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Short Communication

Comparison of Skip-lot sampling plans (SkSP-V vs. SkSP-2)

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Abstract

The purpose of Skip-lot sampling is to reduce the Average Sample Number (ASN) and Average Total Inspection (ATI) as well as inspection costs. The Skip-lot concept is economically advantageous to make decision on the submitted lot. This paper presents the comparison of skip lot sampling plan SkSP-2 and SkSP-V in terms of Probability Accepting, (Pa), Average Outgoing Quality (AOQ), ASN, ATI and also cost reduction. The results indicated that SkSP-2 and SkSP-V were not significant different on the Pa and AOQ. However, SkSP-V gave lowest cost significantly both from ASN and ATI. This property shows the advantage of SkSP-V for the lowest cost inspection but SkSP-2 for easier implementation because of the smaller parameters in actual operation.

Keywords: skip lot sampling, sampling plan, hard disk

1. Introduction

Quality is very important and is concerned in various businesses; especially Hard Disk Drive manufacturers. Most of the electronic parts need to improve their quality continuously to achieve six sigma product level, and customer satisfactions. Moreover, good quality control and continuous improvement in the production process result in the excellent quality history for suppliers. Better quality level from the final inspection often leads to accept lots from normal sampling inspection. Thus, in practice, skip-lot sampling plan may play role.

At the case study plant, the existing sampling plan is a single sampling plan which inspects every lot without doing rectifying inspection. While the skip-lot sampling plan which was developed by Dodge and Perry (Dodge and Perry, 1971) called skip-lot sampling plan-2 (SkSP-2) has its special rule to skip the inspection and do inspect for some lots. (Balamurli *et al.*, 2010) purpose skip-lot sampling plan-V (SkSP-V) by added parameters k (number of lots that consecutively were accepted under skip-lot inspection) and x (number of reduced lots that were accepted under normal inspection in order to change to SkSP-V). Therefore, SkSP-V will reduce both average total inspection (ATI) and average sampling number (ASN). The difference of SkSP-2 compared to SkSP-V occurs when lot was rejected. SkSP-2 (Figure 1) will immediately revert to use the reference plan while SkSP-V (Figure 2) will consider the history of the skip-lot sampling plan. If the history met the criteria (last k lots were accepted), the clearance number for lots will be reduced and need to re-quality the skip-lot sampling plan.

This paper is to compare the 2 types of skip-lot sampling plan (SkSP-2 vs. SkSP-V) based on average outgoing quality (AOQ), ATI, ASN and cost reduction.

2. Materials and Methods

Pholkris and Prapaisri (Pholkris and Prapaisri, 2012) purposed Skip Lot Sampling Plan: a Case Study of Hard Disk Drive Manufacturer. The study presented the Skip-lot sampling plans both SkSP-2 and SkSP-V. SkSP-V has more parameters than SkSP-2. The significant parameters for SkSP-2 are i (number of lots the consecutively accepted under normal inspection) and f (lot fraction inspection under

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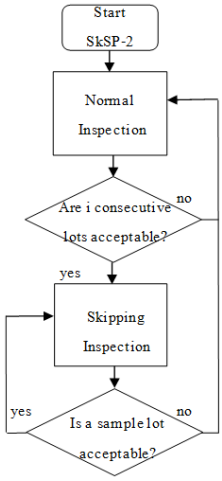

Figure 1. The flow charts of Skip-lot sampling plan for SkSP-2.

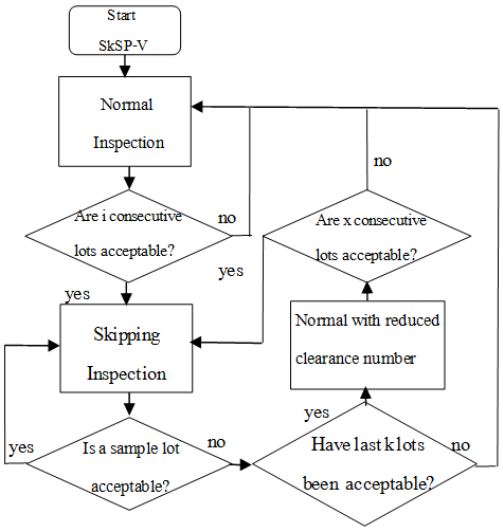

Figure 2. The flow charts of Skip-lot sampling plan for SkSP-V.

normal skip-lot sampling plan). The significant parameters for SkSP-V are i, f, k and x. (Muthulakshmi and Lakshm, 2011).

As mentioned, SkSP-V is similar to SkSP-2 except when lot is rejected. These two plans will be evaluated based on average outgoing quality (AOQ), Probability of accepting lot (Pa), average total inspection (ATI) and average sample number (ASN).

3. Results and Discussion

This paper will illustrate the skip-lot sampling plans, SkSP-2 and SkSP-V when AQL is 0.25%, lot size of 3600, sample size of 200 with the acceptance number (c) is 1. This plan was show in Table 1 with i=5. Table 2 shows the parameters and value of plans and Pa, AOQ, ASN and ATI. From Table 3 by using SkSP-V at i=5, f=1/3, k=3 and x=4 while SkSP-2 parameters at i=5 and f=1/3, the results indicated that SkSP-V is not significant different as compare with SkSP-2 for Pa (p-value = 0.112) and AOQ (p-value=0.517) at 5% significant level. However, the result indicated that SkSP-V was better in terms of ASN (p-value=0.000) and ATI (p-value =0.000).

The cost comparison collected for 3 months period at total inspection 1000 lots and inspection cost at 0.6 baht per unit calculated based on ASN and ATI shown in Table 4 and 5. Besides the statistical results based on paired t test were illustrated.

Although, SkSP-V was not statistically different in terms of Pa, AOQ, the quantity from ASN, ATI and costs of inspection based on ASN and ATI at 5% significant level were very significant. SkSP-V significantly reduced costs of inspection compared to SkSP-2.

4. Conclusions

The comparison of SkSP-V vs. SkSP-2 consider on Probability Accepting (Pa), Average Outgoing Quality (AOQ), Average Total Inspection (ATI), Average Sample Number (ASN) and cost of inspection. From the result found that SkSP-V and SkSP-2 are not significant different in terms of Pa and AOQ but SkSP-V can reduce significantly on ATI, ASN and cost of inspection.

User needs to consider all benefits when using both SkSP-2 and SkSP-V. SkSP-V is better for ATI, ASN but more complicated to control, while SkSP-2 is easier to control.

Acknowledgments

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Table 1. Skip-lot sampling plan-V (SkSP-V) and (SkSP-2) when AQL = 0.25% (lot size=3600, sample size 200 and c=1).

i	f	k	x	Pa		AOQ (ppm)		ASN		ATI	
				SkSP-V	SkSP-2	SkSP-V	SkSP-2	SkSP-V	SkSP-2	SkSP-V	SkSP-2
5	1/5	3	4	97.512%	97.425%	2438	2436	43	44	62	64
	1/5	5	4	97.497%	97.425%	2437	2436	44	44	62	64
	1/5	10	4	97.470%	97.425%	2437	2436	44	44	62	64
	1/5	3	2	97.721%	97.425%	2443	2436	42	44	58	64
	1/5	5	2	97.668%	97.425%	2442	2436	42	44	59	64
	1/5	10	2	97.575%	97.425%	2439	2436	42	44	60	64
	1/3	3	4	96.101%	95.996%	2403	2400	74	76	124	128
	1/3	5	4	96.083%	95.996%	2402	2400	75	76	124	128
	1/3	10	4	96.050%	95.996%	2401	2400	75	76	125	128
	1/3	3	2	96.363%	95.996%	2409	2400	71	76	115	128
	1/3	5	2	96.296%	95.996%	2407	2400	71	76	116	128
	1/3	10	2	96.179%	95.996%	2404	2400	72	76	119	128

Table 2. Comparison of SkSP-V and SkSP-2 based on Pa, AOQ, ASN and ATI.

Sampling plan parameters	SkSP-V (p1)		SkSP-2 (p2)	
	Parameter	Value	Parameter	Value
Pa	i=5, f=1/3, k=3 and x=4	96.101%	i=5 and f=1/3	95.996%
AOQ	i=5, f=1/3, k=3 and x=4	2403 ppm	i=5 and f=1/3	2400 ppm
ASN/SkSP at 1000 lot	i=5, f=1/3, k=3 and x=4	74000/200000 ratio = 37%	i=5 and f=1/3	76000/200000 ratio = 38%
ATI/SkSP at 1000 lot	i=5, f=1/3, k=3 and x=4	124000 506000 ratio = 24.51%	i=5 and f=1/3	128000/506000 ratio = 25.30%

Table 3. Hypothesis test results for significant difference of parameters.

Sampling plan parameters	Hypothesis	Z	P-value	Conclusion
Pa	H0: p1 = p2 H1: p1 > p2	1.21	0.114	SkSP-V is not significant difference as compare with SkSP-2 in term of Pa
AOQ	H0: p1 = p2 H1: p1 < p2	0.04	0.517	SkSP-V is not significant difference as compare with SkSP-2 in term of AOQ
ASN/SkSP at 1000 lot	H0: p1 = p2 H1: p1 < p2	-6.53	0.000	SkSP-V is very significant difference as compare with SkSP-2 in term of ASN
ATI/SkSP at 1000 lot	H0: p1 = p2 H1: p1 < p2	-9.20	0.000	SkSP-V is very significant difference as compare with SkSP-2 in term of ATI

Hypothesis output from Table 3
Test and CI for Two Proportions (Pa)

Sample	X	N	Sample p
1	96101	100000	0.961010
2	95996	100000	0.959960

Difference = p (1) - p (2)
Estimate for difference: 0.00105
95% lower bound for difference: -0.000383069
Test for difference = 0 (vs > 0): Z = 1.21 P-Value = 0.114

Test and CI for Two Proportions (AOQ)

Sample	X	N	Sample p
1	2403	1000000	0.002403
2	2400	1000000	0.002400

Difference = p (1) - p (2)
Estimate for difference: 0.000003
95% upper bound for difference: 0.000116857
Test for difference = 0 (vs < 0): Z = 0.04 P-Value = 0.517

Test and CI for Two Proportions (ASN)

Sample	X	N	Sample p
1	74000	200000	0.370000
2	76000	200000	0.380000

Difference = p (1) - p (2)
Estimate for difference: -0.01
95% upper bound for difference: -0.00748198
Test for difference = 0 (vs < 0): Z = -6.53 P-Value = 0.000

Test and CI for Two Proportions (ATI)

Sample	X	N	Sample p
1	124000	506000	0.245059
2	128000	506000	0.252964

Difference = p (1) - p (2)
Estimate for difference: -0.00790514
95% upper bound for difference: -0.00649105
Test for difference = 0 (vs < 0): Z = -9.20 P-Value = 0.000

Table 4. Cost comparison on Average Sample Number (ASN).

Cost	SkSP-V (μ1)					SkSP-2 (μ2)						
	Parameters				Value	Parameter		Value	Hypothesis	T	P-value	Conclusion
Cost comparison based on ASN	i	f	k	x	Baht	i	f	Baht	H0: μ1 = μ2 H1: μ1 < μ2	-5.29	0.001	SkSP-V is verysignificant differenceas compare with SkSP-2 in term of cost based on ASN.
	5	1/3	3	4	44400	5	1/3	45600				
	10	1/5	5	9	31200	10	1/5	31800				
	15	1/10	5	13	16800	15	1/10	17400				
	20	1/15	5	18	13200	20	1/15	13800				
	5	1/5	3	4	25800	5	1/5	26400				
	10	1/10	5	9	14400	10	1/10	14400				
	15	1/15	5	13	10200	15	1/15	10800				
	20	1/20	5	18	9000	20	1/20	9600				

Hypothesis output from Table 4

Paired T-Test and CI: SkSP-V, SkSP-2 (ASN)

Paired T for SkSP-V - SkSP-2

N	Mean	StDev	SE	Mean
SkSP-V	8	20625	12284	4343
SkSP-2	8	21225	12495	4418
Difference	8	-600	321	113

95% upper bound for mean difference: -385
T-Test of mean difference = 0 (vs < 0): T-Value = -5.29 P-Value = 0.001

Table 5. Cost comparison on Average Total Inspection (ATI).

Cost	SkSP-V (μ1)					SkSP-2 (μ2)						
	Parameters				Value	Parameter		Value	Hypothesis	T	P-value	Conclusion
Cost comparison based on ASN	i	f	k	x	Baht	i	f	Baht	H0: μ1 = μ2 H1: μ1 < μ2	-4.78	0.001	SkSP-V is very significant differenceas compare with SkSP-2 in term of cost based on ATI.
	5	1/3	3	4	74400	5	1/3	76800				
	10	1/5	5	9	49200	10	1/5	50400				
	15	1/10	5	13	24600	15	1/10	25800				
	20	1/15	5	18	19800	20	1/15	20400				
	5	1/5	3	4	37200	5	1/5	38400				
	10	1/10	5	9	18600	10	1/10	19200				
	15	1/15	5	13	13800	15	1/15	14400				
	20	1/20	5	18	12600	20	1/20	13200				

Hypothesis output from Table 5

Paired T-Test and CI: SkSP-V., SkSP-2. (ATI)

Paired T for SkSP-V. - SkSP-2.

N	Mean	StDev	SE	Mean
SkSP-V.	8	31275	21405	7568
SkSP-2.	8	32325	21993	7776
Difference	8	-1050	621	220

95% upper bound for mean difference: -634
T-Test of mean difference = 0 (vs < 0): T-Value = -4.78 P-Value = 0.001