project and my team, and I communicated with them to complete the project and address any issues that arose. Finally, I created a detailed final project report that covered all aspects of the project, including design considerations, data collection, and improvement strategies.



Project Hierarchy

PERSONAL ENGINEERING ACTIVITY

CE 1.3.1

The project involves the implementation of Six Sigma to improve the quality and reduce waste in the production of pipes in the extrusion process of [redacted] industry. The scope includes two types of defects, Gatta and Dori, in the extrusion process of three different products (F-16, Butterfly, and Crystal) produced by the company. The objectives are to identify the major factors causing defects, improve quality, productivity, and profitability by minimizing the cost associated with rejects, and reduce variation in the process using statistical Six Sigma tools. The DMAIC methodology is used, which includes Defining the problem, Measure and document the

process, Analyzing the results and generating a solution, Improving the quality, and Control the process for improvement. The major deliverables are CTQs, factorial design, significant factors affecting quality, and improved sigma level. Data analysis is done using Minitab software, and a literature review of Six Sigma case studies related to manufacturing is conducted. The project concludes the improvement of product quality, customer satisfaction, and cost savings.

CE 1.3.2

I conducted research on the process improvement in the production of mats at [redacted]) industry, the largest mats producing industry in [redacted]. Currently, the company produces three types of mats: F-16 (low-quality product), Butterfly (medium-quality product), and Crystal (pure-quality product). To ensure production, the raw material, polypropylene, is imported from Karachi, Hyderabad, Lahore, and Peshawar, as well as internationally from industries in Saudi Arabia, India, Oman, UK, China, and Thailand. The quality of the raw materials is assured through industry-specific testing techniques.

I employed the DMAIC methodology, which stands for the following:

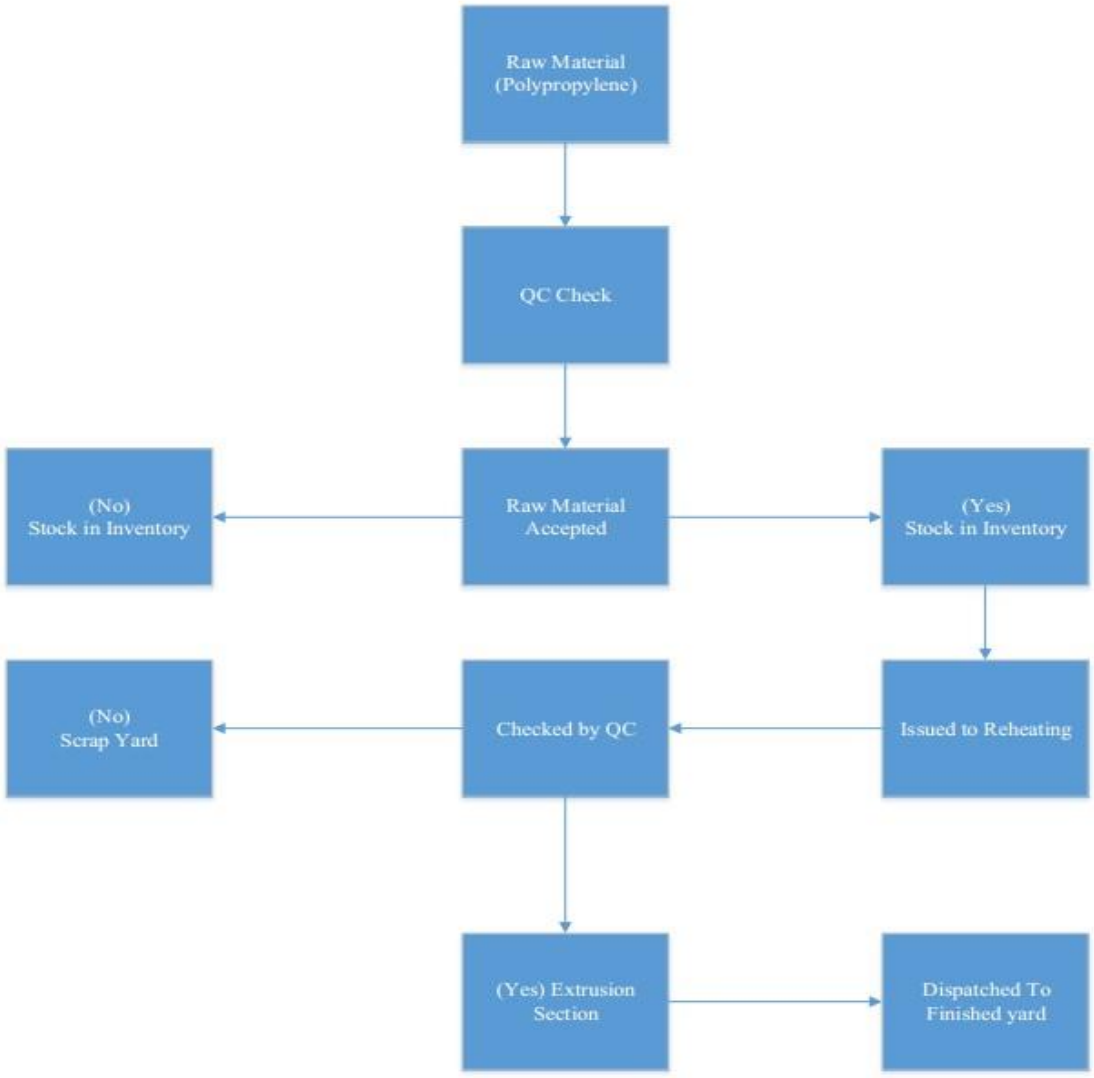
- Define
- Measure
- Analyze
- Improve
- Control

CE 1.3.3

The first step was to define the problem and the project scope, including the desired output result. The quality of the raw material is dependent on the dollar price, where high-quality raw material has a higher price compared to low-quality raw material. The raw materials undergo quality testing when unloaded from the transport vehicle, and quantitative and qualitative analysis is performed. The material is then heated in the furnace according to its quality, and pipes are extruded in the required quantity. The process flow map is presented to visually describe the extrusion process for the production of pipes. The purpose of this mapping is to identify bottlenecks, repetitions, and delays to improve efficiency and generate better ideas for process improvement.

I used statistical tools such as Process Flow Charts and SIPOC to identify how the process should be modified. During the Define phase of my project, I began by describing the process of the [redacted] industry which produces mats of different quality from raw polypropylene materials. I explained that the quality of the raw materials is dependent on the dollar price, with high-quality materials being of current dollar price and low-quality materials usually costing PKR 60-70. To ensure quality control, the raw materials have to pass a quality test when unloaded from the transport vehicle and undergo quantitative and qualitative analysis before being heated in the furnace. I also

developed a SIPOC process map to identify all the activities involved in the project, including suppliers, input, process, output, and customers. This mapping process was necessary to track the current process and provide recommendations for modifications in the remaining phases of DMAIC.



Process Flow Chart

CE 1.3.4

I conducted a Voice of Customer (VOC) analysis to capture the customers' requirements, wants, and needs. I identified internal and external customers and developed scoring criteria to help them choose their priorities. Through market surveys and indoor interviews, I found that customers' top priority was the extrusion process, with the parameters of length, weight, and diameter being the most important. This allowed me to choose the extrusion process to be worked on using Six Sigma methodology. To identify the factors causing defects on the extrusion machines, I brainstormed

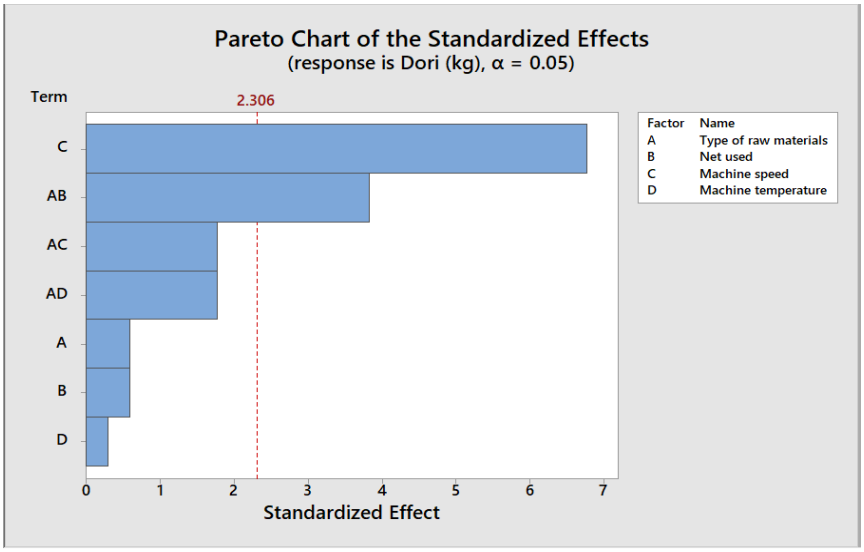
with staff in the industry and asked several questions. I learned that the prices of raw materials differed based on their quality, with recycled polypropylene being generated from waste materials. Polypropylene was allocated to each section daily according to the demand of production and the number of workers in each section.

CE 1.3.5

In the measure phase, I gathered quantitative data to get a clear understanding of the current state of the process. I collected data from the existing production process to identify the source of defects. I identified the critical to quality (CTQ) parameters by conducting brainstorming sessions with quality experts, labors, and foreman along with different external customers and vendors which gives us the voice of customer (VOC). I found length, weight, and diameter per pipe critical to quality standards. I also collected data related to the CTQ standards for the month of [redacted]. Additionally, I found two defects causing variation in the extrusion process named as Gatta and Dori by analyzing the extrusion process where raw material is converted into pipes. The main causes of defects were the type of raw materials, net used, machine speed, and machine temperature. I used the fishbone diagram to identify all the possible causes of the problem that I was trying to solve. The six M's (Machines, Methods, Materials, Measurements, Manpower, Mother Nature) were used to find the causes of scrap and the table with the causes and their effects were also formed.

CE 1.3.6

In the analyze phase, I focused on why defects and variations occur in the process. I converted real-time problems into statistical form and analyzed them statistically using tools such as Normality Tests, ANOVA, and statistical hypothesis testing. I conducted a Pareto analysis to identify the defects that were causing the most waste. Using Minitab software, I created Pareto charts for both the Gatta and Dori defects.

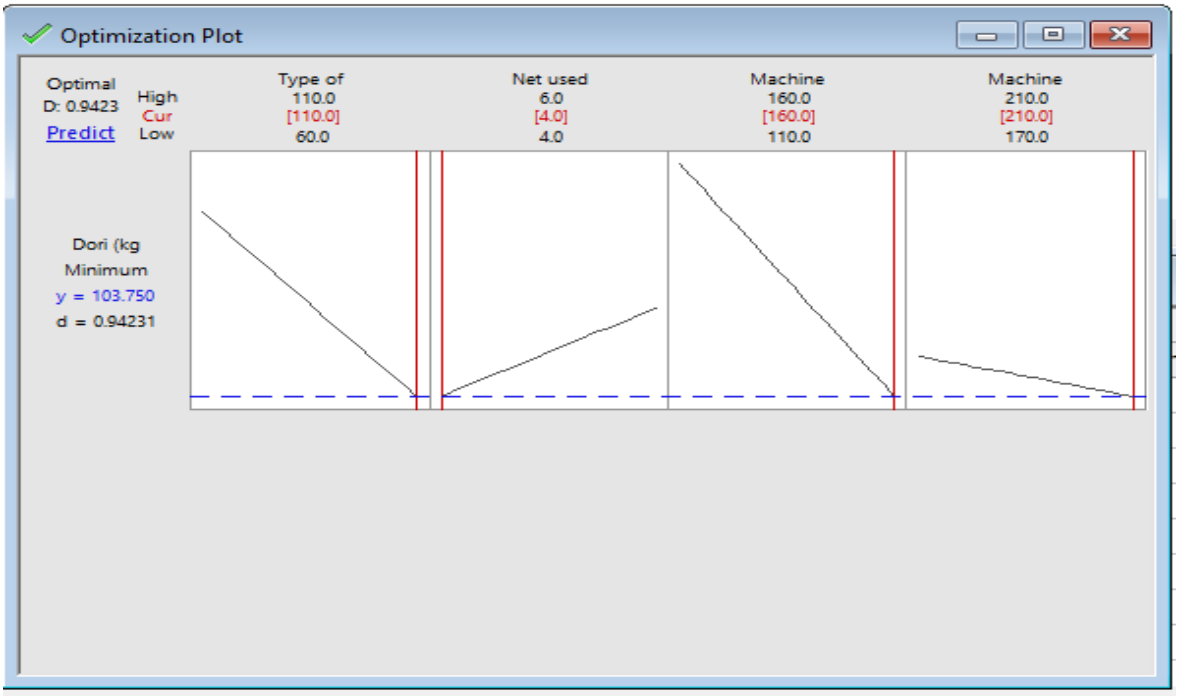


Dori Pareto Chart

The Pareto chart for Dori defect showed that the machine speed and the type of raw material net used were the major causes of the defect. I then used a fractional factorial design to further analyze the defects, and found that there were four factors (type of raw material, net in use, machine speed, and machine temperature), each with two levels. The results of the design showed that the Dori defect was causing more waste than the Gatta defect, and that the machine speed and the type of raw material net used were the primary causes of the defect.

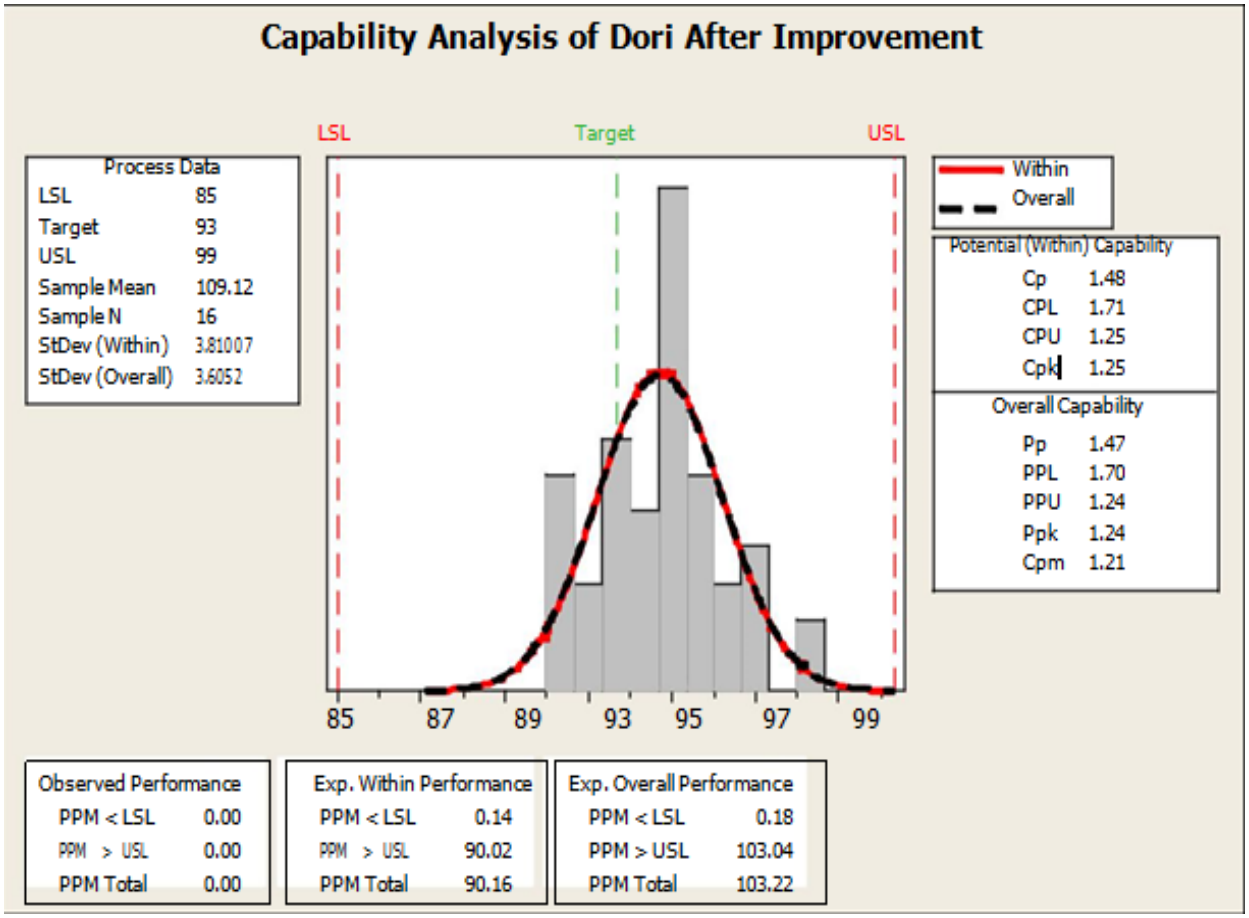
CE 1.3.7

In the improve phase, I developed solutions to reduce variation using tools such as Process Capability Analysis and Designs of Experiments. I analyzed the data collected in the measured phase and found that the Dori defect was causing more waste than the Gatta defect. After gathering more data and analyzing the Dori defect, I created an optimization plot which showed that the new machine settings were optimal for reducing defects.



Optimization plot

The new settings reduced Dori waste from 120kgs to 103kgs. I then conducted a cost analysis on the 16 machines causing the most waste and found that the new settings saved Rs. 56,100 per month. Finally, I analyzed the process capability and process performance of the Dori defect and found that the data was within the model. Overall, I successfully reduced process variation by reducing Dori waste and acquiring optimal machine settings.



Process capability

CE 1.3.8

In the control phase, I focused on maintaining and controlling the implemented improvements by establishing new standards and procedures and training the labor. I ensured that the machine settings on the defective machines were properly trained to the operators and management for familiarity with the new system. Regular monitoring was put in place to check for any deviations and to take quick action if necessary. The performance of the production line with improved machine settings was documented and printed daily for review by foremen and management.

I also used statistical analysis of the data to ensure control of the process. By analyzing the statistical data with the daily reports, I was able to draw conclusions and make suggestions for potential changes in the process. This helped to provide a better understanding of the process and its capability, allowing for stronger control over the process.

To measure the effectiveness of the changes made, I used the Defect Per Million Unit (DPMU) method to calculate the defect rate. I found that the defect rate was at the 4 sigma level (1100 Defects per Million Opportunities), which was a significant reduction from before the improvements were made. Overall, the control phase helped to ensure that the process remained in control and that the improvements made were effective.

SUMMARY

CE 1.4.1

In this career episode, I aimed at reducing waste in a production line of [redacted] industry. The project involved several phases of the DMAIC methodology.

I identified the problem, which was the high amount of waste in the production line. In the Measure phase, I gathered data on the different types of waste, and through statistical analysis, I determined that the Dori defect was causing more waste than the Gatta defect. Moreover, I conducted a root cause analysis to determine the factors that were contributing to the Dori defect. Using Pareto analysis and design of experiments, I identified the major factors that were contributing to the defect, including machine settings, material quality, operator errors, and environmental conditions. I used optimization techniques to determine the optimal machine settings for reducing the Dori defect. After applying the new machine settings, I conducted a cost analysis and determined that the new settings would save the company a significant amount of money.

Finally, I developed a system to monitor the new machine settings and ensure that the improvements were sustained over time. This included proper training for operators and management, daily documentation of performance, and statistical analysis of data to identify trends and potential problems.

Overall, this project was successful in reducing waste and improving the efficiency of the production line. By applying statistical techniques and optimization methods, I was able to identify and address the root cause of the problem and develop a sustainable solution.