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

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**UNIVERSITY MALAYSIA PAHANG**

**FACULTY OF MANUFACTURING ENGINEERING**

We certify that the thesis entitled "Process Capability Study in Electronic Industry-Case Study on Aircoil Lead Frame Welding (HM72B-06XXX) using Statistical Process Control (SPC) is written by Noor Hidayatul Adawiyah bt Shahizan. We have examined the final copy of this thesis and in our opinion; it is fully adequate in terms of scope and quality for the award of degree of Bachelor of Manufacturing Engineering. We herewith recommended that it be accepted in fulfillment of the requirements for degree of Bachelor of Manufacturing Engineering.

Examiner: Signature:

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## SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Manufacturing Engineering.

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## STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature

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# DEDICATION

Specially dedicated to
my beloved family, friends and those who have guided and inspired me
throughout my journey of learning.

## ACKNOWLEDGEMENTS

First, I would like to express my appreciation and grateful to our Al-Mighty Allah because gave me such ability and time to have completed my Final Year Project I and II. I would like to thank to my supervisor, Dr Noraini bt Mohd Razali for her germinal ideas, invaluable guidance, continuous encouragement and her support in making this case study.

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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 |
| $A_2\ A_3$ | Constant used to determining limits for average charts |
| $D_3\ D_4$ | Constant used to determining limits for standard deviation charts. |
| $R$ | Range |
| $\bar{R}$ | Average range |
| $N$ | Number of Observation |

# LIST OF ABBREVIATIONS

| | |
|---|---|
| LCL | Lower control limit |
| QC | Quality control |
| SOP | Standard operation procedure |
| SPC | Statistical process control |
| UCL | Upper control limit |

# 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.

**Table 1.1:** Six Sigma Table

**TABLE 1.1 Sigma Table**

| *Sigma* | *Defects per Million* | *Yield* |
|---|---|---|
| 6.0 | 3.4 | 99.9997% |
| 5.0 | 233.0 | 99.977 |
| 4.0 | 6,210.0 | 99.379 |
| 3.0 | 66,807.0 | 93.32 |
| 2.5 | 158,655.0 | 84.1 |
| 2.0 | 308,538.0 | 69.1 |
| 1.5 | 500,000.0 | 50.0 |
| 1.4 | 539,828.0 | 46.0 |
| 1.3 | 579,260.0 | 42.1 |
| 1.2 | 617,911.0 | 38.2 |
| 1.1 | 655,422.0 | 34.5 |
| 1.0 | 691,462.0 | 30.9 |
| 0.5 | 841,345.0 | 15.9 |
| 0.0 | 933.193.0 | 6.7 |

**Source:** http://6sixsigma.com/rmakale/sigmatable.JPG

## 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.

## 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 an 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 :

$$Cpu = \frac{USL - \overline{X}}{3s} \qquad (Eq\ 2.1)$$

$$Cpl = \frac{\overline{X} - LSL}{3s} \qquad (Eq\ 2.2)$$

$$\text{Cpk=Min}\{\text{Cpl,Cpu}\} \qquad (Eq\ 2.3)$$

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.

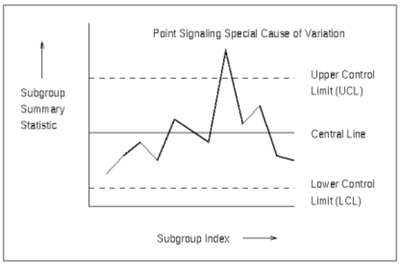



**Figure 2.1:** Example of a Control Chart

**Source:** 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.

## 3.2 PROJECT METHODOLOGY

### 3.2.1 Flow Chart

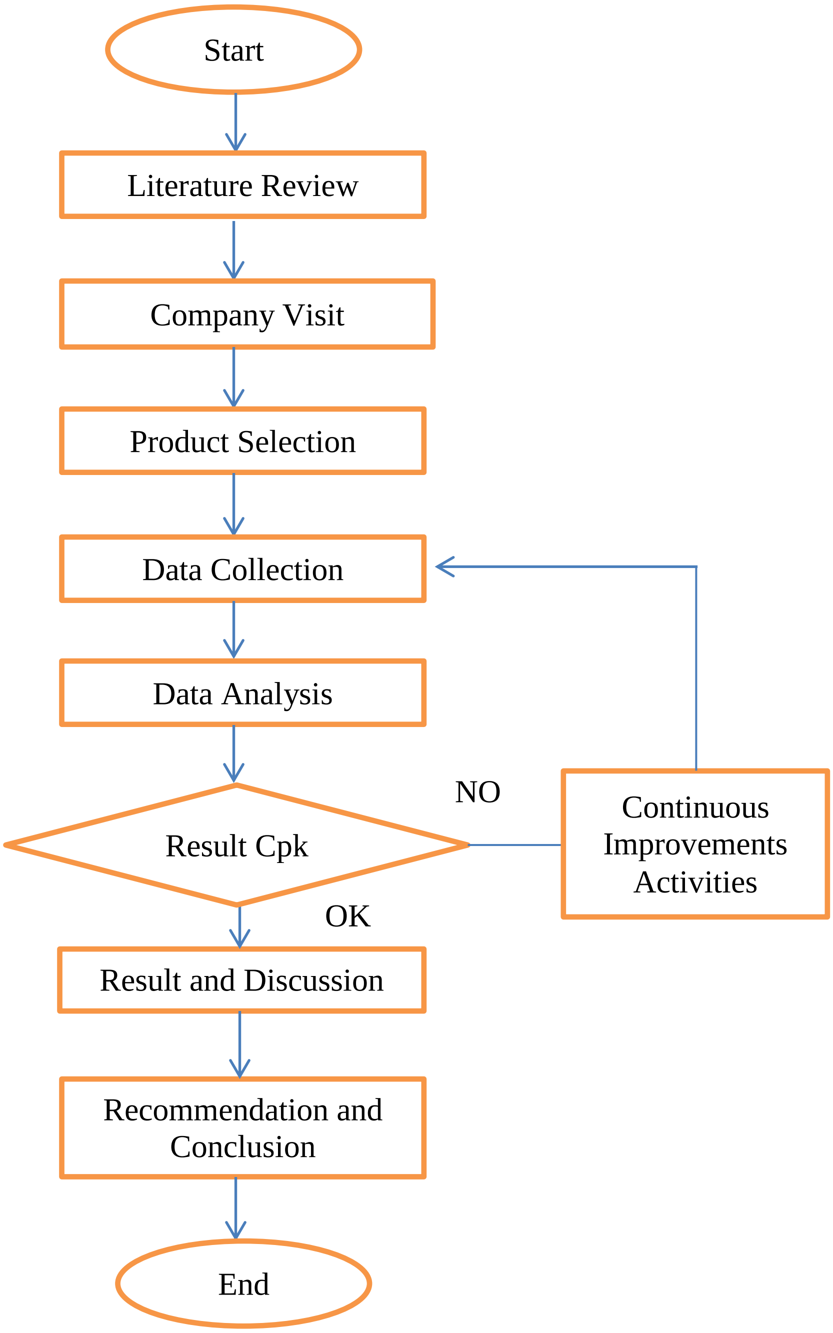



**Figure 3.1:** Flow Chart of the Project

## 3.3 COMPANY VISIT

In order to do research in manufacturing industry, application letters was drafted and sent to BI Technologies at Tanjung Api Kuantan. This company gives a positive feedback and they agreed to allow the project to be done at their company.

The appointment of the company visit is done each time before visiting. During the visit, the Quality Department engineer briefly explained the background of the company; types of the products manufactured in BI Technologies, BI Technologies main customers and how the product is produced. After the briefing, a visit to the production line and Quality Control Department were organized by the engineer to get the whole picture of how the parts are produced. A few problems during production were highlighted by the engineer and all the problems were jotted down for analysis purpose.

## 3.4 PRODUCT SELECTION

After discussion with the engineer who is responsible for the molded process, it is clear that the molded process is one of the critical processes which required highly concern for the quality. The welding for producing the part becomes high focus for production line. Thus, the welding for molded process was taken for further study. The quality performance of the product was observed carefully. Three months data from January until March of the welding molded process was collected from BI Technologies.

In BI Technologies all the collected data samples were directly observed using the histogram as the quality improvement tools. The QC engineer collected the full sample of welding molded from the production line and plot the process capability to determine whether the sample product is within the desired range or not.

According to the QC engineer, the defect of the product usually comes from human mistakes. Normally, when the parts were welded more, it will affect the parts during the assembling later.

## 3.5 DATA COLLECTION AND DATA ANALYSIS

The qualities of BI Technologies product is defined by two sources which are customer and manufacturer itself. A quality product is necessary in order to fulfill the demand of the market and customer expectation. Therefore, the company strictly controls their production by using control chart as the quality control. Each batch of the products is controlled using Microsoft Excel as the software to observe the quality performance.

The reading must be between the upper control limit and the lower control limit of the process control chart that required in SPC system. If the reading of the part is being the limit, the molded will be rejected. Normally, this product cannot be rework because of some factor.

The readings of the molded process are very important to ensure its workability and safety purpose. If the product quality is not good, the product will be quarantine for the entire batch until the engineer find the solution to solve the problems.

### 3.5.1` Inspection Frequency and Sampling Size

Frequency of this product is based on the experience of the production line controllers such as the operators and the engineers. The inspection data are the data which been recorded down that the sample normally take 10 pieces of Aircoil-Lead Frame Welding (HM72B-06XXX) every two hours per day. To calculate the limit and the capability, the data will be plotted on the control chart.

In this project, the subgroups size of 10 samples per 2 hours per daily is used. According to the study paper of “Statistic & Research Methodology” written by Dr Saiful’s notes on Medical Education the large of the subgroup is depends on the large enough to be an accurate representation of the population and also the large enough to achieve statistically significant results. Besides, refer to “Principle of Operation Management Eight Edition”, 2011 written by Heizer and Render said that the bigger the sample size, the better and accurate result can be obtained. Furthermore, the central limit theorem explained that if the subgroup size is equal to or more than 4, the process are similar or as close as normal distribution.

### 3.5.2 Type of Control Chart to be used

The molded shows some variances where the readings are not always same with the fixed dimension. The run out of the dimension must be controlled. In order to measure and represent the variances, the control chart is being used. By build the control chart, it is the best tools to represent the process and tell us what happen in that process. $\bar{X}$ and R charts are one of the variable control chart and its chosen of using $\bar{X}$ charts.

The $\bar{X}$ and R charts helps to determine if a process is stable and predictable. Besides, $\bar{X}$ and R charts is use for standardization which is mean the continuous data collecting and analysis data throughput the process operation will be required.

### 3.5.3 Problem with Current Quality Issues in BI Technologies

In BI Technologies, the quality improvement tools are using control chart to get an idea how the quality of the product. For the Aircoil-Lead (HM72B-06XXX) the problems that always occurred are no welding contact, poor welding contact and also improper lead frame position on fixture.

## 3.6 PROCESS MAPPING

Process mapping is a structural analysis of a process flow such as an order to delivery cycle by distinguishing how work is actually done from how it should be done and what functions a system should perform from the system is built to perform those functions. In this technique, main activities, information flows, interconnections, and measures are depicted as a collage on a large sheet of paper. This graphic representation allows an observer to walk-through the whole process and sees it in it’s entirely.

### 3.6.1 Flow Chart for Aircoil Lead Frame Process

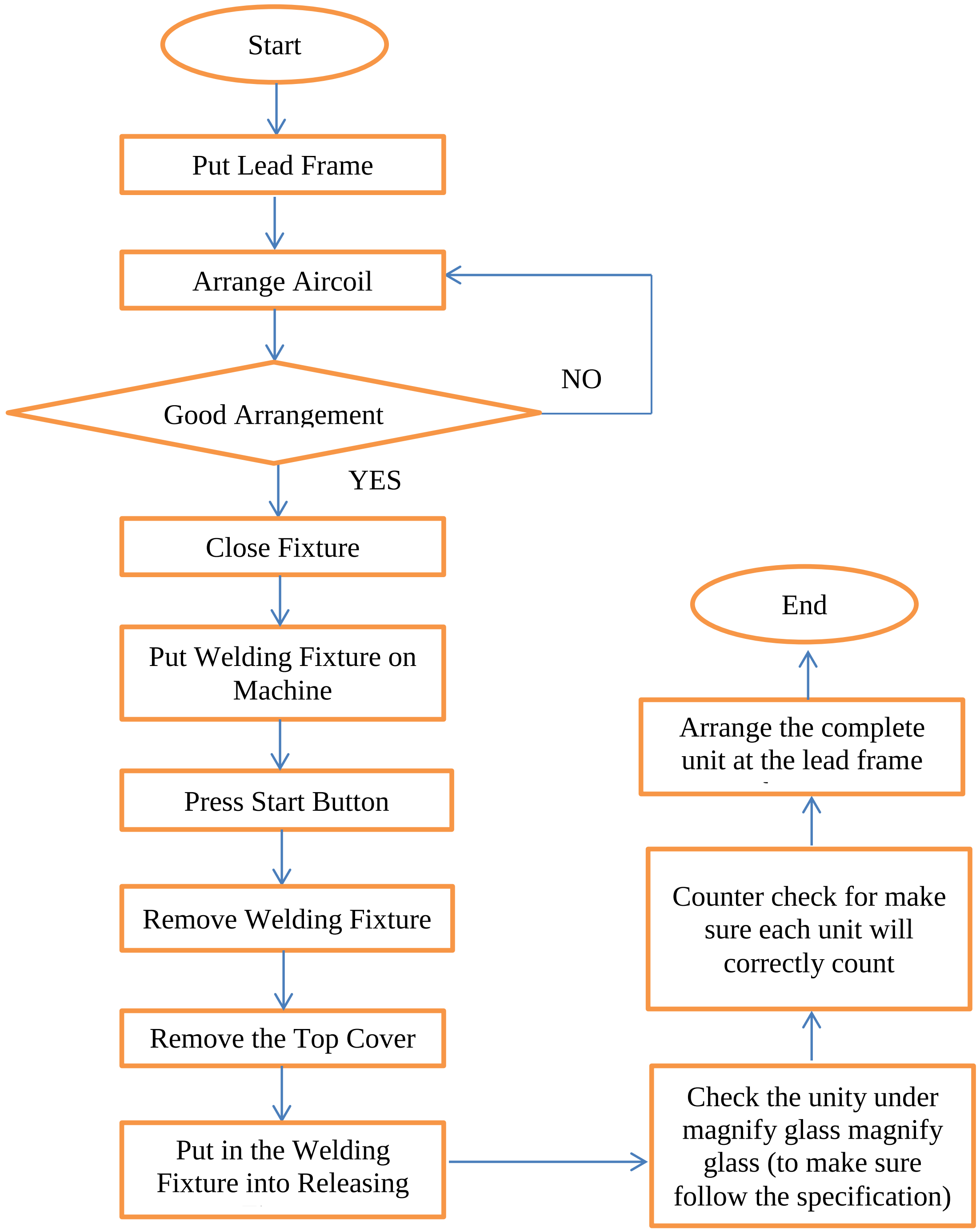



**Figure 3.2:** Flow Chart Process for AirCoil Lead Frame

### 3.6.2 Problem Detected

There are several problems detected during this study. The problems are stated as below:

i. Unbalance Welding

Unbalance welding cause by welding tip that is not correctly install it. To make sure the welding is 100% covered the welding tip must straighten install by checking using the block gauge. It also cause by unclean welding tip and it can avoid it by clean it by using sand paper. Sometimes, the dust also can affect the production. As a solution, we must make sure that the entire fixture is clean from the dust.

ii. Sparking

The pressure is a main cause of sparking. Low pressure will cause a gap between aircoil and the leadframe. Besides, sparking also caused by unclean stripping. Figure 3.4 show the comparison of good and bad stripping.

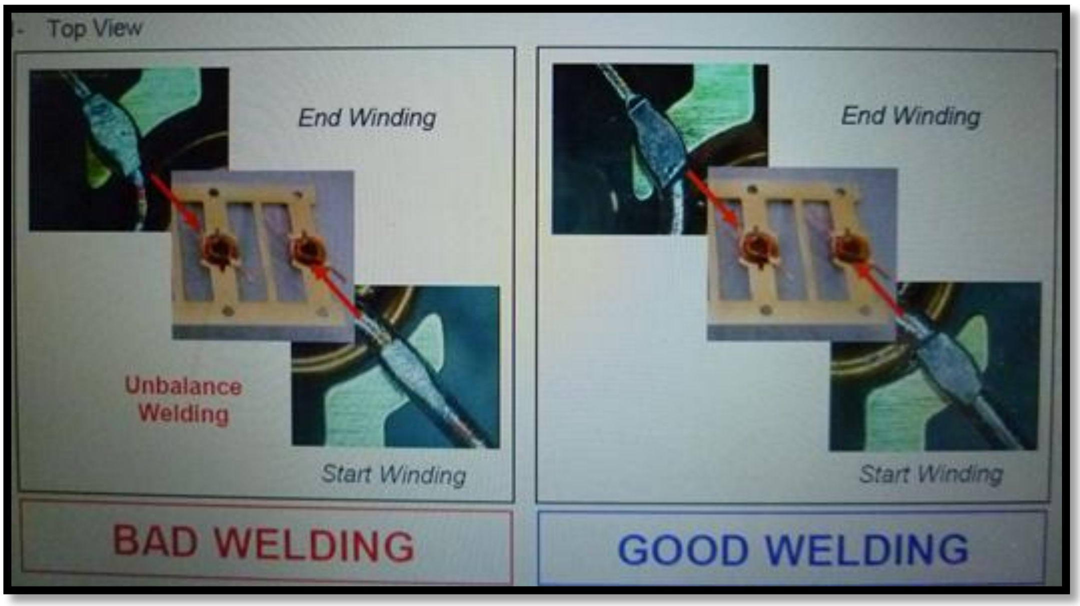
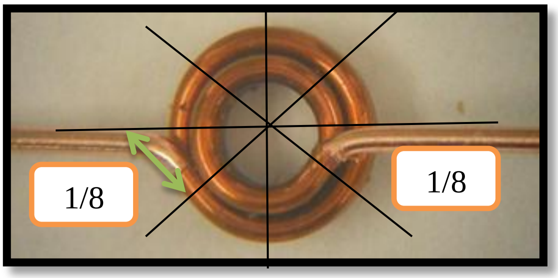


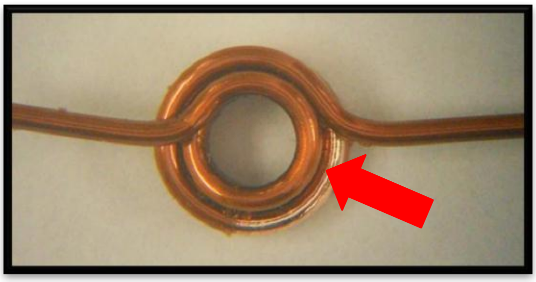

**Figure 3.3:** Unbalance Welding

GOOD AIRCOIL

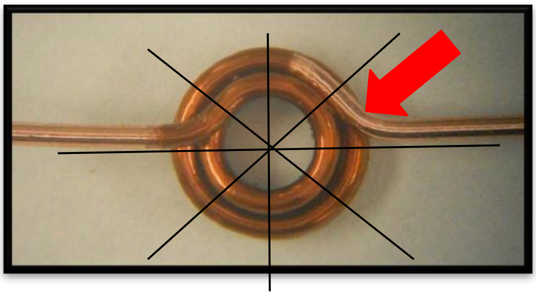



Stripping level not exceed 1/8 turns

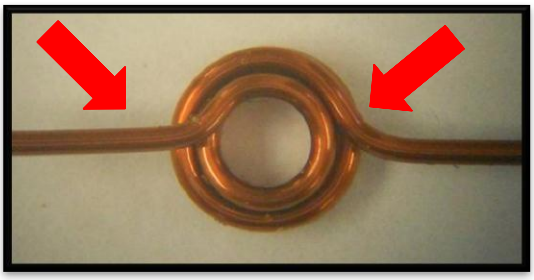
BAD AIRCOIL



Stripping at inter-layer



Stripping more than 1/8



No Stripping

**Figure 3.4:** Stripping Condition

## 3.7 TYPES OF WELDING USED

For this project, BI Technologies had used the spot welding for produce aircoil lead frame. Spot welding is a process in which contacting metal surfaces are joined by the heat obtained from resistance to electric current. Work-pieces are held together under pressure exerted by electrodes. The process uses two shaped copper alloy electrodes to concentrate welding current into a small "spot" and to simultaneously clamp the sheets together. Forcing a large current through the spot will melt the metal and form the weld. The attractive feature of spot welding is that a lot of energy can be delivered to the spot in a very short time.

The amount of heat (energy) delivered to the spot is determined by the resistance between the electrodes and the magnitude and duration of the current. The amount of energy is chosen to match the sheet's material properties, its thickness, and type of electrodes. For this production line, amount of current that had used is around $1.00 \pm 0.2$ KA while the time taken is $5 \pm 2$ ms.

## 3.8 SUGGESTION FOR CONTINUOUS IMPROVEMENT ACTIVITIES

These are some suggestion to improve quality of product at molded inductor line. For this problem it needs to calibrate the auto machine welding. The machine also need for setting again after welding around 1000 pieces of aircoil lead frame.

First, for the unbalance welding, it can check the welding tips flatness. Use a sand paper to clean the welding tips. Check for bottom tip flatness either the distance of aircoil OD is big or small. Then, also check the bottom of the fixture because it maybe has some dusts that cause the frame slanting.

Next, for the obvious burn mark the propose way to solve the problems is check for the setting current likely the current is too high or the setting time is too long or the pressure is too high.

## 3.9 SOFTWARE USED

For analyzing the result for all the three month data collection which is from January until March from BI Technologies, each data will be analyzing by using the Minitab 16 by calculating the mean and range for the data. Then the $\bar{X}$ and R charts will be selected from Minitab 16 and the graph will be plotted. The result obtained from the Minitab 16 will be analysis to determine the stability of the molded process. The upper control limit will be calculated using the Minitab 16 to determine their quality improvements.

## 3.10 PROCESS CAPABILITY

Process capability is an important concept for industrial manager to understand. The challenge in today's competitive markets is to be on the leading edge of producing high quality products at minimum costs. Statistical quality control cannot be done without a systematic approach. Process capability is very important because it allow one to quantify how well a process can produce acceptable product. A manager or engineers can prioritized needed process improvements and identify those processes that need immediately process improvement.

## 3.11 CONCLUSION

In this chapter, mainly discussed is the method used to carry forward the research. Each steps and process were described. Analysis of the process capability, root cause and the countermeasure step will be identify and implemented in order to correct the mistake until the desired result can be obtained.

Through the carefully observation, analysis and comparison between the resulted of the three month quality control (QC) data, the trend of the process can be identified and compare with the ideal parameters. Then applying the SPC control charts on each analysis to minimize the root problems by identified the occurring points.

# CHAPTER 4

# RESULT AND DISCUSSION

## 4.1 INTRODUCTION

This chapter presents the analysis of quality control (QC) data obtained from BI Technologies Industries Sdn. Bhd. The data were been presented manually and with aid of MINITAB software. The output of the current data is observed and compared with the previous data.

## 4.2 $\bar{X}$ CHART AND R CHART

An $\bar{X}$ and R chart is a pair of control charts used with processes that have a subgroup size of two or more. The standard chart for variable data $\bar{X}$ and R charts help determine if a process is stable and predictable. The $\bar{X}$ chart shows how the mean or average changes over time and the R chart show how the range of the subgroups changes over time. It is also used to monitor the effects of process improvement theories. As the standard, the $\bar{X}$ and R charts will work in place of the $\bar{X}$ and s or median and R chart. $\bar{X}$ and R charts had used in this thesis because this process had a subgroup size greater than one. The $\bar{X}$ chart is sensitive to shifts in the process mean, while the R chart is sensitive to shift in the process of standard deviation. By using both graphs, we can track changes in the process distribution.

## 4.3 PROCEDURE OF CONTROL CHART

In this case, I had decided to randomly select a subgroup on n=5 units every two hours, and the current voltage was measured. A total of sample number is 90 subgroups were sampled. The results are recorded as shown in Table 4.1, 4.2, 4.3 and 4.4. The average for each subgroup is computed and recorded in the $\bar{X}$ column. The example of calculation had shown after each table. The range for each subgroup is computed and recorded in the "R" column of the datasheet (see Table 4.1, 4.2, 4.3, and 4.4). The example of calculation had shown after each table.

The overall average ($\bar{\bar{X}}$) is calculated by adding all the value from $\bar{X}$ column and then it divide by 90 subgroups. Then continue with the average range ($\bar{R}$). $\bar{R}$ is computed by adding all the value of range and it will be divided by 90 because of the subgroups. Then, continue to calculated the upper control limit (UCL) and also lower control limit (LCL) by using formula. Value of UCL is got from $\bar{X}$ + $A_2\bar{R}$ while for LCL the value is got from $\bar{X}$ - $A_2\bar{R}$. Value for $A_2$ is constant where it get from the table of factor for computing control limit. (see appendices). Then continue to find the UCL and LCL for $\bar{R}$ chart which the formula for UCL = $D_4\bar{R}$ while LCL = $D_3\bar{R}$.Then, the $\bar{X}$-R chart is constructed as shown in the figure. Value for $D_3$ and $D_4$ also get from the table of factor for computing control limit.

In my project, I had use both of the methods which are by manual calculated and also by using minitab software. From both methods, I had compared the result which are there had get different answer. The differences in the value of UCL and LCL is different from minitab version with the manually calculated is cause by the total number of decimal places.

## 4.4 DATA ANALYSIS

### 4.4.1 Calculation for $\bar{X}$ Chart and R Chart for October

For the calculation of $\bar{X}$ chart and R chart, the data used was as tabulated in Table 4.1.

**Table 4.1:** Welding Pull Test for First Month (October)

| Sub Group No | Reading Sample | | | | | Sum | Mean (X) | Range (R) |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | |
| 1 | 2.72 | 2.35 | 1.23 | 1.46 | 2.95 | 10.71 | 2.14 | 1.72 |
| 2 | 0.88 | 1.86 | 0.96 | 1.27 | 2.23 | 7.20 | 1.44 | 1.35 |
| 3 | 0.86 | 1.42 | 1.66 | 2.01 | 1.83 | 7.78 | 1.56 | 1.15 |
| 4 | 1.18 | 0.81 | 1.96 | 0.86 | 1.14 | 5.95 | 1.19 | 1.15 |
| 5 | 0.94 | 1.14 | 2.42 | 2.22 | 1.84 | 8.56 | 1.71 | 1.48 |
| 6 | 0.82 | 0.63 | 1.88 | 1.83 | 1.92 | 7.08 | 1.42 | 1.29 |
| 7 | 3.21 | 1.95 | 3.14 | 1.07 | 2.75 | 12.12 | 2.42 | 2.14 |
| 8 | 1.93 | 2.07 | 2.71 | 2.79 | 1.92 | 11.42 | 2.28 | 0.87 |
| 9 | 2.70 | 2.17 | 2.54 | 2.64 | 2.00 | 12.05 | 2.41 | 0.70 |
| 10 | 1.29 | 1.92 | 2.93 | 1.66 | 2.22 | 10.02 | 2.00 | 1.64 |
| 11 | 2.41 | 2.46 | 2.98 | 2.71 | 2.17 | 12.73 | 2.55 | 0.81 |
| 12 | 0.89 | 2.29 | 1.64 | 2.19 | 2.10 | 9.11 | 1.82 | 1.40 |
| 13 | 2.08 | 1.91 | 2.53 | 2.66 | 3.21 | 12.39 | 2.48 | 1.30 |
| 14 | 1.53 | 2.12 | 1.93 | 1.16 | 1.90 | 8.64 | 1.73 | 0.96 |
| 15 | 1.99 | 1.23 | 1.83 | 2.20 | 1.84 | 9.09 | 1.82 | 0.97 |
| 16 | 1.25 | 1.90 | 1.66 | 2.15 | 2.59 | 9.55 | 1.91 | 1.34 |
| 17 | 1.74 | 1.15 | 1.29 | 2.22 | 1.72 | 8.12 | 1.62 | 1.07 |
| 18 | 1.44 | 2.09 | 2.22 | 1.56 | 1.25 | 8.56 | 1.71 | 0.97 |
| 19 | 3.06 | 2.83 | 2.00 | 1.94 | 2.76 | 12.59 | 2.52 | 1.12 |
| 20 | 1.75 | 1.97 | 2.05 | 2.10 | 2.55 | 10.42 | 2.08 | 0.80 |
| 21 | 3.37 | 1.36 | 1.31 | 1.53 | 1.66 | 9.23 | 1.85 | 2.06 |
| 22 | 3.15 | 2.55 | 3.24 | 1.94 | 2.15 | 13.03 | 2.61 | 1.30 |
| 23 | 3.73 | 2.86 | 2.02 | 1.33 | 2.80 | 12.74 | 2.55 | 2.40 |
| 24 | 3.22 | 1.23 | 1.33 | 2.72 | 2.52 | 11.02 | 2.20 | 1.99 |
| 25 | 2.21 | 1.02 | 1.14 | 2.97 | 3.28 | 10.62 | 2.12 | 2.26 |
| 26 | 2.49 | 1.44 | 2.06 | 0.91 | 2.49 | 9.39 | 1.88 | 1.58 |
| 27 | 3.04 | 2.68 | 2.04 | 1.91 | 2.90 | 12.57 | 2.51 | 1.13 |
| 28 | 1.36 | 1.16 | 1.50 | 2.31 | 2.51 | 8.84 | 1.77 | 1.35 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 29 | 1.10 | 1.84 | 2.38 | 1.95 | 1.80 | 9.07 | 1.81 | 1.28 |
| 30 | 1.77 | 1.34 | 1.95 | 1.41 | 1.90 | 8.37 | 1.67 | 0.61 |
| 31 | 0.98 | 1.08 | 2.30 | 2.17 | 1.97 | 8.50 | 1.70 | 1.32 |
| 32 | 1.71 | 1.12 | 1.16 | 0.84 | 1.43 | 6.26 | 1.25 | 0.87 |
| 33 | 1.99 | 1.73 | 1.28 | 1.51 | 0.94 | 7.45 | 1.49 | 1.05 |
| 34 | 2.13 | 2.31 | 2.36 | 2.42 | 2.23 | 11.45 | 2.29 | 0.29 |
| 35 | 1.69 | 1.91 | 2.06 | 2.16 | 1.57 | 9.39 | 1.88 | 0.59 |
| 36 | 1.14 | 2.21 | 2.34 | 1.64 | 1.62 | 8.95 | 1.79 | 1.20 |
| 37 | 1.44 | 1.66 | 2.10 | 1.68 | 2.06 | 8.94 | 1.79 | 0.66 |
| 38 | 0.93 | 1.08 | 1.80 | 2.16 | 2.08 | 8.05 | 1.61 | 1.23 |
| 39 | 1.48 | 1.95 | 1.23 | 1.19 | 1.57 | 7.42 | 1.48 | 0.76 |
| 40 | 3.50 | 1.96 | 0.86 | 2.41 | 1.92 | 10.65 | 2.13 | 2.64 |
| 41 | 3.48 | 1.99 | 3.46 | 2.10 | 2.90 | 13.93 | 2.79 | 1.49 |
| 42 | 0.89 | 0.82 | 2.53 | 2.51 | 1.62 | 8.37 | 1.67 | 1.71 |
| 43 | 1.51 | 1.71 | 2.24 | 1.28 | 2.64 | 9.38 | 1.88 | 1.36 |
| 44 | 1.68 | 0.96 | 2.16 | 2.52 | 2.84 | 10.16 | 2.03 | 1.88 |
| 45 | 1.12 | 1.33 | 3.04 | 1.75 | 1.96 | 9.20 | 1.84 | 1.92 |
| 46 | 1.37 | 1.23 | 1.17 | 1.12 | 1.71 | 6.60 | 1.32 | 0.59 |
| 47 | 0.93 | 2.70 | 2.77 | 2.94 | 0.67 | 10.01 | 2.00 | 2.27 |
| 48 | 2.81 | 2.25 | 2.20 | 2.54 | 3.41 | 13.21 | 2.64 | 1.21 |
| 49 | 3.52 | 2.40 | 0.95 | 2.52 | 2.17 | 11.56 | 2.31 | 2.57 |
| 50 | 2.11 | 1.07 | 0.86 | 0.85 | 3.15 | 8.04 | 1.61 | 2.30 |
| 51 | 2.53 | 1.99 | 2.12 | 1.46 | 2.68 | 10.78 | 2.16 | 1.22 |
| 52 | 2.30 | 2.33 | 0.94 | 1.24 | 1.29 | 8.10 | 1.62 | 1.39 |
| 53 | 1.61 | 1.25 | 1.52 | 2.47 | 2.25 | 9.10 | 1.82 | 1.22 |
| 54 | 1.60 | 2.09 | 1.85 | 2.18 | 2.10 | 9.82 | 1.96 | 0.58 |
| 55 | 1.64 | 1.80 | 0.92 | 1.69 | 2.09 | 8.14 | 1.63 | 1.17 |
| 56 | 0.97 | 1.51 | 1.60 | 2.47 | 2.63 | 9.18 | 1.84 | 1.66 |
| 57 | 0.89 | 1.78 | 2.06 | 2.48 | 1.35 | 8.56 | 1.71 | 1.59 |
| 58 | 2.80 | 1.62 | 2.45 | 2.70 | 2.48 | 12.05 | 2.41 | 1.18 |
| 59 | 0.93 | 2.25 | 2.18 | 2.71 | 1.98 | 10.05 | 2.01 | 1.78 |
| 60 | 0.86 | 2.14 | 2.00 | 1.13 | 2.34 | 8.47 | 1.69 | 1.48 |

**Table 4.1:** Continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 61 | 2.20 | 1.20 | 1.30 | 1.33 | 2.12 | 8.15 | 1.63 | 1.00 |
| 62 | 0.85 | 0.84 | 1.23 | 1.84 | 1.98 | 6.74 | 1.35 | 1.14 |
| 63 | 2.97 | 1.56 | 2.74 | 2.62 | 1.02 | 10.91 | 2.18 | 1.95 |
| 64 | 0.98 | 2.57 | 1.77 | 1.88 | 2.80 | 10.00 | 2.00 | 1.82 |
| 65 | 0.86 | 0.91 | 1.17 | 1.86 | 2.53 | 7.33 | 1.47 | 1.67 |
| 66 | 2.18 | 2.74 | 1.48 | 1.88 | 2.32 | 10.60 | 2.12 | 1.26 |
| 67 | 2.09 | 1.35 | 0.89 | 1.91 | 1.50 | 7.74 | 1.55 | 1.20 |
| 68 | 2.53 | 0.88 | 1.07 | 2.11 | 1.48 | 8.07 | 1.61 | 1.65 |
| 69 | 1.51 | 0.89 | 1.90 | 1.77 | 2.72 | 8.79 | 1.76 | 1.83 |
| 70 | 1.65 | 0.83 | 2.57 | 2.00 | 2.48 | 9.53 | 1.91 | 1.74 |
| 71 | 0.81 | 0.87 | 0.88 | 0.98 | 0.85 | 4.39 | 0.88 | 0.17 |
| 72 | 1.15 | 1.63 | 1.67 | 1.75 | 2.31 | 8.51 | 1.70 | 1.16 |
| 73 | 2.26 | 2.51 | 2.31 | 1.24 | 1.25 | 9.57 | 1.91 | 1.27 |
| 74 | 1.66 | 0.88 | 2.15 | 2.55 | 1.15 | 8.39 | 1.68 | 1.67 |
| 75 | 0.87 | 1.27 | 1.28 | 2.02 | 1.64 | 7.08 | 1.42 | 1.15 |
| 76 | 1.05 | 0.97 | 0.89 | 1.21 | 1.11 | 5.23 | 1.05 | 0.32 |
| 77 | 0.85 | 1.11 | 1.14 | 1.52 | 1.65 | 6.27 | 1.25 | 0.80 |
| 78 | 0.84 | 0.82 | 1.20 | 1.02 | 1.11 | 4.99 | 1.00 | 0.38 |
| 79 | 1.89 | 1.28 | 2.52 | 2.21 | 1.43 | 9.33 | 1.87 | 1.24 |
| 80 | 1.96 | 2.13 | 1.72 | 1.99 | 1.34 | 9.14 | 1.83 | 0.79 |
| 81 | 1.49 | 1.27 | 0.81 | 1.48 | 2.72 | 7.77 | 1.55 | 1.91 |
| 82 | 0.97 | 0.90 | 1.14 | 1.96 | 2.43 | 7.40 | 1.48 | 1.53 |
| 83 | 1.27 | 1.28 | 2.02 | 0.89 | 1.52 | 6.98 | 1.40 | 1.13 |
| 84 | 0.89 | 1.90 | 1.77 | 1.20 | 0.98 | 6.74 | 1.35 | 1.01 |
| 85 | 0.81 | 2.01 | 1.54 | 1.01 | 1.25 | 6.62 | 1.32 | 1.20 |
| 86 | 1.55 | 2.48 | 1.94 | 1.05 | 2.74 | 9.76 | 1.95 | 1.69 |
| 87 | 1.00 | 2.06 | 1.50 | 1.79 | 2.48 | 8.83 | 1.77 | 1.48 |
| 88 | 2.05 | 1.06 | 1.50 | 2.23 | 2.23 | 9.07 | 1.81 | 1.17 |
| 89 | 1.04 | 0.86 | 2.07 | 1.81 | 1.91 | 7.69 | 1.54 | 1.21 |
| 90 | 2.52 | 2.31 | 1.80 | 1.24 | 1.20 | 9.07 | 1.81 | 1.32 |
| **TOTAL** | | | | | | | **164.29** | **119.23** |
| | | | | | | | $\bar{\bar{X}}$**=1.83** | $\bar{R}$ **=1.32** |
| | | | | | | **STDEV** | 0.39 | |
| | | | | | | **Cpk** | **0.84** | |

Lower control limit for $\bar{X}$ chart, LCL = $\bar{X} - A_2\bar{R}$

Upper control limit for $\bar{X}$ chart, UCL = $\bar{X} + A_2\bar{R}$

Lower control limit for R chart, LCL = $D_3\bar{R}$

Upper control limit for R chart, UCL = $D_4\bar{R}$

1) $\bar{X}$ chart calculation

$\bar{X}$ = 1.83 (center limit)

$\bar{R}$ = 1.32

| | | | |
|---|---|---|---|
| LCL | = $\bar{X} - A_2\bar{R}$ | UCL | = $\bar{X} + A_2\bar{R}$ |
| | = 1.83 – 0.577(1.32) | | = 1.83 + 0.577(1.32) |
| | = 1.068 | | = 2.592 |

2) $\bar{R}$ chart calculation

$\bar{R}$ = 1.32

| | | | |
|---|---|---|---|
| LCL | = $D_3\bar{R}$ | UCL | = $D_4\bar{R}$ |
| | = 0(1.32) | | = 2.114(1.32) |
| | = 0 | | = 2.790 |

**Minitab 16 Analysis on $\bar{X}$ Chart and R Chart For October**

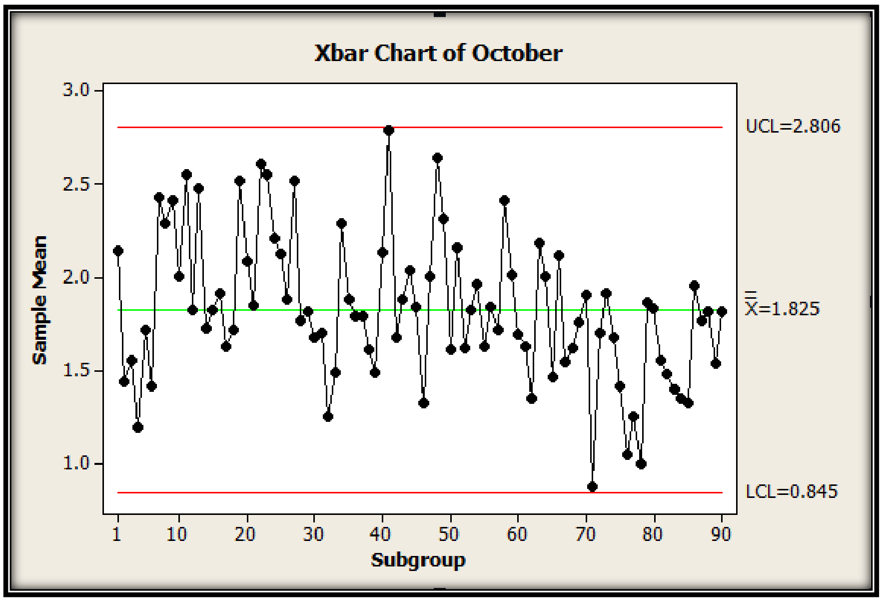



**Figure 4.1:** $\bar{X}$ Chart for October

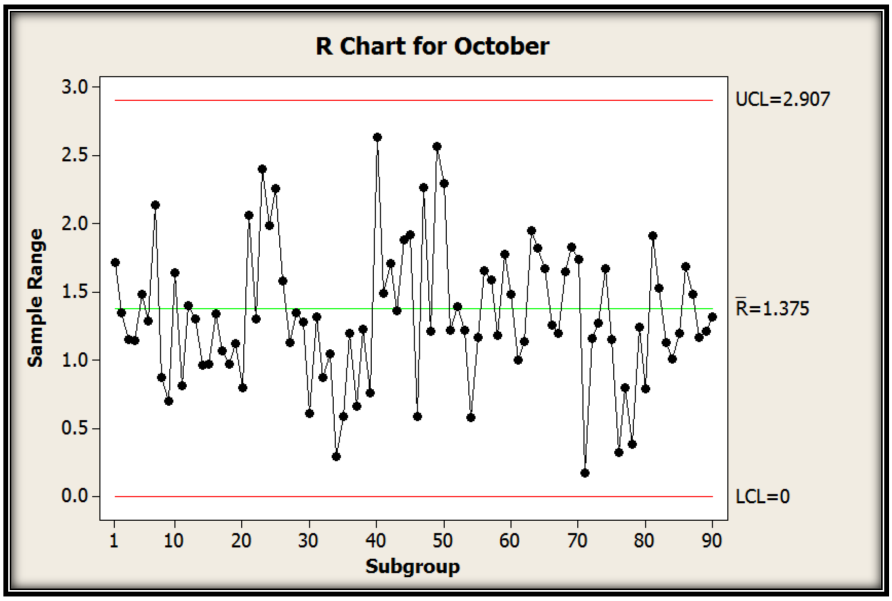



**Figure 4.2:** R Chart for October

### 4.4.2 Calculation for $\bar{X}$ Chart and R Chart for November

For the calculation of $\bar{X}$ chart and R chart, the data used was as tabulated in Table 4.2.

**Table 4.2:** Welding Pull Test for Second Month (November)

| Sub Group No | Reading Sample | | | | | Sum | Mean (X) | Range (R) |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | |
| 1 | 1.96 | 2.13 | 1.72 | 1.99 | 1.34 | 9.14 | 1.83 | 0.79 |
| 2 | 1.49 | 1.27 | 0.81 | 1.48 | 2.72 | 7.77 | 1.55 | 1.91 |
| 3 | 0.87 | 0.90 | 0.89 | 1.96 | 2.43 | 7.05 | 1.41 | 1.56 |
| 4 | 1.27 | 2.28 | 2.02 | 0.84 | 2.56 | 8.97 | 1.79 | 1.72 |
| 5 | 2.18 | 2.74 | 1.48 | 1.88 | 2.32 | 10.60 | 2.12 | 0.84 |
| 6 | 2.09 | 1.35 | 0.89 | 1.91 | 1.50 | 7.74 | 1.55 | 1.20 |
| 7 | 2.53 | 0.88 | 1.07 | 2.11 | 1.48 | 8.07 | 1.61 | 1.65 |
| 8 | 1.51 | 0.89 | 1.90 | 1.77 | 2.72 | 8.79 | 1.76 | 0.89 |
| 9 | 1.65 | 0.83 | 2.57 | 2.00 | 2.48 | 9.53 | 1.91 | 1.74 |
| 10 | 1.81 | 0.87 | 0.88 | 0.98 | 0.85 | 5.39 | 1.08 | 0.96 |
| 11 | 1.74 | 2.15 | 1.29 | 2.22 | 1.72 | 9.12 | 1.82 | 0.93 |
| 12 | 2.40 | 1.09 | 2.22 | 1.25 | 2.75 | 9.71 | 1.94 | 1.66 |
| 13 | 1.06 | 2.83 | 2.00 | 1.94 | 2.76 | 10.59 | 2.12 | 1.77 |
| 14 | 1.75 | 1.97 | 2.05 | 2.10 | 2.55 | 10.42 | 2.08 | 0.80 |
| 15 | 2.37 | 1.36 | 1.31 | 1.53 | 1.66 | 8.23 | 1.65 | 1.06 |
| 16 | 1.56 | 2.55 | 3.24 | 1.94 | 2.15 | 11.44 | 2.29 | 1.68 |
| 17 | 1.99 | 1.73 | 1.28 | 1.51 | 0.94 | 7.45 | 1.49 | 1.05 |
| 18 | 2.13 | 2.31 | 2.36 | 2.42 | 2.23 | 11.45 | 2.29 | 0.29 |
| 19 | 1.69 | 1.91 | 2.06 | 2.16 | 1.57 | 9.39 | 1.88 | 0.59 |
| 20 | 1.04 | 2.95 | 2.34 | 1.64 | 1.62 | 9.59 | 1.92 | 1.91 |
| 21 | 1.44 | 1.66 | 2.10 | 1.68 | 2.06 | 8.94 | 1.79 | 0.66 |
| 22 | 0.93 | 0.99 | 1.80 | 2.16 | 2.08 | 7.96 | 1.59 | 1.23 |
| 23 | 1.93 | 2.07 | 2.71 | 2.79 | 1.92 | 11.42 | 2.28 | 0.87 |

**Table 4.2:** Continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 24 | 2.70 | 2.17 | 2.54 | 2.64 | 2.00 | 12.05 | 2.41 | 0.70 |
| 25 | 1.29 | 1.92 | 2.93 | 1.66 | 2.22 | 10.02 | 2.00 | 1.64 |
| 26 | 2.41 | 2.46 | 1.98 | 2.71 | 2.17 | 11.73 | 2.35 | 0.73 |
| 27 | 0.84 | 2.29 | 1.64 | 2.19 | 1.16 | 8.12 | 1.62 | 0.84 |
| 28 | 2.08 | 1.91 | 2.53 | 2.66 | 3.21 | 12.39 | 2.48 | 1.30 |
| 29 | 2.56 | 2.42 | 2.59 | 2.17 | 0.85 | 10.59 | 2.12 | 1.74 |
| 30 | 2.97 | 2.25 | 2.38 | 1.66 | 1.97 | 11.23 | 2.25 | 1.31 |
| 31 | 0.87 | 1.29 | 1.19 | 0.83 | 1.23 | 5.41 | 1.08 | 0.46 |
| 32 | 1.02 | 0.96 | 1.62 | 2.03 | 2.03 | 7.66 | 1.53 | 1.07 |
| 33 | 1.23 | 0.86 | 0.97 | 2.12 | 2.34 | 7.52 | 1.50 | 1.48 |
| 34 | 2.27 | 1.12 | 0.82 | 0.99 | 0.67 | 5.87 | 1.17 | 1.60 |
| 35 | 1.61 | 1.25 | 1.52 | 2.47 | 2.25 | 9.10 | 1.82 | 1.22 |
| 36 | 2.07 | 0.96 | 2.09 | 1.03 | 1.99 | 8.14 | 1.63 | 1.13 |
| 37 | 2.30 | 2.13 | 0.81 | 2.05 | 2.38 | 9.67 | 1.93 | 1.57 |
| 38 | 1.84 | 2.55 | 2.09 | 2.55 | 2.27 | 11.30 | 2.26 | 0.71 |
| 39 | 1.90 | 1.23 | 1.63 | 1.24 | 1.77 | 7.77 | 1.55 | 0.67 |
| 40 | 1.54 | 1.06 | 1.24 | 2.62 | 1.14 | 7.60 | 1.52 | 1.56 |
| 41 | 2.10 | 2.25 | 1.62 | 2.13 | 2.50 | 10.60 | 2.12 | 0.88 |
| 42 | 1.98 | 1.73 | 1.69 | 1.77 | 1.76 | 8.93 | 1.79 | 0.29 |
| 43 | 2.32 | 2.83 | 2.01 | 2.14 | 2.57 | 11.87 | 2.37 | 0.82 |
| 44 | 1.47 | 2.87 | 2.51 | 2.15 | 3.23 | 12.23 | 2.45 | 1.76 |
| 45 | 1.45 | 2.07 | 1.88 | 2.64 | 2.92 | 10.96 | 2.19 | 1.47 |
| 46 | 1.18 | 2.03 | 1.61 | 2.16 | 0.97 | 7.95 | 1.59 | 1.06 |
| 47 | 2.41 | 2.15 | 2.23 | 1.99 | 2.55 | 11.33 | 2.27 | 0.56 |
| 48 | 2.84 | 1.88 | 2.29 | 2.26 | 1.57 | 10.84 | 2.17 | 1.27 |
| 49 | 3.21 | 2.60 | 1.34 | 1.90 | 1.60 | 10.65 | 2.13 | 1.87 |
| 50 | 1.84 | 1.88 | 1.92 | 1.06 | 1.57 | 8.27 | 1.65 | 0.86 |
| 51 | 1.34 | 1.62 | 1.89 | 2.83 | 2.51 | 10.19 | 2.04 | 1.17 |
| 52 | 1.51 | 1.72 | 2.95 | 2.65 | 2.34 | 11.17 | 2.23 | 1.14 |
| 53 | 1.40 | 1.45 | 1.15 | 2.08 | 2.13 | 8.21 | 1.64 | 0.98 |
| 54 | 1.45 | 1.88 | 0.98 | 1.45 | 2.73 | 8.49 | 1.70 | 1.75 |
| 55 | 1.38 | 2.96 | 1.86 | 1.27 | 1.78 | 9.25 | 1.85 | 1.69 |
| 56 | 2.34 | 1.49 | 2.16 | 1.66 | 1.93 | 9.58 | 1.92 | 0.85 |
| 57 | 1.09 | 1.29 | 1.96 | 2.17 | 2.18 | 8.69 | 1.74 | 1.09 |
| 58 | 1.87 | 2.29 | 2.25 | 1.68 | 1.56 | 9.65 | 1.93 | 0.73 |
| 59 | 2.52 | 2.31 | 2.11 | 1.48 | 1.89 | 10.31 | 2.06 | 1.04 |
| 60 | 1.99 | 2.04 | 1.59 | 1.88 | 1.57 | 9.07 | 1.81 | 0.47 |

**Table 4.2:** Continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 61 | 1.97 | 2.13 | 1.38 | 1.89 | 2.29 | 9.66 | 1.93 | 0.91 |
| 62 | 2.93 | 2.29 | 1.06 | 1.92 | 2.20 | 10.40 | 2.08 | 1.87 |
| 63 | 2.20 | 2.29 | 1.36 | 2.01 | 1.52 | 9.38 | 1.88 | 0.93 |
| 64 | 1.47 | 1.90 | 1.36 | 1.72 | 0.96 | 7.41 | 1.48 | 0.94 |
| 65 | 1.25 | 2.08 | 2.01 | 2.41 | 2.89 | 10.64 | 2.13 | 1.64 |
| 66 | 1.29 | 2.25 | 1.98 | 2.46 | 1.94 | 9.92 | 1.98 | 1.17 |
| 67 | 1.43 | 1.84 | 2.02 | 1.06 | 1.25 | 7.60 | 1.52 | 0.96 |
| 68 | 2.80 | 1.26 | 1.55 | 1.92 | 2.45 | 9.98 | 2.00 | 1.54 |
| 69 | 1.84 | 1.68 | 2.04 | 1.02 | 0.97 | 7.55 | 1.51 | 1.07 |
| 70 | 2.45 | 1.24 | 1.25 | 1.73 | 1.47 | 8.14 | 1.63 | 1.21 |
| 71 | 0.86 | 1.21 | 1.14 | 1.08 | 1.36 | 5.65 | 1.13 | 0.50 |
| 72 | 1.01 | 1.03 | 1.40 | 1.17 | 2.01 | 6.62 | 1.32 | 1.00 |
| 73 | 1.65 | 1.06 | 2.96 | 1.93 | 2.14 | 9.74 | 1.95 | 1.90 |
| 74 | 1.75 | 1.56 | 1.92 | 2.22 | 1.55 | 9.00 | 1.80 | 0.67 |
| 75 | 1.84 | 1.72 | 1.95 | 2.95 | 2.85 | 11.31 | 2.26 | 1.23 |
| 76 | 2.17 | 1.88 | 2.52 | 2.51 | 1.93 | 11.01 | 2.20 | 0.64 |
| 77 | 1.03 | 1.35 | 2.29 | 1.82 | 1.84 | 8.33 | 1.67 | 1.26 |
| 78 | 2.19 | 2.39 | 1.05 | 2.31 | 2.57 | 10.51 | 2.10 | 1.52 |
| 79 | 2.16 | 2.64 | 1.96 | 2.06 | 1.86 | 10.68 | 2.14 | 0.78 |
| 80 | 2.50 | 2.54 | 1.34 | 2.58 | 2.63 | 11.59 | 2.32 | 1.29 |
| 81 | 1.92 | 2.31 | 1.29 | 1.23 | 2.21 | 8.96 | 1.79 | 0.98 |
| 82 | 2.15 | 1.02 | 2.69 | 2.76 | 2.72 | 11.34 | 2.27 | 1.74 |
| 83 | 2.87 | 2.12 | 1.97 | 2.48 | 2.22 | 11.66 | 2.33 | 0.90 |
| 84 | 2.31 | 2.41 | 2.78 | 1.90 | 2.18 | 11.58 | 2.32 | 0.88 |
| 85 | 2.21 | 2.05 | 2.05 | 0.87 | 1.20 | 8.38 | 1.68 | 1.34 |
| 86 | 2.83 | 1.05 | 3.03 | 2.62 | 2.40 | 11.93 | 2.39 | 1.98 |
| 87 | 1.25 | 2.66 | 2.34 | 2.44 | 2.44 | 11.13 | 2.23 | 1.41 |
| 88 | 2.22 | 2.29 | 2.07 | 2.64 | 2.66 | 11.88 | 2.38 | 0.59 |
| 89 | 2.78 | 1.17 | 2.17 | 2.04 | 2.07 | 10.23 | 2.05 | 1.61 |
| 90 | 2.19 | 1.97 | 2.36 | 3.10 | 1.86 | 11.48 | 2.30 | 1.24 |
| **Total** | | | | | | | **171.37** | **104.94** |
| | | | | | | | $\bar{\bar{X}}$**=1.90** | $\bar{R}$ **=1.17** |
| | | | | | | **STDEV** | 0.34 | |
| | | | | | | **Cpk** | **0.91** | |

1) $\bar{X}$ chart calculation

$\bar{X}$ = 1.90 (center limit)

$\bar{R}$ = 1.208

LCL = $\bar{X} - A_2\bar{R}$
= 1.90 – 0.577(1.21)
= 1.202

UCL = $\bar{X} + A_2\bar{R}$
= 1.90 + 0.577(1.21)
= 2.598

2) $\bar{R}$ chart calculation

$\bar{R}$ = 1.208

LCL = $D_3\bar{R}$
= 0(1.21)
= 0

UCL = $D_4\bar{R}$
= 2.114(1.21)
= 2.558

**Minitab 16 Analysis on $\bar{X}$ Chart and R Chart For November**

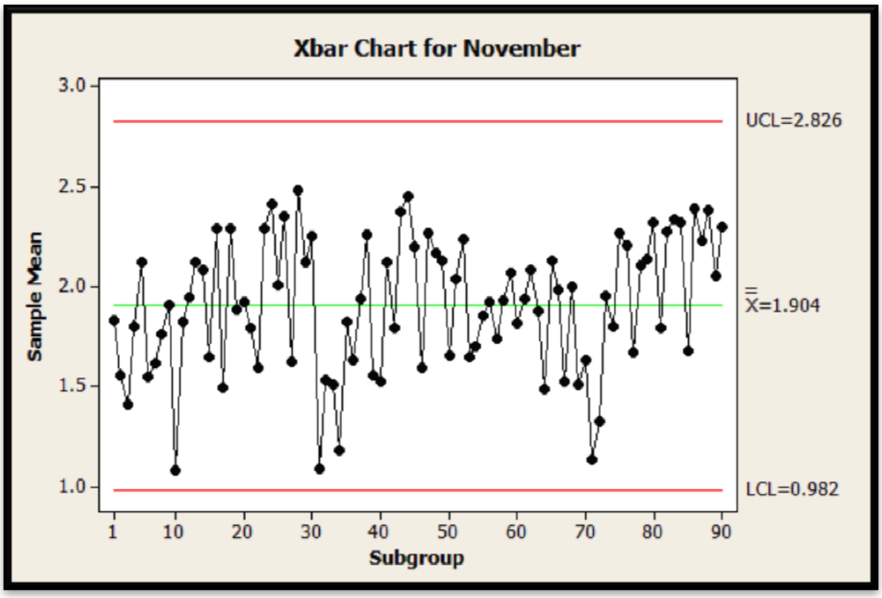



**Figure 4.3:** $\bar{X}$ Chart for November

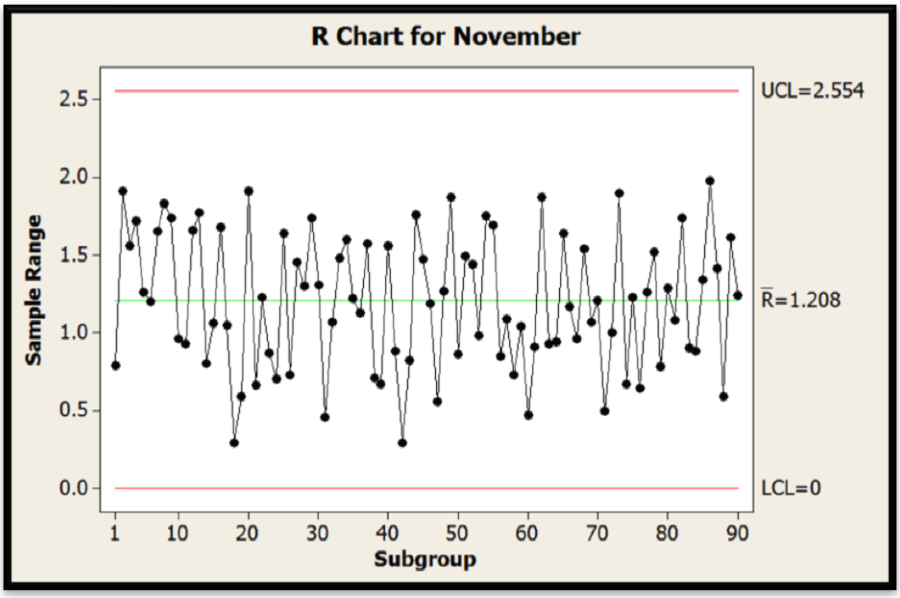



**Figure 4.4:** R Chart for November

### 4.4.3 Calculation for $\bar{X}$ Chart and R Chart for December

For the calculation of $\bar{X}$ chart and R chart, the data used was as tabulated in Table 4.3.

**Table 4.3:** Welding Pull Test for Third Month (December)

| Sub Group No | Reading Sample | | | | | Sum | Mean (X) | Range (R) |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | |
| 1 | 2.83 | 3.47 | 3.38 | 3.45 | 2.85 | 15.98 | 3.20 | 0.64 |
| 2 | 3.08 | 3.30 | 3.11 | 3.25 | 3.02 | 15.76 | 3.15 | 0.28 |
| 3 | 3.22 | 3.39 | 2.83 | 2.86 | 2.82 | 15.12 | 3.02 | 0.57 |
| 4 | 2.83 | 2.99 | 3.35 | 3.34 | 3.23 | 15.74 | 3.15 | 0.52 |
| 5 | 3.33 | 2.99 | 3.50 | 2.85 | 2.87 | 15.54 | 3.11 | 0.65 |
| 6 | 2.82 | 3.41 | 3.03 | 3.16 | 2.92 | 15.34 | 3.07 | 0.59 |
| 7 | 3.21 | 2.91 | 3.04 | 2.84 | 3.17 | 15.17 | 3.03 | 0.37 |
| 8 | 3.39 | 3.03 | 3.20 | 3.34 | 3.28 | 16.24 | 3.25 | 0.36 |
| 9 | 3.13 | 3.00 | 3.41 | 3.03 | 2.93 | 15.50 | 3.10 | 0.48 |
| 10 | 3.33 | 2.88 | 3.08 | 3.46 | 3.21 | 15.96 | 3.19 | 0.58 |
| 11 | 3.02 | 2.95 | 2.85 | 3.41 | 3.41 | 15.64 | 3.13 | 0.56 |
| 12 | 3.16 | 2.85 | 2.84 | 3.43 | 3.26 | 15.54 | 3.11 | 0.59 |
| 13 | 2.84 | 3.33 | 2.85 | 3.39 | 3.19 | 15.60 | 3.12 | 0.55 |
| 14 | 3.13 | 3.11 | 2.82 | 3.33 | 2.89 | 15.28 | 3.06 | 0.51 |
| 15 | 3.03 | 3.42 | 3.47 | 3.39 | 3.37 | 16.68 | 3.34 | 0.44 |
| 16 | 2.97 | 2.87 | 3.36 | 2.96 | 3.36 | 15.52 | 3.10 | 0.49 |
| 17 | 3.26 | 3.20 | 2.82 | 2.91 | 3.45 | 15.64 | 3.13 | 0.63 |
| 18 | 3.33 | 3.04 | 3.06 | 3.50 | 2.93 | 15.86 | 3.17 | 0.57 |
| 19 | 2.95 | 3.00 | 2.90 | 3.50 | 3.04 | 15.39 | 3.08 | 0.60 |
| 20 | 3.08 | 2.93 | 2.99 | 2.94 | 3.24 | 15.18 | 3.04 | 0.31 |
| 21 | 3.47 | 3.09 | 3.19 | 3.45 | 3.08 | 16.28 | 3.26 | 0.39 |
| 22 | 3.36 | 3.25 | 2.82 | 3.40 | 3.42 | 16.25 | 3.25 | 0.60 |
| 23 | 3.23 | 3.28 | 2.88 | 3.09 | 2.98 | 15.46 | 3.09 | 0.40 |

**Table 4.3:** Continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 24 | 2.80 | 3.17 | 3.01 | 3.32 | 2.83 | 15.13 | 3.03 | 0.52 |
| 25 | 3.20 | 3.42 | 3.15 | 3.32 | 3.11 | 16.20 | 3.24 | 0.31 |
| 26 | 2.81 | 3.03 | 3.34 | 3.34 | 3.16 | 15.68 | 3.14 | 0.53 |
| 27 | 3.27 | 3.35 | 2.87 | 3.47 | 2.84 | 15.80 | 3.16 | 0.63 |
| 28 | 3.34 | 2.86 | 3.48 | 3.16 | 3.31 | 16.15 | 3.23 | 0.62 |
| 29 | 3.47 | 2.80 | 3.43 | 2.92 | 2.84 | 15.46 | 3.09 | 0.67 |
| 30 | 2.94 | 3.46 | 3.14 | 3.22 | 3.31 | 16.07 | 3.21 | 0.52 |
| 31 | 2.90 | 3.07 | 3.05 | 3.28 | 2.99 | 15.29 | 3.06 | 0.38 |
| 32 | 3.09 | 3.34 | 3.08 | 2.93 | 2.96 | 15.40 | 3.08 | 0.41 |
| 33 | 3.05 | 2.93 | 3.00 | 3.11 | 3.31 | 15.40 | 3.08 | 0.38 |
| 34 | 3.05 | 3.18 | 2.87 | 2.92 | 3.32 | 15.34 | 3.07 | 0.45 |
| 35 | 3.05 | 3.30 | 3.17 | 2.90 | 3.36 | 15.78 | 3.16 | 0.46 |
| 36 | 3.44 | 3.35 | 2.86 | 2.90 | 3.46 | 16.01 | 3.20 | 0.60 |
| 37 | 3.29 | 2.81 | 3.35 | 2.89 | 2.83 | 15.17 | 3.03 | 0.54 |
| 38 | 3.15 | 3.07 | 3.48 | 3.23 | 3.31 | 16.24 | 3.25 | 0.41 |
| 39 | 2.83 | 3.50 | 3.10 | 3.49 | 2.80 | 15.72 | 3.14 | 0.70 |
| 40 | 3.48 | 3.17 | 3.02 | 3.27 | 3.08 | 16.02 | 3.20 | 0.46 |
| 41 | 3.12 | 3.01 | 3.36 | 3.26 | 3.00 | 15.75 | 3.15 | 0.36 |
| 42 | 3.23 | 3.47 | 2.91 | 3.22 | 2.81 | 15.64 | 3.13 | 0.66 |
| 43 | 3.31 | 2.99 | 3.20 | 2.97 | 3.48 | 15.95 | 3.19 | 0.51 |
| 44 | 3.44 | 3.13 | 3.47 | 3.27 | 2.91 | 16.22 | 3.24 | 0.56 |
| 45 | 3.00 | 3.36 | 3.26 | 3.25 | 2.98 | 15.85 | 3.17 | 0.38 |
| 46 | 2.84 | 3.32 | 3.04 | 3.24 | 2.94 | 15.38 | 3.08 | 0.48 |
| 47 | 3.25 | 3.14 | 3.05 | 3.08 | 3.22 | 15.74 | 3.15 | 0.20 |
| 48 | 3.03 | 3.48 | 3.11 | 3.36 | 3.39 | 16.37 | 3.27 | 0.45 |
| 49 | 3.24 | 3.23 | 3.18 | 2.93 | 3.15 | 15.73 | 3.15 | 0.31 |
| 50 | 3.05 | 3.14 | 3.37 | 3.27 | 3.31 | 16.14 | 3.23 | 0.32 |
| 51 | 3.19 | 3.01 | 2.83 | 3.17 | 3.22 | 15.42 | 3.08 | 0.39 |
| 52 | 3.35 | 2.83 | 2.93 | 3.31 | 2.84 | 15.26 | 3.05 | 0.52 |
| 53 | 2.94 | 3.45 | 3.26 | 3.20 | 3.17 | 16.02 | 3.20 | 0.51 |
| 54 | 2.89 | 3.14 | 2.94 | 3.04 | 3.04 | 15.05 | 3.01 | 0.25 |
| 55 | 3.05 | 3.48 | 3.40 | 3.05 | 3.02 | 16.00 | 3.20 | 0.46 |
| 56 | 3.06 | 2.89 | 2.95 | 3.35 | 3.23 | 15.48 | 3.10 | 0.46 |
| 57 | 3.39 | 3.33 | 3.07 | 3.39 | 2.94 | 16.12 | 3.22 | 0.45 |
| 58 | 3.13 | 3.26 | 2.89 | 3.21 | 2.90 | 15.39 | 3.08 | 0.37 |
| 59 | 3.15 | 2.85 | 3.47 | 2.93 | 3.05 | 15.45 | 3.09 | 0.62 |
| 60 | 2.81 | 3.07 | 3.23 | 3.29 | 3.16 | 15.56 | 3.11 | 0.48 |

**Table 4.3:** Continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 61 | 3.41 | 3.40 | 3.06 | 3.25 | 2.88 | 16.00 | 3.20 | 0.53 |
| 62 | 2.87 | 3.38 | 3.40 | 3.09 | 3.08 | 15.82 | 3.16 | 0.53 |
| 63 | 3.10 | 3.24 | 3.11 | 3.07 | 3.42 | 15.94 | 3.19 | 0.35 |
| 64 | 3.47 | 3.02 | 3.39 | 3.09 | 3.36 | 16.33 | 3.27 | 0.45 |
| 65 | 3.15 | 3.30 | 3.16 | 3.24 | 3.37 | 16.22 | 3.24 | 0.22 |
| 66 | 3.07 | 3.05 | 3.44 | 3.27 | 3.45 | 16.28 | 3.26 | 0.40 |
| 67 | 3.37 | 2.98 | 3.03 | 3.36 | 3.31 | 16.05 | 3.21 | 0.39 |
| 68 | 3.32 | 3.23 | 3.16 | 3.18 | 3.29 | 16.18 | 3.24 | 0.16 |
| 69 | 3.47 | 2.83 | 3.37 | 2.80 | 3.21 | 15.68 | 3.14 | 0.67 |
| 70 | 2.92 | 2.90 | 3.30 | 2.80 | 2.89 | 14.81 | 2.96 | 0.50 |
| 71 | 3.12 | 3.25 | 3.20 | 3.46 | 2.95 | 15.98 | 3.20 | 0.51 |
| 72 | 2.80 | 3.34 | 2.83 | 3.35 | 3.11 | 15.43 | 3.09 | 0.55 |
| 73 | 2.98 | 3.13 | 3.26 | 2.91 | 3.36 | 15.64 | 3.13 | 0.45 |
| 74 | 3.01 | 3.01 | 3.11 | 3.15 | 2.91 | 15.19 | 3.04 | 0.24 |
| 75 | 3.12 | 2.82 | 3.16 | 2.83 | 2.90 | 14.83 | 2.97 | 0.34 |
| 76 | 3.19 | 3.21 | 3.16 | 3.24 | 3.25 | 16.05 | 3.21 | 0.09 |
| 77 | 3.48 | 3.10 | 2.95 | 2.89 | 3.25 | 15.67 | 3.13 | 0.59 |
| 78 | 3.26 | 3.02 | 3.05 | 2.84 | 3.26 | 15.43 | 3.09 | 0.42 |
| 79 | 2.88 | 3.07 | 3.06 | 3.43 | 3.11 | 15.55 | 3.11 | 0.55 |
| 80 | 3.20 | 2.97 | 3.40 | 2.98 | 3.11 | 15.66 | 3.13 | 0.43 |
| 81 | 3.20 | 3.45 | 3.21 | 3.31 | 2.86 | 16.03 | 3.21 | 0.59 |
| 82 | 3.37 | 3.45 | 3.03 | 3.50 | 3.08 | 16.43 | 3.29 | 0.47 |
| 83 | 2.81 | 2.93 | 2.91 | 3.35 | 3.25 | 15.25 | 3.05 | 0.54 |
| 84 | 3.45 | 3.41 | 3.08 | 3.43 | 2.84 | 16.21 | 3.24 | 0.61 |
| 85 | 3.25 | 3.26 | 3.00 | 3.24 | 3.33 | 16.08 | 3.22 | 0.33 |
| 86 | 2.88 | 3.31 | 2.90 | 3.34 | 3.24 | 15.67 | 3.13 | 0.46 |
| 87 | 3.45 | 3.43 | 3.29 | 2.81 | 3.27 | 16.25 | 3.25 | 0.64 |
| 88 | 3.29 | 3.05 | 2.80 | 3.15 | 3.12 | 15.41 | 3.08 | 0.49 |
| 89 | 3.40 | 3.44 | 3.22 | 3.36 | 3.09 | 16.51 | 3.30 | 0.35 |
| 90 | 2.86 | 3.50 | 3.15 | 2.84 | 3.22 | 15.57 | 3.11 | 0.66 |
| **TOTAL** | | | | | | | 283.24 | 42.52 |
| | | | | | | | **$\bar{\bar{X}}$=3.15** | **$\bar{R}$ =0.47** |
| | | | | | | **STDEV** | 0.08 | |
| | | | | | | **Cpk** | **1.07** | |

1) $\bar{X}$ chart calculation

$\bar{X}$ = 3.15 (center limit)

$\bar{R}$ = 0.489

LCL $= \bar{X} - A_2\bar{R}$
= 3.15 – 0.577(0.489)
= 2.868

UCL $= \bar{X} + A_2\bar{R}$
= 3.15 + 0.577(0.489)
= 3.432

2) $\bar{R}$ chart calculation

$\bar{R}$ = 0.489

LCL $= D_3\bar{R}$
= 0(0.489)
= 0

UCL $= D_4\bar{R}$
= 2.114(0.489)
= 1.034

**Minitab 16 Analysis on $\overline{X}$ Chart and R Chart For December**

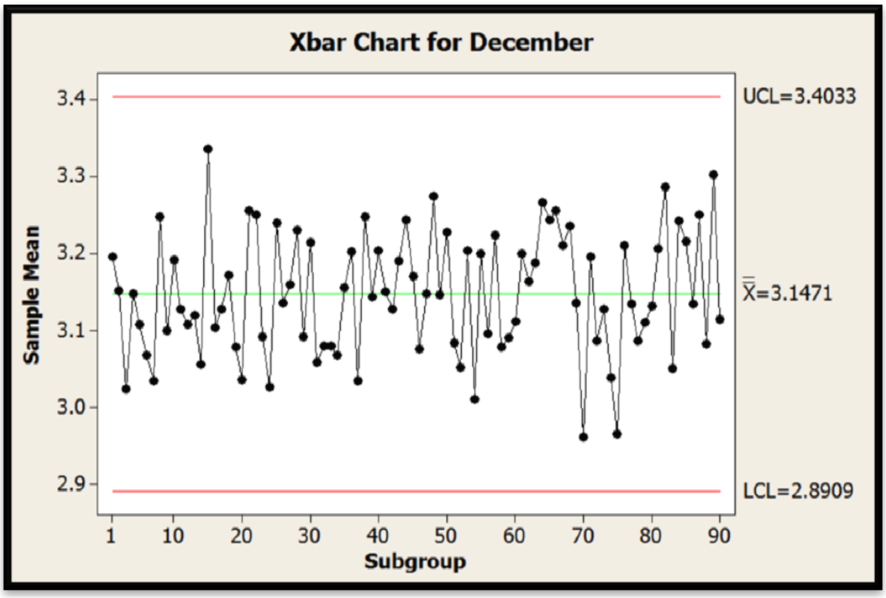



**Figure 4.5:** $\overline{X}$ Chart for December

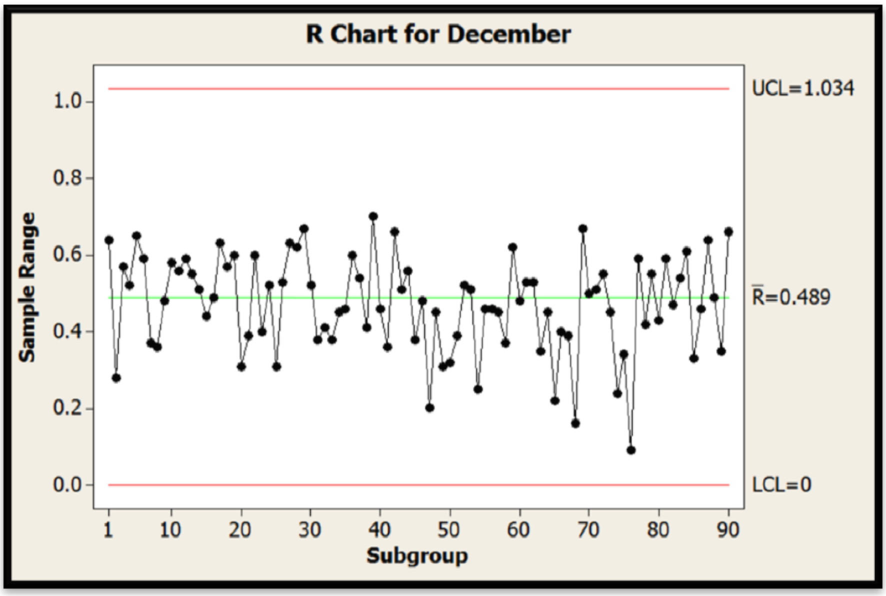



**Figure 4.6:** R Chart for December

### 4.4.4 Calculation for $\overline{X}$ Chart and R Chart for January

For the calculation of $\overline{X}$ chart and R chart, the data used was as tabulated in Table 4.4.

**Table 4.4:** Welding Pull Test for Fourth Month (January)

| Sub Group No | Reading Sample | | | | | Sum | Mean (X) | Range (R) |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | | |
| 1 | 2.19 | 2.30 | 2.97 | 2.50 | 2.56 | 12.50 | 2.50 | 0.78 |
| 2 | 2.8 | 1.64 | 1.2 | 2.9 | 2.4 | 10.88 | 2.18 | 1.62 |
| 3 | 2.2 | 2.24 | 2.4 | 2.5 | 2.2 | 11.50 | 2.30 | 0.32 |
| 4 | 2.8 | 2.11 | 1.2 | 1.3 | 3.0 | 10.36 | 2.07 | 1.72 |
| 5 | 2.1 | 1.95 | 2.7 | 1.6 | 2.7 | 10.96 | 2.19 | 1.13 |
| 6 | 2.0 | 2.21 | 2.2 | 2.6 | 2.7 | 11.64 | 2.33 | 0.65 |
| 7 | 2.8 | 2.49 | 2.5 | 1.3 | 2.7 | 11.73 | 2.35 | 1.46 |
| 8 | 2.4 | 2.81 | 2.7 | 2.8 | 1.5 | 12.17 | 2.43 | 1.30 |
| 9 | 2.6 | 1.56 | 1.9 | 1.6 | 2.9 | 10.46 | 2.09 | 1.31 |
| 10 | 2.7 | 2.42 | 1.9 | 2.1 | 2.7 | 11.81 | 2.36 | 0.74 |
| 11 | 2.3 | 2.57 | 1.3 | 2.6 | 2.2 | 11.03 | 2.21 | 1.30 |
| 12 | 2.3 | 2.23 | 2.4 | 2.2 | 1.1 | 10.26 | 2.05 | 1.31 |
| 13 | 2.7 | 2.62 | 2.5 | 1.9 | 2.1 | 11.71 | 2.34 | 0.81 |
| 14 | 2.3 | 2.23 | 1.2 | 2.2 | 2.1 | 10.14 | 2.03 | 1.10 |
| 15 | 2.6 | 2.08 | 2.1 | 2.8 | 1.6 | 11.16 | 2.23 | 1.25 |
| 16 | 2.7 | 2.3 | 2.1 | 2.5 | 2.5 | 12.17 | 2.43 | 0.60 |
| 17 | 2.6 | 2.91 | 2.6 | 2.3 | 1.4 | 11.81 | 2.36 | 1.52 |
| 18 | 1.3 | 2.51 | 1.2 | 2.8 | 3.0 | 10.72 | 2.14 | 1.79 |
| 19 | 2.7 | 2.23 | 2.5 | 1.7 | 2.7 | 11.86 | 2.37 | 1.02 |
| 20 | 1.7 | 2.09 | 1.8 | 2.7 | 2.8 | 11.06 | 2.21 | 1.12 |
| 21 | 2.6 | 2.77 | 1.2 | 1.3 | 3.0 | 10.84 | 2.17 | 1.77 |
| 22 | 1.4 | 2.84 | 2.9 | 1.2 | 2.7 | 10.97 | 2.19 | 1.65 |
| 23 | 2.0 | 2.11 | 2.2 | 2.5 | 2.3 | 11.09 | 2.22 | 0.48 |

**Table 4.4:** Continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 24 | 2.9 | 1.45 | 1.4 | 2.8 | 2.6 | 11.04 | 2.21 | 1.49 |
| 25 | 2.7 | 2.82 | 2.7 | 2.1 | 2.2 | 12.51 | 2.50 | 0.69 |
| 26 | 2.4 | 1.54 | 1.2 | 2.5 | 2.6 | 10.32 | 2.06 | 1.40 |
| 27 | 2.7 | 1.24 | 2.7 | 2.9 | 1.2 | 10.65 | 2.13 | 1.64 |
| 28 | 2.2 | 2.55 | 1.3 | 2.2 | 2.5 | 10.81 | 2.16 | 1.23 |
| 29 | 2.3 | 1.95 | 2.6 | 3.2 | 2.5 | 12.52 | 2.50 | 1.24 |
| 30 | 2.5 | 2.2 | 2.1 | 2.4 | 2.4 | 11.59 | 2.32 | 0.44 |
| 31 | 2.5 | 1.87 | 2.9 | 2.4 | 1.1 | 10.67 | 2.13 | 1.84 |
| 32 | 1.9 | 1.83 | 2.6 | 1.8 | 2.9 | 10.97 | 2.19 | 1.10 |
| 33 | 2.4 | 2.66 | 2.9 | 1.3 | 2.7 | 11.94 | 2.39 | 1.63 |
| 34 | 2.0 | 2.61 | 2.0 | 1.3 | 2.5 | 10.32 | 2.06 | 1.36 |
| 35 | 2.3 | 2.49 | 2.2 | 2.7 | 2.9 | 12.58 | 2.52 | 0.77 |
| 36 | 2.1 | 2.29 | 1.7 | 2.2 | 2.2 | 10.46 | 2.09 | 0.56 |
| 37 | 1.6 | 2.28 | 2.5 | 2.8 | 1.7 | 10.88 | 2.18 | 1.18 |
| 38 | 2.6 | 1.54 | 2.2 | 3.0 | 2.8 | 12.06 | 2.41 | 1.44 |
| 39 | 2.3 | 1.24 | 2.2 | 2.9 | 1.5 | 10.17 | 2.03 | 1.65 |
| 40 | 1.8 | 2.69 | 1.4 | 2.4 | 3.0 | 11.27 | 2.25 | 1.57 |
| 41 | 1.6 | 2.35 | 2.5 | 2.7 | 2.0 | 11.09 | 2.22 | 1.18 |
| 42 | 1.8 | 1.28 | 2.7 | 2.5 | 1.7 | 9.88 | 1.98 | 1.41 |
| 43 | 1.6 | 2.64 | 1.4 | 2.5 | 2.5 | 10.54 | 2.11 | 1.29 |
| 44 | 2.5 | 2.22 | 1.4 | 3.1 | 1.3 | 10.47 | 2.09 | 1.88 |
| 45 | 2.5 | 2.32 | 1.4 | 2.9 | 3.0 | 12.04 | 2.41 | 1.65 |
| 46 | 1.5 | 2.82 | 2.2 | 2.7 | 3.0 | 12.29 | 2.46 | 1.43 |
| 47 | 2.2 | 1.53 | 1.8 | 2.6 | 2.7 | 10.87 | 2.17 | 1.21 |
| 48 | 2.5 | 2.52 | 1.4 | 2.5 | 2.4 | 11.20 | 2.24 | 1.17 |
| 49 | 1.8 | 2.21 | 2.2 | 1.9 | 2.5 | 10.64 | 2.13 | 0.66 |
| 50 | 1.5 | 2.14 | 2.5 | 2.8 | 2.3 | 11.07 | 2.21 | 1.33 |
| 51 | 2.7 | 1.98 | 2.5 | 1.5 | 2.3 | 10.98 | 2.20 | 1.21 |
| 52 | 2.6 | 2.42 | 2.6 | 2.2 | 2.9 | 12.59 | 2.52 | 0.68 |
| 53 | 2.6 | 2.04 | 2.5 | 2.0 | 2.1 | 11.23 | 2.25 | 0.42 |
| 54 | 2.1 | 2.53 | 2.5 | 2.5 | 2.9 | 12.47 | 2.49 | 0.81 |
| 55 | 2.5 | 2.66 | 1.2 | 3.0 | 2.1 | 11.42 | 2.28 | 1.75 |
| 56 | 2.5 | 2.62 | 1.6 | 2.4 | 2.5 | 11.57 | 2.31 | 0.99 |
| 57 | 2.1 | 2.49 | 2.8 | 2.1 | 2.4 | 11.90 | 2.38 | 0.74 |
| 58 | 2.2 | 2.72 | 2.3 | 1.9 | 1.3 | 10.41 | 2.08 | 1.47 |
| 59 | 2.5 | 2.47 | 2.6 | 1.7 | 2.3 | 11.57 | 2.31 | 0.96 |
| 60 | 2.2 | 2.79 | 2.5 | 2.0 | 2.5 | 11.99 | 2.40 | 0.81 |

**Table 4.4:** Continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 61 | 2.0 | 2.41 | 2.7 | 2.2 | 2.4 | 11.59 | 2.32 | 0.70 |
| 62 | 2.5 | 1.5 | 2.5 | 2.2 | 1.3 | 10.09 | 2.02 | 1.20 |
| 63 | 2.8 | 2.72 | 2.3 | 1.3 | 2.5 | 11.53 | 2.31 | 1.48 |
| 64 | 2.2 | 2.74 | 2 | 2.2 | 2.7 | 11.78 | 2.36 | 0.77 |
| 65 | 2.0 | 2.23 | 2.6 | 2.1 | 2.7 | 11.65 | 2.33 | 0.62 |
| 66 | 1.9 | 2.65 | 2.1 | 1.9 | 2.1 | 10.59 | 2.12 | 0.78 |
| 67 | 1.8 | 2.1 | 2.3 | 1.2 | 3.0 | 10.42 | 2.08 | 1.77 |
| 68 | 2.2 | 2.3 | 1.3 | 2.9 | 2.9 | 11.57 | 2.31 | 1.56 |
| 69 | 2.3 | 2.29 | 1.6 | 2.9 | 2.9 | 11.93 | 2.39 | 1.28 |
| 70 | 2.9 | 2.3 | 1.9 | 2.7 | 2.2 | 11.99 | 2.40 | 0.98 |
| 71 | 2.5 | 2.33 | 1.5 | 1.0 | 2.7 | 10.13 | 2.03 | 1.71 |
| 72 | 2.4 | 1.52 | 2.3 | 2.0 | 1.9 | 10.11 | 2.02 | 0.92 |
| 73 | 2.6 | 1.23 | 2.2 | 2.5 | 2.3 | 10.77 | 2.15 | 1.32 |
| 74 | 2.6 | 1.69 | 2.5 | 2.0 | 1.8 | 10.63 | 2.13 | 0.94 |
| 75 | 2.5 | 2.22 | 1.4 | 3.1 | 0.9 | 10.09 | 2.02 | 2.26 |
| 76 | 2.5 | 2.32 | 1.4 | 2.9 | 0.9 | 9.90 | 1.98 | 1.96 |
| 77 | 2.9 | 1.89 | 2.1 | 1.7 | 2.2 | 10.74 | 2.15 | 1.21 |
| 78 | 2.9 | 2.58 | 1.6 | 2.3 | 0.8 | 10.26 | 2.05 | 2.08 |
| 79 | 1.2 | 2.16 | 1.9 | 2.4 | 2.6 | 10.29 | 2.06 | 1.32 |
| 80 | 2.5 | 2.07 | 1.9 | 2.6 | 1.5 | 10.59 | 2.12 | 1.10 |
| 81 | 2.2 | 2.53 | 2.6 | 2.0 | 2.6 | 11.93 | 2.39 | 0.65 |
| 82 | 2.4 | 1.08 | 2.7 | 2.4 | 2.6 | 11.12 | 2.22 | 1.65 |
| 83 | 2.9 | 2.92 | 1.7 | 2.1 | 1.9 | 11.46 | 2.29 | 1.25 |
| 84 | 2.4 | 2.68 | 2.3 | 2.4 | 2.0 | 11.68 | 2.34 | 0.73 |
| 85 | 1.8 | 1.82 | 1.5 | 2.2 | 2.8 | 10.11 | 2.02 | 1.00 |
| 86 | 2.2 | 2.3 | 1.0 | 2.9 | 2.9 | 11.27 | 2.25 | 1.86 |
| 87 | 2.5 | 2.29 | 2.6 | 1.2 | 2.9 | 11.44 | 2.29 | 1.62 |
| 88 | 2.9 | 2.3 | 1.5 | 2.7 | 2.2 | 11.66 | 2.33 | 1.31 |
| 89 | 2.5 | 2.33 | 1.2 | 2.8 | 2.7 | 11.60 | 2.32 | 1.57 |
| 90 | 2.4 | 2.52 | 1.6 | 1.9 | 1.6 | 10.04 | 2.01 | 0.96 |
| **TOTAL** | | | | | | | 200.95 | 109.59 |
| | | | | | | | $\bar{\bar{X}}$=2.23 | $\bar{R}$ =1.22 |
| | | | | | | **STDEV** | 0.15 | |
| | | | | | | **Cpk** | **1.75** | |

1) $\bar{X}$ chart calculation

$\bar{X}$ = 2.23 (center limit)

$\bar{R}$ = 1.22

LCL = $\bar{X} - A_2\bar{R}$
= 2.23 – 0.577(1.2177)
= 1.527

UCL = $\bar{X} + A_2\bar{R}$
= 2.23+0.577(1.218)
= 2.933

2) $\bar{R}$ chart calculation

$\bar{R}$ = 1.2177

LCL = $D_3\bar{R}$
= 0(1.2177)
= 0

UCL = $D_4\bar{R}$
= 2.114(1.218)
= 2.574

**Minitab 16 Analysis on $\overline{X}$ Chart and R Chart For January**

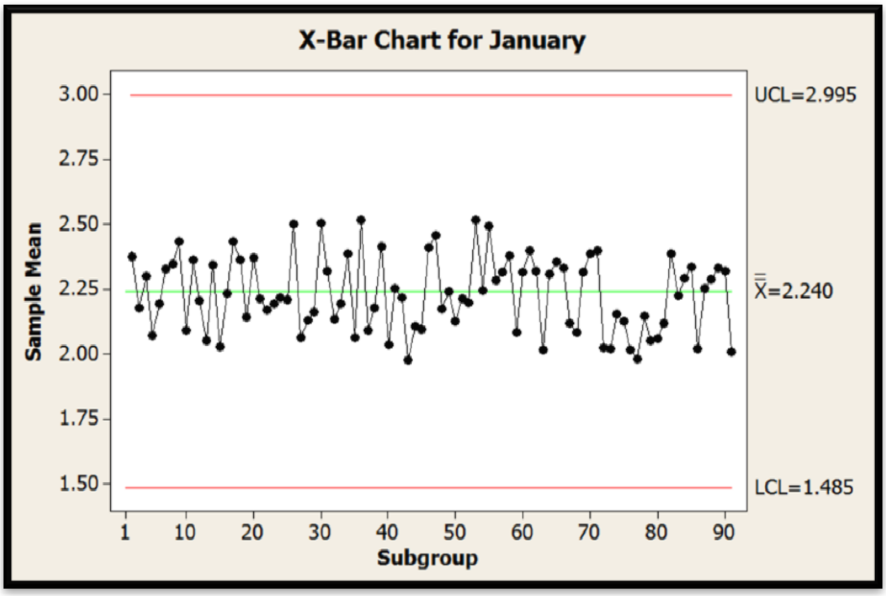



**Figure 4.7:** $\overline{X}$ Chart for January

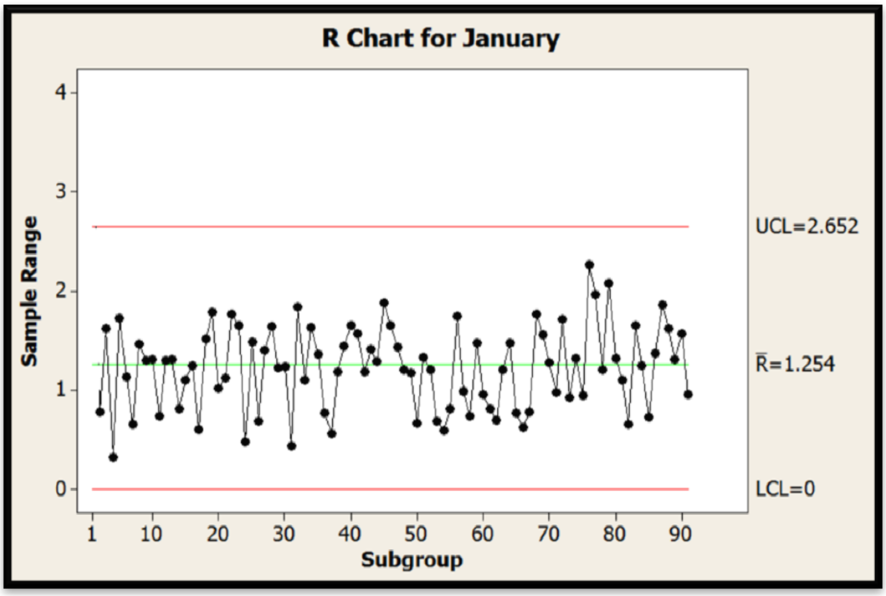



**Figure 4.8:** *R* Chart for January

## 4.5 INTERPRETATION OF $\overline{X}$ CHART AND R CHART

### 4.5.1 Interpretation Chart for October

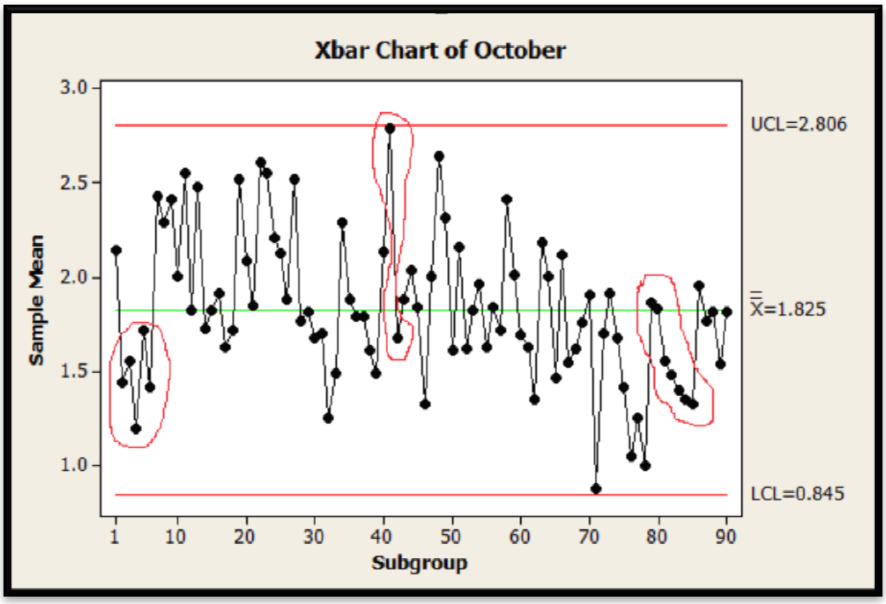



**Figure 4.9:** $\overline{X}$ Chart for October

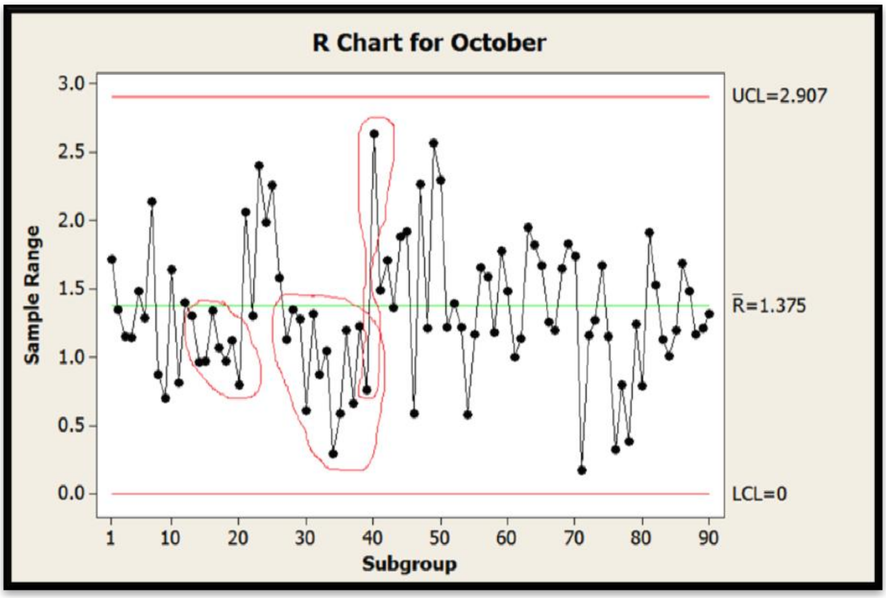



**Figure 4.10:** R Chart for October

From the analysis in October it shows that the process is under control for both $\bar{X}$ Chart (Figure 4.9) and R Chart (Figure 4.10). None of the processes were out of the upper and lower control limits in $\bar{X}$ Chart and R Chart.

In the $\bar{X}$ Chart (Figure 4.9), some of the points, which are point number 2 until point 6 shows the repeated pattern. It is cause by the machine cycling while the process is shift changing.  For point 41 to 42 it showed the suspected difference pattern where it sudden change in process like damaged equipment which is welding tip. At point 79 until 85 it shown negative drift pattern where a trend consist of 7 consecutive decreasing observations. Drift is generally seen in processes where the current process value is partly determined by the previous process state. The cause of the drift pattern is wear of machining tool which is the wear of welding tips.

For the R chart (Figure 4.10) which is in the first month (October), at point 13 until 20 and at point 27 until 39 it shown the probability of eight and thirteen consecutive point of the mean is decreasing under the lower average limit. These shown the negative drift pattern where it causes by the wear of the welding tips and burning welding tips. At point 39 to 40 it shown that there are a big difference pattern. This due to the sudden change in process such as new procedure had introduced to the operator.

The standard deviation for this process is 0.34 while the process capability (Cpk) for this process is only 0.84 which is around $\pm 2$ sigma only. Although the points are balance on both side of the center line, the deviation towards the process limits are noticeably more.

As conclusion, from the chart we can say that all the batches are within control limits. However, all the measurements are very close to the upper specification limits. From both chart, it shown the chart is not accurate and it is not precision and also have a very big dispersion and there cannot shift to the right and left. So, action should be taken to bring the process average to nominal of the specification.

### 4.5.2 Interpretation Chart for November

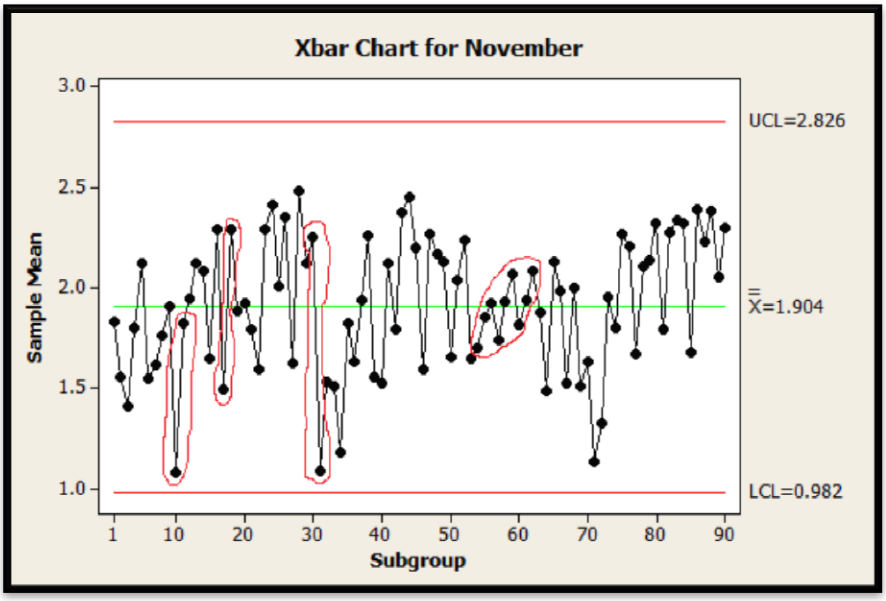



**Figure 4.11:** $\bar{X}$ Chart for November

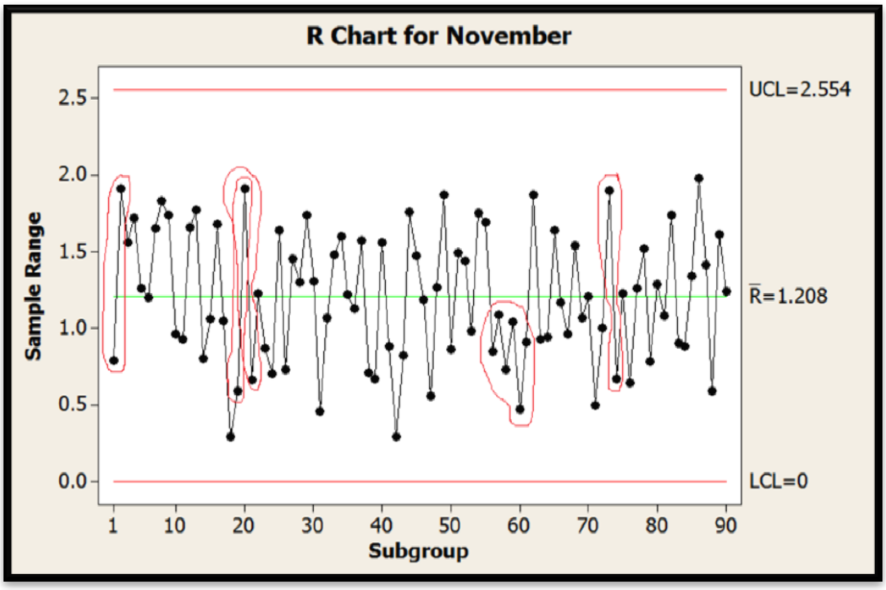



**Figure 4.12:** R Chart for November

The data for November shows that the process is under control for both charts which are $\bar{X}$ Chart in Figure 4.11 and R chart for Figure 4.12.

From the $\bar{X}$ Chart in Figure 4.11 which is for November, it shows the biggest pattern from point 10 to 11, 17 to 18 and at point 30 to 31. The main cause for this problem is from installation of welding tips at the machine. The welding tips should be 90° from the table of the welding machine. So, operators should be train properly by the supervisor or engineers on how to install the correct way. For point 54 until 62, it shown the repeated pattern which the point is goes up and down. These pattern causes by same cycling of machine.

For the R chart (Figure 4.12) which is in the second month (November), at point 1 to 2, 19 to 20, 20 to 21, and at point 72 to 73 where sudden jump in the value occurring the control limit. Sudden change in processes such as new operator recruited is the factor of this pattern occurring. At point 56 until 61 it show the negative drift patterns. It shows that the 6 point under the mean which mean in the process, the wear of the tool on machinery occurred.

For this process, it gives 0.34 for standard deviation while for the capability process (Cpk) it achieve 0.91 which is increase around 7.69% from the previous month but this Cpk is also classified in $\pm 2$ sigma.

For conclusion, both of charts are in control limit but the process is more to the lower control limit. It dispersion is bigger for this month, but is better if compare to the previous month. From the chart also, it shown the process is also accurate but there is no precision. Lastly, engineer should be taken an action to make the process can shift to the right or left if anything happen which is try to get a small dispersion.

### 4.5.3 Interpretation Chart for December

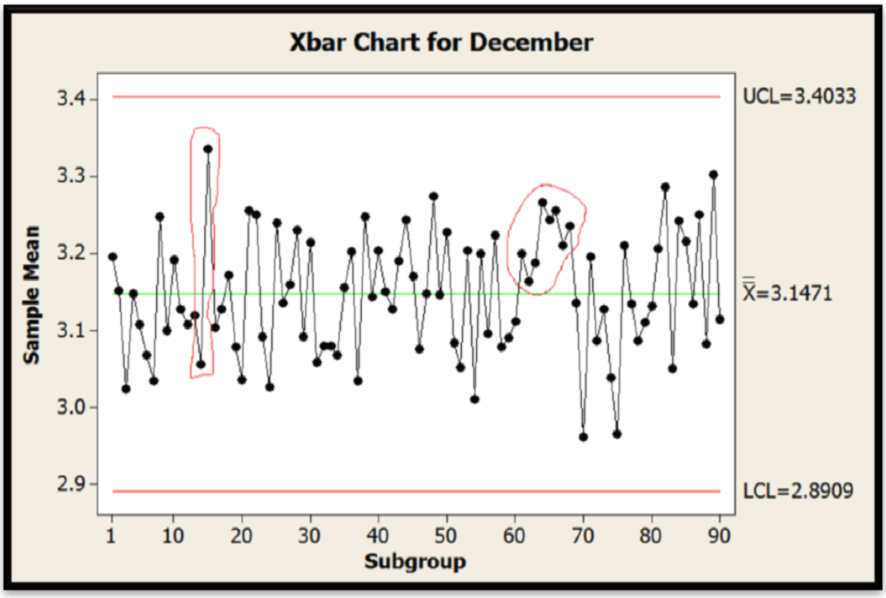



**Figure 4.13:** $\bar{X}$ Chart for December

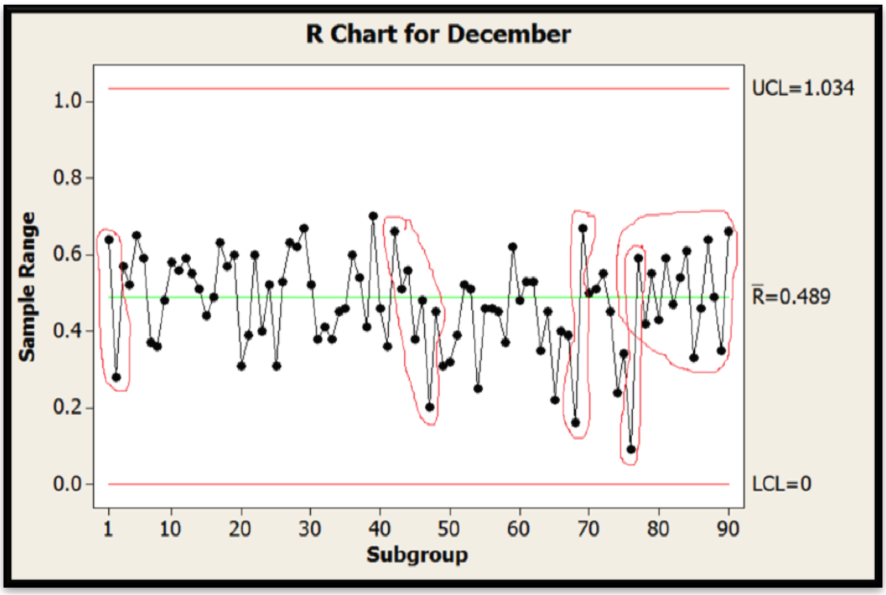



**Figure 4.14:** R Chart for December

From the $\bar{X}$ Chart (Figure 4.13) and R Chart (Figure 4.14) which is for December, it shown that the process is within the control limit. None of the process is beyond the limit.

For $\bar{X}$ Chart (Figure 4.13), the point 14 to 15 had shown a suspected different pattern where sudden jump in the value occur in the control chart. The big difference occur because of the welding tips should be change or should be clean to get smoothly surface. At point 61 to 68 it shows the positive pattern. The pattern shows 8 point is above the mean process.

For R Chart (Figure 4.14), the process is almost approached the center limit of the process but also had a problem. For point 1 to 2 and 67 to 68 it had shown a big differences pattern cause by the wear of the welding tips. Sometimes, the operators complacent do their job until them forgetting to change the welding tips. Then, the repeated pattern also happen in this month which is it showed at point 43 until 49, then it repeated again at point 76 until 90. The main cause of repeated pattern occur due to the same as cycling but there are more than two processes involve which are several machine and shift changing.

For this month, the standard deviation that gets from the process is 0.08 while the process capability is 1.07 which is in 3 sigma category. It shows that the Cpk increase around 14.95% from November. From the $\bar{X}$ Chart, the process is more to lower control limit but if anything happen the process still can shift to the left because the point is far from the upper control limit. So, the dispersion of the process is modest if compared to October and November and the process is accurate but not precision.

As conclusion for this month, engineer need to pay attention to the problems and take serious action to make sure the Cpk for next month will be increase.

### 4.5.4 Interpretation Chart for January

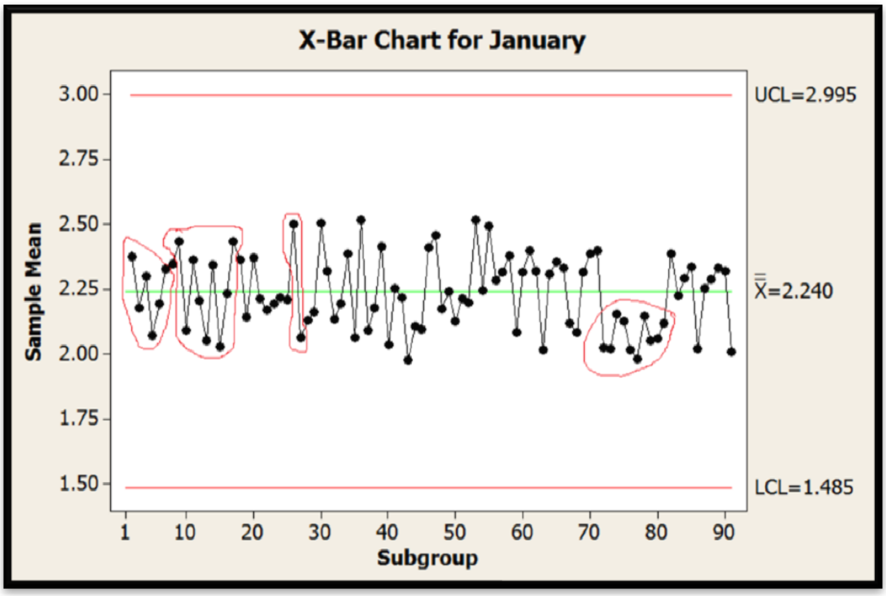



**Figure 4.15:** $\bar{X}$ Chart for January

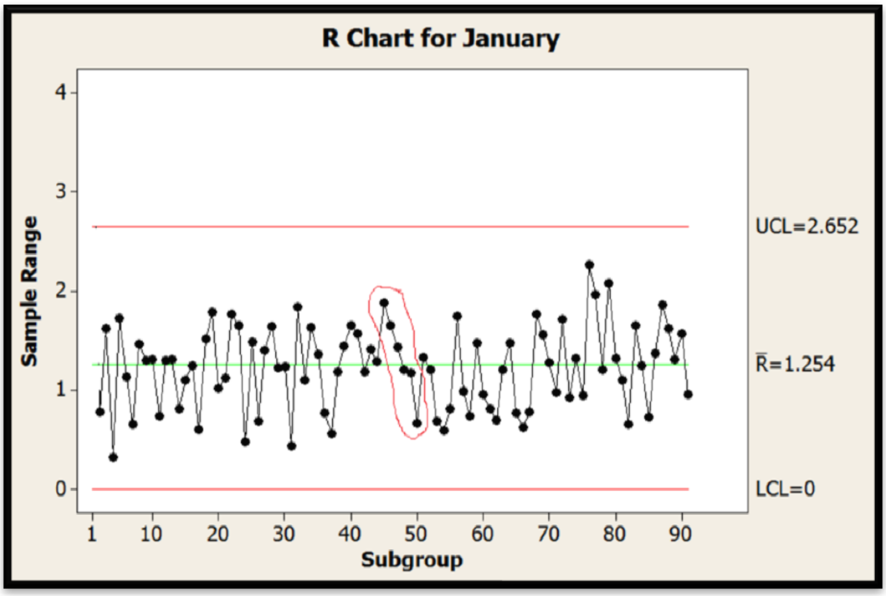



**Figure 4.16:** $R$ Chart for January

From the $\bar{X}$ Chart in Figure 4.15 and R Chart in Figure 4.16, it showed all the process is within the control limit. None of the process is beyond the limit. Especially for this month the process is approached the center limit. It means the process is improving compare to the previous month.

In the $\bar{X}$ Chart in Figure 4.15, some of the point showed the repeated pattern which are from point 1 until point 6 and again happen at point 8 until point 16. The cause is same with the previous problem which is same machine cycling. Then, at point 25 to point 26 it showed a biggest different pattern compared to other points. The big different pattern happen after the operator change the welding tips because the machine will start up the new process so it take time to adjust for get the normal point. At point 70 until point 80 it showed that 10 point consecutive decreasing observation are under the center limit because of the welding tips need to clean after installation to get a smooth surface.

For the R chart, point 44 to 49 it shown the negative drift pattern where a trend consisting of 6 consecutives decreasing observations. Drift is generally seen in processes where the current process value is partly determined by the previous state.

From this month process, the standard deviation gives 0.15 while the process capability is 1.75 which is around 5 sigma. For this month the dispersion of both graph is very small because the process is approached the center limit. So, this process can anytime shift either to the left or right.

As conclusion, from the chart all the batches are within the control limits. All the measurements are very close to the center limits. From both chart it shown the process is accurate and also precise because they are exposed to the target value. Engineers should maintain this Cpk value and should try to improve again the Cpk value to achieve 6 sigma.

## 4.6 OVERALL COMPARISON FOR STABILITY OF COTROL CHART

By using $\bar{X}$ chart, it can clearly identify whether the process in in control or out of control. The charts also represent the average of distribution or center limit created by each process. From the chart, it will show that if the center of distribution shifts, the pattern show in the $\bar{X}$ chart also will be shift.

Next continue to R chart where R chart function is to measures the process uniformity and reacts to changes in variation spread. When the process is constant, the R chart signals give the result which is the process is out of control. The uniformity of the process is reflected by the magnitude of the R chart data. This means the lower magnitude will result the better process occurred.

By observing for the four months which are October until January for $\bar{X}$ chart and R chart, the deviation of process variables are determined very clearly. All the $\bar{X}$ chart shows that the processes are under control which are no points are beyond limit. From the first month, the chart shows that one of the points which is at point 41 and 70 is approached the upper control limit and also lower control limit. This is very danger stage because the tendency of out of process will happen anytime. Besides, it also shows that the tendency of the process become uncontrolled is very high.

Compare $\bar{X}$ chart from the first month which is in October, no point is near the upper and lower center limit. However, there are some points that approach the lower center limit. From the chart, it is shown that point 54 until 62 likely to approach centerline. It also shown that most of the points are far from the upper and lower control limit. The tendency of these points to fail in this month is much lower compare to the first month which is October.

The $\bar{X}$ chart for December shows that the process is under control and all point is far away from upper and control limit. Although there are far from the upper and lower control limit but there are not approaching to the center limit.

Lastly for the last month which is in January, the $\bar{X}$ chart shows that all the point is approaching the center limit. This chart also explained that this process in very stable and the tendency to failed are very smallest. This is because this process can shift anytime if the process suddenly breakdown or get a problem.

## 4.7 THE CAUSE AND EFFECT DIAGRAM FOR 4M

Problem solving consists in using generic for finding solutions to problems. Variety technique developed to solve variety problems. In engineering also we use the problem solving when products or processes fail, so corrective action can be taken to prevent further failures. Technique such as cause and diagram effect can be used to proactively reduce the likelihood of problems occurring.

The cause and effect diagram, also called as fishbone diagram or Ishikawa diagram is a tool for discover the possible causes for a particular effect. For this Ishikawa, it used 4M to identify problems that happen during the process of Aircoil-Lead Frame Welding. There is material where each production process needs the material. For the second M which indicates the Manpower, where in each process we need people to monitoring and operate the process. Next, for each process we have a standard method of processing or for applying material. Lastly, we need a specific machine to complete the process and to make the product.

As a conclusion, all of these factors are related with each other's and it can be classified as 4M cause and effect factors.

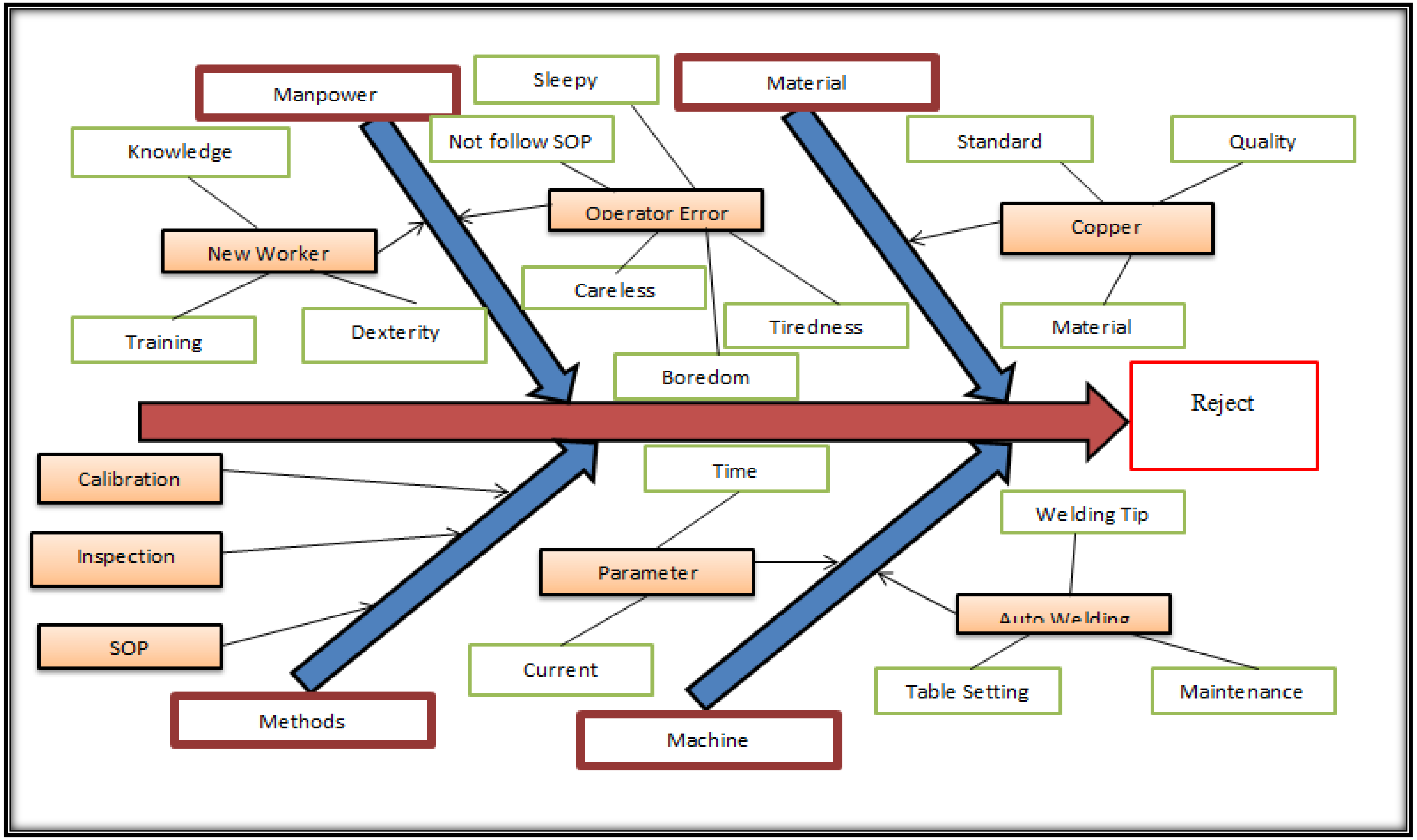



**Figure 4.17:** Ishikawa Diagram of Factor that Affecting to Aircoil-Lead Frame Welding

### 4.7.1 Manpower

Manpower is referring to the operators and workers who perform and involved in an operation. Different operators have different judgment depending on their skills, knowledge and experience. When the aircoil is put under the Miyachi Unitek which is welding machine they need to monitor either the part of aircoil is weld properly and make sure it is in specification. Refer to the FIGURE 4.6.1 for identify either the welding is in good condition or not. An experience and skills operator they will know how to classify the aircoil as reject or in good condition but for the new operator they need time and need to refer Standard Operation Procedure (SOP) for information.

Besides, the new operator will lack of practice or observation on the particular machine and may face the difficulties in handling the process according to the parameter of the machine. So this will increase the defects parts. Work in unsuitable condition also will affect the quality of the product. For example when the operator is continuously working and too concentrated on the single operation, tiredness, careless, boredom and sleepy might be happen. These phenomena will lead the operator to make mistakes and lastly they will not perform well in their work. The careless in forgot to change the tips of welding and also incorrect install the tip also will make defect to the product. Lastly, for make their work faster, they will find a new way and ignore the SOP as a result defect will be happen.

### 4.7.2 Methods

The Aircoil Lead Frame Welding production is started with calibration of the material which is look for their stripping. Refer to FIGURE 4.6.2 for the pass aircoil. If the aircoil is in specification then it will proceed to the next process. An operator needed always monitoring the current of the machine which is around 0.6kA to 0.7kA. Operator need to follow SOP in fixed the tolerance. Next is how to inspect the product. The product will be inspect follow the specification from the customer. Good observation and inspection is very important in order to make sure the process is under control. Refer and follow the SOP will make the process in controllable and the product is in good quality. After complete the process, the aircoil welding frame will be 100% inspected by operator and randomly checked by Quality Control Department.

### 4.7.3 Material

The material used to produce the Aircoil Lead Frame Welding is copper alloy. To ensure the quality of the product, tight material quality controlling is very important. The Aircoil is started with checking and inspect the stripping of the copper alloy. Only the quality and up to standard will be send to Miyachi Unitek Machine to produce a parts.

### 4.7.4 Machine

The Miyachi Unitek Machine used to weld and joint the part or in the other words it is superior welding control for a wide range of micro joining applications. In order to produce a good part of Aircoil, the correct pressure and force are applied to make sure the machine is performing an optimum performance.

Besides, the parameter setting for the Miyachi Unitek Machine is highly been concerned. The monitoring the force and the pressure are applied for the setting can improve the process reliability, reduce the rejected parts and also improved the production control. FIGURE 4.6.4 shown the example of Miyachi United Machine.

## 4.8 CONCLUSION

As conclusion, control chart is the best way to identify the process whether there are in control or out of control. By implementing SPC control for variable $\bar{X}$ and R chart proved to be the best monitoring tool for a process. The stability and compatibility of a process can be monitoring through $\bar{X}$ and R chart. Besides, after got a chart, it wills easily monitoring where the problems came and by see the trends. The important things are the process can be immediately identifying the tendency of the errors occurs and countermeasures of the process can be done immediately to circumvent the rejected part

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 CONCLUSION

Statistical Process Control (SPC) is a powerful tool to measure and control a manufacturing process. The proper monitoring a manufacturing process will help us to predict either the process is in control or out of control. Out of control are process is out from the upper and control limit of the control chart and as a result it will produce more rejected parts. While the controlled process is the acceptable process where the number of rejected parts produced is minimized.

Besides, by using control chart, the trend of the product can be determined immediately and the process can be change before more rejected parts been produced. It will help the engineers to early detection of defect parts and automatically will reduce the overall production cost and will decrease waste especially waste of time. So, implementation of control chart in the manufacturing process is a good practice in company.

This project is was conducted by monitoring the quality performance in the BI Technologies Sdn. Bhd. Shows that the importance of statistical process control (SPC) for the monitoring and ensuring the produced are able to satisfy the customer requirements. From the results of this project, it showed that the control chart can be used to monitor the quality performance of the products.

## 5.2 RECOMMENDATION

In BI Technologies Sdn. Bhd., the process capability is only applicable in molded production line. For the others production line they are not applying the capability process. So, it is suggested that for other products in other production line also should apply the capability process because it can help the company to reduce more cost and the important is they will produce a good quality of products.

Lastly, for Statistical Process Control (SPC) is not only for quality assurances base but it is also can be implemented to employee's, workers, supervisor, and also for the top managements.

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**APPENDIX A**
**PROJECT GANTT CHART FYP 1**
**PROJECT GANTT CHART FYP 2**

# GANTT CHART FOR FYP 1

| CHAPTER | ITEMS | DETAILS | | September | | | October | | | | | November | | | | December | | | | | REMARK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | W01 | W02 | W03 | W04 | W05 | W06 | W07 | W08 | W09 | W10 | W11 | W12 | W13 | W14 | W15 | W16 | | |
| 1 | Research Subjects | In this chapter, it will introduce what is the Project Title, Project Objectives and Project Scope. | P | | | | | | | | | | | | | | | | | | |
| | | | A | | | | | | | | | | | | | | | | | | |
| | | 1.1 Verify Project Title, Project Objectives and Project Scope | P | | | | | | | | | | | | | | | | | | |
| | | | A | | | | | | | | | | | | | | | | | | |
| | | 1.2 Study of Objectives and Scope | P | | | | | | | | | | | | | | | | | | |
| | | | A | | | | | | | | | | | | | | | | | | |
| 2 | Literature Review | Literature review helps to establish a theoretical framework for the project and to identify studies, models and case | P | | | | | | | | | | | | | | | | | | |
| | | | A | | | | | | | | | | | | | | | | | | |
| | | 2.1 Study on process capability to improve quality | P | | | | | | | | | | | | | | | | | | |
| | | | A | | | | | | | | | | | | | | | | | | |
| | | 2.2 Study on statistical tools | P | | | | | | | | | | | | | | | | | | |
| | | | A | | | | | | | | | | | | | | | | | | |
| 3 | Research Methodology | Guideline system for solving a problem, with specific components such as phases, tasks, methods, techniques and tools | P | | | | | | | | | | | | | | | | | | |
| | | | A | | | | | | | | | | | | | | | | | | |
| | | 3.1 Process Mapping | P | | | | | | | | | | | | | | | | | | |
| | | | A | | | | | | | | | | | | | | | | | | |
| | | 3.2 Analysis of Data | P | | | | | | | | | | | | | | | | | | |
| | | | A | | | | | | | | | | | | | | | | | | |
| | Presentation, Report Writing & | | P | | | | | | | | | | | | | | | | | | |
| | | | A | | | | | | | | | | | | | | | | | | |

PREPARED BY:

NOOR HIDAYATUL ADAWIYAH BT SI

FA09054

**GANTT CHART FOR FYP 2**

| PSM 2 | | | Calender Week | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ITEMS | activity | | W01 | W02 | W03 | W04 | W05 | W06 | W07 | W08 | W09 | W10 | W11 | W12 | W13 | W14 |
| 1 | Deeply study problems | P | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | |
| 2 | Find solution | P | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | |
| 3 | Run the solution | P | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | |
| 4 | Data collection | P | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | |
| 5 | Data Analysis | P | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | |
| 6 | Preparation PSM 2 report | P | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | |
| 7 | Complete PSM 2 report | P | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | |
| 8 | Presentation PSM 2 | P | | | | | | | | | | | | | | |
| | | A | | | | | | | | | | | | | | |

# APPENDIX B

## Table of Control Chart Constant

Factors for Computing Central Lines and 3s Control Limits for $\bar{X}$, s, and R Charts

| Observations in Sample, n | Chart for Averages: Factors for Control Limits | | | Chart for Ranges: Factor for Central Line | Chart for Ranges: Factors for Control Limits | | | | | Chart for Standard Deviations: Factor for Central Line | Chart for Standard Deviations: Factors for Control Limits | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A$ | $A_2$ | $A_3$ | $d_2$ | $d_1$ | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $c_4$ | $B_3$ | $B_4$ | $B_5$ | $B_6$ |
| 2 | 2.121 | 1.880 | 2.659 | 1.128 | 0.853 | 0 | 3.686 | 0 | 3.267 | 0.7979 | 0 | 3.267 | 0 | 2.606 |
| 3 | 1.732 | 1.023 | 1.954 | 1.693 | 0.888 | 0 | 4.358 | 0 | 2.574 | 0.8862 | 0 | 2.568 | 0 | 2.276 |
| 4 | 1.500 | 0.729 | 1.628 | 2.059 | 0.880 | 0 | 4.698 | 0 | 2.282 | 0.9213 | 0 | 2.266 | 0 | 2.088 |
| 5 | 1.342 | 0.577 | 1.427 | 2.326 | 0.864 | 0 | 4.918 | 0 | 2.114 | 0.9400 | 0 | 2.089 | 0 | 1.964 |
| 6 | 1.225 | 0.483 | 1.287 | 2.534 | 0.848 | 0 | 5.078 | 0 | 2.004 | 0.9515 | 0.030 | 1.970 | 0.029 | 1.874 |
| 7 | 1.134 | 0.419 | 1.182 | 2.704 | 0.833 | 0.204 | 5.204 | 0.076 | 1.924 | 0.9594 | 0.118 | 1.882 | 0.113 | 1.806 |
| 8 | 1.061 | 0.373 | 1.099 | 2.847 | 0.820 | 0.388 | 5.306 | 0.136 | 1.864 | 0.9650 | 0.185 | 1.815 | 0.179 | 1.751 |
| 9 | 1.000 | 0.337 | 1.032 | 2.970 | 0.808 | 0.547 | 5.393 | 0.184 | 1.816 | 0.9693 | 0.239 | 1.761 | 0.232 | 1.707 |
| 10 | 0.949 | 0.308 | 0.975 | 3.078 | 0.797 | 0.687 | 5.469 | 0.223 | 1.777 | 0.9727 | 0.284 | 1.716 | 0.276 | 1.669 |
| 11 | 0.905 | 0.285 | 0.927 | 3.173 | 0.787 | 0.811 | 5.535 | 0.256 | 1.744 | 0.9754 | 0.321 | 1.679 | 0.313 | 1.637 |
| 12 | 0.866 | 0.266 | 0.886 | 3.258 | 0.778 | 0.922 | 5.594 | 0.283 | 1.717 | 0.9776 | 0.354 | 1.646 | 0.346 | 1.610 |
| 13 | 0.832 | 0.249 | 0.850 | 3.336 | 0.770 | 1.025 | 5.647 | 0.307 | 1.693 | 0.9794 | 0.382 | 1.618 | 0.374 | 1.585 |
| 14 | 0.802 | 0.235 | 0.817 | 3.407 | 0.763 | 1.118 | 5.696 | 0.328 | 1.672 | 0.9810 | 0.406 | 1.594 | 0.399 | 1.563 |
| 15 | 0.775 | 0.223 | 0.789 | 3.472 | 0.756 | 1.203 | 5.741 | 0.347 | 1.653 | 0.9823 | 0.428 | 1.572 | 0.421 | 1.544 |
| 16 | 0.750 | 0.212 | 0.763 | 3.532 | 0.750 | 1.282 | 5.782 | 0.363 | 1.637 | 0.9835 | 0.448 | 1.552 | 0.440 | 1.526 |
| 17 | 0.728 | 0.203 | 0.739 | 3.588 | 0.744 | 1.356 | 5.820 | 0.378 | 1.622 | 0.9845 | 0.466 | 1.534 | 0.458 | 1.511 |
| 18 | 0.707 | 0.194 | 0.718 | 3.640 | 0.739 | 1.424 | 5.856 | 0.391 | 1.608 | 0.9854 | 0.482 | 1.518 | 0.475 | 1.496 |
| 19 | 0.688 | 0.187 | 0.698 | 3.689 | 0.734 | 1.487 | 5.891 | 0.403 | 1.597 | 0.9862 | 0.497 | 1.503 | 0.490 | 1.483 |
| 20 | 0.671 | 0.180 | 0.680 | 3.735 | 0.729 | 1.549 | 5.921 | 0.415 | 1.585 | 0.9869 | 0.510 | 1.490 | 0.504 | 1.470 |