Improving Quality of Seal Leak Test Product using Six Sigma

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Abstract. Seal leak test part is a polyurethane material-based product. Based on past data, defect level of this product was 8%, higher than the target of 5%. Quality improvement effort was done using six sigma method that included phases of define, measure, analyse, improve, and control. In the design phase, a Delphi method was used to identify factors that were critical to quality. In the measure phase, stability and process capability was measured. Fault tree analysis (FTA) and failure mode and effect analysis (FMEA) were used in the next phase to analyze the root cause and to determine the priority issues. Improve phase was done by compiling, selecting, and designing alternative repair. Some improvement efforts were identified, i.e. (i) making a checklist for maintenance schedules, (ii) making written reminder form, (iii) modifying the SOP more detail, and (iv) performing a major service to the vacuum machine. To ensure the continuity of improvement efforts, some control activities were executed, i.e. (i) controlling, monitoring, documenting, and setting target frequently, (ii) implementing reward and punishment system, (iii) adding cleaning tool, and (iv) building six sigma organizational structure.

Keywords: Six Sigma, Defect Level, Delphi Method, FTA, FMEA

1. Introduction
A make-to-stock (MTS) manufacture produces some parts based of rubber, polyurethane, and plastic material. The orders come frequently in constant manner. This manufacture applies quality control system in the production line to assure the product quality. After implementation, this manufacture found a product that still had quality problem. The product was seal leak test that is made by polyurethane. Based on past data, defect level of this product was 8%, higher than the target of 5%. This product demand is very high, so the manufacture should find a strategy to reduce the product defect level. It is because defect product can cause any others problem for the manufacture such as increasing cost, activity, and time.

In this research, six sigma methodology used to improve the product quality. Six sigma is integrated improvement methodology based on the fact and data to prevent defection of product. Six sigma could be applied to the case with the high variance condition, but it need all of stakeholder to join this improvement [1]. Six sigma methodology follow the cycle of DMAIC (define, measure, analyse, improve, and control) in improvement process. This cycle is usually used for continuous improvement strategy.
Six sigma methodology has been applied in many world class manufacture in several countries such as Motorola, General Electric, IBM, DEC, Sony, Kodak, Nokia, Philips Electronic, Alined Signal, Texas Instrument, LG, Hyundai, and Samsung [2]. Based on the new research, Six sigma methodology not only can be implemented in high volume production industry, but also in low volume production level industry or service.

2. Methodology

Six Sigma implement define-measure-analyse-improve-control (DMAIC) cycle as the improvement process framework. There are many alternative tools could be used in each phase. In define phase, we can use SIPOC (supplier-input-process-output-customer) diagram, CTQ (critical to quality) matrix, or stakeholder analysis. In measure phase, we can use measurement matrix, descriptive statistics, process capability calculation, etc. There are many tools could be used in analyse phase such as cause and effect diagram, FMEA, value stream map, ANOVA, design of experiment, etc. In improve phase, we can use theory of constraint (TOC), 5S, pull system, or creative technique. Finally, we can use control chart or project documentation in the control phase [3]. Tool selection process in each phase must consider what the purpose of the improvement.

In this research, define phase was divided in 6 steps which are identifying problem, defining six sigma objective, observing product characteristics, observing production process, identifying defect type and its root cause, and determining the critical to quality (CTQ). Problem was identified by choosing seal leak test as the product scope. The objective of this six sigma project was established by using discussion process between company experts. The objective was to improve product quality by fixing its defect cause. Product types and functions was the characteristics observed in this research for increasing researcher understanding. Then, production process observation was used to identify some causes of defect. From the root cause, researcher could determine what is the critical to quality process should be fixed.

In measure phase, process stability and capability process was measured. Stability process measurement gave the information about the variability of production process. While, capability process gave information about production process effectiveness to meet its requirements. Capability process was measured using defect per million opportunity (DPMO) value before converted to sigma value.

Then, Process stability and capability was analysed in analyse phase to identify the relation between both of them to existing process condition. After that, root cause of defect was analysed using cause and effect diagram failure tree analysis (FTA) tool. Finally, in analyse phase, failure mode and effect analysis (FMEA) was used to prioritize the defect root cause. FMEA using risk priority number (RPN) as weight for ranking all of the root cause. RPN considers severity, occurrence, and detection of each cause.

Priority root causes from analyse phase was used as an input for the next step of improve phase. Company experts did brainstorming to generate solution alternatives. All of the solution was detailed using Kipling method or 5W1H (what, why, where, when, who, how) method. After that, company chose the optimal solution alternative by expert discussion. This solution then developed into implementation plan. This plan should be feasible to be implemented.

Finally, in control phase, process performance should be monitored and compared to the previous performance. Monitoring activity can be done by using SOP and control chart. The result of solution implementation must be documented as the learning process material. If some problem is found in the
monitoring process, company must set new strategy or solution to keep the process performance better. All of the steps in this research’s DMAIC methodology could be seen in Figure 1.

![Figure 1. Six Sigma’s Research Methodology](image)

### 3. Implementation
This research was conducted at BIT Manufacture. BIT had a maximum defect target of 5%. But, at 2013, the average defect rate was still 8.86%. So, manufacture decide to improve its product quality by using six sigma methodology. In design phase, researcher and manufacture expert agree to choose only one product to be improved which was seal leak test. Seal leak test was chosen because of several reasons of its characteristics such as high volume quantity, simple production process, and complete of defect information. This objective study was to improve the seal leak test quality. There were 3 types of defect identified in define phase which were visual defect, bubbling defect, and hardness defect. Visual defect was identified by visual inspection of product form and type. Bubble type is defect cause by existence of bubble inside the material. This type makes product reliability lower. Hardness defect is conducted when the product hardness is lower than 67 or higher than 73. To identify defect root cause, this study using 3 steps of Delphi method. First step of Delphi was used to identify main factors of defect. Then, second and third Delphi used to identify, respectively, sub factor of root cause and critical factor to product quality. As the result, there were 7 CTQ which are (i) operator, (ii) workstation cleanliness, (iii) Machine condition and parameter setting, (iv) maintenance, (v) raw material quality, (vi) manufacture policy, and (vii) work method.

After CTQ had been obtained, process performance of seal leak test product was measured using fraction of defect to know process stability and DPMO to know process capability. It can be known from historical data (see Figure 2) that process stability was still unstable because the defect high variance. DPMO was also can be measured by the value of 26626 with the sigma value of 2.28. It meant that the process capability is still worse from the target of 6 sigma.
In analyse phase, several root cause was identified by considering the CTQ from the previous phase. Two methods were used to identify root cause which were cause and effect diagram and FTA. Then, FMEA used to prioritize the root cause to be chosen. FMEA found five root causes that should be fixed first which were (i) failure of machine, (ii) inexistence of maintenance system, (iii) ineffective of mixing process method, (iv) negligence of operator, and (v) uncleanliness of workstation. From these root causes, several solution alternatives has been generated using 5W1H method. There are four solutions chosen from five for improving quality seal leak test which were (i) providing check sheet for maintenance activity, (ii) providing caution notes for operator to minimize false procedure implementation, (iii) create work instruction derived from SOP, and (iv) doing major service to vacuum machine.

To assurance continuous improvement, some strategies of control phase has been proposed which were (i) controlling and monitoring process performance, (ii) documenting six sigma implementation, (iii) revising the target frequently, (iv) implementing reward and punishment system, (v) providing cleaning tool near the workstation, (vi) building organizational for six sigma, and (vii) setting future six sigma process.

4. Conclusion
Seal leak test is one of BIT product that had a problem in quality with the high number of defect. Six sigma as the quality improvement method was used to overbear this problem. In the define phase, there were 3 types of defect that caused by 7 CTQ which are (i) operator, (ii) workstation cleanliness, (iii) Machine condition and parameter setting, (iv) maintenance, (v) raw material quality, (vi) manufacture policy, and (vii) work method. In measure phase, DPMO has been measured by the value of 26626 with the sigma value of 2.28. After analyses phase, 4 solution was chosen which were (i) providing check sheet for maintenance activity, (ii) providing caution notes for operator to minimize false procedure implementation, (iii) create work instruction derived from SOP, and (iv) doing major
service to vacuum machine. To assure the implementation of solution, control strategy was developed which were (i) controlling and monitoring process performance, (ii) documenting six sigma implementation, (iii) revising the target frequently, (iv) implementing reward and punishment system, (v) providing cleaning tool near the workstation, (vi) building organizational for six sigma, and (vii) setting future six sigma process.

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