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IMPROVING THE QUALITY OF STEEL PLATE FINISHING PROCESS USING SIX SIGMA, FMEA, AND QFD METHODS

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Abstract.

PT. XYZ is a manufacturing company engaged in the hot rolled steel plate rolling mill industry. The results of the finishing production report show that the finishing line process has the highest proportion of defects compared to gas cutting plates (flare cutting). This study identifies the causes and solutions for repairing defects in the finishing line using the Six Sigma and FMEA-QFD methods. Based on the initial calculation results, it was obtained that the sigma level and DPMO value were 3.28 and 37,821. From the results of the Pareto diagram, there are five types of defects, namely chamber, BC (bad cutting), BE (bad edge), handling, and OOS (out of square) . The dominant type of defect is the chamber with a percentage of 31.9%. Factors causing defects include operator fatigue, lack of discipline, poor lighting, less than optimal maintenance, knife quality, worn sideguards , and materials. The results of the FMEA analysis show three priorities for proposed improvements, namely, improving operator supervision and SOPs, developing sideguard designs , and knife replacement standards. The development of the sideguard design uses the QFD method, which produces specifications in the form of integrated roll with a distance of 600mm, sideguard dimensions of 6096x200 millimeters with a thickness of 16mm, and made of ASTM A36 steel. The improvements made showed a more stable process with a decreasing number of chamber defects and increasing the Sigma Level value to 3.4 .

Keywords: Steel Plate, Six Sigma , FMEA, QFD

Abstrak.

PT. XYZ merupakan perusahaan manufaktur yang bergerak di industri rolling mill pelat baja canai panas. Hasil laporan produksi finishing diketahui adanya proses finishing line mengalami proporsi cacat tertinggi dibandingkan gas cutting plate (flare cutting). Penelitian ini mengidentifikasi penyebab dan solusi perbaikan cacat pada finishing line menggunakan metode Six Sigma dan FMEA-QFD. Berdasarkan hasil perhitungan awal diperoleh bahwa tingkat sigma dan nilai DPMO sebesar 3,28 dan 37.821. Dari hasil diagram pareto terdapat lima jenis cacat yaitu chamber, BC (bad cutting), BE (bad edge), handling, dan OOS (out of square). Jenis cacat yang dominan adalah chamber dengan prosentase sebesar 31,9%. Faktor penyebab cacat meliputi operator kelelahan, kurang disiplin, pencahayaan kurang baik, perawatan kurang maksimal, kualitas pisau, sideguard aus, dan material. Hasil analisis FMEA menunjukan tiga prioritas usulan perbaikan yaitu, meningkatkan pengawasan operator dan SOP, pengembangan desain sideguard, dan standar pergantian pisau. Pengembangan desain sideguard menggunakan metode QFD, yang menghasilkan spesifikasi berupa integrated roll dengan jarak 600mm, dimensi sideguard 6096x200 milimeter dengan ketebalan 16mm, dan berbahan baja ASTM A36. Perbaikan yang dilakukan menunjukkan proses yang lebih stabil dengan jumlah cacat chamber yang menurun dan meningkatkan nilai Level Sigma menjadi 3,4.

Kata kunci: Quality Control, Steel Plate, Six Sigma, FMEA, QFD

Introduction

PT. XYZ is a company engaged in the field of steel plate milling (*hot roller steel plate*). Established since 1989, PT XYZ has grown into one of the largest steel plate companies in Indonesia, until now, the company continues to strive to present high-quality products in achieving customer satisfaction and contributing to the progress of the country. PT. XYZ proves its commitment to product quality through a strict control system. This system includes controlling the quality of raw materials, processes, and final products before being sent to customers. Although this system is strict, it is only descriptive and does not provide information about the variability of product results per day.

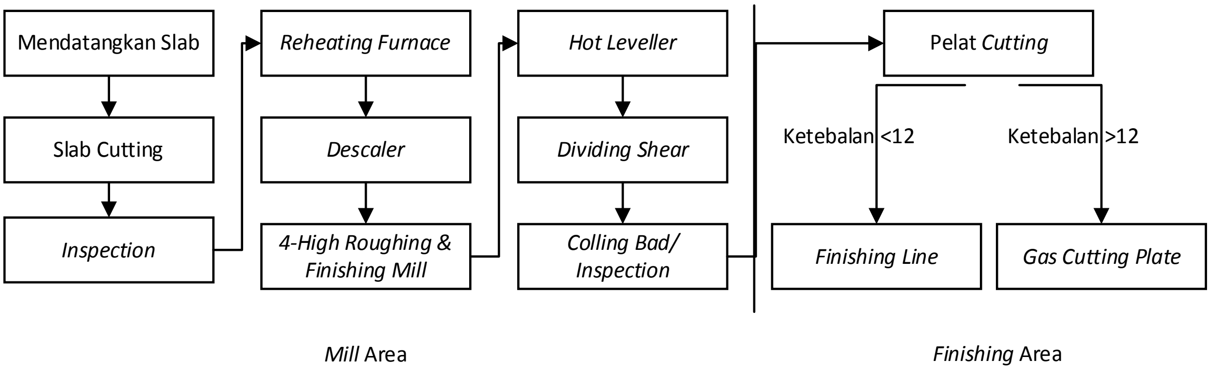


Figure 1Production process flow of PT. XYZ

Production activities at PT. XYZ are divided into several processes handled by different departments. Product inspection in each process is carried out by production operators in each department. The production department is divided into 2 areas: *mill area* and *finishing* can be seen in Figure 1. At the finishing stage it is divided into 2 areas, namely *finishing line* and gas cutting plate (*flare cutting*). This study focuses on the *finishing line stage* , a crucial stage that has the potential to produce defective plates. This is reinforced by the production data from October-December 2023 in Figure 2 which shows a higher proportion of *finishing line defects than gas cutting plate* (*flare cutting*). The high proportion of defects indicates that there are stages of the process in steel plate production that have not been running well [1] . This can cause waste in the company because it will be wasted and/or require rework [2] . And the lack of research at this stage is another reason for this study.

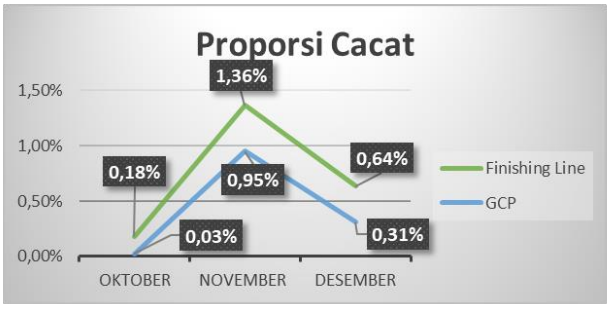


Figure 2Proportion of defects October-December 2023

One method that can be used to analyze the level of defects is the *Six Sigma* and FMEA methods. *Six Sigma* is a highly structured methodology aimed at improving process efficiency and reducing defects in products or services using a combination of statistical techniques and intensive problem-solving tools to achieve goals [3] . The *Six Sigma* DMAIC method aims to identify the root causes of defects and formulate effective improvement strategies to minimize their occurrence [4] . In addition, the *Six Sigma method* through the DMAIC stages can be used to improve processes that have been carried out in the company. *Six Sigma* problem solving can be completed with the DMAIC stages which are equipped with additional improvement steps to achieve the desired results. Improving quality to minimize this failure can be done by providing improvement suggestions to the company using the (FMEA) method to identify failure factors. FMEA is often also called " *Failure Mode Effect Analysis"*. Through the calculation of the RPN value based on the *severity, occurrence* , and *detection values,* FMEA allow to sequence and prioritize corrective actions effectively.

Based on the literature study conducted, research using the *Six Sigma* DMAIC method in a steel company has been conducted previously by [5] and [6] . This method is able to identify factors causing failure. The results of the analysis will be used as a basis for conducting a risk assessment using the FMEA method. Research using the FMEA method has been conducted [7]. and [8] . The application of FMEA and QFD is able to provide alternative suggestions for improvements assisted by QFD in developing machine tool designs. The purpose of this study is to conduct a *Six Sigma analysis* through the DMAIC stages in the *finishing line process* of steel plate products and to provide alternative process improvement actions from the results of the analysis using the *Failure Mode and Effect Analysis* (FMEA) and *Quality Function Deployment* (QFD) methods.

Literature Review

Quality Control

Quality functions as a weapon in competition and is used to provide guarantees to customers. Quality is a very important factor in the production process. Business competition in the industry is increasing, encouraging manufacturers to improve the quality of their products. This is done to survive by competing and sharing export markets [9] . According to [10] , quality is a dynamic condition of products, services, goods, humans and the environment that meet or exceed expectations. Quality has a direct influence on the performance of products or services, so that quality is closely correlated with consumer value and satisfaction [11] .

Quality control is an ongoing process and needs to be done consistently to achieve optimal results. Basically, quality control is a process of arranging raw material to the final product by conducting an inspection, and comparing it to the standards expected by consumers. If there is a deviation from the existing standard, an analysis is carried out to determine where the deviation occurs and the factors causing the deviation [12] . Quality control aims to prevent product defects and ensure that all products meet the established standards. This is done to avoid waste due to defective products, *rework* , or products that must be sold at a lower price. Therefore, quality control is needed to build long-term relationships with customers.

Six Sigma

Introduced by Motorola in 1986 and later popularized by General Electric, *Six Sigma* is a method for improving product and process quality by reducing variation. *Six Sigma* in its application has five phases called the DMAIC cycle (*Define, Measure, Analyze, Improve and Control*) which are used to guide the implementation of *Six Sigma* in achieving goals [13] . The specific goal of *Six Sigma* is to improve the manufacturing process, with a focus on reducing process variability and reducing errors to achieve a DPMO of 3.4 . In *Six Sigma* there is a calculation of DPMO, failures per million opportunities. The following is a table of DPMO conversion to sigma levels.

Table 1Yield Conversion to DPMO and Sigma Level

Yield (Probabilitas tanpa cacat)	DPMO (Defects Per Million Opportunities)	Level Sigma
30,90%	690.000	1
69.2%	308.000	2
93,30%	66.800	3
99,40%	6210	4
99,98%	320	5
100,00%	3,4	6

Source: (Pande, 2003)

Failure Mode and Effect Analysis (FMEA)

FMEA is one way to prevent errors that may occur in the future. FMEA is often called " *Failure Mode Effect Analysis* " and refers to the analysis carried out to find the effects that have the potential to cause errors in a product or production process. FMEA is a process for identifying potential failures in a system, analyzing the causes, effects, and current control mechanisms, and proposing risk reduction plans to improve the safety and reliability of the system [14] . This method is commonly used as a proposal for improvement, FMEA is a technique used to define, identify, and eliminate failures from problems in the production process, then weighting the value based on *the Risk Priority Number* (RPN) [15] . The steps for *failure mode and effect analysis* (FMEA) are to identify the potentials that exist, namely: potential failure, potential effects of *failure mode* , potential causes of *failure mode* and evaluation of existing controls. Steps for conducting FMEA method analysis [15] :

1. Determine the failure mode.
2. Determine the *occurrence value* of the failure rate that frequently occurs.
3. Determine the *severity value* of the severity level.
4. Determine the *detection value* for the occurrence of failure.

FMEA is intended to identify and assess risks related to potential failures. The FMEA method is used to identify all activities that are at risk of causing accidents and analyze their severity.

Research Methodology

This study focuses on the *finishing line process* of PT. XYZ located in Surabaya. The data in this study were obtained from interviews, observations, and internal company data collected during the period October to December 2023. To collect and process data, various instruments were used such as inspection sheets, FMEA, HOQ trees, *Microsoft Excel* , and *Minitab* . The approach used in this study is the *Six Sigma method* with the DMAIC (*Define, Measure, Analyze, Improve, Control*) stages.

Define

define stage is the initial gate in the *Six Sigma methodology* , where problem identification is the main focus. At this stage, identifying problems using a process map *and* determining *Critical to Quality* (CTQ) is a quality limit/standard for the product produced. The standard for this product is input from consumers.

Measure

After identifying the problems in the *finishing line process* , the next step is to measure. This stage is known as *measure* in process improvement methodologies such as *Six Sigma* . At this stage, the company's internal data that has been collected is analyzed to understand current performance and validate problems before improvement. The data used is the amount of output and the number of defects in the *finishing line process* .

Analyze

After validating the problem, the next step is to describe the cause of the failure until reaching the root cause of the problem using the *fishbone diagram tool.*

Improve

improve stage in the DMAIC methodology plays an important role in efforts to improve quality and minimize defects. After understanding the root cause of the problem in the analyze stage , the next step is to determine effective improvement proposals. At this stage, FMEA becomes the main tool for identifying potential failures and determining the priority of preventive actions. In addition, Quality Function Deployment (QFD) also plays a role in developing machine design.

Control

control stage is the last stage of the DMAIC process. This stage focuses on quality control to ensure that the proposed improvements are effective and maintained in the long term. so this stage is done by making a check sheet .

Results And Discussion

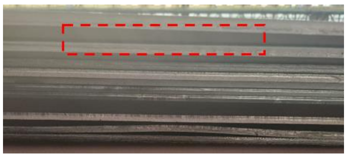
This study focuses on the *finishing line process* with a thickness of less than 12mm, which is a product that is rarely produced when the study was conducted. This study uses production data from October to December 2023, which includes production volume, defect types, and defect quantities as illustrated in Figure

Table 2Production data October-December 2023

Bulan	Minggu Ke-	Pengamatan Ke-	Jumlah Pemoton	Jenis Cacat					Jumlah Cacat
				BC	BE	Handling	OOS	Chamber	
Oktober	2	1	4506	0	0	0	1	0	1
	3	2	1532	0	2	1	2	1	6
	4	3	2369	1	0	1	0	1	3
November	1	4	1612	6	9	3	3	34	55
	2	5	1943	1	4	2	9	5	21
	3	6	2488	2	5	17	1	7	32
	4	7	2521	2	2	0	0	5	9
	5	8	2128	14	4	6	0	0	24
Desember	1	9	1433	0	0	0	0	0	0
	2	10	1977	0	0	0	1	1	2
	3	11	3204	4	4	11	10	6	35
	4	12	1256	4	5	2	0	5	16
Total			26969	34	35	43	27	65	204

Define

Table 3CTQ characteristics of *finishing line process*

CTQ	Description	Visualization
Chamber	One type of defect in the *finishing line process* , the characteristics of this defect are the results of cutting the plate with the shape of the steel plate curved to the left or right. When viewed from above, the side of the steel plate looks convex.	
BC (*Bad Cutting)*	One type of defect in the *finishing line process,* the characteristic of this defect is a texture that causes the cut plate to be uneven.	
BE (*Bad Edge*)	One type of defect in the *finishing line process,* the characteristic of this defect is that there is an uncut steel plate on the left/right side of the cut plate.	
Handling	One type of defect in the *finishing line process,* the characteristic of this defect is a wavy cutting surface.	
OOS (*Out Of Square*)	One type of defect in the *finishing line process,* OOS, is a defect in the steel plate caused by the diagonal size not being up to standard.	

The main objective at the *define* a stage is to find the root cause of quality problems in the steel plate product *finishing line process* . By identifying the types of defects (CTQ) that often occur. 5 CTQ (*Critical to Quality*) are determined in the finishing line process which can be seen in Table 2.

Measure

Next, the frequency of occurrence of each CTQ is calculated in the steel plate product *finishing line process* . The calculation results are then presented in the form of a Pareto diagram to identify the dominant CTQ shown in Figure 3.

In addition, this stage also involves the calculation of DPMO and Sigma Level. DPMO is *Defect Per Million Opportunities,* a calculation that shows the number of defects per million opportunities for defects to occur. In the *finishing line process* , analysis is also carried out using control chart analysis (*P-Chart*) to determine changes after repair.

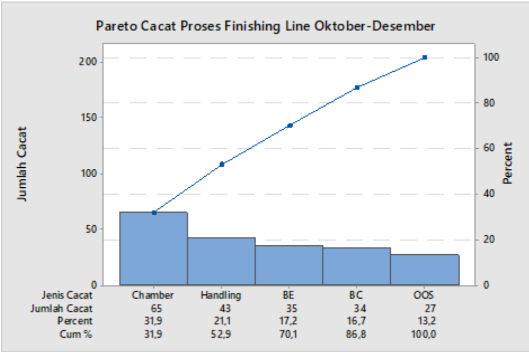


Figure 3Pareto diagram of defective products in steel plate *finishing line process*

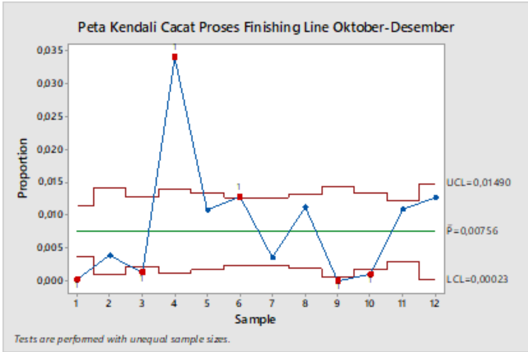


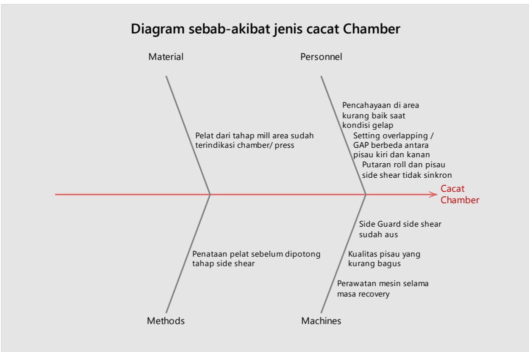
Figure 4 *P-Chart finishing line* process

Table 4Recapitulation of DPMO and Sigma Level calculations

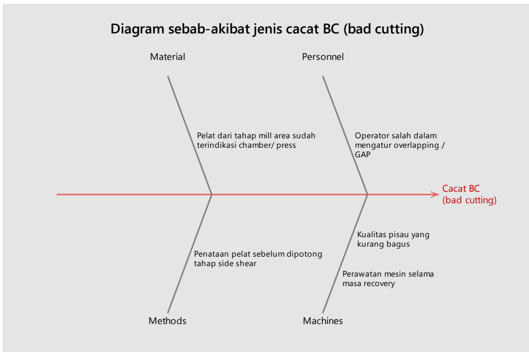
Minggu Ke-	Pengamatan Ke-	Jumlah Pemoton	Jenis Cacat BC	BE	Handling	OOS	Chamber	Jumlah Cacat	DPO	DPMO	Level Sigma
2	1	4506	0	0	0	1	0	1	0,00111	1110	4,56
3	2	1532	0	2	1	2	1	6	0,019582	19582	3,56
4	3	2369	1	0	1	0	1	3	0,006332	6332	3,99
1	4	1612	6	9	3	3	34	55	0,170596	170596	2,45
2	5	1943	1	4	2	9	5	21	0,05404	54040	3,11
3	6	2488	2	5	17	1	7	32	0,064309	64309	3,02
4	7	2521	2	2	0	0	5	9	0,01785	17850	3,60
5	8	2128	14	4	6	0	0	24	0,056391	56391	3,09
1	9	1433	0	0	0	0	0	0	0	0	6,00
2	10	1977	0	0	0	1	1	2	0,005058	5058	4,07
3	11	3204	4	4	11	10	6	35	0,054619	54619	3,10
4	12	1256	4	5	2	0	5	16	0,063694	63694	3,02
Total		26969	34	35	43	27	65	204	0,037821	37821	3,28

Analyze

At the *analyze stage* , an analysis of the factors causing defects in steel plate products in the *finishing line process is carried out* using a cause-effect diagram:



(a)



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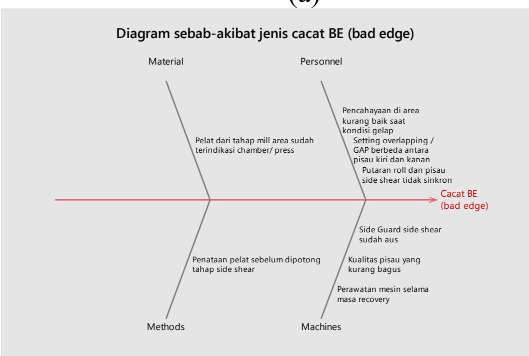

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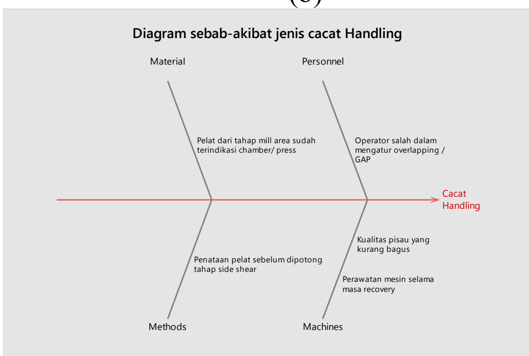
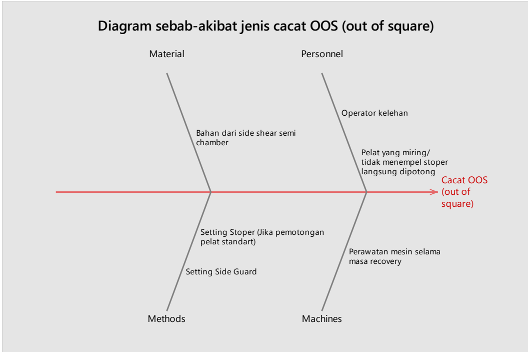


(d)



(e)

Figure 5Cause and effect diagram of defect types (a) *Chamber* , (b)BC, (c)BE, (d) *Handling* , (e)OOS

From the diagram above, it can be concluded that there are five main types of defects identified as having the same root cause , namely a combination of human, machine, material, and method factors. Therefore, a repair solution was created that could overcome the problem . To measure the level of success of the solution, a risk analysis was carried out using the FMEA method. The calibrated *Severity*, *Occurrence* , and *Detection scales* were used to calculate the RPN, which then became the basis for the risk sequencing of each root cause. The results of the RPN calculation are presented in Table 4

Table 5Recapitulation of RPN values

No	Potensial Cause	RPN	Prioritas
1	Pelat dari tahap mill area sudah terindikasi chamber	125	7
2	Pencahayaan di area kurang baik saat kondisi gelap	100	8
3	Setting overlapping / GAP berbeda antara pisau kiri dan kanan	150	6
4	Operator kurang disiplin dalam menerapkan SOP yang ditetapkan	294	1
5	Kualitas pisau yang kurang bagus	216	3
6	Perawatan mesin selama masa recovery	100	8
7	Desain Side guard awal yang aus karena pemakaian	252	2
8	Pelat dari tahap side shear sudah terindikasi chamber	180	4
9	Operator mengalami kelelahan	180	4

From the FMEA analysis results, the three root causes with the highest RPN values are the main priorities for improvement. The priority root causes of the 2 *sideguard designs* are the focus of further research. The *Quality Function Deployment* (QFD) approach is considered relevant to identify optimal design solutions.

Need Statement **and** ***House of Quality*** **(HOQ) Results**

Table 6Interview recapitulation results

No	Need Statement	*Technical Response*
1	Dimensi Proporsional	Ukuran 6096x200x16mm
		Baja ASTM A36
2	Bahan Tahan Lama	Baja ASTM A36
		Permukaan halus, bahan non korosif
3	Tahan Gores dan Aus	Rol terintegrasi
		Rol ditempatkan secara strategis (interval 600mm)
4	Fungsionalitas yang Ditingkatkan	Rol ditempatkan secara strategis (interval 600mm)
5	Pemasangan dan Pelepasan Mudah	Mekanisme penguncian yang mudah digunakan
		Skema warna yang konsisten
6	Pembersihan dan perawatan yang disederhanakan	Permukaan halus, bahan non korosif
7	Desain Yang Menarik	Ukuran 6096x200x16mm
		Baja ASTM A36
		Rol terintegrasi
		Skema warna yang konsisten
		Permukaan halus, bahan non korosif

To ensure the optimal *sideguard design* , a survey was conducted and the interview results were analyzed. The analysis results show the priority of customer needs that will be used as the basis for the design. The highest priority (value 5) will be the main focus in implementing the HOQ method. The results of the HOQ compilation can be seen in Figure 6.

Functional Requirements (How's) → / Customer Requirements - (What's) ↓	IR	Ukuran 6096x200x16mm	Baja ASTM A36	Rol terintegrasi	Rol ditempatkan secara strategis (interval 600mm)	Mekanisme penguncian yang mudah digunakan	Skema warna yang konsisten	Permukaan halus, bahan non korosif
Dimensi Proporsional	5	9	3					
Bahan Tahan Lama	3		9					1
Tahan Gores dan Aus	5			9	3			
Fungsionalitas yang Ditingkatkan	5				9			
Pemasangan dan Pelepasan Mudah	4,5					9	3	
Pembersihan dan perawatan yang disederhanakan	4,5							9
Desain Yang Menarik	2	3	3	3			9	1
Technical importance score		51	48	51	60	40,5	31,5	45,5
Importance %		16%	15%	16%	18%	12%	10%	14%
Priorities rank		**2**	**4**	**2**	**1**	**6**	**7**	**5**

Figure 6HOQ proposed sideguard design improvements

From Table 6 shows that the placement of the rollers (600 mm) is the most important technical response. The integration of the rollers and the specific dimensions (6096x200x16mm) are ranked second, followed by the selection of ASTM A36 steel material.

Improve

At this stage, improvements will be made to the causal factors that have the potential to cause defects and determine the focus of improvements based on the *analysis stage* , namely by designing recommendations for improvements using analysis tools such as FMEA, QFD, and *fishbone diagrams* . Based on the analysis results, some of the main factors that need to be improved are:

1. Suggested improvement 1 (Improve operator discipline in implementing SOP)

To overcome the problem of product defects due to lack of operator discipline, the main focus is to improve compliance with SOPs. Steps to be taken include comprehensive training to improve operator knowledge and skills, standardization of clear and easy-to-understand SOPs, and strict supervision to ensure implementation of SOPs. With these efforts, it is expected that product quality will increase significantly and the level of defects can be reduced to a minimum.

2. Proposed improvement 2 (*Sideguard design*)

Based on the results of the FMEA analysis, the initial *sideguard design* not equipped with a roll guard was identified as one of the main causal factors of the product defect.

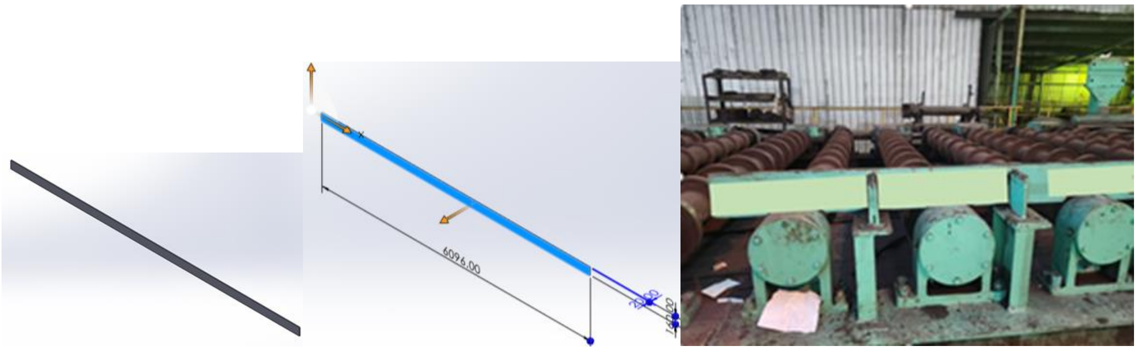


Figure 7*Sideguard* design before repair

To design to overcome this problem, a redesign *of the sideguard has been carried out* by adding rolls at 600 mm intervals. This new design is expected to significantly reduce wear on the side guard, thereby minimizing the risk of defects in the plate during the *finishing line process* .

Figure 8*Sideguard* design after repair

3. Suggested improvement 3 (Blade quality)

Based on FMEA analysis, the quality of the machine blade was identified as one of the main factors causing product defects in the *finishing line process* . To overcome this problem, a blade replacement procedure has been established based on the cutting tonnage. The maximum cutting limit for the *side shear machine* is 1800-1900 MT, while for the *crop shear machine* it is 2400-2500 MT. This tonnage limit is determined based on direct observation in the field with the aim of minimizing product defects.

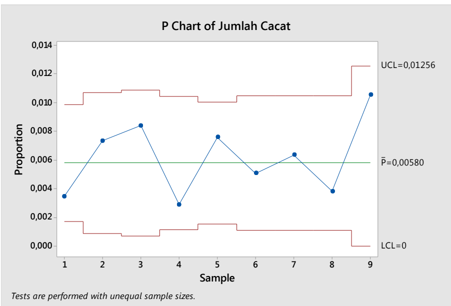


Figure 9 *Pareto diagram* of steel plate defects after repair

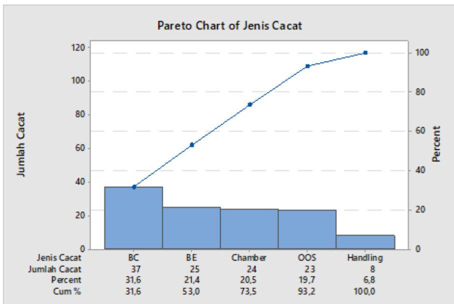


Figure 10 *P-Chart of finishing line* process after repair

the P-Chart control chart , the most dominant type of defect in the steel plate product *finishing line process is bad cutting* (BC), followed by *bad edge* (BE), and *chamber* . However, the results of the analysis show that the overall process is in a controlled condition (*out-of-control). It should be noted that the number of chamber* defects has been successfully reduced after the repairs were made.

Bulan	Minggu Ke-	Pengamatan Ke-	Jumlah Pemoton	Jenis Cacat					Jumlah Cacat	DPO	DPMO	Level Sigma
				BC	BE	Handling	OOS	Chamber				
Maret	1	1	3156	3	5	1	0	2	11	0,017427	17427	3,61
	2	2	2173	4	4	4	4	0	16	0,036815	36815	6,00
	3	3	2023	4	0	0	4	9	17	0,042017	42017	3,23
	4	4	2400	5	0	0	2	0	7	0,014583	14583	6,00
April	1	5	2895	6	2	1	2	7	22	0,037997	37997	3,27
	2	6	2358	2	6	0	3	1	12	0,025445	25445	3,45
	3	7	2361	8	1	1	3	2	15	0,031766	31766	3,36
	4	8	2350	2	0	0	4	3	9	0,019149	19149	3,57
	5	9	1137	3	7	1	1	0	12	0,05277	52770	3,12
	Total		20853	37	25	8	23	24	121	0,029013	29013	3,40

Figure 11DPMO values and sigma levels after improvement

The calculation shows that the average DPMO and sigma values of the *finishing line process* increased to 3.4 after the improvement. This increase indicates that the *finishing line process* has become more stable, so that the number of defects produced has decreased significantly.

Control

At this stage, standardization is carried out by creating IK (Work Instructions) accompanied by a special *check sheet* . This IK will function as a guide for employees in identifying and recording various types of defects that occur at each stage of the production process. Accurately recorded data will be valuable evaluation material for the company to ensure defects do not recur and production efficiency.

Conclusion

Based on the results of data collection and processing that have been carried out, the following conclusions can be obtained. This study focuses on the quality control of plate products in the finishing line process of PT. XYZ using the Six Sigma method with DMAIC stages used to analyze and improve quality. At the define stage, five CTQs are determined in the finishing line process , including chamber , BC (bad cutting), BE (bad edge), handling , OOS (out of square). With Pareto analysis, the most dominant type of defect is chamber . By obtaining an average DPMO value based on data from the October-December 2023 period of 37821 and the average Sigma Level result is at Level 3.28 Sigma. At the analyze stage , it is known that the factors that cause product defects include man, material , methods , and machine factors . From the man and methods factors , it is caused by operator fatigue and lack of discipline in implementing SOPs and poor lighting in the work area. From the machine factor , the root of the problem is that machine maintenance during recovery is not optimal, the quality of the knife is not good, and the sideguard in the side shear process is worn out due to use. While from the material factor , the material from the mill area has indicated chamber. Based on FMEA and QFD analysis, three dominant factors were identified as contributing to the failure of the finishing line process , namely the operator's lack of discipline in implementing SOP, the initial side guard design that was worn out due to use, and poor knife quality. with RPN values of 294; 252; and 216, respectively. To overcome these problems, several corrective steps need to be taken, namely: Improving operator supervision and developing more detailed SOPs, developing sideguard designs, and setting limits for replacing machine knives. The development of the sideguard design was carried out using the QFD and HOQ methods. As a result, there were several proposals for improving the sideguard design with priority order based on the technical importance score (TIS) value . the P-Chart control chart analysis after the improvement showed that the finishing line process was under control with a reasonable proportion of defective products. The improvements made succeeded in reducing the number of chamber defects and increasing the DPMO value and sigma level by 0.12, indicating a more stable and controlled process.

Suggestion

Suggestions for further research involve cost variables in resolving several other types of defects in the *finishing line process area* so that the potential benefits from the repair results can be identified.

Bibliography

[1] R. Ekawati And Ra Rachman, "Analysis Of Horn Product Quality Control PT. MI Using Six Sigma," *Journal Industrial Servicess,* Bd. 3, Nr. 1a, Pp. 32-38, October 2017.

[2] A. Wicaksono And F. Yuamita, "Sardine Production Quality Control Using Failure Mode And Effect Analysis (Fmea) Method To Minimize Canned Defects At Pt. Maya Food Industries," *Journal Of Applied Industrial Technology And Management/ Jtmit,* Bd. 1, Nr. 1, Pp. 1-6, June 2022.

[3] OB Untoro And I. Iftadari, "Six Sigma As A Method To Control And Improve The Quality Of Bed Series Electronic Products," *Industrial Engineering Scientific Journal,* Volume 19, No. 2, Pp. 131-141, December 2020.

[4] D. Dermawan, S. Lestari And Fa Yul, "Application Of Six Sigma In Minimizing Souvenir Product Defects In The Home Industry Of Art Wooden Eyes," *Jurnal Teknik Industri Terintegrasi,* Bd. 2, Nr. 1-7, P. 4, 2021.

[5] DL Trenggonowati, R. Patradhiani And SCE, "Quality Control Of S16 Fin Reinforcement Steel Products Using Six Sigma Method At PT. XYZ," *Jurnal Ilmiah Teknik Industri,* Bd. 5, Nr. 2, Pp. 13-24, 2020.

[6] I. Saidatuningtyas And Ma Rizal, "Analysis Of Quality Control Of Steel Construction Products For Bridges Using Six Sigma Dmaic Method In Steel Fabrication Plant," *Journal Of Technology And Management,* Bd. 21, Nr. 2, Pp. 75-84, 2023.

[7] G. Basuki Hm, "Improvement Of The Quality Of Howard Miller Entertainment Cabinet Products With The Six Sigma Approach At Pt. Singata Furniture," *Matrik Journal,* Bd. Xix, No. 1, Pp. 1-7, 2018.

[8] J. Wibowati, "The Influence Of Service Quality On Customer Satisfaction At Pt Muarakati Baru Satu Palembang," *Journal Of Management,* Bd. 8, Nr. 2, Pp. 15-31, 2021.

[9] A. Maslikhtul, "The Influence Of Product Quality, Service Quality And Price On Consumer Satisfaction Of Amanda Brownies," *Journal Of Management Science And Research,* Bd. 6, Nr. 5, Pp. 1-17, 2017.

[10] ENW Murti And F. Yuamita, "Analysis Of Product Quality Control At PT Djohartex," *J. Ilm. Tech. Machine, Electrical And Computer,* Bd. 3, Nr. 2, Pp. 258-273, 2023.

[11] H. Chen Liu, Improved Fmea Methods For Proactive Healthcare Risk Analysis, Shanghai : China, 2019.

[12] ML George, RD Und B. Kastle, What Is Lean Six Sigma, New York: Mcgraw Hill, 2004.

[13] N. Ardiansyah And Hc Wahyuni, "Product Quality Analysis Using Fmea And Fault Tree Analysis (Fta) Methods In Exotic Ukm Intako," *Prozima,* Bd. 2, Nr. 2, Pp. 58-63, 2018.

[14] IW Sukania, LL Salomon And O. Dharmawan, "PROPOSAL FOR IMPROVING PLASTIC PRODUCT QUALITY WITH QUALITY FUNCTION DEPLOYMENT METHOD IN PT. X," *Jurnal Ilmiah Teknik Industri,* Bd. 5, Nr. 2, Pp. 63-69, 2017.

[15] RN Afifah, MY Lubis And YN Safrudin, "Autolamp Design On Cutting Machine To Minimize Defective Products Using QFD Method At CV. XYZ," *Scientific Journal Of Industrial Engineering And Management,* Bd. 6, Nr. 2, Pp. 1-13, April 2023.

[16] P. Pande, The Six Sigma Way: How To Get More Done With Less Money And Fewer People, New York: Mcgraw-Hill, 2003.