VEHICLE COLOR GLOSSINESS STUDY BY USING SPC IN AN AUTOMOTIVE MANUFACTURING COMPANY

SUHAIMI BIN SULAIMAN

A report submitted in partial fulfillment
of the requirements for the award of the degree of
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
Universiti Malaysia Pahang

NOVEMBER 2007

ABSTRACT

The right color chosen and observation to glossiness rate on the vehicle body panel is ways to the success of automobile sales and give benefit to automotive manufacturing company. Understanding about the glossiness rate study among the automotive manufacturing company is very important to maintain the quality rate and fulfill the specification. This research is conducted on glossiness rate of the metallic color Isuzu D-MAX pickup truck by using Statistical Process Control (SPC). Three specific objectives have been defined to simplify the main objective of the project, that is to implement the SPC techniques to a selected part or product, to analyze the observed data and information and lastly to propose some improvement recommendation from the study. For this research, the Control Chart is chosen to apply in SPC. This is because Control Charts are a powerful statistical tool that may have many different applications. They may also be used in the maintenance of process control and in the identification of special and common causes of variation. In addition, they may also be used for process improvement by showing the effects of process of change. In order to control and prevent the variations, prevention action and recommendation are proposed and to get the process back on its target.

ABSTRAK

Pemilihan warna yang tepat disamping menitikberatkan terhadap tahap kekilatan warna pada badan kenderaan dapat memberi kelebihan kepada syarikat- syarikat pengeluar kenderaan. Adalah sangat penting dikalangan pengeluar kenderaan untuk memahami kajian mengenai tahap kekilatan warna metalik bagi menjamin dan mengekalkan mutu warna tersebut. Laporan projek ini adalah berdasarkan kajian terhadap tahap kekilatan warna metalik untuk kenderaan trak pikap ISUZU D-MAX dengan menggunakan kaedah Kawalan Proses Statistikal (SPC). Bagi menjalankan projek ini, tiga objektif dikenal pasti iaitu untuk mengaplikasikan kaedah Kawaln Proses Statistikal ini terhadap bahagian yang dipilih, untuk menganalisis data dan maklumat yang berkaitan dan memberi cadangan dan rekomen untuk langkah penambahbaikan. Kawalan Carta dipilih daripada senarai yang terdapat dibawah Kawalan Proses Statistikal kerana ianya boleh mengesan variasi atau masalah yang berlaku semasa proses dijalankan.

TABLE OF CONTENT

2 LITERATURE REVIEW

LIST OF SYMBOLS

SPC	-	Statistical Process Control
$\bar{\bar{x}}$	-	Average of the subgroup averages
$\overline{x_i}$	-	Average of the it subgroup
m	-	Numbers of subgroups
UCL	-	Upper control limit for the $\bar{x}$ chart
LCL	-	Lower control limit for the $\bar{x}$ chart
σ	-	Standard Deviation
$\sigma_{\bar{x}}$	-	Population standard deviation of the subgroup average
$\bar{R}$	-	Average of the ranges
R_i	-	Individual range values for the sample
A_2	-	Approximation factor used to calculate control limits
D_3	-	Approximation factor used to calculate range chart control limits
D_4	-	Approximation factor used to calculate range chart control limits
UCL_R	-	Upper control limit for R chart
LCL_R	-	Lower control limit for R chart
σ_R	-	Population standard deviation of the subgroup ranges
USL	-	Upper Specification Limit
LSL	-	Lower Specification Limit
$6s$	-	$6 \times$ standard deviations

CR	-	Capability Ratio
C_p	-	Capability Index
C_{pk}	-	Capability Index

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Metallic Color Glossiness

When a customer came to buy a car, the first criteria that they were looking at is the color. Color could give first impression to costumer and whether it can increase the purchasing of the car. For the metallic color vehicle, the rate of the glossiness at the vehicle panel parts is one of the factors to decide the increasing of the selling. Although the plating on the surface for a vehicle contribute less than one percent from the overall weight of the vehicle, the paint layer can give an impact on the purchasing decision. Nowadays, the employee of the automotive manufacturing company must give attention to maintain and increase the quality for the glossy color for exterior body panel in order to achieve good production and attraction through costumers.

1.2 Problem Statement

In any situation is important to determine what the goal of monitoring a particular quality characteristic or group of characteristic is. If only we can say improve quality, it is not enough. The question is, is it the quality just depends on quantity of production, type of production or customer expectations?

To achieve an optimum standard and highly total product performance, every employee must prepare a specification level. Sometimes several aspect of a part is critical for part performance; occasionally only one is. If there are many produce scrap or reject product in the production process, we can assume that some problem occur. From here, SPC tools can be placed on the process to help determine where the true source of the problem is located.

1.3 Project Objectives

Two specific objectives have been defined to simplify the main objective of the project. There are:

i. To implement the SPC techniques to a selected part or product.
ii. To analyze the observed data and information.

1.4 Scopes of Study

The scope of study for this project is to define the manufacturer background, boundary and population of the process to be studied. These definitions are essentially needed to narrow down the study scope from the wide topic of the SPC.

Manufacturer : ISUZU HICOM MALAYSIA SDN. BHD
(formerly known as MALAYSIAN TRUCK & BUS SDN. BHD (MTB SDN.BHD))

Boundaries : SPC includes those tools used during production to eliminate unexpected causes of variation. Type of taken data is metallic color glossy rate on the horizontal selected surface of the studied vehicle's body.

Population : The study concentrate to production for ISUZU DMAX pick up truck in Angelic White metallic color.

Time period : Two month data taken from the studied vehicle.

1.5 Thesis Disposition

Chapter 1 briefly introduces this project. In this chapter contain the problem statement, the objectives of study, scopes of study, and the initial explanation to the problem to study; the glossiness rate.

All information that related to the title will be conducted on Chapter 2. Literature review will explain deeply through the definitions, example or previous research that had been done. The information gathered through the internet, books, journal, and etc.

Chapter 3 is the methodology of this research. It describes how research is conducted from the beginning to the end. It contains several steps that must be followed before proceeding to the next step.

Chapter 4 described the results of the research. The result will be interpreted by calculation and several formulas given. Then, the result will be analyzed and discussed.

The last chapter for this research is Chapter 5. This chapter includes conclusion and future works in connection with this research. Other than that, several recommendations are recommended in order as the guide to overcome these problems.

CHAPTER 2

LITERATURE REVIEW

2.1 History of Statistical Process Control (SPC)

Statistical Process Control (SPC) was pioneered by Walter A. Shewhart and taken up by W. Edwards Deming with significant effect by the Americans during World War II to improve industrial production. Shewhart created the basis for the control chart and the concept of a state of statistical control by carefully designed experiments. While Dr. Shewhart drew from pure mathematical statistical theories, he understood data from physical processes never produce a "normal distribution curve" (a Gaussian distribution, also commonly referred to as a "bell curve"). He discovered that observed variation in manufacturing data did not always behave the same way as data in nature (Brownian motion of particles). Dr. Shewhart concluded that while every process displays variation, some processes display controlled variation that is natural to the process, while others display uncontrolled variation that is not present in the process causal system at all times.[1]

2.2 Implementing SPC in Manufacturing Process

Manufacturing process, like most other process, have predictable results due the causes by the variations. The difference in complexity among manufacturing processes can be enormous, although manufacturing engineer always tries to keep the processes as simple as possible in order to manage them as easily as possible. There are many ways to interpret a process to get a good result and more manageable without effecting its complexity or its function. In terms by applying the SPC as a manufacturing tool, it must easier to measure the effects of changing variables when measuring the result on a limited segment of the manufacturing process rather than analyze it after it passed through hundreds of operations. [2]

Steps in brief of implementation SPC in manufacturing process:

i. The initial step SPC is diagramming and analyzing the process to decide where control charts may be best to applied.
ii. Decrease any obvious variability in the target process.
iii. This step involves statistically testing the gauge using a gauge capability study. This must be done before measurements are taken for control charting. The variations that show up the control charts must reflect the process variation that needs to be reduced.
iv. Decide the sample plan. Determine the size of the sample and when the sample and when the samples are to be taken.
v. Find the out-of-control situation caused by common-cause and special-cause, evaluates what happened at that specific time to cause it, and the work to prevent that cause. This procedure continues until the control chart indicates that there are no more special-cause variation problems. Then, the process running as well as it possibly can without process modifications and it is said to be in statistical control.
vi. Next step is to put operator in-charge. This step and step 5 actually occurred simultaneously because the operator should be doing the control charting and attaining statistical control.
vii. At this step, determine how capable the process is according to product specifications and customers expectations.
viii. Then, improve the process. Most of the process problems are handled at this stage. Processes changes can be analyzed by apply it to control charts itself or in variable interaction studies for signs of process improvement. To search improvement, designed experiments can be used. When improvements are found, management must follow and see the suitable changes are incorporated in the process without blacklisting.

xi. This step calls for a switch to pre-control, a monitoring technique that compares a measurement with target and warning measurements, when the process is in control and capable.

xii. Quality improvement is a continuous process. There are two things should be done at this step; first, continue to look for ways in term to improve the process and second, return to step 1 if there are critical measurement.

Nowadays, the companies still have option whether to apply the SPC in process production or not. Some companies just met the minimum requirement of providing basic SPC training and discovered that it's was not good enough. So, both operators and supervisors must understand how important of the SPC for their own good to prevent losses and more reject products. For the management board, also must have good interpretation on SPC where when the operators suggestion is made based on SPC analysis, the management should listen their recommendation.

2.3 Definition of Statistical Process Control (SPC)

Statistical Process Control (SPC) is a method of visually monitoring manufacturing processes. With the use of control charts and collecting few but frequent samples, this method can effectively detect changes in the process that may affect its quality. Under the assumption that a manufactured product has variation and this variation is affected by several process parameters, when SPC is applied to "control" each parameter the final result trend to be a more controlled product. SPC can be very cost efficient, as it usually requires collection and charting data already available, while "product control" requires accepting, rejecting, reworking and scrapping products that already went through the whole process. [1]

SPC is applied to evaluate collected data and to produce solutions by utilizing statistical techniques. All the procedures, such as the collection data until the evaluation of the results are known as Statistical Methods. Statistics assists in process control as in many other areas. The complicated nature of production methods and product structure often inhibits efforts to obtain good quality and standard products. Statistics is a basic means to the solution of such problems.

Classical quality control was achieved by inspecting 100% of the finished product and accepting or rejecting each item based on how well the item met specifications. In contrast, SPC uses statistical tools to observe the performance of the production line to predict significant deviations that may result in rejected products. By observing at the right time what happened in the process that let to a change, the quality engineer or any member of the team responsible for the production line can troubleshoot the root cause of the variation that has crept in to the process and correct the problem.

SPC is a technique used within the Total Quality Managemant framework for reducing variation in processes which we deal with everyday. It is a powerful technique to control, manage, analyze and improve the performance of a process by eliminating special causes of variation in processes such as tool wear, operator error, errors in measurements, use of improper raw material, and so on. In Japan, many companies have embraced the technique SPC with great success for tackling quality related problems such as high scrap rate, increased number of customer complaints, high rework costs, incapable processes etc. [4]

A process is defined as being stable if its natural variation is due to common causes. The process is then said to be under statistical control. If a process is unstable, that is because unusual factors are operating on the process. There are two main factor that affected the process and give variations, these factors known as special causes, result in the process being out of statistical control. [5]

In order to achieve the optimum efficiency, productivity and the higher quality, each company employee must be committed to use the effective methods, such as by using SPC. SPC can be applied whenever work is being done. Initially, it was applied to just production processes, but is has evolved to the point where it is applied to any work situation where data can be gathered. As companies work toward to achieve quality target, SPC is used in more diverse situations.

Other defines, SPC as a procedure in which a data is collected organized, analyzed and interpreted. Finally the process can be maintained at its present level of quality or improved to a higher level of quality. [6]

SPC gives an indication to when to act in the process, but also tells when NOT to act in the process. An example would be someone who wants to keep the weight at a certain level and tracks it weekly. A person who does not know SPC concepts would start dieting every time the weight goes up a couple of pounds, and eat more the next week when it went up. This type of action could be harm and generate even more variation. SPC would show exactly what the normal variation is and when the person is in fact gaining or loosing weight.

By using SPC tools, some variations can be recognizes in any process. Some of the process variations are inherent to the process and are unavoidable. Process measurement is established to disregard the effects of common causes of variation. On the other hand, special causes of variation are often introduced into processes, causing them to produce defective product or scrap. These special causes variation are the important input of SPC measurement.

2.4 Concepts of SPC

There are two concepts of SPC that can apply to improve the process.

i. SPC is the primary analysis tool of quality improvement. It is the applied science that helps you collect, organize and interpret the wide variety of information available to your business. Whether you track revenues, billing errors, or the dimensions of manufactured components, SPC can help you measure, understand and control the variables that affect your business processes.[6]

ii. SPC can help you understand and reduce the variation in any business process. Greater consistency in fulfilling your customer's requirements leads to greater customer satisfaction. Reduced variation in your internal processes leads to less time and money spent on rework and waste. Both directly yield greater profitability and security for your business. SPC is one of the essential tools necessary to maintain an advantage in today's competitive marketplace.[6]

2.5 Key Success for the Implementation of SPC

In order to effectively apply SPC in any organization, it is fundamental to understand the essential ingredients that will make the application of SPC successful.

i. Management issues: Total management support and commitment, necessary resources for training and education plus follow-up of training from time to time, actions on the system/processes whenever needed.
ii. Engineering skills: Understanding the key benefits from the introduction and application of SPC, measurement system analysis (stability, capability, linearity etc.), process prioritization, understanding what key characteristics or process parameters to measure and how to measure them, etc.
iii. Statistical skills: Statistical stability, calculation of control limits, interpretation of control limits, selection of control charts, determination of sample size & sub-group size, et
iv. Teamwork skills: Company-wide understanding of SPC and its benefits, co-operation from all levels of the organization, brainstorm what needs to measure in a process and so on. [7]

2.6 The Basic Tools for SPC

There are seven basic tools that can be used for statistical calculation; it is Flow chart, Pareto Chart, Checksheet, Cause-and-Effect Diagram, Histogram, Control Chart and Scatterplot. For this research, the Control Chart is chosen to apply in SPC. This is because Control Charts are a powerful statistical tool that may have many different applications. For example, they may be used to monitor key product variables and process parameters. They may also be used in the maintenance of process control and in the identification of special and common causes of variation. In addition, they may also be used for process improvement by showing the effects of process of change. [8]

2.7 Determining the Quality Characteristic to Be Measured

Choice of a characteristic to be measured depends on what is being monitored for within-piece variation, piece-to-piece variation or variation over time. Characteristic affecting performances are found in many aspect of product, including raw materials, components, subassemblies and finished product. Amount of scraps, number of reworks, dimensions, geometries and shrinkage factors are example of characteristic in a manufacturing industry. The characteristics selected should be the ones that effect product or service performance. It is very important to identify important characteristics because to avoid the tendency to establish many SPC tools for all measurement.

2.8 Concept of Variation

In any evaluation of product attributes, there will have variations because there are no two products are alike. Therefore, it can be said that variation exists on both products. Even variation is small and appears to be the same, but when using high precision instrument to measure them, the instrument will show different readings. Ability to measure variation is the most prior controlling process. Basically, there are three categories of variation in piece-part production; within piece – e.g. surface roughness, piece to piece – e.g. dimensions and time to time – e.g. different outcomes, tool wear, operators tired etc.

Factor that becoming the source of variation can be classified as follows:

i. Equipment – tool wear, misadjustment machine, etc
ii. Material – tensile strength, moisture content in material
iii. Environment – temperature, light, humidity, etc
iv. Operator – method, training
v. Inspection – inspector, inspection equipment

Classification for each type of these factors is done and the factors are categorized as common-causes and assignable-causes (special causes).

2.8.1 Causes for Variation in Manufacturing Process

SPC is used to seek the limit of the variation present in the manufacturing process or the service being provided. There are two types of variation that occur during the production running; common-cause and special-cause.

i. Common causes: These are avoidable process variations that are always present and for which no specific cause can be assigned. As long as it fluctuates in natural or expected manner, which producing stable pattern and gives small variation, it can be neglected. If large magnitude of variation occurred, therefore this type of cause can be treated as assignable causes.

ii. Assignable-causes: Also called special causes of variation. This type of variation arises because of specific circumstance (e.g.: machine wear, misadjust equipment, fatigue or untrained operators, new batch of raw material and etc).

All variations can be detect and identified by using SPC tools. The most common SPC tool which is widely used in industry is control chart. From the control chart, it can show the hint of the problem occur during manufacturing process.

2.9 Control Chart

Control Charts are a powerful statistical tool that may have many different applications. For example, they may be used to monitor key product variables and process parameters. They may also be used in the maintenance of process control and in the identification of special and common causes of variation. In addition, they may also be used for process improvement by showing the effects of process of change.[8]

Control schemes are the mostly widely known and used methods among SPC methods. Control schemes can be used to determine whether the differences in quality resulted from coincidences of operation conditions or from artificial reasons of which the source can be determined. The aims of this study are the determination of the lower and upper control limits, and process capability indices. [3]

Control charts provide the operational definition of the term special cause. A special cause is simply anything which leads to an observation beyond a control limit. However, this simplistic use of control charts does not do justice to their power. Control charts are running records of the performance of the process and, as such, they contain a vast store of information on potential improvements. While some guidelines are presented here, control chart interpretation is an art that can only be developed by looking at many control charts and probing the patterns to identify the underlying system of causes at work. [7]

Control Charts are a powerful statistical tool that may have many different applications. For example, they may be used to monitor key product variables and process parameters. They may also be used in the maintenance of process control and in the identification of special and common causes of variation. In addition, they may also be used for process improvement by showing the effects of process of change.[9]