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Research Paper

Optimization of CASP-CUSUM Schemes Based on Truncated Dagum Distribution

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ABSTRACT: *Acceptance sampling plans are introduced mainly to accept or reject the lots of finished products. There are several techniques available to control the quality. Some of the techniques are popularly used where testing involves destruction, for instance, in the manufacturing of crackers, bullets, batteries, bulbs and so on, it is impossible to go for 100% inspection. In this paper we optimized CASP-CUSUM Schemes based on the assumption that the continuous variable under consideration follows a Truncated Dagum Distribution. The Dagum Distribution is continuous distribution generally used in Life-time Analysis of products, particularly in estimating reliability by considering its distribution. Optimization of CASP-CUSUM Schemes is suggested based on numerical results obtained by changing the values of the parameters of the Dagum distribution.*

Keywords: *CASP-CUSUM Schemes, type C, OC Curve, ARL, Truncated Dagum Distribution.*

I. INTRODUCTION

The term quality now-a-days occupies an *important* place in many fields of research. In the beginning, this was applied to an industrial output, but in recent times it is playing a very important role in almost all fields like Management, Biology, Medicine and Research. Basically the term quality, with reference to consumer products means, 'General excellence' more precisely it means excellence in relation to certain thing that a consumer wants in a particular product. There are a good number of reasons, why a product may have unsatisfactory quality in this popular sense. There may be certain characteristics desired by a customer, for instance, performance, durability, appearance, colour, strength, safety, fool-proof and fail-safe and so on, which were not designed into the product because the manufacturer did not intend to do so. Thus, the quality of a product can be defined as follows:

"The totality of features and characteristics of a product of service that bear on its ability to satisfy the stated or implied needs of the user of the product"

The term 'Quality' is mostly used by Industrialists. Quality means 'fit for use'. Quality is the most important consumer - decision factor in selecting products and services. In modern times we have professional societies, Governmental regulatory body which aim at assuring the quality of products sold to consumers. Every customer has a 'right' to get good quality product, which is consumed by 'Consumer Protection Act, 1986'. Quality is defined based on the view point that products and services must meet the requirements of the consumers. Quality control is a process employed to ensure a certain level of quality in a product or service. Essentially, quality control involves the examination of a product, service, or process for certain minimum levels of quality. The basic goal of quality control is to ensure that the products, services or processes are provided to meet the specific requirements and are dependable satisfactory and fiscally sound.

In past research the term "quality" defines in different dimensions, particularly with regards to consumer point of view, system designer's point of view etc. Particularly in consumer's point of view durability, safety, low-cost, the degree of satisfaction etc are the major characteristics which determine the quality of a product. Where as in producer's point of view the degree of profit and the degree of low cost of production are the major properties that determine the quality. The term quality is closely associated with reliability of the product.

It is well-known that there are several techniques for controlling the quality Acceptance Sampling Plans are introduced to decide the case of lots of finished products-either acceptance or rejection. These are mainly used to test the level of destruction. For example in manufacture of crackers, bullets,..etc, 100% inspection is not possible. Techniques of Acceptance Sampling Plans may not have direct impact in controlling the quality of product. In improving the quality of the product, they have much indirect effect. A product may be continuously rejected for lack of quality, then, the producer will try hard to improve the quality of the product. In case quality of the product not being improved, the user will go for a product of better quality.

Kakoty. S., Chakravaborthy A.B. [5] proposed CASP-CUSUM charts under the assumption that the variable under study follows a Truncated Normal Distribution. Generally truncated distributions are employed in many practical phenomena where there is a constraint on the lower and upper limits of the variable under study. For example, in the production engineering items, the sorting procedure eliminates items above or bellows designated tolerance limits. It is worthwhile to note that any continuous variable be first approximated as an exponential variable.

Lonnie. C. Vance, [6] consider Average Run Length of cumulative Sum Control Charts for controlling for normal means and to determine the parameters of a CUSUM Chart.To determine the parameters of CUSUM Chart the acceptable and rejectable quality levels along with the desired respective ARL's are consider.

Muhammed Riaz, Nasir Abbas and Ronald J.M.M Does [7] proposed two Runs rules schemes for the CUSUM Charts. The performance of the CUSUM and EWMA Charts are compared with the usual CUSUM and weighted CUSUM, the first initial response CUSUM compared with usual EWMA Schemes. This comparison stated that the proposed schemes perform better for small and moderate shifts.

Vardeman.S, Di-ou Ray [9] was introduced CUSUM control charts under the restriction that the values are regard to quality is exponentially distributed. Further the phenomena under study is the occurrence of rate of rare events and the inter arrival times for a homogenous poison process are identically independently distributed exponential random variables.

Hawkins, D. M. [3] proposed a fast accurate approximation for ARL's of a CUSUM Control Charts. This approximation can be used to evaluate the ARL's for Specific parameter values and the out of control ARL's of location and scale CUSUM Charts.

Mohammed Akhtar. P and Sarma K.L.A.P [1] proposed an optimization of CASP-CUSUM Schemes based on truncated two parametric Gamma distribution and evaluate L (0) L' (O) and probability of Acceptance and also Optimized CASP-CUSUM Schemes based numerical results.

In the present paper it is proposed CASP-CUSUM Chart when the variable under study follows truncated Dagum Distribution. Thus it is more worthwhile to study some interesting characteristics of this distribution.

The Dagum Distribution is a continuous probability distribution defined over all positive real numbers. It is named after Camilo Dagum, who proposed it in a series of papers in the 1970s.

A continuous random variable X assuming non-negative values is said to have Dagum Distribution with parameters a, b, p > 0, its probability density function is given by:

$$f(x,a,b,p) = \frac{ap}{x}\left(\frac{(\frac{x}{b})^{ap}}{((\frac{x}{b})^{a}+1)^{p+1}}\right) \qquad \ldots\ldots (4.2.1)$$

The random variable X is said to follow a truncated Burr Distribution as:

$$f_B(x) = \frac{\frac{ap}{x}\left(\frac{(\frac{x}{b})^{ap}}{((\frac{x}{b})^{a}+1)^{p+1}}\right)}{(1+(\frac{b}{B})^{a})^{-p}} \qquad p>0,\ a>0,\ b>0 \qquad \ldots\ldots (4.3.1)$$

where B is the truncated point of the Dagum Distribution

II. DESCRIPTION OF THE PLAN AND TYPE- C OC CURVE

Battie [2] has suggested the method for constructing the continuous acceptance sampling plans. The procedure, suggested by him consists of a chosen decision interval namely, "Return interval" with the length h', above the decision line is taken. We plot on the chart the sum $S_m = \sum (X_i - k_1) X_i's(i = 1,2,3........)$ are distributed independently and k_1 is the reference value. If the sum lies in the area of normal chart, the product is accepted and if it lies of the return chart, then the product is rejected, subject to the following assumptions.

1. When the recently plotted point on the chart touches the decision line, then the next point to be plotted at the maximum, i.e., h+h'

2. When the decision line is reached or crossed from above, the next point on the chart is to be plotted from the baseline.

When the CUSUM falls in the return chart, network or a change of specification may be employed rather than outright rejection.

The procedure in brief is given below.

1. Start plotting the CUSUM at 0.

2. The product is accepted when $S_m = \sum (X_i - k) < h;$ when $S_m < 0$, return cumulative to 0.

3. When h $< S_m <$ h+h' the product is rejected: when S_m crossed h, i.e., when $S_m >$h+h' and continue rejecting product until $S_m >$h+h' return cumulative to h+h'

The type-C, OC function, which is defined as the probability of acceptance of an item as function of incoming quality, when sampling rate is same in acceptance and rejection regions. Then the probability of acceptance P (A) is given by

$$P(A) = \frac{L(0)}{L(0) + L'(0)} \qquad \text{...... (2.1)}$$

Where L (0) = Average Run Length in acceptance zone and
L' (0) = Average Run Length in rejection zone.
Page E.S. [8] has introduced the formulae for L (0) and L' (0) as

$$L(0) = \frac{N(0)}{1 - P(0)} \qquad \text{...... (2.2)}$$

$$L'(0) = \frac{N'(0)}{1 - P'(0)} \qquad \text{...... (2.3)}$$

Where P (0) =Probability for the test starting from zero on the normal chart,
N (0) = ASN for the test starting from zero on the normal chart,
P' (0) = Probability for the test on the return chart and
N' (0) = ASN for the test on the return chart
He further obtained integral equations for the quantities
P (0), N (0), P' (0), N' (0) as follows:

$$P(z) = F(k_1 - z) + \int_0^h P(y) f(y + k_1 - z) dy, \qquad \text{...... (2.4)}$$

$$N(z) = 1 + \int_0^h N(y) f(y + k_1 - z) dy, \qquad \text{...... (2.5)}$$

$$P'(z) = \int_{k_1+z}^{B} f(y) dy + \int_0^h P'(y) f(-y + k_1 + z) dy \qquad \text{...... (2.6)}$$

$$N'(z) = 1 + \int_0^h N'(y) f(-y + k_1 + z) dy, \qquad \text{...... (2.7)}$$

$$F(x) = 1 + \int_A^h f(x) dx :$$

$$F(k_1 - z) = 1 + \int_A^{k_1 - z} f(y) dy$$

and z is the distance of the starting of the test in the normal chart from zero.

III. METHOD OF SOLUTION

We first express the integral equation (2.4) in the form

$$F(X) = Q(X) + \int_c^d R(x,t)F(t)dt \qquad \text{…… (3.1)}$$

where

$$F(X) = P(z),$$
$$Q(X) = F(k-z),$$
$$R(X,t) = f(y+k-z)$$

Let the integral $I = \int_c^d f(x)dx$ be transformed to

$$I = \frac{d-c}{2}\int_c^d f(y)dy = \frac{d-c}{2}\sum a_i f(t_i) \qquad \text{..…. (3.2)}$$

Where $y = \frac{2x-(c-d)}{d-c}$ where a_i's and t_i's respectively the weight factor and abscissa for the Gass-Chibyshev polynomial, given in Jain M.K. and et al [4] using (3.1) and (3.2),(2.4) can be written as

$$F(X) = Q(X)\frac{d-c}{2}\sum a_i R(x,t_i)F(t_i) \qquad \text{..…. (3.3)}$$

Since equation (3.3) should be valid for all values of x in the interval (c, d), it must be true for $x=t_i$, i = 0 (1) n then obtain.

$$F(t_i) = Q(t_i) + \frac{d-c}{2}\sum a_i R(t_j,t_i)F(t_i) \quad j = 0(1)n \qquad \text{…... (3.4)}$$

Substituting

$F(t_i) = F_i, Q(t_i) = Q_i, i = 0(1)n, in \quad (3.4),$ we get

$$F_0 = Q_0 + \frac{d-c}{2}[a_0R(t_0,t_0)F_0 + a_1R(t_0,t_1)F_1 + \ldots\ldots\ldots a_nR(t_0,t_n)F_n)]$$

$$F_1 = Q_1 + \frac{d-c}{2}[a_0R(t_1,t_0)F_0 + a_1R(t_1,t_1)F_1 + \ldots\ldots\ldots a_nR(t_1,t_n)F_n)]$$

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$$F_n = Q_n + \frac{d-c}{2}[a_0R(t_n,t_0)F_0 + a_1R(t_n,t_1)F_1 + \ldots\ldots\ldots a_nR(t_n,t_n)F_n)] \qquad \text{…… (3.5)}$$

In the system of equations except F_i , i= 0,1,2……………n are known and hence can be solved for F_i, we solved the solved the system of equations by the method of Iteration. For this we write the system (3.5) as

$$[1-Ta_0R(t_0,t_0)]F_0 = Q_0 + T[a_0R(t_0,t_0)F_0 + a_1R(t_0,t_1)F_1 + \ldots\ldots\ldots a_nR(t_0,t_n)F_n)]$$

$$[1-Ta_1R(t_1,t_1)]F_1 = Q_1 + T[a_0R(t_1,t_0)F_0 + a_1R(t_1,t_1)F_1 + \ldots\ldots\ldots a_nR(t_1,t_n)F_n)]$$

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$$[1-Ta_nR(t_n,t_n)]F_n = Q_n + T[a_0R(t_n,t_0)F_0 + a_1R(t_n,t_1)F_1 + \ldots\ldots\ldots a_nR(t_n,t_n)F_n)] \qquad \text{….. (3.6)}$$

Where $T = \frac{d-c}{2}$

To start the Iteration process, let us put $F_1 = F_2 = ... = F_n = 0$ in the first equation of (3.6), we then obtain a rough value of F_0. Putting this value of F_0 and $F_1 = F_2 = ... = F_n = 0$ on the second equation, we get the rough value F_1 and so on. This gives the first set of values F_i i= 0,1,2,...,n which are just the refined values of F_i i= 0,1,2,…,n. The process is continued until two consecutive until two consecutive sets of values are obtained up to a certain degree of accuracy. In the similar way solutions P' (0), N (0), N' (0) can be obtained.

IV. COMPUTATION OF ARL's P (A)

We developed computer programs to solve these equations and we get the following results given in the Tables (4.1) to (4.17).

Table – 4.1 Values Of Arls And Type-C Oc Curves When
a = 2, p = 2, b = 2, k_1 =2, h= .25, h'= .25

B	L(0)	L'(0)	P(A)
2.7	2.24929	1.0973451	0.6721045971
2.6	2.44223	1.1022025	0.6890323162
2.5	2.71469	1.1077205	0.7102034688
2.4	3.12660	1.1140136	0.7372992039
2.3	3.81781	1.1212163	0.7729884982
2.2	5.20757	1.1294852	0.8217650056
2.1	9.38804	1.1389970	0.8918026686
2.0	3171.26318	1.1499364	0.9996375442

Table – 4.2 Values Of Arls And Type-C Oc Curves When
a = 2, p = 2, b = 2, k_1 =2, h= .5, h'= .5

B	L(0)	L'(0)	P(A)
2.7	2.03053	1.1736091	0.6337214112
2.6	2.19207	1.1806526	0.6499408484
2.5	2.42036	1.1883866	0.6706926227
2.4	2.76566	1.1968381	0.6979588866
2.3	3.34508	1.2059947	0.7350088358
2.2	4.50871	1.2157682	0.7876194119
2.1	7.99157	1.2259330	0.8669995070
2.0	627.04114	1.2360189	0.9980326891

Table – 4.3 Values Of Arls And Type-C Oc Curves When
a = 2, p = 2, b = 2, k_1 =2, h= .75, h'= .75

B	L(0)	L'(0)	P(A)
2.7	1.83290	1.2267787	0.5990499258
2.6	1.96652	1.2332059	0.6145904660
2.5	2.15541	1.2397506	0.6348479986
2.4	2.44101	1.2461903	0.6620228291
2.3	2.91951	1.2521567	0.6998422146
2.2	3.87666	1.2570558	0.7551372647
2.1	6.70876	1.2599473	0.8418880701
2.0	205.20665	1.2593679	0.9939003587

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Table – 4.4 Values Of Arls And Type-C Oc Curves When
a = 2, p = 2, b = 2, k_1 =2, h= 1.0, h'= 1.0

B	L(0)	L'(0)	P(A)
2.7	1.64896	1.2570492	0.5674305558
2.6	1.75607	1.2604393	0.5821530819
2.5	1.90715	1.2629656	0.6016021371
2.4	2.13466	1.2640980	0.6280702353
2.3	2.51324	1.2630700	0.6655281186
2.2	3.26145	1.2587844	0.7215222716
2.1	5.41624	1.2496966	0.8125249743
2.0	74.61938	1.2336892	0.9837357998

Table – 4.5 Values Of Arls And Type-C Oc Curves When
a = 2, p = 2, b = 2, k_1 =4, h= .25, h'= .25

B	L(0)	L'(0)	P(A)
4.7	8.77006	1.0590464	0.8922540545
4.6	9.87432	1.0598006	0.9030740261
4.5	11.42284	1.0606101	0.9150387049
4.4	13.74888	1.0614799	0.9283285737
4.3	17.62999	1.0624166	0.9431632161
4.2	25.39811	1.0634270	0.9598123431
4.1	48.70593	1.0645192	0.9786114097
4.0	59565.49219	1.0657022	0.9999821186

Table – 4.6 Values Of Arls And Type-C Oc Curves When
a = 2, p = 2, b = 2, k_1 =4, h= .5, h'= .5

B	L(0)	L'(0)	P(A)
4.7	8.25635	1.1115630	0.8813436031
4.6	9.28806	1.1128808	0.8930019736
4.5	10.73470	1.1142912	0.9059589505
4.4	12.90730	1.1158026	0.9204310775
4.3	16.53130	1.1174250	0.9366852045
4.2	23.78069	1.1191691	0.9550532103
4.1	45.49832	1.1210475	0.9759531617
4.0	13925.33594	1.1230739	0.9999193549

Table – 4.7 Values Of Arls And Type-C Oc Curves When
a = 2, p = 2, b = 2, k_1 =4, h= .75, h'= .75

B	L(0)	L'(0)	P(A)
4.7	7.77719	1.1568811	0.8705091476
4.6	8.74139	1.1585495	0.8829740286
4.5	10.09306	1.1603280	0.8968907595
4.4	12.12242	1.1622258	0.9125136137
4.3	15.50576	1.1642538	0.9301587939

4.2	22.26708	1.1664228	0.9502241015
4.1	42.46893	1.1687456	0.9732170701
4.0	5708.09912	1.1712360	0.9997948408

Table – 4.8 Values Of Arls And Type-C Oc Curves When
a = 2, p = 2, b = 2, k_1 =4, h= 1.0, h'= 1.0

B	L(0)	L'(0)	P(A)
4.7	7.32649	1.1945813	0.8598085046
4.6	8.22716	1.1963786	0.8730435371
4.5	9.48940	1.1982838	0.8878818154
4.4	11.38363	1.2003043	0.9046161175
4.3	14.53929	1.2024485	0.9236140251
4.2	20.83655	1.2047243	0.9453423619
4.1	39.57964	1.2071410	0.9704036117
4.0	2937.65356	1.2097076	0.9995883703

Table – 4.9 Values Of Arls And Type-C Oc Curves When
a = 2, p = 2, b = 2, k_1 =6, h= .5, h'= .5

B	L(0)	L'(0)	P(A)
6.7	15.05276	1.0228900	0.9363702536
6.6	17.01758	1.0230497	0.9432919025
6.5	19.77381	1.0232197	0.9507997036
6.4	23.91513	1.0234010	0.9589630365
6.3	30.82693	1.0235946	0.9678625464
6.2	44.66530	1.0238014	0.9775919914
6.1	86.21053	1.0240227	0.9882612824
6.0	**7747628.50**	**1.0242598**	**0.9999998808**

Table – 4.10 Values Of Arls And Type-C Oc Curves When
a = 3, p = 3, b = 3, k_1 =2, h= .25, h'= .25

B	L(0)	L'(0)	P(A)
2.7	1.40538	1.0375016	0.5752967596
2.6	1.52912	1.0473239	0.5935007930
2.5	1.72260	1.0614089	0.6187486053
2.4	2.05261	1.0824252	0.6547324657
2.3	2.69785	1.1154057	0.7074924707
2.2	4.30943	1.1707509	0.7863664627
2.1	11.40720	1.2730014	0.8996071219
2.0	8329921.00000	1.4939585	0.9999998212

Table – 4.11 Values Of Arls And Type-C Oc Curves When
a = 3, p = 3, b = 3, k_1 =3, h= .5, h'= .5

B	L(0)	L'(0)	P(A)
3.0	1.35527	1.0462610	0.5643354654
2.9	1.43479	1.0556575	0.5761166811

2.8	1.54776	1.0684030	0.5916152596
2.7	1.71677	1.0862137	0.6124793291
2.6	1.98866	1.1120265	0.6413612962
2.5	2.47757	1.1512021	0.6827575564
2.4	3.54436	1.2144043	0.7448068857
2.3	7.14213	1.3256384	0.8434489369

Table – 4.12 Values Of Arls And Type-C Oc Curves When

a = 3, p = 2, b = 3, k_1 =2, h= .75, h'= .75

B	L(0)	L'(0)	P(A)
2.7	0.91007	1.0763172	0.4581522346
2.6	0.92014	1.0714453	0.4620143771
2.5	0.94131	1.0607159	0.4701774716
2.4	0.98390	1.0407302	0.4859662652
2.3	1.07239	1.0067253	0.5157911777
2.2	1.28033	0.9520109	0.5735373497
2.1	1.97520	0.8560485	0.6976425052
2.0	33340.19141	0.4710066	0.9999858737

Table – 4.13 Values Of Arls And Type-C Oc Curves When

a = 3, p = 3, b = 3, k_1 =4, h= .25, h'= .25

B	L(0)	L'(0)	P(A)
4.7	3.36666	1.0049667	0.7701160312
4.6	3.72688	1.0051794	0.7875809073
4.5	4.23426	1.0054185	0.8081144094
4.4	4.99943	1.0056887	0.8325282335
4.3	6.28058	1.0059950	0.8619385362
4.2	8.85227	1.0063444	0.8979223371
4.1	16.58747	1.0067451	0.9427797794
4.0	1577420.12500	1.0072070	0.9999993443

Table – 4.14 Values Of Arls And Type-C Oc Curves When

a = 3, p = 3, b = 3, k_1 =4, h= .5, h'= .5

B	L(0)	L'(0)	P(A)
4.7	3.44797	1.0101590	0.7734116912
4.6	3.82084	1.0106038	0.7908276916
4.5	4.34608	1.0111048	0.8112617731
4.4	5.13823	1.0116719	0.8354977965
4.3	6.46462	1.0123168	0.8646080494
4.2	9.12728	1.0130541	0.9000965357
4.1	17.13644	1.0139019	0.9441386461
4.0	1633334.37500	1.0148830	0.9999994040

Table – 4.15 Values Of Arls And Type-C Oc Curves When

a = 3, p = 3, b = 3, k_1 =6, h= .25, h'= .25

B	L(0)	L'(0)	P(A)

6.7	11.15145	1.0031874	0.9174646735
6.6	12.59284	1.0032244	0.9262121320
6.5	14.61496	1.0032641	0.9357632399
6.4	17.65350	1.0033066	0.9462230206
6.3	22.72517	1.0033524	0.9577153325
6.2	32.87988	1.0034015	0.9703865051
6.1	63.36734	1.0034546	0.9844113588
6.0	5685632.50000	1.0035118	0.9999998212

Table – 4.16 Values Of Arls And Type-C Oc Curves When

a = 3, p = 3, b = 3, k_1 =6, h= .5, h'= .5

B	L(0)	L'(0)	P(A)
6.7	11.32275	1.0064687	0.9183672071
6.6	12.78857	1.0065448	0.9270361066
6.5	14.84495	1.0066266	0.9364967942
6.4	17.93500	1.0067142	0.9468520284
6.3	23.09263	1.0068084	0.9582227468
6.2	33.41946	1.0069098	0.9707517624
6.1	64.42374	1.0070192	0.9846093655
6.0	5782015.50000	1.0071372	0.9999998212

Table – 4.17 Values Of Arls And Type-C Oc Curves When

a = 3, p = 3, b = 3, k_1 =4, h= .75, h'= .75

B	L(0)	L'(0)	P(A)
6.7	11.49939	1.0098447	0.9192721248
6.6	12.99047	1.0099623	0.9278620481
6.5	15.08229	1.0100884	0.9372318983
6.4	18.22560	1.0102239	0.9474821687
6.3	23.47215	1.0103693	0.9587309957
6.2	33.97702	1.0105261	0.9711175561
6.1	65.51588	1.0106951	0.9848076701
6.0	5881716.50000	1.0108777	0.9999998212

V. NUMERICAL RESULTS AND CONCLUSIONS

At the hypothetical values of the parameters a,p,b, k_1, h and h' given at the top of each table, we determine optimum truncated point B at which P (A) the probability of accepting an item is maximum and also obtained ARL's values which represents the acceptance zone L(0) and rejection zone L'(0) values. The values of truncated point B of random variable X, L(0), L'(0) and the values for Type-C Curve, i.e. P (A) are given in columns I, II, III, and IV respectively.
From the above tables 4.1 to 4.17 we made the following conclusions

1. From the table 4.1 to 4.4, it was observed that the value of L (0) and P (A) are increase as the value of truncated point decreases thus the truncated point of the random variable and the various parameters for CASP-CUSUM are related.

2. And also we observed that it can be minimize the truncated point B by increasing value of k_1
3. From table 4.1 to 4.4, it is observed that truncated point B of the random variable X decrease from 2.7 to 2.0 as h→ 1.0, while the value of L (0) decrease from 3171.26318 to 74.61938 and rejection zone values changes from 1.1499364 to 1.2336892 where as the probability of acceptance P (A) changes from 0.9996375442 to 0.9837357998 thus hypothetical value h and truncated point B inversely related, while the values L(0), L'(0) and P(A) are positively related.

4. **4.** From table 4.5 to 4.8, it is observed that at the maximum level of probability of acceptance P (A) the truncated point B from 4.7 to 4.0 as the value of h changes from 0.25 to 1.0.
5. **5.** From table 4.5 to 4.8, it is observed that the size of acceptance zone is changes from 59565.49219 to 2937.65356 thus the optimal truncated point and size of the acceptance zone are positively related.
6. **6.** From the table 4.9, it was observed that the truncated point B changes from 6.7 to 6.0 and P (A) is as $h \to 0.50$ maximum **0.9999998808.**Thus truncated point B and h are inversely related and h and P (A) are positively related.
7. **7.** From the table 4.10 to 4.11, it was observed that the value of L (0) and P (A) are increase as the value of truncated point decreases thus the truncated point of the random variable and the various parameters for CASP-CUSUM are related.
8. **8.** From table 4.13 to 4.14, it is observed that at the maximum level of probability of acceptance P (A) the truncated point B from 4.7 to 4.0 as the value of h changes from 0.25 to 0.50
9. **9.** From table 4.13 to 4.14, it is observed that the size of acceptance zone is changes from 1577420.125 to 1633334.375 thus the optimal truncated point and size of the acceptance zone are positively related.
10. **10.** From table 4.15 to 4.17, it is observed that at the maximum level of probability of acceptance P (A) the truncated point B from 6.7 to 6.0 as the value of h changes from 0.25 to 0.75
11. **11.** The various relations exhibited among the ARL's and Type-C OC Curves with the parameters of the CASP-CUSUM based on the above table 4.1 to 4.17 are observed from the following Table 5.1.

Table 5.1

B	a	p	b	k_1	h	h'	$L(O)$	$L'(O)$	$P(A)$
2.0	2	2	2	2	0.25	0.25	3171.26318	1.1499364	0.9996375442
2.0	2	2	2	2	0.5	0.5	627.04114	1.2360189	0.9980326891
2.0	2	2	2	2	0.75	0.75	205.20665	1.2593679	0.9939003587
2.0	2	2	2	2	1.0	1.0	74.61938	1.2336892	0.9837357998
4.0	2	2	2	4	0.25	0.25	59565.49219	1.0657022	0.9999821186
4.0	2	2	2	4	0.5	0.5	13925.33594	1.1230739	0.9999193549
4.0	2	2	2	4	0.75	0.75	5708.09912	1.1712360	0.9997948408
4.0	2	2	2	4	1.0	1.0	2937.65356	1.2097076	0.9995883703
6.0	**3**	**2**	**3**	**6**	**0.5**	**0.5**	**7747628.500**	**1.0242598**	**0.9999998808**
2.0	3	3	3	2	0.25	0.25	8329921.000	1.4939585	0.9999998212
2.3	3	3	3	2	0.5	0.5	7.14213	1.3256384	0.8434489369
2.0	3	3	3	2	0.75	0.75	33340.19141	0.4710066	0.9999858737
4.0	3	3	3	4	0.25	0.25	1577420.125	1.0072070	0.9999993443
4.0	3	3	3	4	0.5	0.5	1633334.375	1.0148830	0.9999994040
6.0	3	3	3	6	0.25	0.25	5685632.500	1.0035118	0.9999998212
6.0	3	3	3	6	0.5	0.5	5782015.500	1.0071372	0.9999998212
6.0	3	3	3	6	0.75	0.75	5881716.500	1.0108777	0.9999998212

By observing the Table 5.1, we can conclude that the optimum CASP-CUSUM Schemes which have the values of ARL and P (A) reach their maximum i.e., **7747628.500**, **0.9999998808** respectively, is

$$\begin{bmatrix} B = 6.0 \\ a = 3 \\ p = 2 \\ b = 3 \\ k_1 = 6 \\ h = 0.5 \\ h' = 0.5 \end{bmatrix}$$

On similar lines we can obtain CASP-CUSUM Schemes when a particular parameter is fixed at a point, for example, if we fixed the value of $k_1 = 2$ in that case only the maximum value of probability of acceptance P(A)= 0.9996375442, is

$$\begin{bmatrix} B = 2.0 \\ a = 2 \\ p = 2 \\ b = 2 \\ k_1 = 2 \\ h = 0.25 \\ h' = 0.25 \end{bmatrix}$$

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