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MINIMIZING SEVEN WASTE IN THE INNER LID PRODUCTION PROCESS USING THE LEAN SIX SIGMA APPROACH

MINIMASI SEVEN WASTE PADA PROSES PRODUKSI INNER LID MENGGUNAKAN PENDEKATAN LEAN SIX SIGMA

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ABSTRAK

PT.X merupakan industri yang memproduksi produk berbahan dasar plastic yaitu Inner Lid, Back Panel, Condensor dan Pet Plate. Produk Inner Lid mengalami defect paling banyak. Inner Lid merupakan penutup bak bagian dalam pada pengering yang ada di mesin cuci. Masalah dominan produk Inner Lid adalah terjadinya cacat saat proses produksi sekitar 1-2% dari hasil produksi persekali produksi sehingga jumlah produk yang dihasilkan tidak memenuhi target yang ditentukan dan kualitas produk yang tidak sesuai spesifikasi. Tujuan dari penelitian ini adalah mengetahui waste yang terjadi pada proses produksi di PT.X, menghitung nilai sigma pada proses produksi, menentukan faktor-faktor yang menyebabkan kegagalan proses produksi dan memberikan usulan perbaikan pada waste dominan yang dilakukan untuk meminimasi kegagalan pada proses produksi. Penelitian ini menggunakan metode Lean Six Sigma yang digunakan untuk mengidentifikasi dan menghilangkan waste yang tidak bernilai tambah dengan peningkatan kualitas terus menerus menuju target 6 sigma atau zero defect. Hasil perhitungan DPMO didapatkan rata-rata sebesar 6.149,341 dan nilai sigma sebesar 4,008. Untuk mengurangi dampak kegagalan akibat seven waste dilakukan analisa bahwa penyebab kegagalan dapat berasal dari faktor manusia, mesin, metode, material dan lingkungan. Kemudian diidentifikasi potensi kegagalan tersebut dan diberikan usulan perbaikan berdasarkan metode Failure Mode Effect and Analysis (FMEA). Berdasarkan RPN tertinggi dengan nilai 140, usulan perbaikan diberikan pada waste defect yaitu perlu ada pengawasan kerja dari kepala produksi dalam memperhatikan mesin dan kinerja operator sehingga bisa meminimalisir kesalahan.

Kata kunci : DPMO, FMEA, inner lid, lean six sigma, waste

ABSTRACT

PT.X is an industry that produces plastic-based products, namely Inner Lids, Back Panels, condensers, and Pet plates. Inner Lid products have the most defects. The inner Lid is the inner tub cover on the dryer in the washing machine. The dominant problem with Inner Lid products is the occurrence of defects during the production process of around 1-2% of the production output per production so that the number of products produced does not meet the set targets and product quality does not meet specifications. The purpose of this research is to find out the waste that occurs in the production process at PT.X, to calculate the sigma value in the production process, to determine the factors that cause the failure of the production process, and provide recommendations for improvements to dominant waste to minimize process failures in the production process. This study uses the Lean Six Sigma method which is used to identify and eliminate waste that is not added value with continuous quality improvement toward the target of 6 Sigma or zero defects. DPMO calculation results obtained an average of 6149.341 and a sigma value of 4.008. To reduce the impact of failure due to seven wastes, an analysis is carried out that the causes of failure can come from human, machine, method, material, and environmental factors. then the potential failures are identified and suggestions for improvements are given based on the Failure Mode Effect and Analysis (FMEA) method. based on the highest RPN with a value of 140, the proposed improvement is given to the waste defect, namely the need for work supervision from the head of a production in paying attention to the machine and operator performance so that errors can be minimized.

Keywords : DPMO, FMEA, inner lid, lean six sigma, waste

INTRODUCTION

In the increasingly fierce industry competition, every company is required to compete with other companies. One way to excel in the competition or at least survive in the competition is to give full focus and attention to the quality of the products produced by the company. Companies are required to continue to make improvements continuously (continuous improvement) to realize the effectiveness and efficiency to measure the company's performance. Quality can be defined as the suitability of product use with market requirements to meet customer satisfaction (Amrina and Fajrah, 2015). the meaning

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of Lean is a continuous effort to identify and reduce activities that do not have added value in the production process, and manage the supply chain to add added value to products that are directly related to customers (Ulfah and Kulsum, 2022) meanwhile the purpose of the lean six sigma method is to solve problems and overcome waste, especially regarding defective products (Sarisky *et al.*, 2015)

PT X is an industry that produces plastic-based products that apply a make-to-order system. Where products manufactured include Inner Lids, Back Panels, Condensers, and Pet Plates. From the information obtained that the product that experienced the most defects in the last two years is the Inner Lid. The inner Lid is the inner cover of the dryer in the washing machine. The dominant problem that often arises is the occurrence of defects during the inner lid production process so sometimes the number of products produced does not meet the specified target. Usually in one month's production, defects occur around 1-2% of production.

The impact arising from the failure in the production process is product quality that is not according to specifications and a decline in the company's image in the eyes of consumers. In the inner lid production process, there are 7 wastes that occur such as inventory, motion, waiting, over process, over-production, transportation, and defects. Types of defects that occur are uneven surface products, blotches, and scorched products. Factors causing product defects can be identified starting from the operator, machine, method, material, and environment. Therefore an improvement proposal is made to minimize defects in the inner lid product. Types of defects that occur are uneven surface products, blotches and scorched products. Factors causing product defects can be identified starting from the operator, machine, method, material, and environment.

The purpose of this study is to find out the waste that occurs, calculate the sigma value, determine the factors that cause production process failure, and provide recommendations for improvements to be made to minimize failure in the production process at PT X.

Of the problems that exist in PT X, namely the number of defective products in the production process so that the production target is not achieved, therefore it is necessary to improve to minimize product defects in the inner lid production process from the 7 wastes that occur using the lean approach concept six sigma. The concept of the Lean management system was developed and expanded for the first time by Toyota, while the concept of the Six Sigma management system came from Motorola (Ulfah et al., 2019). the power of the two concepts this is a synergistically integrated concept (Gaspersz, 2006).

In a previous study, the Improvement process for rolling mill through the DMAIC Six Sigma approach (Ganguly, 2012), The proposed improvements to minimize potential failures using lean six sigma and multi-attribute failure mode analysis approaches (*Ulfah et al.,* 2019), Application of Failure Mode & Effect Analysis (FMEA) For Continuous Quality Improvement – Multiple Case Studies In Automobile SMES (Doshi *et al.,* 2016), Improvement of magazine production quality using Six Sigma method: a case study of a PT.XYZ (Hernadewita *et al.,* 2019), Plastic Injection Quality Controlling Using the Lean Six Sigma and FMEA Method (Mansur *et al.*, 2016), Six Sigma Methodology for Improving Manufacturing Process in Foundry Industry (Sachin *et al.,* 2017).

RESEARCH AND METHODS

This study consists of two stages. In the first stage, direct observations and interviews with the company were carried out regarding problems in the company, while in the second stage, data processing was carried out using the Lean Six Sigma method

In the early stages of this research observation and direct interviews were carried out with PT. X related to problems in the industry, then data collection was carried out both primary data and secondary data collection. Primary data is in the form of data from interviews and questionnaires, while secondary data is in the form of data on production quantities and product defects from inner lid products. The Six Sigma approach with the step of define, measure, analyze, and improve be used after collecting data, and data processing is carried out (Ulfah *et al*., 2021). In the second stage, the methodological stage of the lean six sigma approach is arranged as shown in Figure 1.

RESULT AND DISCUSSION

Define

SIPOC Diagram

The Physical flow starts from the arrival of raw materials from suppliers that are used to make a product to the finished product (Fleace *et al.,* 2018). The SIPOC diagram includes five elements including Supplier, Input, Process, Output, and Customer. The SIPOC diagram is shown in Figure 2.

Waste Identification

Waste that occurs on the production floor can inhibit the flow of the production process and even incur additional costs if not immediately addressed. Waste identification is done by distributing questionnaires to get the weight of the existing waste production process. Waste weight can be shown in Table 1.

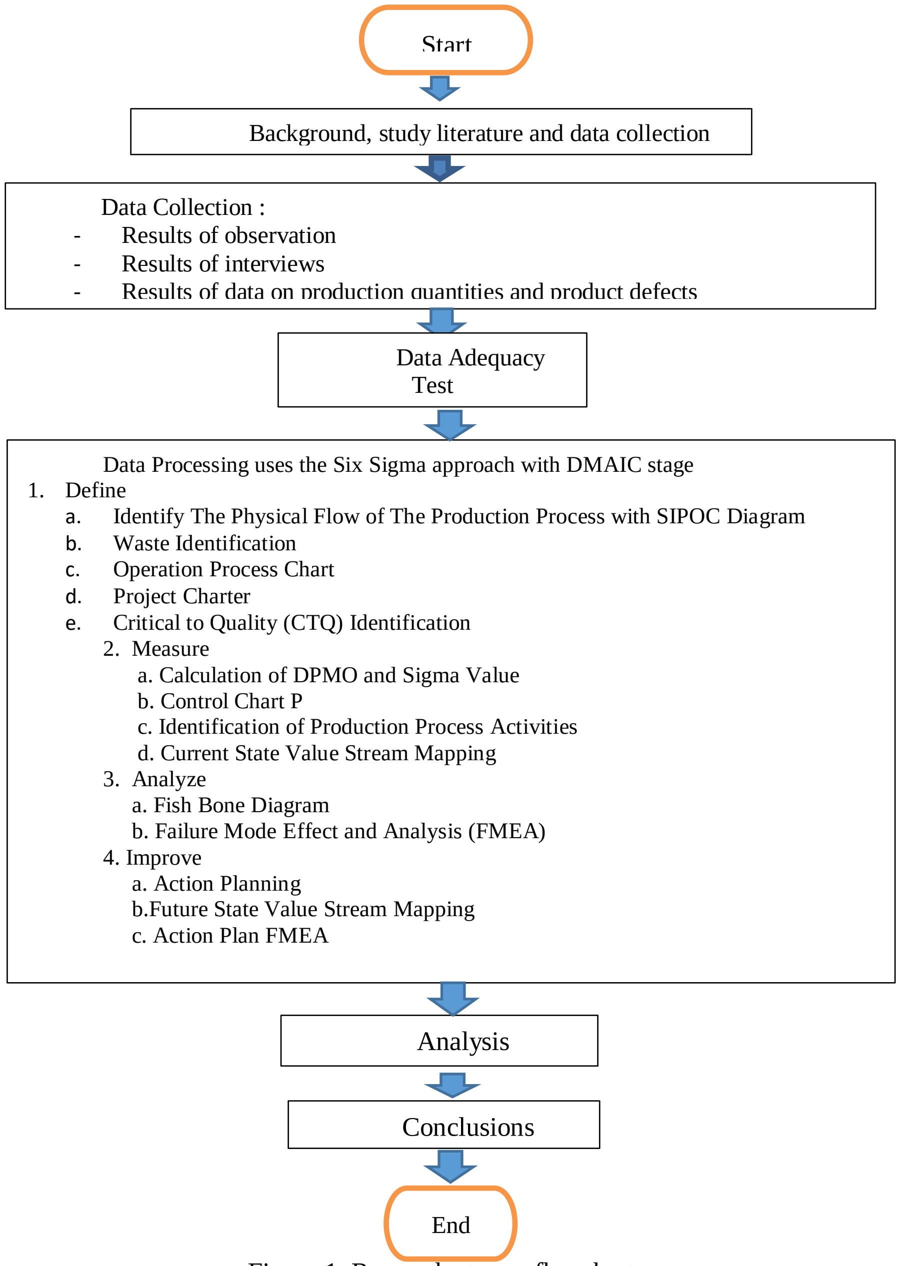

Figure 1. Research stages flowchart

Supplier	*Input*	*Process*	*Output*	*Customer*
PT Gridji	Polypropylene Grey	PP grey plastic pellet smelting Cool time Process Inner Lid Molding process Finishing Inspection Packaging	Inner Lid Product	PT Gridji

Figure 2. SIPOC diagram of Inner Lid Product

Table 1. Result of waste identification

No	Waste type	Weight	Ranking
1	Defect	5	1
2	Waiting	2	3
3	Motion	2	3
4	Over Process	2	3
5	Inventory	1	6
6	Over Production	1	6
7	Transportation	1	6
	Total	14	

After that, the VALSAT calculation is done to find out the tools that will be used for improvement. VALSAT can be shown in Table 2.

Table 2. Result of CTQ inner lid products

No	Type of Disability	Total
1	Uneven Surface	1009
2	Spotting	981
3	Forfeited	117

Operation Process Map

To describe all the activities that exist in the production process, researchers use a map of the operational process (Ahyadi *et al.*, 2017). The activities contained in the operation process map include operations, inspection, inspection, and storage operations combined process.

Project Charter

The project charter contains research information including the name of the institution, time of research, name of research, researcher, inspector, field supervisor, issues raised in this study and the aims, and scope of the study.

CTQ Identification

Critical to quality (CTQ) is a measurement of the product that aims to standard specifications in accordance with customer needs and expectations. This research focuses on inner lid products. The following are some types of defects that occur in inner lid products as shown in Table 3.

Table 3. Result of CTQ inner lid products

No	Type of Disability	Total
1	Uneven Surface	1009
2	Spotting	981
3	Forfeited	117

Measure

Calculation of Sigma Value

Calculations were taken from January 2021 samples

DPMO = DPO x 1,000,000

= 0.006532 x 1000000 = 6531.9865

Sigma value is a measure that states how much the ability of a process. Next is the calculation of the sigma value with Microsoft Excel.

Sigma = NORMSINV (1- (DPMO / (1000000))) + 1.5

= NORMSINV (1 - (6531.9865 / (1000000))) + 1.5

= 3.982

The average sigma value of PT X is 4.008 with an average DPMO value of 6149.341. It can be concluded that the level of achievement of sigma PT X is in the average level of the USA industry.

As a step in using this Six Sigma (Step DMAIC) method, it is necessary to describe the performance of a process, namely through a process control chart and fishbone diagram (Kartini and Jayanthi, 2019).

Map of Control P

The P control chart is an attribute control chart that is used to observe the proportion or comparison between products that do not meet specifications with total production. The following chart is the P control chart for 2021 as shown in Figure 3.

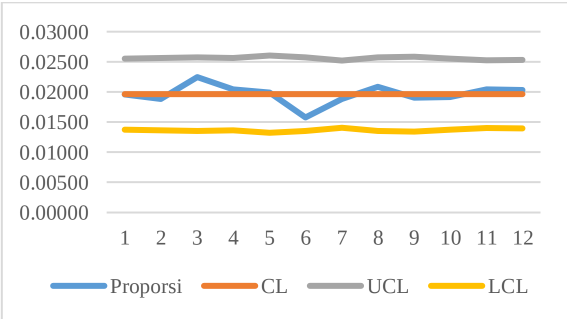

Figure 3. P Control Chart 2021

Furthermore, recalculations were made with 2022 data as a monitoring control chart to find out whether the production process in 2022 was better than before or even decreased. The following chart is the 2022 P control chart as shown in Figure 4.

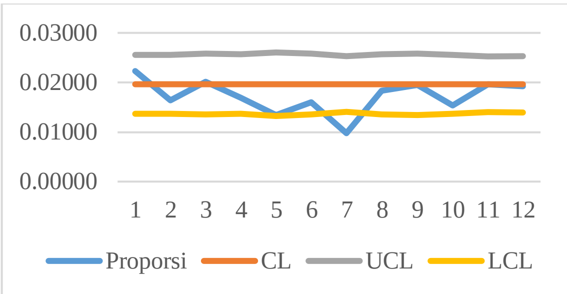

Figure 4. P control chart 2022

Process Activity Mapping

Process Activity mapping is used to find out all the activities of the production process and then classifies based on the type of waste. Process activity mapping can be shown in Table 4.

Table 4. Result of process activity mapping

No	Name	Time (Seconds)	O	T	I	S	D	Information
1	Bring raw materials to the machine	13		T				NNVA
2	Set up machine	40	O					VA
3	PP Gray plastic seed melting process	50	O					VA
4	Cooltime process	35	O					VA
5	Printing process	161	O					VA
6	Finishing	8	O					VA
7	Inspection	3			I			NVA
8	Piling up finished products	576					D	NVA
9	Product was packed	5	O					VA
10	Product is taken to storage	13		T				VA

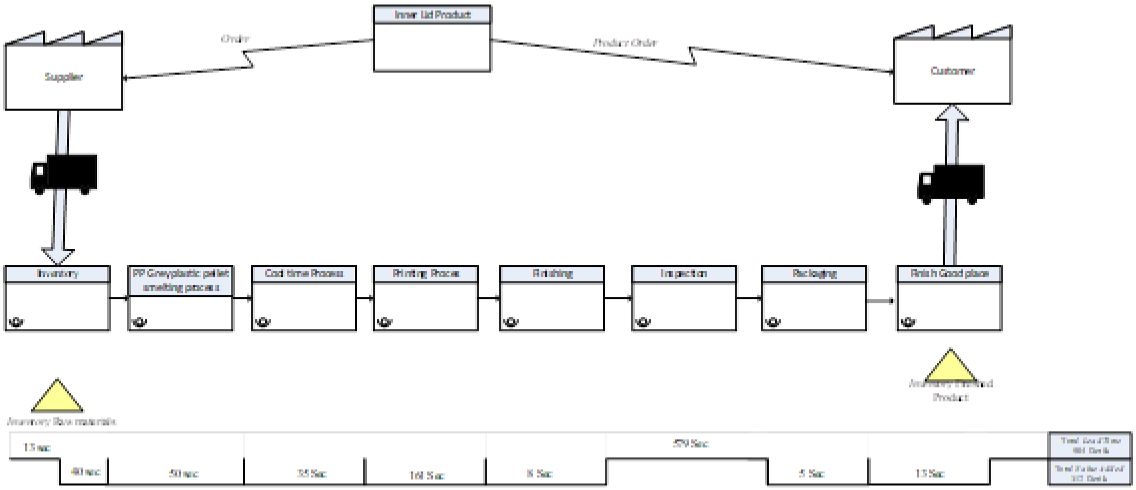

Figure 5. Current value stream mapping

Process Activity mapping is used to find out all the activities of the production process and then classify them based on the type of waste. From table 4 it is known that the total value added time is 312 seconds, necessary non-value added is 13 seconds and non-value added is 579 seconds. The total production time is 904 seconds. The percentage of value added is 35%, necessary non value added is 1% and non-value added is 64%.

Current Value Stream Mapping

Shows an image of all activities or activities carried out by a company. Based on Figure 5 it can be calculated the efficiency of the inner lid production process flow. The efficiency of the production process flow

$$= \frac{\textit{Total Value added time}}{\text{Total lead time}} \text{ x } 100\% = \frac{312}{904} \text{ x } 100\% = 34.51\%$$

Value Stream Mapping (VSM) is a concept from lean manufacturing that shows a picture of all activities or activities carried out by a company. VSM is used to find waste in the value stream depiction, if found then the waste must be eliminated. The depiction of the value stream mapping of the production flow process at PT X can be shown in Figure 5. Starting with a product order from PT Gridji, then PT X ordered raw materials from PT Gridji itself because the customer wanted raw materials from his own company to maintain output quality. then carry out the inner lid production process until sending it to the customer.

Analyze

In the analyze phase contains the analysis conducted by researchers to determine the root causes of failure in the production process. At this stage, an analysis is also carried out to find out the root cause of the defective product using the fishbone diagram. At this stage, an analysis of potential errors or failures in the system is also carried out, and eliminating these errors using the Failure Modes and Effect Analysis (FMEA) method.

Fishbone Diagram

Fishbone diagrams are used to analyze and find factors that cause waste in the inner lid production process based on the type of waste. The waste discussed at this stage includes:

Defect

The factors causing the occurrence of defective products can be shown in Figure 6. In the analysis of the causes of defects caused by several factors including operators, machines, methods, and the environment. In engine factors, there is usually a mechanical problem that suddenly turns off due to 2 causes including an electric short circuit and an overheated engine. the engine that overheats can occur due to the use of the engine that is not resting.on the operator, factor occurs due to an error on the operator himself such as an error in machine settings can occur because the operator is careless usually occurs when changing shifts due to a lack of communication between operators. wavy defective product due to late operator spraying coolant into the hot printing process. This can happen when the operator is less adept at paying attention to a hot printing press. operators are sometimes not disciplined because supervision within the company is less effective. In the method factor, there is usually an error in the time used for finishing the product because the operator is less skilled in doing the job because the operator is inexperienced. on environmental factors, the company has a hot temperature because the machines are close to one another. The heat generated is from the other machines that are operating. This happens because the production floor space is small.

Waiting

The factors that cause waiting for the production process can be shown in Figure 7. The analysis of the causes of waiting can be caused by human and material factors. In the human factor, there is a problem with the speed of the operator not being the same in doing the work because the operator is less experienced. In material factors, problems usually occur when raw materials run out due to delays in delivery. This happened because the party from the old supplier sent the raw material

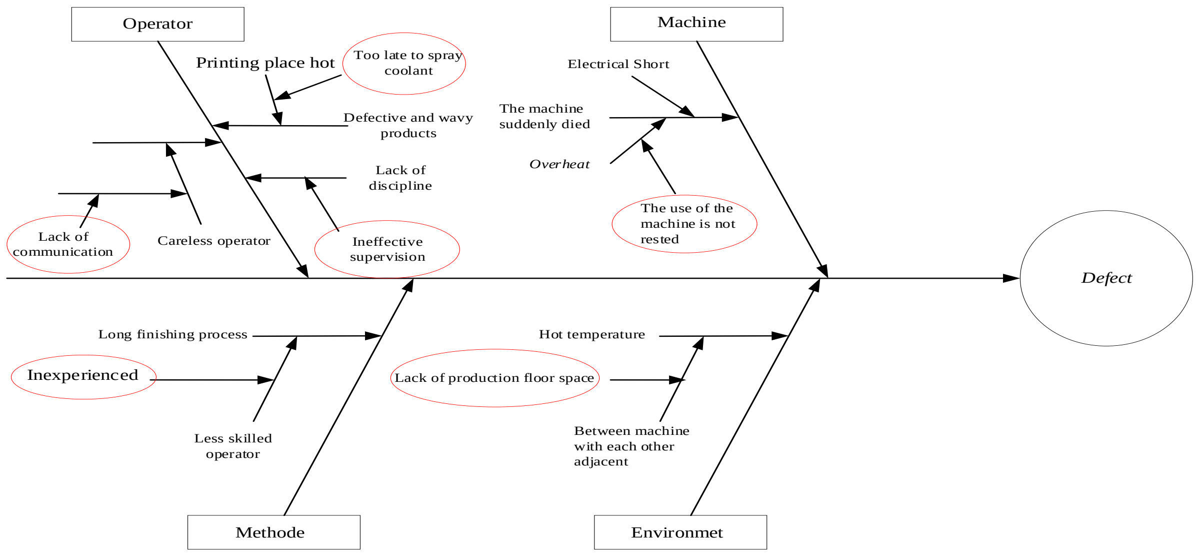

Figure 6. Waste Defect

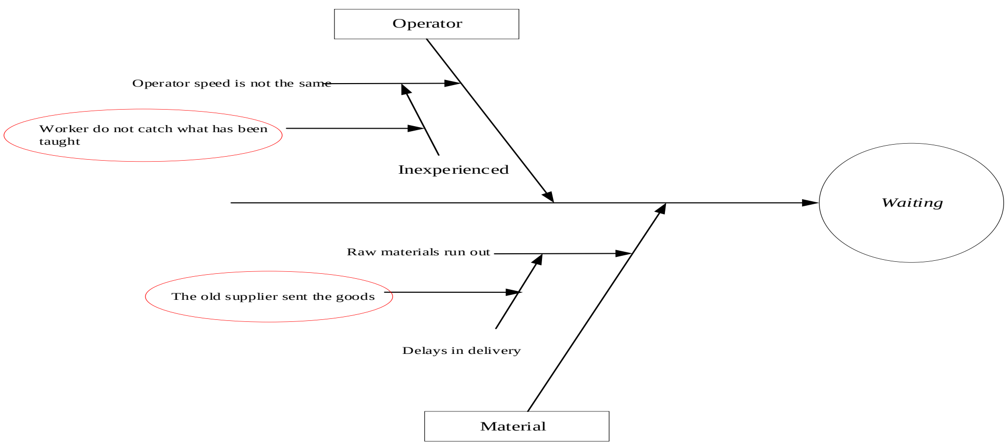

Figure 7. Waste waiting

Motion

In analyzing the causes of motion, as shown in Figure 8, this occurs because there are human factors, such as operators who are still confused about choosing buttons on the machine. Confusion can occur because the operator is inexperienced, usually because the leader has set up the machine beforehand without the operator knowing who will be working. workers in the company are sometimes found playing on their cell phones, and walking around during the production process. This can happen due to ineffective supervision from superiors.

Over Process

Analysis of the causes of overprocess shown in Figure 9, occurs due to machine factors, namely usually re-production due to sudden shutdown of the machine. The machine that suddenly turns off can occur due to two things, namely an electric short circuit or an engine that overheats. there is an engine that overheats can occur due to the use of the engine that is not rested.

Unnecessary Inventory

The factors that cause an unnecessary inventory of raw materials can be shown in Figure 10. The factors that cause an unnecessary inventory of raw materials because the company carries out safety stock for the next month's shipment reserves.

Over Production

The factors that cause unnecessary inventory can be shown in Figure 11. In the analysis of the causes of overproduction in companies, companies often increase the amount of production to anticipate defects

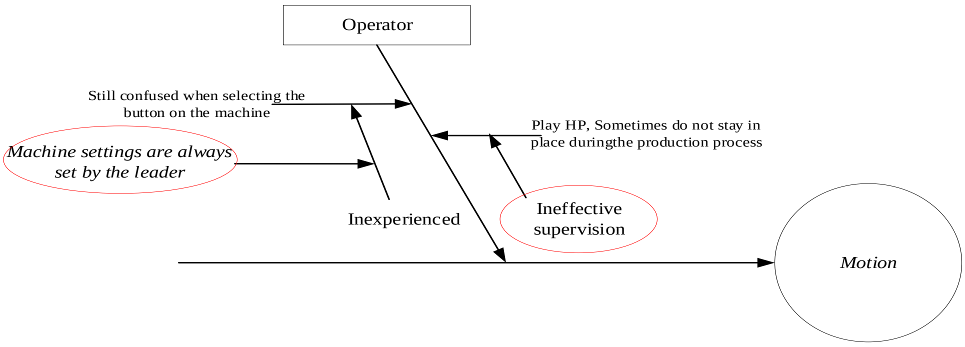

Figure 8. Waste motion

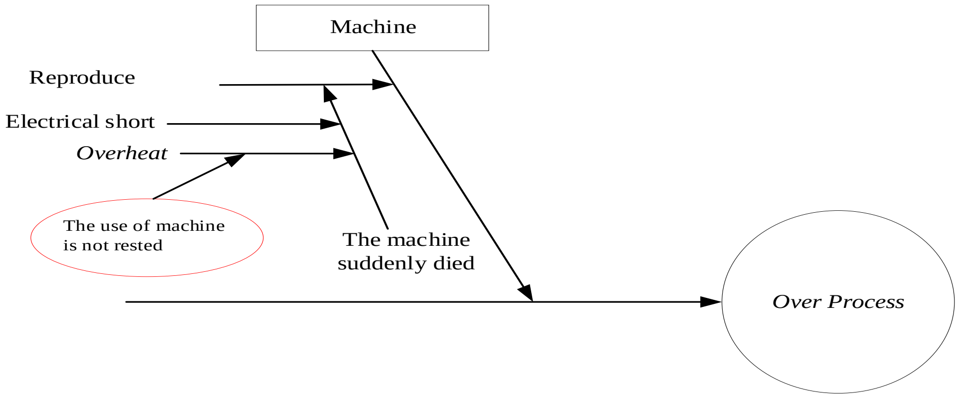

Figure 9. Waste over process

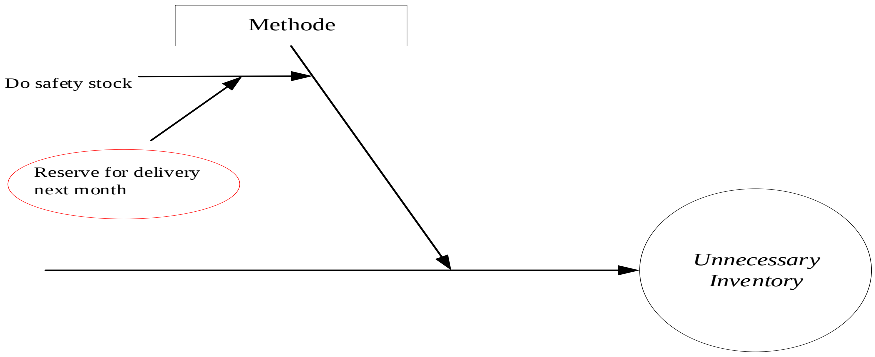

Figure 10. Waste unnecessary inventory

Transportation

The factors that cause waste transportation can be shown in Figure 12. In the analysis of the causes of transportation, the distance between material storage and the machine should be reduced. this is due to the lack of space on the production floor to bring raw materials closer to the machine, causing a less efficient process.

Root Cause Analysis (RCA)

Root cause analysis is a process of identifying the main causes of a problem by using a structured approach with techniques that have been designed to focus on identifying and solving problems (Rahmawati *et al.*, 2016). Root cause analysis can be shown in Table 5.

Failure Modes and Effect Analysis

The FMEA method is carried out to analyze the potential for errors or failures in the system and the identified potential will be clarified according to the magnitude of the potential failures and their effect on the process (Gasperz, 2007). The FMEA suggests analyzing the consequences of a process and its effects on the company (Fitriana *et al.*, 2020). Analysis of Failure Mode and Effect Analysis (FMEA) in the inner lid production process can be shown in Table 6.

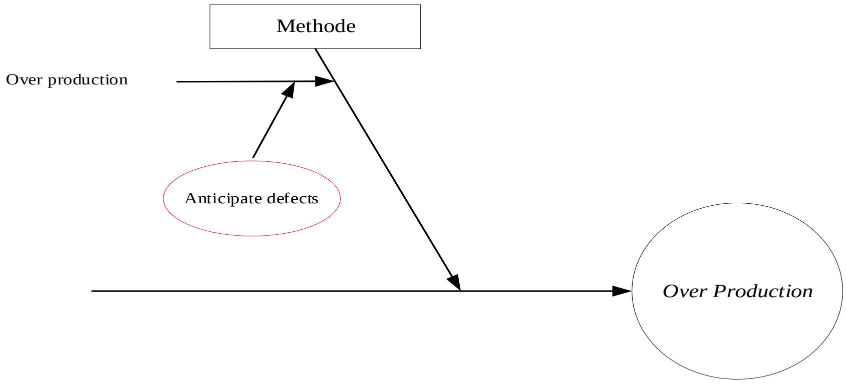

Figure 11. Waste over production

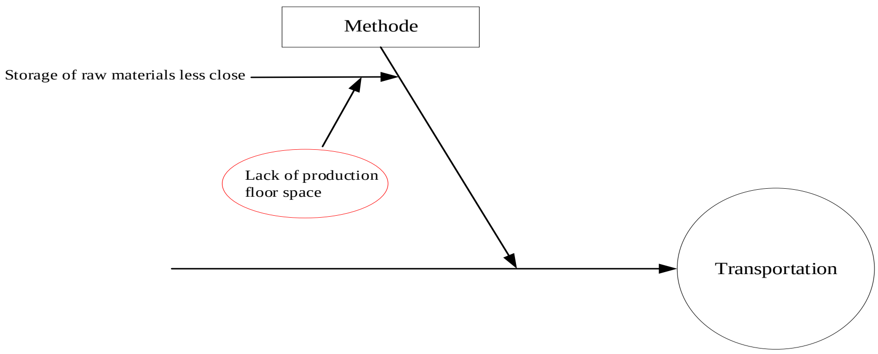

Figure 12. Waste transportation

Table 5. Result of root cause analysis

Defect type	*Why* 1	*Why* 2	*Why* 3	*Why* 4	*Why* 5
Uneven Surface	Corrugated product	The product side has a concave / convex shape	Less contents during the printing process	Printing areas that are too hot	Late spraying the coolant to the printing press
Spotting	Product has stains	From one of the processes carrying different color pigments	The machine part where the gross production process is carried out	The machine isn't cleaned enough	
Forfeited	Product is not intact	The raw material in the melting process is used up	Lack of control to monitor that raw materials are almost gone		

Table 6. Result of Failure Mode and Effect Analysis (FMEA)

Waste	Mode of Failure	Cause of Failure	Effect of Failure	Frequency of Occurrence (1-10)	Degree of Severity (1-10)	Chance of Detection (1-10)	RPN (1-1000)	Recommendations
Defect	Product defects due to operator error	Careless operators usually occur during shift shifts due to lack of communication	Error in machine settings	4	4	1	16	The operator has previously given the replacement operator the machine settings
		Ineffective supervision	Lack of employee discipline	4	2	4	32	Give strict sanctions for workers who do not obey the rules and provide rewards for workers who are disciplined
		The operator is less deft spraying coolant when the printing press is hot	Defective and corrugated products	4	5	7	140	Supervision of work from the head of production in paying attention to the machine and operator performance so as to minimize errors
	Product defects due to engine damage	Can occur due to electrical short circuit or engine overheat because the engine is used continuously without resting	The engine suddenly died	2	4	7	64	Preventive action in the form of checking (payment) of electricity before it runs out and doing routine maintenance activities
	Product defects due to ineffective methods / processes	Operators are less skilled because of inexperienced operators	Making the finishing process a long time	3	4	5	60	Periodic training is held to improve operator skills
	Product defects due to the production floor environment	The distance between the machines with each other close together because of	Hot temperature	9	2	1	18	The addition of work facilities such as cooling
		Limited floor production						blower fan-like room
Waiting	Production delays due to delays in raw materials	Delay in the delivery of raw materials from the supplier because the supplier takes a long time to send the goods	*Stock* raw material used up	2	4	2	16	Preventive prevention such as ordering raw materials before raw materials run out

	The product is waiting to be packaged	The operator is inexperienced because the operator does not understand what the leader has taught	Different levels of speed for each operator	3	4	5	60	Conduct periodic training to improve operator skills
Motion	There are activities that are not supposed to be carried out by the operator	Operators who lack experience in setting the machine because the machine settings are always set by the leader	The operator is still confused when choosing a button on the machine	4	4	7	112	*Leader* teaches how to operate and function buttons on a machine when it wants to run the production process
		Ineffective supervision	Lack of operator discipline such as the courage to play mobile and take a walk during the production process	6	2	1	12	Give strict sanctions to workers who violate and give rewards to disciplined workers
Over Process	*Over Process* which occurs due to engine error	Machines that suddenly die due to electrical short circuit or engine overheat due to continuous use of the engine are not rested	Doing reproduction	2	4	7	56	Preventive action in the form of checking (payment) of electricity before it runs out and doing routine maintenance activities
Unnecessary Inventory	*Inventory* raw material	Reserve delivery for next month	Safety stock of raw materials	8	3	1	24	forecasting calculations to avoid purchasing overstocked raw materials so that inventory remains at its optimum level
Over Production	Overproduction	To anticipate the occurrence of defects during the production process and for safety stock	The amount of production is always excessive	6	3	7	126	Improve performance both human and machine performance so that the products produced are on target and minimize disabilities
Transportation	The distance of material storage from the machine should be reduced	Lack of production floor space to bring raw materials closer to the machine	Inefficient process	2	1	10	20	Transfer of raw materials near the machine to increase the efficiency of the production process

Table 7. Improvement of process activity mapping time

No	Name	Time (Seconds)	Activity O	T	I	S	D	Information
1	Bring raw materials to the machine	6		T				NNVA
2	*Set up* machine	40	O					VA
3	PP Gray plastic seed melting process	50	O					VA
4	Cooltime process	35	O					VA
5	Printing process	161	O					VA
6	*Finishing*	8	O					VA
7	*Packaging*	5	O					VA
8	Product is taken to storage	13		T				VA

Improve Phase

Future Value Stream Mapping

At this stage, the process activity mapping time is improved by reducing non-value-added activities and eliminating non-value-added activities. The following is an improvement in the process activity mapping time shown in Table 7. After that, the calculation of the improvement of physical production flow efficiency is performed as follows.
The efficiency of the production process flow:

$$= \frac{\textit{Total Value added time}}{\text{Total } \textit{Lead time}} \text{ x } 100\% = \frac{312}{318} \text{ x } 100\% = 98.13\%$$

From the results of calculations the improvement of production flow efficiency increased from 34.51% to 98.13%. This shows an increase in the efficiency of the production process by 64%.

CONCLUSION AND RECOMMENDATION

Conclusion

Waste that happens in the inner lid production process at PT X is defect, waiting, motion, over process, inventory, over production, and transportation. The sigma value obtained after doing the sigma calculation in data processing is 4.008. From the average sigma value above it can be concluded that the level of achievement of sigma PT X is at the average level of the USA industry.

The cause of failure caused by several factors in each waste is the waste defect caused by operator factors, machine factors, method factors, and environmental factors. in waste waiting caused by material factors and operator factors. In the waste motion caused by operator factors. Waste over process caused by machine factors. Unnecessary inventory waste is caused by method factors. In waste, overproduction is caused by method factors. Waste transportation, it is caused by method factors.

Proposed improvements given to minimize the impact of waste based on the largest RPN rating are on waste defects, operators who are not dexterous in spraying coolant on overheating printing machines where there needs to be work supervision from the production head in paying attention to machines, and operator performance so as to minimize errors.
The output produced after the proposed improvement is to increase the efficiency of production flow, product quality becomes better, the profits obtained by the company increase, and customers become more loyal.

Recommendation

Based on the results of research using the lean six sigma approach, the results show that the seven waste that occurs in the inner lid process at PT X is caused by human factors, machines, methods, materials, and the environment. Thus it is recommended, among others:

a. The company can apply the proposed improvements given from the research results using the lean six sigma method so that the profits the company gets an increase
b. For Further research using the lean sigma method, it can be carried out on other products from PT X beside the inner lid, and at the improve stage of the six sigma method using the Design of the experiment.

SUGGESTION

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