Analysis of Inspection System based on Zero Acceptance Plans with Inspection Errors

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ABSTRACT

This research evaluate the impact of inspection errors on Zero sampling Plans conducted at incoming, outgoing quality assurance and at Customer site. The incoming lot size is largely greater than the production lot size. With inspection errors of Type II presented, the lot acceptance rate at producer site is increased as expected whereas that at customer site is decreased. The relationship between the amount of inspection errors and the lot acceptance rate can help producer estimate the current inspection error at both incoming and outgoing quality station which will lead to improvement project plans.

Keywords: Zero Sampling Plans, Inspection Errors, Multistage Inspection

INTRODUCTION

A Hard Disk Drive (HDD) supplier is encountering the cost of poor quality according to the low lot acceptance rate (LAR) at customer dock. Even though the 100% inspection can be installed at the outgoing quality assurance (OQA) gate of the producer site, this will lead to extra cost and decreasing produc-tivity. Also this 100% screening may not be effective if the inspection errors are presented. However the producer is planning to tight up the level of inspection instead in order to alleviate this problem. By doing so, the inspection errors could still be a major source of the external failure cost. To quantify the severity of inspection errors on the quality cost, the relationship between the LAR and inspection errors needs to be identified. The quality improvement project as well as measurement system analysis improvement can then be developed under several alternatives. If an automated visual recognition is placed to reduce the inspection error, the producer needs to justify the increased appraisal cost versus reduced external failure cost. Likewise the increased quality should lead to greater LAR. This research aims to associate the external failure cost by evaluating the LAR at customer site under the serially connected production system with inspection errors. The zero sampling plan is used currently at incoming quality assurance (IQA), OQA and at customer IQA station. In this study, the incoming lot size is largely greater than the production lot size. This is the nature of HDD and Electronic manufacturing. Section II explains the methodology and details of the production system. The results are displayed in section III and followed by discussion in the last section.

METHODOLOGY

The study of inspection systems under inspection errors has occurred since 1960. The researchers evaluated the production/inspection systems under various assumptions such as production system with/without replacement, with/without rework station and etc. Recently the developments of installing inspection gate of various types have been presented. See Avinadav and Raz (2003), Barad (1986,1990), Eppen and Hurst (1974), Heredia-Langner et. al. (2002). Most researches assume the same lot sizing between incoming, productions and outgoing. This research considers, without loss of generality, five serially connect process with raw material lot size greater than production lot size. The incoming lot size is taken to be 4,800 where the production lot size is 480. At IQA, the Zero Sampling Plans with 0.65% AQL is currently used by the producer. The current defectives generated from each product at various time (month) is displayed in Figure 1. An example of the LAR estimate is shown in Table 1.

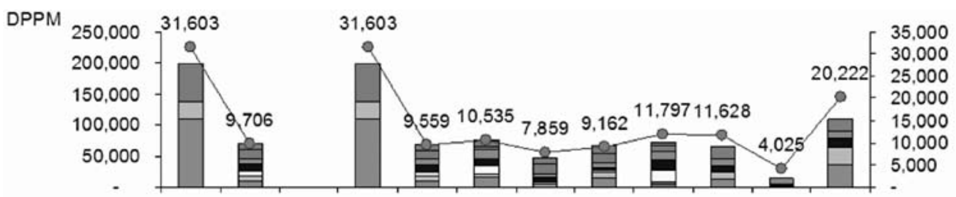

Figure 1. Defective product generated from producer process.

Table 1. Example of Estimation of LAR.

Invoice	QTY	3,266,777
	Inspected	663
	Rejected	234
Lot	QTY	3,287,025
	Inspected	729
	Rejected	257
Sample	Inspected	59,242
	Rejected	575
LAR	By invoice	64.7%
	By lot	64.7%

The estimate of defective is about 15,000 defective parts per million (DPPM) on average. The raw material is estimated to be contaminated with defective of 5,000 DPPM. The in-process 1, 2, 3, 4, and 5 are estimated to generate 5,000, 2,000, 1,000 and 2,000 DPPM respectively. There is no inspection between these in-processes according to the limitation of material handling and continuous manufacturing environment. Defective can be passed from raw material into the process which will be propagated according to those rates. At OQA, every production lot size of 480 will be sampled for inspection using zero sampling plans with 0.25% AQL. The customer is currently appling Zero Sampling Plans with 0.4% AQL. The supplier reported that the LAR at customer is ranged between 55%-65% causing rising cost of re-screening and inspection. An example of the relationship between the incoming quality, inspection errors and the outgoing quality at each stage/process can be depicted in Figure 2.

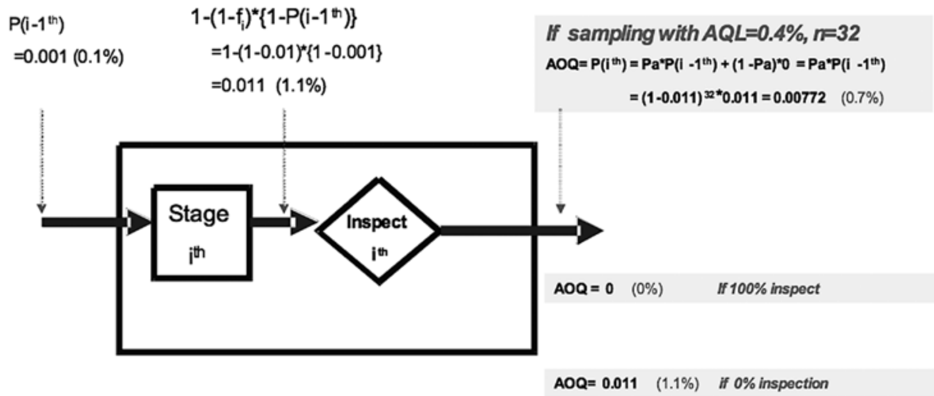

Figure 2. An example of the relationship between the IQA, and OQA for each stage.

With presence of measurement errors of Type II both at IQA, OQA and at Customer site, the LAR can be determined using simulation other than direct computation which may not be done explicitly. Each run represents each lot of raw material. Each production lot size is formed by a random sampling of size equal to production lot. These production lots will be passed through processes where defectives are generated and recorded. The zero sampling plans at OQA will results either accept or reject. If accepted, the production lot will be formed with the same size as raw material. Then it will be sent to customer for justification. If rejected, the whole production lot will be screened and the defectives found will be removed with no replacement. The estimates of Type I, II inspection errors at IQA are determined from measurement system analysis and estimated to be 0 and 0.0045 respectively which is the same as errors occurred at customer site. At OQA stage, the Type I inspection error is set at 0 but the Type II error is varied among 0, 0.1, 0.2, 0.25.

RESULTS

Currently, products are sampled and inspected at IQA. Under Zero Sampling Plans, the raw material will be accepted with high probability of acceptance if there exists inspection error especially of Type II. The researcher simply computed and demonstrated the high probability of acceptance of zero sampling plans, i.e., AQL 0.4% as shown in Table 2. The current sampling plan is inefficient such that, with such as high value of 6,500 DPPM, the IQA will mistakenly accept the lot with at least 73%. This could be a major contribution to the low rate of LAR at the customer site. When inspection errors occur, the probability of acceptance will be a bit greater causing more lowquality lot to be accepted. The efficient integrated sampling plans must prevent the defective product from getting into the assembly line.

Table 2. Probability of Acceptance of Zero Sampling Plans with/without Inspection Errors.

DPPM	Pa. With Inspection Errors of Type II = 0.005	Pa. Without Inspection Errors of Type II
1,000	0.9541	0.9026
1,500	0.9319	0.9026
2,500	0.8890	0.8145
4,000	0.8283	0.8145
6,500	0.7360	0.6627
10,000	0.6235	0.5976
15,000	**0.4915**	**0.4376**
25,000	0.3042	0.2879
40,000	0.1468	0.1232

According to the differences in the incoming lot size and the production lot size, the direct computation of probability of acceptance is complicated especially the without replacement assumption of defective part found at IQA and OQA. Thus, the 1,000 runs of simulation was performed for each case of those errors. The LAR at OQA and at Customer site were estimated and reported in Table 3.

Table 3. Estimates of LAR at OQA and at Customer Site (CS).

	Type II Error = 0		**Type II Error = 0.1**		**Type II Error = 0.2**		**Type II Error = 0.25**	
	LAR at OQA	***LAR at CS***	**LAR at OQA**	***LAR at CS***	**LAR at OQA**	***LAR at CS***	**LAR at OQA**	***LAR at CS***
AQL0.1	19.88%	85.90%	22.02%	82.80%	25.82%	81.20%	28.26%	79.30%
AQL0.15	34.60%	72.30%	38.90%	72.90%	42.43%	65.80%	44.94%	62.70%
AQL0.25	49.93%	63.40%	54.51%	62.10%	57.89%	60%	60.53%	55.70%
AQL0.4	52.20%	59.20%	55.65%	59.70%	60.87%	56.20%	61.29%	52.30%

By tighten the AQL to be 0.15% at OQA, the acceptance rate at the OQA is currently less than 50% causing more unnecessary and redundant appraisal cost. The actual LAR at the OQA stage is ranging about 45%-50% which is the same as the simulated LAR. The increases of the inspection errors of Type II will tends to have lot accepted more at the OQA as expected but the rejection will be increased at customer site. The LAR at customer decreased as the type II error increased at all levels of AQL. The highly tighten AQL level of 0.1% will barely allow manufactured lots of product to pass the OQA stage. Almost 70%-80% of the manufactured lots will be rejected causing huge amount re-inspection cost as well as production losses. The simulation of the system coincides with the actual reported LAR rate. At OQA, the current plan is tighten by using AQL of 0.15%, the LAR reported in Table I matched the computation for the case of inspection error of 0.2.

DISSCUSION

The simulation of the system coincides with the actual reported LAR rate. The actual acceptance rate at the OQA stage is less than 50% causing more unnecessary and redundant appraisal cost. The larger the inspection errors of type II, the more defective products tend to be accepted causing leakage of poor quality lot to customer. The LAR depends heavily on two components; one is the quality of process producing part and the efficiency of the OQA procedure. If the process achieves the zero defects policy, the LAR must be 100% no matter how the inefficiency of the OQA procedure assuming type I error of inspection is nil. According to the LAR shown in Table I of about 64.7%, the producer is realizing that the actual current inspection error is as high as four times than the one expected. The high raising of production quantity per week of more than 1.5 millions part shipped may drive the capacity of OQA up to its limits. This may unintentionally cause inspector to meet such high demand inspection load, loosing meticulous effort to justify the product quality especially the visual inspection part. The current process generated almost 15,000 DPPM. With the errors of inspection which tend to accept product no matter of its quality, this is the main mechanism that results in the low LAR of the producer.

CONCLUSION

The simulation of the system shows that the current capacity of the production process and the inspection system must be improved. The high DPPM of the process is the main driver for the cost of poor quality. If the inspection is efficient, the internal failure cost must override the external failure cost. With high errors of inspection at OQA, high external failure cost is demonstrating since the inspection error cause more leakage of poor quality lot to customer. The simulation of the system depicted the connection between the IQA, in-process, OQA and the customer. This chain of quality/productivity can be used to estimate the cost of poor quality. Hence the improvement project can be initiated. This research exemplifies and shows that the analysis of the inspection system leads to clarification of system's quality performance.

ACKNOWLEDGEMENTS

This research work was supported by National Electronics and Computer Technology Center, National Science and Technology Development Agency and Industry/University Cooperative Research Center (I/UCRC) in HDD Component, the Faculty of Engineering, Khon Kaen University.

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