Investment Cost Analysis and Quality Control of Telco Products at PT XYZ using FMEA Method and Kaizen Approach

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Abstract

PT XYZ is one of the renowned printing industries in Indonesia. One of the main products of PT XYZ is Security Printing, where the production process is located in the Smart Card department. The fluctuating production quantity necessitates that the company is capable of implementing an optimal production process to achieve high-quality outcomes, as well as ensuring the effective and efficient operation of the production process. The issue at PT XYZ is the persistent occurrence of product failures or defects that are difficult to avoid, leading to a product quality that has not yet met the company's expected standards. Hence, it is evident that the existing issues necessitate improvement, which will be conducted using a method suitable for production quality control, namely the Failure Mode and Effect Analysis (FMEA) method. In addition, improvements can also be made with other supporting concepts such as the Kaizen concept and the Five-Step Plan or 5S (Seiri, Seiton, Seiso, Seiketsu, and Shitsuke) concept. This research concludes that it can generate alternative improvement while considering the company's investment feasibility aspects, thereby reducing defects in the production of Telco products at PT XYZ.

Keywords
Quality Control; Failure Mode and Effect Analysis (FMEA); Kaizen, Cost.

1. Introduction
The rapid growth of industries in Indonesia has had an impact on various sectors, including the printing industry. The global industrial competition is expected to intensify due to the increasing demand from consumers. Companies are required to produce high-quality products. The quality of a product is considered one of the critical aspects that a company needs to focus on.

PT XYZ is one of the renowned printing industries in Indonesia. One of its primary products is Security Printing, with the production process located in the Smart Card department. Despite PT XYZ's best efforts in implementing production and quality management systems, there are still instances of unavoidable product failures or defects, resulting in product quality that falls short of the company's standards. Telco products are among the output of PT XYZ. In practice, product failures or defects continue to occur frequently. From August to September 2022, out of a total production of 1,100,000 units, 33,128 were defective, accounting for 3.01% of the total.

In light of these issues, it is essential to employ an appropriate method to address the existing failures and reduce the defect rate within the company. Based on previous research studies, there is a similarity in the problems encountered, making the Failure Mode and Effect Analysis (FMEA) method suitable for addressing these issues. This method allows for evaluating product failures and calculating the Risk Priority Number (RPN) to determine failure priorities. Kaizen represents a mindset for improving Quality, Cost, and Delivery, ultimately leading to the company's customer loyalty and satisfaction goals. A conducive working environment is crucial for ensuring smooth production in an industry. The concept of the Five-Step Plan or 5S (Seiri, Seiton, Seiso, Seiketsu, and Shitsuke) serves as the foundation for improvement efforts and cultivating quality awareness. By implementing the Failure Mode and Effect Analysis (FMEA) method along with the Kaizen approach using the 5W + 1H and 5S (Seiri, Seiton, Seiso, Seiketsu, and Shitsuke) concepts, it is expected that the company can undertake improvements and evaluations of the products produced in the Smart Card department, particularly in the Telco product line.

2. Literature Review

Quality control is carried out as a corrective action within the production process whenever there are products that do not meet expectations, ensuring that they continue to yield outputs of high quality. The objective of quality control is to assist in enhancing production while reducing costs that may arise if product quality falls short of expectations. Non-conforming or defective products refer to those that cannot meet the original intent of their production, whether intentionally or unintentionally, or fail to meet safety requirements as expected by consumers. Defective products can also be defined as products that are produced but do not meet the established criteria and can still be improved.

A measurement tool in the form of a diagram used for determining the priority of failures or event categories, thereby identifying the dominant value from its cumulative value, is commonly referred to as a Pareto diagram. Pareto follows the 80/20 principle, which means that 80% of failures in a product are caused by 20% of the failure caused in a production process. Therefore, the types of failures with a cumulative total of 80% are assumed to represent all the defect types that occur. This can assist in identifying the most critical issues that need immediate attention as opposed to those that can be addressed later.

By minimizing all potential failure modes, Failure Mode and Effect Analysis (FMEA) can be employed to enhance product quality, leading to increased customer satisfaction. The process in this method involves determining values for Severity, Occurrence, and Detection. Subsequently, the Risk Priority Number (RPN) is calculated as an indicator for prioritizing improvements.

Through the FMEA method, it is possible to identify which products have the highest defect rates and require improvement actions. Additionally, there is the Kaizen approach, also known as Continuous Improvement, which involves ongoing efforts to enhance quality. Kaizen is aligned with Total Quality Management (TQM), Zero Defect (ZD), Just-in-Time (JIT), and other activities aimed at quality control. Kaizen places quality as the primary foundation of an organization's production process. A key characteristic of Kaizen is its focus on the process rather than the outcome, supporting continuous quality control improvements.
Furthermore, investment feasibility is of paramount importance for companies when making long-term investment decisions in their plans. The financial aspect is a crucial key factor in investment feasibility. If other aspects are deemed feasible but the financial aspect yields unfavorable results, the company's proposal may be rejected because it does not provide economic benefits.

3. Methods

The research begins with an initial identification phase, which includes field studies, literature reviews, problem identification, problem formulation, research objectives determination, and research method selection. This phase is conducted through observations and interviews with employees, operators, and quality control personnel in the Smart Card department at PT XYZ. Observations and interviews are carried out for one month to understand the production line and identify the types of defects occurring in the Smart Card department, particularly in the Telco product line. During this stage, problem formulation is also conducted to define the research focus within the company, specifically regarding the types of defects and the most dominant causal factors leading to product defects, as well as the most influential factors contributing to defective products.

Additionally, there is the data collection and processing phase, involving the gathering of necessary research data such as the sequence of Telco production, data on types of defects in Telco products, causes of product defects, and production data for Telco products during the period of August to September 2022. The collected data will undergo several data processing steps using the Failure Mode and Effect Analysis (FMEA) method and the Kaizen approach to identify the most high-risk causes. An investment feasibility analysis is also conducted to determine whether the proposed improvements can be implemented by the company in the long term.

4. Data Collection

Data gathering methods and research tools are essential for undertaking data collection. The following data collection methods were used in this study.

a. Observation
   The observation is carried out by directly observing the production process at PT XYZ based on the observation sheet that was prepared beforehand. Direct observation is conducted through interviews with company personnel, including the quality control department, employees, and operators in the Smart Card department at PT XYZ.
b. Interview
   The interviews conducted are structured interviews involving asking questions to the informants by the interview guidelines that have been prepared to obtain information in the form of data and facts.
c. Documentation
   The required documentation data for the researcher are related to the business process, including the sequence of Telco production, types of defects in Telco products, causes of product defects, and production data for Telco products during the period of August to September 2022. The obtained data will undergo data processing using the Failure Mode and Effect Analysis (FMEA) method and the Kaizen approach to identify the most high-risk causes. This process aims to generate the best alternative solutions while considering the investment feasibility for the company's future.
   In the research carried out, the data used is data on defective or defective products on Telco products for the period August – September 2022. In the data on defective or defective products on Telco products, there is information in the form of defect types, the number of good products and defective or rejected products, total product inspection, and product percentage is good. Based on the data collected, the data will be collected based on the type of reject that occurs, so that we can find out the type of reject with the most dominant frequency or occurs frequently. The following is a recapitulation of data on reports of defective products or defects in Telco products found in the period August – September 2022 (Table 1):

Table 1. Data Defect of Telco Products August - September 2022

No	Defect	Frequency
1	*Printing*	9913
2	*Misscut*	1129
3	*Scratch*	546
4	*Peel Off*	982
5	*Bad Implant*	2288
6	*Bad Punch*	124
7	*Bubble Chip*	102
8	*Bad Milling*	416
9	*Bad Welding*	80
10	*Chip* Luka	416
11	*Card Body* Tanpa *Chip* (2 sisi)	2124
12	*Card Body* Tanpa *Chip* (1 sisi)	5227
13	*Card Body*	2154
14	ATR Mati	6972
15	*Material*	508
16	*Chip Material*	87
17	*Machine Jam*	55
18	Laser	5
TOTAL		**33128**

Based on the data recapitulation above, it can be seen that in the period August – September 2022, Telco product production in the Smart Card department at PT XYZ had 18 types of failure with a total of 33,128 defective products.

5. Results and Discussion

5.1 Pareto Diagram

The creation of a Pareto diagram was conducted to determine the most frequently encountered failure priorities. Below is a recapitulation of the defect percentages in Telco products for the period of August to September 2022:

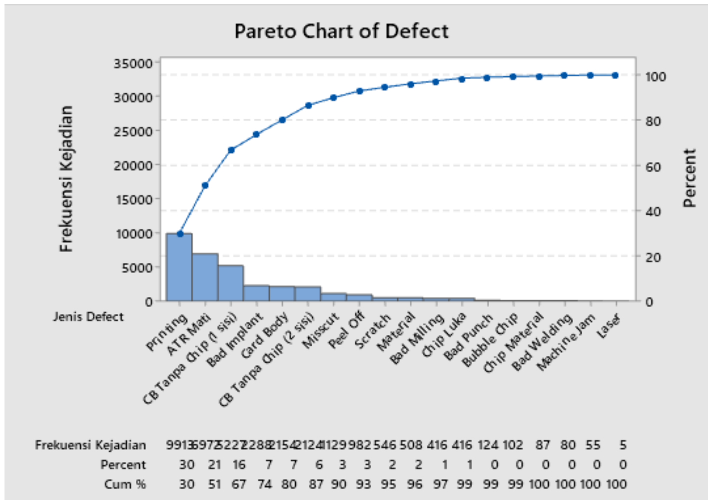

Figure 1. Pareto Diagram of Defects in Telco Products for August - September 2022

Based on the Pareto diagram (Figure 1) above, it is evident that the largest defects contribute to the cumulative percentage of 80%. The main defective products include printing with a defect percentage of 29.92%, ATR dead with a defect percentage of 21.05%, one-sided card body without a chip with a defect percentage of 15.78%, and bad implants with a defect percentage of 6.91%. Therefore, the focus of improvement efforts can be directed towards these top five causes, namely printing, ATR dead, one-sided card body without a chip, and bad implant.

5.2 Calculation of Risk Priority Number (RPN) Using the Failure Mode and Effect Analysis (FMEA) Method

This method aims to identify which causal factors pose the highest risk, indicated by the highest Risk Priority Number (RPN) values. Defect types with the highest risk will be analyzed to find their root causes. Below is the calculation of the Risk Priority Number (RPN):

The Risk Priority Number (RPN) (Table 2) value for the failure mode of suboptimal machine settings is 120. From the calculation above, it can be concluded that 'bad implant' is the most high-risk defect in the production of Telco products because it has an RPN value above 100, categorizing it as critical (RPN>100) and requiring immediate corrective action.

Table 2. Risk Priority Number (RPN)

***Risk Priority Number* (RPN)**							
Process	**Failure Mode**	**Potential Failure**	**Severity (S)**	**Causes of Potential Failure**	**Occurrence (O)**	**Detection (D)**	**RPN**
Telco Product Production	Operators pay less attention to work process provisions	Reject Printing	9	There is no clear SOP regarding the production process	7	1	63
	Machine settings are not optimal	Bad Implant	8	Lack of operator accuracy	5	3	120
	Failure in the previous process	Card Body Without Chip (1 side)	5	Chip is not in good condition (black hole, broken)	9	1	45
	Chip quality is not good	ATR Mati	9	Less selective in vendor selection	2	3	54

5.3 Kaizen Approach

The Kaizen approach, which includes the 5W+1H (What, Why, Where, When, Who, and How) and the Kaizen Five-Step Plan or 5S (Seiri, Seiso, Seiton, Seiketsu, and Shitsuke), is implemented to propose improvements aimed at achieving optimal product quality.

5.3.1 The 5W+1H Concept

The 5W+1H concept is applied to prioritize defect types based on the Risk Priority Number (RPN) data processing results. Based on the data processing conducted earlier, proposed improvement solutions can be analyzed for factors influencing suboptimal machine settings. The following Table 3 presents the proposed improvement concepts:

Table 3. Improvement Concepts Based on the 5W+1H Concept

Common Causal Factors	5W + 1H	Description	Action
Machine settings are not optimal	*What*	What is the purpose of the improvements made?	Produce optimal quality products and minimize the level of product defects in accordance with company and consumer expectations
	Why	Why are improvements being made?	Because machine settings that are less than optimal are the main factors that greatly influence production results
	Where	Where will the improvements plan be carried out?	Improvements were made to the Smart Card department, especially in the milling embedding process
	When	When will the improvements be carried out?	Repairs are carried out regularly and continuously, so it is hoped that operators will pay more attention to the initial settings on the machine when it is to be used and maintain skills and accuracy in carrying out their duties.
	Who	Who plays a role in implementing improvements?	All operators are under the supervision of the quality control leader and operator coordinator
	How	How will the countermeasures and improvements be implemented?	Routine machine maintenance (e.g: 1 month, twice at the beginning and end of the month) and making a replacement schedule or holding stock of spare parts before they are damaged considering that the ordering time for spare parts is quite long
			Review and improve work regulations or SOPs
			Increase supervision on the production line and motivate workers to improve the quality of their work

5.3.1 The Kaizen Five-Step Concept (5S)

The Kaizen Five-Step Plan or 5S concept is employed to create a conducive work environment for improvement and instill quality awareness.

An assessment using the Kaizen Five-Step Plan or 5S approach aims to evaluate the values of various aspects within PT XYZ, particularly in the Smart Card department. The evaluation of the Kaizen Five-Step Plan or 5S checklist is based on interviews with employees and operators in the Smart Card department at PT XYZ. The values range from 1 to 5, where 1 signifies very poor, 2 signifies poor, 3 signifies fair, 4 signifies good, and 5 signifies excellent. The following are the results of the Kaizen Five-Step Plan or 5S checklist:
From the assessment above, it is evident that in the Seiri (Sort) and Seiso (Shine) factors, the values are still below 3. Both of these factors are subject to analysis and can be used as improvement proposals for the company. The following are proposed improvements to be considered for future enhancements (Table 4):

Table 4. Improvement Concepts Based on the 5S Concept

Factor	Impact	Improvements
Seiri	Operators find it difficult to find items to use	a. Providing special boxes for each type of equipment
	Work space and movements are disrupted	b. Providing shelves as a place to store operator goods in the workplace
	The quality of materials and goods is not guaranteed	c. Selection of items between those that are needed and those that are not needed so that there is no accumulation in the work area
Seiso	Uncomfortable work environment	a. Carry out cleaning 5 minutes before and after work, both in the production and sorting processes
	Damage to work equipment	b. Providing special waste bags for sorting rejected products
	Reduce productivity	c. Cleaning the work area is carried out by special personnel, not only the responsibility of the operator concerned

5.4 Improvement Design

Based on the data processing conducted, it was found that the Seiri (Sort) and Seiso (Shine) factors are the primary areas requiring immediate action. Through direct observation and interviews with employees and operators at PT XYZ, it is evident that there is an urgency for the company to provide special boxes and shelves for storing equipment in the workplace, particularly in the quality control department. Below is the proposed improvement design (Figure 2):

Figure 2. Improvement Design

5.5 Investment Feasibility of Improvement Proposal

a. Production Cost

In designing the improvement proposal, cost assumptions for producing the boxes and shelves are necessary. The following are the production costs used in the creation of boxes and shelves (Table 5).

Table 5. Production Cost

No	Details	Qty	Unit	Price	Total
1	Wooden	4	board	Rp 550.000	Rp 2.200.000
2	Iron	2	pcs	Rp 30.000	Rp 60.000
3	Nail	0,5	kg	Rp 25.000	Rp 12.500
4	Plywood	2	pcs	Rp 50.000	Rp 100.000
5	Sandpaper	1	roll	Rp 30.000	Rp 30.000
6	Woodstain	2	set	Rp 58.000	Rp 116.000
	Total Variable Cost				**Rp 2.518.500**
1	Saw	1	pcs	Rp 30.000	Rp 30.000
2	Hammer	1	pcs	Rp 25.000	Rp 25.000
3	Drill	1	pcs	Rp 300.000	Rp 300.000
	Total Equipment				**Rp 355.000**
1	Labor	1	person	Rp 300.000	Rp 300.000
	Total BTKL				
1	Electricity	1	pcs	Rp 400.000	Rp 400.000
2	Salary	2	person	Rp 450.000	Rp 900.000
	Total BOP				**Rp 1.300.000**
	Total Production Cost				**Rp 4.418.500**

b. Initial Balance

The initial balance is used to indicate a part of the financial statement containing information about assets, liabilities, and equity. Below is the initial balance used to assess the investment feasibility of the improvement proposal (Table 6).

Table 6. Initial Balance

Initial Balance			
Cash			Rp 1.745.000
Equipment			Rp 2.518.500
Tools			Rp 355.000
Tools Assests			Rp 4.618.500
Liability Fees			
Modal			Rp 4.418.500
Total Liabilities			Rp 4.418.500

c. Company Cashflow
The company's cash flow for 5 years with a discount rate of 10% is as follows (Table 7):

Table 7. Cashflow

Year	**Cashflow**
0	-Rp 4.418.500
1	3.000.000,00
2	2.500.000,00
3	4.500.000,00
4	2.000.000,00
5	3.500.000,00

Additionally, the cash flow diagram for the investment proposal over 5 years is as follows (Figure 3).

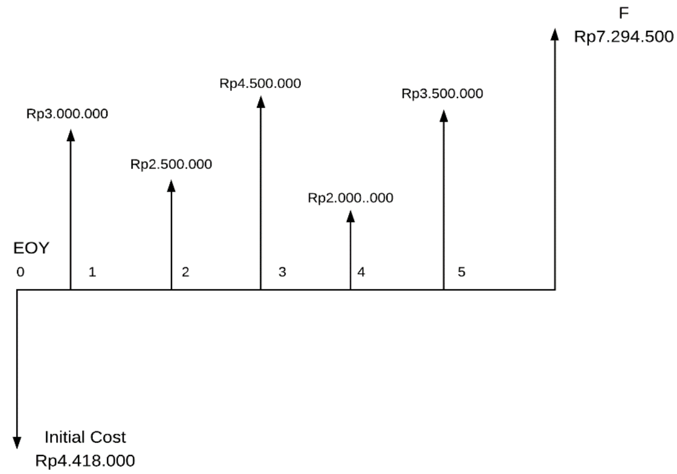

Figure 3. Cashflow Diagram

d. Net Present Value (NPV)
From the cashflow calculations performed earlier and the Present Value (PV) values obtained from the PVIFA Table 8 with a discount factor of 10%, the NPV of the improvement proposal, including boxes and shelves, is as follows.
It is known that the NPV of the investment proposal is positive, indicating that the proposed improvement will be profitable for the company in the future.

Table 8. Net Present Value (NPV)

Year	**Cashflow**	**PV 10%**	**Present Value**
0	-Rp 4.418.500	1	-Rp 4.418.500
1	3.000.000,00	0,9090	Rp 2.727.000
2	2.500.000,00	0,8264	Rp 2.066.000
3	4.500.000,00	0,7513	Rp 3.380.850
4	2.000.000,00	0,6830	Rp 1.366.000
5	3.500.000,00	0,6209	Rp 2.173.150
Total PV's			Rp 11.713.000
Initial Investment			Rp 4.418.500
NPV			Rp 7.294.500

e. Internal Rate of Return (IRR)
The Internal Rate of Return (IRR) calculation is used to determine the efficiency level of an investment. Below is the IRR for the improvement proposal.
It is known that the IRR of the investment proposal is acceptable because it yields a rate of 63%, which is higher than the discount rate (10%) (Table 9).

Table 9. Internal Rate of Return (IRR)

Year	Cashflow		PV 10%	Present Value	
0	-Rp	4.418.500	1	-Rp	4.418.500
1	Rp	3.000.000	0,9090	Rp	2.727.000
2	Rp	2.500.000	0,8264	Rp	2.066.000
3	Rp	4.500.000	0,7513	Rp	3.380.850
4	Rp	2.000.000	0,6830	Rp	1.366.000
5	Rp	3.500.000	0,6209	Rp	2.173.150
Total PVs				Rp	11.713.000
Initial investment				Rp	4.418.500
NPV				Rp	7.294.500
IRR				63%	

f. Payback Period (PP)
The payback period calculation is used to determine the time it takes to recover the capital invested in the improvement proposal. Below is the payback period calculation for the improvement proposal (Table 10).

Table 10. Payback Period (PP)

Year	Cashflow		PV 10%	Present Value	
0	-Rp	4.418.500	1	-Rp	4.418.500
1	Rp	3.000.000	0,9090	Rp	2.727.000
2	Rp	2.500.000	0,8264	Rp	2.066.000
3	Rp	4.500.000	0,7513	Rp	3.380.850
4	Rp	2.000.000	0,6830	Rp	1.366.000
5	Rp	3.500.000	0,6209	Rp	2.173.150
Total PVs				Rp	11.713.000
Initial investment				Rp	4.418.500
NPV				Rp	7.294.500
IRR				63%	
Payback Period				2,47	

So, the payback period for the investment of design improvements is 2.5 years.

6. Conclusion

The conclusions drawn from the research conducted at PT XYZ are as follows:

1. During the production process of Telco products in the period of August to September 2022, four dominant defects were identified in the Smart Card department at PT XYZ. These defects include 9,931 reject printings, 6,972 ATR dead units, 5,227 one-sided card bodies without a chip, and 2,288 bad implants.
2. The most influential failure mode causing defects in the most dominant Telco product in the Smart Card department at PT XYZ, with the highest Risk Priority Number (RPN), is the suboptimal machine setting failure mode. This is caused by the potential failure factor of operator precision. The calculated Risk Priority Number (RPN) based on an interview with the quality control leader is 120 RPN.
3. Proposed suggestions for consideration include providing shelves for storing operator equipment in the workspace, distinguishing between necessary and unnecessary items to prevent clutter in the workspace, allocating specific boxes for different types of equipment, particularly in the sorting or quality control area, conducting a 5-minute cleaning before and after work processes, providing dedicated bags for disposing of rejected products in the sorting area, and assigning specialized personnel for workspace cleaning, not solely relying on operators or related workers.
4. The improvement proposal is considered feasible and implementable by PT XYZ. This conclusion is based on the positive NPV, indicating that the investment in the improvement proposal is acceptable. The IRR is above the discount rate, further supporting the feasibility of the improvement proposal. The payback period for the

investment is estimated to be 2.5 years, investing in adding boxes and shelves to reduce product defects at PT XYZ worthwhile as it will provide benefits to the company in the future.

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