Minimization of Defective Products in The Department of Press Bridge & Rib Through Six Sigma DMAIC Phases

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Abstract. This study proposes the DMAIC Six Sigma approach of Define, Measure, Analyze, Improve/Implement and Control (DMAIC) to minimizing the number of defective products in the bridge & rib department. There are 5 types of defects were the most dominant are broken rib, broken sound board, strained rib, rib sliding and sound board minori. The imperative objective is to improve the quality through the DMAIC phases. In the define phase, the critical to quality (CTQ) parameters was identified minimization of product defects through the pareto chart and FMEA. In this phase, to identify waste based on the current value stream mapping. In the measure phase, the specified control limits product used to maintain the variations of the product, the calculation of the value of DPMO (Defect Per Million Opportunities) and the calculation of the value of sigma level. In analyze phase, determine the type of defect of the most dominant and identify the causes of defective products. In the improve phase, the existing design was modified through various alternative solutions by conducting brainstorming sessions. In this phase, the solution was identified based on the results of FMEA. Improvements were made to the seven priority causes of disability based on the highest RPN value. In the control phase, focusing on improvements to be made. Proposed improvements include making and define standard operating procedures, improving the quality and eliminate waste defective products.

1. Introduction

Intense competition in the business world today makes the company must constantly improve itself in order to survive and be able to continue its business. Companies should always strive to improve the quality and productivity levels for the use of resources more effectively and efficiently so that it will reduce production costs, produce higher quality products and produce better services.

Musical instrument manufacturing company has several divisions in the manufacture of piano, one of which is the press department of the bridge and rib. This department is responsible for the process of pinning cabinet treble and bass bridge, the pressing process rib on the sound board and the process of scraping residual glue on the sound board after the pressing process. In the course of the work, a product defect is difficult to avoid, product defects that often occur in the form of a broken rib, broke sound board, strained rib, rib sliding, rib defects, bass bridge chipped, rib curved, sound board striped rib passengers, bridge sliding, one press bridge, sliding bore, uki sound board, sound board peeling, trible broke and fiber sound board upside down.

The six sigma tools and techniques have been applied in various manufacturing area, which encourages continuous improvement in achieving less cost, variation and high quality of end products [1]. Six Sigma philosophy is to continuously monitor the process and aims at the elimination / reduction
of defects or failures of the manufacturing process [2]. DMAIC methodology is the Six Sigma’s unique approach to continuous process and quality improvement [3]. [4] States that the step by step approach or road map using DMAIC methodology is key success factors to Six Sigma. A systematic approach that Six Sigma DMAIC (Define, Measure, Analyze, Improve, and Control) phase is used for the elimination of waste [5]. Six Sigma is a measure of variation about the average in the service industry or the manufacturing process [6]. The primary objective of six sigma is the elimination of waste or non-value added process activities along with continuous improvement [7]. [8] States that Six Sigma is an approach to improve the efficiency and quality, by eliminating defects and errors. [9] Any deviation in the performance of the critical to quality (CTQ) characteristics are called defect. [10] Proposed that integration of statistical quality systems with six sigma results give effective results to identify the most relevant improvement areas. Based on the literature review, six sigma DMAIC used as a systematic approach to eliminate waste and the best way for improving quality/ reducing waste. This research used to determine the average value of the sigma level, the possibility of defect, the most dominant defect and propose action in an effort to minimize defects.

2. Methodology

2.1. Define
Define aims to describe the problems that occur in the company [6]. This stage contains explanations of the production lines at the press bridge and rib through SIPOC diagram (Suppliers, Inputs, Process, Outputs, and Customer) as shown by Figure 1. This stage also contains the current state value stream mapping as shown by Figure 2. This figure used to determine the flow of the production process from beginning to end. Moreover, this stage identifies waste, especially waste of defective products. Figure 1 and Figure 2 obtained from observation at a musical instrument manufacturing company.

Warehouse provides input to the press in the form of pin bridge, rib, and solid sound board. machine bridge provides input in the form of treble and bass bridge, as well as provide input in the form of cold press Sound Board Laminating. The production process starts from the pin bass & treble, press rib, press treble & bass and scrape residual glue. The resulting output is a solid and sound board laminate that has been assembled with the rib, treble & bass bridge that will be sent to the sound board assy painting up.

![SIPOC Diagram](image-url)

Figure 1. SIPOC Diagram
2.2. Measure

In the measure phase, we calculate the value of sigma level at the press bridge and rib. The data needed is total production, the number of defective products, CTQ, DPU, TOP, DPO and Defect per Million opportunities (DPMO). Products control limit are used to maintain product variation (Figure 3 and Figure 4). DPMO used to determine the value of sigma level (Figure 5).

![Figure 3. P Control Chart of Sound Board & Rib Defective Unit](image-url)

**Figure 2. Current State Value Stream Mapping**

**Figure 3. P Control Chart of Sound Board & Rib Defective Unit**
Figure 3 shows that the data produced in sample 5 passed the control limits Upper Control Limit (UCL). Data that exceeds the control limits cannot be used at a later stage.

![Revised P Control Chart of Sound Board & Rib Defective Unit](image1)

Figure 4. Revised P Control Chart of Sound Board & Rib Defective Unit

![Sigma Level Value for Press Bridge & Rib](image2)

Figure 5 Sigma Level Value for Press Bridge & Rib

2.3. **Analyze**

This stage determined the most dominant types of defects and identify the causes of defective products. Analyzes were performed using pareto diagrams and fishbone diagrams.
Analysis of the causes of defects predominant obtained through observation, interviews and brainstorming with the VSM & IE members as well as group head portion press bridge and rib discussing the cause of the defect is rib tableware, sound board tableware, rib cozy, rib slide and sound board minori.
Broken Rib
Improper storage
Work space temperature is too high
Missed quality control process
The water content in the wood is still high
Improper treatment

Machine

Broken S.B
Excessive seasoning process
Working environment temperature is not stable
High water content
Store fault
Dirty jig press

Environment

Figure 8 Fishbone diagram for broken rib

Figure 9 Fishbone diagram for broken sound board

Distantly Rib
Improperly release the jig press rib
Work space temperature is too high
Uneven gluing

Installation of rib on jig press rib less precise
Uneven rib surface
Corrugated rib surface
Moisture content not retested
Glue has not dried

Machine

Figure 10 Fishbone diagram for distantly rib
2.4. Improve
At this stage, the calculation of the value of the RPN (risk priority number) in the analysis of FMEA (failure mode and effect analysis) through interviews with members of VSM & IE as well as group head portion press bridge and rib in determining the value of severity, occurrence and detection in determining the value of the RPN for identifies priorities for the cause of the defect.

| Mode of Failure (Defect) | Potential Failure          | Cause of Failure                                      | Current Process Control             | RPN   | Rank |
|--------------------------|---------------------------|-------------------------------------------------------|------------------------------------|-------|------|
| Broken Rib               | Mc value changed          | Work space temperature is too high                    | Adding AC or blower in the work area | 336   | 1    |
| Broken Sound Board       | Mc value changed          | Working environment temperature is not stable         | Adding AC or blower in the work area | 336   | 1    |
| Distantly Rib            | No standard on gluing the rib | No standard operating procedure                       | Create standard operating procedure | 98    | 1    |
| Sliding Rib              | Checking jig unfavorable  | Checking is only done at the beginning                | The checks carried out 2 times      | 140   | 1    |
| Minori Sound Board       | Mc value changed          | Work space temperature is too high                    | Adding AC or blower in the work area | 336   | 1    |
2.5. Control
This phase contains the control that focuses on continuous improvement. Improvements to do is create and define the standard operating procedures for supervising the causes of disabilities in order for defective products can be minimized as well as increasing productivity, improving the quality and eliminate waste defective products on the part of the press bridge and rib. The application of the concept of kaizen (continuous improvement) and 5S are aimed at building a corporate culture to make improvements from small and sustainable.

3. Conclusion
The conclusion of this study are as follows:
1. The sigma level average value is equal to 4,125 and the possibility of defects by 4639 units based on DPMO value calculation.
2. There are 5 types of defects were the most dominant of broken rib with the main causes of EMC (Equilibrium Moisture Content) changes in rib, broken sound board with the main causes of the change in EMC on the sound board, rib cozy with the main causes is no standard in the gluing rib, rib slide the main cause is the lack of checking jig press in a machine press and sound board minori with main causes of EMC changes in the sound board.
3. Based on the results of FMEA with the highest RPN value of each type of defect that occurs then the proposal can be given in an effort to minimize the defects are:
   - To maintain temperature stability, it can be added to the air conditioner or blower the press area and close the emergency door in the area in order to press the external temperature does not mix with the working environment temperature.
   - For the press operator to check the condition of the press jig press machines, to ensure that the press jig installed appropriately.
   - Provide standard sizing in the treble and bass bridge and rib in order to become more flat gluing using tools or using machinery.
   - Creating standard operating procedure (SOP) in the process of quality control in the rib and the sound board as the amount of sampling done, the pressure on the rib and perform quality control for solid sound board.
   - Reviewing the procedures of stacking rib in the warehouse and training to new employees more time to how or techniques work better.

The future work lies in improving the sigma level to reach 3.2 DPMO by continuously improving on the maintain temperature stability that eliminate the defect.

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