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Economic design for double inspection quick switching system

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Abstract
Production industries, concentrate for achieve their customers to produce good quality product or defect free product and minimize the cost. In this article provides Economic Design for Double Inspection Quick Switching System has been proposed to minimize the total cost while satisfying both the producer's and the consumer's quality and risk requirements. Tables are constructed for Total Cost based on different Acceptance Numbers, Proportion Defective, Inspection Cost, Outgoing Cost, and Failure cost. A practical example is presented to demonstrate the proposed plan for its applicability.

Keywords: Double inspection, quick switching, economic design, single sampling and operating characteristic function

Introduction
Quality is an essential tool to create goodwill of the product and industry. There are several paths to produce a good product and reduce errors in production. One of the essential methods in production is statistical quality control, now various concepts of statistical quality control are in progress in industrial sectors, but quick switching system is the basic and most widely used sampling system in SQC. Dodge (1967) has proposed a new type of sampling plan namely Quick Switching Sampling System and investigated by Romboski (1969), after many authors extended and applied Quick Switching Sampling System in various branches of statistical quality control.

Romboski introduced QSS-1 (n; c_N, c_T) which is a QSS-1 with single sampling plan as a reference plan [(n, c_N), (n,c_T) respectively the normal and tightened single sampling plans with $c_T < c_N$], Soundarrajan and Devaraj Arumai Nayagam (1990) [13] have developed Construction and Selection of Modified Quick Switching System have developed Selection of Single-sampling Quick Switching System for given Acceptable and Limiting Quality Levels. Soundarrajan and Devaraj Arumai Nayagam (1992) [14] have developed Quick switching system for costly and destructive testing. Senthilkumar *et al*. (2012) [12] have developed Construction of quick switching variable sampling system indexed by cross over point. Vennila and Devaraj Arumainayagam (2018) [15] have developed Quick Switching System with different reference plans. Senthilkumar and Sabarish (2020) [6] have developed the Construction and Selection of Double Inspection Single Sampling Plan [DISSP (0,1)]. Senthilkumar and Sabarish (2021) [7] have developed Selection and Development of Double Inspection Single Sampling Plan. Senthilkumar and Sabarish (2021) [7] have developed Economic Design of Double Inspection Single Sampling Plan. Senthilkumar And Sabarish (2022) [8] have developed Design Of Double Inspection Quick Switching System [DIQSS (0, 1)] Senthilkumar and Sabarish, (2022) [8] have developed "Construction and Selection of Double Inspection Single Sampling Plan for an Independent Process using Bivariate Poisson Distribution. The work presented in this paper is Double Inspection Quick Switching System band with Economic Design for Acceptance Sampling Plan has been proposed.

Operating procedure for DIQSS
Select a random sample of size 'n' units from the lot 'N'. The first inspection is to test the first quality characteristic of the product using quick switching methodology.

First Inspection
1. In first inspection, find the number of defectives d_{11} at the normal level, if $d_{11} \leq c_N$ move to second inspection otherwise shift to tightened level.

2. Count the number of defectives 'd_{12}' at the tightened level, if $d_{12} \leq c_T$ move to second inspection, otherwise reject the lot.

After the conditions in first inspection is satisfied, move to second inspection for the same sample, to test the second quality characteristic of the same product using quick switching methodology.

Second inspection

i) In Second inspection find the number of defectives d_{21} at the normal level, if $d_{21} \leq c_N$ accept the lot otherwise shift to tightened level.
ii) Count the number of defectives 'd_{22}' at the tightened level, if $d_{22} \leq c_T$ accept the lot otherwise reject the lot.

1. **The Bayesian approach**: This approach assesses the costs and a loss involved in Operating a sampling plan and tries to minimize the total costs. The expected cost per batch includes the cost of sampling and the loss of wrong decisions, which is a function of the process quality p. The optimal single sampling plan (n, c) is obtained by minimizing the expected cost per batch with respect to these two variables.
2. **The minimax approach:** This approach also aims at minimizing costs but without assuming knowledge of the process quality p. Thus the average cost per batch C(p) is a function of p. For any given sampling plan, C(p) will go through a maximum as p runs from 0 to 1. The minimax principle chooses the plan that minimizes this maximum.
3. **Semi-economic approach:** Here a point on the OC curve is specified. The fixed point on the OC curve can be the producer's risk point, the consumer's risk point, or the point of Indifference quality. The fixed point determines a relationship between c and n. The plan that minimizes the average amount of inspection at the process average quality is chosen

Tagaras [1994] [11] developed an economic model for the selection of minimum cost acceptance sampling plans by variables. The quadratic Taguchi loss function is adopted to model the cost of accepting items with quality characteristics deviating from the target value. Ferrell and Chhoker [2002] [1] have presented a sequence of models that addressed 100% inspection and single sampling with and without inspector error when a Taguchi-like loss function is used to describe the cost associated with any deviation between the actual value of product's quality characteristics and its target value. The purpose of this paper is to design an economic model to determine the sampling plan that minimizes the producer's total cost while satisfying both the producer's and the consumer's quality and risk requirements
These attribute acceptance plans set the parameters while assuming the rejected lots are 100 percent inspected and defectives are replaced with non-defectives. Users must specify values for consumer's risk (β), the approximate actual percent defectives, the lot size (N), and the lot tolerance percent defective (LTPD) McWilliams *et al.* (2001) [5]. provided a method of finding exact designs for single sample acceptance sampling plans. More specifically, the design problem is to find the parameters n; c_1 and c_2 such that,

$$P_a(AQL) = P(X \leq c \mid n, AQL) = 1-\alpha \quad (1)$$

And

$$P_a(LTPD) = P(X \leq c \mid n, LTPD) = \beta \quad (2)$$

Where X is the number of defective items found in 'n' sampled items and $P_a(p)$ is the probability of accepting the lot if the defect level is p.

Measures of performance
Operating characteristics function

$$Pa(p) = \left[Pa1(p) = \frac{P_T}{P_T + (1-P_N)}\right] * \left[Pa2(p) = \frac{P_T}{P_T + (1-P_N)}\right] \quad (3)$$

Average outgoing quality

$$AOQ = p * P_a(p) \quad (4)$$

Average total inspection

$$ATI = n(Pa(p)) + N(1-Pa(p)) \quad (5)$$

Let D_d denote the defective items detected and D_n denote the defective items not detected, then we have

$$D_d = np + (1-P_a(p))(N-n)p \quad (6)$$

$$D_n = P_a(p)(N-n)p \quad (7)$$

Note that if the inspection is 100% reliable, for the sampled n items, the expected defective items np will be detected for sure. If the lot is rejected (with probability 1- P_a (p)), it will be 100% inspected and the remaining (N-n) p defective items will be detected. On the other hand, if the lot is accepted (with probability P_a (p)), the (N-n) p defective items will not be detected. To derive the total quality cost per lot for a given sampling plan, we define the following cost parameters;
C_i: Inspection cost per item,
C_f: Internal failure cost; i.e., the cost of rework, repair or replacement for a defective item which is not released to the market for a finished product or not released to production for an incoming raw material,
C_o: The cost of an outgoing defective unit, i.e. the post-sale failure cost. For a finished product, this is the cost of replacement and loss of good will for a defective item which is released to the market. For an incoming raw material, this will be the attendant cost when a defective item is released for production use.

The economic sampling plan can be found through the following mathematical model.

$$\text{Minimize } TC = C_i.ATI + C_f.D_d + C_o.D_n \quad (8)$$

Subject to

$$1-P_a(AQL) \leq \alpha \quad (9)$$

$$P_a(LTPD) \leq \beta \quad (10)$$

Illustration

A smart glass manufacturing company two inspectors checking two different quality Characteristics like Checking quality of the display (c_1) and Checking the performance of the Bluetooth Indicator (c_2) these two quality characteristics are Important and costliest, the inspection are independent. Here the inspector fixing the parameters like sample size n = 60, acceptance number for first inspection c_1 = 1, acceptance number for second inspection c_2 = 2

Table 1: Values for plotting curves

p	OC	AOQ	ATI
0.01	1.00000	0.01000	61.00006
0.02	0.99996	0.02000	61.03523
0.03	0.99846	0.02995	62.45022
0.04	0.97820	0.03913	81.46813
0.05	0.84289	0.04214	208.52717
0.06	0.44456	0.02667	582.55613
0.07	0.09865	0.00691	907.36573
0.08	0.01243	0.00099	988.32740
0.09	0.00144	0.00013	998.65147
0.1	0.00018	0.00002	999.82755
0.11	0.00003	0.00000	999.97479

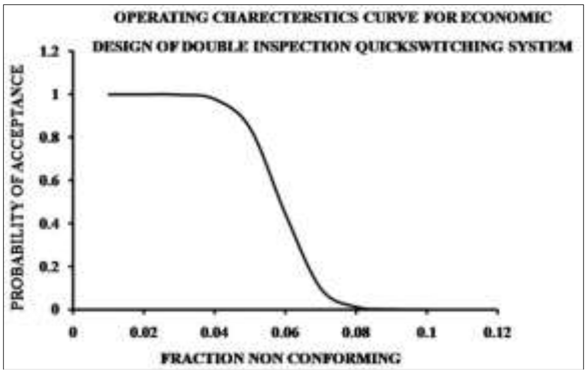

Fig 1: Operating characteristics curve for economic design of double inspection quick switching System

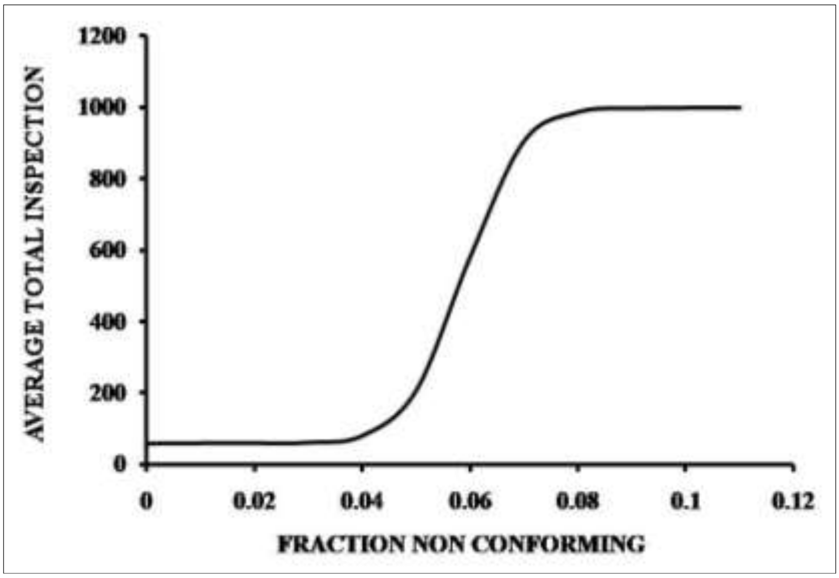

Fig 2: Average total inspection curve for economic design of double inspection quick switching system

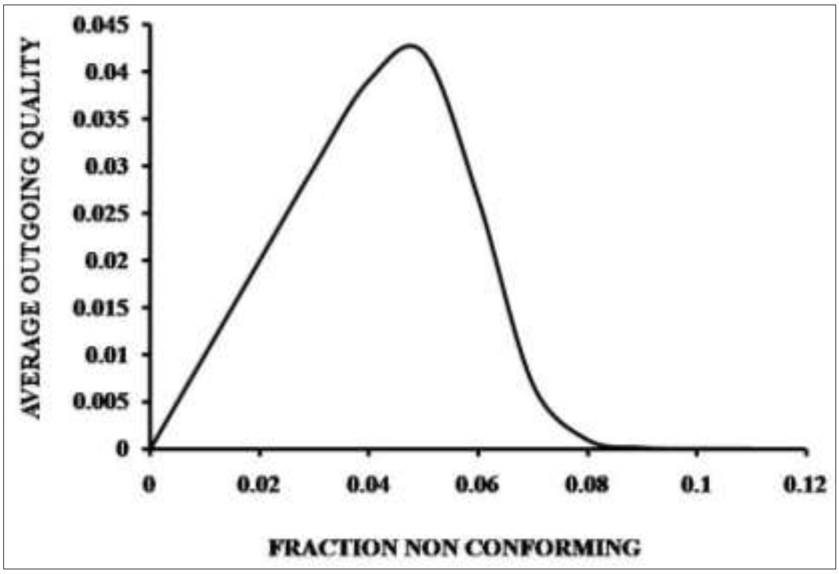

Fig 3: Average outgoing quality curve for economic design of double inspection quick switching System

Description of figures

Table 1 explains the plotting curves like Operating Characteristics curve, Average Outgoing Quality curve and Average Total Inspection Figure 1 Operating Characteristics curve Figure 2 shows the Average Outgoing Quality curve and Figure 3 shows the Average Total Inspection Curve for Economic design of Double Inspection Quick Switching System (n=61, c_T= 0 and c_2=8).

Description of tables

For the purpose of illustration, we consider the following set of input parameters: The lot size, N = 500, AQL = 0.02, LTPD = 0.07, α = 0.05, β = 0.10, p = 0.03, C_i = 1.0, C_f = 2.0, and C_o = 10. The Double Inspection single sampling plan with sample size n less than or equal to 500 that satisfy both the producer's and consumer's quality and risk requirements. To indicate the performance measurements, Table 2 lists part of the Double Inspection Quick Switching System for ‘n’ up to 200.

From Table 2, one can see that both the producer’s risk (1-Pa(AQL)) and average total inspection (ATI) increase, and the consumer’s risk Pa(LTPD) decreases as ‘n’ increases and c_1 & c_2 remains unchanged; on the contrary, both the producer ’s risk and average total inspection decrease, and the consumer’s risk increases as ‘c’ increases and ‘n’ remains unchanged. Based on the above input parameters, the optimal sampling plan is n =61, c_T = 40 and c_N= 8 with the minimum total cost TC = 347.462. Note that this example indicates that without integrating the producer's and the consumer's risk requirements into the economic design of the acceptance sampling plans, the plan obtained by the model, although minimizing the producer's total cost, may not be acceptable to the consumer. Table 3 shows the sensitivity analysis of the optimal Double Inspection single sampling with different levels of p. As ‘p’ increases, the optimal sample size first increases and then decreases. For p = 0.11, the optimal sampling plan will have a near zero probability of accepting the lot, resulting in a 100% inspection of the entire lot. As a result, all the defective products will be detected and replaced (ATI = 500 and AOQ = 0).

Table 4 shows the sensitivity analysis of the inspection cost C_i. If $C_i \leq 0.2$, the inspection cost is relatively low compared to the failure costs (C_f and C_o). Therefore, the optimal sampling plan is to have a 100% inspection of the entire lot. For $0.3 \leq C_i \leq 10$, the optimal sampling plans remain to be n = 61; c_T = 0 and c_N = 8.

Table 5, one can see the internal failure cost C_f is relatively insensitive to the optimal sampling plan. However, when the inspection cost C_i is small, e.g., C_i =0.2 (see Table 6), the internal failure cost C_f has an effect on the optimal sampling plan.

Table 7shows the sensitivity analysis of the post-sale failure cost C_o For $C_o \leq 35$ the optimal sampling plans remain to be n = 61; c_T = 0 and c_N =8. However, when $C_o \geq 40$, the optimal sampling plan changes to have a 100% inspection of the entire lot.

Table 2: Double Inspection Quick Switching System satisfying AQL= 0.02. LTPD= 0.07, α=0.05, β=0.10, with ≤ 200.

n	cT	cN	DIQSS	AOQ	ATI	DD	DN	TC	LTPD	1-PAQL
40	0	4	0.9505	0.0285	87.5350	2.6261	27.3739	366.5266	0.0814	0.0063
41	0	4	0.9439	0.0283	94.7601	2.8428	27.1572	372.0177	0.0664	0.0071
42	0	4	0.9368	0.0281	102.5880	3.0776	26.9224	377.9669	0.0539	0.0080
43	0	4	0.9289	0.0279	111.0513	3.3315	26.6685	384.3990	0.0437	0.0091
44	0	4	0.9203	0.0276	120.1814	3.6054	26.3946	391.3379	0.0354	0.0102
45	1	3	0.8586	0.0258	180.0226	5.4007	24.5993	436.8172	0.0994	0.0340
46	1	3	0.8479	0.0254	191.1174	5.7335	24.2665	445.2492	0.0873	0.0368
47	1	3	0.8367	0.0251	202.6224	6.0787	23.9213	453.9930	0.0766	0.0398
48	1	3	0.8251	0.0248	214.5300	6.4359	23.5641	463.0428	0.0672	0.0429
49	1	3	0.8130	0.0244	226.8305	6.8049	23.1951	472.3912	0.0588	0.0462
50	1	3	0.8005	0.0240	239.5126	7.1854	22.8146	482.0295	0.0514	0.0497
51	1	4	0.9307	0.0279	116.7460	3.5024	26.4976	388.7270	0.0954	0.0108
52	1	4	0.9245	0.0277	123.5985	3.7080	26.2920	393.9349	0.0829	0.0119
53	1	4	0.9178	0.0275	130.8130	3.9244	26.0756	399.4178	0.0719	0.0129
54	1	4	0.9108	0.0273	138.3985	4.1520	25.8480	405.1829	0.0622	0.0141
55	1	4	0.9033	0.0271	146.3635	4.3909	25.6091	411.2362	0.0538	0.0154
56	1	4	0.8954	0.0269	154.7153	4.6415	25.3585	417.5836	0.0464	0.0167
57	1	5	0.9673	0.0290	87.8425	2.6353	27.3647	366.7603	0.0912	0.0034
58	1	5	0.9640	0.0289	91.9137	2.7574	27.2426	369.8544	0.0785	0.0037
59	1	5	0.9604	0.0288	96.2215	2.8866	27.1134	373.1283	0.0673	0.0041
60	1	4	0.8595	0.0258	192.0977	5.7629	24.2371	445.9942	0.0255	0.0230
61	0	8	0.9985	0.0300	62.4502	1.8735	28.1265	347.4622	0.0987	0.0000
62	2	4	0.8946	0.0268	160.8325	4.8250	25.1750	422.2327	0.0934	0.0200
63	1	6	0.9848	0.0295	77.2131	2.3164	27.6836	358.6819	0.0867	0.0010
64	1	6	0.9832	0.0295	79.7415	2.3922	27.6078	360.6036	0.0739	0.0012
65	2	4	0.8736	0.0262	183.2023	5.4961	24.5039	439.2337	0.0678	0.0244
66	2	4	0.8660	0.0260	191.1394	5.7342	24.2658	445.2659	0.0608	0.0260
67	2	4	0.8582	0.0257	199.3159	5.9795	24.0205	451.4801	0.0545	0.0278
68	1	7	0.9937	0.0298	73.8257	2.2148	27.7852	356.1075	0.0964	0.0003
69	1	7	0.9930	0.0298	75.4991	2.2650	27.7350	357.3793	0.0818	0.0003
70	1	7	0.9922	0.0298	77.2386	2.3172	27.6828	358.7013	0.0692	0.0004

Table 2: continued

n	c_T	c_N	DIQSS	AOQ	ATI	DD	DN	TC	LTPD	1-PAQL
71	2	5	0.9356	0.0281	130.8628	3.9259	26.0741	399.4557	0.0632	0.0082
72	2	5	0.9310	0.0279	136.0319	4.0810	25.9190	403.3843	0.0561	0.0088
73	2	6	0.9771	0.0293	94.2346	2.8270	27.1730	371.6183	0.0979	0.0019
74	3	4	0.8392	0.0252	222.8628	6.6859	23.3141	469.3757	0.0838	0.0366
75	3	4	0.8319	0.0250	230.4823	6.9145	23.0855	475.1666	0.0772	0.0386
76	3	4	0.8244	0.0247	238.2437	7.1473	22.8527	481.0652	0.0710	0.0406
77	3	4	0.8167	0.0245	246.1437	7.3843	22.6157	487.0692	0.0653	0.0427
78	3	5	0.9234	0.0277	148.6579	4.4597	25.5403	412.9800	0.0946	0.0115
79	3	5	0.9189	0.0276	153.6692	4.6101	25.3899	416.7886	0.0864	0.0122
80	3	5	0.9143	0.0274	158.8313	4.7649	25.2351	420.7118	0.0789	0.0130
81	3	5	0.9095	0.0273	164.1461	4.9244	25.0756	424.7510	0.0719	0.0138
82	3	5	0.9046	0.0271	169.6149	5.0884	24.9116	428.9073	0.0655	0.0146
83	3	5	0.8994	0.0270	175.2390	5.2572	24.7428	433.1816	0.0596	0.0155
84	3	5	0.8941	0.0268	181.0196	5.4306	24.5694	437.5749	0.0542	0.0164
85	3	5	0.8886	0.0267	186.9574	5.6087	24.3913	442.0876	0.0492	0.0174
86	3	5	0.8829	0.0265	193.0532	5.7916	24.2084	446.7204	0.0447	0.0184
87	3	5	0.8770	0.0263	199.3074	5.9792	24.0208	451.4736	0.0405	0.0195
88	4	5	0.8905	0.0267	187.8500	5.6355	24.3645	442.7660	0.0980	0.0191
89	4	5	0.8855	0.0266	193.2744	5.7982	24.2018	446.8886	0.0912	0.0201
90	4	5	0.8804	0.0264	198.8110	5.9643	24.0357	451.0964	0.0847	0.0212
91	4	5	0.8752	0.0263	204.4591	6.1338	23.8662	455.3889	0.0787	0.0223
92	2	9	0.9975	0.0299	94.2410	2.8272	27.1728	371.6232	0.0766	0.0001
93	4	5	0.8643	0.0259	216.0870	6.4826	23.5174	464.2261	0.0678	0.0246
94	4	5	0.8586	0.0258	222.0650	6.6620	23.3380	468.7694	0.0628	0.0258
95	4	5	0.8529	0.0256	228.1509	6.8445	23.1555	473.3947	0.0582	0.0271
96	4	5	0.8470	0.0254	234.3434	7.0303	22.9697	478.1010	0.0539	0.0284
97	4	5	0.8409	0.0252	240.6411	7.2192	22.7808	482.8873	0.0498	0.0298
98	4	5	0.8348	0.0250	247.0426	7.4113	22.5887	487.7524	0.0461	0.0311
99	4	5	0.8285	0.0249	253.5461	7.6064	22.3936	492.6950	0.0426	0.0326
100	4	5	0.8221	0.0247	260.1498	7.8045	22.1955	497.7138	0.0393	0.0341

Table 3: Optimal Double Inspection Quick Switching System as a function of the product quality p (other input parameters are given as the base set)

P	n	c_T	c_N	DIQSS	AOQ	ATI	DD	DN	TC	LTPD	1-AOQL
0.01	61	0	8	1.0000	0.0100	61.0001	0.6100	9.3900	156.1201	0.0987	0.0000
0.02	68	1	7	0.9997	0.0200	68.2692	1.3654	18.6346	257.3461	0.0964	0.0003
0.03	69	1	7	0.9930	0.0298	75.4991	2.2650	27.7350	357.3793	0.0818	0.0003
0.04	63	1	6	0.9034	0.0361	153.4810	6.1392	33.8608	504.3671	0.0867	0.0010
0.05	70	1	7	0.6982	0.0349	350.6774	17.5339	32.4661	710.4064	0.0692	0.0004
0.06	64	1	6	0.2741	0.0164	743.4572	44.6074	15.3926	986.5977	0.0739	0.0012
0.07	40	0	4	0.0814	0.0057	921.8522	64.5297	5.4703	1105.6150	0.0814	0.0063
0.08	57	1	5	0.0253	0.0020	976.1180	78.0894	1.9106	1151.4025	0.0912	0.0034
0.09	58	1	5	0.0054	0.0005	994.8801	89.5392	0.4608	1178.5664	0.0785	0.0037
0.1	73	2	6	0.0015	0.0001	998.6455	99.8646	0.1354	1199.7291	0.0979	0.0019
0.11	92	2	9	0.0000	0.0000	999.9817	109.9980	0.0020	1219.9978	0.0766	0.0001
0.12	41	0	4	0.0002	0.0000	999.8327	119.9799	0.0201	1239.9933	0.0664	0.0071
0.13	59	1	5	0.0000	0.0000	999.9747	129.9967	0.0033	1260.0010	0.0673	0.0041
0.14	61	0	8	0.0000	0.0000	999.9998	140.0000	0.0000	1280.0000	0.0987	0.0000
0.15	57	1	5	0.0000	0.0000	999.9956	149.9993	0.0007	1300.0009	0.0912	0.0034
0.16	63	1	6	0.0000	0.0000	999.9997	160.0000	0.0000	1320.0001	0.0867	0.0010
0.17	40	0	4	0.0000	0.0000	999.9982	169.9997	0.0003	1340.0007	0.0814	0.0063
0.18	70	1	7	0.0000	0.0000	1000.0000	180.0000	0.0000	1360.0000	0.0692	0.0004
0.19	41	0	4	0.0000	0.0000	999.9998	190.0000	0.0000	1380.0001	0.0664	0.0071
0.2	69	1	7	0.0000	0.0000	1000.0000	200.0000	0.0000	1400.0000	0.0818	0.0003

Table 4: Optimal Double Inspection Quick Switching System as a function of the inspection cost Ci (other input parameters are given as the base set)

CI	n	cT	cN	DIQSS	AOQ	ATI	DD	DN	TC	LTPD	1-AOQL
0.1	500	14	18	0.51930	0.01558	740.35113	22.21053	7.78947	196.35084	0.00000	0.01550
0.2	500	14	18	0.51930	0.01558	740.35113	22.21053	7.78947	270.38595	0.00000	0.01550
0.3	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	303.74701	0.09865	0.00004
0.4	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	309.99204	0.09865	0.00004
0.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	316.23706	0.09865	0.00004
1	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	347.46217	0.09865	0.00004
1.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	378.68728	0.09865	0.00004
2	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	409.91239	0.09865	0.00004
2.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	441.13751	0.09865	0.00004
3	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	472.36262	0.09865	0.00004
3.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	503.58773	0.09865	0.00004
4	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	534.81284	0.09865	0.00004
4.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	566.03795	0.09865	0.00004
5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	597.26306	0.09865	0.00004
5.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	628.48818	0.09865	0.00004
6	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	659.71329	0.09865	0.00004
6.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	690.93840	0.09865	0.00004
7	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	722.16351	0.09865	0.00004
7.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	753.38862	0.09865	0.00004
8	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	784.61374	0.09865	0.00004
8.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	815.83885	0.09865	0.00004
9	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	847.06396	0.09865	0.00004
9.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	878.28907	0.09865	0.00004
10	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	909.51418	0.09865	0.00004

Table 5: Optimal Double Inspection Quick Switching System as a function of the internal failure cost C_f (other input parameters are given as the base set)

C_f	n	c_T	c_N	DIQSS	AOQ	ATI	DD	DN	TC	LTPD	1-AOQL
0	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	343.715157	0.098652	0.000038
0.5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	344.651910	0.098652	0.000038
1	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	345.588663	0.098652	0.000038
1.5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	346.525417	0.098652	0.000038
2	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	347.462170	0.098652	0.000038
2.5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	348.398923	0.098652	0.000038
3	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	349.335677	0.098652	0.000038
3.5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	350.272430	0.098652	0.000038
4	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	351.209183	0.098652	0.000038
4.5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	352.145937	0.098652	0.000038
5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	353.082690	0.098652	0.000038
5.5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	354.019443	0.098652	0.000038
6	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	354.956197	0.098652	0.000038
6.5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	355.892950	0.098652	0.000038
7	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	356.829703	0.098652	0.000038
7.5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	357.766457	0.098652	0.000038
8	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	358.703210	0.098652	0.000038
8.5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	359.639964	0.098652	0.000038
9	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	360.576717	0.098652	0.000038
9.5	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	361.513470	0.098652	0.000038
10	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	362.450224	0.098652	0.000038

Table 6: Optimal Double Inspection Quick Switching System as a function of the internal failure cost Cf (other input parameters are given as the base set) Ci= 0.2

CF	n	cT	cN	DIQSS	AOQ	ATI	DD	DN	TC	LTPD	1-AOQL
0	500	14	18	0.51930	0.01558	740.35113	22.21053	7.78947	225.96489	0.00000	0.01550
0.5	500	14	18	0.51930	0.01558	740.35113	22.21053	7.78947	237.07015	0.00000	0.01550
1	500	14	18	0.51930	0.01558	740.35113	22.21053	7.78947	248.17542	0.00000	0.01550
1.5	500	14	18	0.51930	0.01558	740.35113	22.21053	7.78947	259.28069	0.00000	0.01550
2	500	14	18	0.51930	0.01558	740.35113	22.21053	7.78947	270.38595	0.00000	0.01550
2.5	500	14	18	0.51930	0.01558	740.35113	22.21053	7.78947	281.49122	0.00000	0.01550
3	500	14	18	0.51930	0.01558	740.35113	22.21053	7.78947	292.59649	0.00000	0.01550
3.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	300.31225	0.09865	0.00004
4	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	301.24900	0.09865	0.00004
4.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	302.18576	0.09865	0.00004
5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	303.12251	0.09865	0.00004
5.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	304.05926	0.09865	0.00004
6	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	304.99602	0.09865	0.00004
6.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	305.93277	0.09865	0.00004
7	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	306.86952	0.09865	0.00004
7.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	307.80628	0.09865	0.00004
8	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	308.74303	0.09865	0.00004
8.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	309.67978	0.09865	0.00004
9	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	310.61654	0.09865	0.00004
9.5	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	311.55329	0.09865	0.00004
10	61	0	8	0.99846	0.02995	62.45022	1.87351	28.12649	312.49004	0.09865	0.00004

Table 7: Optimal Double Inspection Quick Switching System as a function of the internal failure cost Co (other input parameters are given as the base set)

C_o	n	cT	cN	DIQSS	AOQ	ATI	DD	DN	TC	LTPD	1-AOQL
5	500	14	18	0.519298	0.015579	740.351135	22.210534	7.789466	823.719533	0.000000	0.015499
10	500	14	18	0.519298	0.015579	740.351135	22.210534	7.789466	862.666863	0.000000	0.015499
15	500	14	18	0.519298	0.015579	740.351135	22.210534	7.789466	901.614192	0.000000	0.015499
20	500	14	18	0.519298	0.015579	740.351135	22.210534	7.789466	940.561522	0.000000	0.015499
25	500	14	18	0.519298	0.015579	740.351135	22.210534	7.789466	979.508852	0.000000	0.015499
30	500	14	18	0.519298	0.015579	740.351135	22.210534	7.789466	1018.456182	0.000000	0.015499
35	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	1050.624502	0.098652	0.000038
40	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	1191.256969	0.098652	0.000038
45	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	1331.889435	0.098652	0.000038
50	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	1472.521902	0.098652	0.000038
55	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	1613.154368	0.098652	0.000038
60	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	1753.786835	0.098652	0.000038
65	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	1894.419301	0.098652	0.000038
70	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	2035.051767	0.098652	0.000038
75	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	2175.684234	0.098652	0.000038
80	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	2316.316700	0.098652	0.000038
85	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	2456.949167	0.098652	0.000038
90	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	2597.581633	0.098652	0.000038
95	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	2738.214100	0.098652	0.000038
100	61	0	8	0.998456	0.029954	62.450224	1.873507	28.126493	2878.846566	0.098652	0.000038

Conclusion

Double Inspection Single Sampling plan was suitable for when there is a possibility of costliest, mass production and Human intervention is much involved, with aim to produce best quality products. The OC function for Double Inspection Quick Switching System n; c_N & c_T under Bivariate Poisson distribution. This plan will be provide protection to both producer and consumer. There are many ways to determine an acceptance sampling plan. In this paper, economic design of double inspection quick switching system has been proposed to minimize the total cost of the producer under the condition that both the producer's and consumer's quality and risk requirements are satisfied.

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