Quality Control Chart for Controlling the Defect in Production Output

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Abstract—The Quality of product is a major important in all kind of industries on the world to enhance the competitiveness belong the competitors in business area. It is important to inspect quality into a product because in manufacturing process the stability, repeatable and capable of the operating with little variability around the target is quite important, in this study the researcher trying to implement the statistical process control in the output of conceptual logic simple production line to detect the process still in control, from this study the defect of product shown still in control circumstance but for the average control condition of the process still not in control, it need develop detect with combination methods to measure and make it in control or analysed more in the future to know it cause by machine, raw material or by operator and simultaneous solve the problems.

Keywords—Defect; quality control; variability; u chart.

1. INTRODUCTION

The control chart is a tool for distinguishing between the common causes of variation (variation due to the system itself) and special causes of variation (variation due to factors external to the system) for a CTQ or a CTP (X). Control charts are used to assess and monitor the stability of a CTQ or an X (presence of only common causes of variation). The data for a control chart are collected from a subgroup or sample of items selected at each observation session.

Control charts can be divided into two categories that are determined by the type of data used to monitor a process. These two broad categories are called attribute control charts and measurement (variable) control charts. Attribute control charts are used to evaluate CTQs or Xs that defined by attribute data. The attribute control charts covered in this chapter are as follows:

1. Proportion nonconforming charts (p-charts) for classification data:
   a. Proportion of nonconformities for constant subgroup size.
   b. Proportion of nonconformities for variable subgroup size.
2. Area of opportunity charts for count data:
   a. Number of defects charts (c-charts) for constant areas of opportunity.
   b. Number of defects per unit charts (u-charts) for variable areas of opportunity.

The distinction between the two causes of variation is crucial because special causes of variation are considered to be those that are not due to the process, whereas common causes of variation are due to the process. Only management can change the process.

One experiment that is useful to help you appreciate the distinction between common and special causes of variation was developed by Walter Shewhart more than 80 years ago.

In some applications, the areas of opportunity vary in size. Generally, the construction and interpretation of control charts are easier when the area of opportunity remains constant, but sometimes changes in the area may be unavoidable. For example, samples taken from a roll of paper may need to be manually to and from rolls, so that the areas of opportunity will vary, and the number of typing errors in a document will have areas of opportunity that will vary with the lengths of the documents. When the areas vary, the control chart you use is a u-chart.

The u-chart is similar to the c-chart because it is a control chart for the count of the number of events, such as the number of defects (nonconformities over a given area of opportunity). The fundamental difference lies in the fact that during construction of a c-chart, the area of opportunity remains constant from observation to observation, whereas this is not a requirement for the u-chart. Instead, the u-chart considers the number of events (such as complaints or other defects) as a fraction of the total size of the area of opportunity in which these events were possible, thus circumventing the problem of having different areas of opportunity for different observations. The characteristic used for the chart, u, is the ratio of the number of events to the area of opportunity in which the events occur.

As with the c-chart, subgroups should be of sufficient size to detect an out-of-control event. A general rule for subgroup size for a u-chart is that the subgroup size should be large.
enough to detect a special cause of variation if it exists. Additionally, subgroup frequency should be often enough to detect changes in the process under study. This requires expertise in the process under study. If the process can change very quickly, more frequent sampling is needed to detect special causes of variation. If the process changes slowly, less frequent sampling is needed to detect a special cause of variation ([6], [7]).

II. THEORY

The standard deviation used to calculate control chart limits for variables data is computed from the data. For the binomial distribution-based and Poisson distribution-based control charts we assume that when a process is in statistical control the underlying probabilities remain fixed over time. This does not happen very often and can have a dramatic impact on the binomial distribution-based and Poisson distribution-based control chart limits when the sample size gets large. For large sample sizes batch-to-batch variation can be greater than the prediction of traditional theory because of the violation of an underlying assumption. This assumption is that the sum of one or more binomial distributed random variables will follow a binomial distribution. This is not true if these random variables have differing values. The implication of this is that with very large sample sizes, classical control chart formulas squeeze limits toward the centerline of the charts and can result in many points falling outside the control limits. The implication is that the process is out of control most of the time (unpredictable process), when in reality the control limits do not reflect the true common-cause variability of the process.

The usual remedy for this problem is to plot the attribute failure rates as individual measurements. One problem with this approach is that the failure rate for the time of interest can be very low. For this situation the control chart limit might be less than zero, which is not physically possible. One approach to get around this problem is to use XmR charts to track time between failures and/or to make an appropriate transformation to the data. Another problem with plotting failure rates directly as individual measurements is that there can be a difference in batch sample size ([8],[9]).

A. Control limit and pattern,

The most typical form of a control chart sets control limits at plus or minus three standard deviations of the statistic of interest (the mean, the range, the proportion, etc.). In general, control limits are computed as follows:

Once you compute these control limits from the data, you evaluate the control chart by determining whether any nonrandom pattern exists in the data. Figure 1 illustrates three different patterns.

In panel A of Figure 1, there does not appear to be any pattern in the ordering of values over time, and there are no points that fall outside the three standard deviation control limits. The process appears to be stable; that is, it contains only common cause variation. Panel B, on the contrary, contains two points that fall outside the three standard deviation control limits. Each of these points should be investigated to determine if special causes led to their occurrence. Although panel C does not have any points outside the control limits, there are a series of consecutive points above the mean value (the center line), a series of consecutive points below the mean value, as well as a clearly visible long-term overall downward trend in the value of the variable [2].

B. Result for determining out of control point

The simplest rule for detecting the presence of a special cause is one or more points falling beyond the Three-Sigma limits. The control chart can be made more sensitive and effective in detecting out-of-control points by considering other signals and patterns that are unlikely to occur by chance alone. For example, if only common causes are operating, you would expect the points plotted to approximately follow a bell-shaped normal distribution. Presents a control chart in which the area between the UCL and LCL.

Exhibit 2 provides some rules for deciding when a process is out of control. If only common causes are operating in a process, each of these events is statistically unlikely to occur. For example, the probability that you will observe eight consecutive points on a given side of the center line by chance alone is \((0.5)^8 = 0.0039\). (This is based on the binomial distribution.) Consequently, either a low-probability event occurred (eight points in a row on one side of the center line) or a special cause of variation is present in the process. Many statisticians agree that if the probability of an event is less than 1/100 (in this case, 0.0039), it is reasonable to assume the event is likely due to a special cause of variation, not due to the occurrence of a low-probability common cause of variation (event).

One of the premises for a c-chart is that the sample sizes had to be the same. The sample sizes can vary when a u-chart is being used to monitor the quality of the production process, and the u-chart does not require any limit to the number of potential defects. Furthermore, for a p-chart or an np-chart the number of nonconformities cannot exceed the number of
items on a sample, but for a $u$-chart it is conceivable because what is being addressed is not the number of defective items but the number of defects on the sample. The first step in creating a $u$-chart is to calculate the number of defects per unit for each sample \[2\].

\[
u = \frac{c}{n}
\]

where $u$ represents the average defect per sample, $c$ is the total number of defects, and $n$ is the sample size. Once all the averages are determined, a distribution of the means is created and the next step is to find the mean of the distribution—in other words, the grand mean.

\[
\bar{u} = \frac{u_1 + u_2 + \cdots + u_k}{k}
\]

where $k$ is the number of samples. The control limits are determined based on $u$ and the mean of the samples, $n$:

\[
UCL = \bar{u} + 3 \sqrt{\frac{\bar{u}}{n}}
\]

(3)

\[
CL = \bar{u}
\]

(4)

\[
LCL = \bar{u} - 3 \sqrt{\frac{\bar{u}}{n}}
\]

(5)

Notice that the UCL is not a straight line. This is because the sample sizes are not equal and every time a sample statistic is plotted, adjustments are made to the control limits. The process has shown stability until Sample 27 is plotted. That sample is out of control. \[2\]

The logic modelling production flow design which is start from the module raw material, assigning, process-1, decide, process-2, production-1 and production-2 moduls.

Fig.3 Simple logic production model flow

IV. EXPERIMENTAL RESULT

A. Data and Analysis

The data collected from the product that produced each day from the production unit. The result output from the process and in the process data shown in table I. as follow :

<table>
<thead>
<tr>
<th>Day</th>
<th>Output</th>
<th>Defect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>495</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>146</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>247</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>304</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>291</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>298</td>
<td>24</td>
</tr>
<tr>
<td>7</td>
<td>319</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>146</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
<td>403</td>
<td>29</td>
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<tr>
<td>10</td>
<td>318</td>
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<tr>
<td>11</td>
<td>656</td>
<td>38</td>
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<tr>
<td>12</td>
<td>286</td>
<td>23</td>
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<tr>
<td>13</td>
<td>398</td>
<td>29</td>
</tr>
<tr>
<td>14</td>
<td>146</td>
<td>15</td>
</tr>
<tr>
<td>15</td>
<td>853</td>
<td>53</td>
</tr>
<tr>
<td>16</td>
<td>498</td>
<td>32</td>
</tr>
<tr>
<td>17</td>
<td>730</td>
<td>43</td>
</tr>
<tr>
<td>18</td>
<td>212</td>
<td>18</td>
</tr>
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<td>19</td>
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<td>53</td>
</tr>
<tr>
<td>20</td>
<td>645</td>
<td>38</td>
</tr>
</tbody>
</table>

The data need to be analysis with the $u$ chart of the defect with calculate the CL, UCL and LCL before plotted in the graph, from the data above the UCL 0,0737; LCL 0,0615 and
CL 0.0676, then plot the graph with statistical control charts in new u attributes charts.

IV. CONCLUSION

This study try to measured the process from the output of product and usage of method to see what problems with the assumed the conditional process and how the method applied in the data. From this study the result is the process still shown as a statistical process control it mean the process is still in control but we need to see the data in the average data of the output to control the process as average condition it shown the 5 points were in the out of control limit from the process this process maybe have some problems at the process that could be made appeared by machine problems, raw material quality and the operator problem, to make sure the point is still in control or un control we cannot thought out that point but we must to understand deeply to know the exact problems, meaning it must be more analyse to see the three factors above. For the future work that study it should be develop to check where the problems come from. If we already known the problem it good to develop some methods to combine to solve the problem.

REFERENCES

[7] Shewhart, W. A. Economic Control of Quality of Manufactured Product