Available online at: http://publikasi.mercubuana.ac.id/index.php/ijiem

IJIEM (Indonesian Journal of Industrial Engineering & Management)

ISSN (Print) : 2614-7327 ISSN (Online) : 2745-9063

Quality Control Analysis to Minimize the Risk of Defective Products Using Statistical Process Control (SPC) and Failure Modes and Effect Analysis (FMEA) Methods (Case Study: PT XYZ Samarinda)

Azura Dahlia, La Ode Ahmad Safar Tongsuku , Suwardi Gunawan
Faculty of Engineering, Mulawarman University, Jalan Sambaliung No.9, Samarinda City, East Kalimantan 75119 Indonesia

ARTICLE INFORMATION

Article history:

Received: 6 November 2023
Revised: 13 December 2023
Accepted: 10 February 2024

Category: Research paper

Keywords:
Quality
Defect
SPC
FMEA
5W+1H

DOI: 10.22441/ijiem.v5i2.24039

A B S T R A C T

PT. XYZ is a company that produces plywood. The issue faced by this company is the increasing risk of defective plywood products resulting from the production process. This research conducts a risk analysis of rejected defective products using the Statistical Process Control (SPC) method to identify the types of defects and their causes, as well as the Failure Mode and Effect Analysis (FMEA). Based on production data from January 2022 to April 2023, PT. XYZ Samarinda has produced 6,629,815 plywood pieces, with 356,137 rejected defective products. There are 10 types of defects, namely delamination defects, blisters, 2x process fractures, impacts, cores that are too narrow, patches, defective sander F/B, F/B too narrow, defective press F/B, and uneven cores. The results obtained from the SPC method indicate that there are four priority defect types: delamination defects, blisters, 2x process fractures, and impacts. According to the FMEA method, the most risky cause for delamination defects is applying a layer of adhesive that is too thin, with an RPN value of 280. The most risky cause for blister defects is an excessively high adhesive dose, with an RPN value of 180. The most risky cause for 2x process fractures is excessive pressure during the core scratching process that penetrates the F/B, with an RPN value of 210. The most risky cause for impact defects is careless workers when moving plywood lots using a cart, with an RPN value of 144. Subsequently, improvement proposals are made using the 5W+1H method to determine the causes of defects and the necessary improvements that the company should undertake.

***Corresponding Author**
Azura Dahlia
E-mail: azuradhl04@gmail.com

1. INTRODUCTION

Plywood is one of the most important commodities among Indonesia's forest products, ranking among the top eight export products from Indonesia with the highest export value. Data from APKINDO indicates that Indonesia is the world's second-largest exporter of plywood, following China. According to BPS data, Indonesia's plywood exports worldwide reached 4.458 million m3, with a foreign exchange value of US$2.513 billion in 2021. The increasing demand for plywood products underscores the importance of paying attention to product quality to ensure consumer acceptance and competitiveness with similar products from other companies. The increasingly intense business competition demands companies to produce high-quality products. The rising demand for products places an obligation on companies to have an effective and efficient production system because any hindrance or error in the production process can result in losses for the company. Every production process inevitably faces challenges and risks in producing defective products, such as products not meeting standards or experiencing a downgrade in product grade. According to Windarti (2014), a production process that prioritizes product quality will inevitably yield defect-free products, thereby reducing wastage. Many companies incur losses due to the production of non-standard or defective products. Therefore, it is crucial to implement quality control in companies to maintain the quality of the products produced. The statement by Nurdewanti (2022)**,** asserts that quality is the standard of a product, be it goods or services, aimed at providing purpose and benefits according to customer needs. Therefore, quality is a crucial factor for the product to compete with similar businesses and meet customer satisfaction.

PT. XYZ is a company that produces plywood. Established in 1980, PT. XYZ is located in Loa Buah Village, Sungai Kunjang Subdistrict, Samarinda City, East Kalimantan. The production process at PT. XYZ involves seven stages: rotary process, dryer process, glue process, cold press process, hot press process, cutting process, sanding process, and the final stage of selecting finished goods, including grading and packing. The company faces a challenge of increasing risks of defective plywood products resulting from the production process. In this research, the author will implement quality control measures for the reject type of defective products. This focus on reject-type defective products is due to the fact that they can lead to production waste and cause greater financial losses to the company. Based on the production data obtained from PT. XYZ for the period from January 2022 to April 2023, the company has produced a total of 6,629,815 plywood pieces, with 356,137 pieces being rejected as defective products. From the 16-month data, it is evident that the percentage of reject defects produced ranges from 4% to 6% each month. This indicates that the percentage of defective reject products exceeds the maximum tolerance limit set by the company, which is 2% to 3%. The problem arises due to insufficient maintenance of the production process machines, inadequate human resources, and raw materials experiencing natural defects. This situation is detrimental to the company in terms of costs, time, and overall performance. Therefore, a quality control strategy is necessary to maintain a balance in production activities, ensuring that the produced products adhere to the applicable quality standards and minimizing the risk of defective plywood products. The methods that can be employed for quality control efforts include Statistical Process Control (SPC) and Failure Mode and Effect Analysis (FMEA), along with the 5W+1H analysis. The SPC method is utilized to identify the types and risks of defect causes. Subsequently, the FMEA method is employed to determine the types and priority risks of defect causes in plywood products, providing improvement proposals to minimize defective products using the 5W+1H principles.

2. LITERATURE REVIEW

Quality is the standard characteristic of a product, whether it be a good or a service, aimed at satisfying customer needs. Quality can be deemed good when it aligns with established goals and provides corresponding benefits. By ensuring quality for consumers, producers can earn trust and cultivate strong business relationships. Therefore, the role of quality is crucial for a product to compete effectively with rivals, comprehend customer satisfaction more deeply, and grasp the concepts for improving the quality of the produced products (Nurdewanti, 2022)**.** According to Bastuti et al., (2018), the definition of quality by various experts includes: (1) Quality is a condition related to products, services, humans, processes, and the environment that meets or even exceeds expectations. (2) Quality is the totality of the form and characteristics of goods/services that demonstrate their ability to meet both apparent and hidden needs. (3) Quality is the sum of attributes or properties described within the respective product. (4) Quality is the overall features and characteristics of a product or service that have the ability to satisfy consumer needs. (5) Quality is the conformity with its purpose or benefit. According to Elbert et al., (2019), state that quality control has a very broad meaning and various definitions. Quality control can be influenced by various factors, such as machine factors and human resource factors. In terms of human resources, it is expected that in a company, there is good cooperation and competence, resulting in high-quality products or services that can satisfy customers. Quality control is a control mechanism for a product to ensure that it meets the needs or desires of consumers. Quality control refers to the control of processes to ensure product quality, comparing it with specifications or requirements, and taking appropriate corrective action if problems arise during the production process. This control involves the implementation of quality assurance steps, such as procedures and standard testing methods (Rahmah & Pawitan, 2017)

The objectives of quality control are to reduce the volume of errors and repairs, maintain or improve quality to meet standards, reduce consumer complaints or rejections, enable output grading, and enhance or maintain the company's image (Desianti, 2018). According to Elbert et al., (2019) state that the aim of quality control is to ensure that the specifications set for products or services are reflected in the final results. Further details on the objectives of quality control are as follows: (1) To ensure that the produced products or services meet the established quality standards. (2) To strive for minimal inspection costs. (3) To strive for minimal design costs of products or services and processes using certain quality. (4) To strive for minimal overall costs incurred. Controlling a process beyond its capabilities or capacity will not have a positive impact on the company. The specifications for the desired production output must be applicable, considering both the process capabilities and the desires or needs of consumers for the intended production results. Quality standards involve controlling a process to minimize the production of substandard products as much as possible (Rahmah & Pawitan, 2017).

According to Bastuti et al. (2018), the Statistical Process Control (SPC) method is a statistical technique widely used to ensure that a process meets standards. In other words, SPC is a process used to monitor, control standards, make measurements, and take corrective actions while a product or service is being produced. According Mahaputra (2021), further explains that SPC is an excellent scientific method for controlling product quality with a focus on the process. This statistical method helps understand the sources of process variation that may occur, allowing for the control of product quality during the production process. Montgomery (2009), mentioned that the Statistical Process Control (SPC) method was developed in the 1920s by Walter A. Shewhart from the Bell Telephone Laboratories. The objectives behind the creation of this method are: (1) Presenting the basic tools for problem-solving in SPC, referred to as the seven tools, and explaining how these tools form an integrated and practical framework for quality control. (2) Explaining the statistical fundamentals of Shewhart control charts. This involves understanding how decisions about sample size, intervals, and the placement of control limits impact the performance of control charts. (3) Discussing and illustrating some practical issues in the implementation of SPC.

The Statistical Process Control (SPC) method is a set of tools for quality control that aims to solve problems, achieve process stability, and enhance capability by reducing variation. SPC provides fundamental approaches in sampling products, testing, evaluating, and utilizing information in the data to control and improve the manufacturing process. To ensure that the production process remains in good and stable condition, and the produced products consistently meet the specified standards, inspections related to maintaining and improving product quality should be conducted (Suhartini, 2020)**.**

Failure Mode and Effect Analysis (FMEA) is a reliability assessment technique designed to recognize potential failures with repercussions that impact the functionality of a system within specified application boundaries. This allows for the identification of priority actions. FMEA stands as a crucial approach for preventing quality issues and ensuring reliability. It encompasses the examination and evaluation of all potential failure modes, their causes, and effects during the initial stages of system development (Novianti & Rochmoeljati, 2023). According to Nurfarizi et al. (2023), Failure Mode and Effects Analysis (FMEA) is a structured tool used to determine the outcomes or consequences of a system failure and to prevent potential failures. FMEA is employed as an initial step for conducting improvement analysis. By assessing various components, assemblies, and subsystems, it identifies the types of failures, their causes, and their effects. In general, FMEA identifies: (1) Factors causing risks of system, design, or process failure. (2) The impact of the failure on the system, and (3) The criticality level of the failure. According to Fathurrozi et al. (2021), FMEA is a structured procedure aimed at identifying and preventing as many failure modes as possible. The FMEA method is used to identify sources and root causes of quality issues.

3. RESEARCH METHOD

This research was conducted at the PT. XYZ, Loa Buah Village, Sungai Kunjang Subdistrict, Samarinda City, East Kalimantan. The data is obtained through :

a. Field Observation

Field observation is conducted by the researcher to directly observe the plywood production process and identify defective products resulting from the production process at PT. XYZ.

b. Interview

Interviews are conducted by the researcher to obtain information about the types of defective products and their causes. The interviews are carried out with relevant personnel in the production process, specifically Mr. Sarwoko, who serves as the production recovery.

c. Questionnaire

Questionnaires are used to determine the Risk Priority Number (RPN) in the FMEA method. The questionnaires are distributed to relevant individuals in the quality control department, particularly Mr. Sulung Butar-Butar, who serves as the head of the quality control department.

Montgomery (2009), explains that Statistical Process Control (SPC) is a powerful set of problem-solving tools useful for achieving process stabilization and improvement through variation reduction. SPC is considered one of the greatest technological developments of the 20th century because it is based on solid principles, easy to use, and applicable to any process. The seven main tools in SPC are histogram, check sheet, Pareto chart, cause and effect diagram, scatter diagram, control chart, and flow chart, which are described as follows: (1) Check Sheet, this tool is used for collecting and analyzing data presented in a table containing the quantity of produced items and types of non-conformities along with their respective quantities (Rahmah & Pawitan, 2017). The purpose of using a check sheet is to facilitate the data collection and analysis process and identify problem areas based on the frequency of existing types or causes (Ningrum, 2019). (2) Scatter Diagram, it is a chart that displays the relationship between two variables, showing whether the relationship between these two variables is strong or not, such as the process factors influencing the production process and the quality of the resulting product (Ningrum, 2019). (3) Cause and Effect Diagram, also known as a fishbone diagram, it is useful for showing the main factors or root causes that affect quality and have consequences on the issue at hand (Rustendi, 2012). (4) Pareto Chart, it is a bar chart where the length of the bars represents the frequency, arranged in descending order from the longest on the left to the shortest on the right. It helps identify the most significant situations. The Pareto principle, also know as the 80/20 rule, states that about 80% of effects come from 20% of the causes (Juran et al., 1999). (5) Process Flow Chart, it is a graphical representation of a process or system using boxes and connecting lines (Ningrum, 2019). (6) Histogram, it is used to show the characteristics of data divided into classes. It is a method for summarizing data for easy analysis (Ningrum, 2019). (7) Control Chart, it is a tool used to monitor and evaluate whether a process is within statistically controlled quality limits, enabling problem-solving and quality improvement (Rahmah & Pawitan, 2017). The p control chart is utilized in this research, and it helps in quality control and provides information on when quality improvement should be implemented (Suhartini, 2020). For the p control chart, the following steps are outlined by Susetyo et al. (2018):

a. Calculate the percentage of defective products:

$$p = \frac{\text{Number of defective products}}{\text{Total Production}}$$

b. Calculate the central line (CL):

$$CL = \frac{\text{Total number of defective products}}{\text{Total number of production}}$$

c. Calculate the upper control limit (UCL):

$$UCL = p + 3\sqrt{\frac{p\,(1-p)}{n}}$$

where: p = is the average of defective products, n = is the total number of products.

d. Calculate the lower control limit (LCL):

$$LCL = p - 3\sqrt{\frac{p\,(1-p)}{n}}$$

where: p = is the average of defective products, n = is the total number of products.

FMEA strives to enhance customer satisfaction by averting failures at every stage, ranging from the inception of the product to its final completion and delivery. The objective is to ensure heightened quality and reliability, guaranteeing timely delivery of a product that meets or exceeds user expectations (Zuniawan, 2020). (Rahman & Perdana, 2021), suggest criteria for determining the priority of a failure mode based on the following factors: (1) Severity.Severity assesses the seriousness of the effects. It identifies the level of seriousness of each failure from the overall system perspective. (2) Occurrence. Occurrence identifies the frequency level of a failure. In other words, it is a rating related to the estimation of the frequency of failure resulting from a specific cause in an element with the current control method. (3) Detection.Detection value identifies the probability that a failure can be detected with the ability to control or manage the failure. It is an assessment of the capability as an evaluation criterion to prevent or reduce the potential for failure. (4) Risk Priority Number (RPN). RPN aims to determine the priority of failures that need attention. The RPN value can be calculated using the formula:

RPN = *Severity* x *Occurance* x *Detection*

Ebrahemzadih et al., (2014), describe three levels of crisis, which include: (1) Normal level. In this level, all three RPN factors have values less than 5, or the RPN is very low and does not require corrective or preventive action but can still be performed (RPN < 70). (2) Semi-critical level. Where at least one of the three RPN factors has a value greater than 5 but the RPN is relatively low; in this case, corrective or preventive action is essential (70 < RPN < 140). (3) Critical level. Where at least two of the three RPN factors have high values or the RPN value is too high, making it clear that corrective or preventive action is necessary (RPN > 140).

(Mahaputra, 2021), states that improvement actions using the 5W+1H principle can identify each dominant cause of defective products by clarifying why it needs to be fixed: (1) What (what is the improvement or mitigation). (2) Why (why the improvement action plan needs to be implemented). (3) Where (where the improvement action will take place). (4) When (when the improvement action will be carried out). (5) Who (who will implement the improvement action plan). (6) How (how the improvement action will be executed)

4. RESULT AND DISCUSSION

The SPC method was utilized to identify the types of defects and their causes in the defective products. The FMEA method was applied to determine the priority of the risk factors causing the defects. Subsequently, a 5W+1H analysis was conducted to provide the best recommendations for addressing the issues faced by the company.

1. The first step taken in the effort to control the quality of plywood production at PT. XYZ is the collection of production data using a check sheet. This study was conducted solely on defective reject products, and the data utilized for the research consists of the production quantity and the number of defective products during the period from January 2022 to April 2023.

Table 1. Check sheet for defective rejects

Month	Total of Production Products	Defective Reject									
		Delamination	Blister	2x Process Fractures	Bumped	*Core* are Less Wide	Patches	F/B Sander Defect	F/B Less Wide	F/B Defect *Press*	Uneven Cores
Jan-22	663.713	11.373	6.240	5.540	3.415	3.109	2.430	1.211	362	298	628
Feb-22	578.720	19.303	4.326	4.987	2.596	2.188	2.551	971	448	245	654
Mar-22	783.082	20.619	5.269	7.030	4.009	2.929	2.852	1.395	570	403	575
Apr-22	598.135	7.430	3.249	5.020	3.068	2.344	1.543	1.478	347	268	317
Me-22	416.848	12.851	3.444	3.949	2.661	2.176	1.580	1.422	300	176	309
Jun-22	743.773	11.419	3.960	4.897	3.630	2.845	1.671	2.573	641	416	605
Jul-22	695.559	10.134	3.333	6.237	4.628	2.887	1.713	1.922	686	605	985
Aug-22	627.656	21.392	3.644	4.993	3.170	1.681	996	1.069	480	437	345
Sep-22	527.813	14.273	4.093	4.688	2.777	2.209	1.568	1.264	368	352	238
Oct-22	196.919	5.156	1.401	1.205	733	748	297	407	23	147	77
Nov-22	84.289	2.053	529	509	450	294	235	122	46	98	58
Dec-22	93.801	3.768	560	706	503	328	209	119	49	86	34
Jan-23	125.386	1.656	343	1.008	579	470	264	214	145	390	250
Feb-23	182.420	2.675	542	1.639	1.153	450	354	519	144	316	223
Mar-23	214.180	3.161	726	1.668	1.149	553	640	778	146	512	378
Apr-23	97.521	1.491	302	542	416	233	363	228	49	164	72
Total	**6.629.815**	**148.754**	**41.96**	**54.618**	**34.937**	**25.444**	**19.266**	**15.692**	**4.804**	**4.913**	**5.748**

2. The next step taken in an effort to plywood quality control is to make a scatter diagram. The scatter diagram is made to find out whether there is a relationship between two variables, namely between the number of production factors and the number of defective products produced.

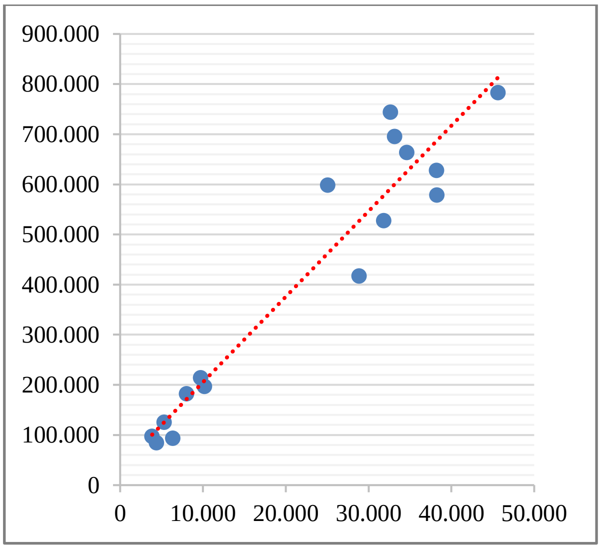

Figure 1. Scatter plot defective reject

3. The next thing to do is to make a histogram. Histograms are made with the aim of showing the frequency distribution of how often each type of defect in the period January 2022 to April 2023 occurs.

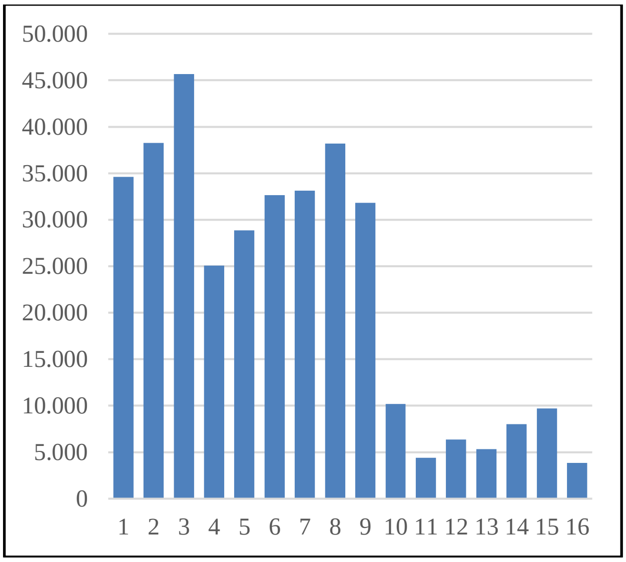

Figure 2. Histogram defective reject

4. Pareto Diagrams are made to find out the most dominant types of defects at PT. XYZ which will be a priority for immediate improvement. Pareto diagrams use the 80/20 principle which states that about 80% of product defects come from 20% of the actions or causal factors of the production process. The steps for making this diagram by sorting the types of defects, defect presentations and accumulated defects of each type of defect can be seen in Figure 3.

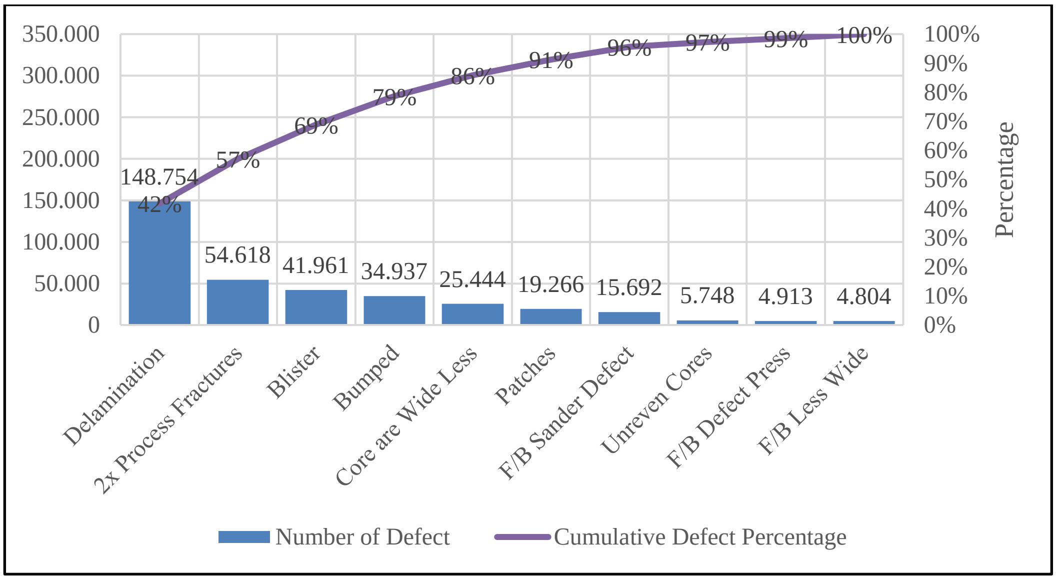

Figure 3. Pareto diagram of reject defects

From the results of Figure 3 obtained, it is known that improvements can be made by focusing on the most dominant types of defects, namely delamination defects, 2x process fracture defects, blister defects and bumping defects.

5. Control Chart (p Control Chart), The next step taken in the quality control effort is to create a control map. Based on the Pareto diagram, there are types of defects that are focused on and need immediate improvement, namely delamination defects, 2x process fractures, blisters, and bumps. Therefore, a control map will be made based on the type of defect to determine whether the production process at PT XYZ is at the control limit or out of control. The control map used in this study is the p control map because the quality control carried out is attribute and the data used as observation samples are not fixed (Rahmah & Pawitan, 2017). The work of the control map can be seen as follows (Table 2).

Table 2. P control chart calculation

Month	Product Production Quantity	Number of Defective Products	Proportion of Defects	CL	UCL	LCL
Jan-22	663.713	26.568	0,0400	0,0423	0,0430	0,0415
Feb-22	578.720	31.212	0,0539	0,0423	0,0431	0,0415
Mar-22	783.082	36.927	0,0472	0,0423	0,0430	0,0416
Apr-22	598.135	18.767	0,0314	0,0423	0,0431	0,0415
Me-22	416.848	22.905	0,0549	0,0423	0,0432	0,0413
Jun-22	743.773	23.906	0,0321	0,0423	0,0430	0,0416
Jul-22	695.559	24.332	0,0350	0,0423	0,0430	0,0416
Aug-22	627.656	33.199	0,0529	0,0423	0,0430	0,0415
Sep-22	527.813	25.831	0,0489	0,0423	0,0431	0,0414
Oct-22	196.919	8.495	0,0431	0,0423	0,0436	0,0409
Nov-22	84.289	3.541	0,0420	0,0423	0,0444	0,0402
Dec-22	93.801	5.537	0,0590	0,0423	0,0442	0,0403
Jan-23	125.386	3.586	0,0286	0,0423	0,0440	0,0406
Feb-23	182.420	6.009	0,0329	0,0423	0,0437	0,0409
Mar-23	214.180	6.704	0,0313	0,0423	0,0436	0,0410
Apr-23	97.521	2.751	0,0282	0,0423	0,0442	0,0403

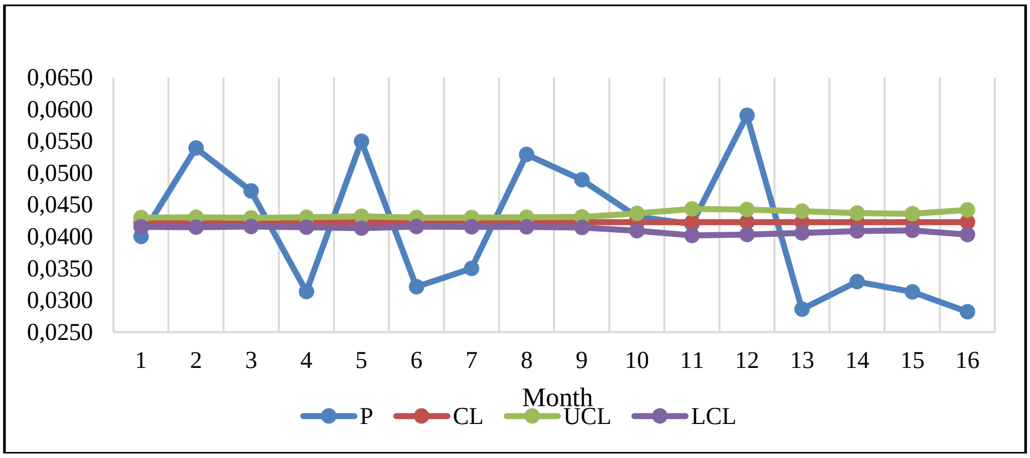

Figure 4. p control chart

Based on the control chart above, it can be seen that there is still data that passes the upper control limit point and the lower control limit. Because there is data that is outside the control limits, it can be said that the production process at PT XYZ is not running well and is not under control. Therefore, further improvement is needed by analyzing the causes of deviations or types of defects using cause and effect diagrams.

6. Cause and Effect Diagram. The next step in the effort to control the quality of plywood is to identify the causes of defects that occur in the production process using a cause and effect diagram or fishbone diagram. The cause and effect diagram is created based on the results of the Pareto diagram, which focuses on defect types that need immediate improvement, such as delamination defects, 2x process fractures, blisters, and bumping.
   a. Delamination Defect Type.
      Based on the data, delamination defect is the most dominant defect at PT. XYZ. The cause and effect diagram for delamination defect can be seen in Figure 5.

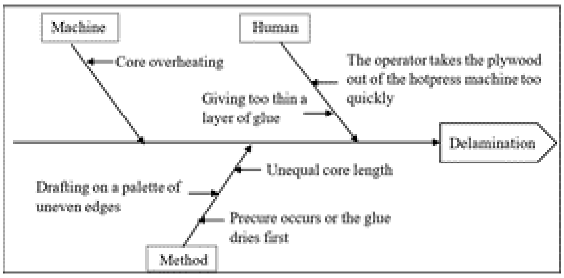

Figure 5. Delamination defect

   b. 2x Process Fractures Defect Type
      The cause and effect diagram for the 2x process fractures defect type at PT. XYZ can be seen in Figure 6.

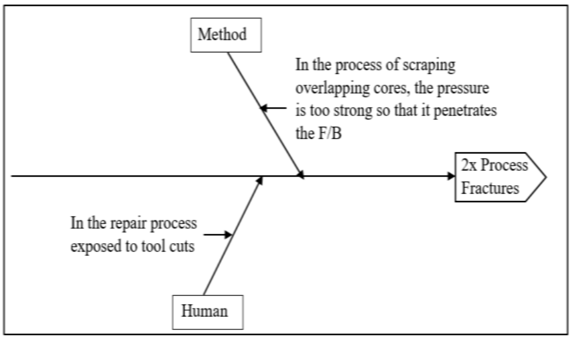

Figure 6. 2x Process fractures defect

   c. Blister Type of Defect
      The cause-and-effect diagram for the blister defect type at PT. XYZ can be seen in Figure 7.

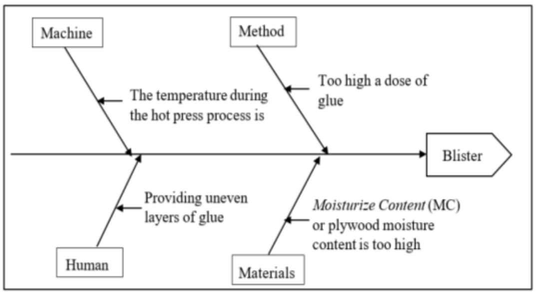

Figure 7. Blister defect

   d. Type of Bumping Defect
      The causal diagram for the type of bumping defect at PT XYZ can be seen in Figure 8 below.

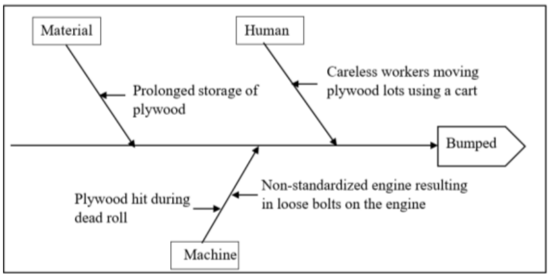

Figure 8. Bumping defect

Furthermore, from this causal diagram, an analysis will be carried out using the Failure Mode and Effect Analysis (FMEA) method to determine the risk priority of the causes of each type of defect. After processing the data using the SPC method to identify the types of defects and the risk causes of defects, the next step is to process the data using the FMEA method. Data processing using the FMEA method is conducted to identify the priority of risk causes that need immediate improvement. The determination of risk priorities is done by assessing severity (S), occurrence (O), and detection (D), and then determining the Risk Priority Number (RPN). The determination of the priority of risk causes for each type of defect is explained as follows. Assessment of Severity (S), Occurance (O) and Detection (D) and Determining the Risk Priority Number (RPN) can be seen in Table 3 .

Table 3. SOD results and RPN assessment

Disability	Causes of Defects	S	O	D	RPN	Risk Level
Delamination	*Precure* occurs or the glue dries first	4	2	3	24	Normal
	Giving too thin a layer of glue	8	7	5	280	Critical
	core overheating	4	1	2	8	Normal
	Drafting on a palette of uneven edges	6	4	3	72	Semi-Critical
	Unequal *core* length	5	3	3	45	Normal
	The operator is too quick to remove the *plywood* on the *hot press* machine	8	3	5	120	Semi-Critical
Blister	*Moisturize Content* (MC) or *plywood* moisture *content is* too high	8	4	3	96	Semi-Critical
	Too high a dose of glue	6	6	5	180	Critical
	Providing uneven layers of glue	5	4	2	40	Normal
	The temperature during the *hot press* process is too high	3	3	2	18	Normal
2x Process Fractures	In the process of scraping overlapping *cores, the* pressure is too strong so that it penetrates the F/B	7	6	5	210	Critical
	In the *repair* process exposed to tool cuts	4	2	2	16	Normal
Bumped	Careless workers moving *plywood lots* using a cart	9	8	2	144	Critical
	plywood hit during *dead roll*	6	3	5	90	Semi-Critical
	Prolonged storage of *plywood*	4	4	5	80	Semi-Critical
	Non-standardized engine resulting in loose bolts on the engine	4	2	5	40	Normal

Based on the FMEA results that have been obtained, it is known that there are types of defects with causes that have RPN values entering the critical risk level. This type of defect is a priority risk that must be immediately given corrective action in order to reduce or prevent the occurrence of defective products.

Table 4. Risk priority

Disabilities	Cause Of Disability	RPN	Risk Level
Delamination	Giving too thin a layer of glue	280	Critical
Blister	Too high a dose of glue	180	Critical
2x Process Fractures	In the process of scraping overlapping cores, the pressure is too strong so that it penetrates the F/B	210	Critical
Bumped	Careless workers moving plywood lots using a cart	144	Critical

Based on Table 4 above, it is known that there are 4 types of defects with causes that have the highest RPN value and are included in the critical risk level. The four types of defects are delamination defects, blister defects, 2x process fracture defects and bumping defects, these four types of defects will be the main focus for immediate corrective action. After knowing the risk priorities on plywood, then provide a plan of improvement proposals using the 5W + 1H principle. The 5W + 1H principle includes what improvements (what), why should be repaired (why), when improvements are made (when), where improvements are made (where), who is doing the repair (who) and how the improvement plan (how). The proposed improvements with the 5W+1H analysis can be seen in Table 5.

Table 5. Correction proposal for delamination defects

	Delamination
Causes of Defects	Giving too thin a layer of glue
What	Checking on the *veneer* whether the glue application is in accordancewith the standard with the applicable provisions and performing the standard glue application in accordance with the company's SOP.
Why	So that the *plywood* material used during the production process meetsthe standards and does not hinder the production process.
When	Before the material goes to the next stage of the process and during theproduction process
Where	Production area of *glue spreader* process section
Who	Head of production
How	Create a new work section or new task in charge of supervising and rechecking the work of workers so as to reduce errors caused by *humanerror* and create clear work instructions or SOPs so that workers easily understand work procedures.

Table 6. Correction proposal for blister defects

	Blister
Causes of Defects	Too high a dose of glue
What	Calculate the dosage of glue according to the standard and conductstricter inspection and checking of materials
Why	To obtain the appropriate glue dosage composition and to comply with work instructions in the *plywood* production process.
When	During the glue-making process and before applying glue to the *Veneer*
Where	Production area of *glue mixer* process section
Who	*Glue mixer* operator
How	Provide explanations related to the calculation of standard glue dosageaccording to glue *viscosity*, glue pH and glue temperature, and check the materials every hour after sampling so that the production process runs smoothly.

Table 7. Correction proposal for 2x process fractures defects

	2x Process fractures
Causes of Defects	In the process of scraping overlapping *cores, the* pressure is toostrong so that it penetrates the F/B
What	Checking the sharpness of knives/chisels before carrying out theproduction process and improving workers' skills related to *plywood* working procedures during the production process.
Why	In order to be able to use knives/chisels in accordance with the standards and so that workers can carry out the stages of the production process properly and correctly in accordance with their responsibilities.
When	After training scheduling occurs
Where	Training venue area
Who	Head of production
How	Create regular and scheduled training programs for both new and existing workers to improve workers' skills so as to reduce errors.

Table 8. Correction proposal for bumping defects

	Bumped
Causes of Defects	Careless workers moving *plywood lots* using a cart
What	Increase the accuracy and discipline of workers in carrying out the production process and workers must always carry out workaccording to the company's SOP.
Why	So that the production process is in accordance with the company's SOP so that workers do not need to make mistakes inthe production process.
When	During the production process
Where	Production area

Who	Supervisor in the production area
How	Provide strict supervision and warnings during implementation so that workers work carefully and in accordance with company SOPs.

The improvement proposals presented, such as increased supervision, accurate calculation of glue dosage, improved sharpness of production tools, and increased worker discipline, can be implemented gradually. This can increase efficiency, reduce defects, and improve product quality. The 5W+1H principle (What, Why, Where, When, Who, and How) is used in the improvement proposal. Companies can adopt this principle in the development of operational solutions, ensuring a comprehensive understanding of the changes required. Upgrading workers' skills through scheduled training can bring about positive changes in production quality. A training program managed by the head of production can be a long-term investment for continuous improvement. Close supervision of workers' compliance with company SOP's, especially in the production process, can minimize errors and improve consistency in production.

5. CONCLUSION

Based on production data from January 2022 to April 2023 at PT. XYZ, a positive correlation exists between total production and total defects. Ten defect types were identified, with delamination, blister, 2x process fractures, and impacts prioritized based on Pareto analysis. Control chart analysis indicates an uncontrolled production process. The cause-effect diagram highlights human, methodological, machinery, and material factors for each defect. FMEA identifies four critical defects with the highest RPN values: delamination (thin adhesive), blister (excessive adhesive dosage), 2x process fractures (scoring pressure), and impacts (carelessness). These defects require immediate attention. Improvement proposals follow the 5W+1H principle. For delamination, introduce a new supervisory role and clear work instructions. Blister improvement involves explaining standard adhesive dosage and regular material checks. 2x process fractures suggest warnings, tool readiness checks, and periodic training. Impact correction recommends sufficient rest breaks, strict supervision, and adherence to SOP. After conducting research on plywood quality control, several suggestions were obtained for the company and further researchers, namely suggestions for the company that the proposed improvements obtained during the research can be considered to be applied to the company to help reduce defective products produced. Suggestions for future researchers are the authors suggest that they can conduct further research and develop research with other quality control methods such as the DMAIC method, TRIZ and New Seven Tools.

REFERENCES

Bastuti, S., Kurnia, D., & Sumantri, A. (2018). Analisis Pengendalian Kualitas Proses Hot Press Pada Produk Cacat Outsole Menggunakan Metode Statistical Processing Control (Spc) Dan Failure Mode Effect and Analysis (Fmea) Di PT. Kmk Global Sports 2. *Teknologi : Jurnal Ilmiah Dan Teknologi*, *1*(1), 72. https://doi.org/10.32493/teknologi.v1i1.1419

Desianti, N. G. N. (2018). Analisis Pengendalian Kualitas Produk Dengan Menggunakan Statistic Processing Control (SPC) Pada CV. Pusaka Bali Persada (Kopi Banyuatis). *Jurnal Pendidikan Ekonomi Undiksha*, *10*(2), 636–645. https://doi.org/10.23887/jjpe.v10i2.20151

Ebrahemzadih, M., H. Halvani, G., Shahmoradi, B., & Giahi, O. (2014). Assessment and Risk Management of Potential Hazards by Failure Modes and Effect Analysis (FMEA) Method in Yazd Steel Complex. *Open Journal of Safety Science and Technology*, *04*(03), 127–135. https://doi.org/10.4236/ojsst.2014.43014

Elbert, Setyawan, & Widjaja. (2019). Pengendalian Kualitas Menggunakan Metode FMEA (FAILURE MODE AND EFFECT ANALYSIS) Di PT. Asia Mandiri Lines Surabaya. *Jurnal Ilmiah*

Mahasiswa Universitas Surabaya, *7*(2), 2570–2583.

Fathurrozi, M., Ismiyah, E., & Jufriyanto, M. (2021). Analisis Penyebab Kecatatan Dan Usulan Perbaikan Pada Produk Sopak Menggunakan Metode Failure Mode and Efect Analysis. *RADIAL : Jurnal Peradaban Sains, Rekayasa Dan Teknologi*, *9*(2), 195–209. https://doi.org/10.37971/radial.v9i2.236

Juran, J. M., Godfrey, a B., Hoogstoel, R. E., & Schilling, E. G. (1999). Juran's Quality Handbook. In *Training for Quality* (Vol. 1, Issue 3). http://knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=623&VerticalID=0

Mahaputra, M. S. (2021). Analisis Pengendalian Kualitas Produk Plastik Injeksi dengan Menggunakan Metode Statistical Process Control (SPC) dan Kaizen di CV. Gradient Kota Bandung. *Media Nusantara*, *18*(1), 1–16.

Montgomery, D. C. (2009). Introduction to Statistical Sixth Edition Quality Control. In *Angewandte Chemie International Edition, 6(11), 951–952.* (Issue Mi).

Ningrum, H. F. (2019). Analisis Pengendalian Kualitas Produk Menggunakan Metode Statistical Process Control (SPC) Pada PT Difa Kreasi. *Jurnal Bisnisman : Riset Bisnis Dan Manajemen*, *1*(2), 61–75. https://doi.org/10.52005/bisnisman.v1i2.14

Novianti, F., & Rochmoeljati, R. (2023). Quality Control of Edamame Products Using Statistical Quality Control (SQC) and Failure Mode Effect Analysis (FMEA) Methods in PT. XYZ. *IJIEM - Indonesian Journal of Industrial Engineering and Management*, *4*(2), 221. https://doi.org/10.22441/ijiem.v4i2.20550

Nurdewanti, R. (2022). Implementasi Metode Failure Mode Effect And Analysis (FMEA) Dengan Konsep PDCA Untuk Mengurangi Defect Produk Cokelat White Compound di PT. XYZ. *Briliant: Jurnal Riset Dan Konseptual*, *7*(2), 503. https://doi.org/10.28926/briliant.v7i2.962

Nurfarizi, R., Nurul Azizah, F., & Sukanta. (2023). Analisis Kerusakan Mesin Pada Mobil Tangki Bahan Bakar Minyak dengan Metode FMEA (Studi Kasus: CV Amanda Jaya). *Jurnal Serambi Engineering*, *VIII*(2), 5409–5415.

Rahmah, A. N., & Pawitan, G. (2017). Aplikasi Statistical Process Control (SPC) dalam Pengendalian Kualitas Produksi Susu di PT. Ultra Peternakan Bandung Selatan. *Journal of Accounting and Business Studies*, *2*(1), 1–18.

Rahman, A., & Perdana, S. (2021). Analisis Perbaikan Kualitas Produk Carton Box di PT XYZ Dengan Metode DMAIC dan FMEA. *Jurnal Optimasi Teknik Industri (JOTI)*, *3*(1), 33–38. https://doi.org/10.30998/joti.v3i1.9287

Rustendi, I. (2012). Aplikasi Statistical Process Control (SPC) Dalam Pengendalian Variabilitas Kuat Tekan Beton. *Teodolita*, *14*(1), 16–36. https://doi.org/10.4135/9781412950602.n749

Suhartini, N. (2020). Penerapan Metode Statistical Proses Control (Spc) Dalam Mengidentifikasi Faktor Penyebab Utama Kecacatan Pada Proses Produksi Produk Abc. *Jurnal Ilmiah Teknologi Dan Rekayasa*, *25*(1), 10–23. https://doi.org/10.35760/tr.2020.v25i1.2565

Windarti, T. (2014). Pengendalian Kualitas Untuk Meminimasi Produk Cacat Pada Proses Produksi Besi Beton. *J@Ti Undip : Jurnal Teknik Industri*, *9*(3), 173–180. https://doi.org/10.12777/jati.9.3.173-180

Zuniawan, A. (2020). A Systematic Literature Review of Failure Mode and Effect Analysis (FMEA) Implementation in Industries. *IJIEM - Indonesian Journal of Industrial Engineering and Management*, *1*(2), 59. https://doi.org/10.22441/ijiem.v1i2.9862