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An Exploitation of Target Costing Technique in Quality Management

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Abstract: The target costing technique, mathematically discussed by Sauers, only uses the C_p index along with Taguchi loss function and $\overline{X}$-R control charts to setup goal control limits. The new specification limits derived from Taguchi loss function is linked through the C_p value to $\overline{X}$-R control charts to obtain goal control limits. In this study, the target costing technique is exploited by further considering the reflected normal loss function and the C_{pk} index together with $\overline{X}$-S control charts to setup goal control limits. Finally, an example is provided to illustrate how the target costing technique works.

Keywords: target costing technique; process capability index; loss function; control chart; goal control limit.

1. Introduction

Sauers has stated that the Japanese companies tend to use target costing technique to determine the price of products [1, 2]. By starting with the anticipated acceptable market price, the companies subtract the desired profit margin to obtain a target manufacturing cost. Then, design and manufacturing engineers are responsible to bring the product into being at this cost. Obviously, price can be driven down to the process level, and continuous improvement can be acted by relentlessly improving product quality from cost consideration [2-4].

When the target costing technique is used, the specification limits are derived from Taguchi loss function or other types of applicable loss functions. Later, the derived specification limits are linked through a predetermined capability index value, either obtained from the original data or given by management, along with the conventional control charts to setup goal control limits [1, 2]. Therefore, goal control limits form the foundation for directed continuous improvement efforts by considering the price from the marketplace.

This study only focuses on the "nominal-the-best" of Taguchi loss function, and the formula is as follows:

$$L(y) = k\left(y - T\right)^2, \tag{1}$$

where $L(y)$ is the average or expected loss over all customers, k is the quality loss coefficient, and T is the target value. Consider a component with product specification limits $T \pm \Delta$, and let A_0 be the expected or long run average costs occurred for products with the specification limits $T \pm \Delta$, then k becomes

$$k = \frac{A_0}{\Delta^2}. \tag{2}$$

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By incorporating Eq. (2), Eq. (1) is expressed as follows:

$$L(y) = \frac{A_0}{\Delta^2}\left(y-T\right)^2. \tag{3}$$

The loss to society is minimized when the products are produced at the target value. Moreover, as the product is away from the target value, the loss increases. In contrast to Taguchi loss function with infinite maximum loss, Spiring [5] has pointed out that things such as production resources, cost of identification, scrap or rework and liability generally have a maximum loss. In fact, the traditional loss function with an infinite maximum loss is inadequate to describe the loss associated with a product characteristic. Therefore, Spiring [5] has developed the reflected normal loss function to provide a quantifiable maximum loss and magnitude of losses associated with extreme deviations from the target value. The formula and figure of this reflected normal loss function are provided in Eq. (4) and Figure 1.

$$L(y) = K\left\{1-\exp\left(-\frac{\left(y-T\right)^2}{2\gamma^2}\right)\right\}$$

$$= K\left\{1-\exp\left(-\frac{8\left(y-T\right)^2}{\Delta^2}\right)\right\}, \tag{4}$$

where y represents the quality measurement, K is the maximum-loss parameter, T is the target value, and γ is a shape parameter, defined as $\Delta/4$, where Δ is the distance from the target value to the point where K first occurs. The target value, shape, and maximum-loss parameters can be customized to meet practitioners' requirements.

The property of the reflected normal loss function is asymptotic to the maximum loss incurred only at $\pm\infty$. The term of $\gamma = \Delta/4$ ensures that the loss function at the points $T \pm \Delta$ will be $0.9997K \approx K$. The expected loss associated with the reflected normal loss function is

$$\mathrm{E}(L(y)) = K - K\int \exp\left(-\frac{\left(y-T\right)^2}{2\gamma^2}\right) f\left(y\right)dy, \tag{5}$$

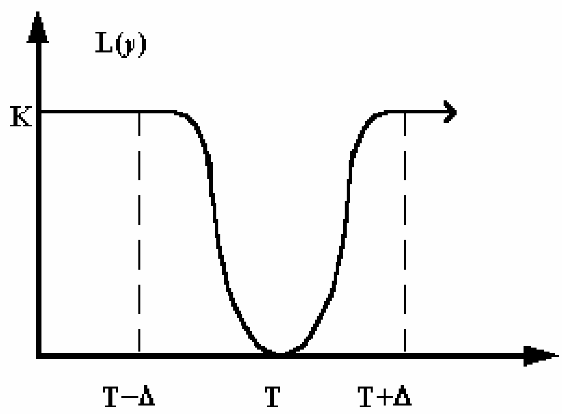

Figure 1. The reflected normal loss function

where $f(y)$ is the associated probability density function. If the quality characteristic follows a normal distribution with a mean of μ and a standard deviation of σ, the expected loss becomes

$$\mathrm{E}L(y) = K - K\int \frac{1}{\sqrt{2\pi}\sigma}$$

$$\exp\left\{-\frac{1}{2}\left(\frac{\left(y-T\right)^2}{\gamma^2} + \frac{\left(\left(y-\mu\right)^2\right.}{\sigma^2}\right)\right\}dy$$

$$= K\left\{1-\frac{\gamma}{\sqrt{\sigma^2+\gamma^2}}\exp\left(-\frac{\left(\mu-T\right)^2}{2\left(\sigma^2+\gamma^2\right)}\right)\right\}, \tag{6}$$

where the minimum is incurred at $\mu = T$. The applications of the reflected normal loss function in practice can be seen in [6].

The target costing technique, mathematically discussed by Sauers [1], is very limited in its development and applications. This technique only incorporates Taguchi loss function, $\overline{X}$-R charts, and the C_p index to setup goal control limits. To strengthen and broaden the target costing technique in practice, this study considers both Taguchi and reflected normal loss functions and takes into account the C_{pk} index on $\overline{X}$-S charts to form goal control limits. Section 2 reviews $\overline{X}$-S charts and the C_p and C_{pk} indices. The exploited target costing technique with the "nominal-the-best" of Taguchi loss function and Spiring's loss function, the $\hat{C}_{pk}$ index, and $\overline{X}$-S charts are discussed in Section 3. An example using Taguchi loss function and the $\hat{C}_{pk}$ index on $\overline{X}$-S charts to setup goal control limits is illustrated in Section 4. Finally, conclusions are drawn in Section 5.

2. $\overline{X}$-S charts and the C_p and C_{pk} indices

Control charts can be used to indicate if any special cause of variation is present in a process. Smith [7] has pointed out that if the charts indicate a source of variation occurs, the chart patterns would provide hints to the causes of the variation, and the workers can use the hints along with their experiences to identify and eliminate the source of variation. When all of the special causes of variation are eliminated from the process, then the process is said to be in statistical control.

Two types of control charts are typically seen in the text: variables and attributes control charts. $\overline{X}$ and S control charts are one of the most commonly seen and applied variables control charts in practice. The formulas of $\overline{X}$ and S charts are as follows:

$$\mathrm{UCL}(S) = B_4 \overline{S}, \tag{7}$$

$$\mathrm{CL}(S) = \overline{S}, \tag{8}$$

$$\mathrm{LCL}(S) = B_3 \overline{S}, \tag{9}$$

$$\mathrm{UCL}(\overline{X}) = \overline{\overline{X}} + 3\frac{\hat{\sigma}}{\sqrt{n}} = \overline{\overline{X}} + 3\frac{\overline{S}}{c_4\sqrt{n}} = \overline{\overline{X}} + A_3 \overline{S}, \tag{10}$$

$$\mathrm{CL}(\overline{X}) = \overline{\overline{X}}, \tag{11}$$

and

$$\mathrm{LCL}(\overline{X}) = \overline{\overline{X}} - 3\frac{\hat{\sigma}}{\sqrt{n}} = \overline{\overline{X}} - 3\frac{\overline{S}}{c_4\sqrt{n}} = \overline{\overline{X}} - A_3 \overline{S}, \tag{12}$$

where UCL, CL, and LCL stand for upper control limit, center line, and lower control limit, respectively, $\overline{S}$ is the average of the sample standard deviation, $\overline{\overline{X}}$ is the average of the subgroup average, $\hat{\sigma} = \overline{S}/c_4$, n is the sample size of the subgroup, and B_4, B_3, A_3, and c_4 are constant and can be found in the text of Smith [7].

When the process is in statistical control, the next step is to conduct process capability analysis to determine how good the measurements are especially compared with the specification limits. The C_p and C_{pk} indices are the two commonly used indices for process capability analysis when the process data are normally distributed. Furthermore, the C_p index measures the relationship between the process spread and the specification limits. On the other hand, the C_{pk} index measures the location shift of a process with the specification limits. In fact, the C_{pk} index is more sensitive than the C_p index in detecting the shift of the process mean [8, 9].

The expressions of the C_p and C_{pk} indices are

$$C_p = \frac{USL - LSL}{6\sigma} = \frac{\Delta}{3\sigma}, \tag{13}$$

and

$$\begin{aligned} C_{pk} &= \min\,(C_{pu}, C_{pl}) \\ &= \min\,(\frac{USL-\mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}) \\ &= \min\,(\frac{(T+\Delta)-\mu}{3\sigma}, \frac{\mu-(T-\Delta)}{3\sigma}), \end{aligned} \tag{14}$$

where *USL*, *T*, and *LSL* are the upper specification limit, target value, and lower specification limit, respectively, and 2Δ is the distance between *USL* and *LSL*. In Eqs. (13) and (14), μ is the mean which is the sum of the numerical values of the measurement divided by the number of items examined, and σ is the standard deviation which is the square root of the average squared deviates from the mean.

Typically, μ and σ are usually unknown, and estimations from the sample data are required. Thus, Eqs. (13) and (14) can be revised as follows:

$$\hat{C}_p = \frac{USL - LSL}{6\hat{\sigma}} = \frac{\Delta}{3\hat{\sigma}}, \tag{15}$$

and

$$\begin{aligned} \hat{C}_{pk} &= \min\,(\hat{C}_{pu}, \hat{C}_{pl}) \\ &= \min\,(\frac{USL-\bar{\bar{X}}}{3\hat{\sigma}}, \frac{\bar{\bar{X}} - LSL}{3\hat{\sigma}}) \\ &= \min\,(\frac{(T+\Delta)-\bar{\bar{X}}}{3\hat{\sigma}}, \frac{\bar{\bar{X}}-(T-\Delta)}{3\hat{\sigma}}), \end{aligned} \tag{16}$$

where $\bar{\bar{X}}$ is computed from $\bar{X}$ control chart. In Eqs. (15) and (16), $\hat{\sigma}$ can be replaced by $\bar{S}/c_4$ if $\bar{X}$-*S* charts are applied prior to process capability analysis [7, 10].

3. The exploitation of the target costing technique

If a quality improvement program is implemented, and the average loss of *L*(*y*) using Taguchi loss function is expected to be *hL*(*y*) $= L'(y) = k(\Delta')^2$, where $0 < h < 1$, then Δ' is

$$\Delta' = \sqrt{\frac{L'(y)}{k}} = \Delta\sqrt{\frac{L'(y)}{A_0}} = \Delta\sqrt{\frac{hL(y)}{A_0}}. \tag{17}$$

The $\hat{C}_p$ and $\hat{C}_{pk}$ values can be directly computed from the raw data. If the management decides to maintain the $\hat{C}_{pk}$ value from the raw data with the specification limits $T \pm \Delta'$, $\hat{C}_{pk}$ based upon Eq. (16) is written as follows:

$$\hat{C}_{pk} = \min\,(\frac{(T+\Delta')-\bar{\bar{X}}}{3\hat{\sigma}'}, \frac{\bar{\bar{X}}-(T-\Delta')}{3\hat{\sigma}'}), \tag{18}$$

where $\hat{\sigma}'$ is the new standard deviation to achieve the $\hat{C}_{pk}$ value. The $\hat{\sigma}'$ incorporating Eqs. (17) and (18) becomes

$$\begin{aligned} \hat{\sigma}' &= \min\,(\frac{(T+\Delta')-\bar{\bar{X}}}{3\hat{C}_{pk}}, \frac{\bar{\bar{X}}-(T-\Delta')}{3\hat{C}_{pk}}) \\ &= \min\,(\frac{T-\bar{\bar{X}}+\Delta\sqrt{\frac{hL(y)}{A_0}}}{3\hat{C}_{pk}}, \\ &\quad \frac{\bar{\bar{X}}-T+\Delta\sqrt{\frac{hL(y)}{A_0}}}{3\hat{C}_{pk}}), \end{aligned} \tag{19}$$

where $\hat{\sigma}'$ is greater than or equal to zero. On the contrary, if Spiring's loss function is considered, the mathematical relationship is as follows: Suppose a quality improvement program is implemented, the general loss is reduced to $L_1(y) = hK$ with the specification limits $T \pm \Delta'$, where $0 < h < 1$. Then the loss function $L_1(y)$ at the point y, where $(y-T)^2 = (\Delta')^2$, becomes

$$L_1(y) = hK = K\left\{1 - \exp\left(-\frac{8(\Delta')^2}{\Delta^2}\right)\right\} \tag{20}$$

and

$$\Delta' = \sqrt{\frac{-\Delta^2}{8}\ln(1-h)} = \frac{\Delta}{2}\sqrt{\frac{-\ln(1-h)}{2}}. \tag{21}$$

If the management decides to maintain the quality level at the $\hat{C}_{pk}$, value with the specification limits $T \pm \Delta'$, $\hat{\sigma}$, based upon Eqs. (18) and (21), is as follows:

$$\hat{\sigma}' = \min\left(\frac{(T+\Delta') - \overline{\overline{X}}}{3\hat{C}_{pk}}, \frac{\overline{\overline{X}} - (T-\Delta')}{3\hat{C}_{pk}}\right)$$
$$= \min\left(\frac{(T + \frac{\Delta}{2}\sqrt{\frac{\ln(h-1)}{2}}) - \overline{\overline{X}}}{3\hat{C}_{pk}}, \frac{\overline{\overline{X}} - (T - \frac{\Delta}{2}\sqrt{\frac{\ln(h-1)}{2}})}{3\hat{C}_{pk}}\right). \tag{22}$$

When $\hat{\sigma}'$ is known from either Eq. (19) or Eq. (22) depending upon the type of the loss function used, the general format of the goal control limits for $\overline{X}$-S charts are

$$\mathrm{UCL}(\overline{X}) = \overline{\overline{X}} + 3\frac{\hat{\sigma}'}{\sqrt{n}}$$
$$= \begin{cases} \overline{\overline{X}} + 3\frac{1}{\sqrt{n}}\frac{(T+\Delta') - \overline{\overline{X}}}{3\hat{C}_{pk}} & (\text{if } \hat{C}_{pu} \le \hat{C}_{pl}) \\ \overline{\overline{X}} + 3\frac{1}{\sqrt{n}}\frac{\overline{\overline{X}} - (T-\Delta')}{3\hat{C}_{pk}} & (\text{if } \hat{C}_{pu} \ge \hat{C}_{pl}) \end{cases} \tag{23}$$

$$\mathrm{CL}(\overline{X}) = \overline{\overline{X}}, \tag{24}$$

$$\mathrm{LCL}(\overline{X}) = \overline{\overline{X}} - 3\frac{\hat{\sigma}}{\sqrt{n}}$$
$$= \begin{cases} \overline{\overline{X}} - 3\frac{1}{\sqrt{n}}\frac{(T+\Delta') - \overline{\overline{X}}}{3\hat{C}_{pk}} & (\text{if } \hat{C}_{pu} \le \hat{C}_{pl}) \\ \overline{\overline{X}} - 3\frac{1}{\sqrt{n}}\frac{\overline{\overline{X}} - (T-\Delta')}{3\hat{C}_{pk}} & (\text{if } \hat{C}_{pu} \ge \hat{C}_{pl}) \end{cases} \tag{25}$$

$$\mathrm{UCL}(S) = B_4\overline{S}' = B_4 c_4 \hat{\sigma}'$$
$$= \begin{cases} B_4 c_4 \frac{(T+\Delta') - \overline{\overline{X}}}{3\hat{C}_{pk}} & (\text{if } \hat{C}_{pu} \le \hat{C}_{pl}) \\ B_4 c_4 \frac{\overline{\overline{X}} - (T-\Delta')}{3\hat{C}_{pk}} & (\text{if } \hat{C}_{pu} \ge \hat{C}_{pl}) \end{cases} \tag{26}$$

$$\mathrm{CL}(S) = \overline{S}' = c_4\hat{\sigma}'$$
$$= \begin{cases} c_4 \frac{(T+\Delta') - \overline{\overline{X}}}{3\hat{C}_{pk}} & (\text{if } \hat{C}_{pu} \le \hat{C}_{pl}) \\ c_4 \frac{\overline{\overline{X}} - (T-\Delta')}{3\hat{C}_{pk}} & (\text{if } \hat{C}_{pu} \ge \hat{C}_{pl}) \end{cases} \tag{27}$$

and

$$\mathrm{LCL}(S) = B_3\,\overline{S}' = B_3\,c_4\,\hat{\sigma}'$$

$$= \begin{cases} B_3\,c_4\,\dfrac{(T+\Delta') - \overline{\overline{X}}}{3\hat{C}_{pk}} & (\text{if } \hat{C}_{pu} \le \hat{C}_{pl}) \\ B_3\,c_4\,\dfrac{\overline{\overline{X}} - (T-\Delta')}{3\hat{C}_{pk}} & (\text{if } \hat{C}_{pu} \ge \hat{C}_{pl}) \end{cases} \tag{28}$$

In summary, the target costing technique, originally mathematically discussed by Sauers [1], has been exploited by further considering the C_{pk} index as well as both Taguchi and the reflected normal loss functions. Specifically, the C_{pk} index provides much more information about the process. In addition, the advantage of applying the reflected normal loss function provides alternatives to measure the quality loss of a particular product characteristic. Obviously, the exploited target costing technique is more universal by taking into account the C_{pk} index as well as Taguchi and the reflected normal loss functions.

4. An example

To demonstrate how the target costing technique is practical, the data from Gitlow, Oppenheim, and Oppenheim [11] are used and provided in Table 1. Assume the values of *USL*, *T*, and *LSL* are to be 2.45, 2.10, and 1.75, respectively. The UCL, CL, and LCL of *S* chart using Eqs. (7)-(9) are 0.189, 0.109, and 0.031, respectively; whereas the respective UCL, CL, and LCL values of $\overline{X}$ chart using Eqs. (10)-(12) are 2.227, 2.12, and 2.013, where $\hat{\sigma} = \overline{S}/c_4 = 0.112$, $c_4 = 0.9727$, $A_3 = 0.975$, $B_3 = 0.284$, and $B_4 = 1.716$ for $n = 10$. Since the process is in statistical control, the $\hat{C}_p$ and $\hat{C}_{pk}$ values using Eqs. (15) and (16) are 1.04 and 0.98.

Table 1. The data from Gitlow, Oppenheim, and Oppenheim [1]

Subgroup	Sample size for each subgroup (n = 10)										$\overline{X}$	S
1	2.08	2.26	2.13	1.94	2.30	2.15	2.07	2.02	2.22	2.18	2.14	0.111
2	2.14	2.02	2.14	1.94	2.30	2.08	1.94	2.12	2.15	2.36	2.12	0.137
3	2.30	2.10	2.20	2.25	2.05	1.95	2.10	2.16	2.37	1.98	2.15	0.136
4	2.01	2.10	2.15	1.97	2.25	2.12	2.10	1.90	2.04	2.08	2.07	0.098
5	2.06	2.12	1.98	2.12	2.20	2.02	2.19	2.03	2.02	2.09	2.08	0.074
6	2.14	2.22	2.18	2.27	2.17	2.26	2.15	2.07	2.02	2.36	2.18	0.099
7	2.07	2.05	1.97	2.05	2.16	2.02	2.02	2.14	2.07	2.00	2.06	0.059
8	2.08	2.31	2.12	2.18	2.15	2.17	1.98	2.05	2.00	2.26	2.13	0.107
9	2.13	1.90	2.12	2.04	2.40	2.12	2.15	2.01	2.30	2.14	2.13	0.141
10	2.13	2.16	2.12	2.22	2.12	2.07	2.04	2.28	2.12	2.10	2.14	0.070
11	2.24	2.34	2.40	2.26	2.13	2.15	2.08	2.02	2.05	2.18	2.19	0.125
12	2.25	1.91	1.96	2.04	1.93	2.08	2.29	2.42	2.10	2.00	2.10	0.170
13	2.03	2.10	2.24	2.20	2.25	2.03	2.06	2.19	2.13	2.20	2.14	0.084
14	2.08	1.92	2.14	2.20	2.02	2.04	1.94	2.05	2.12	2.06	2.06	0.086
15	2.04	2.14	2.18	2.12	2.00	2.02	2.05	2.34	2.12	2.05	2.11	0.101
16	1.92	2.10	2.13	2.02	1.93	2.17	2.24	1.98	2.34	2.12	2.10	0.136
17	2.12	2.30	2.01	2.20	2.11	1.93	2.02	2.25	2.05	2.10	2.11	0.115
18	1.98	2.30	2.31	2.12	2.08	2.10	2.15	2.35	2.12	2.26	2.18	0.121
19	2.08	2.12	2.11	2.22	2.00	1.95	2.15	2.14	2.28	2.31	2.14	0.113
20	2.22	2.05	1.93	2.08	2.15	2.27	1.95	2.11	2.12	2.10	2.10	0.106
Total											42.43	2.189
Average											2.12	0.109

Suppose the target costing technique is applied, A_0 is \$10 and Δ equals 0.35. The quality loss coefficient k is $A_0/\Delta^2 = 10/0.35^2 = 81.63$. If the company decides to reduce the cost by 10 percent with the $\hat{C}_{pk}$ value of 1.00, then Δ' becomes 0.33, $L'(y) = 0.9(10) = 9 = 81.63\,\Delta'^2$. The value of $\hat{\sigma}'$ applying Eq. (19) is

$$\hat{\sigma}' = \min\left(\frac{(2.10+0.33)-2.12}{3(1.00)},\ \frac{2.12-(2.10-0.33)}{3(1.00)}\right)$$
$$= \min(0.103, 0.117) = 0.103$$

The goal control limits for both $\overline{X}$-S charts using Eqs. (23)-(28) are

$$\mathrm{UCL}(\overline{X}) = \overline{\overline{X}} + 3\frac{\hat{\sigma}'}{\sqrt{n}} = 2.12 + 3\frac{0.103}{\sqrt{10}}$$
$$= 2.218$$
$$\mathrm{CL}(\overline{X}) = \overline{\overline{X}} = 2.12$$
$$\mathrm{LCL}(\overline{X}) = \overline{\overline{X}} - 3\frac{\hat{\sigma}'}{\sqrt{n}} = 2.12 - 3\frac{0.103}{\sqrt{10}}$$
$$= 2.022$$
$$\mathrm{UCL}(S) = B_4\,\overline{S}' = B_4\,c_4\,\hat{\sigma}'$$
$$= (1.716)(0.9727)(0.103) = 0.172$$
$$\mathrm{CL}(S) = \overline{S}' = c_4\,\hat{\sigma}' = (0.9727)(0.103)$$
$$= 0.100$$
and
$$\mathrm{LCL}(S) = B_3\,\overline{S}' = B_3\,c_4\,\hat{\sigma}'$$
$$= (0.284)(0.9727)(0.103) = 0.028$$

If the target costing technique is applied by reducing the 10% cost and achieving the $\hat{C}_{pk}$ value of 1.00, the standard deviation becomes smaller, i.e., from 0.112 to 0.103. Thus, tighter goal control limits are formed to ensure all of the average ($\overline{X}$) and standard deviation (S) values should be within the goal control limits.

If the $\hat{C}_{pk}$ value is to be improved from the current 1.00 to 1.25, the goal control limits are determined as follows:

$$\hat{\sigma}' = \min\left(\frac{(2.10+0.33)-2.12}{3(1.25)},\ \frac{2.12-(2.10-0.33)}{3(1.25)}\right)$$
$$= \min(0.083, 0.093) = 0.083$$
$$\mathrm{UCL}(\overline{X}) = \overline{\overline{X}} + 3\frac{\hat{\sigma}'}{\sqrt{n}} = 2.12 + 3\frac{0.083}{\sqrt{10}}$$
$$= 2.199$$
$$\mathrm{CL}(\overline{X}) = \overline{\overline{X}} = 2.12$$
$$\mathrm{LCL}(\overline{X}) = \overline{\overline{X}} - 3\frac{\hat{\sigma}'}{\sqrt{n}} = 2.12 - 3\frac{0.083}{\sqrt{10}}$$
$$= 2.041$$
$$\mathrm{UCL}(S) = B_4\,\overline{S}' = B_4\,c_4\,\hat{\sigma}'$$
$$= (1.716)(0.9727)(0.083) = 0.139$$
$$\mathrm{CL}(S) = \overline{S}' = c_4\,\hat{\sigma}' = (0.9727)(0.083)$$
$$= 0.081$$
and
$$\mathrm{LCL}(S) = B_3\,\overline{S}' = B_3\,c_4\,\hat{\sigma}'$$
$$= (0.284)(0.9727)(0.083) = 0.023$$

Clearly, the standard deviation becomes much smaller, i.e., from 0.103 to 0.083. The S values in subgroups 9 and 12 are above UCL(S). Therefore, a corrective action should be taken. If Spiring's loss function is applied, the procedure is very similar. As long as the reflected normal loss function discussed in Eqs. (20) and (21) is determined, and $\hat{\sigma}'$ is computed by Eq. (22), the goal control limits of $\overline{X}$-S control charts will be established. The target costing technique can be applied to both reduce the cost and improve the process performance at the same time. It can also be used by either reducing the cost or improving the product quality. As a result, the company can become more competitive in the marketplace.

5. Conclusions

This study exploits the target costing technique by further considering the $\hat{C}_{pk}$ index, both Taguchi and the reflected normal loss functions, and $\overline{X}$-S control charts. The new specification limits derived from either Taguchi or Spiring's loss function is linked through the $\hat{C}_{pk}$ value to $\overline{X}$-S charts to obtain goal control limits. The philosophy of the target costing technique is to relentlessly improve product quality and reduce costs such that a more robust product would be more competitive in the marketplace. Finally, an example is demonstrated to show how the target costing technique can be applied in practice.

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