PROCESS CAPABILITY STUDY IN ELECTRONIC INDUSTRY- CASE STUDY ON AIRCOIL LEAD FRAME WELDING (HM72B-06XXX)

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ABSTRACT

The aim of this project is to implement the industrial engineering tools in selected manufacturing company to identify the process capability at the company production lines and to improve the quality of the product of company. The chosen company is B.I Technology Sdn. Bhd. and the product being analyzed is molded inductor. The capability data were obtained from B.I Technology and further analysis on the data was done manually and by using MINITAB software. The process of understanding the control and the capability (PUCC) is an iterative closed loop process for continuous improvement. It covers the DMAIC toolkit in the three phases. PUCC is an iterative approach that rotates between the three pillars of the process of understanding, process control, and process capability. The objective of the six sigma study of Molded Inductance is to achieve perfection molded manufacturing by reviewing the present robust manufacturing process, to find out way to improve and modify the process, which will yield molded inductance that are defect free and will give more customer satisfaction. The application of six sigma led to an improved process capability. At the end of this project the result is the Cpk had being improved from 0.84 to 1.75.
ABSTRAK

Tujuan kajian ini adalah untuk pelaksanaan alat kejuruteraan industri di syarikat perkilangan yang dipilih untuk mengenal pasti keupayaan proses di syarikat itu pusat pengeluaran dan meningkatkan kualiti produk syarikat. Syarikat yang dipilih adalah B.I Technology Sdn. Bhd dan produk dianalisis dibentuk pengaruh. Data keupayaan diperolehi dari Teknologi BI dan analisis lanjut mengenai data dilakukan secara manual dan dengan menggunakan perisian MINITAB. Proses memahami kawalan dan keupayaan (PUCC) adalah proses lelaran gelung tertutup untuk penambahbaikan yang berterusan. Ia meliputi Kit yang DMAIC dalam tiga fasa. PUCC adalah lelaran pendekatan yang berputar di antara tiga tiang dalam proses pemahaman, kawalan proses, dan keupayaan proses. Objektif enam sigma kajian kearuhan dibentuk adalah untuk mencapai pembuatan acuan kesempurnaan dengan mengkaji proses pembuatan yang teguh ini, untuk mengetahui cara untuk memperbaiki dan mengubah suai proses, yang akan menghasilkan kearuhan acuan yang kecacatan percuma dan akan memberi lebih kepuasan pelanggan. Permohonan enam sigma membawa kepada keupayaan proses yang lebih baik. Hasil kajian ini adalah Cpk telah diperbaiki 0.84 kepada 1.75.
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LIST OF SYMBOLS

$\bar{X}$  Mean

$A_2A_3$  Constant used to determining limits for average charts

$D_3D_4$  Constant used to determining limits for standard deviation charts.

$R$  Range

$\bar{R}$  Average range

$N$  Number of Observation
LIST OF ABBREVIATIONS

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<td>LCL</td>
<td>Lower control limit</td>
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<tr>
<td>QC</td>
<td>Quality control</td>
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<td>SOP</td>
<td>Standard operation procedure</td>
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<td>SPC</td>
<td>Statistical process control</td>
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<td>UCL</td>
<td>Upper control limit</td>
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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Six sigma is a system of practices originally developed to systematically improve processes, by eliminating the defects. The defects are defined as units that are not members of intended population. Since it was originally developed, six sigma has become an element of many total quality management (TQM) initiatives. Six sigma is a registered service mark and trademark of Motorola, Inc. Motorola has reported over US $17 billion in savings from six sigma, as of 2006. Other companies using this technique are Honeywell International (previously known as Allied Signal) and Raytheon and General Electric (introduced by Jack Welch). In recent times six sigma has been integrated with the TRIZ methodology for problem solving and product design.

A process that is six sigma (six sigma process quality is considered as world class quality) will yield just two instances of non-conformances out of every billions opportunities, provided there is no shift in the process average, and the same process will yield 3.4 instances of non-conformances out of every million opportunities with an expected shift of 1.5 sigma in the process average. A process at four sigma levels (considered average process) is expected to yield 63 instances of non-conformances for every million opportunities, without a shift in process average and 6210 instances of non-conformances with a shift in the process average. Contrary to the above, a process at the two signal level is considered a poor quality process and is expected to yield 308537 instances of non-conformances with the shift of 1.5 sigma in the process. The data for the process at different sigma levels are given in Table 1.1.
Defect values in the Table 1.1 suggest that as the sigma level goes up the defect rate reduces, which means the product quality improves. Six sigma, therefore, is a powerful tool that can transform defect prone business/industry into an organization of perfection. Thus a journey toward sigma level means a journey toward making fewer and fewer mistakes in everything.

Process capability (Cpk) is very important in order to achieve a better sigma. In recent years, Cp and Cpk indexes have become very popular as a measure of process capability in relation to the specification requirements. In other words, Cp and Cpk create more interest today than all other types’ indices. The Process Capability is a measurable property of a process to the specification. Two parts of process capability are measure the variability of the output of a process, and compare that variability with a proposed specification or product tolerance. The output of a process is expected to meet customer requirements, specifications, or engineering tolerances. Engineers can conduct a process capability study to determine the extent to which the process can meet these expectations. The ability of a process to meet specifications can be expressed as a single number using a process capability index or it can be assessed using control charts. Statistical process control defines techniques to properly differentiate between stable processes, processes that are drifting, and processes that are growing more variable.
1.2 PROBLEM STATEMENT

Nowadays, many companies want to improve their output and productivity to achieve their yearly target by eliminating some causes and production time that affect profit for company. In the manufacturing process, there are so many defects that can affect the profit of the business. The manufacturer must minimize the defect during the production of the product so that the profit of the business can be improved and the production cost can be minimized.

Aircoil lead frame welding consist of welding fixture, frame welding, and aircoil that is made of cooper. The main problem for this product is the welding is not 100% covered the area. So, the main purpose of this project is to find the effective way on how to make sure the resistance or this spot welding is 100% covered of the area and at once the product will follow customer requirements.

### Table 1.1: Six Sigma Table

<table>
<thead>
<tr>
<th>Sigma</th>
<th>Defects per Million</th>
<th>Yield</th>
</tr>
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<tbody>
<tr>
<td>6.0</td>
<td>3.4</td>
<td>99.9997%</td>
</tr>
<tr>
<td>5.0</td>
<td>233.0</td>
<td>99.977</td>
</tr>
<tr>
<td>4.0</td>
<td>6,210.0</td>
<td>99.379</td>
</tr>
<tr>
<td>3.0</td>
<td>66,807.0</td>
<td>93.32</td>
</tr>
<tr>
<td>2.5</td>
<td>158,655.0</td>
<td>84.1</td>
</tr>
<tr>
<td>2.0</td>
<td>308,538.0</td>
<td>69.1</td>
</tr>
<tr>
<td>1.5</td>
<td>500,000.0</td>
<td>50.0</td>
</tr>
<tr>
<td>1.4</td>
<td>539,828.0</td>
<td>46.0</td>
</tr>
<tr>
<td>1.3</td>
<td>579,260.0</td>
<td>42.1</td>
</tr>
<tr>
<td>1.2</td>
<td>617,911.0</td>
<td>38.2</td>
</tr>
<tr>
<td>1.1</td>
<td>655,422.0</td>
<td>34.5</td>
</tr>
<tr>
<td>1.0</td>
<td>691,462.0</td>
<td>30.9</td>
</tr>
<tr>
<td>0.5</td>
<td>841,345.0</td>
<td>15.9</td>
</tr>
<tr>
<td>0.0</td>
<td>933,193.0</td>
<td>6.7</td>
</tr>
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</table>

Source: http://6sixsigma.com/rmakale/sigmatable.JPG
1.3 PROJECT OBJECTIVES

This is the main objective had been defined to be focused on to simplify the project as stated below:

i) To improve Cpk at assembly line of BI Technology Company and achieve a value of Cpk from 0.84 to above 1.67.

1.4 SCOPE OF STUDY

The project objective is narrowed down by performing scopes of study. Firstly comprehensive literature review has been conducted to determine the best quality statistical method. Secondly a case study has been conducted at BI Technologies Industries Sdn. Bhd. on molded inductor production for aircoil lead frame welding. Then, the processes of the case study analyzed using statistical process control method which is control chart. The data collected was then analyzed using MINITAB.

1.5 IMPORTANCE OF THE PROJECT

To practice the knowledge and skill of the student that has gathered before in solving problem using academic research. This project is also important to train and increase the student capability to get to know on the research, data gathering, data analysis making and to solve the problem by research or scientific research.

1.6 CONCLUSION

As a conclusion, the overview of this project is reviewed. The problem statement is identified after selecting the suitable issued in BI Technologies Company. The scope and objective of this project are stated to specify the boundary of the study to avoid any deviation from the title of the project. Lastly, the arrangement of report and its summary of each chapter were discussed in this project.
CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discussed about literature review of the Process Capability to improve quality. It began with the introduction of the six sigma history, the meaning of six sigma, the method of Define, Measure, Analyzed, Improve and Control (DMAIC), process capability, the basic tools of statistical process control (SPC), types of control chart, about the quality, and software used.

2.2 HISTORY OF SIX SIGMA

The roots of Six Sigma as a measurement standard can be traced back to Carl Frederick Gauss (1777-1855) who introduced the concept of the normal curve. Six Sigma as a measurement standard in product variation can be traced back to the 1920's when Walter Shewhart showed that three sigma from the mean is the point where a process requires correction. Many measurement standards (Cpk, Zero Defects, etc.) later came on the scene but credit for coining the term “Six Sigma” goes to a Motorola engineer named Bill Smith. (Incidentally, “Six Sigma” is a federally registered trademark of Motorola).

In the early and mid-1980s with Chairman Bob Galvin at the helm, Motorola engineers decided that the traditional quality levels — measuring defects in thousands of opportunities – didn’t provide enough granularity. Instead, they wanted to measure the defects per million opportunities. Motorola developed this new standard and created
the methodology and needed cultural change associated with it. Six Sigma helped Motorola realize powerful bottom-line results in their organization— in fact, they documented more than $16 Billion in savings as a result of our Six Sigma efforts.

Since then, hundreds of companies around the world have adopted Six Sigma as a way of doing business. This is a direct result of many of America’s leaders openly praising the benefits of Six Sigma. Leaders such as Larry Bossidy of Allied Signal (now Honeywell), and Jack Welch of General Electric Company. Rumor has it that Larry and Jack were playing golf one day and Jack bet Larry that he could implement Six Sigma faster and with greater results at GE than Larry did at Allied Signal. The results speak for themselves.

Six Sigma has evolved over time. It’s more than just a quality system like TQM or ISO. It’s a way of doing business. As Geoff Tennant describes in his book Six Sigma: SPC and TQM in Manufacturing and Services: “Six Sigma is many things, and it would perhaps be easier to list all the things that Six Sigma quality is not. Six Sigma can be seen as: a vision; a philosophy; a symbol; a metric; a goal; a methodology.” We couldn’t agree more.

2.3 WHAT IS SIX SIGMA

Six sigma is defined by Liderman et al. (2003) as “an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make the dramatic reductions in customer defined defect rates”.

Academic research, such as Zu et al. (2008) and Schroeder et al. (2008), has tried to determine which elements in Six Sigma make it effective. Besides its role structure and focus on metrics, Six Sigma’s structure improvement procedure is seen as a novel and effective contribution to quality management. This improvement procedure is generally known under the acronym DMAIC standing for Define, Measure, Analyze, Improve and Control.

Six Sigma at many organizations simply means a measure of quality that strives for near perfection. Six Sigma is a disciplined, data-driven approach and methodology
for eliminating defects (*driving toward six standard deviations between the mean and the nearest specification limit*) in any process – from manufacturing to transactional and from product to service.

The statistical representation of Six Sigma describes quantitatively how a process is performing. To achieve Six Sigma, a process must not produce more than 3.4 defects per million opportunities. A Six Sigma defect is defined as anything outside of customer specifications. A Six Sigma opportunity is then the total quantity of chances for a defect.

Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (*errors*) and minimizing variability in manufacturing and business processes. It uses a set of quality management methods, including statistical methods, and creates a special infrastructure of people within the organization. The term Six Sigma originated from terminology associated with manufacturing, specifically terms associated with statistical modeling of manufacturing processes. The maturity of a manufacturing process can be described by a sigma rating indicating its yield or the percentage of defect-free products it creates. A six sigma process is one in which 99.9999966% of the products manufactured are statistically expected to be free of defects (*3.4 defects per million*). Six Sigma initiatives with the aim of reducing cost and improving quality.

### 2.4 DMAIC METHOD

DMAIC stands for Define, Measure, Analyze, Improve and Control. DMAIC is similar in function as its predecessors in manufacturing problem solving, such as Plan-Do-Check-Act and the Seven Step method of Juran and Gryna (*Balakrisnan et al.*, 1995). In the theory of organizational routines, DMAIC is a met routine; a routine for changing established routines or for designing new routines (*Schroeder et al.*, 2008). Originally described as a method for variation reduction, DMAIC is applied in practice as a generic problem solving and improvement approach (*McAdam and Laffery*, 2004). It is instrumental in the implementation of Six Sigma as a process improvement methodology (*Chakravotary*, 2009).
This work aims to study the Six Sigma DMAIC method from the perspective of scientific theories in the field of problem solving as published in the operations research and management science and industrial engineering literatures. Six Sigma is often describe as a problem solving methodology, and for that reason, theoretical insight from the problem solving literature should provide insight on DMAIC.

2.5 PROCESS CAPABILITY

Statistical process control (SPC) has been successfully used by companies to compete in and dominate high profit markets by improving quality and productivity for the last 20 years. A common way to summarize process performance is to use process capability indices (PCIs) which provide information concerning the variability of a process with respect to engineering specification (McCoy, 1991).

PCIs were developed in quality control branches of various large industrial and engineering institutions in Europe, Japan, and the US. The CPI of interest, Cpk, is computed using both location and dispersion information about the process. The estimate of Cpk is based on two other PCIs which are Cpu and Cpl indices:

\[
\begin{align*}
C_{pu} & = \frac{USL - \bar{X}}{3s} \\
C_{pl} & = \frac{\bar{X} - LSL}{3s} \\
C_{pk} & = \text{Min}\{C_{pl}, C_{pu}\}
\end{align*}
\]

\[
(Eq\ 2.1)
\]

\[
(Eq\ 2.2)
\]

\[
(Eq\ 2.3)
\]

Cpk is the shorter standardized distance from the center of the process to either USL or LSL. With computed values of Cpk, it is possible to estimate the number of nonconforming parts or parts per million nonconforming (Alsup and Watso, 1993).
2.6 BASIC TOOL FOR STATISTICAL PROCESS CONTROL (SPC)

Basically, there are seven quality control tools or diagrams for SPC which are check sheet, run chart, histogram, Pareto chart, scatter diagram, cause and effect diagram, and control chart (Ishikawa, 1985. and Pimblott., 1990). These seven quality control tools also known as Total Quality Management (TQM) tools (Jay and Barry, 2008).

So, for in this case study it will use control chart (see figure 2.1) as a guideline to study. The control chart is basically a run charts with upper and lower limits that allows an organization to track process performance variation. Control charts are also called process behavior chart.

![Figure 2.1: Example of a Control Chart](http://support.sas.com/documentation/cdl/en/qcug/63922)

2.7 TYPES OF CONTROL CHART

A control chart is a statistical tool used to distinguish between variations in a process resulting from common causes and variation resulting from special causes. It preset a graphic display of process stability or instability overt time.

Every process has variation. Some variation may be the result of causes which are not normally present in the process. This could be special cause variation. Some variation is simply the result of numerous, ever-present differences in the process. This is common cause variation. Control Charts differentiate between these two types of variation.
One goal of using a Control Chart is to achieve and maintain process stability. Process stability is defined as a state in which process has displayed a certain degree of consistency in the past and is expected to continue to do so in the future. There are two types of control charts which are attribute data and variables data.

Control chart are used to identify process variation over time which in the other words is the process for identifying processes that are out of control. The degree of variance and the causes of the variance can be determined using control charting techniques. There are several types of control charts (Philip L Ross, 1998).

i) c-chart
This chart uses a constant sample size of attribute data, where the average sample size is greater than five. It is used to chart the number of defect. C stands for nonconformities within a constant sample size.

ii) U-Chart
This chart uses a variable sample size of attribute data. This chart is used to chart the number of defects in a sample or set of sample. U stands for the number of nonconforming with varying sample sizes.

iii) np-chart
This chart uses a constant sample size of attribute data, usually greater than or equal to 50. This chart is used to chart the number defective in a group. np stands for the number defective.

iv) p-chart
This chart uses a variable sample size of attribute data, usually greater than or equal to 50. This chart is use to chart the fraction defective found in a group. p stands for the proportion defective.

v) X and mR chart
These charts use variable data where the sample size is one
vi) $\bar{X}$ and R charts

These charts use variable data where the sample size is small. They can also be based on a large sample size greater than or equal to ten. $\bar{X}$ stands for the average of the data collected. R stands for the range (distribution) of the data collected.

For this case study purposes, $\bar{X}$ and R charts is chosen. The sample data that obtained from the visited company is suitable to use this control chart method analysis. This will be further discusses in the next chapter.

2.8 QUALITY

Quality improvement (QI) of industrial products and processes requires collection and analyses of data to solve quality related manufacturing problems. Quality Improvement programs such as six sigma ($6\sigma$) keep encouraging collection of data to attack quality problems. According to Deming’s basic philosophy on quality, productivity improves as variability decreases due to vary causing a statistical method in quality control needed.

2.9 SOFTWARE USED

Minitab 16 is commercial software which was used to create the randomly selected normally distributed data set. Minitab 16 is the leading statistical software for analyzing data in Six Sigma and process improvement projects and statistic education. This software is frequently used for data and file management, regression analysis, power and sample size, table and graph. Minitab software also easily to use for time series and forecasting by helping to show trends in data. So, Minitab 16 is able to give a clear visual about the normal distribution graph.
2.10 CONCLUSION

Literature review that regarding to this project title has been done in this chapter. In this chapter, details descriptions of related subjects are being reviewed. Nevertheless, the details of the selected company for research will be presented in the next chapter.
CHAPTER 3

METHODOLOGY

3.1 PURPOSE OF METHODOLOGY

The purpose of the methodology is to achieve the objective of the study. Its start understanding the title of the study and will be end with an appropriate report. The methodology is a guideline of the study to make sure that all the process follows the plan. The study will be done on the molded inductor production for aircoil welding at BI Technologies. The study will cover up the only part of Cpk.