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Selection Of Mixed Sampling Plan Indexed Through Aoq_{cc} With Chain Sampling Plan(Chsp)-1 Plan As Attribute Plan

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Abstract

In this paper a procedure for the selection of Mixed Sampling Plan (MSP) indexed through AOQ_{cc} which is a convex combination of consumer oriented concept, AOQL (Average Outgoing Quality Limit) and producer oriented concept, MAAOQ (Maximum Allowable Average Outgoing Quality) with Chsp-1 plan as attribute plan is given. This plan may safeguard the interests of both producer as well as consumer by properly choosing a right combination using the gain parameter λ(0<λ<1). Tables are also constructed for the easy selection of the plan.

Key words*:* Operating Characteristic curve, Average outgoing quality limit, Maximum allowable percent defective, Maximum allowable average outgoing quality, Poisson Distribution, Convex combination.

1. Introduction

The AOQL is the average quality that the consumer will receive in the long run when the defective items are replaced by non-defective items. The construction of sampling plans based on AOQL is largely consumer oriented and MAAOQ is the average outgoing quality at the inflection point is a producer oriented, which is the average outgoing quality at MAPD. The advantage of using MAAOQ for designing a sampling plan instead of AOQL is that it reduces the sample size to be inspected which indirectly reduces the total cost. The use of MAAOQ for deriving sampling plans was justified by Suresh and Ramkumar (1996). Radhakrishnan (2002) studied various sampling plans indexed through MAPD and MAAOQ. Radhakrishnan and Mallika (2008) constructed single sampling plans indexed through AOQ_{cc}. Radhakrishnan and Esther Jenitha (2011a, 2011b, 2011c, 2011d) constructed continuous sampling plan of the type CSP, CSP-3, CSP V (i-2x), Continuous Sampling Plan of the Type T CSP-3 plan indexed through AOQ_{cc} which is the convex combination of AOQL and MAAOQ. In this paper an attempt is made to introduce AOQ_{cc} in MSP using Chsp-1 plan as an attribute plan. This plan may safeguard the interests of both producer as well as consumer by choosing a right combination using the gain parameter λ.

Sampling plans indexed through p* (MAPD) which is the quality level corresponding to the inflection point of the operating characteristic (OC) curve has been explained by Mandelson (1962), Mayer (1967) and further studied by Soundararajan (1975). The MAPD is the value of fraction defective ($p= p_*$) at which

$$d^2P_a(p)/ dp^2= 0, \text{ for } p= p_*$$
$$d^2P_a(p)/dp^2 < 0, \text{ for } p< p_*$$
$$\text{and } d^2P_a(p)/dp^2 > 0, \text{ for } p> p_*$$

A variety of plans and procedures have been developed for special sampling situations involving both measurements and attributes. Each is tailored to do a specific job under prescribed circumstances. They range from a simplified variables approach to a more technically complicated combination of variables and attributes sampling in a so-called mixed sampling plans. Mixed sampling plan is a two stage sampling procedure involving variables inspection in the first stage and attributes inspection in the second stage if the variables inspection of the first sample does not lead to acceptance. Use of variables on the first sample with attributes on the second sample combines the economy of variables for quick acceptance on the first sample with the broad non-parametric protection of attributes sampling when a questionable lot requires a second sample.

The mixed sampling plans are initially introduced by Dodge (1932) and later developed by Bowker and Goode (1952). Schilling (1967) has given a method for determining the operating characteristics for mixed variables-attributes sampling plans. Using Schilling's procedure, Devaarul (2003) has constructed mixed sampling plan. Sampath Kumar (2007) constructed mixed sampling plan with several plans as attribute plans indexed through the parameters MAPD, AOQL and MAAOQ.

2. Glossary of Symbols

The symbols used in this paper are as follows:

p : submitted quality of lot or process
p_j : submitted quality of lot or process 'j'
$P_a(p)$: probability of acceptance for given quality p
p_*: maximum allowable percent defective (MAPD)
p_m: the product quality at which AOQ is maximum
p_t : the point at which the inflection tangent of the OC curve cuts the 'p'axis

h_*: relative slope at 'p_*'
n_1: sample size for variable sampling plan
$n_{1,2}$: first sample size for attribute sampling plan
$n_{2,2}$: second sample size for attribute sampling plan
i: The number of previous samples
β_j : probability of acceptance for lot quality p_j
β_j': probability of acceptance assigned to first stage for percent defective p_j
β_j'' :probability of acceptance assigned to second stage for percent defective pj
z (j):'z' value for the j^{th} ordered observation z(p) : standard normal deviate
k: variable factor such that a lot is accepted if $\bar{X} \leq A = U - k\sigma$.

3. Formulation of MSP with Chsp-1

Procedure: Independent Plan

- Determine the four parameters of the mixed plan n_1, n_2, k and 'i' with reference to ASN and OC curves.
- Take a random sample of size n_1 from the lot assumed to be large.
- If the sample average $\bar{X} \leq A = U - k\sigma$, accept the lot.
- If the sample average $\bar{X} > A = U - k\sigma$, take a second sample of size n_2 and count the number of defectives'd' therein.
- If the number of defectives d=0, accept the lot.
- If the number of defectives $d \geq 2$, reject the lot.
- Accept the lot if d=1 and if no defective units are found in the immediately preceding 'i' samples of size 'n'.

5. CONSTRUCTION OF MSP WITH Chsp-1 PLAN AS ATTRIBUTE PLAN INDEXED THROUGH MAPD

The general procedure given by Schilling (1967), is used for constructing the mixed sampling plan having chain sampling plan of the type Chsp-1 plan as attribute plan indexed through MAPD (p_*) [for $\beta_*'' = (\beta_* - \beta_*') / (1-\beta_*')$].

Construction of Tables

The probability of acceptance for ChSP-1 plan under Poisson model is given by

$$Pa(p) = e^{-np} + (e^{-np})^{i+1}\, np$$

The inflection point (p_*) is obtained by using $[d^2Pa(p)/dp^2] = 0$ and $[d^3Pa(p)/dp^3] \neq 0$.

The relative slope of the OC curve h_* $= \left[\dfrac{-p}{Pa(p)}\right]\dfrac{dPa(p)}{dp}$ at $p = p_*$. The inflection tangent of the OC curve cuts the 'p' axis at $p_t = p_* + (p_*/h_*)$. The values of h_*, n_2p_*, n_2p_t and R are calculated for $\beta_*'=0.65$ using visual basic program and presented in Table 1.

The general procedure for designing a Chsp-1 plan indexed through a parameter which is a convex combination of AOQL and MAAOQ using Poisson distribution as base line distribution is given below.

Step 1. Determine n_2MAAOQ and n_2AOQL for Chsp-1 for various combinations of i and n_2p_*. Find $R_1 = n_2AOQL/ n_2p_*$ and $R_2 = n_2MAAOQ/ n_2p_*$.

Step 2. Find $n_2AOQ_{cc} = \lambda\ n_2AOQL + (1-\lambda)\ n_2MAAOQ$ and $R_3 = n_2AOQ_{cc}/ n_2p_*$ for selected values of λ.

Step 3. Present the results of Step1and Step 2 in Table 1.

Selection of the Plan

The Table 1 is used to construct the plan when MAPD and AOQ_{cc} are specified. One can find the ratio $R_3 = AOQ_{cc}$/MAPD and locate the value in Table 1 under the column R_3 (for a fixed values of λ) and the corresponding values of i and n_2p_* are noted. The value of n is determined using $n_2 = n_2p_*$/MAPD and hence the parameters, n and i are determined.

Example :

(i) For a specified AOQL = 0.0081 and p_*= 0.004 compute the ratio R_1= AOQL/ p_*= 2.025 which is associated with i=8 in Table 1 and $n_2=n_2p_*/p_*$=0.1797/0.004 = 45. Thus $n_{1,2}$=45, $n_{2,2}$=45, i =8 are the parameters selected for the MSP with Chsp-1 as attribute plan for a specified p_*=0.004, AOQL=0.0081.

(ii) For a specified MAAOQ = 0.0032 and p_* = 0.004 compute the ratio R_2= MAAOQ/ p_* = 0.8000 which is associated with i =3 in Table 1 and $n_2=n_2p_*/p_*$=0.3439/0.004 = 86. Thus $n_{1,2}$=86, $n_{2,2}$=86, i =3are the parameters selected for the MSP with Chsp-1 as attribute plan for a specified p_*=0.004, MAAOQ=0.0032

(iii) For a specified value of AOQL = 0.0081, MAAOQ = 0.0032 and p_* = 0.004 and λ=0.2, AOQ_{cc} = 0.00418 compute $R_3 = AOQ_{cc} / p_*$ =1.045 with i = 5 in Table 1 and $n_2=n_2p_*/p_*$=0.2503/0.004 = 63. Thus $n_{1,2}$=63, $n_{2,2}$=63, i =5 are the parameters selected for the MSP with Chsp-1 as attribute plan for a specified p_*=0.004, AOQL = 0.0081, MAAOQ=0.0032.

Practical application:

Suppose the plan with n_1 = 10, k = 1.5 is to be applied to the lot-by-lot acceptance inspection of screw, the characteristic to be inspected is the "screw diameters in mm" for which there is a specified upper limit (U) of 45mm with a known standard deviation (σ) of 0.006 mm.

In this example, U=45 mm, σ = 0.006 mm and k = 1.5

Now, in applying the variable inspection first, take a random sample of size n_1=10 from the lot. Record the sample results and find $\bar{X}$. If $\bar{X} \leq A = U - k\sigma$ =44.991 mm, accept the lot otherwise take a random sample of size n_2 =63 and apply attribute inspection.

Under attribute inspection, by taking Chsp-1 Plan as attribute plan, if the manufacturer fixes the values β_*'=0.05, p_* = 0.004 (4 non-conformity screws out of 1000) and the consumer fixes the quality level AOQ_{cc}=0.00418 (418 non-conformity screws out of 100000 screws) then select a sample of 63 screws and count the number of non-conformities (d). If the number of defectives d=0, accept the lot. If the number of defectives $d \geq 2$, reject the lot. Accept the lot if d=1 and if no defective units are found in the immediately preceding '5' samples of size '63'.

The OC and AOQ curves for the above Example are represented in Figure 1 and Figure 2 respectively.

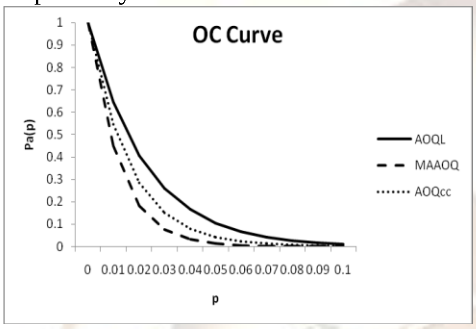

Figure 1:OC curves for $n_{1,2}$=45, $n_{2,2}$=45,i =8 (AOQL) $n_{1,2}$=86, $n_{2,2}$=86, i =3(MAAOQ) $n_{1,2}$=63, $n_{2,2}$=63, i =5 (AOQ_{cc})

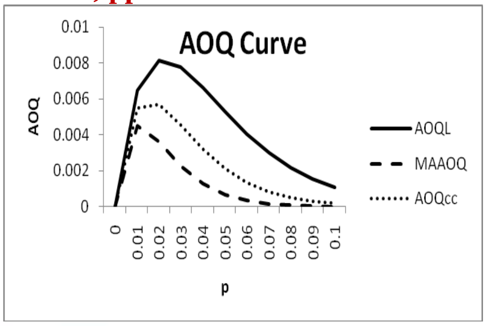

Figure 2:AOQ curves for $n_{1,2}$=45, $n_{2,2}$=45,i =8 (AOQL) $n_{1,2}$=86, $n_{2,2}$=86, i =3(MAAOQ) $n_{1,2}$=63, $n_{2,2}$=63, i =5 (AOQ_{cc})

8. Conclusion

In this paper an attempt is made to construct mixed sampling plans indexed through AOQ_{cc}, a convex combination of AOQL, consumer's preference and MAAOQ, producer's preference with the gain parameter λ using Chsp-1 plan as attribute plan. $nAOQ_{cc}$ values are also presented for the selected values of λ (0.2,0.4,0.6)in Table1. These sampling plans will safeguard the interest of both producer as well as consumer by choosing a right combination of the gain parameter λ. These plans will help the floor engineers to suggest the quality level AOQ_{cc} after knowing the interest of both producer and consumer which can be understood from OC and AOQ curves. This work can be extended for mixed sampling plan using other plans as attribute plan.

Table 1: Parameters of Mixed Sampling plan Chsp-1 for β_*' = 0.05, β_m' = 0.05

i	n_2p^*	n_2AOQL	R_1	nMAAOQ	R_2	λ=0.2		λ=0.4		λ=0.6	
						$nAOQ_{cc}$	R_3	$nAOQ_{cc}$	R_3	$nAOQ_{cc}$	R_3
1	0.5830	0.5023	0.8616	0.4314	0.7399	0.4603	0.7893	0.4815	0.8257	0.4954	0.8494
2	0.4288	0.4196	0.9786	0.3301	0.7698	0.3660	0.8532	0.3921	0.9142	0.4097	0.9552
3	0.3439	0.3872	1.1260	0.2737	0.7959	0.3181	0.9250	0.3510	1.0207	0.3735	1.0860
4	0.2891	0.3741	1.2941	0.2362	0.8171	0.2885	0.9980	0.3280	1.1345	0.3559	1.2310
5	0.2503	0.3693	1.4753	0.2089	0.8344	0.2673	1.0677	0.3123	1.2477	0.3458	1.3815
6	0.2210	0.3673	1.6620	0.1876	0.8488	0.2507	1.1346	0.3009	1.3614	0.3394	1.5360
7	0.1983	0.3667	1.8494	0.1707	0.8608	0.2373	1.1969	0.2918	1.4713	0.3347	1.6880
8	0.1797	0.3665	2.0394	0.1565	0.8712	0.2265	1.2602	0.2849	1.5854	0.3316	1.8451
9	0.1646	0.3663	2.2257	0.1448	0.8800	0.2175	1.3214	0.2793	1.6969	0.3292	2.0001
10	0.1520	0.3663	2.4102	0.1349	0.8876	0.2100	1.3814	0.2748	1.8081	0.3272	2.1529

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