MINIMUM AFI FOR MODIFIED CSP-T CONTINUOUS SAMPLING PLAN

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ABSTRACT: This paper explores of the problem of minimum average fraction inspected (AFI) for a modified CSP-T continuous sampling plan. A solution procedure is used to find the optimal parameters (i,f) that meets the AOQL requirement and also minimizing the AFI for the modified CSP-T plan with specified number of inspection level when the process average $\bar{p}$ (>AOQL) is known.(Key Words: Average Outgoing Quality, Average Outgoing Quality Limit, Average Fraction Inspected, Modified CSP-T continuous sampling plan.)

INTRODUCTION

Continuous sampling plan is the most commonly used inspection procedure in the continuous product flow when the units are not grouped into the lots**.** Continuous sampling plan was first introduced by Dodge [1] and that initial plan is called CSP-1. There have been a number of variations in the original Dodge CSP-1 plan. One variation was designed to meet the objection that the occurrence of a single isolated defective unit sometimes does not the warrant return to 100% inspection, this is true when dealing with minor defects and also it is decided how to calculate the average fraction inspection and the average outgoing quality for CSP-1 plan. Dodge showed that as the incoming fraction defective p varies, when the AOQ reaches a maximum, then it is known as the average outgoing limit. The inspection cost for a continuous sampling plan is directly proportional to AFI.The AOQL is one of the exponent to the performance of the measures of every continuous sampling plan. Ghosh, Resnikoff and Chen et al have addressed the problems of achieving the minimum AFI for the CSP-1 plan. In this paper we present the problems of minimizing the AFI for the modified CSP-T plan. A simple method of the solution procedure is developed to find the optimal parameters (i, f) that will meet the AOQL requirements while also minimum AFI for the modified CSP-T continuous sampling plan with specified number of inspection when the process average $\bar{p}$ (> AOQL) is known.

AVERAGE FRACTION INSPECTED AND AVERAGE OUTGOING QUALITY OF THE MODIFIED CSP-T PLAN

According to S. Balamurali and Chi-Hyuck Jun, the procedure of the modified CSP-T (MCSP-T) plan is as follows.

Step 1:
In the order of production MCSP-T plan starts with 100% inspection of units.
(i) If the first i consecutive units are found non-conforming then discontinue 100% inspection and switch to sampling inspection at level 2, where only a specified fraction f/2 of the units are inspected.
(ii) Otherwise, 100% inspection continue until any run of i consecutive units found non-conforming and then we proceed the sampling inspection at level 1, where only a pre-specified fraction f of the units are inspected.

Step 2:
When non-conforming units are found on sampling level 1, the sampling inspection revert immediately to 100% inspection and then continue as in step 1.

Step3:
If the sampling inspection is in level 2 or level 3, then continue the inspection until non-conforming units are found. When this occurs revert immediately to 100% inspection and then;
(i) If the first i consecutive units are found conforming then discontinue 100% inspection and go to sampling inspection at level 3, where a pre-specified fraction f/4 of the units are inspected.
(ii) Otherwise, continue step 1.

Step 5:
Replace or correct all the non-conforming units found with conforming units.
From S. Balamurali and Chi-Hyuck Jun, the average outgoing quality and average fraction inspection functions for the modified CSP-T plan are given by

$$AOQ = \frac{pq^i[(1-f)+q^i+2q^{2i}]}{f+(1-f)q^i+q^{2i}+2q^{3i}} \quad (1)$$

$$AFI = \frac{f}{f+(1-f)q^i+q^{2i}+2q^{3i}} \quad (2)$$

Where,
p = the incoming fraction defective
q = 1 – p
i = the clearance number of the 100% inspection stage.
f = the sampling frequency at inspection

AOQL FOR THE MODIFIED CSP-T PLAN

For each MCSP-T plan, AOQ has a maximum value. The AOQ function for the modified CSP-T plan is given by equation (1). The AOQ function of the MCSP-T plan is unimodel function. In general the maximum of the AOQ for all the values of p is obtained by using AOQ function. We accept the numerical method for finding the AOQL for MCSP-T plan. In the practical the inspection of a MCSP-t plan is performed at the rate of every fixed sampling interval. Thus the parameters of the sampling intervals (i.e.) n, of the MCSP-T plan must be integer. From Appendix A we can find the incoming fraction defective p This can be find by differentiating the formula for AOQ in equation (1) with respect to p_1 which reaches the maximum value of AOQ with he given parameters (i,f).

METHOD OF MINIMUM AVERAGE FRACTION INSPECTED FOR MODIFIED CSP-T PLAN

Montgomery points out that as a general rule, For a CSP-1 plan, it is not a good idea to choose the values of sampling interval large the 200 because the production against bad quality in a continuous run of production then it will becomes very poor. The solution procedure to find the parameters (i, f) that satisfy the minimum AFI under the specified values of AOQL.

1. Let we take i=1 and adopt Appendix A for finding the value of AOQL of MCSP-T plan with the given f.
2. Repeat step 1 with i=2, i=3, etc... Now we terminate when it is obvious that the specified value of AOQL, p_L has been found.
3. Compute the value of AFI for the parameters obtained from step 2.
4. According to the result of Ghosh we determine the value of maximum i as $[(1-\bar{p})/(\bar{p}-p_L)]$ (where [x] defines the greatest integer $\leq$ x).For all the $2 \leq n \leq 200$ and the value i ,we repeat step 1 through step 3 in order to find the corresponding value of AFI. By doing the comparison of the respective AFI and AOQL, we can select the most reasonable parameters (i, f) that achieve the specified p_L value and also minimize the value of AFI for the modified CSP-T plan.

NUMERICAL EXAMPLE

Assume that the manufacturing process is in control. The process average $\bar{p} = 0.02$ and $p_L = 0.01$.By adopting the above solution procedure the optimal solution for the MCSP-T plan are (i^*, f^*) = (70 ,1/5), AFI=0.184088 AOQL =1.01302x10^{-2}.

CONCLUSION

The authors of MCSP-T plan point out that "The important feature of the proposed this MCSP- T plan is that one cannot go back from one level of sampling inspection to another sampling level without going back to 100% inspection. In this paper we have presented the calculation of the approximate AOQL for the MCSP-T plan based on the numerical method. A simple method of the solution procedure is developed to find the optimal parameters (i, f) that will meet the AOQL requirements while also minimum AFI for the modified CSP-T continuous sampling plan with specified number of inspection when the process average $\bar{p}$ (> AOQL) is known. Further direction of study will extend this method to the economic design of the modified CSP-T plan with other inspection cost.

REFERENCES

[1] Balamurali, S. (1999). Modified two level continuous sampling plans. Economic Quality Control, 14, 123-133.
[2] Balamurali, S. and Govindaraju, K., "*Modified Tightened Two-Level Continuous Sampling Plans*", Journal of Applied Statistics, 2000; 27: 397-409.

[3] Balamurali.S and Chi-Hyuck Jun *"Modified CSP-T Sampling Procedures for Continuous Production Processes"*, Quality Technology & Quantitative Management Vol. 1, No. 2, pp. 175-188, 2004.
[4] Derman, C., Littauer, S. and Solomon, H., "*Tightened Multi-Level Continuous Sampling Plans*", Annals of Mathematical Statistics, 1957; 28: 395-404
[5] Dodge, H. F. (1943): **"***A Sampling Inspection Plan for Continuous Product* The Annals of Mathematical Statistics, **14**, pp. 264- 279.
[6] Dodge, H. F. & Torrey, M. N. (1951): **"***Additional continuous sampling Inspection plans***"**, Industrial Quality Control, **7**, pp. 7- 12.
[7] Lieberman, G. J. & Solomon, H. (1955): **"***Multi-level continuous sampling plans***"**,The Annals of Mathematical Statistics, **26**, pp. 686- 704.
[8] Schilling, E. G., (1982): **"***Acceptance Sampling in Quality Control***"**, Marcel Dekker, Inc.,
[9] Montgomery,D.C..,"*Introduction to statistical quality control"*, 2nd edition, John Wiley & sons,Inc.,New York (1991).
[10] Stephens, K. S. (1995): **"***How to Perform Continuous Sampling (CSP)***"**, 2nd edn,**2**, The ASQC Basic References in Quality Control: Statistical Techniques (Milwaukee, WI, American Society for Quality Control).

APPENDIX A: AOQL FOR MCSP-T PLAN WITH THE GIVEN (I,F)

From S. Balamurali and Chi-Hyuck Jun, the AOQ function for the modified CSP-T plan is given by,

$$AOQ = \frac{pq^i[(1-f)+q^i+2q^{2i}]}{f+(1-f)q^i+q^{2i}+2q^{3i}} \qquad \text{(A1)}$$

Where,

p = the incoming fraction defective
q = 1 – p
i = the clearance number of the 100% inspection stage.
f = the sampling frequency at inspection
S. Balamurali and Chi-Hyuck Jun pointed as 'The AOQL, the maximum of the AOQ for all values of p, may be finding graphically by using AOQ function'. However we accept the numerical method for finding the AOQL for MCSP-T plan. Differentiating equation (A1) with respect to p and equating the result to zero (i.e.) $\frac{d(AOQ)}{dp}=0$, we obtain

$$f+(1-f)q^i+q^{2i}+2q^{3i} = \frac{ipq^i[(1-f)+q^i+2q^{2i}][(1-f)+2q^{i-1}(1+3q^{i-1})]}{(1-f)(q-pi)+q^i(q-2pi)+2q^i(q-3pi)} \qquad \text{(A2)}$$

Let p_1 be the incoming fraction defective when AOQ reaches a maximum values of i and f. Equation (A2) can be written as

$$f+(1-f)q_1^{\,i}+q_1^{\,2i}+2q_1^{\,3i} = \frac{ip_1q_1^{\,i}[(1-f)+q_1^{\,i}+2q_1^{\,2i}][(1-f)+2q_1^{\,i-1}(1+3q_1^{\,i-1})]}{(1-f)(q_1-p_1i)+q_1^{\,i}(q_1-2p_1i)+2q_1^{\,i}(q_1-3p_1i)} \qquad \text{(A3)}$$

Where $q_1 = 1-p_1$

From equation (A1) ,we've

$$\max AOQ = p_L = \frac{p_1q_1^{\,i}[(1-f)+q_1^{\,i}+2q_1^{\,2i}]}{f+(1-f)q_1^{\,i}+q_1^{\,2i}+2q_1^{\,3i}} \qquad \text{(A4)}$$

Where p_L is the specified value of AOQL.

Substituting equation (A3) into (A4), we obtain

$$p_L = \frac{(1-f)(q_1-p_1i)+q_1^{\,i}(q_1-2p_1i)+2q_1^{\,i}(q_1-3p_1i)}{i[(1-f)+2q_1^{\,i-1}(1+3q_1^{\,i-1})]} \qquad \text{(A5)}$$

Equation (A5) can be simplified as

$$F(q_1) = (1-f)[q_1(1+i)-i] + q_1^{\,i}\{[q_1(1+2i)-2i] + 2q_1^{\,i}[q_1(1+3i)-3i]\} - ip_L[(1-f) + 2q_1^{\,i-1}(1+3q_1^{\,i-1})] \quad \text{(A6)}$$

We adopt the conventional Newton's method for solving equation (A6). Hence, we can obtain the AOQL for the modified CSP-T plan with the given (i,f). If p_1 doesn't exit, then there is unsatisfactory AOQL for this modified plan.