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A Variable- Attribute Modified Chain Sampling Plan Constructed on Process Potential Index

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Abstract:

Product control measures are significant for any manufacturing industry. Measures on product control can be achieved with the effective control on the process which reflects an increase of quality check. Research on Process and Product Control measures are currently ongoing which involves the concept of Process Potential Index. In this study, a variable-attribute modified chain sampling plan with process potential index, is discussed. The Probability of acceptance and allied measures are given. Tables are made to get the parameters of the plan. In this plan the variable inspection sample size is found instead of fixing it. The projected variable-attribute sampling plan is greatly used in industries to inspect the product with respect to the description limits and to protect the period and price of inspection to influence on the closing result.

Keywords: *Modified Chain Sampling, Process potential index, Producers' and Consumer's risks*

Introduction

. In these days the acceptance sampling plans are broadly used in many industries and fabrications for limiting the cost of inspection, and assisting to assure the worth of the product. Process potential measure is a vital tool to monitor the constant progress in quality and efficiency. The variable inspection is done by process potential index $\hat{C}_{pmk}$, constructed on normal distribution and chi square distribution. The attribute inspection is done by an attribute sampling plan constructed on Poisson distribution. For practical reason, acceptance number of zero plans is more insisted in the attribute inspection. Therefore modified chain sampling plan which yield small sample size is suggested in the attribute inspection.

Literature Review

V.E Kane (1986), Kotz et.al. (2002) have contributed in Process capability indices. Research has been done in modified chain sampling plans (Govindaraju et.al, 1998). Further study has been carried out in multi-dimensional mixed sampling plans (Suresh et.al, 2003). Research contribution has been made in process capability indices on Sample size determination (Chuan et.al, 2003). Advance research woks done in variable sampling plan constructed on process potential index (Chein-Wei et.al, 2008). Deep search and study also been carried out in variables repetitive group sampling plan based on process capability index (M. Aslam et.al, 2008). Extension work has been done in mixed sampling plans for costly or destructive items (Deva Arul et.al, 2013). Extensive study also carried out for developing an algorithm in mixed quality characteristics (Edna et.al, 2019).

Formulation of the Proposed Process and Product Control sampling plan.

Assuming that the process is independent, the design of mixed sampling plan using $\hat{C}_{pmk}$ with known
standard deviation is defined by four parameters, n_1, k, n_2 , i

n_1 is the variable inspection sample size

n_2 is the attribute inspection sample size, if the process is not accepted in the variable sampling inspection

k is the critical acceptance value

i is the index of chaining the lots

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Operating Method of the Independent Variable-Attribute Sampling Plan (n_1, k, n_2, i):

Step 1: Take a random sample of size n_1 from the lot

Step 2: Calculate

$$\hat{C}_{pmk} = \min\left\{ \frac{USL-\overline{X}}{3\sqrt{S^2_{n_1}+\left(\overline{X}-T\right)^2}}, \frac{\overline{X}-LSL}{3\sqrt{S^2_{n_1}+\left(\overline{X}-T\right)^2}} \right\}$$

Step 3: If the process potential measure $\hat{C}_{pmk} \geq k$,then admit the entire lot or process.

Step 4: If $\hat{C}_{pmk} < k$ then draw a sample of size n_2 for attribute inspection.

Step 5: Examine and count the numeral of imperfects in the attribute inspection sample.

If the following conditions are true, then admit the lot.

. (i) present sample and previous 'i' samples have zero imperfect units.

(ii) present sample has zero imperfect units, though any one of the 'i' previous samples have only one imperfect unit and the remaining (i-1) samples have zero

$$\int_0^{b_1\sqrt{n_1}/(1+3k)} G\left(\frac{(b_1\sqrt{n_1}-t)^2-t^2}{9k^2}\right)\left[\varphi(t+\xi\sqrt{n_1})+\varphi(t-\xi\sqrt{n_1})\right]dt=\beta_1$$

imperfect units.

Or else, reject the lot.

Measures of Independent Variable-Attribute Sampling Plan

1. Probability of acceptance is indicated below;

$$P_a\left(p\right)=P_{n_1}\left(\hat{C}_{pmk}\geq k\right)+P_{n_2}\left(\hat{C}_{pmk}<k\right)\,P_0(P_0^{\,i}+iP_0^{\,i-1}P_1)$$

Where, $P_0=e^{-n_2p}$ and $P_1=n_2pe^{-n_2p}$

$$P_a\left(p\right)=P_{n_1}(\hat{C}_{pmk}\geq k)+P_{n_2}\left(\hat{C}_{pmk}<k\right)\quad e^{-n_2p(i+1)}(1+in_2p)$$

Where $P_{n_1}\left(\hat{C}_{pmk}\geq k\right)=\int_0^{b\sqrt{n_1}/1+3k} G\left(\frac{(b\sqrt{n_1}-t)^2-t^2}{9k^2}\right)\left[\phi(t+\xi\sqrt{n_1})+\phi(t-\xi\sqrt{n_1})\right]dt$

2. Average Sample Number (ASN):

$$\text{ASN} = n_1 + n_2P\left(\hat{C}_{pmk} < k\right)$$

3. Average Total Inspection (ATI):

$$\text{ATI}=\text{ASN} + (\text{N} - n_1 - n_2)\ (1 - P_a(\text{p}))$$

4. Average Outgoing Quality (AOQ):

$$\text{AOQ}=\text{P}.\,P_a(\text{p})$$

Designing and Selection of the Sampling Plan (n_1, k, n_2, i)

The method for defining the acceptance sampling plan, given (p_1, β_1) (p_2, β_2) and C_{AQL}, C_{LTPD} of a variable-attribute independent sampling plan is as follows:

1. The probability of acceptance is split and that shall be allotted to the variable inspection. Say, $\beta_1^{\,1}$ and $\beta_2^{\,1}$ respectively, such that $\beta_1 \geq \beta_1^{\,1}$ and $\beta_2 \geq \beta_2^{\,1}$.

2. Let C_{AQL}, C_{LTPD} be potential requirement corresponding to AQL and LTPD. The variable inspection sample size n_1 and critical acceptance constant k of $\hat{C}_{pmk}$ are obtained from the following equations,

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$$\int_{0}^{b_2\sqrt{n_1}/(1+3k)} G\left(\frac{(b_2\sqrt{n_1}-t)^2-t^2}{9k^2}\right)\left[\phi(t+\xi\sqrt{n_1})+\phi(t-\xi\sqrt{n_1})\right]dt=\beta_2^{'}$$

Where $b_1 = 3C_{AQL}(1+\xi^2)^{1/2} + |\xi|$

$$b_2 = 3C_{LTPD}(1+\xi^2)^{1/2} + |\xi|$$

$$C_{AQL} > C_{LTPD}$$

3. Now define the probability of acceptance, $\beta_1^{''}$ and $\beta_2^{''}$ allotted to the attribute inspection as

$$\beta_1^{''} = \frac{\beta_1 - \beta_1^{'}}{1-\beta_1^{'}}$$

$$\beta_2^{''} = \frac{\beta_2 - \beta_2^{'}}{1-\beta_2^{'}}$$

4. Calculate the attribute inspection sample size n_2 and acceptance number from

$e^{-n_2 p(i+1)}(1+in_2 p) = \beta_1^{''}$ for fraction imperfect p=p_1

$e^{-n_2 p(i+1)}(1+in_2 p) = \beta_2^{''}$ for fraction imperfect p=p_2

TABLE 1: Values of n_1, k, n_2, i given, $(p_1,\beta_1),(p_2,\beta_2)$ and C_{AQL} = 1.33, C_{LTPD} = 1.00

Let $\beta 1'$=0 .9, $\beta 2'$=0 .9, ξ=.5

p_1	β_1	$\beta_1^{'}$	$\beta_1^{''}$	p_2	β_2	$\beta_2^{'}$	$\beta_2^{''}$	n_1	C_0 (or)K	Values of n_2				
										i=1	i=2	i=3	i=4	i=5
.001	.990	.905	.91	.052	.01	.025	.074	100	1.2002	92	74	52	39	20
.002	.985	.925	.85	.062	.1	.015	.092	135	1.2035	70	46	30	20	13
.003	.975	.9025	.76	.035	.1	.015	.092	125	1.2128	78	56	39	22	18
.004	.955	.90	.50	.035	.1	.015	.092	123	1.2128	76	50	34	20	16
.005	.975	.90	.77	.051	.1	.025	.074	101	1.2002	18	12	9	6	5
.006	.975	.90	.77	.045	.1	.015	.092	127	1.2128	12	10	7	6	6
.007	.990	.925	.85	.052	.1	.015	.092	127	1.2128	10	6	4	2	2

EXAMPLE: In an industrial manufacturing of fibred glass bowls, the target value T is given as .6mm with respect to the thickness of the fiber. The USL of fiber thickness is .65mm and the LSL is .53mm. C_{AQL} and C_{LTPD} are given as 1.33 and 1.00 respectively. Find the acceptance criterion of the process and product control sampling plan for (p_1,β_1) = (0.004, 0.955), (p_2,β_2) = (0.035, 0.1) and i=3

Solution:

The parameters are n_1, k, n_2, i, from the table $n_1 = 127, k = 1.2128, n_2 = 34, i = 3$

Where $\beta_1^{'}$ =0 .90, $\beta_1^{''}$=0.50, $\beta_2^{'}$ =0 .015, $\beta_2^{''}$=0.092.

If $\hat{C}_{pmk}$ > 1.2128, admit the entire lot or process. If $\hat{C}_{pmk}$ < 1.2128,

Take an attribute inspection sample of size n_2=34

(i)Examine and count the numeral of imperfects in the attribute inspection sample.

(ii)The lot is admitted if, the present sample along with the previous i=3 samples are of zero imperfect.

(iii) Also the lot is admitted if, the present sample has zero imperfect units, though any one of the i=3

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previous samples of size n_2=34 contain only one imperfect and the remaining i-1=2 samples are clear as of imperfects. Or else discard the lot.

Conclusion

The process potential index $\hat{C}_{pmk}$ is greatly used in industries to screen the product with respect to the specified parameters. The above process potential index is suitable to diminish the discrepancy in the production process. The projected plan is used to reduce the risk of producers and consumers. Since the attribute inspection sample size is small, the projected variable-attribute plan is able to protect the period and price of inspection to influence on the closing result.

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