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Full Length Research Paper

Construction of chain sampling plan-1 indexed through producer's nano quality level and consumer's nano quality level

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Motorola (1980) introduced the concept of "six sigma" as a quality philosophy and a management strategy, which when adopted in a system of organization will reduce wastages, increase the profit to the management and enhance the satisfaction of the customer. If this concept of six sigma is adopted in an organization it can results in 3.4 or less number of defects per million opportunities in the long run. In recent days in developed and developing countries more and more organization started working beyond six sigma level and thereby the performance level increases with number of defectives reduced to near zero level. In this paper a new procedure for the construction of chain sampling plan-1(ChSP-1) indexed through producer's nano quality level (PNQL) and consumer's nano quality level (CNQL) is introduced and suitable tables are provided for the easy selection of the plan.

Key words: Nano quality level, Poisson distribution, chain sampling plan, Operating Characteristic (OC) curve, six sigma quality level.

INTRODUCTION

The concept of chain sampling plan (ChSP) was introduced by Dodge (1955). Dodge has given OC curves of ChSP-1 plans with various values for n = 4, 5, 6 and 10 and i = 1, 2, 3, 4, 5 and ∞. Chain sampling plan-1(ChSP-1) is a special type of sampling inspection plan and is very useful for application to product characteristics involving destructive or costly tests under certain conditions. Complete review and bibliography on chain sampling plans can be seen in Stephens (1982).

Soundararajan (1978a, b) constructed tables for the selection of chain sampling plan-1 (ChSP-1) plans. Soundararajan and Govindaraju (1982) made contribution in the designing of ChSP-1 plans.

Radhakrishnan and Sampathkumar (2006) constructed chain sampling plans using various parameters. Further, Radhakrishnan and Sivakumaran (2008) introduced the concept of six sigma quality level and constructed single sampling plan with Poisson distribution as the base line distribution. Radhakrishnan and Balamurugan (2009a, b, 2010a, b, 2011) constructed various control charts based on six sigma initiatives for average fraction defectives, mean, number of defects, Xbar using standard deviation and fraction defectives.

Radhakrishnan and Vinotha (2011) provided a procedure for the construction of sampling plans using nano quality levels.

In this paper chain sampling plan-1 (ChSP-1) is constructed using producer's nano quality level (PNQL) and consumer's nano quality level (CNQL). The new sampling plan is constructed with the point on the OC curve (PNQL, $1-\gamma_1$), similar to (AQL, $1-\alpha$), $\alpha=0.05$ suggested by Dodge (1955) and (SSQL-1, $1-\alpha_1$), $\alpha_1=3.4\times10^{-6}$ suggested by Radhakrishnan and Sivakumaran (2008). Similarly a new sampling plan can be constructed with a point on the OC curve (CNQL,γ_2), $\gamma_2=2\gamma_1$ is similar to (LQL, β), $\beta=2\alpha$ suggested by Dodge (1955) and (SSQL-2, β_1), $\beta_1=2\alpha_1$ suggested by Radhakrishnan and Sivakumaran (2008).

Thus a ChSP-1 plan has two parameters namely 'n', the sample size for each submitted lot and 'i', the number of previous samples on which the decision of acceptance

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Table 1. Parameters of ChSP-1 plans for a specified PNQL.

i	nPNQL
1	0.0000260
2	0.0000200
3	0.0000170
4	0.0000150
5	0.0000138
6	0.0000127
7	0.0000118
8	0.0000111
9	0.0000105
10	0.0000100
11	0.0000095
12	0.0000091
13	0.0000088
14	0.0000085
15	0.0000082
16	0.0000079
17	0.0000077
18	0.0000075
19	0.0000073
20	0.0000071

or rejection of the lot is based.

OPERATING PROCEDURE OF CHSP-1

The operating procedure for ChSP-1is as follows:

Step 1 :Select a random sample of size ‘n’ units from a lot with size ‘N’.
Step 2 : Inspect all the items included in the sample. Let‘d’ be the number of non-conformities in the sample.
Step 3 : If d = 0, accept the lot.
Step 4 : If d >1, reject the lot.
Step 5 : Accept the lot if d =1 and if no non-conforming units are found in the immediately preceding ‘i’ samples of size ‘n’.

Conditions for application

(i) The production is steady so that results of past, present and future lots are broadly indicative of a continuing process.
(ii) Lots are submitted sequentially in the order of their production.
(iii) Inspection is by attributes, with the lot quality defined as the proportion defective.
(iv) Human involvement should be less in the manufacturing process.
(v) The companies are to have sufficient experience in adopting Six Sigma initiatives in their process to ensure the system has the potentiality to produce nearly zero defectives.

Operating characteristic function

Under Poisson model the OC function of the ChSP-1 plan is given by:

$$P_a(p) = e^{-np} + npe^{-np(i+1)}, \qquad (i > 0) \tag{1}$$

where: n - the sample size for each submitted lot; and i - the number of previous samples on which the decision of acceptance or rejection of the lot is based.

RESULTS AND DISCUSSION

Construction of CHSP-1 plans indexed through PNQL

By fixing the probability of acceptance of the lot as $1\text{-}10^{-9}$ with Poisson distribution as the basic distribution and from Equation (1), the values of nPNQL are obtained for various combinations of ‘i’ using Excel package and are presented in Table 1. The sample size ‘n’ is obtained using n = nPNQL / PNQL. Hence the parameters of the ChSP-1 plan ‘n’ and ‘i’ are obtained for various values of PNQL.

Example 1

For a given PNQL = 0.00000003, i=2 the value of nPNQL is selected from Table 1 as 0.000020 and the corresponding sample size ‘n’ is computed as n = 0.000020/ 0.00000003 =667. Hence the parameters of ChSP-1 are n = 667 and i = 2 for a specified PNQL = 0.00000003.

Practical application

In a wrist watch manufacturing company, if the manufacturer fixes the quality of watches as PNQL =

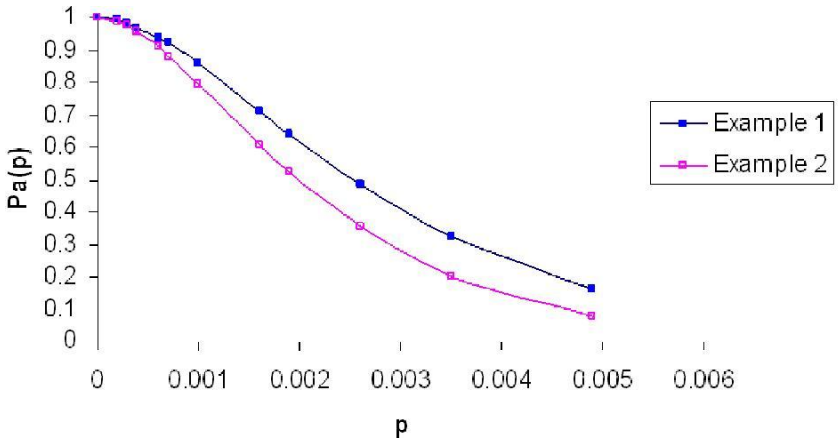

Figure 1. OC curves for the plan n = 667 and i = 2 and n = 850 and i = 3.

0.00000003(3 faulty watches out of 10 crore watches) from the manufactured lot of a particular week/month and count the number of faulty watches (d).

If d = 0 accept the lot of watches manufactured in that week/month and if d > 1, reject the watches manufactured in that week/month and inform the management for the quality improvement. If d = 1, and no defective watches are found in the immediately preceding two sample of sizes 667 each, accept the lot of watches manufactured in the same week/month, otherwise reject the lot of watches manufactured in that week/month and inform the management for the quality improvement.

Example 2

For a given PNQL = 0.00000002, i=3 the value of nPNQL is selected from Table 1 as 0.000017 and the corresponding sample size 'n' is computed as n = 0.000017/ 0.00000002= 850. Hence the parameters of ChSP-1 are n = 850 and i = 3 for a specified PNQL = 0.00000002.

The OC curves of the plans provided in Examples 1 and 2 are presented in Figure 1.

Construction of CHSP-1 plans indexed through CNQL

By fixing the probability of acceptance of the lot as $\gamma_2=2\gamma_1$, where $\gamma_1 = 1\text{x}10^{-9}$ with Poisson distribution as the basic distribution and from Equation (1), the values of nCNQL are obtained for various combinations of 'i' using Excel package and are presented in Table 2. The sample size 'n' is obtained using n = nCNQL/CNQL. Hence the parameters of the ChSP-1 plan 'n' and 'i' are obtained for various values of CNQL.

Example 3

For a given CNQL = 0.01, i=1 the value of nCNQL is selected from Table 2 as 20.0303 and the corresponding sample size 'n' is computed as n = 20.0303 / 0.01=2003. Hence the parameters of ChSP-1 are n =2003 and i = 1 for a specified CNQL = 0.01.

Practical application

In a wrist watch dealer firm, if the distributor fixes the quality of watches as CNQL = 0.01 (1 faulty watch out of 100 watches), from the supplied lot of a particular week/month and count the number of faulty watches (d). If d = 0 accept the lot of watches supplied in that week/month and if d > 1, reject the watches supplied in that week/month and inform the management for the quality improvement. If d = 1, and no defective watches are found in the immediately preceding one sample of size 2003 each, accept the lot of watches supplied in the same week/month, otherwise reject the lot of watches supplied in that week/month and inform the management for the quality improvement.

Example 4

For a given CNQL = 0.02, i=2 the value of nCNQL is selected from Table 2 as 20.0303 and the corresponding sample size 'n' is computed as n = 20.0303/0.02=1002. Hence the parameters of ChSP-1 are n =1002 and i = 2 for a specified CNQL = 0.02.

The OC curves of the plans provided in Examples 3 and 4 are presented in Figure 2.

Conclusion

In this paper a new quality concept nano quality with two quality levels such as producer's nano quality level (PNQL) and consumer's nano quality level (CNQL) is introduced and the procedure for constructing ChSP-1

Table 2. Parameters of ChSP-1 plans for a specified CNQL.

i	nCNQL
1	20.0303
2	20.0303
3	20.0303
4	20.0303
5	20.0303
6	20.0303
7	20.0303
8	20.0303
9	20.0303
10	20.0302
11	20.0302
12	20.0302
13	20.0302
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15	20.0302
16	20.0301
17	20.0301
18	20.0301
19	20.0301
20	20.0301

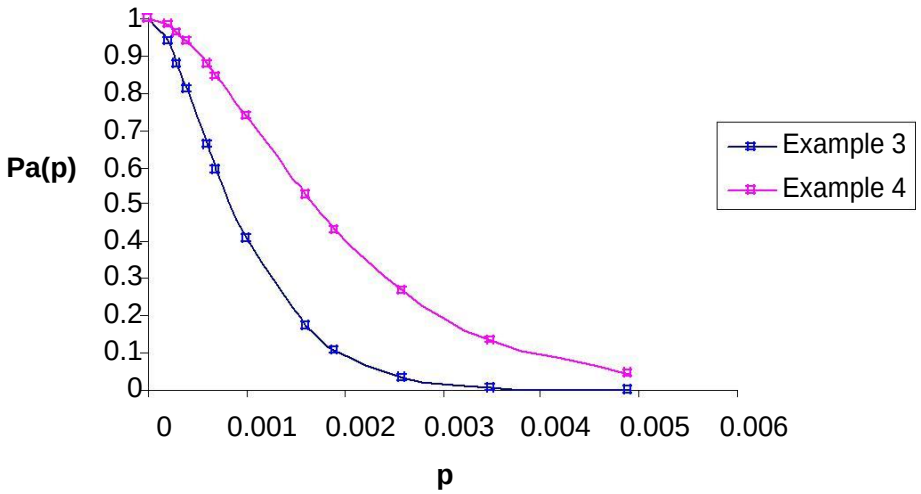

Figure 2. OC curves for the plan n =2003 and i = 1 and n =1002 and i = 2.

indexed through these quality levels with Poisson distribution as the base line distribution are also presented. The procedure indicated in this paper can replace the existing quality levels adopted in the construction of sampling plans because more organizations have specialized in adopting six sigma initiatives in their system and are willing to shift towards nano technology that will results in nearly zero non-conformities. So it is necessary for those companies to adopt the quality levels in the construction of the plan suggested in this paper. This will increase the confidence of the producer in providing a better sampling inspection procedure in enhancing the satisfaction of the consumers. The procedure outlined in this paper can be used for other plans also.

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