ICEBIT
The 4th International Conference On Economics , Business and Information Technology
June 10, 2023 pp. 41-53

Product Quality Optimization by Applying the Six Sigma Methodology: DMAIC in CV XYZ (A Case Study of an Indonesian Subcontractor Company)

Devita Mutiara Putri
Institut Teknologi Bandung
Bandung, Indonesia
(+62) 82165643522
devita_mutiara@sbm-itb.ac.id

ABSTRACT

Reflecting the increasing demand in the motorcycle industry, it requires brands to sustain their product quality to meet customer satisfaction. The quality of the end product depends on the quality of spare parts. Hence, local suppliers were critical in ensuring the product quality is fulfilled. This research is limited only to CV XYZ which is known as a motorcycle spare part third-party supplier that is based in Cimahi, Indonesia. Recently, they faced decreasing customer trust because they obtained a “D” score in Performance Quality written in the Performance Supplier Report January 2023 that is sent by one of their customers. This research aims to identify solutions for the improvement of product quality. The Six Sigma Methodology DMAIC is the basis of this problem-solving research. The author utilizes historical data and undertakes the recommendation given by the previous study in literature reviews. The analysis proved that the process needs repair according to Performance Supplier Report. Three root causes of the issue with the shaper tools were overused, hasty working behavior, and lack of a monitoring system. Currently, these root causes were improperly handled. So, solutions proposed include reconditioning and scheduling, job rotation procedures, and the Poka-Yoke: Cleaning Numerator.

Keywords : Customer satisfaction; Improvement; Motorcycle industry.

1. INTRODUCTION

ASEAN is a region that is undergoing a fast transition in terms of automotive manufacturing. Indonesia is expected to remain the second largest producer in 2023, with 1 million automobiles sold each year. To remain competitive, local supplier businesses must maintain suitable standards for materials and final goods. Companies like CV XYZ are one of those that manufacture motorcycle spare parts. This research is focusing on CV XYZ which is based in Indonesia. In CV XYZ, there are no marketing or human resources departments to help with the production process. The most important factors for clients to consider when buying spare parts from CV XYZ are pricing and product quality. The organization should take customer happiness into account when defining goals as a key factor in customer satisfaction. To meet quality requirements, the business must make ongoing changes, such as goal setting, progress measurement techniques, goal refinement, goal-setting strategies, and defining new goals over time. Additionally, the organization must improve operation management and other management facets, and be accountable for their actions and consequences. Regular performance assessments are also necessary to assess the quality of products (Deming, 2008).

CV XYZ has faced decreasing customer trust since the beginning of 2023. CV XYZ is a subcontractor (third-party supplier) for PT X and PT Y companies. The problem started at the beginning of February after CV XYZ received the Performance Supplier Report, Period of January from PT X. They obtained a “D” score in Performance Quality and a “B” score in Performance Delivery. The scores are summed, resulting in Level “D” in Performance Supplier. Until March 2023, CV XYZ did not receive any bad reports again, but their production tender is likely to be revoked.

2. LITERATURE REVIEW

2.1 Quality Management

Building effective growth, low-cost, and response strategies starts with quality management. The quality objective is to create products with excellent quality that guarantee reliability, safety, and durability while minimizing costs. Quality does not just happen; it requires planning (Juran, 1989). In other definition, Philip Crosby (1984) in Quality 101 Self-Directed Learning Program (1999) explained that the definition of quality must be compliance with specifications rather than goodness, and prevention instead of an appraisal is the system for delivering quality.

2.2 Six Sigma

Pyzdek (2003) proposed a new definition of quality to connect Six Sigma with potential and actual quality. Six Sigma helps businesses create goods more quickly, efficiently, and with outstanding quality by reducing waste. It is also closely related to Sigma Level, which helps identify the competitiveness level of current and desired processes as stated in Table 1.

Table 1. Sigma Level and Competitive Levels

Sigma Level	Defect Rate (PPM)	Yield in %	Cost of Poor Quality (% of sales)	Competitive Level
6σ	3.4	99.99966	<10%	World Class
5σ	233	99.9767	10 to 15%	
4σ	6,210	99.379	15 to 20%	Industry Average
3σ	66,807	93.3193	20 to 30%	
2σ	308,537	69.1462	30 to 40%	Non-competitive
1σ	690,000	31	>40%	

Source: Harry (1998) in Mahajan (2008)

The Competitive Level column in Table 2.1 reflects them. Above, companies have generally chosen three or four sigma levels as their standard. The level of 6 Sigma also responds to the rising customer expectations and the complexity of modern products and processes (Pyzdek, 2009).

2.2.1 DMAIC as the Six Sigma Methodology

Thomas Pyzdek's book "The Six Sigma Handbook Third Edition" outlines the five phases of DMAIC, one of the Six Sigma Methodology. Define phase include creating a project charter and construct a team. Measure phase is used to determine the level of performance of the current process. Analyze phase the using descriptive and exploratory data analysis. Improve phase is utilizing project management and additional organizing and managing tools. Control phase used to modify reward and incentive programs, regulations, expenditures, etc.

2.2.2 Six Sigma Management and Execution

Six Sigma is a quality improvement tool to help the managerial division of a company improve its system and product quality. The CEO or other senior leader should be responsible for developing the Six Sigma Deployment Manual, which must have a strict timeline, detailed needs, and official approval from the managerial levels (Pyzdek, 2009).

2.2.3 Previous Research Studies

The researcher used ProQuest to analyze previous studies about DMAIC in the automotive industry. Conference Papers & Proceedings were used as sources and had Full Text and Peer Reviewed filters applied, making the papers credible.

Table 2. Previous Research Studies

No.	Researcher, Year	Title	Objective	Methodology	Result
1.	Jou, Yung-Tsan; Silitonga, Riana Magdalena; Ming-Chang, Lin; Sukwadi, Ronald; Rivaldo, Jovian (2022)	Application of Six Sigma Methodology in an Automotive Manufacturing Company: A Case Study	Identifying solutions to brushless motor rejection.	DMAIC	Applying the Six Sigma methodology, the sigma level in MTM increased from 4.93 in 2020 to 5.11 in 2021, then finally to 5.44 in 2022.
2.	Rifqi, H., Zamma, A., Souad, B.S. & Hansali, M. (2021)	Lean Manufacturing Implementation through DMAIC Approach: A Case Study in the Automotive Industry	The DMAIC principle is used to reduce waste materials and increase productivity in manufacturing by optimizing the physical flow.	Lean method, DMAIC	DMAIC concept emphasizes the importance of each step, but also enables team members to monitor progress through project structuring.
3.	Godina, R. & Beatriz Gomes, R.S. (2021)	A DMAIC Integrated Fuzzy FMEA Model: A Case Study in the Automotive Industry	A fuzzy FMEA system is being tested to detect subjective failures that are difficult to diagnose through visual inspection.	Fuzzy FMEA: input interface module (fuzzification), knowledge base module (rules base), output interface model (defuzzification), DMAIC	The concept was tremendously helpful in terms of how the project was organized, perceived, and imitated.
4.	Gupta, V., Jain, R., Meena, M.L. & Dangayach,	Six-Sigma Application in the Tire-	DMAIC strategy improved bead splice process capability	DMAIC	Six Sigma DMAIC can improve tire manufacturing plant

No.	Researcher, Year	Title	Objective	Methodology	Result
	G.S. (2018)	Manufacturing Company: A Case Study	index.		process performance.
5.	Noori, B. & Latifi, M. (2018)	Development of Six Sigma Methodology to Improve Grinding Process	This study aims to improve automotive sector performance through Six Sigma.	DMAIC	Six Sigma identifies root causes of issues to reduce quality costs.

DMAIC, FMEA, and Sigma are all used to reduce defects in the automotive industry. The fifth paper suggests using Poka-Yoke as an improvement for future studies. After reviewing all the papers, the researcher concluded that DMAIC is highly implementable to decrease defects.

3. RESEARCH METHODOLOGY

3.1 Research Design

Green and Tull (1978) proposed a research design that outlines procedures and methods for gathering data from various sources. Kerlinger (1973) argued that the design should be suitable for valid tests of the relationships between variables. This research aims to explain occurrences by collecting numerical data and analyzing it using statistical techniques.

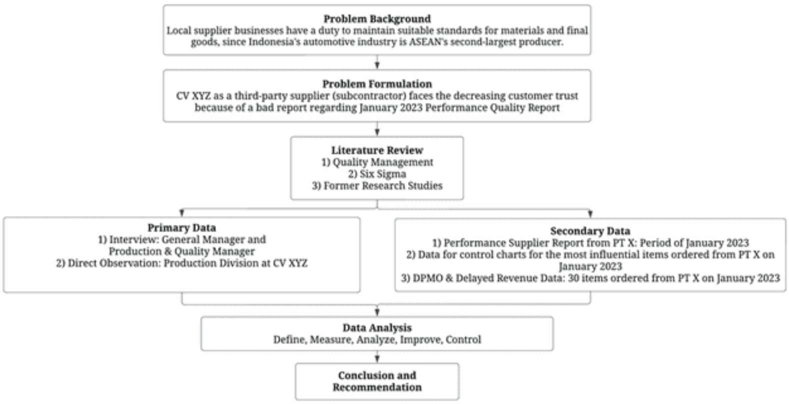


Figure 1. Research Design

The research will start with a problem background, problem formulation, literature review, primary and secondary data, data analysis, and a conclusion recommendation to improve CV XYZ's operational production problem.

3.2 Research Methodology

W. Edwards Deming developed the DMAIC framework in the 1950s to analyze data as in Figure 2.

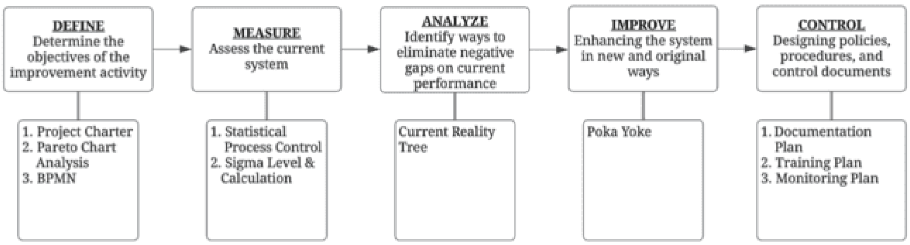


Figure 2. Research Methodology

Thomas Pyzdek (2009) proposed the use of Project Charter and Pareto Chart Analysis to identify the problem statement, project objective, or purpose of a project. This methodology is used to determine how many types of items should be analyzed. In the Business Process Model and Notation (BPMN) phase, the researcher dives into the numerical data of product length observed five times a day and highlights Statistical Process Control using Minitab Statistical Software. Meanwhile, for Sigma Level and DPMO, the researcher uses West Gard Six Sigma Calculators. In Analyze phase, Current Reality Tree (CRT) is used to identify which negative gaps that need to be eliminated. In Improve phase, the Poka-Yoke is utilized to generate creative solutions. Meanwhile, in Control Phase, technicians and operators needed the control documents for the complete solutions implemented for CV XYZ. Three types of document control can be used to help the company make a renewed system in creative and original ways.

3.3 Research Methodology

3.3.1 Interview

Trent Focus Group (1998) and Sewell (n.d.) both emphasize the importance of interviews for data collection. In this case, the related managers are open to being interviewed from what the researcher sees in the CV DKA's condition.

3.3.2 Direct Observation

Non-participant Observation is a type of observation used to observe production lines, operators, technicians, assignable variations, machines, and defective products to gain a more dynamic understanding of circumstances that are difficult to capture using other techniques (Liu & Maitlis, 2010).

3.3.3. Secondary Data

Boslaugh (2007) and Vartanian (2010) define secondary data as any dataset that was not gathered by the researcher, such as the study of information gathered by someone else. To make this research more comprehensive, the researcher utilizes secondary data such as January 2023 Performance Report, control charts, and item pricing data.

3.3.4. Data Analysis

DMAIC is a five-stage data analysis system invented by Deming that is explained by Thomas Pyzdek (2009) in the Six Sigma Handbook 3rd Edition as followed:

Table 3. DMAIC Analysis Tool Explanation

DMAIC Phase	Applicated Tools	Explanation
Define	Project Charter	The Project Charter outlines six elements for fulfilling the objectives of the research, including Business Case, Problem Statement, Goal Statement, Project Scope, Project Plan, and Team Selection.
	Pareto Chart	The Pareto Chart analysis is adopting the rule of 80/20, which means every 20% of items in the highest peak of resulting impact is responsible for causing any effects to the other 80% of items.
	Business Process Model and Notation	BPMN is a key component of a business process. In this case, the BPMN that should be made is for the 20% items selected in Pareto Chart Analysis.
Measure	Statistical Process Control	SPC makes a massive difference in distinguishing between current and ideal conditions. Thus, the use of SPC is to reduce the negative impact by discovering assignable variations other words, SPC gives the ability to maintain and track the manufacturing processes.
	Sigma Level Calculation	The researcher uses WestGard Six Sigma Calculators to obtain Defects per Million and Sigma-Metric (Sigma Level).
Analyze	Current Reality Tree	Current Reality Tree is a visual statement used in the Theory of Constraints to identify root causes relevant to problems being studied. It is similar to the Problem Tree, but with an oval shape to signify cause-and-effect effects.
Improve	Poka-Yoke	Poka-Yoke is a mistake-proofing technique to avoid common workplace mistakes. The concept of Poka-Yoke is not about detecting and fixing existing mistakes. However, Poka-Yoke is about designing processes requiring a particular system to make mistakes or problems that are not occurring.
Control	Training Plan	The researcher and Production & Quality Manager should plan a training program and select the best candidates to train employees.
	Documentation Plan	Documentation Plan is used to ensure production methods and materials meet requirements. Additionally, to organize the specifics of the job to be done.
	Monitoring Plan	Monitoring strategy collects data to assess effectiveness of enhanced process.

4. RESULT/FINDING

4.1 Define Phase

Based on Define focuses on the project's goals, objectives, and constraints before identifying the necessary process data while considering the customer's concept of quality.

4.1.1 Project Charter

As stated in the subchapter of Research Methodology, Project Charter contains six essential elements to give a comprehensive picture of the current problem as depicted in Table 4.

Table 4. Project Charter

Project Charter	
<u>Business Case</u>	<u>Problem Statement</u>
CV XYZ has faced decreasing customer trust since the beginning of 2023. CV XYZ is a subcontractor (third-	We currently have the score in Performance Quality 1577 PPM (Level D). Our customers expect at least we

party supplier) for PT X. The problem started at the beginning of February after CV XYZ received the Performance Supplier Report, Period of January from PT X. They obtained a “D” score in Performance Quality and a “B” score in Performance Delivery. The scores are summed, resulting in Level “D” in Performance Supplier. Until March 2023, CV XYZ did not receive any bad reports again, but their production tender is likely to be revoked.

are in the range of 501-1000 PPM (Level B).

Goal Statement

Decrease the number of defects until the PPM is in the ideal range by the middle of 2023.

Project Scope

Item Producing - Core Process

Start: Raw materials are being processed according to the system.

Stop: Finished products are ready to be sorted and packed.

Project Plan

No	Activity	Time			
		Feb	Mar	Apr	May
1	Examine the problem with the ones that has related job function in CV XYZ (interview)	■			
2	Determining team members for the project	■	■		
3	Do direct observation		■		
4	Data gathering (secondary data)		■		
5	Analyze the data obtained		■	■	
6	Generate feasible solution			■	
7	Meeting with the GM, talking about solutions for the issue			■	■
8	Structuring step by step implementation and control documents				■

Team Selection

Production and Quality Manager: Berry Shabar	
Machine Technicians: Mamat and Memed	
Machine Operators:	
Mach. FINE BLANK 25T (6 machines): 1. Rosita 2. Idah 3. Imas 4. Dedah 5. Atik 6. Anik	Mach. FINE BLANK 60T (5 machines): 1. Agus 2. Isal 3. Ade 4. Eman 5. Nuh
Mach. FINE BLANK 40T (5 machines): 1. Madi 2. Ayi 3. Abo 4. Irfan 5. Rian	Mach. FINE BLANK 150T (1 machine): 1. Andi

4.1.2 Pareto Chart

In current conditions, CV XYZ receives Debit Advice from PT X about defect notifications that also informed PT X would not pay CV XYZ before their defective products are repaired. The researcher then uses this condition to determine which product contributes the most to the total defect and has the high price related to delayed revenue in January 2023. The data could not be shown due to limited space, yet, depicted in Figure 3 is the result of Pareto Chart.

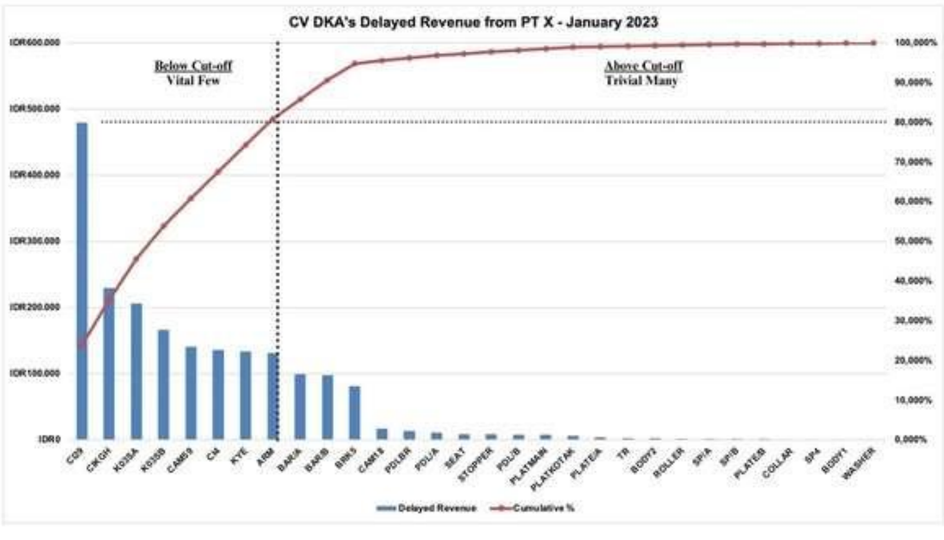


Figure 3. Pareto Chart January 2023

The Pareto Chart above shows the 80/20 rule, indicating that 80% of effects are from the 20% causes. Then, the researcher split the chart into two areas: Below Cut-off or Vital Few and Above Cut-off or Trivial Many. The left area (Below the Cut-off) is the area of the 20% causes. Instead, the right area (Above the Cut-off) is the 80% effect. Thus, from now on, the research will only focus on the 20% area since these items contributed the most delayed revenue, which comes from many defects and mid to high prices. The analysis will be focusing on CI29, CIKGH, K03SA, K03SB, CAM59, CI4, KYE, and ARM. The objective of choosing item to be analyzed through the Pareto Chart is to have a reliable base in determining which item should be reviewed and do the implementation of renewed solution first. Other than that, if CV XYZ succeeds in renewing the system to make substantial changes to decrease defects for these eight items, the researcher hopes that it will increase PT X’s satisfaction level.

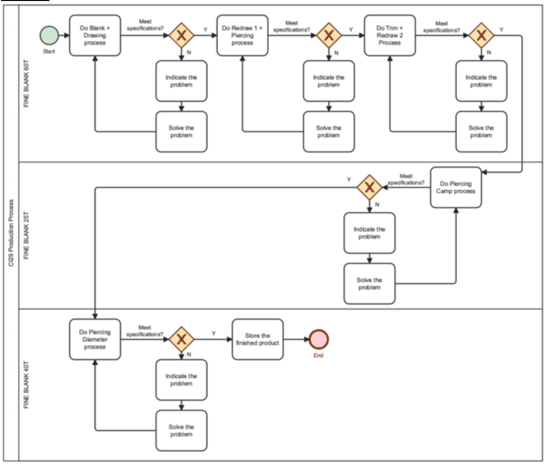
4.1.3 Business Process Model and Notation

To map out the continued analysis of eight items based on the Pareto Chart, the researcher created the BPMN limited to only the Production Division that handles the production process. The researcher feels compelled to do this because the BPMN diagram as a whole only emphasizes the production division, making it pointless to add any other divisions that are not involved in the process. It will be simple to distinguish the procedure this way since calling the swim lanes after the machine also represents the fact that each machine has workers who operate it. The operator teams were referring to Team Selection in the Define Phase, Table 4. Hence, below, there are seven BPMNs contained with the detailed activity that has been executed in every machine, as depicted in Table 5.:

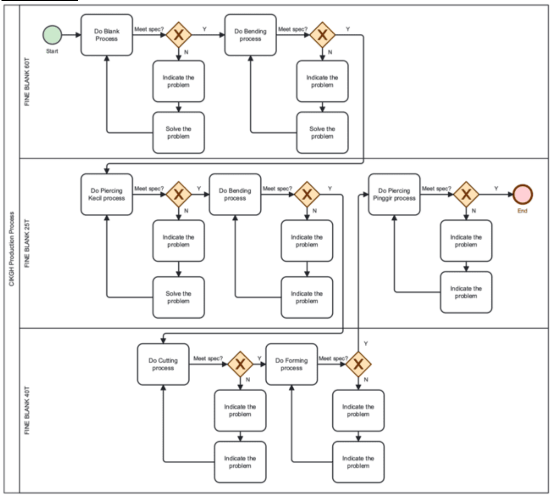
Table 5. BPMN 8 Items

BPMN 8 Items

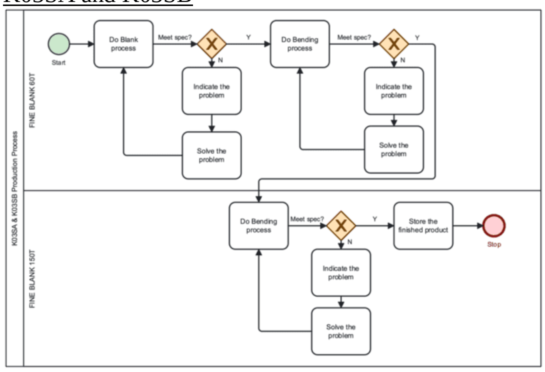
CI29



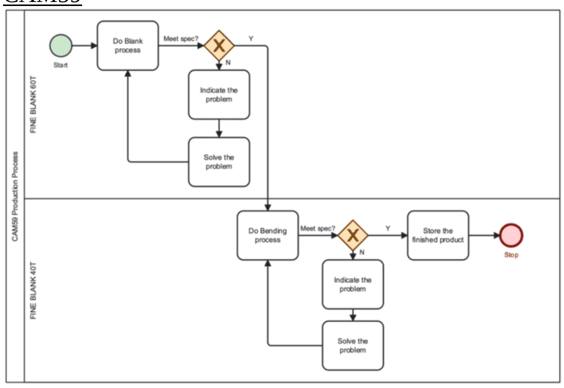
CIKGH



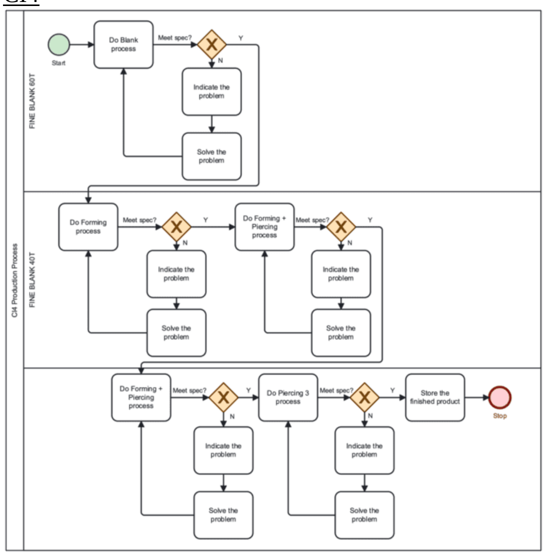
K03SA and K03SB



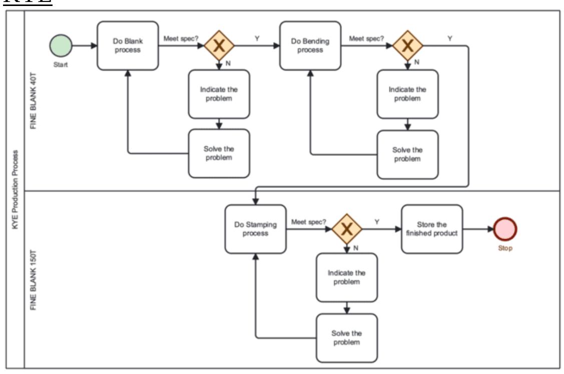
CAM59



CI4

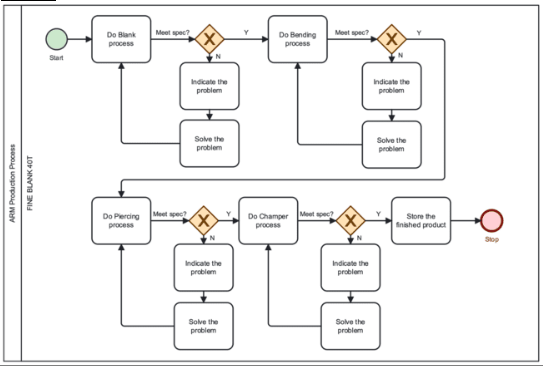


KYE



BPMN 8 Items

ARM



Since several items go through the same production process, the researcher only produced seven BPMNs as opposed to eight. The production steps for K03SA and K03SB are the same, hence they are all grouped together. In particular, the only shape difference between K03SA and K03SB is their length. The task symbol, which was written in the action verb, was used to continue the activity after the start event symbol. A process is being examined by the Production & Quality Manager, according to the gateways. The PQM will work with the technicians to address any issues they identify once they have been flagged as process problems. The Work-in-Process (WIP) that was unable to be corrected due to the issue will be replicated once the issue has been resolved.

4.2 Measure Phase

Since we discussed the quality management problem solving, the researcher needs problem-proofing from the data given. Thus, the Measure phase helps the researcher to quantify the current operating results with a specific mechanism.

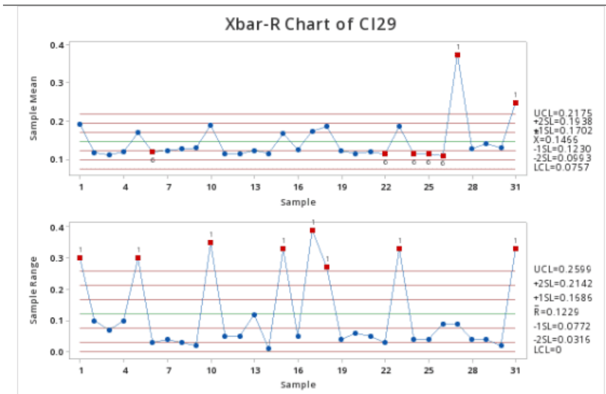
4.2.1 Statistical Process Control

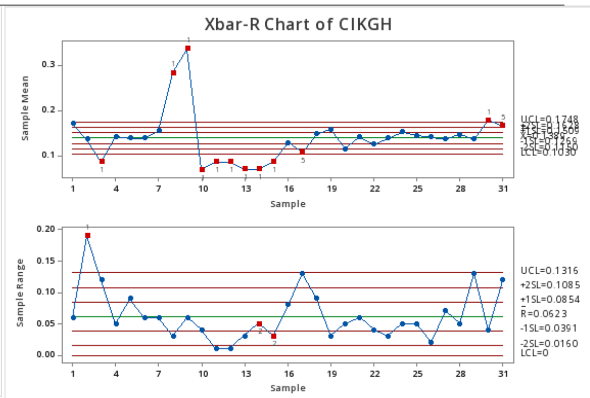
Measuring the process with a process behavior chart or SPC is to monitor the executed production process statistically. Primarily using an Xbar-R chart on every item chart, the researcher's motive is to map based on its subgroup size. In this case, the subgroup size on every item is five. The subgroup (X1-X5) reflects that one product sample was assessed at each inspection time. In total, there are five inspection times a day (the data source is depicted in the Appendix Chapter) which reflects the subgroup size is greater than 2 and smaller than 9. Each item has 155 data (31 days x 5 inspection time). Other than that, the data are classified into continuous data since the numbers are expressed as decimals and have infinite value possibilities. These two grounds lead the researcher to select the Xbar-R chart as the control chart type. It must be noted that the analysis concerns only four MINITAB rules that are the same as WECO rules. The rules implemented are:

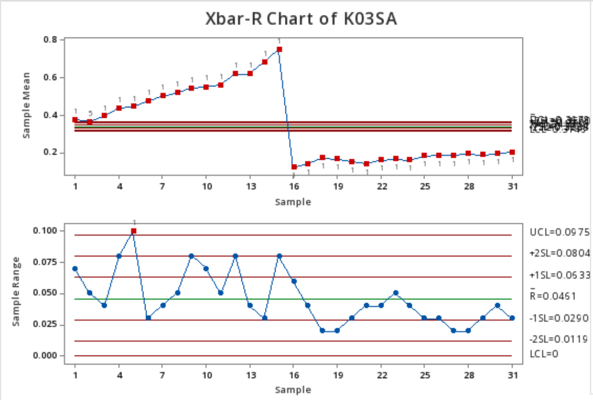
- Rule 1 MINITAB = Rule 1 WECO
- Rule 2 MINITAB = Rule 4 WECO
- Rule 5 MINITAB = Rule 2 WECO
- Rule 6 MINITAB = Rule 3 WECO

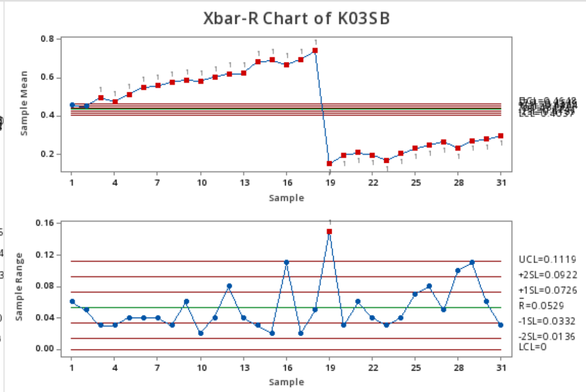
Table 6. Xbar-R Control Charts

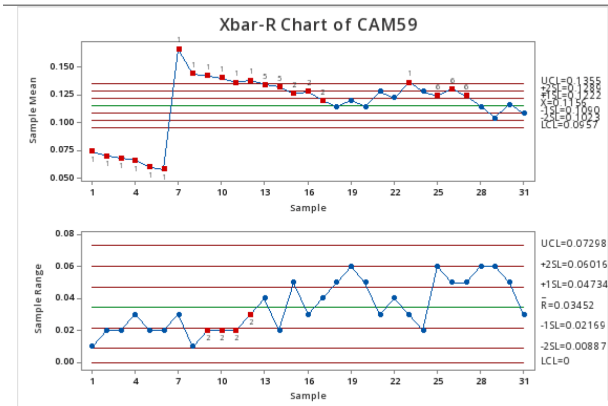
Control Chart: Xbar-R Chart

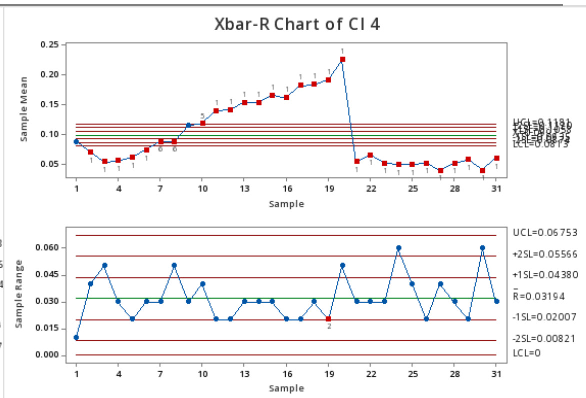


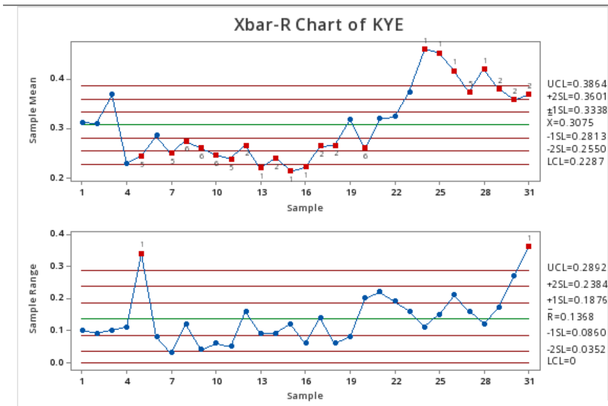


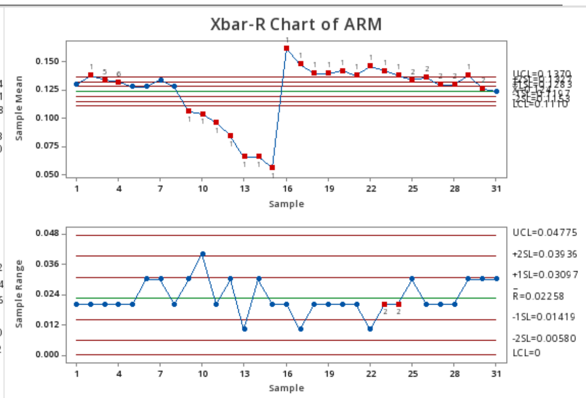












The Xbar-R Chart was used to interpret the production process, which was out of control due to violations of the Rule 1 and Rule 2 of MINITAB. The R Chart showed variations, such as CI29, CIKGH, K03SA, K03SB, and KYE's, that violated the 3 sigma or UCL level. The data of some products indicated that the system is not thoroughly checked, resulting in these variations to be occurring again on the other day. The control limits in the Xbar Chart were imprecise since the values in the Xbar Chart are based on R Chart values. Process capability analysis can only be executed after the values of the X bar and R chart are within the defined limits (Ted Hessing, n.d.), so the process capability analysis is not applicable for this case. The reason why the SPC indicated there are assignable variations occurred was that the products' dimensions weren't inherent with the ideal measurement because the dies (shaper) were found imperfect, as thoroughly will be discussed in Figure 3 Current Reality Tree.

4.2.1 Statistical Process Control

The Problem Statement section in Project Charter states that the PPM target is at least 501-1000. So, the analysis below will calculate the target that must have been fulfilled to obtain the desired PPM level.

Table 7. Current and Ideal Condition – PPM and Six Sigma Calculation

Item Name	Current					Ideal			
	Sample size	Defect Number	PPM	% defect of total item production	Sigma Level	Defect number	PPM	% defect of total item production	Sigma Level
CI29	71460	351	4912	0.49%	4.1	36	504	0.05%	4.8
CIKGH	55000	105	1909	0.19%	4.4	28	509	0.05%	4.8
K03SA	45000	123	2733	0.27%	4.3	23	511	0.05%	4.8
K03SB	52935	199	3759	0.38%	4.2	27	510	0.05%	4.8
CAM59	37000	83	2243	0.22%	4.4	19	514	0.05%	4.8
CI4	37000	80	2162	0.22%	4.4	19	514	0.05%	4.8
KYE	45000	117	2600	0.26%	4.3	23	511	0.05%	4.8
ARM	45000	115	2556	0.26%	4.3	23	511	0.05%	4.8

CV XYZ needs improvement to reduce defects in eight items, resulting in a total PPM of 744. This falls within the desired range of 501-1000 (Level B). The analysis encourages CV XYZ to implement renewed ideas to increase customer satisfaction.

4.3 Analyze Phase

We identified the current and ideal conditions of the production division and analyzed the root cause of the defect item in January 2023.

4.3.1 Current Reality Tree

Current Reality Tree (CRT), which is seen in Figure 3, is the tool for determining the underlying root causes/core issue.

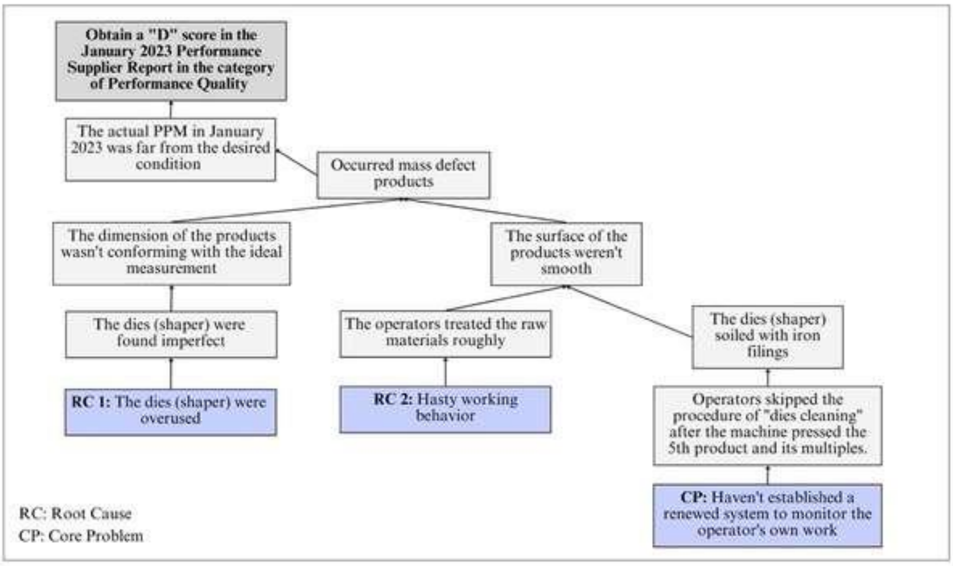


Figure 4. Current Reality Tree

The tree above was designed based on an interview result with CV XYZ's General Manager and the Production & Quality Manager. The tree shows an Undesirable Effect (UDE) that states, "Obtained a D score in the January 2023 Performance Supplier Report in the category of Performance Quality". The intermediate effects are shown below the UDE, in which the figure shows branches leading to specific causes. The current condition of why the products were called Not-Good/Defect/Reject is because the products' condition was not perfect. In the automotive industry, precision is the number one priority, so CV XYZ could not supply a not-good product to the first supplier as a third supplier. The products were inspected by dimension measurement and visual inspection. The analysis has concluded with two root causes and one core problem. Root Cause 1 (RC 1) was the only cause for discussing the tool, while the rest of the causes are in line with humans, or operators in this case.

4.4 Improve Phase

Improve Phase prioritizes root causes and provides solutions for each root cause to ensure no one root cause is left without a solution.

4.4.1 Proposed Solutions

The customers declared that the imperfect dies caused a non-conforming product dimension with the ideal measurement, so solutions were generated.

RC 1: The dies (shaper) were overused.

CV XYZ's current coping mechanism is to buy new dies, but this will cost Rp500,000-Rp3,000,000. However, CV XYZ's day-to-day production activities must use different types of dies to make many shapes, so their bluntness cannot be avoided.
Proposed Solution 1: The Dies Reconditioning and Scheduling.
The most important details in this text are that the iron plates must be cut to a perfect measurement using sharp dies, and that a honing tool should be used to sharpen the dies. This strategy can keep costs to a minimum, and it can be planned every day before manufacturing begins. The activities of dies reconditioning will be executed by male operators, while female operators undertake checking activities every morning before the production starts to detect imperfect dies. This strategy can keep costs to a minimum and prevent every die in every machine from being in poor condition.

RC 2: Hasty working behavior.
The GM has tried to minimize the occurrence of operators treating raw materials (iron plates) carelessly by rotating the staff. However, there are cons to this solution, such as the number of products processed will be slightly smaller than the previous operators, and the Production Division is trying to achieve production targets. The proposed solution for RC 2 is to rotate the sorting staff to handle the Production Division.

Proposed Solution 2: Enhancement of Job Rotation Procedure.
Job rotation can be used to overcome occurrences, but it can be enhanced with a protocol that staff should follow. The step of job rotation enhancement is divided into two steps.
Step 1: Work Behavior Test
The Production & Quality Manager should select which operators to replace based on their comprehension ability and behavior in treating raw materials. The considerations for replacing operators included a variety of factors, which are:
1) Operators' ability to understand Production & Quality Manager's commands.
2) Operators must be careful when handling raw materials.
Step 2: On-the-Job Training (OJT Training)

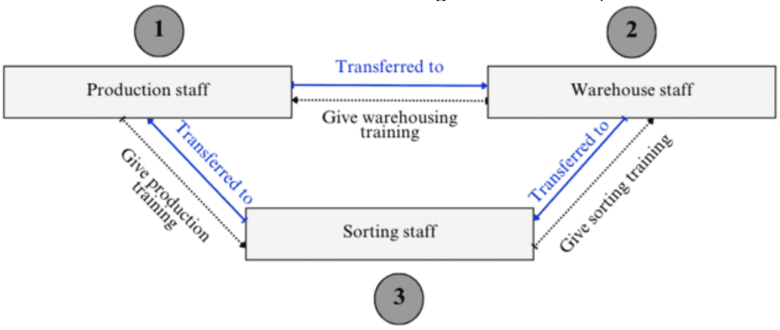


Figure 5. On-the-Job Training Illustration

The production staff will be transferred to Warehousing, Sorting, and Production Divisions, where they will receive trainings according to the job in every division.

CP: Have not established a renewed system to monitor the operator's own work.
Operators must follow procedures to produce high-quality products to maintain a sense of fulfillment.

Proposed Solution 3: Poka-Yoke: Cleaning Numerator
Work demonstration is important to help operators absorb the new Poka-Yoke system, which is based on the Poka-Yoke concept and uses an unusual digital number counter.

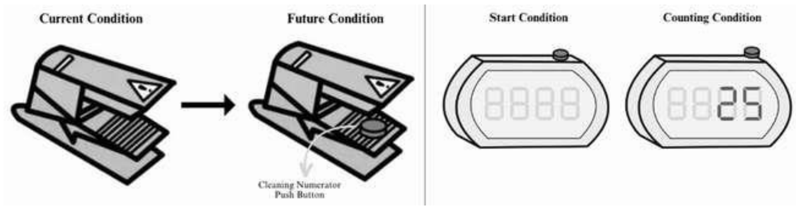


Figure 6. Poka-Yoke: Cleaning Numerator Pedal Illustration

The Poka-Yoke concept uses a Cleaning Numerator push button that is attached to the machine pedal to stop users from forgetting or ignoring the die-cleaning process. The researcher likewise illustrated the digital number counter on the right side of the above graphic. Operators can now track their job using a number counter thanks to this novel approach. According to the BPMN for the Define phase, four different machine types—FINE BLANK 25T, 40T, 60T, and 150T—are utilized to create eight other items. A training plan is necessary since human resources differ for each type of machine to prevent issues. The Control phase comes after, when the Training Plan for Proposed Solutions 1 and 2 is kept.

4.5 Control Phase

Control is the last stage of the DMAIC Methodology, aiming to ensure tools, processes, and training are in place to achieve the improvement target. The case study has 3 Control Plans, including a Documentation Plan, Training Plan, and Monitoring Plan.

4.5.1 Documentation Plan

A documentation plan should be created to identify the person in control and the types of documents they must handle, allowing them to focus on their responsibilities.

Table 8. Proposed Documentation Plan

Documentation Plan				
Document	**Item Necessary**	**Immediate Responsibility**	**Modification Responsibility**	**Review Responsibility**
Training Manuals	Laptop/computer, staff database, printer	Production & Quality Manager, Warehousing Manager, Sorting Manager	Production & Quality Manager, Warehousing Manager, Sorting Manager	General Manager
Daily production observation notes	A5 notebooks, stationery, post-it			
K3 (Kesehatan, Keamanan, dan Keselamatan kerja) Tools Information	K3 photos, laptop/computer, printer.	Production & Quality Manager	Production & Quality Manager	General Manager
Machine Operating SOP	Step-by-step photos, laptop/computer, printer	Production & Quality Manager	Production & Quality Manager	General Manager
Purchasing Order List	Laptop/computer	Production & Quality Manager, Sales Manager	Production & Quality Manager, Sales Manager	General Manager
Job Rotation Procedure	Laptop/computer, printer	Production & Quality Manager, Warehousing Manager, and Sorting Manager	Production & Quality Manager, Warehousing Manager, and Sorting Manager	General Manager
Dies Recondition Schedule	Laptop/computer, printer	Production & Quality Manager	Production & Quality Manager	General Manager
Production Schedule	Laptop/computer, printer	Production & Quality Manager, Warehousing Manager	Production & Quality Manager, Warehousing Manager	General Manager
Product Sorting Procedure	Laptop/computer, printer	Sorting Manager	Sorting Manager	General Manager

The Documentation Plan can be accessed and revised by other managers outside the Production Division, depending on the type of documents being reviewed.

4.5.2 Training Plan

The training's implementation is described in a training plan, which includes a Gantt chart and serves as the primary source of evidence for evaluating the training in the future. The training plan for two programs is shown in Table 9.

Table 9. Proposed Training Plan

Training Plan												
Proposed Solution	**Training Module**	**Who Will Create the Module**	**Schedule for Training Modules Completion**			**Who Will be Trained**	**Schedule for Training**			**Trainer(s)**	**Integra-tion into Ongoing New Employees Training**	**Final Location of Employee Manuals**
			Start	**Days**	**End**		**Start**	**Days**	**End**			
2	On-the-Job Training	Production & Quality Manager, Warehousing Manager	02/07/2023	2	03/07/2023	All staffs related	05/07/2023	1	06/07/2023	Production & Quality Manager, Warehou-sing Manager	Basic Training in Each Division	Order Handling Training Module
3	Poka-Yoke Training	Production & Quality Manager	08/07/2023	4	11/07/2023	All operators	13/07/2023	2	14/07/2023	Production & Quality Manager	Basic Production Training	Quality Training Module

The two programs for Proposed Solutions are Enhancement of Job Rotation Procedure and Poka-Yoke: Cleaning Numerator. For Proposed Solution 1, there will be no training program, but these two programs will be restored in two files of Employee Manuals: Order Handling Training Module and Quality Training Module.

4.5.3 Monitoring Plan

The researcher constructed a monitoring plan to be followed by the Production & Quality Manager in CV XYZ. This plan is in the form of FMEA, which helps to anticipate and prioritize failures. The rubrics to explain the meaning of each number to rate SEV, OCC, and RPN, as well as the FMEA Monitoring Plan, are provided.

Table 10. Rubrics for FMEA Scoring

Score	Interpretation	Severity (SEV)	Occurrence (OCC)	Detection (DET)
1	Low	Can be repaired	Rarely occurred	Feasible to detect
2	Medium	Not necessarily repairable	Quite often occurred	Quite difficult to detect
3	High	Scrapped (Defect)	Often occurred	Difficult to detect

Table 11. Proposed Monitoring Plan

Failure Modes and Effects Analysis (FMEA)														
No.	Process Function (Step)	Potential Failure Modes (Process Defects)	Potential Failure Effects (Y's)	SEV	Potential Cause of Failure (X's)	OCC	Current Process Controls	DET	RPN	Recommend Actions	Responsible Person	Target Time	Taken Actions
1	Main production activities: Iron plate shaping	Shaping tool (dies) condition that will be getting worse day by day	Imperfect shape of sparepart	2	The dies are overused	1	Purchase new dies	1	2	The Dies Reconditioning and Scheduling	Production & Quality Manager, Operators	Every day	Practice, create schedule, perform
2		Defect occurred even from the phase of raw material has not processed yet		3	Operators' hasty working behavior	2	Job Rotation	2	12	Enhancement of Job Rotation Procedure	Production & Quality Manager, Sorting Manager, Warehousing Manager	1 month	Conduct observation, pre-test, training, and evaluation
3		Non-smooth items		2	Skipped production procedure	3	Reminds the operators regularly	3	18	Poka-Yoke: Cleaning Numerator	Production & Quality Manager, Operators	1-2 month	Approach vendor(s), discussions, install, work demonstration

In Table 11, the Risk Priority Number (RPN) shows three different scores, which represent the ranks of failure that should be prioritized to be anticipated. The bigger the RPN score, the more anticipated failure. The first is number 3 (RPN=18), then followed by number 2 (RPN=12), and the last is number 1 (RPN=2). After comparing with the previous analysis in Improve and Analyze, it is reasonable that failure number 3 has the largest RPN score since the occurrence of this problem was not predictable and was not addressed with the right mechanism.

5. CONCLUSION AND RECOMMENDATION

For managerial levels in CV XYZ, the researcher recommends to keep the production line to be stable by adopting renewable tools that contained in this research and open for further adjustments in the future. By doing the three proposed solutions above, CV XYZ can decrease these eight items to gain the desired PPM in the middle of 2023. For academicians, it is also advised to use the SCAMPER method for further Six Sigma DMAIC research to come up with a more detailed and innovative improvement strategy. Because currently, the fifth phase of the DMAIC (Improve) is rarely conducted with the use of this method.

REFERENCES

Adam, E. E., & Ebert, R. J. (1986, January 1). Production and Operations Management: Concepts, Models and Behavior. https://doi.org/10.1604/9780137248575

Brief, M. (n.d.). What is a Current Reality Tree? Definition and meaning. What Is a Current Reality Tree? Definition and Meaning. https://www.mbabrief.com/what_is_current_reality_tree.asp

Challenges & Opportunities of Indonesian Automotive Industry Development in the Era of CASE and MaaS - Events : ERIA. (n.d.). Challenges & Opportunities of Indonesian Automotive Industry Development in the Era of CASE and MaaS - Events : ERIA. https://www.eria.org/events/challenges-opportunities-of-indonesian-automotive-industry-development-in-the-era-of-case-and-maas/

Crosby, P. (1989, April 1). Crosby talks quality. The TQM Magazine, 1(4). https://doi.org/10.1108/eb059474

Crosby, P. B. (1984, January 1). Quality Without Tears: The Art of Hassle-Free Management. https://doi.org/10.1604/9780070145306

Document Management in Manufacturing. (2022, January 19). Tulip. https://tulip.co/blog/document-management-in-manufacturing/

G. (2013, October 12). Monitoring & Response Plan | Template & Example. GoLeanSixSigma.com. https://goleansixsigma.com/monitoring-plan/

Godina, R., Silva, B. G. R., & Espadinha-Cruz, P. (2021, April 20). A DMAIC Integrated Fuzzy FMEA Model: A Case Study in the Automotive Industry. Applied Sciences, 11(8), 3726. https://doi.org/10.3390/app11083726

Gupta, V., Jain, R., Meena, M. L., & Dangayach, G. S. (2017, September 20). Six-sigma application in tire-manufacturing company: a case study. Journal of Industrial Engineering International, 14(3), 511–520. https://doi.org/10.1007/s40092-017-0234-6

Haaften, R. V. (n.d.). Customer satisfaction. Customer Satisfaction. https://www.van-haaften.nl/customer-satisfaction/customer-satisfaction-models/84-customer-satisfaction.

Indonesia's stable economic growth in 2023 to support local automotive market, Gaikindo reveals. (2023, January 4). MarkLines Automotive Industry Portal. https://www.marklines.com/en/news/281143

Motorcycle sales hit 5.2 million units in 2022 | IDNFinancials. (2023, January 11). Motorcycle Sales Hit 5.2 Million Units in 2022 | IDNFinancials. https://www.idnfinancials.com/news/45654/motorcycle-sales-hit-units

Nelson Rules – Lean Manufacturing and Six Sigma Definitions. (n.d.). Nelson Rules – Lean Manufacturing and Six Sigma Definitions. https://www.leansixsigmadefinition.com/glossary/nelson-rules/

Noori, B., & Latifi, M. (2018, March 5). Development of Six Sigma methodology to improve grinding processes. International Journal of Lean Six Sigma, 9(1), 50–63. https://doi.org/10.1108/ijlss-11-2016-0074

Nugent, C. (2022, April 26). The Complete Guide to X-bar Charts for Quality Control - Dot Compliance. Dot Compliance. https://www.dotcompliance.com/blog/quality-4-0/guide-to-x-bar-charts-for-quality-control/

O'Connor, P. D. T. (1991, January). Leadership for Quality, J.M. Juran, Free Press/Macmillan, 1990. Number of pages: 376. Price: $35.00. Quality and Reliability Engineering International, 7(1), 58–58. https://doi.org/10.1002/qre.4680070117

Pyzdek, T. (2003, April 10). The Six Sigma Handbook, Revised and Expanded: The Complete Guide for Greenbelts, Blackbelts, and Managers at All Levels. https://doi.org/10.1036/0071410155

Ramana PV, T. H., Hessing, T., & PV, R. (2014, April 25). X Bar R Control Charts. Six Sigma Study Guide. https://sixsigmastudyguide.com/x-bar-r-control-charts/

Ribeiro Serra, F. A., Martins, F. S., & Carneiro da Cunha, J. A. (n.d.). Secondary Data in Research – Uses and Opportunities. Secondary Data in Research &Ndash; Uses and Opportunities. https://www.redalyc.org/journal/3312/331259758001/html/

Rifqi, H., Zamma, A., Ben Souda, S., & Hansali, M. (2021, July 31). Lean Manufacturing Implementation through DMAIC Approach: A Case Study in the Automotive Industry. Quality Innovation Prosperity, 25(2), 54–77. https://doi.org/10.12776/qip.v25i2.1576

Shigeo Shingo - Poka yoke, source inspection, mistake proofing and SMED - Management for the Rest of Us. (2004, December 4). Management for the Rest of Us. https://mftrou.com/shigeo-shingo/

Staples, S. (2017, November 29). Current Reality Trees. Medium. https://medium.com/ingeniouslysimple/current-reality-trees-ea13acbfd6e1

The Basics of Business Process Modeling and Notation (BPMN). (2022, January 6). The Basics of Business Process Modeling and Notation (BPMN) | IBM. https://www.ibm.com/cloud/blog/bpmn

WECO Rules. (n.d.). WECO Rules. https://ats-help.com/ATS_Inspect_6_3/Variable_Data_Collect/WECO_Rules.htm

What is Documentation Plan? (n.d.). What Is Documentation Plan? https://clickhelp.com/software-documentation-glossary/documentation-plan/

What Is Pareto Analysis? How to Create a Pareto Chart and Example. (2022, December 30). Investopedia. https://www.investopedia.com/terms/p/pareto-analysis.asp

Wood, J. C. (Ed.). (2005, June 9). Joseph M. Juran. https://doi.org/10.1604/9780415325714