Evaluation of Product Quality Improvement Against Waste in the Electronic Musical Instrument Industry

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ABSTRACT

Customer satisfaction is one of the main factors that must be considered by every company to compete in the global market. One way to increase customer satisfaction is to reduce defective products and reduce waste. This method is a continuous improvement that must be carried out by every manufacturing industry. The Musical Instrument Industry is one of the producers of electronic musical instruments such as pianos. The production process has occurred several problems such as low product quality and waste (ineffective processes, inappropriate layouts, overproduction, and poor production quality). The biggest problem with this company is the large number of products that are not following company standards, such as not achieving quality standards and production not achieving targets. To improve the quality of its production, companies need to make the production process streamlined so that it will create a more effective and efficient production line. A balance between effectiveness and efficiency can be made by reducing waste. Lean Six Sigma is an approach that focuses on improving quality and eliminating waste and sustainable strategy to improve product quality while reducing waste. The company's strategy to be able to compete in the global market must be able to improve product quality and eliminate waste. This study aims to improve product quality and analyze the effect of improving quality on waste. The method used is Lean Six Sigma with dynamo stages, namely pre-study, measurement, analysis, and implementation. The results showed that the quality of the product had increased. Quality improvement has a significant effect on waste.

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1. INTRODUCTION

Currently, the business competition in the manufacturing industry has increased rapidly. This increase will have an impact on the competition with similar industries in the domestic and international markets. Tighter competition between manufacturing industries encourages every company to increase productivity and quality [1-2]. Customer satisfaction is the level of customer or consumer feeling after getting a product or service from a company. Customer satisfaction has a significant role in winning the competition [3-4]. There are many parameters in determining customer satisfaction, including in terms of marketing, productivity, and delivery time [5]. In addition, product quality also plays a major role in ensuring customer satisfaction [6]. For this reason, the quality and productivity improvement program must always be implemented by every company on an ongoing basis.

However, the quality and productivity improvement program may not be able to run if the production system still has several problems such as machine disturbances, failed material supply, lack of manpower capacity, and others [7]. In addition, the presence of waste in the production line is also the biggest disturbance that must be corrected [8-9].

The Musical instrument industry is one of the producers of electronic musical instruments. The company has large customers both at home and abroad. Based on initial observations, there are wastes such as ineffective processes, inappropriate layouts, overproduction, and poor production quality. The biggest problem with this company is the large number of products that are not following company standards, such as not achieving quality standards and production not achieving targets. To improve the quality of its production, companies need to make the production process streamlined so that it will create a more effective and efficient production line. A balance between effectiveness and efficiency can be made by reducing waste [10-11]. Based on these problems, strategies or methods are needed to overcome them.

Lean Six Sigma is an approach that focuses on improving quality and eliminating waste [12-15]. This concept is one of the main business process strategies that can be used by various companies to improve manufacturing performance [16-17]. This concept can also identify complex problems [18-19] proposed that the integration of Lean and Six Sigma can provide effective results for optimizing production costs so that efficient production costs are obtained.

Lean Six Sigma is a sustainable strategy to improve product quality while reducing waste [20-21]. With the increase in quality and the loss of waste, the company's productivity will increase [22]. Lean Six Sigma also aims to improve the overall efficiency and effectiveness of manufacturing companies [23]. In other words, the goal of Lean Six Sigma is to achieve zero-defect performance, on-time delivery without accidents, and waste in the production process [24]. The implementation of Lean Six Sigma must be carried out in a sustainable manner [25]. In its implementation, Lean Six Sigma is rarely evaluated. Evaluation is very important in the improvement process. This is to find out how far the repair process has been carried out. Therefore, it is very important to evaluate the quality improvement of waste. Several studies have evaluated quality improvement with Anova [26-27]. This study aims to improve the quality of production and analyze the effect of improving quality on waste. The novelty of this study is to analyze the effect of increasing production quality on waste with the Anova test. The research steps used are dynamo++ stages, namely pre-study, measurement, analysis, and implementation [28-30].

2. METHOD

This research uses a methodology to run in a systematic and directed manner. The steps that design improvements use the Dynamo++ steps [28, 30]. The stages used include Pre-study, measurement, analysis, and implementation, as shown in Fig. 1 for dynamo++ stages [28, 30].

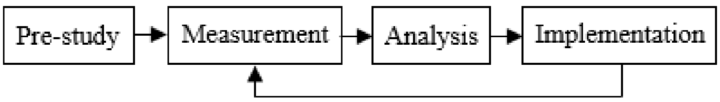

Fig. 1. Dynamo methodology [28, 30]

Pre-study

The pre-study begins by defining the waste problem that occurs in the production line. This stage uses Pareto diagrams to prioritize the biggest problems. Then map the production process with the Operation process chart and then determine the CTQ.

Measurement

Measurement begins with measuring production capacity, measuring distance and transportation time, making control charts, and measuring sigma values. At this stage, the tool used is a Pareto diagram to determine CTQ. The P-control chart is used to see the stability of a process.

Analysis

The analysis identifies the factors causing the problem with Fishbone Diagram. Fishbone diagram is made based on the results of the Focus Group Discussion (FGD). Then determine the priority of repair with Failure

Mode and Effect Analysis (FMEA). This analysis considers three factors Occurrence (O), Severity (S), and Detection (D), to get the highest Risk Priority Number (RPN).

Implementation

Implementation is designing improvement plans and implementing improvements with Kaizen. Improvements to each problem resulted from the FGD. After the improvements are implemented, then return to the measurement stage to measure the results of the improvements. In the measurement phase, hypothesis testing was also carried out. Hypothesis testing was carried out to analyze the effect of improving quality on the waste that occurred. Hypothesis testing was carried out using the ANOVA test. Before the ANOVA test, the data were tested for assumptions as a condition for the ANOVA test. The assumption test used is the normality test of the data and the homogeneity test. The following is the hypothesis of the Anova test. H_0 is an effect of improving the quality of waste. H_1 is no effect of improving quality on waste.

Data collection

The data collected is divided into two groups, namely primary data and secondary data. Primary data in this study were obtained through observation, such as the flow of the production process, factory layout, transportation distance, and all machines and equipment used in the production process. Secondary data is obtained from the annual report of production, such as the number of production and the number of defective products.

3. RESULTS AND DISCUSSION

In this chapter, data analysis is carried out using dynamo stages. The results of the analysis will then be discussed on the findings and contributions of research to similar industries.

Pre-study

The first step is to make a production process flow and define the waste that occurs in the production line. Making the production process flow using production process activity data obtained through observation. OPC is used to describe the production flow that has the biggest problems. Fig. 2 explains that the Side Board production process is a process that will be researched due to the low quality of the product, and this process has received a rank 1 rating from the customer. The OPC of the piano production process can be seen in Fig. 2.

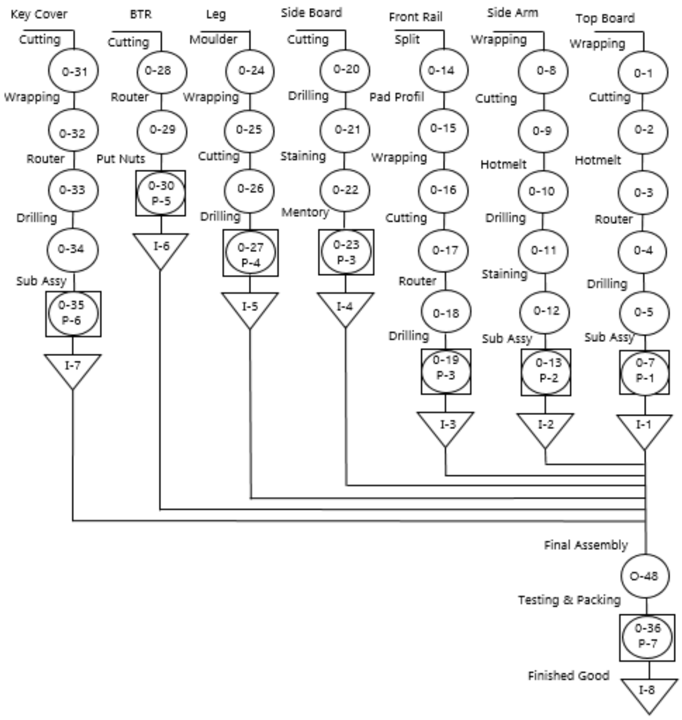

Fig. 2. Operation process chart of side board

The main problem in the production process is waste, such as ineffective processes, inappropriate layouts, overproduction, and poor production quality. This needs to be improved to create customer satisfaction. Based on the analysis using the Pareto diagram [31] in Fig. 3, it can be seen that defect is the highest waste. This waste causes the company's productivity to decrease. Thus it becomes a priority for waste that will be improved.

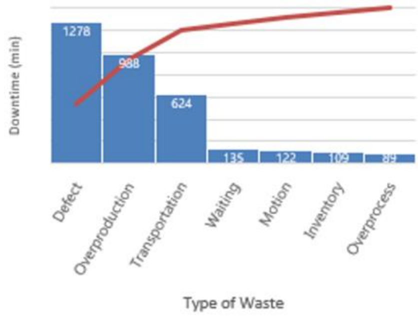

Fig. 3. Pareto diagram of waste

1. Defect

Defects occur because the products produced do not meet the specifications set by the company. Defects that occur in the production process are high enough so that customer satisfaction related to quality will be reduced. It is necessary to improve the process so that the resulting product is close to zero defects. Based on Fig. 3, the biggest defects occur in scratch defects, so that these defects become a priority for repairs.

2. Overproduction

Overproduction occurs because the number of products produced is more than the number ordered by customers. This overproduction has an impact on the production area being full. This problem occurs because the control system is not good. Overproduction is one type of waste that can support the occurrence of other wastes.

3. Transportation

Transportation is included in non-value-added activities. The problems of this waste are long lead times, manual material handling equipment, displacement distances, additional space for movement of goods and storage. Transportation also causes product defects due to handling.

Measurement

Measurements are made on the waste that occurs in the production line. This stage measures production capacity measures transportation time and distance, which are mapped with the Flow Process Chart in Fig. 4.

Flow Process Chart	
Activity	: Process Side Board
Area	: Wood Working 2
Operator	: 10 Person
Supervisor	: 1 Person

Summary		
Activity	Current	Future
Operation	3	3
Transport	5	4
Delay	0	
Inspection	0	
Storage	3	3
Time (s)	1741	1368
Distance (m)	119	110

Process Descript	Symbol					Time (s)	Distance (m)	Remark
Handling	○	□	➡	D	▽	385	40	
WIP Side Board	○	□	⇨	D	▼			
Handling	○	□	➡	D	▽	112	15	
Cutting	●	□	⇨	D	▽	138		
Handling	○	□	➡	D	▽	54	12	
Drilling	●	□	⇨	D	▽	260		
Handling	○	□	➡	D	▽	63	14	
Mentory	●	□	⇨	D	▽	200		
Handling	○	□	➡	D	▽	20	9	
Staining	●	□	⇨	D	▽	183		
Finish Good	○	□	⇨	D	▼			
Handling	○	□	➡	D	▽	326	29	
WIP	○	□	⇨	D	▼			

Fig. 4. Flow process chart of side board

Mapping with the Flow Process Chart is then transformed by mapping the overall Side Board production flow using VSM. As shown in Fig. 5, before the product is sent to other parts, it is carried out in 4 processes, namely the cutting process, drilling process, staining process, and mentoring process.

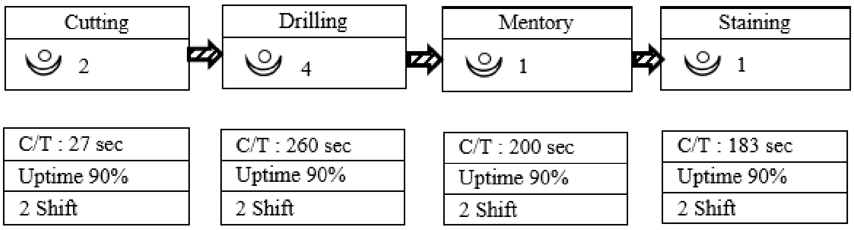

Fig. 5. Value stream mapping of sideboard

Other measurements are carried out to determine the stability of the process. Product control limits are used to determine product variance. P chart before repair can be seen in Fig. 6.

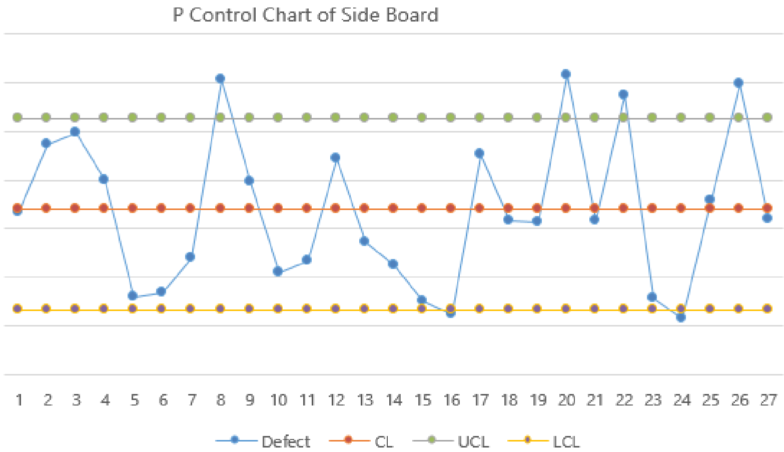

Fig. 6. P control chart

The P Control Map shows that several points are outside the control limits. This shows that the process is not yet fully stable. The points are in observations No. 8, 16, 20, 22, 24, and 26. Therefore, it is necessary to make improvements to get a good process. The next step is to calculate the defect per million opportunities (DPMO) value. Calculations are carried out in 6 calendar months before repairs are made. The results of the DPMO values are then transformed into sigma level values. Table 1 describes the average monthly DPMO values. Calculation of the DPMO value for July shows that after one million products are produced. It is possible to get 22,215 defects or not according to the specifications set by the company. This result is still far from the company's expectations to achieve zero defects. Improvements will be made to improve quality towards zero defects to provide full satisfaction to customers.

Table 1. DPMO and sigma level

No	Month	DPMO	Sigma
1	Jul	22.215	3.51
2	Aug	21.178	3.53
3	Sep	19.226	3.57
4	Oct	18.309	3.59
5	Nov	24.998	3.46
6	Dec	19.699	3.56

Analysis

This phase identifies the main causes of each waste. The tool used in this stage is the Fishbone Diagram. The Fishbone diagram is an analysis and identification of the causes of waste problems based on FGD. The following analysis of the factors causing each waste with a fishbone diagram can be seen in Fig. 7, Fig. 8 and Fig. 9.

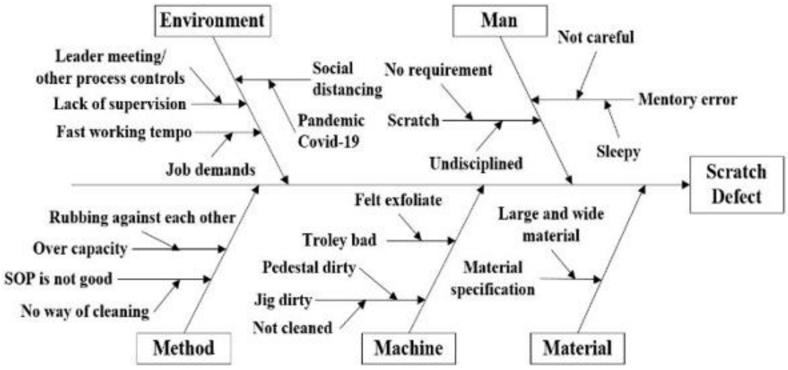

Fig. 7. Fishbone diagram of defect

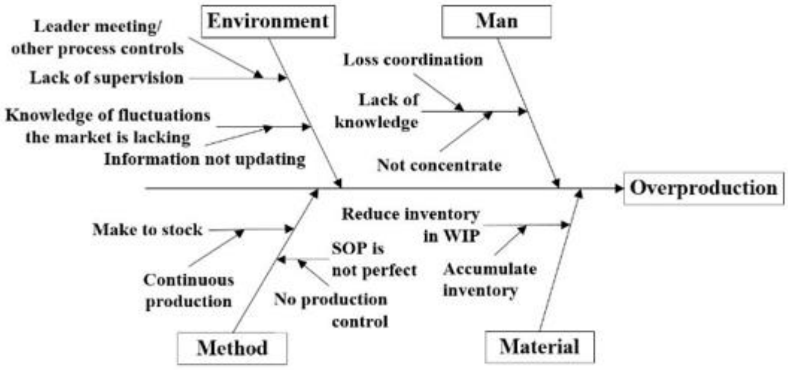

Fig. 8. Fishbone diagram of overproduction

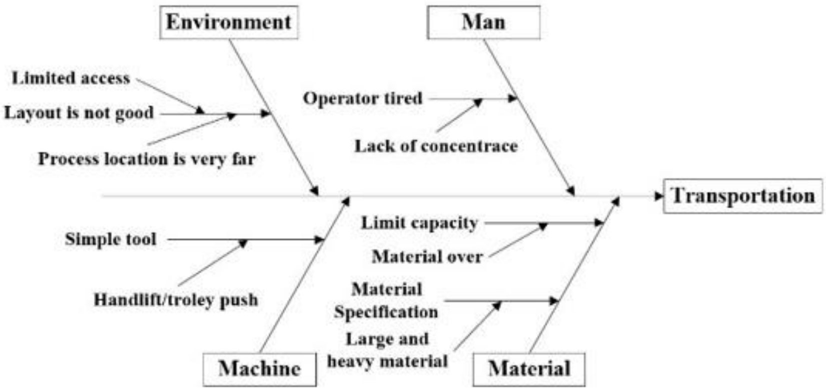

Fig. 9. Fishbone diagram of a transportation

After the root cause is identified, the next step is to calculate the RPN value using the FMEA method. This calculation is used to determine the priority ranking for improvement. This RPN assessment is carried out by expert judgment. Table 2 is the highest-ranking result of calculating the RPN value from each waste.

Implementation

Based on the results of the analysis with FMEA, then the highest ranking will be improved. Improvements were made using the kaizen implementation method in the field. The Kaizen project team went to the field to carry out the implementation for 2 working calendar weeks. The following is an explanation of each of the improvements made.

Table 2. Calculate RPN value

Waste	Potential Failure Mode	Sev	Potential Failure Effects	Occ	Potential Cause of Failure	Det	RPN	Rank
Overproduction	SOP is not perfect	5	Excess production output	6	Lack of production control	7	210	1
Transportation	The layout is not good	6	Long time transportation	6	Process location is very far	7	252	1
Defect	Nonstandard process capacity	6	Between materials rubbing against each other	7	No protective appearance	6	252	1
	Trolley and jig is bad	6	The material hit the sharp edge	6	Chipped felt	7	252	1

1. Defect

The defect repairs carried out were weekly validation on jigs and trolleys, forming a Total Productive Maintenance (TPM) team, and conducting weekly TPM. Changing the material storage area by providing a felt barrier between materials. Other improvements were made by updating the Mentoring and staining process specifications

2. Overproduction

The overproduction improvement made is to add a target LED control system to the production line with the importance of avoiding overproduction. When forming the Master Production Schedule, planning is carried out with short-term production forecasting.

3. Transportation

The transportation improvement made is a change in the layout of the factory in the material storage area. Changed the make to stock method to make to order. Eliminate material movement from supplier to WIP area. Inlinenization of staining and mentoring processes into one analyst process (can be seen in Fig. 10). The effect obtained reduces the Side Board production cycle time by 373 seconds. One operator was omitted.

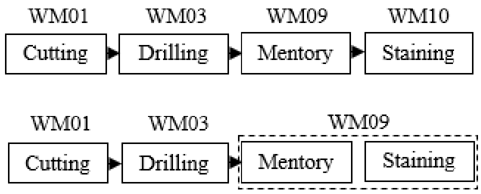

Fig. 10 Inlinezation of process

Measurement

Based on the improvements made, then re-measurement some objects that were repaired. Calculation of sigma level value after repair, production lead time, production capacity, and production yield. The improvement results are summarized and compare the results between the process before and after the improvement. This comparison is stated in the summary of the results of the study. The summary of the results of this study can be seen in Table 3.

ANOVA Test

The Anova test was conducted to determine whether there were differences in the results of quality improvement, overproduction, and transportation. Data processing on the ANOVA test was carried out using Statistic simulation. The first step was to test the normality of the data and test the homogeneity as a condition to meet the assumptions of the ANOVA test. Table 4 shows the normality test of the data using the Kmolgorov Smirnov method [32] that the average significance value is 0.05. This shows that the data is normally distributed. Table 5 shows the Homogeneity Test that the average significance value is greater than 0.05 (0.051>0.05). This shows that all population variations are the same so that the assumption of variance between homogeneous groups is fulfilled. After the assumption conditions are met, the next step is the ANOVA test. Table 6 shows the results of the Anova test analysis with IBM SPSS Statistic 21 software. Based on the output, it can be seen that the significance/probability value is 0.000. This value (0.000 < 0.05) thus the hypothesis H0 is rejected. This shows that there are differences in the results of quality improvement, overproduction and transportation so that the increase in quality can affect the reduction in wastage.

Table 3. Comparison before and after improve

Waste	Before improvement	After improvement
Defect	Sigma level 3.50	Sigma level 3.79
Overproduction	Overproduction 1.69%	Overproduction 0.6%
Transportation	Lead time 1741 s	Lead time 1368 s
	8 Operator	7 Operator
	4 element process	3 element process
	Completion Slip	Not use
Waiting	Lead time 1741 s	Lead time 1368 s

Table 4. Normality test

		Tests of normality					
Waste		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
	Quality	0.237	8	0.200*	0.900	8	0.287
Value	Overproduction	0.274	8	0.079	0.803	8	0.031
	Transportation	0.284	8	0.056	0.758	8	0.010

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 5. Homogeneity test

Test of homogeneity of variances			
Value			
Levene Statistic	df1	df2	Sig.
3.448	2	21	0.051

Table 6. ANOVA test

ANOVA					
Value					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	979.231	2	489.615	25.200	0.000
Within Groups	408.009	21	19.429		
Total	1387.240	23			

Findings

The findings of this study have had a significant impact on the musical instrument industry. Improvements made to product quality have increased and have an impact on reducing wastage. This research has a relationship or relevance to previous studies. This research has an update compared to previous research. The novelty of this research is that there is a hypothesis test using the ANOVA test. The results of the hypothesis test show that improving quality reduces wastage.

Research Contribution

Most of the musical instrument industry in Indonesia is in the middle and large groups. Every industry player has implemented improvements to increase the level of their industry. The results of this study have provided a good future direction for similar industries so that the musical instrument industry in Indonesia can move forward to achieve a competitive advantage. The results of this study guide similar industries to achieve operational excellence and become more competitive. In addition to improving product quality and reducing waste, the implications of this research are to provide an effective and efficient production system, direct companies to achieve targets, reduce labor, establish new process standards and increase customer satisfaction. The essence of the results of this study is to improve the quality of production and eliminate variables that cause waste so that waste is reduced. Some improvements that have not been achieved in this study create limitations that must be developed in further research.

4. CONCLUSION

This study aims to improve the quality of production and analyze the effect of improving quality on the waste that occurs. In this study, there are three types of waste problems, namely overproduction, transportation, and defects. The solutions given to overcome these problems include repairing defects by forming a TPM team and conducting TPM periodically on jigs and material storage equipment. Changed the method of material storage by providing a felt barrier between materials. Product quality has increased the average sigma level from 3.56 to 3.79. The results of the study are still far from the zero-defect target but provide significant results on the waste that occurs in the production line. Based on the quality improvements made, waste decreased. This research was applied to one design of production, as each model has a different production capacity. When changing the model, it must adapt to existing improvements. Further research studies can be carried out by combining Lean Six Sigma with Single Minute Exchange of Dies.

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