DEFECT IDENTIFICATION: APPLICATION OF STATISTICAL PROCESS CONTROL IN PRODUCTION LINE


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**Abstract**

Control chart is a statistical process control (SPC) that use to monitor the quality characteristics of processes to ensure the required quality level. The purpose of this study is to observe the pattern of process variability based on data ~~input have been~~ taken from production lines in the months of July and August. 40 products' samples from the production lines have been selected. The methods used to analyse the defect samples data are Microsoft Excel and Minitab16 Statistical Software. Next, control charts test was done on the data. The result shows, after control charts were able to detect defect on the microprocessor being produced, it allowed revised centre line and control limits for changes in production. In conclusion, the control charts offers a reliable solution that is particularly suited to line production and testing operations such as those found in an automated manufacturing environment.



Key Words: Statistical process control, defect identification, control chart, production line


## 1 Introduction

In today's fierce competition markets, product-quality control has become a vital task for manufacturers to sustain their mass-production products with low production cost and high quality. The most useful technique to maintain quality and reduce variability of products is using statistical process control (SPC) in line production. Goetsch & Davis (2003) defines SPC is as a statistical method of separating variation resulting from special causes from natural variation and to establish and maintain consistency in process, enabling process improvement. SPC is able to reduce variability of the key quality characteristic, achieving process stability and improving productivity as well as able to detect defect sample and identify abnormal conditions so as to prevent defects, scrap and rework of final products. Orhan Engin, Ahmet Çelik, İhsan Kaya (2008) and Lee-Ing Tong, (1998) ) proposed used of control chart approach in engine valve manufacturing process.

The basic idea in SPC is to take random samples of products from a production line and examine the products to ensure that certain criteria of quality are satisfied. If the products sampled are found to be of inferior quality, then the manufacturing process is checked to seek out assignable causes of inferior quality to bring the process back to control.

SPC is a used to monitor standard, making measurements and taking corrective action on the product being produced or service delivered. The process applies mathematics and statistics in the evaluation of its process performance. This methods have been widely used in production for abnormality detections and it is the important technique for measuring the value of the quality characteristic and help to identify a change or variation in some quality of the product. SPC has also become the backbone of modern quality control in both theory and practice. It is also useful for managing the production floor to ensure the quality, safety and realibility of the output.

This study is conducted in a manufacturing company that produce microprocessor. Top plates is used by this company to detect defect on production line and Tim Adhesive is used to correct it if the defect is found. Even thought after using top plates some defects on the microprocessor still being identified. Therefore, this study would like to investigate the process variability of these output based the data sample. It focuses on identify the pattern of process variability based on data sample and to determine whether there is a significant difference in the process mean of the data sample.

### 1.1 Preliminary of the control chart

In this study control chart is used to identify defect sample by monitoring the activities of a line production. It is widely used to help manufacturer to take decisions such as the need for machine or technology replacement to meet quality standards. It has attracted the attention of many researchers as James D.T. Tannock, (1997) used it for economic comparison between variables control charting and other inspection for various scenarios. Meanwhile, Joekes S. Barbosa E. P. (2013) introduce an adjusted control limits of the *p*-chart. Simionescu M. (2015), developed it predict the national unemployment rate using unemployment rates at regional level. Gilenson M., Hassoun M., L (2014) formulated a trade-off between the expected values of the CT and the die Yield and found out control chart model enables decision makers to knowingly sacrifice Yield to shorten CT and vice versa. Another researcher But Wenbin Wang, Wenjuan Zhang, (2008) found that control chart are also not very sensitive to the small casual changes in the data. Finally Orhan Engin, Ahmet Çelik, İhsan Kaya (2008) proposed used of control chart approach in engine valve manufacturing process. It can be concluded that the application of control chart is widely used by industry from different sectors in producing the quality products.

The control chart consists of three lines; an upper control limit (UCL), a lower control limit (LCL) and a center line (CL). The upper and lower control limits are the maximum and minimum values for a process characteristic to be considered in control, while the centre line is the mean value for the process. These limits are arbitrarily established at three standard deviations above and below the centre line.

## 2. Methodology

The variables which will be used in this study are defect sample on production line. The analysis is done by using control chart and MiniTAB16. The defect data bases on inspection which done by operator or engineer on several lots and inspected one by one by using a special top plate. The table of data was designed to obtain important information about the collected data such as lots number, model of product, number of product for one lots, number of defect and total of defect. The data is collected from forty (40) samples.

## 2.1 Type of Attributes Data

For this study, the type of data that has been collected is determined and based on the characteristics of the data type, is called as an attribute. Meanwhile U-chart is chosen for further analysis since the sample number are unequal. For this study, two types of u-chart will be used for analysis, they are:

(a)u-chart using variable-width control limit

$$\text{control limits} = \bar{u} \pm 3\sqrt{\frac{\bar{u}}{n_i}} \;\; ; \quad \text{where } \bar{u} = \frac{\sum_{i=1}^{m} c_i}{\sum_{i=1}^{m} n_i}$$

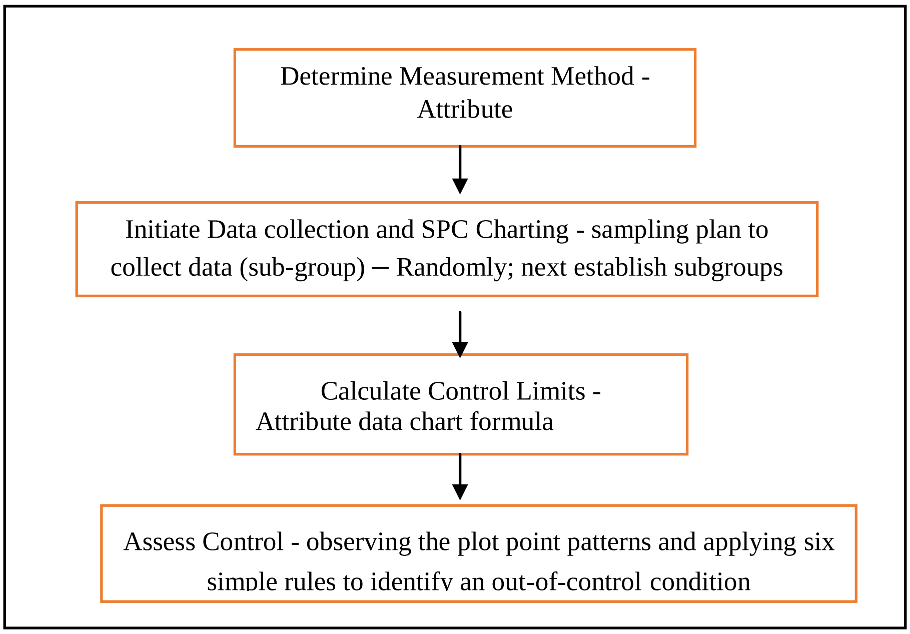
(b) u-chart based on average sample size

$$\text{control limits} = \bar{u} \pm 3\sqrt{\frac{\bar{u}}{\bar{n}}} \;\; ; \quad \text{where } \bar{u} = \frac{\sum_{i=1}^{m} c_i}{\sum_{i=1}^{m} n_i} \;\text{ and }\; \bar{n} = \frac{\sum_{i=1}^{m} n_i}{m_i}$$

## Analysis of data

After data are collected, data is analyzed by using. In this study, MiniTab16 is used for the u-chart output. Figure 2.0 illustrates the steps involved in analysis for this study.

**2.0 Determine Measurement Method**




## 3. Result

### 3.1 Control Chart before running at Tim and Adhesive line

Result from Microsoft Excel 2007 is used to calculate control chart- Control limit (CL); Upper Control Limit (UCL) and Lower Control Limit (LCL). The formula as below:

$\bar{u}_i = \frac{c_i}{n_i}$ $\bar{u} = \frac{\sum c_i}{\sum n_i} = \frac{514}{31971} = 0.0161$ CL – 0.0161;

Since the sample size is not constant, CL has been calculated per sample (4); $\bar{u} \pm 3\sqrt{\frac{u}{n_i}}$ ;

$n_i$ =797; UCL = 0.029563; LCL = 0.002616; $n_i$ =798, UCL = 0.029576; LCL = 0.002625; $n_i$ =799; UCL = 0.029566; LCL = 0.002633; $n_i$ =800, UCL = 0.029558; LCL = 0.02956

Next, the result is plotted on a u-chart by using MiniTab16.

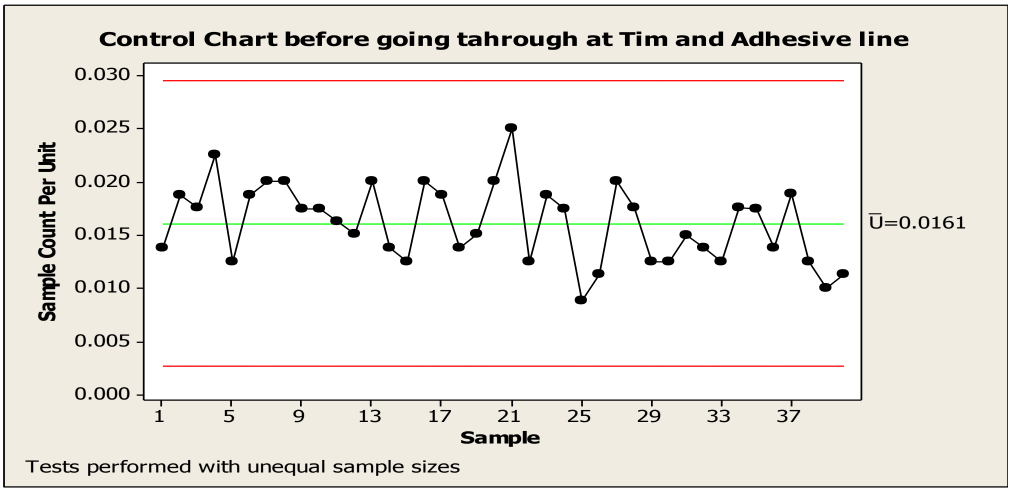



Figure 3.1 : Control chart before going through Tim and Adhesive line

From the figure 3.1, it is identified that all samples of microprocessor are within the control limit and they present a reasonably random pattern around $\bar{u}$. Hence the process is said to be in control. Next, the similar sample are going through Tim and Adhesive line.

### 3.2 After going through at the Tim and Adhesive line

The same data were observed by using a special top plate to identify the defect. The result shows the number of defect increased. Since there is a defect, the data is being tested again by using MiniTab16 and CL, UCL and LCL per sample (4) by using this formula;

$\bar{u} \pm 3\sqrt{\frac{u}{n_i}}$ ; CL = 0.0208, the result is below:

$n_i$ =797; UCL = 0.036125; LCL = 0.005474; $n_i$ =798, UCL = 0.036116; LCL = 0.005483; $n_i$ =799; UCL = 0.036106; LCL = 0.005493; $n_i$ =800, UCL = 0.036097; LCL = 0.005496

Base on above result, the sample fraction nonconformities from each preliminary sample is plotted in this chart. It is noted that two points, those from sample 10 and 30, plot above the UCL, so the process is not in control. So, these points must be investigated to see an assignable cause can be determined.

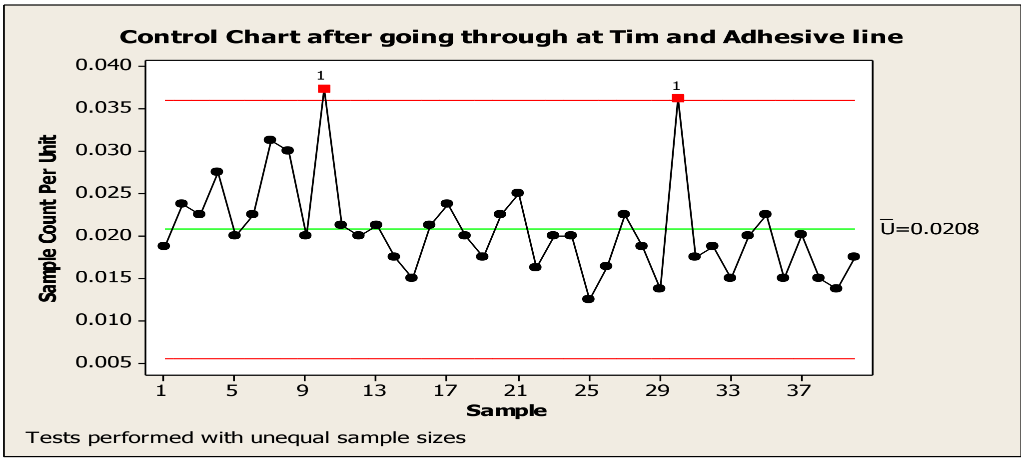



Figure 3.2 : Control chart after going through Tim and Adhesive line

Assuming assignable cause, the control limits are revised. Sample 10 and 30 are eliminated from the control limits calculation, and the new center line and revised control limits are calculated.

### 3.3 Calculation of revised center line and control limits

Revised of CL can be done by using the following formula:

$$\bar{n} = \frac{\sum n_i}{\sum k_i} = \frac{31971-800-800}{40-2} = \frac{30371}{38} = 799.236$$

$$\bar{u} = \frac{\sum c_i}{\sum n_i} = \frac{664\text{ -30-29}}{31971-800-800} = 0.0199$$

CL = 0.0199; UCL = 0.0349; LCL = 0.0049

The revised center line and control limits are shown on the control chart in Figure 4.3. This annotation of the control chart to indicate unusual points, process adjustments, or the type of investigation made at a particular point in time forms a useful record for future process analysis and should become a standard practice in control chart usage.

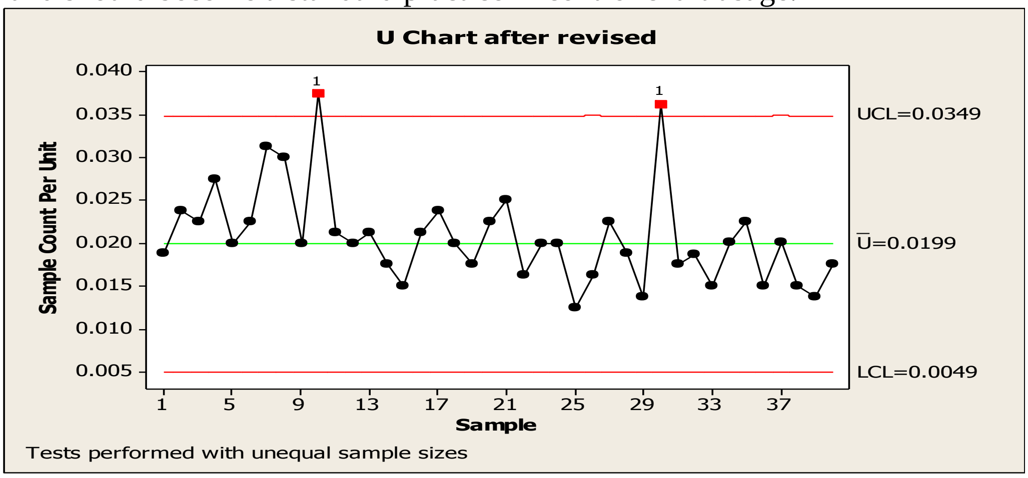



Figure 3.3 : Control chart after revised

Therefore, it can be concluded that these new control limits in Figure 3.3 can be used for future samples. The control limits [0.0049,0.0349] are adopted as trial control limits for use in the following month where monitoring of future production is of interest. The center line of 0.0199 is considered as the mean of the process.

## 4. Conclusion

Based on the result, it can be concluded that the overall performance of the sample can be control before and after process of Tim and Adhesive line by using Control chart. It showed that sample can be revised for data that were out of control. This is done in order to ensure the center line and control limits of the same sample can be used for following months. In conclusion, control chart is an essential tool to continuous quality control. The control chart shows, how the process is performing and how the process are effected by change to the process. It is very useful for SME in order to improve their quality product. The study suggested future study is needed, especially in identifying what could possibility reasons for defect and the process may be simplified. For example, companies can come out with a system that is more user friendly for those who do not have statistic backgrounds.

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