IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 7 (July. 2018), ||V (I) || PP 12-16

Performance of X-Bar Chart Associated With Mean Deviation under Three Delta Control Limits and Six Delta Initiatives

Kalpesh S. Tailor[1]
[1]*Assistant Professor,Department of Statistics,M. K. Bhavnagar University, Bhavnagar-364001*
Corresponding author: Kalpesh S. Tailor[1]

Abstract: A control chart is a graphical device for representation of the data for knowing the extent of variations from the expected standard. The technique of control chart was suggested by W.A. Shewhart of Bell Telephone Company based on three sigma limits. M. Harry, the engineer of Motorola has introduced the concept of six sigma in 1980. In six sigma initiatives, it is expected to produce 3.4 or less number of defects per million of opportunities. Moderate distribution proposed by Naik V.D and Desai J.M, is a sound alternative of normal distribution, which has mean and mean deviation as pivotal parameters and which has properties similar to normal distribution. Naik V.D and Tailor K.S. have suggested the concept of 3-delta control limits and developed various control charts based on this distribution. In this paper an attempt is made to construct a control chart based on three delta and six delta initiatives for X-bar chart associated with mean deviation. Suitable Table for mean deviation is also constructed and presented for the engineers for making quick decisions.

Key words: Moderate distribution, X-bar, Mean deviation, Six Delta.

Date of Submission: 21-06-2018 Date of acceptance: 05-07-2018-

---

I. INTRODUCTION

The technique of quality control was developed by W. A. Shewhart (1931). It was based on 3sigma control limits. The concept of six-sigma was introduced by Motorola by the engineer Mikel Harry in 1980. He developed methods for problem solving that combined formal techniques, particularly relating to measurement, to achieve measurable savings in millions of dollars. The companies, which are practicing Six Sigma, are expected to produce 3.4 or less number of defects per million opportunities.

R.Radhakrishnan and P.Balamurugan (2010, 2011, and 2016) have developed six sigma based control charts for mean, Exponentially Weighted Moving Average(EWMA), X bar using standard deviation, standard deviation, range and moving averages.

Naik V.D and Desai J.M (2015) have proposed an alternative of normal distribution called moderate distribution, which has mean(μ) and mean deviation(δ) as pivotal parameters and which has properties similar to normal distribution. V.D.Naik and K.S.Tailor (2015) have suggested 3δ(3 mean deviation) control limits based on moderate distribution. On the basis of 3δ control limits, they have developed $\bar{X}$ -chart, R-chart, s-chart and d-chart. K.S.Tailor (2016) has also developed moving average and moving range chart and exponentially moving average chart under moderateness assumption.

Similar to six sigma concept, here an attempt is made to develop six delta concepts. The six sigma control limits are based normality assumption and the control limits are determined by using standard deviation (σ-sigma) of the statistic, whereas the six delta control limits are based on moderateness assumption and the control limits are determined by using mean deviation (δ-delta) of the statistic. In six sigma initiatives, it is expected to produce 3.4 or less number of defects per million of opportunities whereas in six delta initiatives, it is expected to produce 1.7 or less number of defects per million of opportunities. If the companies practicing Six Delta initiatives use the control limits, then no point fall outside the control limits because of the improvement in the quality of the process. Kalpesh S Tailor (2017) has proposed sample standard deviation(s) chart, sample mean deviation (d) chart and exponentially weighted moving .average (EWMA) chart based on six delta initiatives. Here an attempt is made to construct a control chart based on three delta and six delta initiatives for X-bar chart associated with mean deviation. Suitable Table for mean deviation is also constructed and presented for the engineers for making quick decisions.

II. CONCEPTS AND TERMINOLOGIES

A. Upper specification limit (USL)

It is the greatest amount specified by the producer for a process or product to have the acceptable performance.

B. Lower specification limit (LSL)

It is the smallest amount specified by the producer for a process or product to have the acceptable performance.

C. Tolerance level (TL)

It is the difference between USL and LSL, TL = USL-LSL

D. Process capability (Cp)

This is the ratio of tolerance level to six times mean deviation of the process.

Cp = (TL/ $6\sqrt{\frac{\pi}{2}}\delta$) = (TL/10.6369$\delta$) = (USL-LSL)/10.6369$\delta$

E. Mean deviation ($\delta_{6\delta}$): For many purposes mean deviation is the most useful measure of dispersion of a set of numbers. It is the mean of absolute deviation.

F. Quality Control Constant (D_{md})

The constant D_{md} is introduced in this paper to determine the control limits based on six delta initiatives for $\bar{X}$-chart associated with mean deviation.

III. THREE DELTA CONTROL LIMITS FOR $\bar{X}$- CHART ASSOCIATED WITH MEAN DEVIATION:

Suppose that the main variable of the process x follows moderate distribution. The mean of x is E(x) = μ and mean deviation of x = δ_x =δ'. According to the central limit theorem for moderate distribution if the distribution of x is not moderate, it can be said that $\bar{X}$ follows moderate distribution for a large sample. So, mean of $\bar{X}$ = E ($\bar{X}$) = μ and mean deviation of $\bar{X}$ is δ_x =$\frac{\delta_x}{\sqrt{n}}$.

On the basis of 3δ criteria suggested by Naik and Tailor, the control limits for x̄- chart associated with mean deviation can be represented as follows.

$$CL_{3\delta} = \mu_0 \quad (1)$$

$$LCL_{3\delta} = \mu_0 - 3\frac{\delta}{\sqrt{n}} \quad (2)$$

$$UCL_{3\delta} = \mu_0 + 3\frac{\delta}{\sqrt{n}} \quad (3)$$

Where μ_0 is the target value of the mean and δ is the process mean deviation.

IV. SIX DELTA BASED CONTROL LIMITS FOR $\bar{X}$- CHART ASSOCIATED WITH MEAN DEVIATION:

Fix the tolerance level (TL) and process capability (C_p) to determine the process mean deviation δ(termed as $\delta_{6\delta}$), which is calculated from Cp = (TL/10.6369δ). For a specified TL and C_p of the process, the values of $\delta_{6\delta}$ is calculated, and presented in table 2. The value of D_{md} is obtained by using $P(Z \leq D_{md})$= 1- α_1, where $\alpha_1 = 1.7 \times 10^{-6}$ and Z is a standard moderate variate. Thus, the control limits for six delta based control chart for moving average chart are determined as,

$$CL_{6\delta} = \mu_0 \quad (4)$$

$$LCL_{6\delta} = \mu_0 - \frac{D_{md}\,\delta_{6\delta}}{\sqrt{n}} \quad (5)$$

$$UCL_{6\delta} = \mu_0 + \frac{D_{md}\,\delta_{6\delta}}{\sqrt{n}} \quad (6)$$

V. AN EMPIRICAL STUDY FOR $\bar{X}$- CHART ASSOCIATED WITH M.D AND COMPARISION OF THREE DELTA LIMITS AGAINST SIX DELTA INITIATIVES

To illustrate the use of x̄- chart associated with mean deviation with three delta and six delta limits, a data set is taken from E.L.Grant & R.S.Leavenworh (1988). The data, together with the corresponding values of mean and mean deviation are shown in Table 1.Three delta and six delta control limits are computed from this data set, and control charts are plotted under these two limits.

Lot	X_1	X_2	X_3	X_4	X_5	$\bar{\bar{X}}$	$\hat{\delta}$
1	77	80	78	72	78	77	2.72
2	76	79	73	74	73	75	2.16
3	76	77	72	76	74	75	1.44
4	74	78	75	77	77	76.2	1.44
5	80	73	75	76	74	75.6	1.96

6	78	81	79	76	76	78	2.2
7	75	77	75	76	77	76	0.84
8	79	75	78	77	76	77	1.52
9	76	75	74	75	75	75	0.88
10	71	73	71	70	73	71.6	4.2
11	72	73	75	74	75	73.8	2
12	75	73	76	73	73	74	1.88
13	75	76	78	79	77	77	1.52
14	77	77	78	77	76	77	1.2
15	77	76	77	77	77	76.8	1
16	77	77	77	79	79	77.8	2

TABLE 1: Data set

(a) Three delta control limits for $\bar{x}$- chart associated with M.D:

Here the target mean (μ_0) is estimated by the average value of sample mean and process mean deviation (δ) is estimated by the average value of sample mean deviation. Hence $\mu_0 = 75.8$ and $\delta = 1.81$. The three delta control limits are computed using equations (1), (2), (3) and are found as,

LCL = 73.3717, CL = 75.8 and UCL = 78.2283

(b) Control limits based on six delta initiatives for $\bar{x}$- chart associated with M.D :

For a given data set USL = 78, LSL = 71.6, TL = 78 – 71.6 = 6.4 and C_p = 1.5. The value of $\delta_{6\delta}$ = 0.4011, which is found from the Table 2, D_{md} = 5.815 which is calculated from $P(Z \leq D_{md})$ = 1- α_1, where $\alpha_1 = 1.7 \times 10^{-6}$. The value of μ_0 is taken to be 75.8. Hence, the control limits based on six delta initiatives for this chart for a specified TL and D_{md} are computed using equations (4), (5), (6) and are found as,

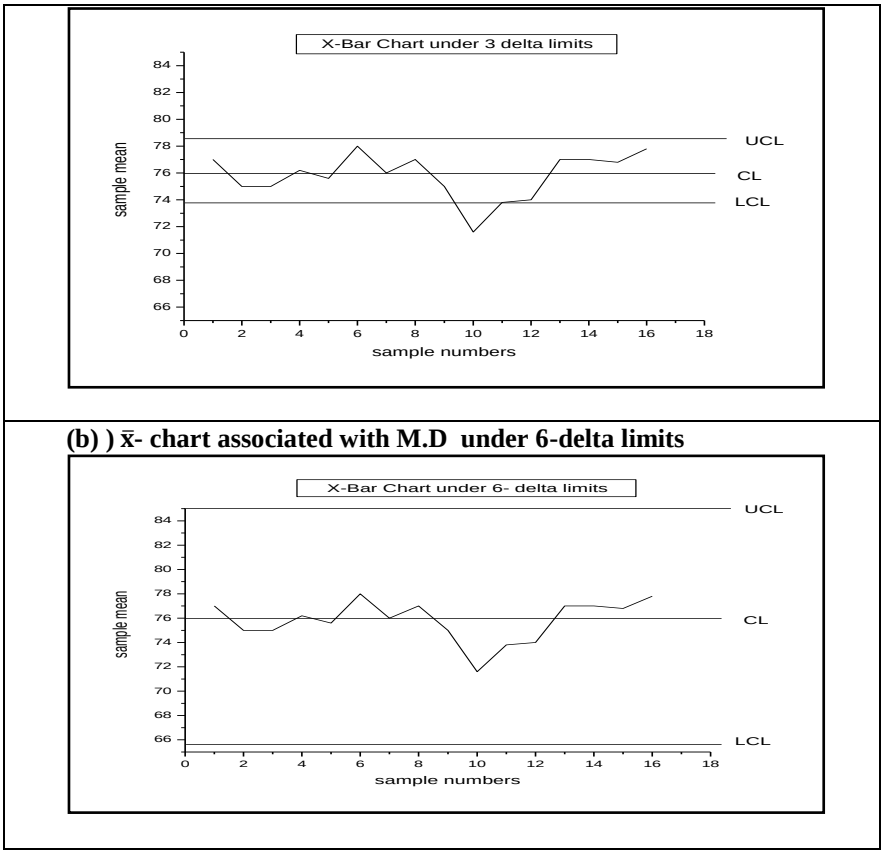
$LCL_{6\delta}$ = 65.9210, $CL_{6\delta}$ = 75.8, $UCL_{6\delta}$ = 85.6789

TL / C_p	**6.1**	**6.2**	**6.3**	**6.4**	**6.5**
1.0	0.5735	0.5829	0.5923	0.6017	0.6111
1.1	0.5213	0.5299	0.5384	0.5470	0.5555
1.2	0.4779	0.4857	0.4936	0.5014	0.5092
1.3	0.4411	0.4484	0.4456	0.4628	0.4701
1.4	0.4096	0.4163	0.4231	0.4298	0.4365
1.5	0.3823	0.3886	0.3949	0.4011	0.4074
1.6	0.3584	0.3643	0.3702	0.3761	0.3820
1.7	0.3373	0.3429	0.3484	0.3539	0.3595
1.8	0.3186	0.3238	0.3290	0.3343	0.3395
1.9	0.3018	0.3068	0.3117	0.3167	0.3216
2.0	0.2867	0.2914	0.2961	0.3008	0.3055
2.1	0.2731	0.2776	0.2820	0.2865	0.2910
2.2	0.2607	0.2649	0.2692	0.2734	0.2778
2.3	0.2493	0.2534	0.2575	0.2616	0.2657
2.4	0.2389	0.2429	0.2468	0.2507	0.2546
2.5	0.2294	0.2332	0.2369	0.2407	0.2444

TABLE 2: Values of δ for a specified C_p and TL

(c) $\bar{x}$- chart for data set given in Table 1 based on three delta and six delta limits

(a) $\bar{x}$- chart associated with M.D under 3-delta limits



(b)) $\bar{x}$- chart associated with M.D under 6-delta limits

Figure 1

VI. SUMMARY AND CONCLUSION

In this paper, $\bar{x}$- chart associated with mean deviation is discussed under three delta and six delta control limits with an illustration. From figure 1, it can be seen that the production process is out of statistical control when we are applying 3-delta control limits but the process is under the statistical control when we are using six-delta based control limits.. So it can be concluded that the chart under six delta control limits are more effective towards detecting the shift in the value of mean than the charts under three delta control limits. This is a next generation control chart technique and it can replace existing six sigma technique. So it is recommended that the control charts under six delta control limits should be used for the best results.

REFERENCES

[1]. E.L.Grant and R.S.Leavenworh (1988): Statistical Quality Control, McGraw-Hill.

[2]. J. Ravichandran (2016): Six Sigma Based X-bar control chart for Continuous Quality Improvement, International Journal for Quality Research, Vol. 10, Issue.2, 257-266

[3]. K.S.Tailor(2016): Moving Average And Moving Range Charts Under The Assumption Of Moderateness And Its 3δ Control Limits, Sankhya Vignan, December-2016,No.2, 18-31

[4]. K.S.Tailor(2017): Exponentially Weighted Moving Average (EWMA)Charts Under The Assumption Of Moderateness And Its 3-delta Control Limits, Mathematical Journal of Interdisciplinary Sciences(MJIS), March-2017, Vol. 5, No. 2, 121-129

[5]. K.S.Tailor(2017):Sample Standard Deviation(s) Chart Under The Assumption Of Moderateness And Its Performance Analysis, International Journal of Research- Granthaalayah (IJRG), Vol. 5, Issue 6,June - 2017, 368-377

[6]. R.Radhakrishnan and P.Balamurugan(2010):Six Sigma based Exponentially Weighted Moving Average Control Chart, Indian journal of Science and Technology (IJST), Vol.3, No. 10, October, pp. 1052-1055

[7]. R.Radhakrishnan and P.Balamurugan(2011):):Construction of control chart based on six sigma initiatives for moving average, International Journal of Current Scientific Research, Vol.1, No. 3,111-114

[8]. R.Radhakrishnan and P.Balamurugan(2016):Construction of control chart based on six sigma initiatives for standard deviation ,American International Journal of Research in Science, Technology, Engineering & Mathematics, June- August , pp. 245-248

[9]. V.D. Naik and J.M. Desai (2015): Moderate Distribution: A modified normal distribution which has Mean as location parameter and Mean Deviation as scale parameter, VNSGU Journal of Science and Technology, Vol.4, No. 1, 256-270

[10]. V.D. Naik and K.S. Tailor (2015):On performance of $\overline{X}$ and R-charts under the assumption of moderateness rather than normality and with 3δ control limits rather than 3σ control limits, VNSGU Journal of Science and Technology, Vol.4, No. 1, 243-255

[11]. W.A. Shewhart (1931): Economic Control of Quality of Manufactured Product, New York: Van Nostrand

Kalpesh S. Tailor "Performance of X-Bar Chart Associated With Mean Deviation under Three Delta Control Limits and Six Delta Initiatives "IOSR Journal of Engineering (IOSRJEN), vol. 08, no. 7, 2018, pp. 12-16