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Research Article

CONSTRUCTION OF CONTROL CHART BASED ON SIX SIGMA INITIATIVES FOR XBAR CHART USING MOVING RANGE

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ABSTRACT

A control chart is a statistical device used for the study and control of repetitive process. W.A. Shewhart [22] of Bell Telephone Laboratories suggested control charts based on the 3 sigma limits. Now the companies in developed and developing countries started applying Six Sigma initiatives in their manufacturing process, which results in lesser number of defects. The companies practicing Six Sigma initiatives are expected to produce 3.4 or less number of defects per million opportunities, a concept suggested by Motorola [23]. If the companies practicing Six Sigma initiatives use the control limits suggested by Shewhart [22], then no point fall outside the control limits because of the improvement in the quality of the process. In this paper an attempt is made to construct a control chart based on six sigma initiatives for X bar chart using moving Range specially designed for the companies applying Six Sigma initiatives in their organization. Suitable Table – 2 is also constructed and presented for the engineers to take quick decisions.

INTRODUCTION

The concept of Six Sigma was introduced by Motorola [23] by the engineer M.Harry who analyzed variations in outcomes of the company's internal procedures and realized that by measuring variations it will be possible to improve the working of the system. The procedure was aimed at taking action to improve the overall performance. The companies, which are practicing Six Sigma, are expected to produce 3.4 or less number of defects per million opportunities. Radhakrishnan and Sivakumaran [16-21] used the concept of Six Sigma in the construction of sampling plans such as single, double and repetitive group sampling plans indexed through Six Sigma Quality Levels (SSQLs) with Poisson distribution as the base line distribution. Radhakrishnan [2] suggested single sampling plan indexed through Six Sigma quality levels (SSQLs) based on Intervened Random Effect Poisson Distribution and Weighted Poisson Distribution as the base line distributions. Radhakrishnan and Balamurugan [3-15] constructed control charts based on six sigma initiatives for defects, mean, average fraction defectives, number of defectives, X bar using standard deviation, Exponentially Weighted Moving Average (EWMA), proportion defectives – number of defectives, Fraction defectives, Standard deviation with variable sample size, Standard deviation, average number of nonconformities per multiple units and number of defects - average number of defects per unit. The control charts originated by W.A. Shewhart [22] was based on 3 sigma control limits. If the same charts are used for the products of the companies which adopt six sigma initiatives in the process, then no point will fall outside the control limits because of the improvement in the quality. So a separate control chart is required to monitor the outcomes of the companies, which adopt six sigma initiatives.

In this paper an attempt is made to construct a control chart based on six sigma initiatives for X bar chart using moving Range. Suitable Table – 2 is also constructed and presented for the engineers to take quick decisions.

Concepts and Terminologies

Upper specification limit (USL)

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

Lower specification limit (LSL)

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

Tolerance level (TL)

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

Process capability (Cp)

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

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$$c_p = \frac{TL}{6\sigma} = \frac{USL - LSL}{6\sigma}$$

Moving Range (MR)

It is defined as $MR_i = |x_i - x_{i-1}|$

Quality Control Constant ($J_{6\sigma}$)

The constant $J_{6\sigma}$ introduced in this paper to determine the control limits based on six sigma initiatives for $\bar{x}$ chart using Moving range.

Construction of control chart based on six sigma initiatives for $\bar{x}$ chart using Moving Range

Fix the tolerance level (TL) and process capability (C_P) to determine the process standard deviation ($\sigma_{6\sigma}$). Apply the value of $\sigma_{6\sigma}$ in the control limits $\bar{X} \pm J_{6\sigma}\sigma_{6\sigma}$, to get the control limits based on six sigma initiatives for $\bar{x}$ chart using Moving range. The value of $E_{6\sigma}$ is obtained using $p(z \le z_{6\sigma}) = 1 - \alpha_1, \alpha_1 = 3.4 \times 10^{-6}$ and z is a standard normal variate. For a specified TL and C_P of the process, the value of σ (termed as $\sigma_{6\sigma}$) is calculated from $c_p = \frac{TL}{6\sigma}$ using a C program and presented in Table 2 for various combinations of TL and C_P. Further the value of $E_{6\sigma}$ is also obtained using the procedure given above and the control limits based on six sigma initiatives for $\bar{x}$ chart using Moving range are

$$UCL_{6\sigma} = \bar{X} + J_{6\sigma}\sigma_{6\sigma}$$

$$\text{Central Line } CL = \bar{X}$$

$$LCL_{6\sigma} = \bar{X} - J_{6\sigma}\sigma_{6\sigma}$$

Conditions for Application

- Human involvement should be less in the manufacturing process
- The company adopts Six sigma quality initiatives in its processes

Table 1 Viscosity of Aircraft Primer Paint

Batch Number	Viscosity	Moving Range
1	33.75	
2	33.05	0.70
3	34.00	0.95
4	33.81	0.19
5	33.46	0.35
6	34.02	0.56
7	33.68	0.34
8	33.27	0.41
9	33.49	0.22
10	33.20	0.29
11	33.62	0.42
12	33.00	0.62
13	33.54	0.54
14	33.12	0.42
15	33.84	0.72

Example

The example provided by Montgomery, D.C, 2001 [1] is considered here. The viscosity of aircraft primer paint is an important quality characteristic. The product is produced in batches, and as each batch takes several hours to produce, the production rate is too slow to allow sample sizes greater than one. The viscosity of the previous 15 batches is given below.

$\bar{X} = 33.52$ and $\overline{MR} = 0.48$

Three Sigma Control limits for $\bar{x}$ chart using Moving range

The 3σ control limits suggested by shewhart (1931) are $\bar{X} \pm (3/d_2)\overline{MR}$

$$UCL_{3\sigma} = \bar{X} + (3/d_2)\overline{MR} = 33.52 + 3\frac{0.48}{1.128} = 34.80$$

$$\text{Cental line } CL_{3\sigma} = \bar{X} = 33.52$$

$$LCL_{3\sigma} = \bar{X} - (3/d_2)\overline{MR} = 33.52 - 3\frac{0.48}{1.128} = 32.24$$

It is clear from the Figure 1 that the process is in control, since **the entire batch numbers** lie inside the control limits.

Control limits based on six sigma initiatives for $\bar{x}$ chart using Moving range

For a given TL = 0.76 (USL-LSL =0.95-0.19) & CP = 1.5, it is found from the Table-2 that the value of $\sigma_{6\sigma}$ is 0.08. The control limits based on six sigma initiatives for the $\bar{x}$ chart using Moving range for a specified TL and $J_{6\sigma}$ are $\bar{X} \pm 4.831\sigma_{6\sigma}$ with

$$UCL_{6\sigma} = \bar{X} + J_{6\sigma}\sigma_{6\sigma} = 33.52 + (4.831 \times 0.08) = 33.91$$

$$\text{Cental line } CL_{6\sigma} = \bar{X} = 33.52$$

$$LCL_{6\sigma} = \bar{X} - J_{6\sigma}\sigma_{6\sigma} = 33.52 - (4.831 \times 0.08) = 33.13$$

From the Figure 1, batch numbers **3rd and 6th** goes above the upper control limit and the batch numbers **2nd, 12th and 14th** goes below the lower control limit. Therefore the process does not exhibit statistical control.

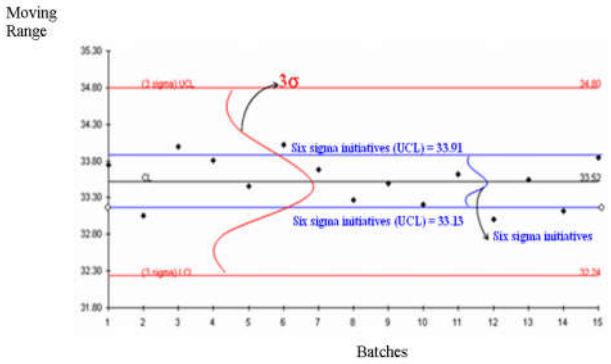

Figure 1 Comparison of the process: 3σ limits and control limits using Six Sigma initiatives

Table 2 $\sigma_{6\sigma}$ Values for a specified C_p and TL

C_p \ TL	0.76	0.77	0.78	0.79	0.80
1.0	0.13	0.13	0.13	0.13	0.13
1.1	0.12	0.12	0.12	0.12	0.12
1.2	0.11	0.11	0.11	0.11	0.11
1.3	0.10	0.10	0.10	0.10	0.10
1.4	0.09	0.09	0.09	0.09	0.10
1.5	**0.08**	0.09	0.09	0.09	0.09
1.6	0.08	0.08	0.08	0.08	0.08
1.7	0.07	0.08	0.08	0.08	0.08
1.8	0.07	0.07	0.07	0.07	0.07
1.9	0.07	0.07	0.07	0.07	0.07
2.0	0.06	0.06	0.07	0.07	0.07
2.1	0.06	0.06	0.06	0.06	0.06
2.2	0.06	0.06	0.06	0.06	0.06
2.3	0.06	0.06	0.06	0.06	0.06
2.4	0.05	0.05	0.05	0.05	0.06
2.5	0.05	0.05	0.05	0.05	0.05

CONCLUSION

In this paper, a procedure is given to construct a control chart based on six sigma initiatives for X bar chart using moving Range with an example. It is found that the process was not in control even when six sigma initiatives are adopted. It is very clear from the comparison that when the process is centered with reduced variation many points fall outside the control limits than the 3 sigma control limits, which indicate that the process is not in the level it was expected. So a correction in the process is very much required to reduce the variations. The charts suggested in this paper will be very useful for the companies practicing Six Sigma initiatives in their process. These charts will replace the existing Shewhart [22] control charts in future when all the companies started implementing six sigma initiatives in their organization.

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