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Analysis Of Metallize Product Quality Control Using The Plan Do Check Action (PDCA) Methods at PT. Polyplex Films Indonesia

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Abstract. PT. Polyplex Films Indonesia is a manufacturer of Metallize Film products. This polymer film is coated with a tiny aluminum foil coating, giving it a bright metallic appearance. Metalized film materials have extensive use in decoration, food packaging, and specialized uses, including insulation and electronics. The production results of metalized film production show that in the most recent year, 2022, the number of defects was 1.6%, which is higher than the tolerance limit the company set at 0.5% of total annual production. Maintaining the consistency of the quality of the metalized film products that the company produces is much easier. The number of defects settled by the different types: Heat line accounts for 42% of the defects, pinhole accounts for 31%, and Star sky accounts for 27%. The company employs the PDCA method to mitigate issues in the production line. The implementation results demonstrate that the PDCA method has led to a reduction in the number of defects. Specifically, the Heat Line defects decreased from 274 tons to 57 tons, representing a decrease of 79.19%. Similarly, the Star Sky defects decreased from 178 tons to 85 tons, resulting in a reduction of 52%. The pinhole defects decreased from 202 to 51 tons, indicating a 74.8% decrease. The findings of this study should deepen our understanding of how the PDCA technique actually works to enhance product quality. This is because the changes are produced during the action phase, allowing for long-term retention of the gains. Product recommendations for additional investigation include PET (polyethylene terephthalate), BOPP (bi-axially oriented polypropylene), and CPP (cast polypropylene) films.

Keywords: Metallize Film, Defect, Product Quality, PDCA

1. INTRODUCTION

The company, PT Polyplex Films Indonesia, manufactures metalized film products. The product in question is a polymer film coated with a thin layer of aluminum foil with a metallic sheen. Metallic film is utilized extensively for various purposes, including but not limited to decorations, food packaging, and specialized applications such as insulation and electronics.

The potential for Metallize Film products to be highly popular with customers motivates PT. Polyplex Films Indonesia will keep striving for product excellence. Businesses are encouraged to produce quality products consistently because of consumers' high demand for metalized film products.

The reality, however, is that the product of the desired quality is more complex to manufacture. According to accurate data, there is still a high incidence of product defects

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in metalized films (MMT52CI). The significant incidence of product defects is evident from January to December 2022, where out of a total production of 39,866 tons, there were 654 tons of defective products. Indicates that the proportion of product defects in total annual production is 1.6%. However, heat lines, star sky, and pin holes were responsible for 1.6% of product defects, surpassing the company's tolerance limit of 0.5% for defects in annual production. In response to the defect values surpassing the designated tolerance limits, the company implemented the PDCA (Plan–Do–Check–Action) method as part of its corrective measures.

2. METHODS

The PDCA (Plan–Do–Check–Action) method uses continuous, iterative Continuous Process Improvement. The process comprises three distinct stages [3]:

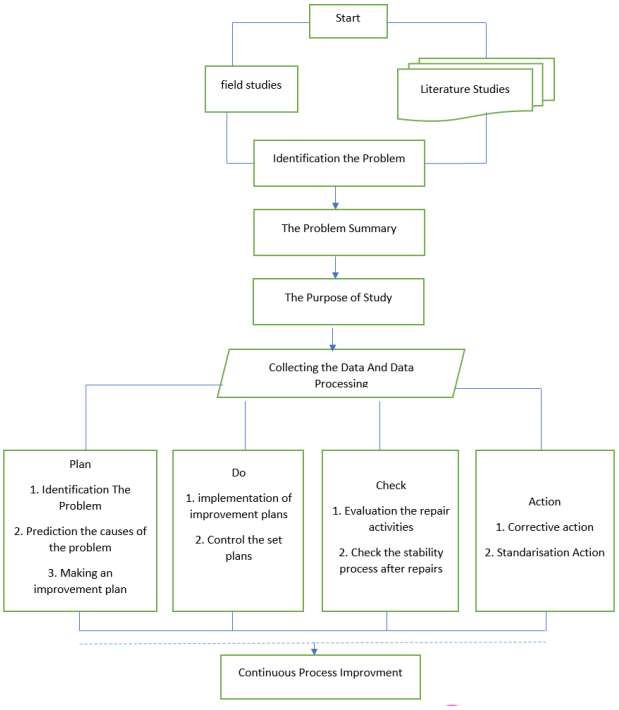

Figure 1. Research Flow Chart

a. The plans involve identifying the root cause of product defects and establishing quality standards for Metallize Film products.
b. *Do* implementation activities and controlling plans set in stages to align with achievement targets?
c. *Check* is the activity of checking, controlling, and researching the results of achievements by comparing the conditions before and after to determine whether they are by predetermined standards.

d. *Action* is carrying out necessary adjustment actions due to the check stage. The corrective action, which is a solution to the settled problem, and the standardization action, which is a standardized method are included in this action.
e. Standardizing product standards is essential for several reasons, one is guaranteeing that improvements can be sustainably implemented over time.

The already completed levels will lead to a standardization of product quality, which will be established continuously throughout the company.

3. RESULTS and DISCUSSION

To address the issues, PT Polyplex Films Indonesia implemented the PDCA method. To ensure that the manufactured products are of consistent quality, the PDCA method is currently being implemented at PT Polyplex Films Indonesia to resolve any defects that may manifest themselves by 2022. The total number of defects has reached one point six percent of the total annual production. The procedures listed below have to put the PDCA method into practice:

A. Plan Stages

Plans were carried out to identify quality problems in the product, and the data collection results from January 2022 to December 2022 on metalize production (MMT52CI) reveal that this product has three product defects.

Table 1. Metallize Production Data (MMT52CI)

2022 period	**Production Amount (Tons)**	**Production Defect Data (Tons)**			**Number of Defective Products (Tons)**	**Percentage (%)**
		Heat-Line	***Star Sky***	***Pin Holes***		
January	3100	14	10	2	26	0.8
February	2563	12	8	10	30	1,2
March	3114	18	11	14	43	1.4
April	3594	40	20	16	76	2.1
May	3373	19	13	16	48	1.4
June	3234	20	2	18	40	1,2
July	3475	28	16	18	62	1.8
August	3528	24	19	32	75	2.1

September	3298	7	28	16	51	1.5
October	3413	28	16	18	62	1.8
November	3561	30	17	19	66	1.9
December	3613	34	18	23	75	2.1
Total	39866	274	178	202	654	1.6

Source: PT Polyplex Films Indonesia, 2023

According to the data in Table 1, the most prevalent defect is the heat line, with 274 tons affected. The Pareto diagram is employed as a measurement tool to identify the most influential defects during production.

Based on the data in Table 1, the Pareto diagram drawing is as follows:

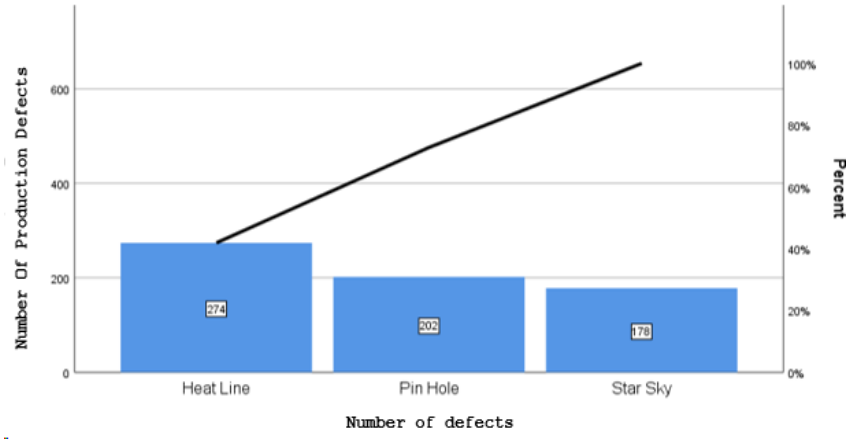

Figure 2. Pareto diagram.

Source: Processed data, 2023

Table 1 analyzes the data using a check sheet during the Plan Stage. Total defects accounted for 1.6% of the total annual production, exceeding the company's tolerance limit of 0.5%. The deviation from the company's tolerance limit is 1.1%, three times the specified limit.

Since the effect of waste increases as the number of defects exceeds the target set, this issue will influence product quality, affecting costs/prices, efficiency, competitiveness, and consumer satisfaction.

The fewer defects produced in production, the higher the product quality made and the less waste occurs, which will also increase competitiveness. Effectiveness, productivity, profitability, and sustainability of company systems. [5,16]

According to the findings, defects such as heat line (42%), pinhole (31%), and star sky (27%), which contributed to 1.6% of the defective products produced from a

total production of 39,866 tons per year, were responsible for the production of faulty products. Look at Figure 1 of the Pareto diagram and apply the solution based on the principle. It can represent all types of defects where the cumulative defects are visible. These include heat line defects, which account for 42% (274 tons), and pinholes, which account for 31% (202 tons). The company can prioritize these two categories of flaws to handle the problem so that the impact can reduce the number of issues already present and improve the quality of the products made from metalized films.

Using the Pareto diagram, you can determine and sort the cumulative frequency percentage from the highest problem to the lowest and prioritize the issues that occur. Pareto analysis is applied to identify essential successes in resolving issues based on the dominant levels influencing a product's quality.

B. Stages Do

This step quantifies the type of error that occurs when using the control map. Control charts graphically show existing product quality. Quality attributes of errors are measured on this control map. Using a control chart is one way to determine if production is under control. Production was not under control if data exceeded the limit.

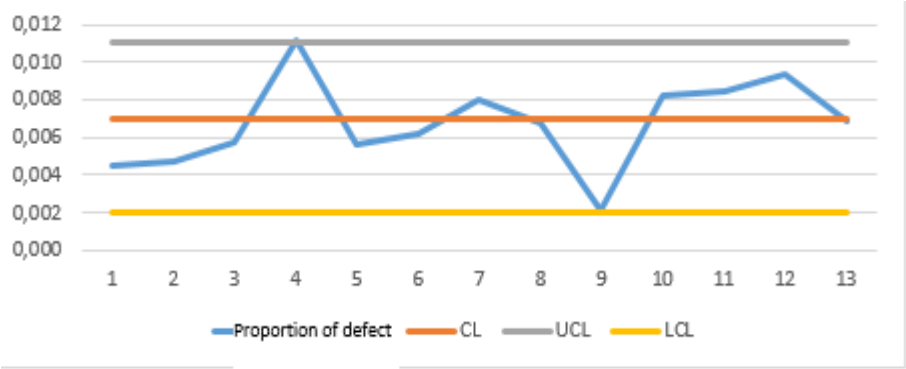

Figure 3 Control Chart-p Heat-Line.

Source: Processed data, 2023

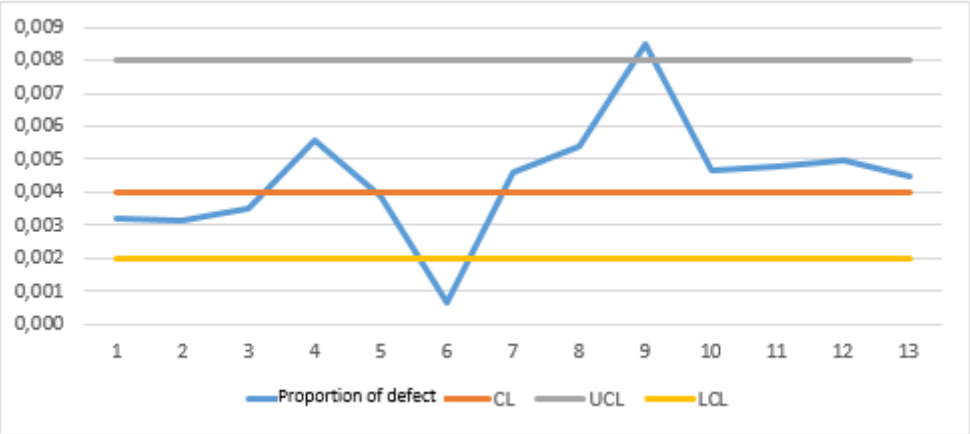

Figure 4. Control Chart-p Star Sky.

Source: Processed data, 2023

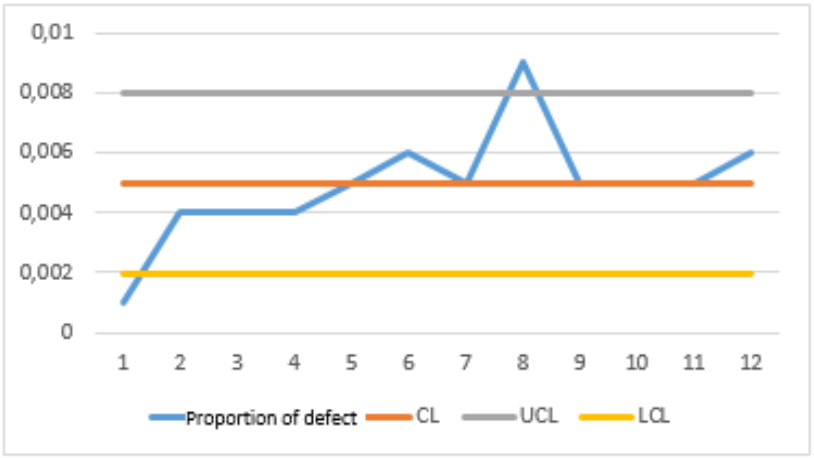

Figure 5. Control Chart-p Pin Hole.

Source: Processed data, 2023

In the Do stage, using control chart analysis, there are three variable types: pinhole, star sky, and heat line defects. Companies can take action to handle the three types of defects that occur by first analyzing whether there is a correlation between the three types of defects. The proportion of heat line defects is still within the upper and lower control limits. In contrast to the kind of Star Sky defects in the last period, two months, the lower control limit in the 6th month and the upper control limit in the 9th month. According to the research that month, the issue started when the wire component machine became stuck, producing faulty goods. Despite being mixed with new material, the material used had already passed its expiration date. The reason for this

action is that the material in the warehouse currently needs to be made available due to the purchasing department's tardy reordering of the material.

Meanwhile, pinhole defects exceed the upper control limit in the 8th month and the lower control limit in the 1st month. Because the vacuum coating machine is damaged, the coating layer must come ideally, and the function of a vacuum machine is to coat and add a thin layer of aluminum. This process failed because the vacuum chamber pressure did not function below or above 0.0005 mbar. In this machine room, the aluminum wire becomes the feed material entering the evaporator, changing the liquid phase that evaporates between the heated metal with resistance. In this process, the flexible substrate also goes through a cooling process through an evaporation source at a speed of 1000 m/min, and the aluminum vapor condenses onto the substrate, creating a coating layer.

By using a control chart, you can monitor and control, anticipate preventive actions before they have a fatal impact on product quality, and, at the same time, set standards. [8,10]. Control charts can also show whether there is a correlation between the variables of the type of product defects that occur, and knowing if value > 0.2 and p-value < 0.05 means there is a correlation between variables [9.11].

C. Check Stages

A *check* stage comes to determine the primary reason for the issue. The image of a fishbone diagram makes it possible to explain the factors that led to a product's failure.

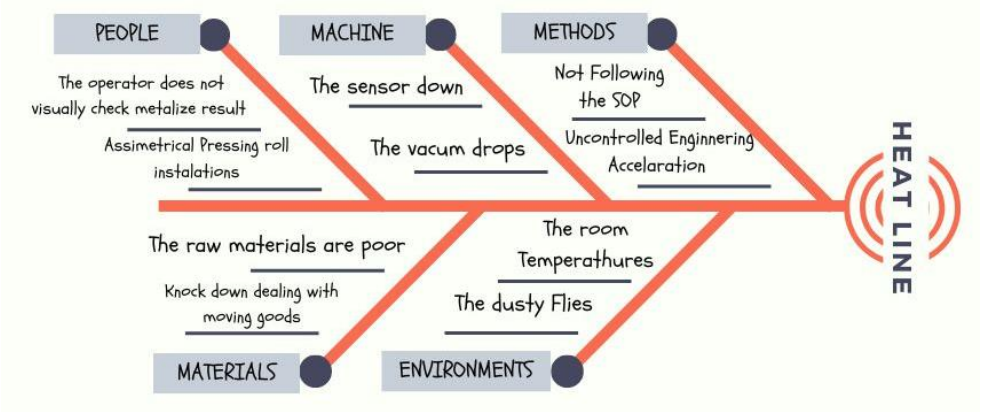

Figure 6. Heat Line Cause and Effect Diagram.

Source: Processed data, 2023

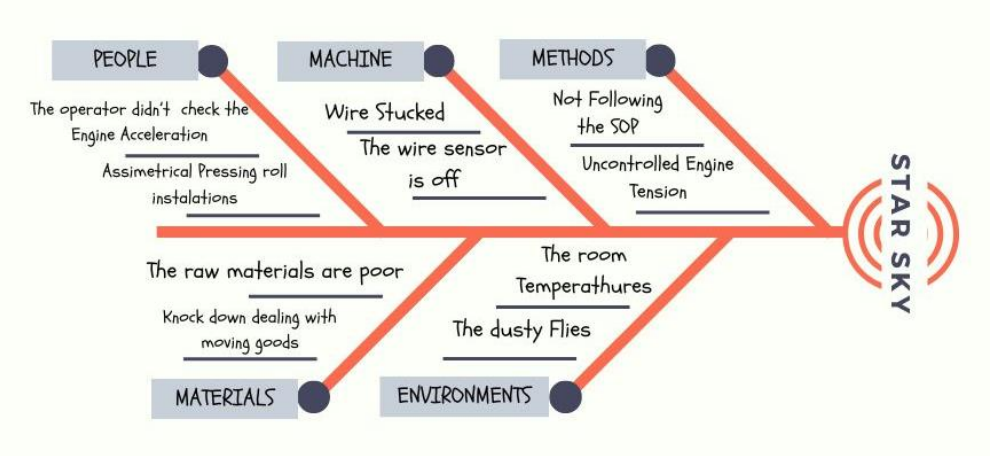

Figure 7. Star Sky Cause and Effect Diagram.

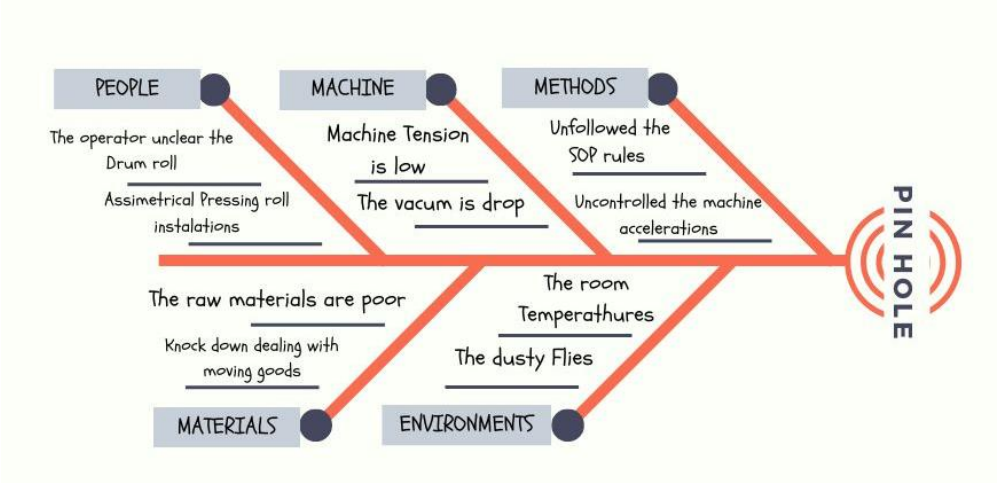

Figure 8. Pin Hole Cause and Effect Diagram.

In this check, we used a fishbone diagram to identify the issue's origin; by analyzing the resulting picture, we determined what went wrong with the product.

Following an investigation into the source of the issue using a fish bone, as shown in Figure 6, the type of heat line defect was 42%. Several factors contributed to this outcome, including human factors, such as the installation of asymmetrical pressing rolls; machine factors, such as the sensor being turned off; method factors, such as the operator not following standard operating procedures; material factors, such as the poor quality of raw materials, and environmental factors, such as flying dust. It is possible to solve this issue by taking the following steps: providing training, performing routine machine maintenance, ensuring that operators adhere to the standard operating

procedures (SOPs), inspecting materials that are purchased before their use, and cleaning the production area before the production process begins.

The 27% star sky defect type is shown in Figure 7. It is influenced by machine factors, namely jammed wires, resulting in production results not being optimal, human factors, operator negligence in working, and material factors that use quality raw materials that do not meet standards. The maintenance section carries out regular maintenance, gives a warning or sanction to the operator directly, cross-checks all materials before use, and returns the materials to the supplier. For this type of pinhole defect, it is 31%, in Figure 8.

The most common causes of defects are the vacuum machine falling and the human factor installing the pressing roll asymmetrically. Both of these cause defects. To solve this problem, and to provide operator training and perform routine maintenance on the scheduling of machines.

D. Action Stages

In the action stage, quality control results prevent the recurrence of the same problem and minimize the number of failures in the future by setting standards for the company after improvement [13]. Manufacturing process standardization is a periodic improvement action to overcome/prevent problems with products' metalized films. Work standards are created based on the results of the inspection phase evaluation, where work standardization is determined.

The results of the improvements are measured to determine the level of success and outcomes of the improvements made. Based on this, the percentage of defects that existed before and after the repair is complete, and the action outlined here is to improve the production process by utilizing the 5W+1H design.

Table 2. 5W + 1H Analysis of Heat-Line Defects

No	Defects that occur	The root of the problem		what	Why	Where	When	Who	How
		Causative factor	the causing Factors matter	(what happened)	(why needs improvement)	(where needs to be fixed)	(when should it be repaired)	(who will do the repairs)	(how to fix)
1.	Heat line	Man	Asymmetrical pressing roll	The work results are less	operators focus on work	Operator	Before further damage occurs	SPV	Provide training to

			installations	than optimal					employees
		Machine	Sensor is off	Product results are not optimal	get a good product	Machine	Before further damage occurs	Maintenance	Carry out regular maintenance
		Method	Not following SOPs	Product results are not optimal	get products that comply with SOP	Method	Before getting a product that does not abide by the SOP,	SPV	Ensure operators follow SOPs
		Material	The quality of raw materials is poor	Materials do not comply with SOP	To get the desired product	Material	Before the occurrence of raw materials that are not SOP	Quality control	Carry out inspections of purchased materials
		Environment	The Dust flies	Product results are not optimal	To get a good product	Environment	Before, the atmosphere was dirty	Operator	Clean the environment before carrying out the production process

Source: Processed data, 2023

Table 3. Analysis of 5W + 1H on Star Sky Defects

No	Defects that occur	The root of the problem		what	Why	Where	When	Who	How
		Causative factor	Factors causing its occurrence	(what happened)	(why needs improvement)	(where needs to be fixed)	(when should it be repaired)	(who will do the repairs)	(how to fix)
1.	Star sky	Man	Not focused on work	The work results are less than optimal	The operators concentrate on work	Operator	Before further damage occurs	SPV	Give a warning to the operator directly
		Machine	Wire Stucked	Product results are not optimal	To get a good product	Machine	Before further damage occurs	Maintenance	Carry out regular maintenance
		Method	Not following SOPs	Product results are not optimal	To get products that comply with SOP	Method	Before getting a product that does not abide by the SOP,	SPV	Ensure operators follow SOPs

		Material	The quality of raw materials is poor	Materials do not comply with SOP	To get the desired product	Material	Before the occurrence of raw materials that are not SOP	Quality control	Carry out inspections of purchased materials
		Environment	The Dust flies	Product results are not optimal	To get a good product	Environment	Before, the atmosphere was dirty	Operator	Clean the environment before carrying out the production process

Source: Processed data, 2023

Table 4 5W + 1H Analysis of Pin Hole Defects

No	Defects that occur	The root of the problem		what	Why	Where	When	Who	How
		Causative factor	Factors causing its occurrence	(what happened)	(why needs improvement)	(where needs to be fixed)	(when should it be repaired)	(who will do the repairs)	(how to fix)
1	Pin holes	Man	Asymmetrical pressing roll installations	The work results are less than optimal	operators focus on work	Operator	Before further damage occurs	SPV	Give training
		Machine	Vacuum drop	Product results are not optimal	To get a good product	Machine	Before further damage occurs	Maintenance	Carry out regular maintenance
		Method	Not following SOPs	Product results are not optimal	To get products that comply with SOP	Method	Before getting a product that does not abide by the SOP,	SPV	Ensure operators follow SOPs
		Material	The quality of raw materials is not good	Materials do not comply with SOP	To get the desired product	Material	Before the occurrence of raw materials that are not SOP	Quality control	Carry out inspections of purchased materials
		Environment	The Dust flies	Product results are not optimal	To get a good product	Environment	Before, the atmosphere was dirty	Operator	Clean the environment before carrying out the production process

Table 5. Implementation of PDCA to reduce the number of product defects

No	Factor	Corrective action
1	The pressing roll installation is not symmetrical	– Conduct training for operators regarding pressing roll installation. – Providing rewards as company appreciation to employees to encourage them to work enthusiastically.

2	Sensor is off	– Carry out preventive maintenance to keep the machine running as it should – Replace spare parts with quality ones so they don't break down quickly
3	Not following SOPs	Ensure operators/employees follow applicable Standard Operating Procedures.
4	The quality of raw materials is not good	– Inspect raw materials when they arrive at the warehouse – Separate raw materials that meet standards from those that are rejected
5	Dust flies	Clean the work area before and after work so that dust and dirt do not stick to the product.

Source: Processed data, 2023

Table 6. Number of Defects Before and After Repair (Tons)

No	Type of Defect	Number of Defects before repair (tons)	Number of defects after repair (tons)	% Difference
1	Heat-Line	274	57	79.19 %
2	Star Sky	178	85	52%
3	Pin Holes	202	51	74.8%
Total		654	193	

Table 7. PDCA Implementation Results

No	Type of Defect	Product **before repair**	Product **after repair**
1	Heat line		
2	Pin holes		

3	Star Sky		

4. CONCLUSION

As a result of the processing and analysis of the data that carries, the following are some of the conclusions from the findings:

a. The high number of defects, 1.6%, is higher than the tolerance limit established by the company, which is one percent of the total annual production. The number of different types of defects is added up. The handicap for the heat line is 42%, the handicap for the pinhole is 31%, and the handicap for the star sky is 27%.

b. The implementation of the PDCA method has the potential to reduce the number of defects in the Heat Line from 274 tons to 57 tons with a percentage of 79.19%, the number of defects in the Star Sky from all 178 tons to 85 tons with a percentage of 52%, and the number of defects in the Pin Hole from 202 tons to 51 tons with a percentage of 74.8 percent. The PDCA method can reduce the number of defects by seventy percent, as demonstrated by the implementation results, which show that the method is exceptional overall.

c. Businesses should implement this method for quality issues not only for Metallized Film products, such as PET (Polyethylene Terephthalate) films, BOPP (Biaxially Oriented Polypropylene) Films, and CPP (Cast Polypropylene) Films, but also for other types of films.

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