Paper 293-2012

The Alarm Effect of SPC Control Process in Vehicle Manufacturing

Wang Ying, Shanghai GM, Shanghai, China

ABSTRACT

Statistical process control (SPC) is the application of statistical methods to the monitoring and control of a process to ensure that it operates at its full potential to produce conforming product. Under SPC, a process behaves predictably to produce as much conforming product as possible with the least possible waste. While SPC has been applied most frequently to controlling manufacturing lines, it applies equally well to any process with a measurable output. Key tools in SPC are control charts, a focus on continuous improvement and designed experiments.

Much of the power of SPC lies in the ability to examine a process and the sources of variation in that process using tools that give weight to objective analysis over subjective opinions and that allow the strength of each source to be determined numerically. Variations in the process that may affect the quality of the end product or service can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer. With its emphasis on early detection and prevention of problems, SPC has a distinct advantage over other quality methods, such as inspection, that apply resources to detecting and correcting problems after they have occurred.

SAS® Enterprise Guide ® is a Microsoft Windows client application that provides a guided mechanism to use SAS and publish dynamic results throughout an organization in a uniform way. It is marketed as the default interface to SAS for business analysts, statisticians, and programmers. With SAS Enterprise Guide, the SPC method can be carried out conveniently.

INTRODUCTION

The Shewhart chart is named after Walter A. Shewhart (1891-1967), a physicist at the Bell Telephone Laboratories, who introduced the method in 1924. The concepts underlying the control chart are that the natural variability in any manufacturing process can be quantified with a set of control limits and that the variation exceeding these limits signals a change in the process.

In industry, the Shewhart chart is the most commonly applied statistical quality control method for studying the variation in output from a manufacturing process. Shewhart charts are typically used to distinguish between the variation that is due to special causes and the variation that is due to common causes. Special causes, also referred to as assignable causes, are local, sporadic problems. Common causes are problems that are inherent in the manufacturing system as a whole.

When the special causes have been identified and eliminated, the process is said to be in statistical control. Once statistical control has been established, Shewhart charts can be used to monitor the process for the occurrence of future special causes and to measure and reduce the effects of common causes.

The Shewhart control chart is a graphical and analytical tool for determining whether a process is in statistical control.

The Individual Measurements Chart task creates control charts for the individual measurements and the moving ranges. These charts are appropriate when only one measurement is available for each subgroup sample and when the measurements are independently and normally distributed. For example, suppose that an aeronautics company that manufactures jet engines measures the inner diameter of the forward face of each engine (in centimeters). The diameter measurements of 20 engines are stored in a SAS data set. Each point on the individual measurements chart indicates the inner diameter of a particular engine. Each point on the moving range chart indicates the range of the two most recent measurements. If all the individual measurements and moving ranges fall within the control limits, you can conclude that the process is in statistical control.

The Mean and Range Chart task creates mean and range charts for the subgroup means and the subgroup ranges. These charts are useful for analyzing the central tendency and the variability of a process. For example, suppose that in the manufacture of silicon wafers, batches of five wafers are sampled, and their diameters are measured in millimeters. The measurements for 25 batches are stored in a SAS data set, which is used to create the mean and range charts. Each point on the mean chart represents the average (mean) of the measurements for a particular batch. Each point on the range chart represents the range of the measurements for a particular batch. If all the points fall within the control limits, you can conclude that the process is in statistical control.

For the month yields of cars, every MIS (Month In Service) there is only one IPTV (claim times per 1000 vehicles). So the Individual Measurements Chart task is available. Next I will introduce how to use this method to conduct the Individual Measurements Chart.

APPLICATION

STEP 1: DATA SELECTION AND PREPARATION

Suppose there are totally k observations $x_1, x_2, \cdots x_k$, and every observation is in each time slice. Then the dots used for giving chart are:

Individual points: $x_1, x_2, \cdots x_k$

Moving ranges (MR): $R_1, R_2, \cdots R_k$

where $R_2 = | x_2 - x_1 |, R_3 = | x_3 - x_2 |$.

It can be seen that the number of moving ranges is one smaller than that of individual points.

STEP 2: CALCULATE THE CONTROL LIMITS

The mean of k-sample and the mean of moving ranges are as follows:

$$\bar{X} = \frac{1}{k}\sum_{i=1}^{k} x_k, \bar{R} = \sum_{i=2}^{k} R_i$$

For the two volume sample it is easy to calculate:

$$E(R) = 1.128\sigma, \quad Var(R) = (0.853)^2 \times \sigma^2,$$

$$\hat{\sigma}_x = \bar{R}/1.128 = 0.8865\bar{R}, \hat{\sigma}_R = 0.853 \times 0.8865\bar{R} = 0.756\bar{R}$$

Apply the 3-Sigma criterion, the control limits of the individual moving ranges are:

	X-chart	R-chart
Central Limit (CL)	$\bar{X}$	$\bar{R}$
Upper Control Limit (UCL)	$\bar{X} + 2.66\bar{R}$	$3.27\bar{R}$
Lower Control Limit (LCL)	$\bar{X} - 2.66\bar{R}$	0

STEP 3: DIAGNOSE THE PROCESS STATIONARY

Check whether the dots in the $\bar{X}$ -chart exceed the control limits, and has an abnormal trend. For $\bar{X}$ -chart, there are eight abnormal waves. Mark A，B，C，C，B，A in the chart. Each width of these six regions is 1-sigma，Two C, two B and two A are symmetrical with regard to the central limit.

The Alarm Effect of SPC Control Process in Vehicle Manufacturing, Continued

CL is the central line. The interval between A and B is the One Sigma as the distance from B to C. The distance between UCL and CL is three Sigma.

The eight abnormal waves are shown below:

（1） One dot exceeds the control limit;

（2） Nine continuous dots are on the same side or in the C-region;

（3） Six continuous dots increase or decrease steadily;

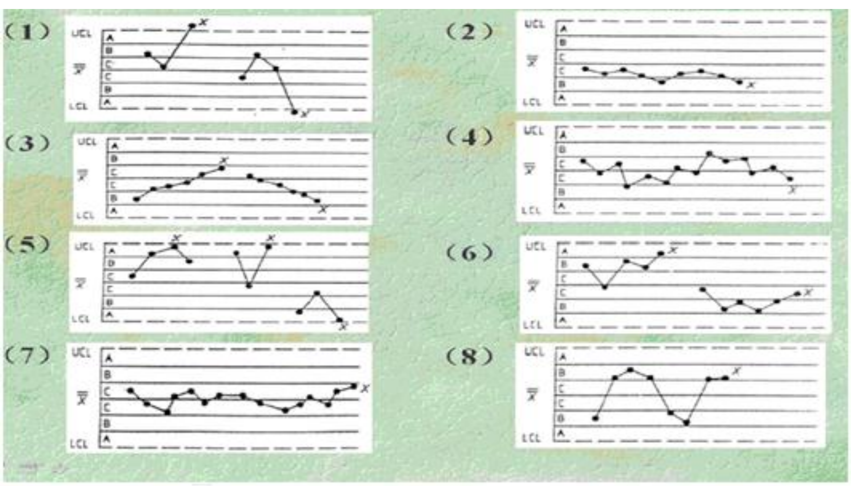
（4） Fourteen continuous dots are up-and-down by turns;

（5） Three continuous dots are within or outside the A-region;

（6） Five continuous dots are within or outside the B-region;

（7） Fifteen continuous dots lie on one or two sides of the mid-line of the C-region;

（8） Eight continuous dots lie on one or two sides of the mid-line and no dot in the C-region;



X-R abnormal waves

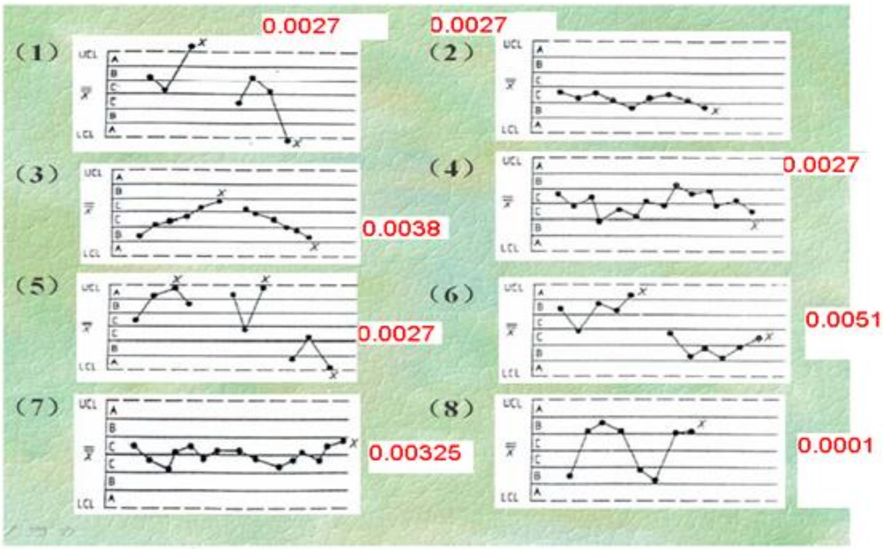
For the stationary process, the data point T can be measured which should follow the normal distribution. Assume T follows N(μ， σ), by the formula below, the probability of dots in any appointed region can be calculated.

$$P(t_1 \le T \le t_2) = \phi(t_2) - \phi(t_1),$$

where $\phi(t)$ is the normal probability distribution.

And the probability of each abnormal wave referred above is as follows:

The Alarm Effect of SPC Control Process in Vehicle Manufacturing, Continued



X-R abnormal waves

As is shown above, the probability of fifteen continuous dots lying on one or two sides of the mid-line of the C-region is 0.00325, which rarely happens. If this event is found in the vehicle manufacturing, it means that the IPTV is out of the way, or the control process is not stable. The staff can lower the control variance to improve the pipelining.

STEP 4: USING THE SHEWHART TO DIAGNOSE THE IPTV STATIONARY IN SGM

4.1 OPEN THE IPTV DATA TO DIGNOSE

	modl_yr	prod_mth	laborcode	iptv_12
1	2006	200612	M520603	80.4597701
2	2007	200701	M520603	69.4444444
3	2007	200702	M520603	108
4	2007	200703	M520603	203.610108
5	2007	200704	M520603	140.954813
6	2007	200705	M520603	108.454494
7	2007	200706	M520603	52.780464
8	2007	200707	M520603	65.6418804
9	2007	200708	M520603	72.2781932
10	2007	200709	M520603	76.3794863

- The IPTV_DIGNOSE is the data for checking IPTV stationary in different production month which is summarized by the production month in the SAS background batch code.
- The variable modl_yr means the production model year
- The variable prod_mth means the month for the car production date.
- The variable laborcode means the error type in car claim.
- The variable IPTV_12 means the IPTV value.

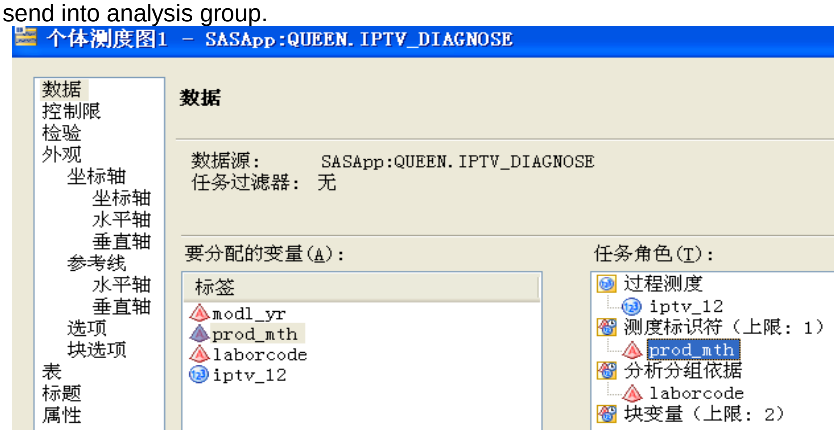
4.2 CHOOSE “CONTROL CHARTS”->” INDIVIDUAL MEASUREMENT SHEWHART”

- Individual Measurements Chart task creates control charts for the individual measurements and the moving ranges. These charts are appropriate when only one measurement is available for each subgroup sample and when the measurements are independently and normally distributed.
- The iptv_12 send into process measurement.
- The prod_mth send into measurement identifier.

The Alarm Effect of SPC Control Process in Vehicle Manufacturing, Continued

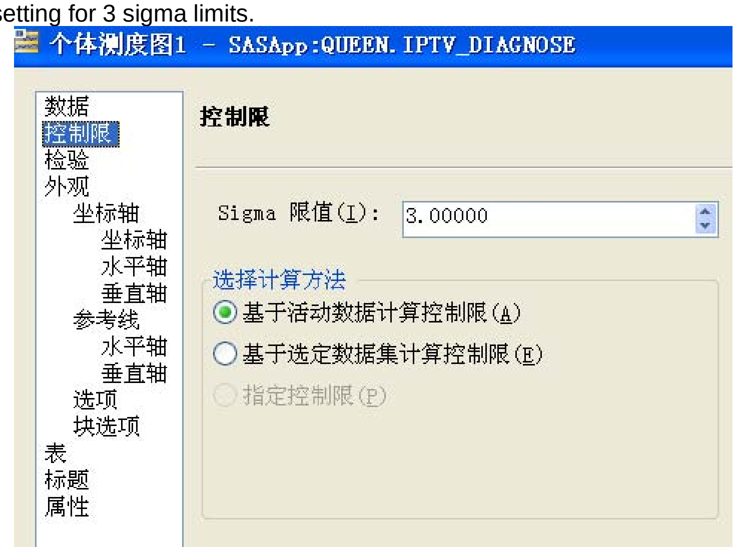
4.3 SETTING IN INDIVIDUAL MEASUREMENT SHEWHART.

- The iptv_12 send into process measurement.
- The prod_mth send into measurement identifier.
- The laborcode send into analysis group.



(Variable Division)

- The Control limit is setting for 3 sigma limits.



(3 sigma limits)

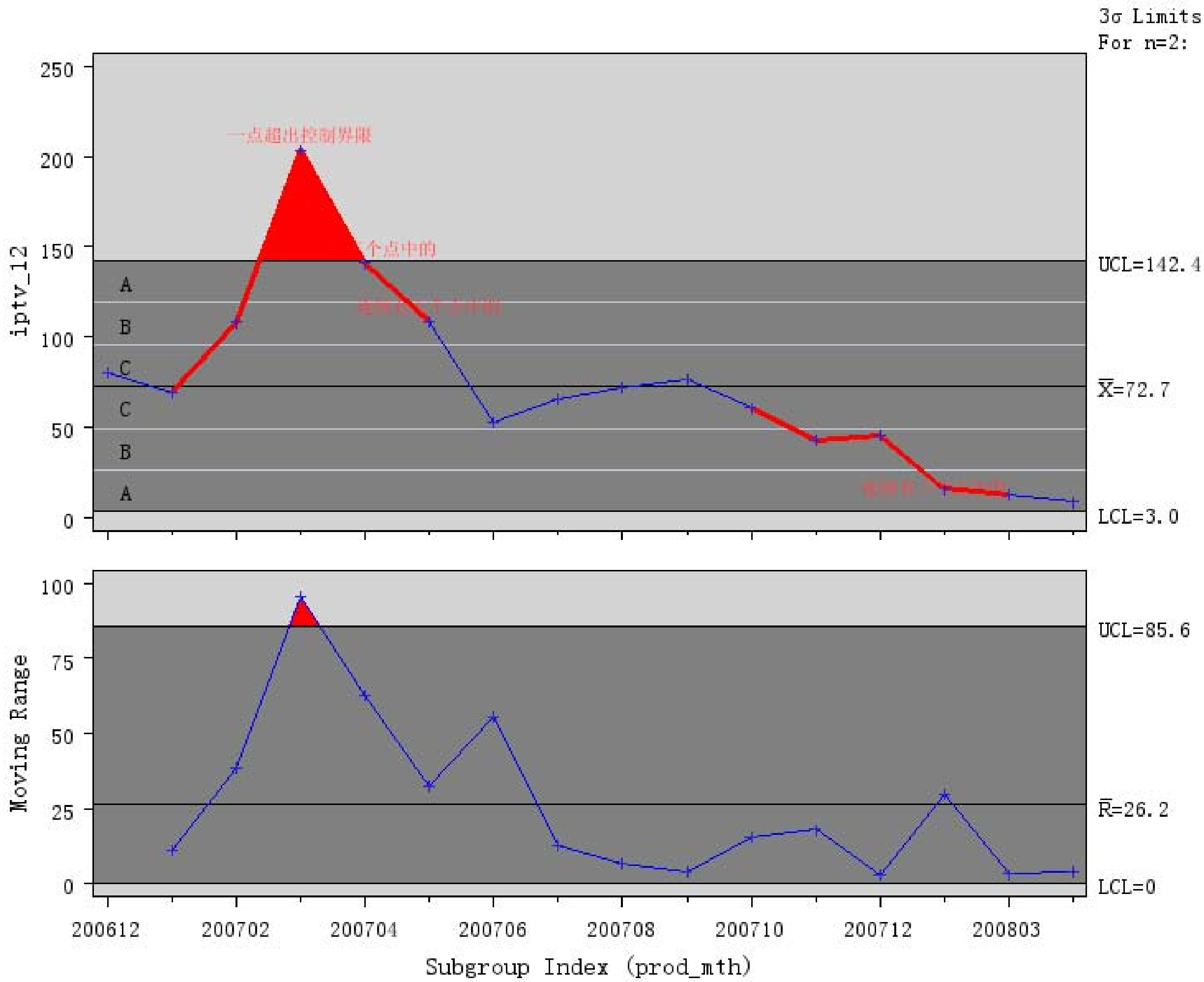
The Alarm Effect of SPC Control Process in Vehicle Manufacturing, Continued

- The tests selection is for 8 tests. And define the label for every test.
- Display Zone lines
- Override 3 Sigma Limits

RESULT

Because of the stable manufacture, the relative claim is also stationary, which can be used with the SPC method to alarm. For example, the 16-months IPTV for a model “Laborcode” from some vehicle manufacturer can be drawn the control chart.

The Alarm Effect of SPC Control Process in Vehicle Manufacturing, Continued



Seen from the graph above, the mark 1 stands for the first abnormal wave, that is when March, 2007, IPTV exceeds the limit and the reason should be surveyed. And the mark 5 shows three continuous IPTVs are in the A-region, from March, 2007 to May. But for the mark 6, four in five continuous IPTVs in the B-region illuminates the apparent quality improvement, but for process control, it is not stable which should be ameliorate by mean and variance re-confirmed.

CONCLUSION

The SPC Control Process is commonly applied in industry, which can give us the timely alarm effect in vehicle manufacturing. With Enterprise Guide, a powerful analytical tool, SPC control method can be easily carried out.

REFERENCES (HEADER 1)

ACKNOWLEDGMENTS (HEADER 1)

RECOMMENDED READING (HEADER 1)

CONTACT INFORMATION (HEADER 1)

Your comments and questions are valued and encouraged.Contact the author at:

Name: Wang Ying
Enterprise: Shanghai General Motors Co. Ltd
Address: 1500 Shengjiang RD
City,StateZIP: 201206
Work Phone: +86-21-28902868
Fax:
E-mail:ying_wang@shanghaigm.com
Web: