



## Control Engineering

*Elixir Control Engg.* 36 (2011) 3200-3203

**Elixir**  
ISSN: 2229-712X

# Determining process variation via statistical process control

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## ARTICLE INFO

### Article history:

Received: 2 May 2011;

Received in revised form:

18 June 2011;

Accepted: 27 June 2011;

### Keywords

Control Chart,  
Finished Product,  
Quality,  
Scatter Diagram,  
Statistical Process Control Tools.

## ABSTRACT

This research is carried out to study the used of SPC tools towards identifying the variation in quality finished product at Bio-organic fertilizer company. The objectives of this research are to analyze and monitor quality of finished product using Xbar R chart and identify the relationship between variables using scatter diagram. Data was obtained from Quality Department through finished product of 5.5.SPE from January 2008 until December 2008. This finished product can be measure according to pH, moisture, and crash. SPSS version 11.5 software has been used to analyze and interpret the data into control chart and scatter diagram. The unstructured interview with respective workers was done in order to support the data analysis. The finding revealed that the SPC tools can determine process variation in finished product through systematical analysis with more accurately. Since All Cosmos has no specific tool to analyze the data, it is suitable for them to implement this tool.

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## Introduction

Quality has been proven as a requirement to succeed in the world of business. The business tends to use this requirement as a ticket to compete and survive among them. In order to improve quality product, we can use Statistical Process Control Tools. As referred to [1] statistical process control is a part of quality control to prevent them from continuously producing rejected items. Prevention refers to those activities designed to prevent defects, defectives and inconsistency in products and services.

Moreover, by using SPC, researcher can identify a variation of process effects towards quality product. According to [2], using SPC two forms of variation can identify, first common causes or sources of variation that are unavoidable and secondly, special or assignable causes of variation that can be corrected or eliminated. Thus, reducing in process variation is important because any reduction in variation is similar to reduction in loss.

## Background of Research

The case study was done at Bio-organic fertilizer company. The factory is sited on six acres of land in Pasir Gudang Industrial Estate Johor Bahru. To respond to the government pleasure, Bio-organic fertilizer company has produced bio-organic fertilizer which is based on scientific findings of studies in soil, plant nutrition and agricultural fertilizer systems.

Bio-organic fertilizer company produces 300,000 tonnes of fertilizer annually which would be exported to Indonesia, the Philippines, Vietnam, and Singapore. Most of these fertilizers will be exported 65% to other countries and 35% to our local market.

In respect to the export of the product, they seek to give a high quality product for both marketplaces. In addition, as a holder of MS ISO 9001:2000, they have to ensure that the qualities are meeting the international requirement. If the product is rejected due to the quality issue they have to bear with the loss of rejection.

## Problem Statement

The company's quality policy is to reduce 1.85 percent of production rejection rate a year. In order to achieve the target

consistently, it is important for the quality department to control the quality of processes from incoming of raw materials until the finished product. Otherwise, if the rejection and rework processes have taken place, the productivity will be decreased. One of the ways to control the quality of the processes in the industry is by implementing the use of control chart.

According to the Quality Controller, there is no specific tool to analyze data and detect the variation in All Cosmos Sdn Bhd. It causes a difficulty for them in terms of determining the cause of rejected product. Thus, by using the control chart, the main cause of variation can be identified so that the earlier action can be taken in order to overcome and avert similar variation and problem occurred in the future.

## Literature review

### SPC technique tools

The research done by [3] found out that, although SPC has proven as a powerful tool for process understanding and quality improvement in the manufacturing and process industries, but it is not a panacea for it to be effective in the software environment. Thus, it needs to be operated within a culture of continual improvement driven by measurement. However, even in such environments there is a need for greater awareness and analysis of the statistical characteristics of software quality data prior to the use of SPC methods. In addition, a more widespread understanding of the inherent limitations of the basic SPC methods as well as knowledge of the usable alternatives needs to be fostered within the software engineering community.

On the other hand, there are seven major tools in SPC that are histogram or stem-and-leaf plot, check sheet, pareto chart, cause and effect diagram, defect concentration diagram, scatter diagram and control chart [4]. These tools can be applied in any process however; researcher only uses two of them as below:

### Control Charts

#### Scatter Diagram

Based on the data obtained in All Cosmos, researcher tends to choose control chart for variable known as Xbar and R chart. It is because the data are significant with continuous in nature

that can be measured. Xbar R chart is widely used in industry to study a quality characteristic. This statement was supported by [5], an efficient implementation procedure for control charts should include the contemporary implementation of two charts for monitoring both the process mean and dispersion: to do this, the sample mean Xbar and R, practitioners.

#### Control Chart for Variables

Variable are the measureable characteristics of product or service. Thus, variable data contain more information compared to attribute data. Furthermore the variable data are consisting of numerical measurement. Examples of variables include weight, height, pH, or length of a part. There had three types of variables control chart consist of Xbar and R chart, Xbar and s chart and the individual and moving range chart.

#### Xbar and R Chart

According to [6], the Xbar chart is used to monitor the variation of the subgroup averages, and to chart the process location, otherwise, the use of subgroup range, R, is to chart the process variability. Basically, the Xbar chart is used to monitor the variation in the average value of the measurements of groups of samples. Other than that, the subgroup ranges, R, is used as measure of dispersion of data. Both of centerline in R chart and Xbar chart indicates that the process is centered. The upper and lower control limits describe the spread of the process. Since control chart shows changes in process measurements, they allow for early detection of process changes. Hence, the Xbar R chart is suitable and significant with this research towards analyzing the variation besides it's easy to construct in studying a process.

#### Scatter Diagram

The second SPC tools choose to analyze the data is scatter diagram. Basically, scatter diagram is a graphical technique that is used to analyze the relationship between two different variables. The independent variables that can manipulate is recorded on the x axis. The dependent variable, the one being predicted, is displayed on the y axis. From this diagram, researcher can determine of a connection or relationship exists between variables.

#### Methodology

This chapter discusses the methodology used in this research. In order to meet the aims and objectives of the research, a comprehensive methodology was needed to capture a good finding. In general, the research was conducted in four parts which is in the early research, researcher has to determine the nature of industry chosen, and secondly obtain data to analyze using congruent SPC tools. The third part consists of identifying the amount of variation in the process and the relationship between variables. Finally, researcher will give suggestions toward the analysis based on unstructured interview done at Bio-organic fertilizer company to avert the same variation occurred in the process.

#### Secondary Data

Secondary data research is a systematic data collection and assessment of objectively previous data [7]. Data were obtained from the Quality Control Department in Bio-organic fertilizer company which contain the finished product of 5.5.5PE. This factory which is located in Pasir Gudang, Johor Bahru is owned by a Taiwanese. By applying the SPC tools, this secondary data will be analyzed and interpreted using the tool consisting of Xbar-R Chart to determine variation due to rejection, otherwise, the scatter diagram is use to recognize the relationship between

variables. This data is collected within twelve months series of 5.5.5PE data from January 2008 until December 2008.

#### Interview

Interview is two ways of conversation between people with the purpose of collecting information towards the research [7]. According to [8], Interview must be more than collecting information, it must reflex towards real life issue. Researcher has done unstructured interviewed with Quality Control Officer and Marketing Manager at Bio-organic fertilizer company in order to find out more regarding the present situation of the factory.

#### Data Analysis

The secondary data that has been collected can be measured and analyzed and identified by the variation in the processes using SPSS software. The process variation can be utilized via control chart and otherwise the relationship between variables can be generalized via scatter diagram. Thus, the rejection data was measured via pH, moisture, crash and NPK. The incomplete measuring variables data at All Cosmos Sdn Bhd, has unable researcher to analyze all the variables. Researcher has noticed that, the checking test for NPK ratio will only do if requested by management.

#### Analysis and findings

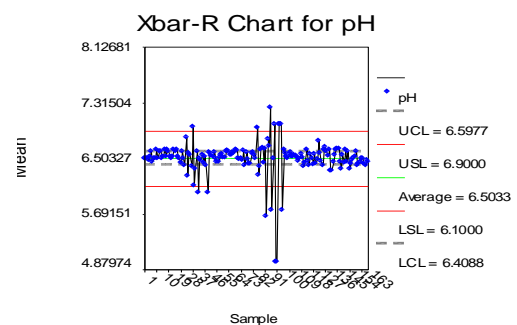
##### Analysis: research data

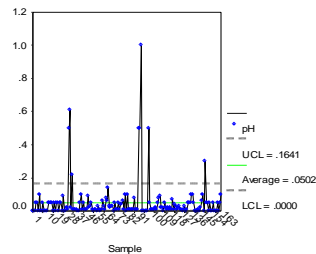
This research data has been collected in twelve series of months starting from January 2008 until December 2008. The specifications of the research data is pertaining to finished product of 5.5.5 PE. There are various types of raw materials consisting of Cocoa Shell, CIRP, Dolomite, and ERP to name a few. The data then can be measured according to pH, moisture and crash. Researcher tends to focus on analyzing the finished product data compared to raw material data, as concerned, the quality controller tends to measure more on physical variables when checking the raw materials rather than concentration.

The important factor of why pH, moisture and crash are important to be measured is because certain plants grow best in certain pH, if pH value is too high or low it will affect the growth the plants. Otherwise if fertilizer is too moist or too crash it can affect the composition required in product.

##### Analysis: Control Chart

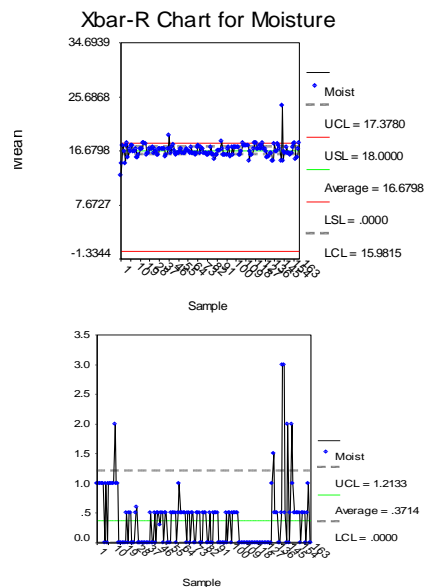
A one-year of data has been analyzed using SPSS software. The collective data consist of pH, moisture and crash will be merged into a year accordingly. The research data then are converted into X-Bar and R Chart. Researcher focuses more on analyzing the control limits known as voice of process rather than specification limit. Researcher will analyze further regarding to the control limits instead of the specification limit as the aim of the research is to know the variation of process in the finished product. Below are the analysis of the control chart including pH, moisture, and crash respectively.





**Figure 4.1: X-Bar and R Chart (pH) for January 2008 until December 2008**

Figure 4.1 is the one year samples of pH data which is consist of January 2008 until December 2008, its indicates that several samples are out of control. It occurs when the samples fall outside of the control limits. The observations on sample 4, 6, 7, 10, 12, 13, 16, 18, 19, 23 until 25, 54, 55, 61 until 63, 68, 69, 74, 75, 78, 79, 85, 92, 95, 96, 98, 99 until 104, 105, 106, 110, 116, 120, 121 until 124, 127, 129, 131, 132, 133, 134 until 137, 139 until 141, 144 until 146, 148, 151, 153, 154, 159, 160 and 166 exhibits that the process is lack of statistical control when they fall outside the control limits. For explanatory purpose, the specification limits do not meet the customer's needs when few samples falls out of the limits. As shown by the R Chart, there is a slight variation of the sample number 34, 33, 36, 95, 96, 104 and 154 indicates it falls beyond the control limits.

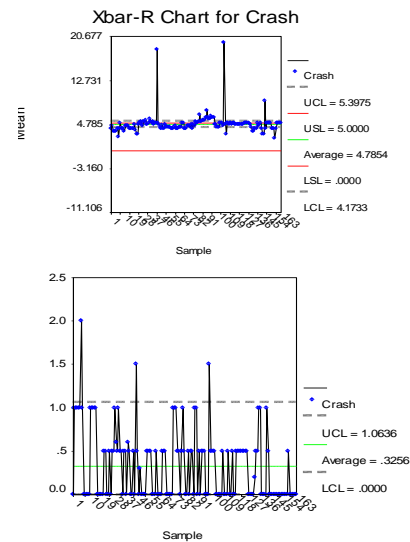


**Figure 4.2: X-Bar and R Chart (Moisture) for January 2008 until December 2008**

Figure 4.2 in Xbar chart exhibits that several samples are out of control which are samples numbers 1, 2, 5, 7, 23 and 24. 31, 32, 36, 43, 44, 46, 48, 91, 95, 118, 135, 137, 145, 146, and 154. While the process is out of control, the customer's needs also are not being met as 2 of the samples is out of the specification limits. R chart represents the amount of variation present in the process consisting samples number 16, 139, 147, 148, 152 and samples 154.

While Figure 4.3 shows samples number 8, 10, 32, 46, 54, 70, 71, 82, 83, 88, 99, 103, 104, 105, 107, 111, 112, 113, 137, 141 until 168 are falls outside the control limits. The samples also indicate the grouping or bunching pattern, which is due to the special cause of variation. While the process is out of control, the specification limits indicate that 3 samples are out of control, thus the customer's needs are not being met. R Chart indicates that samples 6, 47 and 105 fall outside the control

limits. Otherwise, the pattern indicates freaks pattern occurred during a year process.



**Figure 4.3: X-Bar and R Chart (Crash) for November until December 2008**

**Comparison for out of control between variables in finished products of 5.5.5pe.**

The comparison are shown at the following table.

**Table 4.2: Summary of out of Control Points in the Finished Product of 5.5.5PE on January 2008 until December 2008**

Variables	Xbar Chart	R Chart
pH	72	10
Moisture	50	13
Crash	47	8

The above table exhibits the summary of out of control in Xbar R chart which is consisting of UCL and LCL. The highest product rejection is due to high pH, moisture and high percentage of crash. Further discussion is needed to find out the caused of variation in the process.

### Discussion and Conclusion

This chapter discusses the analysis of the variation in the product of 5.5.5PE using the X-Bar R chart and scatter diagram. The discussion will be supported with the observation and unstructured interviews done at All Cosmos Sdn Bhd. The conclusion will ensure the objectives of the research to achieve the goals. Moreover, at the end of the chapter, researcher will propose suggestions. The research suggestions will be conducted in two parts. The first part of the suggestions will propose to the industry to implement the SPC. Secondly is for the future researchers who intend to broaden a research in the topic discussed. Patterns on a control chart exhibit lack of statistical control and cause variation in the product. On the other hand, as noted in X-Bar R chart, USL and LSL indicate the specification limits made by designer. According to [9], it is important that a process will not necessarily meet the specification as established by the customer or designer. As concerned the control limits and specification limits are two different concepts. Specifications can be considered the voice of the customer or designer in terms of what they expect, want or need from the process. On the other hand, control limit is the assumption of the variation present in the process known as the voice of process. The differences between the specification and control limits are specification relies on wishes and control limit tell the reality. Researcher will discuss further pertaining to the control limits instead of the specification limit as the aim is to analyze the data using SPC tools in finished product.

### Out of Control

Based on the unstructured interviews with the officers, they agree that producing fertilizer is a tough task as they have to bear with various factors which can influence the variability of the process output. Within this industry, environment is a major influence; a good quality product relies on the environment. Hence, as proven in the control chart, the high variation occurs in most of the variable due to uncertainty in the environment. According to the officer, in April, August, September and December, Johor received a high volume of rainfall, and to be considered wet months. Thus, variables such as crash, pH and moisture have been affected due to this phenomenon. Moreover, this uncertain condition has contributed to the increase of variation in the finished product.

From observation, unpleasant working condition such as noise, dirt and poor ventilation also has contributed to workers' vital force to complete their duties. Moreover, it also will decrease workers' performance as they have to face this daily condition resulting a lack quality in their work. When the quality of work is decreasing, they tend to make mistakes in their jobs. Thus, the variation in the process will be affected by these causes.

Basically, the departments that are influenced by this phenomenon are from the quality control and production. As referred to officers in Bio-organic fertilizer company, the turnover in the quality department is a common issue, one of the reasons of this turnover is the environment. On the other hand, when new employees who do not have any experience conducting quality equipment, they will make mistakes in checking purposes. The sheet of record contains various specifications needed to be recorded, mistake occur when new employees record the data consisting of the incoming raw materials and finished product.

In production team line, management tends to use foreigners as workers. The management has to face problems with communication. The initial mistake will occur when they do not have the ability to do a task as required due to miscommunication. This will also contribute to the number of variation in the process. In addition, the controlling machine in the room panel was in charged by one controller who is an expert in conducting this machine. The long hours of working period to control the machine will eventually causes tiredness to do the work.

### Control Chart Patterns

Normally, lack of control patterns such as sawtooth and freaks exist whenever changes occur in the incoming raw materials. According to the officers, the raw materials are coming from various descriptions and suppliers. Different supplier will causes different problem. The inconsistency when the checking raw materials have caused variation in the finished product. The tendency while checking the raw material based on observation has caused high variation in the finished product.

### Correlation between Variables

The scatter diagram is another quality tool that can be used to show the relationship between paired data, and provide more useful information pertaining to the production process. The purpose of using scatter diagram is to recognize the relationship between variables.

The dots, which are actually the data points, have various relationships. The strong positive relationship between moist and crash indicates that the amount of variation in crash clearly increases as the amount of variation in moist increases. The interrelatedness between paired proved that one item affects the other closely. On the other hand, there is no correlation between pH and moist, and pH and crash as stated that when pH value is increasing the moist or crash value will remain, as there is no significant relationship between these variables.

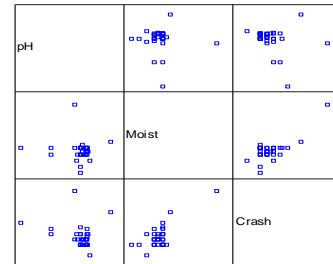


Figure 5.1: Scatter Diagram

### Conclusion

The goal of most processes is to produce products with less or no variation. In order to recognize the process variation, researcher has used the control chart and scatter diagram to identify the relationship between variables. The Xbar R chart indicates that from November until December, the samples fall outside the control limits are the highest. It is due to the environment. By using the control chart, researcher has successfully identified the processes and causes of the variation. Most of the causes are due to the environment, workers, and raw materials. On the other hand, the lack of control in the control chart indicates that it is important for the industry to check all the incoming raw materials based on the requirement.

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