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Enhance quality improvement through lean six sigma in division Side Board Clavinova piano's

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Abstract:

A lean production system is one of the main factors that every company must have to improve quality, especially reducing waste that occurs in the production line. The musical instrument industry such as Piano manufacturing includes industries that reduce waste by improving the manufacturing system. The company's strategy to eliminate this waste is to create an effective and efficient work system. The piano production process still has several problems, such as the presence of waste. This is an obstacle in improving the quality of production by reducing the waste that occurs. For this reason, this research focuses on improving the quality of production by reducing waste that occurs, finding the cause of the problem and taking corrective action. The method used in this research is the integration of Lean and Six Sigma and the DMAIC framework. The process is waste flow and production problems are identified in Define phase and residual measurement is measured in Measurement phase. Fishbone diagrams and the application of FMEA are used to analyze the factors that cause problems that occur and prioritize improvements to solve these problems. The implementation of Value Stream Mapping (VSM) is applied to the Enhance of quality improvement phase to reduce waste. The results showed that product quality increased from an average sigma level of 3.53 to 3.79 where overproduction decreased by 41% and Side Board production leadtime decreased by 373 second.

Key words:

Quality improvement, lean production, dmaic, value stream mapping.

1. Introduction

Nowadays business development is going very fast, especially in the manufacturing industry. The rapid development of the manufacturing industry will have an impact on intense competition in the domestic and international markets (Hernadewita et al., 2019). The competitiveness among manufacturing industries encourages each company to increase their own productivity in various ways (Gupta et al., 2016; Soundararajan & Reddy, 2020). In addition, the best way to win the competition in the global market is to improve production quality by minimizing waste (Henny et al., 2019). The productivity and quality improvement must be proportional to the increase in product value to customers by increasing in the quality of production process (Costa et al., 2020).

The Musical Instrument Industry is one of the electronic manufacturing industries that produces the Upright piano's and Clavinova piano's. Companies are being develop various improvement strategies to increase productivity and quality (Santos et al., 2020). The production process of the Clavinova piano is devided into several sub-processes, one of which is the Side Board manufacturing process. In the production process, there have been still occured some problems that need to be fixed. As on preliminary observed, there were found wastes

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such as ineffective processes, improper layout, overproduction and poor production quality. To improve the quality of its production, the Side Board division needs to create a streamlined production process so that it will create a more effective and efficient production line. A balance between effective and efficient can be made by reducing waste (Karim & Arif-uz-zaman, 2014).

According to Liker & Meier (2006) waste is any activity that has non-value added. To eliminate waste, companies can use the concept of integration of Lean and Six Sigma (Narottam et al., 2019; Megawati et al., 2020). These two concepts are one of the main business process strategies that can be used by various companies to improve manufacturing performance (Pugna et al., 2016; Raval et al., 2019). This concept can also identify complex problems (Nandakumar et al., 2020). According to Mahato et al. (2017) propose that the integration of lean and six sigma can provide effective results for optimization of production costs so that efficient production costs are obtained. Research on Lean Six Sigma has also been developed large-scale manufacturing industries (Swarnakar et al., 2020). The application of Lean Six Sigma can not only be applied in large industries but also in small and medium industries by improving the production process (Alexander et al., 2019). Lean is a sustainable strategy to eliminate waste (Kumar et al., 2019). The loss of waste will increase the company's productivity (Prayugo & Zhong, 2021). A tool that can be used to reduce waste is Value Stream Mapping (VSM) (Lacerda et al., 2016). VSM can assist companies in identifying non-value added activities (Kosasih et al., 2019). Meanwhile, Six Sigma is an improvement to reduce variance in products so that they can provide value to customers (Belu et al., 2018; Setiawan & Setiawan, 2020). The popular Six Sigma method d is DMAIC (Bhargava & Gaur, 2021). DMAIC is used as a systematic approach to eliminate waste and the best way to improve quality in the production process (Garg et al., 2020).

This study aims to help companies to eliminate waste on the production floor and propose corrective actions to improve the production quality of the Side Board division.

Based on previous research conducted in the Musical Instrument Industry (Rochman & Agustin, 2017), it was found that the Six Sigma- DMAIC was able to reduce the level of defects in the soundboard and side piano production process. Santosa & Sugarindra (2018) were found that the Lean Manufacturing method can reduce waste in the Upright piano sanding process. Both studies focused on the Upright piano. Thus, there is a gap to conduct recent studies with different subjects.

2. Methodology

This study uses the Lean Six sigma integration method. The stages th design improvements use the systematic steps Define, Measure, Analyze, Improve, Control (DMAIC). The define phase begins by mapping the production process, defining waste and determin the Critical to Quality (CTQ). The measurement phase starts with measuring the amount of production, measuri the distance and time of transportation, creating a control chart and measuring the sigma value. The analysis phase identifies the dominant causative factor. The improve phase designs the improvement plan and implements the improvements. The last phase of process control is by setting Key Performance Indicators (KPIs). The study framework for this research can be seen in Figure 1.

3. Result And Discussion

3.1. Define Phase

Define is the first step in the DMAIC stage, the steps taken are making a production process flow

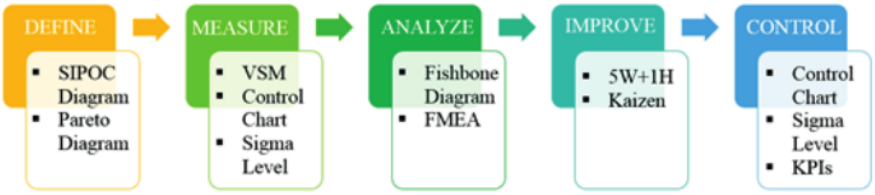

Figure 1. Study Frame Work.

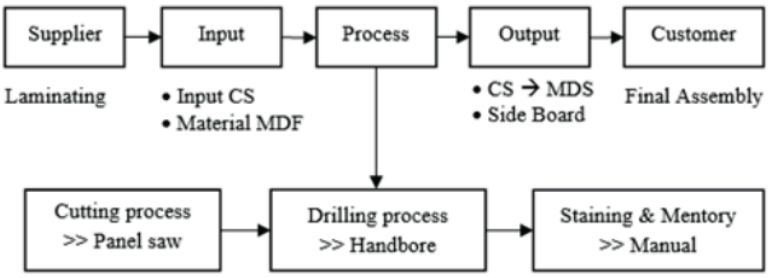

Figure 2. SIPOC diagram of the Side Board production process.

and defining the waste that occurs in the Side Board production line. SIPOC diagram making uses Side Board production process activity data obtained through observation. SIPOC diagram of the Side Board production process describes the Side Board production flow from suppliers to customers which can be seen in Figure 2. There are 7 wastes of lean manufacturing in industrial sector such as transportation, overproduction, defects, motion, inventory, waiting and overprocessing. The results of this research on the piano music instrument industry show that there are 3 wastes of lean manufacturing which dominantly affect the quality of product, namely overproduction, transportation and defects.

The results obtained in this research are:

1. *Overproduction*. Overproduction occurs because the number of products produced is more than the quantity ordered by the customer. Overproduction is a type of waste that can support the occurrence of other wastes.
2. *Transportation*. Transportation is included in non-value added activities. The disadvantage of this waste is the addition of material handling, transportation equipment, moving distances, additional space for the movement of goods and storage. Transportation can also cause product defects due to handling.
3. *Defect.* The defect occurs because the product produced does not meet the specifications set by the company. Defects that occur in the Side Board process are high enough so that customer satisfaction related to quality will be reduced, so it is necessary to improve the process so that the resulting product is close to zero defect. The type of defect in this research are scratch, not flat, exfoliate, bubble, gloss and other. By using the

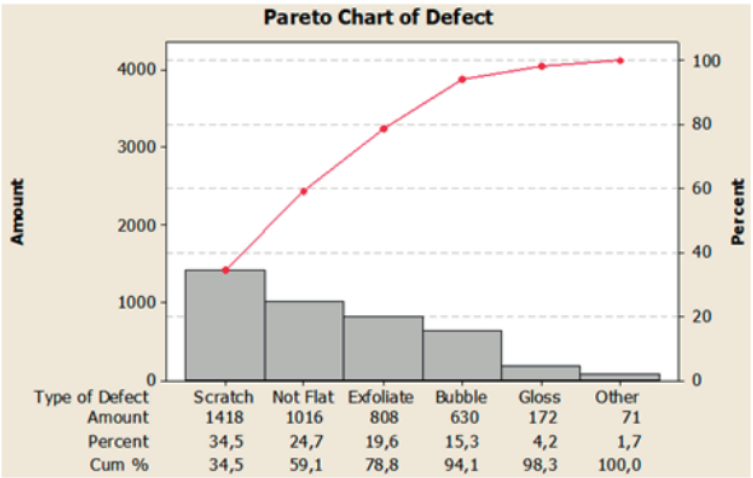

Figure 3. Pareto diagram of accumulated defects.

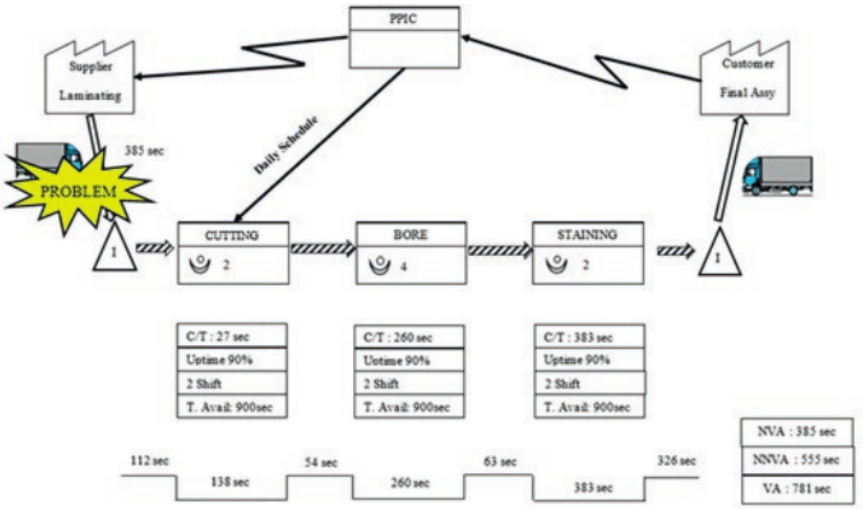

Figure 4. Value stream mapping of the Side Board process.

Pareto diagram in Figure 3, the biggest defect that occurs in the Side Board production line occurs in a scratch defect with the percentage 34,5.

3.2. Measure phase

This stage measures the waste that occurs on the production line, namely calculating the output of the amount of production, measuring the time and distance of transportation. To map the entire Side Board production flow using Value Stream Mapping. This mapping is used to find out which activities are included in the non-value added. The following value stream mapping can be seen in Figure 4.

Based on the value stream mapping map as shown in Figure 4, it can be seen that the Non-Value Added (NVA) activity is 385 second, the Value Added (VA) activity is 781 second and the Non-Value Added Necessary (NNVA) activity is 112 second.

Product control limits are used to determine product variance. The number of samples used for observation was 27 times. P chart before improvement of case in the electrican music pianos can be seen in Figure 5. Figure 5 shows that there are several points outside the of product control limit. This shows that the production process is not completely under control. Therefore it is necessary to make improvements to get a good production process.

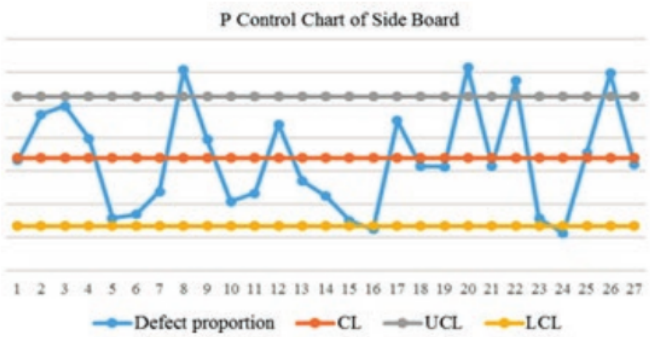

Figure 5. P-Chart of defect before improvement.

3.3. Analyze phase

Analyze phase is identifies the main factors causing each waste. Fishbone diagram are used as the tool for analyse and identify the cause of waste problem. The factors that cause each waste at Fishbone diagram can be seen in Figure 6, Figure 7 and Figure 8.

After the root cause has been identified, the next step is to calculate the Risk Priority Number (RPN) value using the Failure Mode and Effect Analysis (FMEA) method. This calculation is used to determine the priority ranking for improvement. This RPN assessment is carried out by expert judgment. Table 1 is a calculation of the RPN value of each waste.

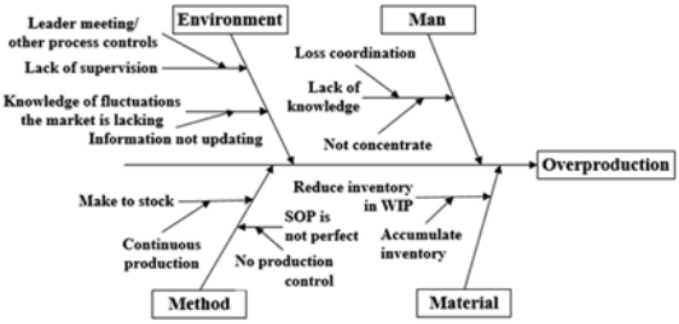

Figure 6. Fishbone diagram of overproduction.

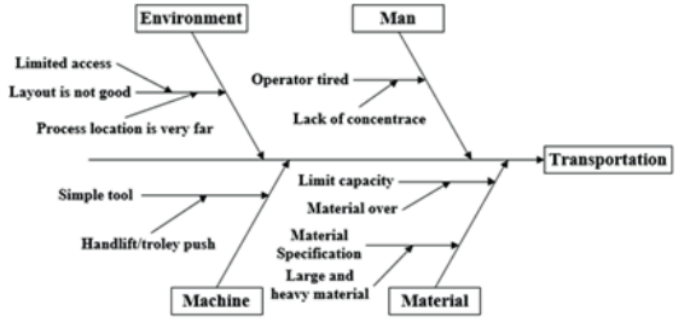

Figure 7. Fishbone diagram of transportation.

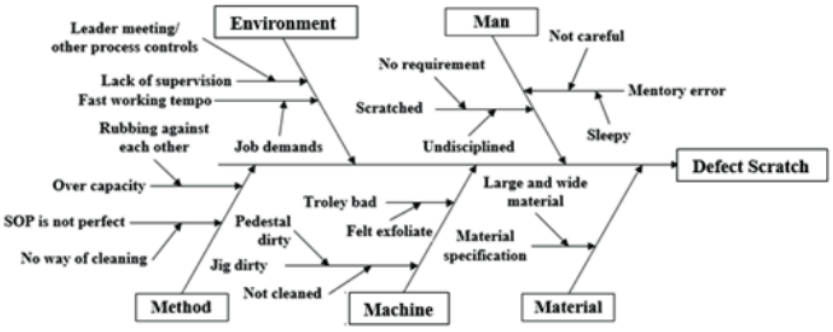

Figure 8. Fishbone diagram of defect.

Table 1. Calculation of the RPN value for each waste.

Waste	Potential Failure Mode	Sev	Potential Failure effects	Occ	Potential Cause of Failure	Det	RPN	Rank
Overproduction	SOP is not perfect	5	Excess production ouput	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

3.4. Improve phase

Based on the results of the analysis in the previous stage, the improvement of each waste can be done by the Why, What, Where, When, Who, How (5W+1H) method. Analysis of improvements with the 5W+1H method can be seen in Table 2.

The results of improvement of each waste using 5W+H are:

1. *Overproduction*. Improvements to overproduction, namely providing operators with daily production cards and posting them to general information boards. Added target control LED to the production line with the importance of avoiding overproduction. Make short-term production forecasts.

2. *Transportation*. Transportation improvement is to do kaizen re-layout in the material storage area. Change the make to stock method to make to order. Eliminates material movement from supplier to WIP area. The effect obtained reduces the Side Board production cycle time by 261 seconds.

3. *Defect*. Improvement of defects scratch, namely doing weekly validation on jigs and trolley, forming a Total Productive Maintenance (TPM) team and doing TPM weekly. Changed the method of material storage by providing felt barriers between materials

3.5. Control phase

This phase performs product control improvements with the P Chart. After improvement of product control, the production process become stable. All samples are within product control limits. P chart pf product control limits after repair can be seen in Figure 9.

In control phase also calculates the DPMO value and the sigma level. Calculation of the sigma value was carried out by taking a sample of 6 months and after the improvement took a sample of 2 months. During the observation, the sigma value show that

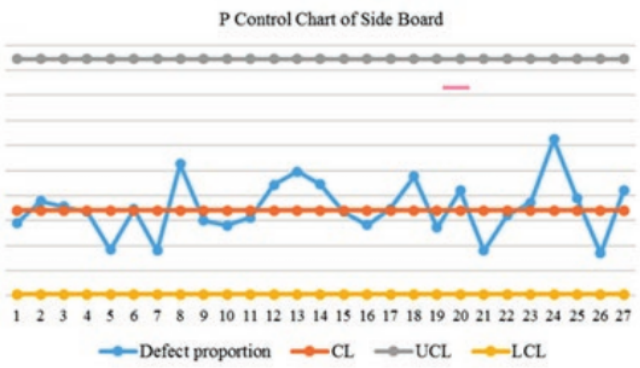

Figure 9. P chart of the defect after improvement.

Table 2. Matrix of 5W+1H analysis.

Waste	Causes	Why	What	Where	When	Who	How
		Why should it be fixed?	What needs to be fixed?	Where are the repairs done?	When is it implemented?	Who is carrying out?	How to implement?
Overproduction	Lack on production control	Maintain the production is not excessive.	SOP terkait schedule dan quantity produksi	Line Side Board	At the beginning of production and model change	Operator Side Board	Carry out briefings at the beginning of each shift to increase production targets. Provide operators with daily production plan cards. Installing LED control production system in the production line.
Transportation	Remote location	Keep the production leadtime shorter	Layout pabrik	Line Side Board	December 2020	Team of *Kaizen* wood working	Changed the system: from make to stock to job order. Thus, factory re-layout by eliminating material transfer from suppliers to the WIP line Side Board area
Defect-scratch	Felt appearnace	Keep no scratch defect products	Penggantian felt yang tidak layak pakai	Line Side Board	Saat felt terkelupas	Team of jig engineeing	Establish a TPM team. Conduct weekly validation. Preventive on the jig, so that when an abnormal jig is found, repairs are immediately carried out.
	Material storage method-missed placed	Keep no scratch defect products	Memberikan sekat pembatas antar material	Line Side Board	December 2020	Tim of *Kaizen* wood working	Changing the method of stacking material, which was originally without a partition, is now given a barrier using white felt
	Clamp stiffness	Keep no defective decoction product	Jig	Jig Engineering	At the jig abnormal	Team of jig engineeing	Establish a TPM team. Conduct weekly validation. Preventive on the jig, so that when an abnormal jig is found, repairs are immediately carried out.
Defect-peeled off	Operator -Lack of understanding	Keep no flaky defective products	Pembaruan SOP	Line Side Board	December 2022	Staff Engineering	Add the SOP points related to the correct mentoring process flow, starting from the direction of the mentoring process and standard equipment requirements to be used.

it has increased. Figure 10 show the results of sigma values comparison before and after improvement of production process. The average difference value every month is 3.5 except at January and February.

After the improvement and implementation plan are carried out, the production process control is carried out by applying KPI as a measure of success. The KPI determination at this control stage is expected to have a significant influence and role on the target action plan planned by the Side Board production line. The target of this action plan is derived from the company's vision and mission as well as the company's strategy towards a zero-defect target.

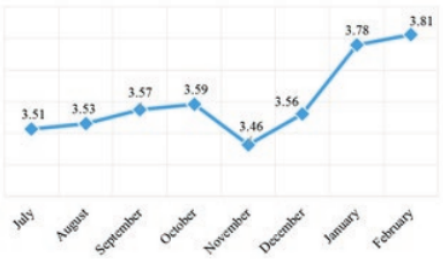

Figure 10. Sigma value comparison before and after improvement.

4. Conclusion

The main problem that occurs in the Side Board production line is the low quality of the production process which causes waste on the production floor. The low quality of the production process has a loss impact on the company. To overcome this problem, several corrective actions must be taken, including:

1. Improved overproduction by giving operators with daily production cards, installing LED controls on production lines and forecasting short-term production. The effect is that overproduction has decreased by 41%.

2. Improved kaizen re-layout on the Side Board production line can reduce the overall cycle time by 261 seconds

3. Perform TPM on jigs and trolleys. The effect is that the quality of the product has increased the average sigma level from 3.56 to 3.79

Its suggested in conducting empirical studies based on causality statistics to determine the variables that have a significant effect on company productivity and quality.

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