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A design for special type double sampling plan under fuzzy environment

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Abstract
Acceptance sampling is effective tool in quality assurance. This paper introduces a new design for special type double sampling plan when their main parameters are fuzzy. Fuzzy special type double sampling plan (FSTDSP) is given by providing fuzzy acceptance probability of special type double sampling plan using fuzzy Poisson distributions. Definitions and calculation of fuzzy special purpose double sample plan (FSTDSP) is provided with an example. OC curve for fuzzy special purpose double sampling plan is provided.

Keywords: Acceptance sampling plan, fuzzy set theory, special type double sampling plan, fuzzy special purpose double sample plan (FSTDSP)

Introduction
Inspections of materials, destructive testing of samples and in reducing hundred percent inspections, acceptance sampling plan are effective. Special type double sampling plan is one of the acceptance sampling plans, used when there is a conflict arises between the selection of single sampling plan with zero acceptance number and single sampling plan with one acceptance number, because single sampling plan with zero acceptance number satisfy consumer where as single sampling plan with one acceptance number satisfy producer. In Special type double sampling plan the decision are based on first and second sample. Acceptance sampling plan the parameters are not always consider as crisp values in these cases the parameters are considered as linguistic variables.

Application of fuzzy in acceptance sampling plan has done by, Ohta. H, H.Ichihashi (1998) [2] in acceptance SSP using fuzzy membership, Kanagawa.A, Ohta.H (1990) [3] in SSP using fuzzy set theory. Tamaki.F, Kanagawa.A, Ohta.H (1991) [4] in attribute sampling inspection plans using fuzzy. Grzegorzewski.P (2001) [5] in acceptance sampling plans with fuzzy risks and quality levels. Ezzatallah Baloui Jamkhaneh, Bahram Sadeghpour Gildeh (2012) designed OC curve, ASN, ATI, AOQ curves of double sampling plan when proportion defectives are fuzzy number. In 2010 they have discussed SSP and DSP where parameters are fuzzy numbers using fuzzy binomial and fuzzy Poisson distribution, in 2012 they have designed fuzzy acceptance sampling plan in which characteristic curves of single and double sampling plans are derived. Muthulakshmi.s and Malathi.D in special double sampling plan when proportion defective is fuzzy parameter.

Special type double sampling plan
Govindaraju in 1984 designed a Special type double sampling plan, in special type double sampling plan the acceptance of lot cannot be decided in first sample acceptance can only be decided only after the inspection of both first and second sample.

The operating procedure for special type double sampling plan is as follows:

- Select a sample of size n1 randomly and inspect for number of defectives (d1) in the sample. And reject the lot if the defects in then sample n1 are greater than one.
- If the defects equal to one, select a second sample of size n2 randomly, and inspect for number of defectives (d2) in the sample n^2. If the resulted defects are less than one then accept the lot otherwise reject the lot.

The probability of acceptance of special type double sampling plan is:

Pa (p) = e^{-np}(1+µnp) (1)

Where, µ=n2/n, n=n1+n2.

Fuzzy fraction defectives

Special type double sampling plan when fraction defective p is fuzzy parameter and indicated as $\tilde{p}$. $\tilde{P}_i$ represents the fuzzy probability of m events in n events as follows.

$\tilde{P}_i(\alpha)$=[$f_{1\ (m,y)}(\alpha)$, $f_{r\ (m,y)}(\alpha)$] (2)

$f_{1\ (m,y)}(\alpha)$=min { $e^{-\tilde{y}}$ $(1+\mu\tilde{y})$ / $\tilde{p}\epsilon p(\alpha)$} (3)

$f_{r\ (m,y)}(\alpha)$=max { $e^{-\tilde{y}}$ $(1+\mu\tilde{y})$/$\tilde{p}\epsilon p(\alpha)$} (4)

Where $\tilde{y}=n\tilde{p}$, µ=n2/n, n=n1+n2

Here, fraction defective p is defined as triangular fuzzy number and α-cut of fraction defective is derived as follows:

$\tilde{p} = (p_a, p_b, p_c)$

p (α) ={ $p_a + (p_b - p_a)\alpha, p_c + (p_b - p_c)\alpha$} (5)

Fuzzy number of events

Consider Special type double sampling plan where the probability of events p, number of events n1 and n2 are triangular fuzzy numbers. The fuzzy probability of n events using fuzzy Poisson distribution is calculated as below:

$\tilde{P}_i(\alpha)$=[$f_{1\ (m,y)}(\alpha)$, $f_{r\ (m,y)}(\alpha)$] (6)

$f_{1\ (m,y)}(\alpha)$=min { $e^{-\tilde{y}}$ $(1+\tilde{\mu}\tilde{y})$ / $\tilde{y}\epsilon y(\alpha)$,$\tilde{\mu}$ ϵµ(α)} (7)

$f_{r\ (m,y)}(\alpha)$=max { $e^{-\tilde{y}}$ $(1+\tilde{\mu}\tilde{y})$ /$\tilde{y}\epsilon y(\alpha)$, $\tilde{\mu}$ ϵµ(α)} (8)

Where $\tilde{y}=\tilde{n}\tilde{p}$, $\tilde{\mu}=\frac{\widetilde{n2}}{\tilde{n}}$, $\tilde{n}=\widetilde{n_1}+\widetilde{n_2}$

Here, number of events n is defined as triangular fuzzy number and α-cut of number of events is derived as follows:

$\tilde{n} = (n_a, n_b, n_c)$

n (α) ={ $n_a + (n_b - n_a)\alpha, n_c + (n_b - n_c)\alpha$} (9)

Fuzzy acceptance special type double sampling plan

Special type double sampling plan is considered with the parameters n,p,µ as fuzzy parameter. The acceptance probability of fuzzy special type doubles sampling plan (FSTDSP) using the fuzzy Poisson distribution is given below:

$\tilde{P}_i(\alpha)$=[$f_{1\ (m,y)}(\alpha)$, $f_{r\ (m,y)}(\alpha)$] (10)

$f_{1\ (m,y)}(\alpha)$=min { $e^{-\tilde{y}}$ $(1+\tilde{\mu}\tilde{y})$ / $\tilde{y}\epsilon y(\alpha)$,$\tilde{\mu}$ ϵµ(α)} (11)

$f_{r\ (m,y)}(\alpha)$=max { $e^{-\tilde{y}}$ $(1+\tilde{\mu}\tilde{y})$ /$\tilde{y}\epsilon y(\alpha)$, $\tilde{\mu}$ ϵµ(α)} (12)

Where $\tilde{y}=\tilde{n}\tilde{p}$, $\tilde{\mu}=\frac{\widetilde{n2}}{\tilde{n}}$, $\tilde{n}=\widetilde{n_1}+\widetilde{n_2}$

Example

In biscuit manufacturing company, some products are indentified as defectives after the completion of production. Hence the parameters are considered as linguistic variables these are expressed as fuzzy numbers as follows. Let us consider that the Fuzzy Special type double sampling plan (FSTDSP) with fraction defective is approximately "0.01" and first sample size approximately is "10" and the second sample size approximately is "20". Then the fuzzy probability of acceptance using fuzzy Poisson distribution is calculated as follows:

$\tilde{y}=\tilde{n}\tilde{p}$= (28 30 32) (0.01 0.02 0.03).

Using equation "7"and "8" the α cut of the $\tilde{P}_i$ are calculated and shown in table 1 below and the membership function is shown in fig1

Pa (p) = {min $e^{-\tilde{y}}$ $(1+\tilde{\mu}\tilde{y})$, max { $e^{-\tilde{y}}$ $(1+\tilde{\mu}\tilde{y})$}

Pa (p) = { $e^{-.\widetilde{28}}\left(1+.\widetilde{656}\,.\widetilde{28}\right)$, $e^{-.\widetilde{96}}\left(1+.\widetilde{678}.\widetilde{96}\right)$}

= (0.6641, 0.7884, 0.9028)

The α-cut values and membership function of P_i (α) is shown in the $table_1$ and $figure_1$ below respectively.

Table 1: Membership function of P_i (α)

n1 l (a)	n1u (b)	n2 l (a)	n2 u (b)	a	pl (d)	pu (e)	$f_{1\ (y,m)}$ (α)	$f_{r\ (y,m)}$ (α)
9	11	19	21	0	0.01	0.03	0.664192	0.902826
9.01	10.99	19.01	20.99	0.01	0.0101	0.0299	0.665395	0.901801
9.02	10.98	19.02	20.98	0.02	0.0102	0.0298	0.666721	0.900687
9.03	10.97	19.03	20.97	0.03	0.0103	0.0297	0.667984	0.899615
9.04	10.96	19.04	20.96	0.04	0.0104	0.0296	0.669248	0.898542
9.05	10.95	19.05	20.95	0.05	0.0105	0.0295	0.670512	0.897467
9.1	10.9	19.1	20.9	0.1	0.011	0.029	0.676827	0.892065
9.2	10.8	19.2	20.8	0.2	0.012	0.028	0.689439	0.881136
9.3	10.7	19.3	20.7	0.3	0.013	0.027	0.702021	0.870046
9.4	10.6	19.4	20.6	0.4	0.014	0.026	0.714564	0.858801
9.5	10.5	19.5	20.5	0.5	0.015	0.025	0.727058	0.847408
9.6	10.4	19.6	20.4	0.6	0.016	0.024	0.739494	0.835875
9.7	10.3	19.7	20.3	0.7	0.017	0.023	0.751864	0.824209
9.8	10.2	19.8	20.2	0.8	0.018	0.022	0.764159	0.812417
9.9	10.1	19.9	20.1	0.9	0.019	0.021	0.776371	0.800508
10	10	20	20	1	0.02	0.02	0.78849	0.78849

*We consider only the integer numbers because the parameters n and i should be integers

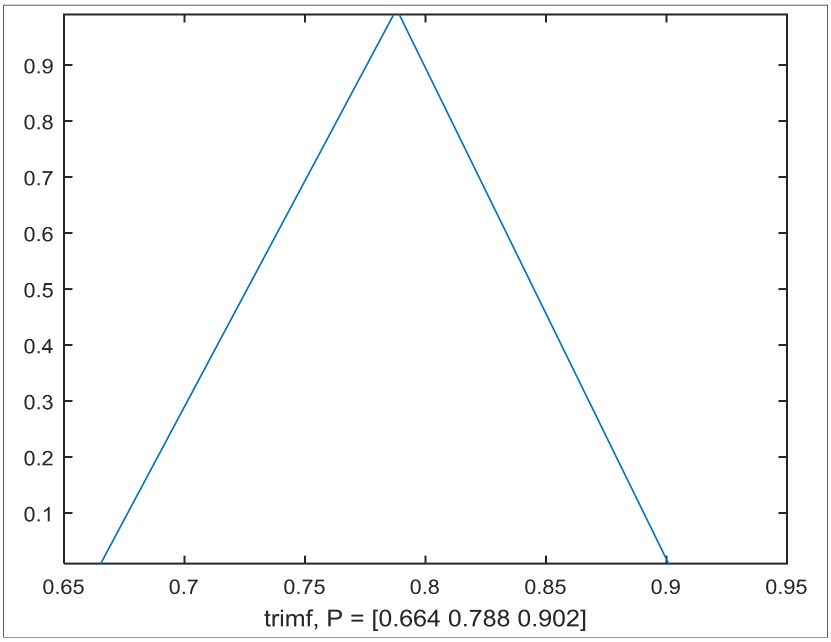

Fig 1: Membership function of P_i (α)

Fuzzy operating characteristic

Operating characteristics curve plots the values of, probability of acceptance versus proportion defectives. Fuzzy operating characteristic curve is a band with upper and lower bounds. Where these bandwidth depends on the uncertainty level on the proportion defective and the number of samples. The bandwidth and the uncertainty are directly proportional, that is the bandwidth increases when uncertainty increases and decreases when the uncertainty decreases.

Consider the above example, the operating characteristic curve is obtained by calculate as below using the equation "10". The fuzzy acceptance probability values are represented in the following table 2, based on these values the operating curve is displayed below in the figure 2.

Table 1: Fuzzy Acceptance Probability

P	Pa(p) L	Pa(p) U	P	Pa(p) L	Pa(p) U
(0.0005,0.0015)	0.961891	1	(0.485,0.495)	1.31E-06	1.49E-05
(0.002,0.003)	0.94185	0.99999	(0.5,0.51)	8.32E-07	1E-05
(0.0035,0.0045)	0.921575	0.9835	(0.515,0.525)	5.29E-07	6.77E-06
(0.005,0.015)	0.705634	0.952521	(0.53,0.54)	3.36E-07	4.57E-06
(0.02,0.03)	0.523606	0.893341	(0.545,0.555)	2.13E-07	3.08E-06
(0.035,0.045)	0.389302	0.742044	0.56,0.57)	1.35E-07	2.07E-06
(0.05,0.06)	0.281302	0.567878	(0.575,0.585)	8.57E-08	1.4E-06
(0.065,0.075)	0.199069	0.425896	(0.59,0.6)	5.43E-08	9.39E-07
(0.08,0.09)	0.138653	0.314509	(0.605,0.615)	3.44E-08	6.31E-07
(0.095,0.105)	0.09537	0.22943	(0.62,0.63)	2.18E-08	4.24E-07
(0.11,0.12)	0.064938	0.165716	(0.635,0.645)	1.38E-08	2.85E-07
(0.125,0.135)	0.043848	0.118719	(0.65,0.66)	8.7E-09	1.91E-07
(0.14,0.15)	0.029401	0.084466	(0.665,0.675)	5.5E-09	1.28E-07
(0.155,0.165)	0.019596	0.059745	(0.68,0.69)	3.47E-09	8.6E-08
(0.17,0.18)	0.012994	0.042045	(0.695,0.705)	2.19E-09	5.77E-08
(0.185,0.195)	0.008578	0.029459	(0.71,0.72)	1.38E-09	3.87E-08
(0.2,0.21)	0.005641	0.02056	(0.725,0.735)	8.74E-10	2.59E-08
(0.215,0.225)	0.003696	0.0143	(0.74,0.75)	5.51E-10	1.73E-08
(0.23,0.24)	0.002414	0.009916	(0.755,0.765)	3.47E-10	1.16E-08
(0.245,0.255)	0.001573	0.006857	(0.77,0.78)	2.19E-10	7.77E-09
(0.26,0.27)	0.001022	0.00473	(0.785,0.795)	1.38E-10	5.2E-09
(0.275,0.285)	0.000663	0.003255	(0.8,0.81)	8.69E-11	3.48E-09
(0.29,0.3)	0.000429	0.002236	(0.815,0.825)	5.47E-11	2.32E-09
(0.305,0.315)	0.000277	0.001533	(0.83,0.84)	3.44E-11	1.55E-09
(0.32,0.33)	0.000178	0.001049	(0.845,0.855)	2.17E-11	1.04E-09
(0.335,0.345)	0.000115	0.000717	(0.86,0.87)	1.36E-11	6.93E-10
(0.35,0.36)	7.38E-05	0.000489	(0.875,0.885)	8.57E-12	4.63E-10
(0.365,0.375)	4.74E-05	0.000333	(0.89,0.9)	5.39E-12	3.09E-10
(0.38,0.39)	3.03E-05	0.000227	(0.905,0.915)	3.39E-12	2.06E-10
(0.395,0.405)	1.94E-05	0.000154	(0.92,0.93)	2.13E-12	1.38E-10
(0.41,0.42)	1.24E-05	0.000105	(0.935,0.945)	1.34E-12	9.18E-11
(0.425,0.435)	7.94E-06	7.09E-05	(0.95,0.96)	8.41E-13	6.13E-11

(0.44,0.45)	5.06E-06	4.81E-05	(0.965,0.975)	5.28E-13	4.08E-11
(0.455,0.465)	3.23E-06	3.25E-05	(0.98,0.99)	3.31E-13	2.72E-11

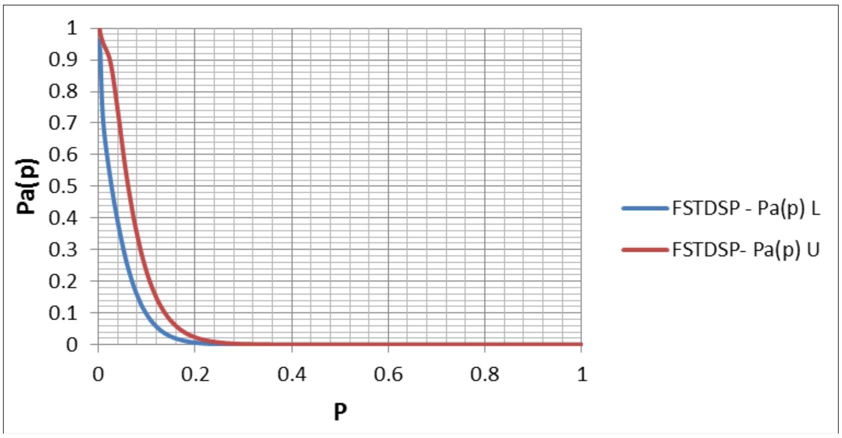

Fig 2: Fuzzy Acceptance Probability

Conclusion

Fuzzy special type double sampling plan (FSTDSP) using fuzzy Poisson distribution is developed. The main parameters of the special type double sampling plan, proportion defective, sample of size are considered as triangular fuzzy number with these parameters the Fuzzy operating characteristic curve is calculated and presented in this paper. Designing the special type double sampling plan (FSTDSP) in Fuzzy environment gives a versatility results. The use of fuzzy parameter in sampling plan gives upper and lower bounds in probability of acceptance and the optimum sample size.

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