



Analyzing and Evaluation of Quick Switching System using Neutrosophic Poisson Distribution

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Abstract

In Statistical Quality Control (SQC), the judgement of the accepting the lot or rejecting the lots carried out with the help of acceptance sampling plans in the inspection process of any manufacturing industry. Based on the predefined risk the output is attained with minimum inspection cost based on the optimum sample size. Generally Classical statistics is used based on the deterministic nature of the information and measurements. In some circumstances, the quality characteristics may not be certain enough leading to vagueness or impreciseness situation. Accordingly, in past few decades Fuzzy logic is one of the most popular techniques to model the uncertainty in the manufacturing industries. As an advent of technology and knowledge data era, an extension of Fuzzy, a new concept known as Neutrosophic Logic is in progress to apply to achieve these uncertainties. In this, such vagueness, imprecise is called as indeterminants. Thus, Neutrosophic Logic taken its role in Acceptance Sampling Plans with Probability distributions for various plan parameters such as AQL, LQL and Neutrosophic defection status are offered for Poisson distribution in the first time. The chief formulations of Acceptance Sampling plans for Single Sampling were derived based on Neutrosophic Statistics. As an advanced step the mixture of Acceptance Sampling plans with the shifting ruling for swapping from one plan to another plan are named as Sampling System and one such system is Quick Switching System the most widely applicable to safeguard from bad quality which give high level protection as well as to reduce the cost of inspection and time. In this study, Quick Switching System (QSS) with Single Sampling Plan (SSP) as reference plan is constructed based on Neutrosophic sets on Poisson distribution as baseline distribution. The procedures, OC Curves and tables have been redesigned and presented with numerical example.

Keywords: Fuzzy logic; NS; SQC; QSS; SSP; OC; Poisson distribution; Classical Statistics.

1.Introduction

In this contemporary era, there is a high rivalry among the industries to get good reputation in the market. For the well-reputed industry, “Quality” is regarded as a benchmark under numerous features. Checking the conformity of the manufactured product outputs to the quality specifications is an essential one. On the other hand, inspecting each and every item of the produced products is expensive and consumes much time. Thus, inspection of the finished product is approved out with the support of Acceptance Sampling plans in SQC. A mixture of Acceptance Sampling plans within the switching rules of shifting from one plan to another plan are called Acceptance Sampling System and one such system is Quick Switching System (QSS) introduced by Dodge and Romig (1967). QSS employs basic Attribute sampling plans such as Single Sampling Plan (SSP), Double Sampling Plan (DSP), Multiple Sampling Plan and other special purpose plans like CSP, SkSp and so on for inspecting the lot considered as the reference plans with base line distributions. In Classical Sampling, the defective proportion of items is expressed as a certain value. In some real-world situations, these particulars may contain some uncertainty or vagueness and the term “Fuzzy Logic” is used for formulating the uncertainty environment. Fuzzy logic denotes the uncertainty level with membership functions ($u(x)$) by using a continuous variable (x) inside $[0,1]$ interval; that creates the main difference between Classical Logic (CL) and Fuzzy Logic (FL). Fuzzy Sets (FSs) are lengthened for some specific case to carry out the uncertainty in a right and sound way. In this scenario, as an extension of FL, a new approach known to be Neutrosophic Sets (NSs) having three terms for membership(truthiness), non-membership (falsity) and indeterminacy emerged in this advent and knowledge

data discovery world. The term indeterminacy tackles the inconsistent and handle the vague data case makes the Neutrosophic logic resembles human thinking. Literature reflects that indeterminacy is not considered in some constrains for analyzing sampling plans based on NSs. Accordingly, this paper aims to analyze and formulates the Quick Switching System based on Neutrosophic Poisson Distribution with Single Sampling Plan as the reference plan. The paper is designed with the construction of Operating procedure, the equivalent OC curve and essential tables are considered with numerical example. The other sections of this paper has been organized as follows: Section 2 includes brief information about SQC and ASPs. The NSs have been detailed into Section 3. QSS With Single Sampling Plan Using Neutrosophic Poisson Distribution is Constructed and analyzed in Section 4. A numerical example is detailed into Section 5. Section 6 indicates the obtained results and upcoming research directions.

1.1. Review of Literature

In last few years, Acceptance Sampling plans taken its footstep into the concept of Neutrosophic Logic which is the extension of Fuzzy Logic and suited under the uncertainty environment. Neutrosophic Logic handles Vague or imprecise or doubtfulness data which was first founded by Florentin Smarandache (1998) from the University of New Mexico, United States and further developed it by establishing the concept Neutrosophic Descriptive Statistics (NDS) [20]. Later the NS started its journey in the essential concepts such as the Neutrosophic Inferential Statistics (NIS), Neutrosophic Applied Statistics (NAS), and Neutrosophic Statistical Quality Control (NSQC) which was introduced by Aslam (2018), from the King Abdulaziz University, Saudi Arabia. Accordingly, Aslam [2] initiated his work in both attribute and variable acceptance sampling plans and proposed a new attribute sampling plan by employing the Neutrosophic Interval method and the Neutrosophic Binomial distribution is utilized for computing the lot acceptance, rejection and indeterminate probabilities at various specified sample size and acceptance number parameters. Also in the same year Aslam [3] also proposed a new variable sampling plan using the Neutrosophic Statistical Interval method. The Neutrosophic Normal distribution is used for deriving the (NOC) Neutrosophic Operating Characteristic as well as the proposed plan is compared with the Classical Statistics plan. Gurkan Isik and Ihsan Kaya [11] from the Department of Industrial Engineering, Yildiz Technical University, Istanbul, Turkey for the first time formulated the Single Acceptance Sampling plans based on the Neutrosophic sets and systems for Poisson distribution. Authors formulated Double ASPs and analyzed based on Neutrosophic Sets and Systems by making use of Binomial distribution.

QSS were first proposed by Dodge in 1967 and later on investigated by Romboski in 1969[19]. Soundarajan and Arumainayagam [1] examined QSS-r, r=1,2,3 with reference plans as SSP, DSP, Chain sampling plan and Repetitive group sampling plan. Arumainayagam and Uma (2009) examined QSS-r, r=1,2,3 with three stage multiple sampling plan as a reference plan. Jamkhaneh, Gildeh and Yari [12] discussed the Single acceptance sampling plan when the proportion of defective items is a fuzzy number. Divya [8] presented the Quality interval acceptance single sampling plan when the fraction of defective items is a fuzzy number being modeled based on Poisson distribution. The new procedure for implementing fuzzy logic in quality interval acceptance single sampling plan has also been carried out. Kahraman, Bekar and Senvar [14] proposed multi-objective mathematical models for fuzzy single and fuzzy double acceptance sampling plans with illustrative examples. Ramya and Uma [18] evaluated and selected Quick Switching System with reference to Double Sampling plan for sample size tightening using Fuzzy binomial distribution. Nandhinidevi, Uma and Manjula [16] elaborately gave the concept of fuzzy logic on QSSDSS holds the SSP as Normal plan and the DSP as tightened plan. The paper focused on the sampling system which helps to solve the new Uncertainty environment using the Fuzzy Concept for an Acceptance Number Tightening and highlighted its advantages.

2. Statistical Quality Control and Acceptance Sampling Plans

2.1. SQC is referred to as a Quality Controlling System” carry out inspecting the product, testing and analyzing to infer whether t/he product quality meets the standards. Statistical Quality Control is advantageous because of its less inspection cost and makes the inspection consistent. The two concepts in SQC include

1. Process Control (control the processing for quality) and
2. Acceptance Sampling (Accept/Reject the products already manufactured). In ASP, products with good quality will be accepted and products with bad quality will be rejected.

2.2. Acceptance Sampling Plans

ASP assumes sample represents the whole lot from which it is drawn. The samples are randomly chosen out and checked up for the defectives in it. If the number of defectives is less, the lot will be accepted. If the number of defectives is more, the lot will be rejected. Acceptance sampling plan reduce the cost of inspection and saves time too. Sampling plans specify the lot size, number of samples and the acceptance/rejection criteria. Sampling plans involves Single sampling, Double sampling and Multiple sampling. OC (Operating Characteristic) curve is a graph plotted between ratio defect 'p' and Probability of acceptance 'P_a'. The plan parameters like 'n' (sample size) and 'c' (acceptance number) are determined by OC curve, producer's risk (α) and consumer's risk (β). Montgomery in 2009 stated that the good sampling plan should have the probability of acceptance (P_a) close to producer's risk(α). The OC curve for Single Sampling Plan is plotted below.

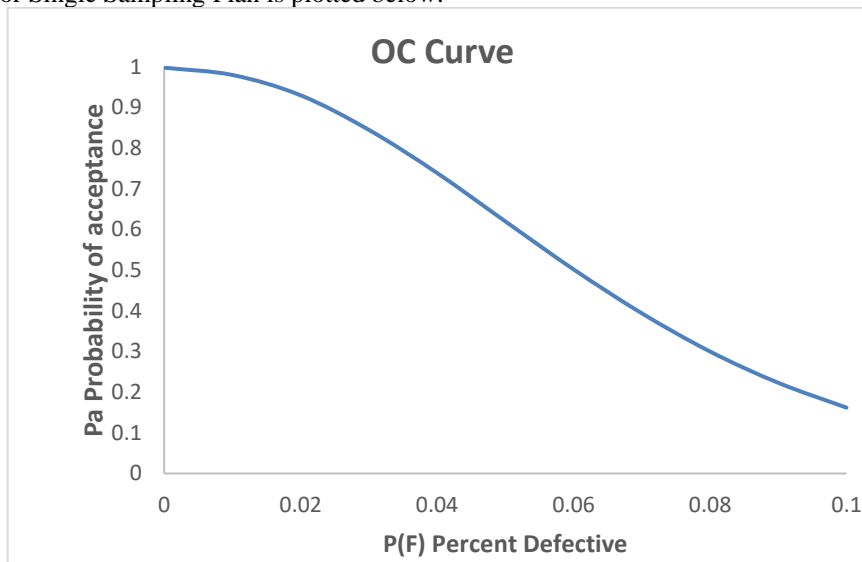


Figure 1: An example OC Curve

The probability of accepting a lot is formulated for Poisson distribution as shown below in Eq (1) though non-confirming frequency ' λ ' = n. p, given by Montgomery in 2009.

$$P_a = P\{d \leq c\} = \sum_{d=0}^c \frac{\lambda^d e^{-\lambda}}{d!} \quad (1)$$

where 'P_a' be the probability of acceptance
 'd' be the number of defectives
 'c' be the acceptance number
 ' λ ' be the mean

2.3. Quick Switching System

QSS be in need of normal plan for good quality of products and tightened plan for bad quality of products. In 1967, Dodge suggested a new sampling system involving normal and tightened sampling plans along with the switching rules to construct a sampling system. This sampling system is applied as shown below

- A pair of sampling plans – Normal(N) and Tightened(T) the plan to be tighter 'OC' wiser than plan (N) is applied .
- Use plan N (normal) for the first lot.
- For the inspection of each and every item, when the lot is accepted, plan N(Normal) is used for the next lot and when the lot is rejected, plan T(Tightened) is used for the next lot.

Due to instant switch between normal and tightened sampling plan, the system is called as QSS. Romboski in 1969 derived the OC function of QSS as follows,

$$P_a = \frac{P_T}{(1-P_N)+P_T} \quad (2)$$

Where, P_a be the acceptance probability. P_N be the acceptance probability for Normal Single Sampling plan using Neutrosophic Poisson and P_T be the acceptance probability for tightened Single Sampling plan using Neutrosophic Poisson Distribution.

2.3.1. Conditions of Application

The conditions for application under which the QSS can be applied and the operation procedure is given below:

- The production is steady therefore the results on the current and the proceedings lots are broadly indicative of a continuing process and submitted lots are expected to be essentially of the same quality.
- Lots are submitted substantially in the order of production.
- Inspection is by attributes with quality define as fraction non confirming.

The below table gives the designation of QSS where Single Sampling plan is the reference plan utilizing two kind of tightening procedure.

- Acceptance number tightening
- Sample size tightening

3. Fuzzy Vs Neutrosophic

Fuzzy set theory can only handle fuzzy, vague information. But it cannot deal with the incomplete and inconsistent information. Neutrosophic, introduced by Smarandache, can handle incomplete information as well as inconsistent information. Neutrosophy is a relatively new branch of philosophy that studies the origin, nature and scope of neutralities as well as their interactions with different ideational spectra. Neutrosophy has laid the foundation for a whole family of new mathematical theories generalizing both their classical and fuzzy counterparts, such as eutrosophic set theory, Neutrosophic Probability, Neutrosophic Statistics and Neutrosophic Logic.

3.1. Neutrosophic Set

- Let X be a space of points(objects), $x \in X$.
- A Neutrosophic set A on X is characterized by a truth-membership function, an indeterminacy membership function I_A and a falsity function F_A .
 $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or non-standard subsets of $[-0, 1+]$
- There is no restriction on the sum of $T_A(x)$, $I_A(x)$ and $F_A(x)$
 $-0 \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$

4. Construction of QSS With Single Sampling Plan Using Neutrosophic Poisson Distribution as a Base Line Distribution

The operating procedure for the construction of QSS with Neutrosophic Poisson Distribution is given below:

Step 1: From the lot, take a random sample of size 'n' at the normal level and count the number of defective items 'd' and indeterminate items 'i'.

- a) If $d \leq c_N$ and $i \leq I$, accept the lot and repeat step 1 for the next lot.
- b) If $d > c_N$, reject the lot and go to step 2.
- c) If $d \leq c_N$, $i > I$, the lot is indeterminate

Step 2: From the next lot, take a random sample of size 'n' at the tightened level and count the number of defective items 'd' and number of indeterminate items 'i'.

- a) If $d \leq c_T, i \leq I$, accept the lot and repeat step 1 for the next lot.
- b) If $d > c_T$, reject the lot and repeat step 2.
- c) If $d \leq c_T, i > I$, the lot is indeterminate,

The probability of acceptance for QSS is calculated using the normal SSP and Tightened SSP.

For normal single sampling plan, the Neutrosophic probability of acceptance is represented as ‘ P_{aN} ’, the rejection probability is represented as ‘ P_{rN} ’ and the indeterminacy probability is represented as ‘ P_{iN} ’.

$$P_{aN} = \sum_{d=0}^{C_N} \frac{\lambda_F^d}{d!} \left[\sum_{i=0}^{\min(I, n-d)} \frac{\lambda_I^i}{i!} e^{-(\lambda_I + \lambda_F)} \right] \tag{3}$$

$$P_{rN} = \sum_{d=C_N+1}^{C_N} \frac{\lambda_F^d}{d!} \left[\sum_{i=0}^{n-d} \frac{\lambda_I^i}{i!} e^{-(\lambda_I + \lambda_F)} \right] \tag{4}$$

$$P_{iN} = \sum_{i=I+1}^n \frac{\lambda_I^i}{i!} \left[\sum_{d=0}^{\min(N, n-i)} \frac{\lambda_F^d}{d!} e^{-(\lambda_I + \lambda_F)} \right] \tag{5}$$

$$P_{aN} + P_{rN} + P_{iN} = I \dots\dots\dots \text{total probability}$$

Similarly, for tightened single sampling plan, the Neutrosophic probability of acceptance is represented as ‘ P_{aT} ’, the rejection probability is represented as ‘ P_{rT} ’ and the indeterminacy probability is represented as ‘ P_{iT} ’.

$$P_{aT} = \sum_{d=0}^{C_T} \frac{\lambda_F^d}{d!} \left[\sum_{i=0}^{\min(I, n-d)} \frac{\lambda_I^i}{i!} e^{-(\lambda_I + \lambda_F)} \right] \tag{6}$$

$$P_{rT} = \sum_{d=C_T+1}^{C_N} \frac{\lambda_F^d}{d!} \left[\sum_{i=0}^{n-d} \frac{\lambda_I^i}{i!} e^{-(\lambda_I + \lambda_F)} \right] \tag{7}$$

$$P_{iT} = \sum_{i=I+1}^n \frac{\lambda_I^i}{i!} \left[\sum_{d=0}^{\min(T, n-i)} \frac{\lambda_F^d}{d!} e^{-(\lambda_I + \lambda_F)} \right] \tag{8}$$

$$P_{aT} + P_{rT} + P_{iT} = I \dots\dots\dots \text{total probability}$$

Therefore, the probability of acceptance ‘ P_a ’ is calculated using,

$$P_a(p) = \frac{P_{(a)T}}{1 - P_{(a)N} + P_{(a)T}} \tag{9}$$

Where, $P_{(a)N}$ is the proportion of lots expected to be accepted using Neutrosophic Normal SSP.
 $P_{(a)T}$ is the proportion of lots accepted to be accepted using Neutrosophic Tightened SSP.

Operating Characteristic Curve is formed as a surface depending upon P(F), P(I) and P_a . The following figure 3 shows OC surface for a plan having a parameters - ($n=30, C_N=2$ and $C_T=1, I=2$)

(n=30, C_N=2, I=2)

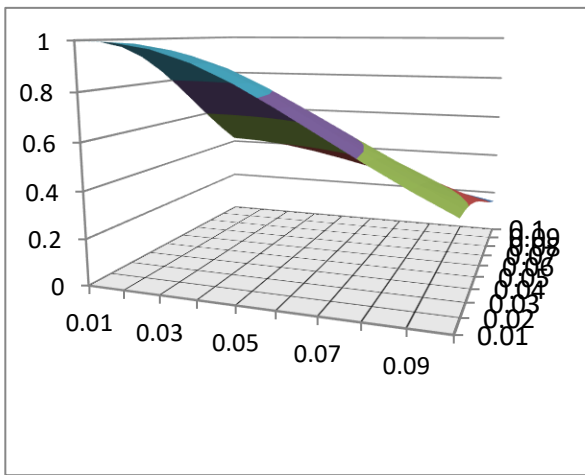


Figure 2: OC of Normal Plan

(n = 30, C_T=1, I =2)

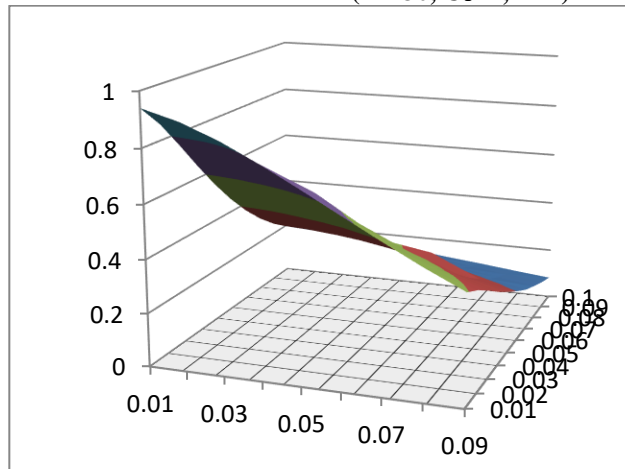


Figure 3: OC of Tightened Plan

(n=30, C_N=2, C_T=1, I=2)

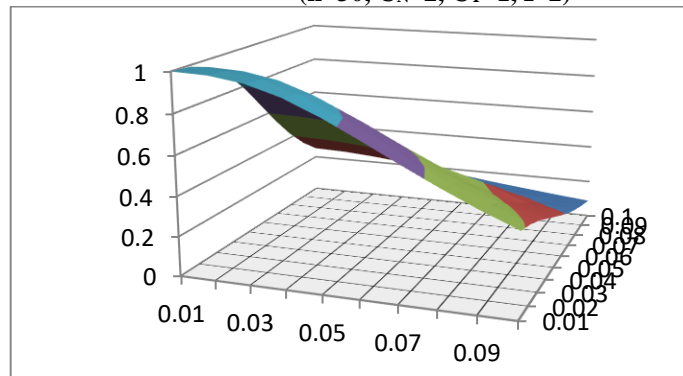


Figure 4: OC of QSS plan

5. Illustration

A company want to buy a steel nuts from the producer. The steel nuts can have many defects with variety of importance levels such as break defects and shear burst defects. Few of the steel nuts can have many defects at the same time. Most of the break defects are little but some of the defects are not acceptable. The company may become undecided in some cases the products have multiple defects with multiple levels. Therefore, the compromise is made between company and the producer with quality level. The producer declares the item as non-defective probability, indeterminate probability, defective probability. The company controls the quality of incoming steel nuts by applying Quick Switching System based on Neutrosophic Poisson Distribution.

Out of 600, 30 nuts are chosen for inspection and in normal plan, if the number of faulty items is less or equal to two and indeterminate items are less than or equal to two, the customer will purchase the lot. Otherwise the customer will not purchase the lot. But if the number of faulty items is less than or equal to ‘2’ and number of indeterminate items is greater than ‘2’, the customer leads to indeterminate state. In tightened plan, if the number of faulty items is less or equal to one and indeterminate items are less than or equal to two, the customer will purchase the lot. Otherwise the customer will not buy. But if the number of faulty items is less than or equal to one and number of indeterminate items is greater than two, the customer leads to indeterminate state.

The following table 1 gives the probability of acceptance for QSS using Neutrosophic Poisson distribution with acceptance number tightening in which the sample size is kept same for Normal and Tightened plan.

Table 1: Probability of Acceptance (n=30, C_N=2, C_T=1, I=2)

N	N	c _N	c _T	I	P(S)	P(F)	P(I)	P _{An}	P _{rN}	P _{iN}	P _{aT}	P _{rT}	P _{iT}
600	30	3	2	2	0.95	0.05	0.05	0.779	0.057	0.164	0.6528	0.1902	0.1541
600	30	2	1	2	0.95	0.04	0.02	0.862	0.118	0.020	0.4502	0.4146	0.1781
600	30	2	1	2	0.83	0.03	0.04	0.781	0.080	0.139	0.6788	0.2271	0.0918
1200	30	3	2	2	0.95	0.05	0.05	0.779	0.057	0.164	0.6528	0.1902	0.1541
1200	30	2	1	2	0.95	0.05	0.05	0.683	0.173	0.143	0.4502	0.7970	0.1063

6. Conclusion

A Quick Switching System based on Neutrosophic Poisson Distribution using single sampling plan as reference plan is presented in this paper. The proposed Quick Switching System under Neutrosophic Statistics is more flexible and effective for current state of manufacturing process under uncertainty than the existing method of Neutrosophic Statistics using Single Acceptance Sampling Plans. The lot acceptance probability for various acceptance numbers and sample sizes are presented. The Acceptance number tightening is considered in this paper. It is recommended that the proposed system should apply for the inspection of lot of products under uncertainty environment. The Practitioners can apply the proposed method to save time and efforts in the industry.

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