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Selection of Skip Lot Sampling Plan V with Multiple Repetitive Group Sampling Plan As Reference Plan Through Minimum Angle Criteria

Statistics

KEYWORDS : Skip-lot Sampling Plan, Multiple Repetitive Group Sampling Plan, Minimum Angle Method, Acceptable Quality Level

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ABSTRACT

Under acceptance sampling producer's risk and consumer's risk has become increasingly common in maintaining quality products especially in industries. These issues should be considered simultaneously when determining quality decision. In this paper a skip lot sampling plan of type (SkSP-V) with Multiple Repetitive Group Sampling plan as reference plan has been studied. Producer's risk and Consumer's risk has been minimized by minimizing the tangent angle passing though (AQL, 1-α) and (LQL, β). Designing methodologies are provided to illustrate the solution procedures. This paper provides computational analysis that leads to variety of managerial insights. This method seems to be versatile and can be even adopted to the elementary production process, where the stipulated quality level is advisable to fix at a later stage and provides less producer risk and consumer risk.

INTRODUCTION

Acceptance sampling plan is used to either accept or reject a lot based on the sampling inspection. The primary objective of sampling inspection is to reduce the cost of inspection while at the same time assuring the customer to satisfy an adequate level of quality on items being inspected. Inspection of raw materials, semi finished products, or a finished product is an important part of quality assurance. When inspection is done for the purpose of acceptance or rejection of a product, and it is based on adherence to a standard the type of inspection procedure employed, such a procedure is usually called acceptance sampling. Sampling is widely used in government sector and industry for controlling the quality of shipment of components, supplies and final products.

In this paper a skip lot sampling plan of type SkSP-V with Multiple Repetitive Group Sampling Plan as reference plan has been proposed. Producer risk and Consumer Risk has been minimized through minimizing the tangent angle passing through *(AQL,1-α)* and *(LQL, β).* It is discussed how the declination angle of the tangent at the inflection point of the OC curve which discriminates the Multiple Repetitive Group Sampling plan. Tables are presented for the selection of plans based on Acceptable Quality Level (AQL) and Limiting Quality Level (LQL) with discriminant or declination angle of the tangent.

Dodge [2] has introduced the concept of skip-lot sampling, by applying the principles of a continuous sampling plan of type CSP-1 to a series of lots or batches of material. Normal Bush et al. [8] have suggested two points on the OC curve namely *(AQL, 1-α), and (IQL, 0.50), and the cosine angle of chord length to describe the direction of OC curve.*

Perry [9] has developed a system of sampling inspection plan known as SkSP-2. This Plan involves inspection of only a fraction *'f '* of the submitted lots when quality of the submitted product is good as demonstrated by the quality of the product. Suresh [13] has given

for the selection of Skip-lot Sapling Plan of type SkSP-2 with reference plans SSP*(c=0),* SSP*(c≠0)* and DSP(0,1) using consumer and producer quality levels. Muthulakshmi [7] has proposed a method of designing skip lot sampling plan, SkSP-2 based on minimum angle criteria is proposed. Tables for the selection of SkSP-2 plans involving minimum angle are presented for specified AQL and LQL.

Jayalakshmi [5] has presented a procedure for designing skip lot sampling plan of type SkSP-2 with STDS as reference plan involving minimum angle method between the lines formed by the points *(AQL, 1-α), (AQL, β)* and *(AQL, 1-α), (LQL, β)* are given. Balamurali and Jun [1] developed a new system of skip lot sampling plan designated as SkSP-V based on the principles of CSP-V plan. Recently Muhammad Aslam et. al [6] has studied optimal designing of an SkSP-V skip lot sampling plan with Double Sampling Plan as the reference plan. The design parameters are determined so as to minimize the average sample number while the specified producer risk and the consumer risks are satisfied.

SKIP LOT SAMPLING PLAN V

The CSP-V plan is a single-level continuous sampling plan which provides for alternating sequences of 100% inspection and sampling inspection and requiring a shorter sequence of 100% inspection if it has been a long time since the previous 100% inspection phase. Based on the principles of CSP-V plan, a new system of skip-lot sampling plan designated as SkSP-V skip lot sampling procedure is developed for the quality inspection of continuous flow of bulk products. The SkSP-V plan, like other skip-lot plans, has both a continuous sampling part for choosing which lots to inspect, and a lot sampling part called 'reference plan' for inspecting the chosen lots.

THE OPERATING PROCEDURE FOR SkSP-V PLAN

- At the outset, start with normal inspection using the reference plan. During the normal inspection, lots are inspected one by one in the order of production or in the order of being submitted to inspection.
- When *i* consecutive lots are accepted on normal inspection, discontinue the normal inspection and switch to skipping inspection.
- During skipping inspection, inspect only a fraction *'f'* of the lots selected at random. Skipping inspection is continued until sampled lot is rejected.
- When a lot is rejected on skipping inspection before *k* consecutively sampled lots are accepted, revert to normal inspection as per (1) above.
- When a lot is rejected after *k* consecutive lots have been accepted revert to normal inspection with reduced clearance number *x* as per (6) given below.
- During normal inspection with clearance number *x,* lots are inspected one by one in the order of being submitted to inspection. This continues until either a lot is rejected or *x* lots are accepted, whichever occurs earlier.
- When a lot is rejected, immediately revert to normal inspection with clearance number *i* as per (1) given above.
- When *x* lots are accepted, discontinue normal inspection and switch to skipping inspection as per (3) above.

MULTIPLE REPETITIVE GROUP SAMPLING PLAN

The concept of Repetitive Group Sampling (RGS) plan was introduced by Sherman [10] in which acceptance or rejection of a lot is based on repeated sample results in the same lot. Soundararajan and Ramaswamy [12] have derived the operating characteristics curve and various designing procedure for the selection of plan parameters. Gaurishankar and Mohapatra [3] have developed a new

repetitive group sampling plan named as Conditional RGS plan. Gaurishankar and Joseph [4] proposed another new RGS plan which is an extension of Conditional RGS plan designated as Multiple Repetitive Group Sampling plan in which disposal of a lot on the basis of repeated sample results is dependent on the outcome of the inspection of the immediate preceding i lots.

Suresh and Kaviyarasu [14] have studied QSS-1 with Multiple RGS Plan as Reference plan indexed with Acceptable Quality Level (AQL), Limiting Quality Level (LQL), Indifference Quality Level (IQL) and its Operating Ratio. Poisson unity values have been tabulated to facilitate the operation and construction of the plan. Illustrations are also provided for selection of plan parameters.

OPERATING PROCEDURE FOR MRGS PLAN

Draw a random sample of size n and determined the number of defectives (d) found therein.

- Accept the lot, if $d < c_1$
  Reject the lot, if $d > c_2$
- If $c_1 < d \le c_2$, repeat the above steps provided i successive previous lots are accepted under RGS inspection system, otherwise reject the lot.

Thus MRGS plans are characterized by four parameters, namely, n, c_1, c_2 and acceptance criterion i. Here, it may be noted that when $c_1=c_2$, the resulting plan is simple single sampling. Also, for i=0 one can have the RGS plan of Sherman.

OPERATING CHARACTERISTICS FUNCTION

The operating characteristics function Pa(p) of Multiple Repetitive Group Sampling plan is derive by Shankar and Joseph using poisson model as

$$P_a(p) = \frac{P_a(1-P_c)^i}{(1-P_c)^i - P_c P_a^i}$$

Where, $P_a = \sum_{x=0}^{c_1} \frac{e^{-p}(p)^x}{x!}$

$$P_r = 1 - \sum_{x=0}^{c_2} \frac{e^{-p}(p)^x}{x!}$$

$$P_c = \sum_{x=0}^{c_2} \frac{e^{-p}(p)^x}{x!} - \sum_{x=0}^{c_1} \frac{e^{-p}(p)^x}{x!}$$

DESIGNING METHOD USING MINIMUM ANGLE CRITERIA

Norman Bush et. al. have considered two points on the OC curve as *(AQL, 1-α)* and *(IQL, 0.05)* for minimizing the consumer's risk. Here another approach of minimization of angle between the lines joining the points *(AQL, β), (AQL, 1- α)* and *(AQL, 1- α), (LQL, β)* was given by Singaravelu [11].

Applying this method one can get a better plan which has an OC curve approaching to the ideal OC curve.

The formula for $tan\theta$ is given as

$$\tan \grave{e} = \frac{Opposite\ side}{Adjacent\ side}$$

$$n \tan\theta = \frac{np_2 - np_1}{P_a(p_1) - P_a(p_2)}$$

Using this formula, the angle θ is minimized for the given *np1* and *np2* values.

SELECTION PROCEDURE FOR SKSP-V WITH MRGS PLAN

Table 1 can be used for obtaining plan parameters with the minimum tangent angle *(ntanθ)* between the lines formed by the points *(AQL, 1-α), (AQL, β)* and *(AQL, 1-α), (LQL,* β). One can find the sampling plan from the tables with minimum tangent angle *(ntanθ)* by the following procedures:

- Compute the operating ratio *p2/p1*
- With the computed values of *p2/p1* enter the value from the table headed by *p2/p1* this is equal to or just greater than the computed ratio.
- The sample size is then obtained as *n = np1/p1*, since θ is known, the parameter *n* can be computed.
- Thus the minimum angle can be found as *{(θ = tan θ/n}*

SELECTION OF PLAN FOR GIVEN, *i,k, f, p1* AND *p2*

To select a plan for given i, k, f, p1 and p2, first calculate the operating ratio p2/p1. Select and then the table corresponding to the given i, k,c1, c2, i_{mrgs} and 'f' and locate the value or in the row headed with OR which is very close to the desired ratio. The parameter np1 and ntanθ are can obtained from the selected table corresponding to given i, k,c1, c2, imrgs and 'f' along with producers and consumers risk. The sample size thus obtained as n = np1/p1 and the minimum angle $\theta = \tan^{-1}\{(n\tan\theta)/n\}$. For example for given p1=0.01, p2=0.4 one can compute p2/p1= 0.40/0.01=40. The OR value exactly equal to 40 with i =1, k = 2, i_{mrgs}=2 and f = 1/2 one find the following values for skip-lot plans from the constructed Table 1.

ntanθ =5.4301	c_1=1	c2=2	α=0.02	β=6.61
ntanθ=5.7332	c_1=1	c2=3	α=0.00	β=4.77
ntanθ =6.8463	c_1=2	c2=3	α=0.00	β=8.86
ntanθ =7.1031	c_1=2	c2=4	α=0.00	β=6.66

The skip lot plans corresponding to minimum angle from the above set of values are

(1,2,1/2,40) with θ=22.67	α=0.02	β=6.61
(1,2,1/2,40) with θ=22.27	α=0.00	β=4.77
(1,2,1/2,40) with θ=23.17	α=0.00	β=8.86
(1,2,1/2,40) with θ=22.68	α=0.00	β=6.66

Thus for given i = 1, k = 2, i_{mrgs}=2, f = 1/2, c_1=1, c_2=3) the minimum angle θ=22.27

CONSTRUCTION OF TABLES

The probability of acceptance for SkSP-V with reference plan is

$$P_a(p) = \frac{fP + (1-f)P^i + fP^{k+1}(P^i - P^k)}{f(1+P^{i+k} - P^{2k}) + (1-f)P^i} \quad (1)$$

When *P* is MRGS reference plan and its OC function as

$$P_a(p) = \frac{P_a(1-P_c)^i}{(1-P_c)^i - P_c P_a^i} \quad (2)$$

Where $P_a = \sum_{x=0}^{c_1} \frac{e^{-p}(p)^x}{x!}$

$$P_r = 1 - \sum_{x=0}^{c_2} \frac{e^{-p}(p)^x}{x!} \quad P_c = \sum_{x=0}^{c_2} \frac{e^{-p}(p)^x}{x!} - \sum_{x=0}^{c_1} \frac{e^{-p}(p)^x}{x!}$$

When np1 and p2/p1 are known np2 can be calculated from np2 = np1 (p2/p1).

The following search procedure is used to obtained the parametric value, fixing α = 0.05 and β = 0.10

- Set c1=0, c2=1
- Compute α and β using equation 1 and 2 for given i, k, f, np1 and OR
- If $P^a(p1) \ge 1-\alpha$ go to step (6), If $P^a(p2) \le \beta$ go to step (6)
- Find n tan θ using np_1, α and β and computed np_2 = OR x np1
- Record minimum of n tan θ
- Increase c by 1 go to step (2)
- Records the c value for which ntanθ is minimum.

The above search procedure is used to obtain the optimum value for *c* which minimize the tangent angle for certain specific values of np1 and np2 by keeping the producer's risk below 5% and consumer's risk below 10%.

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Table 1 : Minimum Angle SkSP–V with MRGS plans for given OR and np1 for imrgs=2, f=1/2

OR	np_1	c_1	c_2	i	k	ntanθ	α	β
60	0.09	1	2	1	2	5.6265	0.01	5.62
	0.1	1	3	1	2	6.1084	0.00	3.41
	0.11	2	2	1	2	7.0311	0.01	7.69
	0.12	2	3	1	2	7.4501	0.00	4.97
	0.13	2	4	1	2	7.9205	0.00	3.16
	0.14	3	3	1	2	8.8107	0.00	6.25
	0.15	3	4	1	2	9.2339	0.00	4.16
55	0.1	1	3	1	2	5.6948	0.00	5.18
	0.12	2	3	1	2	7.0196	0.00	7.69
	0.13	2	4	1	2	7.4016	0.00	5.16
	0.14	2	5	1	2	7.8272	0.00	3.41
	0.15	3	3	1	2	8.7007	0.00	6.90
	0.16	3	4	1	2	9.0728	0.00	4.77
50	0.11	1	2	1	2	5.6848	0.01	5.18
	0.12	1	3	1	2	6.0877	0.00	3.41
	0.13	1	4	1	2	6.5153	0.00	2.23
	0.14	1	5	1	2	6.9608	0.00	1.45
	0.15	2	2	1	2	7.6559	0.03	3.97
	0.16	2	3	1	2	8.0587	0.00	2.71
	0.17	2	4	1	2	8.4861	0.00	1.84
45	0.12	1	3	1	2	5.5944	0.00	5.62
	0.14	2	3	1	2	6.8064	0.00	9.50
	0.15	2	4	1	2	7.0895	0.00	6.90
	0.16	2	5	1	2	7.4081	0.00	4.97
40	0.13	1	2	1	2	5.4301	0.02	6.61
	0.14	1	3	1	2	5.7332	0.00	4.77
	0.16	2	3	1	2	6.8463	0.00	8.86
	0.17	2	4	1	2	7.1031	0.00	6.66
35	0.14	1	2	1	2	5.1988	0.02	8.42
	0.15	1	3	1	2	5.4460	0.00	6.35
	0.18	2	4	1	2	6.7626	0.00	9.50
30	0.16	1	4	1	2	5.1066	0.00	9.14
	0.17	1	5	1	2	5.3125	0.00	7.20

CONCLUSION

Acceptance sampling is the techniques which deals with the procedure in which a decision either to accept or reject lots or processes which are based on the examination of samples. In acceptance sampling the producer and consumer plays a dominant role and hence one allows certain level of risk for both producer and consumer, namely α=0.05, β=0.10. In practice it is desirable to design any such sampling plan with the associated quality levels, which has concern to both producer and consumer. The result presented in this paper are mainly related with new procedure for designing sampling plan and necessary tables for selection of sampling system through minimum angle method involving producer and consumer quality levels.

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