Stochastic Modeling and Applications
Vol.26 No. 1 (January-June, 2022)
ISSN: 0972-3641

Received: 30th October 2021 *Revised: 25th December 2021* *Selected: 07th January 2022*

FUZZY ATTRIBUTE CONTROL CHART FOR NUMBER OF DEFECTIVES USING PROCESS CAPABILITY

S. PRABU AND C. NANTHAKUMAR*

Abstract. In standard control outlines, all information ought to be all through known. All the while, express quality credits can't be permitted on the mathematical scale, like attributes for appearance, affectability, and covering. Cushioned seat hypothesis is an excellent numerical way to deal with oversee administer separate insufficiencies, problematic and without that can etymologically portray information in these conditions (Sogandi et al. 2014). Woolen control follows have been gotten out by changing over the shocking sets related to etymological or fascinating traits into scalars saw as master respect. In this paper, we pull in another delicate control outline for the proportion of defectives with a model.

1. Introduction

There are two head sorts of careful cycle control (SPC). The focal sort works with evaluation information. For example, a model would be assessing the broadness of a chamber showed a part that is passed on by machining headway. The standard SPC method for controlling assessment information is to utilize R follows (Shewhart, 1931). The subsequent kind structures with brand name information. For the current condition, rather than managing the guaranteed appraisal data, the correspondence control solitary presents a brand name like pass or dismissal. A standard SPC structure utilizes a p-plan subject to joined wellsprings of data and using binomial scattering. These common progressions work appropriately up to a piece of single information is needed for the appraisal information issues and as long as twofold information is required in the brand name information issues. Cushioned SPC is colossal when transparent information sources are needed for these two SPC issue types, Montgomery (2008).

Wang and Raz (1990) plan two frameworks for making variable control subject to etymological information. Consequently, Raz and Wang (1995) given out cushioned sets to each phonetic term to create and organize control graphs for etymological information. Gulbay and Kahraman (2004) made α -level fragile control follows for credits information to address the risks of the information and uncommon of the appraisal. There are different cases with inadequacy, challenging, and restricted or semantically depicted information in fundamental applications. Almost certainly, suggested information influence the presentation of the brand name control plan. Later on, it is significant to utilize another construction that makes

Key words and phrases. Fuzzy, Fuzzy Control Outline, Number of Defectives, and Interaction Capacity.

versatility in a degree of data. Then, improve the introduction of an expansive worth control diagram in the straightforwardness of assignable clarification. Finally, we consider another technique for control diagrams to change cushioned sets into scalars subject to α-level tricky midrange. This evaluation paper is summed up as the hypothetical advancement of a delicate standard with the proportion of defective control strategies utilizing a measure limit is given under a game plan.

2. Control charts for attributes

There are various conditions where it is captivating to record recognizing information instead of parts (assessment) information.

In one strategy for brand name testing, every unit is poor down and surmised a few insignificant classes; the standard practice is to utilize only two groupings, for example, broken and interfacing, yet branches could, likewise, be picked lacking adequate first quality, satisfying second quality, and so forth. Another arrangement joins checking and recording the level of turns in a standard unit of creation.

3. Importance of the study

In the unfathomably veritable world, the possibility of the thing and affiliation expect an enormous part. The clients' fulfillment is seen as key for a reasonable advancement in their business. Any industry overpowers their business if it outfits lovely quality things and relationships with the most held satisfaction to their clients. These days, the undertakings in the East or Western space of the world concerning globalization turn more around the Quality Control measures to improve the thing rules.

In this article, we consider the condition when the standard worth of sigma is frail. We are amped designed checking past information, tie care concerning assessor that has a particular shape and being adequately quantifiable and needs little appraisal time. In like manner, in this article, we change the fantastic control plan for the proportion of defectives utilizing past many's opinions on possible.

4. Methods and materials

In the current Shewhart (1931) system, the technique for the control plan for number of defectives is worked with by the going with condition:

$$\begin{aligned} UCL_{np} &= n\overline{p} + 3\sqrt{n\overline{p}(1-\overline{p})} \\ CL_{np} &= n\overline{p} \\ LCL_{np} &= n\overline{p} - 3\sqrt{n\overline{p}(1-\overline{p})} \end{aligned}$$

where UCL is the upper control limit, CL is the middle line and LCL is the lower control breaking point of np control outline.Fuzzy numbers (Pb_x, Pb_y, Pb_z) are addressed with respect $(\tilde{\overline{p}}_{b_{x_j}}, \tilde{\overline{p}}_{b_{y_j}}, \tilde{\overline{p}}_{b_{z_j}})$ to each fuzzy perception on the control diagram for number of defectives. The middle line (CL) for the np - control chart is as follows:

$$CL = (n\tilde{\overline{p}}_{b_{x_j}}, n\tilde{\overline{p}}_{b_{y_j}}, n\tilde{\overline{p}}_{b_{z_j}}), \text{ where } j = 1, 2, 3, \ldots, n.$$

By considering the nuances of - control limits and feathery numbers basically dependent upon three-sided support works, the soft focus line, fleecy upper and cushioned lower eliminate points of the cushy standard - control diagram are given as follows:

$$\begin{aligned}
(UCL_{n\tilde{\overline{p}}_{b_x}}, UCL_{n\tilde{\overline{p}}_{b_y}}, UCL_{n\tilde{\overline{p}}_{b_z}}) &= \begin{pmatrix} n\tilde{\overline{p}}_{b_x} + 3\sqrt{n\tilde{\overline{p}}_{b_x}(1-\tilde{\overline{p}}_{b_x})}, \\ n\tilde{\overline{p}}_{b_y} + 3\sqrt{n\tilde{\overline{p}}_{b_y}(1-\tilde{\overline{p}}_{b_y})}, \\ n\tilde{\overline{p}}_{b_z} + 3\sqrt{n\tilde{\overline{p}}_{b_z}(1-\tilde{\overline{p}}_{b_z})} \end{pmatrix} \\
(CL_{n\tilde{\overline{p}}_{b_x}}, CL_{n\tilde{\overline{p}}_{b_y}}, CL_{n\tilde{\overline{p}}_{b_z}}) &= (n\tilde{\overline{p}}_{b_{x_j}}, n\tilde{\overline{p}}_{b_{y_j}}, n\tilde{\overline{p}}_{b_{z_j}}) \\
(LCL_{n\tilde{\overline{p}}_{b_x}}, LCL_{n\tilde{\overline{p}}_{b_y}}, LCL_{n\tilde{\overline{p}}_{b_z}}) &= \begin{pmatrix} n\tilde{\overline{p}}_{b_x} - 3\sqrt{n\tilde{\overline{p}}_{b_x}(1-\tilde{\overline{p}}_{b_x})}, \\ n\tilde{\overline{p}}_{b_y} - 3\sqrt{n\tilde{\overline{p}}_{b_y}(1-\tilde{\overline{p}}_{b_y})}, \\ n\tilde{\overline{p}}_{b_z} - 3\sqrt{n\tilde{\overline{p}}_{b_z}(1-\tilde{\overline{p}}_{b_z})} \end{pmatrix}
\end{aligned}$$

The proposed and affirmed standard deviations $(\tilde{\sigma}_{i.n\overline{p}:F-C_p, i=x,y,z})$ for $n\overline{p}$-fuzzy control graph are assessed and carefully assessed by receiving measure ability

$$C_p = \frac{USL_{i.n\tilde{p}:F-C_p} - LSL_{i.n\tilde{p}:F-C_p}}{6\sigma}, i = x, y, z.$$

In this way, the after effects of the proposed fuzzy control limits for umber of defectives (np) with the help of interaction capacity, (Radhakrishnan and Balamurugan, 2011) are as per the following:
The $n\tilde{p}$-control cutoff points of the α-cut fuzzy strategy for three-sided fuzzy numbers are gathered as follows:

$$\begin{aligned}
(UCL_{n\tilde{\overline{p}}_{b_x}:C_p}, UCL_{n\tilde{\overline{p}}_{b_y}:C_p}, UCL_{n\tilde{\overline{p}}_{b_z}:C_p}) &= \begin{pmatrix} n\tilde{\overline{p}}_{b_x} + 3\tilde{\sigma}_{x.n\overline{p}:F-C_p}, \\ n\tilde{\overline{p}}_{b_y} + 3\tilde{\sigma}_{y.n\overline{p}:F-C_p}, \\ n\tilde{\overline{p}}_{b_z} + 3\tilde{\sigma}_{z.n\overline{p}:F-C_p} \end{pmatrix} \\
(CL_{n\tilde{\overline{p}}_{b_x}:C_p}, CL_{n\tilde{\overline{p}}_{b_y}:C_p}, CL_{n\tilde{\overline{p}}_{b_z}:C_p}) &= (n\tilde{\overline{p}}_{b_{x_j}}, n\tilde{\overline{p}}_{b_{y_j}}, n\tilde{\overline{p}}_{b_{z_j}}) \\
(LCL_{n\tilde{\overline{p}}_{b_x}:C_p}, LCL_{n\tilde{\overline{p}}_{b_y}:C_p}, LCL_{n\tilde{\overline{p}}_{b_z}:C_p}) &= \begin{pmatrix} n\tilde{\overline{p}}_{b_x} - 3\tilde{\sigma}_{x.n\overline{p}:F-C_p}, \\ n\tilde{\overline{p}}_{b_y} - 3\tilde{\sigma}_{y.n\overline{p}:F-C_p}, \\ n\tilde{\overline{p}}_{b_z} - 3\tilde{\sigma}_{z.n\overline{p}:F-C_p} \end{pmatrix} \\
(UCL^{\alpha}_{n\tilde{\overline{p}}_{b_x}}, UCL^{\alpha}_{n\tilde{\overline{p}}_{b_y}}, UCL^{\alpha}_{n\tilde{\overline{p}}_{b_z}}) &= \begin{pmatrix} n\tilde{\overline{p}}^{\alpha}_{b_x} + 3\sqrt{n\tilde{\overline{p}}^{\alpha}_{b_x}(1-\tilde{\overline{p}}^{\alpha}_{b_x})}, \\ n\tilde{\overline{p}}^{\alpha}_{b_y} + 3\sqrt{n\tilde{\overline{p}}^{\alpha}_{b_y}(1-\tilde{\overline{p}}^{\alpha}_{b_y})}, \\ n\tilde{\overline{p}}^{\alpha}_{b_z} + 3\sqrt{n\tilde{\overline{p}}^{\alpha}_{b_z}(1-\tilde{\overline{p}}^{\alpha}_{b_z})} \end{pmatrix} \\
(CL^{\alpha}_{n\tilde{\overline{p}}_{b_x}}, CL^{\alpha}_{n\tilde{\overline{p}}_{b_y}}, CL^{\alpha}_{n\tilde{\overline{p}}_{b_z}}) &= (n\tilde{\overline{p}}^{\alpha}_{b_x}, n\tilde{\overline{p}}^{\alpha}_{b_y}, n\tilde{\overline{p}}^{\alpha}_{b_z}) \\
(LCL^{\alpha}_{n\tilde{\overline{p}}_{b_x}}, LCL^{\alpha}_{n\tilde{\overline{p}}_{b_y}}, LCL^{\alpha}_{n\tilde{\overline{p}}_{b_z}}) &= \begin{pmatrix} n\tilde{\overline{p}}^{\alpha}_{b_x} - 3\sqrt{n\tilde{\overline{p}}^{\alpha}_{b_x}(1-\tilde{\overline{p}}^{\alpha}_{b_x})}, \\ n\tilde{\overline{p}}^{\alpha}_{b_y} - 3\sqrt{n\tilde{\overline{p}}^{\alpha}_{b_y}(1-\tilde{\overline{p}}^{\alpha}_{b_y})}, \\ n\tilde{\overline{p}}^{\alpha}_{b_z} - 3\sqrt{n\tilde{\overline{p}}^{\alpha}_{b_z}(1-\tilde{\overline{p}}^{\alpha}_{b_z})} \end{pmatrix}
\end{aligned}$$

Where, $\tilde{p}_{b_x} = \tilde{p}_{b_x} + \alpha(\tilde{p}_{b_y} - \tilde{p}_{b_x})$ and $\tilde{p}_{b_z} = \tilde{p}_{b_z} + \alpha(\tilde{p}_{b_z} - \tilde{p}_{b_y})$.

$$\begin{aligned}
(UCL^{\alpha}_{n\tilde{\bar{p}}_{b_x}:C_p}, UCL_{n\tilde{\bar{p}}_{b_y}:C_p}, UCL^{\alpha}_{n\tilde{\bar{p}}_{b_z}:C_p}) &= \begin{pmatrix} n\tilde{\bar{p}}^{\alpha}_{b_x} + 3\tilde{\sigma}^{\alpha}_{x.n\bar{p}:F-C_p}, \\ n\tilde{\bar{p}}_{b_y} + 3\tilde{\sigma}_{y.n\bar{p}:F-C_p}, \\ n\tilde{\bar{p}}^{\alpha}_{b_z} + 3\tilde{\sigma}^{\alpha}_{z.n\bar{p}:F-C_p} \end{pmatrix} \\
(CL^{\alpha}_{n\tilde{\bar{p}}_{b_x}:C_p}, CL_{n\tilde{\bar{p}}_{b_y}:C_p}, CL^{\alpha}_{n\tilde{\bar{p}}_{b_z}:C_p}) &= (n\tilde{\bar{p}}^{\alpha}_{b_x}, n\tilde{\bar{p}}_{b_y}, n\tilde{\bar{p}}^{\alpha}_{b_z}) \\
(LCL^{\alpha}_{n\tilde{\bar{p}}_{b_x}:C_p}, LCL_{n\tilde{\bar{p}}_{b_y}:C_p}, LCL^{\alpha}_{n\tilde{\bar{p}}_{b_z}:C_p}) &= \begin{pmatrix} n\tilde{\bar{p}}^{\alpha}_{b_x} - 3\tilde{\sigma}^{\alpha}_{x.n\bar{p}:F-C_p} \\ n\tilde{\bar{p}}_{b_y} - 3\tilde{\sigma}_{y.n\bar{p}:F-C_p}, \\ n\tilde{\bar{p}}^{\alpha}_{b_z} - 3\tilde{\sigma}^{\alpha}_{x.n\bar{p}:F-C_p} \end{pmatrix}
\end{aligned}$$

We suggested the σ-level fuzzy $n\tilde{p}$-control limits, alongside the standard deviations $\tilde{\sigma}^{\alpha}_{x.n\bar{p}:F-C_p}$ and $\tilde{\sigma}^{\alpha}_{z.n\bar{p}:F-C_p}$ and the interaction ability

$$C_p = \frac{USL^{\alpha}_{i.n\tilde{p}:F-C_p} - LSL^{\alpha}_{i.n\tilde{p}:F-C_p}}{6\sigma}, i = x \text{ and } z.$$

By utilizing the α-cut strategy for three-sided fuzzy numbers, are as per the following:

(a) Method 1: Cycle condition for fuzzy number of defectives $(n\tilde{p})$ **in light of fuzzy midrange**

The α-level fuzzy midrange control graph for the quantity of defectives $(n\tilde{p})$ is developed and given underneath.

$$\begin{aligned}
UCL^{\alpha}_{n\bar{p}.mid} &= \left(\frac{n\tilde{\bar{p}}^{\alpha}_{b_x} + n\tilde{\bar{p}}^{\alpha}_{b_z}}{2}\right) + \left[3\sqrt{\frac{n(n\tilde{\bar{p}}^{\alpha}_{b_x} + n\tilde{\bar{p}}^{\alpha}_{b_z})(1 - (n\tilde{\bar{p}}^{\alpha}_{b_x} + n\tilde{\bar{p}}^{\alpha}_{b_z}))}{2}}\right] \\
CL^{\alpha}_{n\bar{p}.mid} &= \left(\frac{n\tilde{\bar{p}}^{\alpha}_{b_x} + n\tilde{\bar{p}}^{\alpha}_{b_z}}{2}\right) \\
LCL^{\alpha}_{n\bar{p}.mid} &= \left(\frac{n\tilde{\bar{p}}^{\alpha}_{b_x} + n\tilde{\bar{p}}^{\alpha}_{b_z}}{2}\right) - \left[3\sqrt{\frac{n(n\tilde{\bar{p}}^{\alpha}_{b_x} + n\tilde{\bar{p}}^{\alpha}_{b_z})(1 - (n\tilde{\bar{p}}^{\alpha}_{b_x} + n\tilde{\bar{p}}^{\alpha}_{b_z}))}{2}}\right]
\end{aligned}$$

We need to decide the α-level soft midrange of test j for the measure of defectives from the affiliation

$$S^{\alpha}_{j:n\tilde{p}.mid} = \frac{\{(\tilde{p}_{b_x} + \tilde{p}_{b_z}) + \alpha[(\tilde{p}_{b_y} - \tilde{p}_{b_x}) - (\tilde{p}_{b_z} - \tilde{p}_{b_y})]\}}{2}$$

Moreover, the entire interaction in-control when

$$LCL^{\alpha}_{n\tilde{p}.mid} \leq S^{\alpha}_{j:n\tilde{p}.mid} \leq UCL^{\alpha}_{n\tilde{p}.mid}.$$

We suggested the α-level fuzzy midrange-control limits, alongside $\tilde{\sigma}^{\alpha}_{Mid.n\tilde{p}:F-C_p}$ and the cycle ability

$$C_p = \frac{USL^{\alpha}_{Mid.n\tilde{p}:F-C_p} - LSL^{\alpha}_{Mid.n\tilde{p}:F-C_p}}{6\sigma}$$

by utilizing the α-cut technique for three-sided fuzzy numbers, are as per the following:

$$\begin{aligned} UCL^{\alpha}_{n\tilde{p}.mid:C_p} &= \left(\frac{n\tilde{\bar{p}}^{\alpha}_{b_x} + n\tilde{\bar{p}}^{\alpha}_{b_z}}{2}\right) + [3\tilde{\sigma}^{\alpha}_{Mid.n\tilde{p}:F-C_p}] \\ CL^{\alpha}_{n\tilde{p}.mid:C_p} &= \left(\frac{n\tilde{\bar{p}}^{\alpha}_{b_x} + n\tilde{\bar{p}}^{\alpha}_{b_z}}{2}\right) \\ LCL^{\alpha}_{n\tilde{p}.mid:C_p} &= \left(\frac{n\tilde{\bar{p}}^{\alpha}_{b_x} + n\tilde{\bar{p}}^{\alpha}_{b_z}}{2}\right) - [3\tilde{\sigma}^{\alpha}_{Mid.n\tilde{p}:F-C_p}] \end{aligned}$$

Moreover, the entire interaction in-control when

$$LCL^{\alpha}_{n\tilde{p}.mid:C_p} \leq S^{\alpha}_{j:n\tilde{p}.mid} \leq UCL^{\alpha}_{n\tilde{p}.mid:C_p}.$$

(b) Method 2: Cycle condition for fuzzy number of defectives $(n\tilde{p})$ in view of fuzzy standard

Consider the cases wherein the fuzzy number of defectives $(n\tilde{p})$ lies absolutely inside or outside the fuzzy control limits. The state of the interaction is in-charge when and the state of the cycle is crazy when $b_z < UCL_{n\tilde{p}_{b_x}}$ and $b_x > UCL_{n\tilde{p}_{b_z}}$ and the condition of the process is out-of-control when $b_x > UCL_{n\tilde{p}_{b_z}}$ or $b_z < UCL_{n\tilde{p}_{b_x}}$.

Consider the cases wherein the fuzzy number of defectives$(n\tilde{p})$ lies absolutely inside or outside the fuzzy control limits utilizing measure capacity. The state of the cycle is in-charge when $b_z < UCL_{n\tilde{p}_{b_x}:C_p}$ and $b_x > UCL_{n\tilde{p}_{b_z}:C_p}$ and the state of the interaction is wild when $b_x > UCL_{n\tilde{p}_{b_z}:C_p}$ or $b_z < UCL_{n\tilde{p}_{b_x}:C_p}$.

5. Conclusion

Maybe the central quantifiable correspondence control (SPC) contraptions are property control outline that screens quality credits. A few causes like mental assessment withdrew information and human decisions in the quality brand name, impelling some degree of eccentricity and deficiency in the property control outline. In these conditions, it is cannier to apply the warm set speculation for control follows. Accordingly, in this paper, we drew a shocking np-layout utilizing measure capacity to screen property quality brand name. Although the thing/association isn't in superb quality undoubtedly unequivocally precisely true to form, fittingly a change and improvement are needed by then/structure. It is kept up to utilize the proposed dubious control graph as an option instead of the Shewhart control plan.

References

1. Gulbay, M. Kahraman, C and Ruan, D. α-Cut fuzzy control charts for linguistic data, *International Journal of Intelligent Systems*, **19** (2004) 1173–1195.
2. Montgomery, D.C. Introduction to statistical Quality Control, 4th Edition, (2008) *John Wiley & Sons, Inc.,* New York.
3. Radhakrishnan, R and Balamurugan, P. Construction of control charts based on six sigma Initiatives for the number of defects and average number of defects per unit. *Journal of Modern Applied Statistical Methods*, **10**-2 (2011) 639–645.

4. Shewhart, W.A. Economic Control of Quality of Manufactured Product. (1931) Van Nostrand.
5. Sogandi, F. Meysam Mousavi, S and Ghanaatiyan, R. An extension of fuzzy p-control chart based on α-level fuzzy midrange, *Advanced Computational Techniques in Electromagnetics*, (2014) 1–8.
6. Wang, J.H and Raz, T. On the construction of control charts using linguistic variables, *The International Journal of Production Research*, **28**-3 (1990) 477–487.
7. Wang, R.C and Chen, C.H. Economic statistical np-control chart designs based on fuzzy optimization. *International Journal of Quality & Reliability Management*, **12**-1 (1995) 82–92.

Ph.D. Research Scholar, Department of Statistics, Salem Sowdeswari College, Salem – 636010
Email address: prabustat80@gmail.com

Assoicate Professor & Head, Department of Statistics, Salem Sowdeswari College, Salem – 636010
Email address: nanthakumarstat@gmail.com