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Quality Control of Paint Tube Products Using Six Sigma and FMEA Methods

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Abstract

PT XYZ is facingproduct quality challenges, especially visual defects in 25 kg pail tubes such as unmold tubes, jetting tubes, and IML on overlapping tubes with unmold tubes reached 55%. This study aims to analyze the main causes of defects in paint tube products at PT XYZ. The methods used are Six Sigma and FMEA with secondary data from the type of 25 kg tube defects in the last 3 months, involving 15 samples with 3 types of defects. The results show that material, mold, machine, and human factors contribute to defects. The Six Sigma value is 3.36, which is below standard. Recommendations for quality improvement are given to reduce the defect rate, with the highest RPN being 240 for unmold tubes.

Introduction

In the era of globalization and increasingly tight market competition, product quality is one of the main factors that determine the success of a company. In manufacturing companies, product quality control aims to achieve optimal productivity in product quality so that it can achieve the target production quality standards optimally. In the research on product quality control methods carried out, researchers chose a manufacturing company with a continuous production process as the object of research (Sugiharto et al., 2023). Control and supervision aim to ensure that production and operations run according to plan, and allow for corrections if deviations occur in order to achieve the desired results. Quality control is an effort to maintain product quality to comply with the specifications set by company policy (Paulin et al., 2022; Tapiero, 2012; Qamar et al., 2024; Biazzo & Bernardi, 2003; World Health Organization, 2024).

PT XYZ is a manufacturing company engaged in the plastic packaging and printing sector.. This company produces plastic tube packaging for the paint, chemical, and food industries in various sizes and models. PT XYZ faces various challenges related to product quality, especially visual defects in 25 kg pail tubes such as unmold tubes, jetting tubes, and IML (In-Mould Labeling) on overlap tubes. This challenge poses a significant risk, because packaging products that do not meet quality standards can affect the performance of the final product used by customers (Safirin et al., 2023; Syamil et al., 2023). Factors that cause these visual defects include materials, molds, machines, and humans. If the company does not carry out strict quality control, this can lead to high levels of product defects and cost losses. Therefore, steps need to be taken to improve quality control by addressing, reducing, and suppressing the level of product defects. A quality control analysis is needed using the Six Sigma and

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FMEA (Failure Mode and Effect Analysis) methods to find out improvement solutions that can improve the quality of 25 kg pail tube products (Anggraini, 2021; Putri , 2019).

One method in quality control is Six Sigma. Six Sigma is a measurement method that uses statistical tools and techniques to reduce defects to no more than 3.4 DPMO (defects per million opportunities) or achieve a quality level of 99.99966 percent, with the main goal of meeting customer satisfaction. This approach is disciplined and follows the five stages of DMAIC (Define, Measure, Analyze, Improve, and Control). Identification of production defects consists of the define stage including plastic injection machines and IML (In Mold Labeling) robots (Dias et al., 2022; Zulfiqar et al., 2021). Analysis using the fishbone method and FMEA (Failure Mode and Effect Analysis) indicates the need for corrective action. It is hoped that with these corrective steps, the company can improve its performance and profitability (Usman & Nanang, 2021; Putra, 2023). FMEA is a method used to identify and analyze potential failures and their consequences, in order to prevent these failures from occurring (Hernanda & Winursito, 2024).

Methods

Six Sigma is an approach to improving business processes by identifying and reducing the causes of failure in production. This method aims to shorten process cycles and reduce costs, so as to better meet customer needs through increased productivity (Yusuf, 2019; Palange & Dhatrak, 2021). Data processing in this study uses secondary data, such as the number of defective products during production, derived directly from company records from June-July 2024 which have been obtained from the company which will then be processed and a Six Sigma analysis will be carried out. The steps of Six Sigma include:

Data analysis

The research uses the DMAIC stages (*Define, Measure*, *Analyze*, *Improve*, And*Control*) to solve problems and improve the quality of the production process.

Stage *Define*

It is the first operational step that sets targets and objectives for quality improvement and identifies product defects. The define step aims to identify factors that influence service quality in the research object (Ramadan et al., 2022). Defective products can affect the visual and functional of the product. If it happens continuously, it will affect customer satisfaction which can have a negative impact on the company's image. The most dominant defect criteria that occur during production at PT XYZ are:

Unmold Tube

Unmold tube occurs when the tube exit process on the machine experiences damage to the shape and the shape of the tube is not perfect. This can affect the visual and functionality of the product. If it occurs in

Jetting Tube

Jetting tube occurs when the tube exit process on the injection machine finds a pattern like a spray path on the surface of the product.

IML on Overlap Tube means that the stickers that are applied around the tube are not the same length. This unevenness can cause the label to look messy or uneven when applied to the Tube.

Measure Stage

The measure stage is the stage of determining critical to quality. *Critical to Quality*(CTQ) is a characteristic or attribute of a product or service that has a significant impact on satisfaction.

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At this stage, relevant data is collected to support the analysis of the process that is the main focus of the problem (Fitriana & Anisa, 2019). Thencalculate the sigma value, and the defect per million of opportunity (DPMO) value based on the conditions before implementation.

Defect Per Unit(DPU)

DPU = DPU = $\frac{\boldsymbol{Defect}}{\boldsymbol{Unit\ Produced}}$ (1)

Information:

DPU : Defect Per Unit (damage to each unit)

D :*Defect*(damage)

U : Unit (unit)

Total Opportunities (TOP)

TOP = U x CTQ
(2)

Information :

TOP : Total Opportunities (totalopportunity)

U :Unit (unit)

OP : Opportunities (opportunities)

***Defect Per Opportunity*(wanted)**

DPO =$\frac{\boldsymbol{Defect}}{\boldsymbol{TOP}}$ (3)

Information :

DPO :*Defect Per Opportunity*(damage every chance)

D : Defect (damage)

TOP : Total Opportunities (totalopportunity)

***Defects Per Million Opportunities*(DPMO)**

DPMO = DPO x 1,000,000 (4)

Sigma Level

Normsinv ((1,000,000 - DPMO)/1,000,000) + 1.5 (5)

(Ghiyats et al., 2020)

Analyze Stage

Analyze(analysis) is the third step in the Six Sigma quality improvement program using a U-chart and identifying problems and determining the cause of a problem using fishbone (Widyarto et al., 2019). Here is the formula for making a U-Chart

Ubar =$\frac{\boldsymbol{Total\ Defect}}{\boldsymbol{Total\ Number\ of\ Samples}}$ (6)

UCL = Ubar + 3 x $\sqrt{\frac{\boldsymbol{Ubar}}{\boldsymbol{Banyaknya\ sampel}}}$ (7)

LCL = Ubar- 3 x $\sqrt{\frac{\boldsymbol{Ubar}}{\boldsymbol{Number\ of\ Samples}}}$ (8)

Improve Stage

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At this stage, the FMEA method is used based on the analyze stage. The FMEA method is used by giving severity, occurrence and detection weighting to each cause of failure. FMEA calculations are carried out based on the RPN (risk priority number) weighting parameters.

Control Stage

At this stage is the last stage of the operation. At this stage, all procedures and results of quality improvement are documented as work standards. The goal is to prevent the same problems from recurring or the return of old, less efficient practices (Widiyawati & Assyahlafi, 2017).

Results and Discussion

The data used is secondary data, namely data on the type of 25 kg cylinder defects and the number of 25 kg cylinder products that experienced defects in the last 2 months, namely June and July, and has 15 sample data with 3 defects, namely Unmold Cylinders, IML on Overlap Cylinders, and Jetting Cylinders.

Data collection

Table 1. 25 Kg Tube Defect Data No. 10 VC TM

Date	Number of Samples	Unmold Pail Tube	Pail Jetting Tube	IML Movies Are Not the Same Length	Total Reject
6/1/2024	1890	13	51	40	104
6/2/2024	1930	61	0	0	61
6/3/2024	1340	50	30	0	80
6/6/2024	1290	15	30	31	76
6/7/2024	1570	13	40	0	53
6/8/2024	430	57	0	0	57
7/3/2024	1070	0	76	0	76
7/4/2024	320	0	70	0	70
7/10/2024	530	39	0	40	79
7/11/2024	650	80	0	0	80
7/12/2024	400	90	0	13	103
7/13/2024	110	85	0	0	85
7/14/2024	1810	7	80	0	87
7/15/2024	1870	69	0	0	69
7/17/2024	1880	55	0	25	80
Total	**17090**	**636**	**377**	**149**	1162

The data above is the defect data for 25 kg Pail Cylinder No. 10 VC TM. Because for August, 25 kg cylinder no. 10 was not produced, the sample data was only taken for 2 months, namely June and July and had 15 sample data with 3 defects, namely unmold cylinder, IML on Overlap Cylinder and jetting cylinder.

Define Stage

25 Kg Cylinder is a product of storage container for paint. The cylinder is made of PP (Polypropylene) material then processed in an injection machine with a special molding mold. When the cylinder has been processed on the injection machine, it often experiences problems such as unmold cylinder, jetting cylinder and IML on the Overlap cylinder. The 25 kg cylinder no. 10 which has the most defects is the 25 Kg Cylinder No. 10 VC TM.The purpose of this study is to apply the six sigma method to control the quality of the 25 kg No. 10 VC TM Cylinder product so that the company can improve the quality of its products and increase

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customer satisfaction.The solution to this problem can be overcome using the six sigma method.

Figure 1. Defect in Tube No. 10 VC TM

Measure Stage

The production volume of 25 kg no. 10 VC TM cylinders produced during June-July 2024 was 17,090 pails. From the production results, 1,162 pails of defective products were found, with details of 636 unmold cylinders, 377 jetting cylinders, and 149 IML on overlap cylinders.

Table 2. Classification of Defect Percentage of 25 Kg Cylinder No. 10 VC TM

Reject Type	Number of Rejects	Reject Percentage (%)	Cumulative Percentage (%)
Unmold Tube	635.98	55%	55%
Jetting Tube	377.00	32%	87%
IML on Overlap Tube	149.00	13%	100%
Total	**1162**	**100%**	

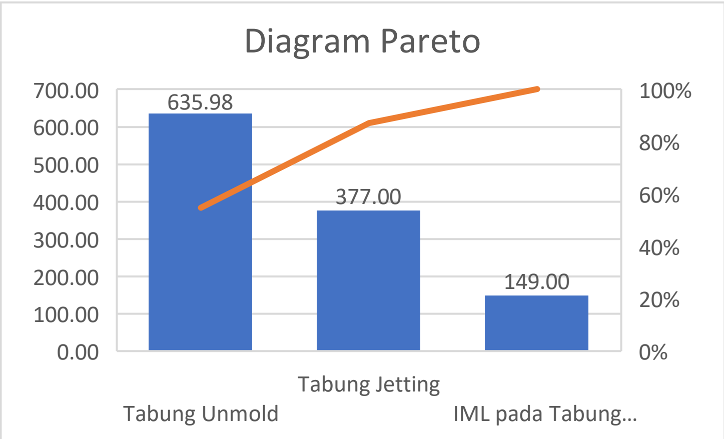

Figure 2. Pareto diagram based on defect type

Based on the Pareto diagram above, it can be seen that the highest number of non-conformities in the 25 kg no. 10 VC TM cylinder product is in the form of unmold cylinders with a percentage of 55%, followed by jetting cylinders with a percentage of 32% and IML on overlap cylinders with a percentage of 13%. Pareto analysis of the largest non-conformities in the 25 kg no. 10 VC TM cylinder comes from the unmold cylinder, reaching a percentage of 55%. The dominant defect is qualified as a CTQ that must be immediately corrected.

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Table 3. Classification of Defect Percentage of 25 Kg Cylinder No. 10 VC TM

CTQ	Criteria	Description
CTQ-1	Unmold Tube	Unmold tube occurs when the tube exit process on the injection machine experiences damage to the shape due to the hopper material running out and the cycle time process being too fast. So that the tube printing process on the mold is not optimal, resulting in an imperfect tube shape.
CTQ-2	Jetting Tube	Jetting tube occurs when the tube exit process on the injection machine finds a pattern like a spray path on the surface of the product caused by a poor gate position so that the material flow process entering through the gate is too far and causes a spray of material like wire.
CTQ-3	IML on Overlap Tube	IML on the overlapping tube occurs when the tube exits the IML machine, the IML sticker has a different length so that it displays an untidy and non-uniform visual.

Table 4. Calculation of DPU, TOP, DPO, DPMO, and Sigma Value (α)

Date	Number of Samples	Total Reject	CTQ	DPU	TOP	DPO	DPMO	SIX SIGMA
6/1/2024	1890	104	3	0.0548	5670	0.0183	18281.87	3.5906
6/2/2024	1930	61	3	0.0318	5790	0.0106	10586.33	3.8049
6/3/2024	1340	80	3	0.0597	4020	0.0199	19900.50	3.5558
6/6/2024	1290	76	3	0.0592	3870	0.0197	19747.57	3.5590
6/7/2024	1570	53	3	0.0337	4710	0.0112	11225.43	3.7827
6/8/2024	430	57	3	0.1335	1290	0.0445	44509.86	3.2006
7/3/2024	1070	76	3	0.0710	3210	0.0237	23676.01	3.4831
7/4/2024	320	70	3	0.2188	960	0.0729	72916.67	2.9544
7/10/2024	530	79	3	0.1498	1590	0.0499	49919.37	3.1456
7/11/2024	650	80	3	0.1231	1950	0.0410	41025.64	3.2389
7/12/2024	400	103	3	0.2575	1200	0.0858	85833.33	2.8669
7/13/2024	110	85	3	0.7770	330	0.2590	259013.21	2.1464
7/14/2024	1810	87	3	0.0482	5430	0.0161	16074.04	3.6426
7/15/2024	1870	69	3	0.0369	5610	0.0123	12292.61	3.7479
7/17/2024	1880	80	3	0.0427	5640	0.0142	14223.40	3.6911
Total	**17090**	**1162**					**46615.06**	**3.36**

From the calculation shows that the Six Sigma value above is 3.36 indicating the six sigma value is below the standard. It should be noted that the normal sigma value is above 3.4. This shows that the production process of 25 kg No. 10 VC TM Cylinder has not met the standard specification limits of the minimum six sigma value limit. This requires further improvement and taking a series of strategic steps to improve the quality of 25 kg No. 10 VC TM Cylinder.

Analyze Stage

At this stage, a U-Chart control chart is carried out which is useful for determining whether the production process of 25 kg no. 10 VC TM cylinders during June to July 2024 is under control or not. Based on the results of the measure stage, it is known that there are 1662 defective products originating from 3 defects, namely unmold cylinders, jetting cylinders and IML on overlap cylinders.

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Table 5. U Map Calculation

Date	Number of Samples	Total Defect	U	UCL	Ubar	LCL
6/1/2024	1890	104	0.055	0.086	0.0680	0.050
6/2/2024	1930	61	0.032	0.086	0.0680	0.050
6/3/2024	1340	80	0.060	0.089	0.0680	0.047
6/6/2024	1290	76	0.059	0.090	0.0680	0.046
6/7/2024	1570	53	0.034	0.088	0.0680	0.048
6/8/2024	430	57	0.134	0.106	0.0680	0.030
7/3/2024	1070	76	0.071	0.092	0.0680	0.044
7/4/2024	320	70	0.219	0.112	0.0680	0.024
7/10/2024	530	79	0.150	0.102	0.0680	0.034
7/11/2024	650	80	0.123	0.099	0.0680	0.037
7/12/2024	400	103	0.258	0.107	0.0680	0.029
7/13/2024	110	85	0.777	0.143	0.0680	-0.007
7/14/2024	1810	87	0.048	0.086	0.0680	0.050
7/15/2024	1870	69	0.037	0.086	0.0680	0.050
7/17/2024	1880	80	0.043	0.086	0.0680	0.050
TOTAL	**17090**	**1162**				

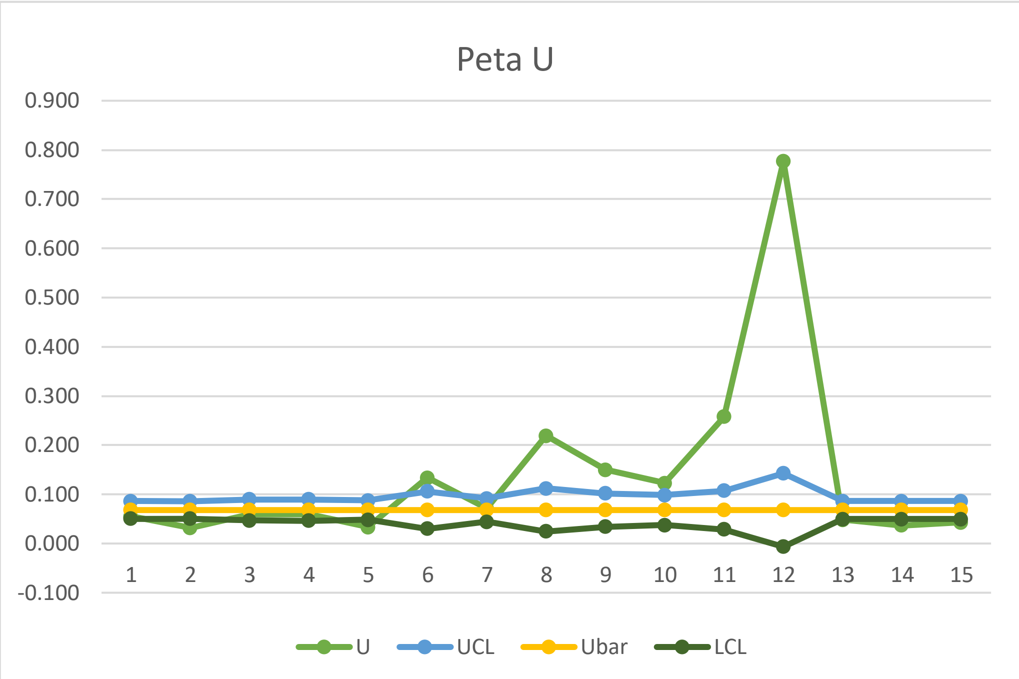

Figure 3. U Control Map

In the image above there are 6 points located above the UCL which means there is uncontrolled product data exceeding the control limit (out of control) namely on June 8 with defect products of 13.35%, July 4 with defect products of 21.88%, July 10 with defect products of 14.98%, July 11 with defect products of 12.31%, July 12 with defect products of 25.75%, and July 13 with defect products of 77.70%. Furthermore, an analysis was carried out to find the factors causing defect products in the final product of 25 Kg No. 10 VC TM tube in the form of a fishbone diagram.

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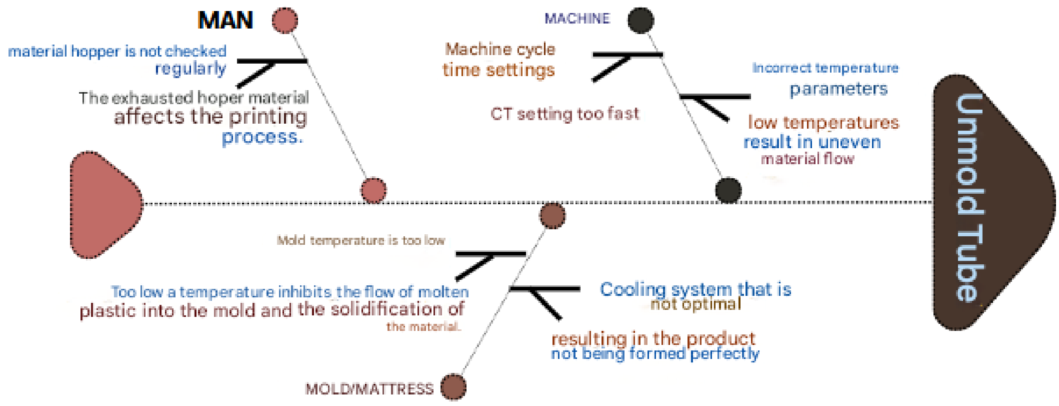

Figure 4. Fishbone Diagram of Unmold Tube

In the fishbone diagram image for the unmold tube is influenced by several factors, namely human, machine, and mold factors. In the machine factor, the incorrect machine cycle time (CT) setting causes the CT setting to be too fast, this affects the shape of the tube. As we know, CT is the time required to carry out one cycle, starting from when the mold is closed, the injection process, the mold opening process to the demolding process (product removal from the mold). If CT is too fast, the plastic flow does not have enough time to fill the entire mold cavity. In addition, inappropriate temperature parameters result in uneven material flow. Temperatures that are not hot enough can cause the flow of liquid plastic not to flow smoothly, this results in an imperfect tube shape. In the man factor, the hopper material is not checked regularly, causing the hopper material to run out, which can affect the molding process. The tube is not formed perfectly if the material is not completely filled with liquid plastic material. In the mold factor, the mold temperature is too low, causing the flow of liquid plastic in the mold to be hampered and accelerating the freezing of the material. In addition, a less than optimal cooling system results in the product not being formed perfectly. After the tube product is molded, the tube product must be cooled first before leaving the mold. If the cooling process is not optimal, it will result in a risk of deformation (change in shape).

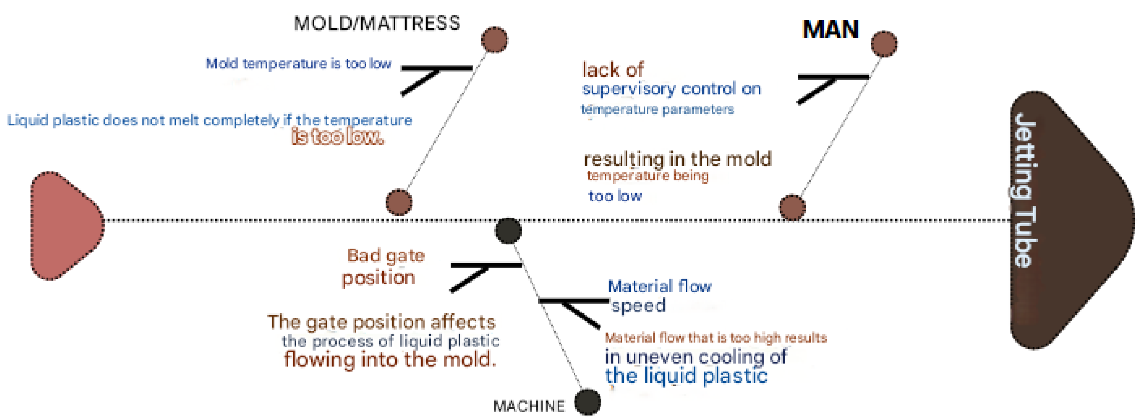

Figure 5. Fishbone Diagram of Jetting Tube

In the fishbone diagram image for the unmold tube is influenced by several factors, namely human factors, machines, molds, and materials. In the machine factor, namely the poor position of the gate causes the molten plastic flow process to have to travel a longer distance and causes the flow of materials such as long and narrow wires to eventually not flow evenly. In addition, the material flow rate is too high, resulting in uneven cooling and eventually

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causing turbulent flow on the surface of the product.In the mold factor, the mold temperature is too low, resulting in the plastic not being able to melt perfectly with the liquid plastic that first enters. In the human factor, the lack of control over temperature parameters results in the mold temperature setting being low.

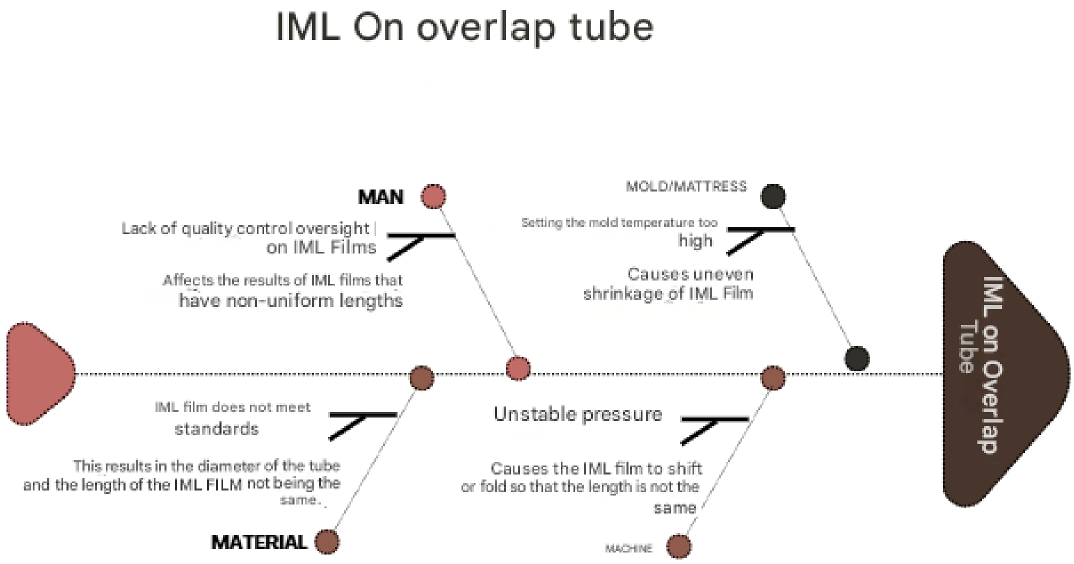

Figure 4. Fishbone Diagram of IML on Overlap Tube

In the picture*fishbone*The diagram for unmold tubes is influenced by several factors, namely human, machine, mold, and material factors. In the machine factor, unstable pressure causes the IML film to shift or fold so that the length of the IML film overlaps. In the material factor, the IML film does not match the standard, resulting in the diameter of the tube and the length of the IML film being different. The size of the IML film ordered from the supplier sometimes does not meet the specifications of the Company so that the length and width of the IML film do not match the diameter of the tube. In the mold factor, the mold temperature setting is too high, causing uneven shrinkage in the IML film. This shrinkage affects the length and width of the IML film. In the man factor, the lack of quality control supervision on the IML film can affect the results of the IML film. The absence of repeated checks causes the IML film to have an uneven length

Improve Stage

At this stage, the FMEA method is used based on the analyze stage. The FMEA method is used by giving severity, occurrence and detection weighting to each cause of failure. FMEA calculations are carried out based on the RPN (risk priority number) weighting parameters.

Severity

*Severity*used to determine how big the impact of the failure is. Severity uses a value range of 1-10 to identify the highest and most influential effects on the resulting product.

Table 6. Severity Description

Number	*Rating*	Information
1	Small chance	Very low impact, failure does not cause significant effects
2-5	Small possibility	Low impact, failure causes significant effects but the main function continues to function.
6-7	Moderate possibility	Moderate impact, failure affects some functions but does not cause major losses.

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8-9	Most likely	High impact, failure seriously affects the main function or quality of the product, can cause serious problems.
10	Very likely	Very high impact, failure causes safety risk or major loss, the product cannot be used.

Occurrence

The occurrence scale is used to find out how often failures occur. The occurrence scale criteria are done by using a range of values from 1-10 to find out in detail about the cause of the failure.

Table 7. Occurrence Description

Number	***Rating***	**Information**
1	Small chance	Cpk>1.67
2-5	Small possibility	Cpk>1.33
6-7	Moderate possibility	Cpk>1.00
8-9	Most likely	Process out of control limits
10	Very likely	Failure is inevitable

Detection

*Detection*used to determine how difficult the failure is to detect for quality control. The Detection Scale ranges from 1 to 10.

Table 8. Detection Description

Number	***Rating***	**Information**
1	Small chance	Detection reliability is almost 100%
2-5	Small possibility	Detection reliability is more than 99.8%
6-8	Moderate possibility	Detection reliability is around 98%
9	Most likely	Detection reliability is more than 90%
10	Very likely	Detection reliability is less than 90%

The FMEA method is used by providing a weighting of the assessment or rating of severity (S), Occurrence (O), and Detection (D) then the RPN value can be calculated to determine the priority in determining recommendations for corrective actions. RPN calculation with the formula RPN = S x O x D.

Table 9. RPN Description

Risk Level	**RPN Value Scale**	**Description**
Very Low	<50	The risk is very low, requiring almost no action or sufficient monitoring
low	$50 \leq RPN \leq 150$	Low risk, requires regular monitoring
Moderate	$150 \leq RPN \leq 300$	Medium risk, requires attention and precautions
High	$300 \leq RPN \leq 450$	High risk, requires immediate action
Very High	≥ 450	The risk is very high, requiring emergency action

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Table 10. FMEA of 25 Kg No. 10 VC TM Cylinder Production Process

Product Function Failure	***Potential Failure Effect***	**Severity = S**	***Cause***	**Occurrence = O**	***Current Control***	**Detection = D**	**RPN = SOD**	**Recommended Action**
Unmold Tube	May affect product functionali ty	6	Hoper material is out	3	Regular checks and ensuring the hopper machine is always filled with material	1	18	Create a regular hopper filling schedule and monitoring of temperature parameters every minute/hour
Product Function Failure	***Potential Failure Effect***	**Severity = S**	***Cause***	**Occurrence = O**	***Current Control***	**Detection = D**	**RPN = SOD**	**Recommended Action**
Unmold Tube	Obstructio n of the flow of liquid plastic into the mold	5	Mold temperat ure too low	6	Regular monitoring of temperature parameters	3	90	Create a regular hopper filling schedule and monitoring of temperature parameters every minute/hour
Unmold Tube	CT setting too fast	8	Machine cycle time setting	6	Periodic monitoring of machine cycle time settings	5	240	Reset machine cycle time
Jetting Tube	The jet of material that passes through the gate is like a long, narrow wire	6	Bad gate position	5	Visual	4	120	Change the gate position so that the flow will immediately hit the product wall and the flow will split.
	Liquid plastic does not melt perfectly	6	Mold temperat ure too low	4	Regular monitoring of temperature parameters	4	96	Monitoring of temperature parameters every minute/hour
	Uneven cooling of the material	5	Material flow rate is too high	1	Visual	1	5	Reducing and optimizing excessive material flow
IML on Overlap Tube IML on Overlap Tube	The diameter and length of the IML are not the same	5	IML Film Size does not meet standards	6	Visual	2	60	submit a complaint to the supplier regarding the IML size or changes to new standards for the IML size if necessary.

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	IML Film Length has been reduced	3	Mold temperature too high	1	Regular monitoring of temperature parameters	4	12	Monitoring of temperature and pressure parameters every minute/hour
	IML film shifts or folds	1	Unstable pressure	2	Visual	2	4	

Based on the FMEA table, the highest RPN value for unmold tube defects is 240, jetting tubes are 120 and IML on overlap tubes is 60. The highest RPN value is obtained for unmold tubes, obtaining an RPN value of 240, this indicates a moderate risk level category, which means moderate risk, the tube requires attention and preventive measures. While the jetting tube obtains an RPN value of 120, this indicates a low risk level category, which means low risk, the tube requires routine monitoring. Then for IML on the overlap tube, the RPN value is 60 indicating a very low level category, which means very low risk, the tube does not require action, just monitoring. Human causal factors such as lack of accuracy in CT (cycle time) settings and inappropriate IML film size standards, while machine factors such as poor gate positions have a major influence on the occurrence of defects in 25 Kg No. 10 VC TM Tubes. This is due to less than optimal cycle time settings, inappropriate IML standards and poor gate placement design. The actions that have been implemented by the company are periodic monitoring of cycle time settings and visual inspection of the product. Then the recommended action is to reset the cycle time on the machine so that defects in the unmold tube can be avoided, submit a complaint to the supplier and change the new standard on the size of the IML film and change the position of the gate so that the flow immediately hits the product wall so that the flow can be split. Implementation of the recommended action for the hopper filling schedule is to assign an operator to be responsible for ensuring that the hopper is always filled, monitor the machine cycle time and temperature parameters for each production carried out and communication is needed to the supplier regarding changes to the IML standard. The evaluation implemented by the company is to analyze how much the level of defects in unmold tubes, jetting tubes and IML on overlap tubes is increasing or decreasing.

Control Stage

At this stage is the last stage of the operation. But in this study can not implement control because at the improve stage is only limited to proposals, so at this stage the measurement results are documented to be used as work guidelines. The main function of the control stage is to ensure that the improvements that have been made to the process will continue and provide consistent results. The actions that need to be taken are as follows:

Implementation of SOP (Standard Operating Procedure)

SOP (Standard Operating Procedure) is a detailed written guide on how to carry out a particular process or task correctly and consistently. SOP is very important to ensure that employees can follow the steps according to the rules to achieve the desired results. With SOP, the risk of error can be minimized, and the quality of products or services can be maintained.

Employee Training

Training refers to training programs provided to employees to improve their skills. This includes technical training (i.e. how to use machines), managerial skills training (i.e. how to manage time) and introduction to new procedures. Through proper training, employees can work more efficiently and reduce the risk of errors.

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An audit is a systematic and independent process to assess the extent to which a company complies with established standards, policies, and procedures. Audits can be conducted internally by a company team or externally by a third party.

Continuous Improvement

*Continuous Improvement*is an approach that focuses on continuous efforts to improve products, services, or facilities within a company. The goal is to achieve continuous improvement in efficiency, quality, and performance. Continuous Improvement applies analytical methods such as PDCA (plan-do-check-act), six sigma, lean manufacturing, total quality management (TQM) and kaizen as improvements to optimize and improve the quality of the company's system

Conclusion

Six Sigma analysis revealed that product no. 10 VC TM had the highest nonconformance rate with the unmold tube at 55%. A Six Sigma value of 3.36 indicated that the process was below standard. FMEA showed the unmold tube had an RPN of 240, the jetted tube 120, and the IML on the overlap tube 60. Human and machine factors were the primary causes. Recommendations included employee training, cycle time re-adjustment, and gate design improvements.

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