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A STUDY ON APPLICATION OF ACCEPTANCE SAMPLING PLAN IN PROCESSING CONTROL AND MONITORING.

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Abstract

This study examined the use of acceptance sampling technique as an efficient tool for quality assurance in deciding whether a given lot of product is to be accepted or rejected in the market. This study designed two single sampling plans with a sample size of 125 from a lot of size 1350 bread loaves and an allowable number of defectives as 4 and 6 (i.e. c=4 and 6). The result indicated that the probability of rejecting the manufacturers' product of good quality by the consumers is about 0.371 (producers risk, α=0.371) with the first plan of c = 4. However, the second plan proved more efficient in controlling quality in the industry with c = 6, the producers risk, α=0.235 with the least average total inspection value. The continuous improvement and review of acceptance sampling plan is important to improve the products quality and ensure continuous customer satisfaction.

Keywords: Acceptance sampling, Decision making, Producer's risk, Consumer's risk

Introduction

In this twenty first century age, there is strict competition of close substitutable products in the market between companies and in order to stay competitive, companies need to build up a very good reputation with their products available in the market. So quality of products is one major characteristic that consumers watch out for in the market and this implies that for companies to build and protect a good market reputation, product quality maintenance is important. A very good quality of products denotes a good reputation of the producing company. Problems with product quality or performance may cause producers to incur warranty expenses, damage market reputation and prevent producers from maintaining or increasing its market share. The Nigerian market is being flooded with many sub-standard products. The problem of quality control has become a blow to manufacturing firms and regulatory bodies in Nigeria. To build up quality maintenance, the company must be crucial in product inspection before releasing such product into the market. The inspection should begin from the raw materials down to the finished product to ensure good product quality. Often time, the process of inspection, a 100% inspection of product lot/batch may be practically impossible due to certain consideration like time and cost. For this reason, a sampling plan is important. A sampling plan is aimed at reducing the time of inspection and its corresponding cost. The sampling plan is also aimed at keeping the producer informed on how to improve product quality and gain a more competitive power in the market. As the decision about the lot of product is taken based on the sample inspection result, there is a chance of committing errors. The chance of rejecting a lot that meets the given quality specification is called the producer's risk, and accepting a lot with a bad quality is known as the consumer's risk. Therefore, sampling plans are designed to give those parameters for the inspection of a lot of product, where these two risks are satisfied.

Aydemir and Olgun (2010) were of the opinion that if producers have large amount of tested units, all the items cannot be subjected for testing. This is a problem that that is common with destructive testing. In order to proffer a solution to this problem, statistical methods of quality control. They added that an acceptance sampling which refers to the application of specific plans to a designated lots or sequence of lots and lots of products are acceptable for this purpose as a statistical method. They focused on single and double acceptance sampling plans to evaluate bearing cap part from a bakery machine manufacturing system for analyzing the effects of input quality control process and comparing of the best plans. The result of their study included that for the part of bearing cap, the company must be selected the double sampling that is n_1=50, c_1=0, r_1=3, n_2=50, c_2=4 the lack of quality levels decreased on the product costs with a good product quality level as the parts receiving for the manufacturing processes.

Baridam (2001) suggested that the customer decides the disposition of an incoming lot based on a standard specifying the maximum proportion of nonconforming items in the sample. The decision can be to accept or reject the entire lot, or to continue sampling. Acceptance sampling also has been adapted to problems not identified with procurement.

Kiermeier (2008) on his part was of the opinion that if the process has been controlled satisfactorily, the product would be accepted and passed to the customer. If the process or quality controls have broken down, the sampling procedures will prevent defective products from going any further or leakage to the customer. The manufacturing department, as part of the process or quality control program uses sampling techniques for quality monitoring purposes. Effective acceptance sampling involves effective selection of the products and the application of specific rules for lot inspection that follows the standards. The acceptance-sampling plan applied on a lot-by-lot basis becomes an element in the overall approach to maximize the quality level at minimum cost.

According to Deros et al (2008), effective acceptance sampling involves effective selection and the application of specific rules for lot inspection. The acceptance- sampling plan applied on a lot-by-lot basis becomes an element in the overall approach to maximize quality at minimum cost. Since different sampling plans may be statistically valid at different times during the life of a process, therefore all sampling plans should be periodically reviewed.

According to Carlo (2013), in the quality control of a production process (of goods or services), from a statistical point of view, acceptance sampling is used to inspect either the process output (final product) or the process input (raw material). The purpose of the design of a sampling plan is to determine a cause of action that, if applied to a series of lots/batches of a given quality, and based on sampling information, leads to the risk of accepting / rejecting them. Thus, acceptance sampling yields quality assurance.

Akinola (2009) examined the characteristics of a good quality service and methods used in controlling quality of service in the Nigerian Banking industry using the technique of quality control. She found out that most banks do not use the quality control technique to improve their services to the populace. Based on her finding, she recommended that banks should improve their service delivering system using statistical process control mechanism. An acceptance sampling plan indicates the rules for accepting or rejecting a lot that is being inspected.

Acceptance sampling involves both the producer (supplier) of materials and the consumer (or buyer). Consumers need acceptance sampling to limit the risk of accepting goods with bad quality. Burge et al, (2011) in their study on the usefulness of acceptance sampling stated that two levels of quality are considered in the design of an acceptance sampling plan. When applying the acceptance sampling plan for a process several quality control charts for attributes can be used. The most frequently used is the average outgoing quality (AOQ) which is fitted in a probability curve relation the proportion non-conforming and probability of acceptance.

MODEL SPECIFICATION

It has been focused on when the inspection required is destructive testing, 100% inspection is not feasible due to the cost or time so an acceptance sampling plan is created to define how many samples must be taken to verify the lot. Acceptance sampling (AS) procedures can be applied to lots of items when testing reveals non-conformance or non-conformities regarding product functional attributes. It can also be applied to variables characterizing lots, thus revealing how far product quality levels are from specifications. Both AS applications have the basic purpose of classifying a lot as accepted or rejected, given the quality levels required for it. The design of acceptance sampling plans for attributes determines essentially the size of the samples to be inspected and the number of non-conformities tolerated in order for a lot to become accepted. The Operating Characteristic (OC) curve describes the probability of accepting a lot as a function of the lot's quality.

Estimating Acceptance Sampling

The probabilities of acceptance an isolated lot of finite size N, is given by the hyper-geometric distribution.

$$\mathrm{P}_{(a)} = \sum_{x=0}^{n} \frac{\binom{d}{x}\binom{N-d}{n-x}}{\binom{N}{n}} \; ; \qquad x = 0,1,\ldots,n$$

In a single sample plan we accept the lot if the number of nonconforming items is c or less. This means we are interesting in the probability of 0, 1, …, c items. We write this as

$$\mathrm{P}_{(a\le c)} = \sum_{x=0}^{c} \frac{\binom{d}{x}\binom{N-d}{n-x}}{\binom{N}{n}} \; ; \qquad x = 0,1,\ldots,c$$

Where,

P(a) = probability of acceptance

N = lot size

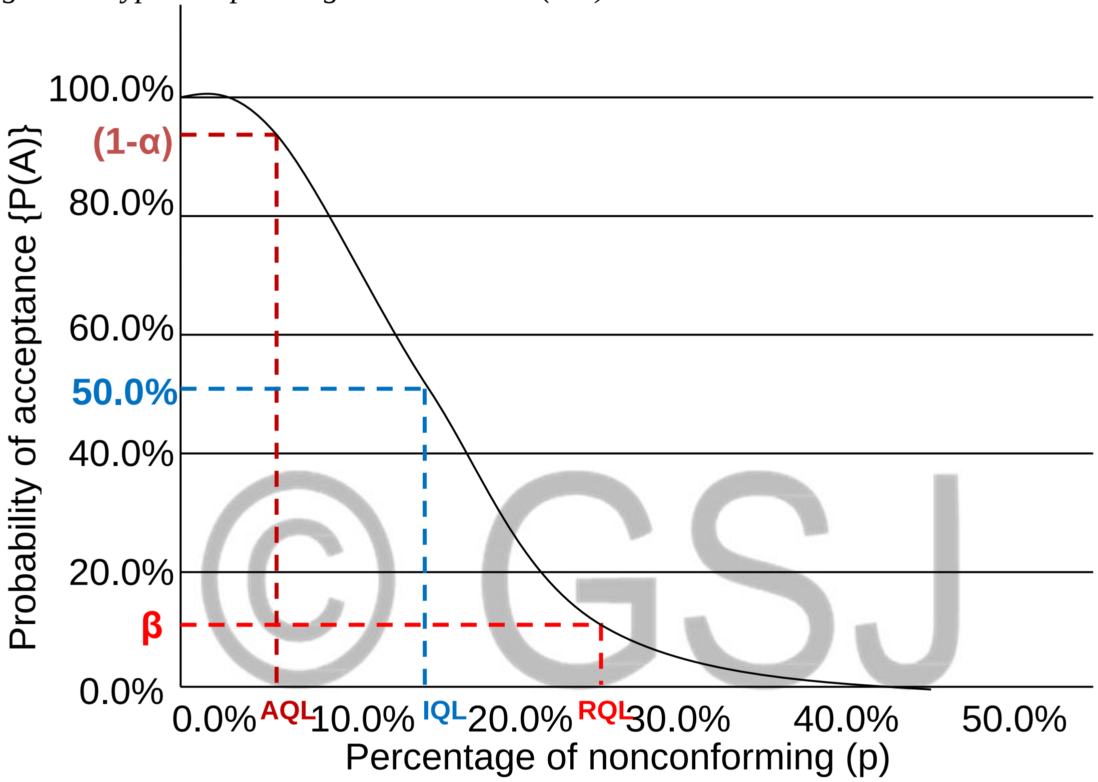
n = sample size

x = acceptance number (c)

d = number of nonconforming items in the lot

The probability of rejecting a lot of good quality is called the producer's risk and is represented by α i.e. Pr(rejection/acceptable quality) = α. the probability of accepting a lot of poor quality is called the consumer's risk, denoted by β i.e. Pr(accepting/unacceptable quality) = β. These probabilities are represented in figure 1 below;

Figure 1: Typical Operating Characteristic (OC) Curve



The producer's risk is usually set at 0.05, while the consumer's risk is set at 0.10. Though these probabilities could vary. the average fraction defective of both the accepted lots and those rejected and screened 100% is called the average outgoing quality (AOQ). Corresponding to the producer's is the lot of good quality, π_1, called acceptable quality level (AQL) which the manufacturer wishes to be accepted with high probability 1 – α. Also corresponding to the consumer's risk is the lot of poor quality percent defective π_2 which the customer would wish to have accepted with a low probability β. the AOQ is calculated using the formula: AOQ = $\pi L(\pi)$. The maximum value of AOQ for all values of incoming process quality, π is called the average outgoing quality limit (AOQL). For proportion defective following a poisson process. The number of defects in each item in the sample is ascertained, and the batch is accepted or rejected according to the number of defects or average number of defects per piece or per hundred found in the sample.

Let d_n = number of defects in the sample of size n

$\overline{d_n}$ = d_n/n the average number of defects per item in the sample

Let λ = average number of defects per item in the lot

$\overline{d_n}$ is poisson with parameters n and λ, i.e.

Prob ($\overline{d_n}$ = r) = $(\lambda^r e^{-\lambda})/r!$ with the following decision rule:

Accept the lot if $d_n \leq c$ or $\overline{d_n} \leq \bar{c}$

Reject the lot if $d_n > c$ or $\overline{d_n} > \bar{c}$

The operating characteristic curve (OC) for this sampling plan for the lot of quality λ is

L(λ) = Prob ($d_n \leq c/\lambda$) or prob ($\overline{d_n} \leq \bar{c}/\lambda$)

$$= \sum_{d=0}^{c} \frac{e^{-n\lambda}(n\lambda)^d}{d!}$$

This study used data from a bread production firm, where the lot implies the number of bread slotted in an oven once. The defect is accounted for as the burnt bread or compressed loaf. The probability of accepting the lot is the probability that there is c or fewer nonconforming items in the sample. This is the equation above, and is what we plot as the OC curve.

DISCUSSION OF RESULT

Table 1: Sampling plan 1

Measurement type: Go/no go				
Lot quality in proportion defective				
Lot size: 1350				
Acceptable Quality Level (AQL)	0.04			
Rejectable Quality Level (RQL or LTPD)	0.1			
Compare User Defined Plan(s)				
Sample Size	125			
Acceptance Number	4			
Accept lot if defective items in 125 sampled ≤ 4; otherwise reject.				
Proportion Defective	Probability Accepting	Probability Rejecting	AOQ	ATI
0.04	0.629	0.371	0.01555	825.1
0.10	0.003	0.997	0.00025	1346.6

The result of the design indicated that the probability of rejecting the manufacturers product of good quality by the consumers is about 0.371 (producers risk, α=0.371). This implies that nearly half of the goods produced will be considered bad and hence, the producer will experience loss with the plan on acceptable number of defects as 4. The estimated average outgoing quality is very poor and that increases the corresponding value of the average total inspection number.

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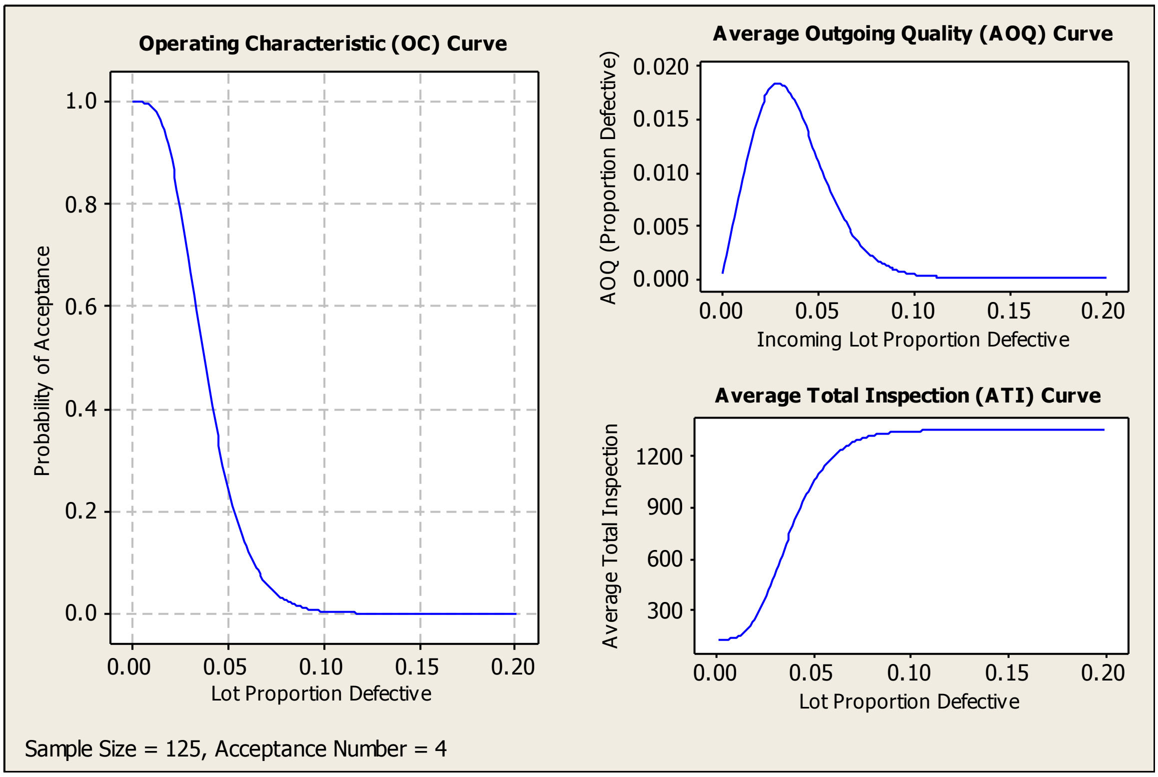
Figure 2: OC curve of probability of acceptance



The operating characteristic curve for acceptance number as 4 and computed AQL as 0.04, indicated that the probability of acceptance is relatively low as supported by the result in table 1 above. From the above, the average outgoing quality limit is 1.56% for the given sampling plan. This is the average fraction defective of both the accepted lots and those rejected and screened 100%. From figure 4 above, the average number of items inspected per lot is 825.1.

Table 2: Sampling plan 2

Measurement type: Go/no go				
Lot quality in proportion defective				
Lot size: 1350				
Acceptable Quality Level (AQL)	0.04			
Rejectable Quality Level (RQL or LTPD)	0.1			
Compare User Defined Plan(s)				
Sample Size	125			
Acceptance Number	6			
Accept lot if defective items in 125 sampled ≤ 6; otherwise reject.				
Proportion Defective	Probability Accepting	Probability Rejecting	AOQ	ATI
0.04	0.765	0.235	0.02777	412.6
0.10	0.028	0.972	0.00256	1315.4

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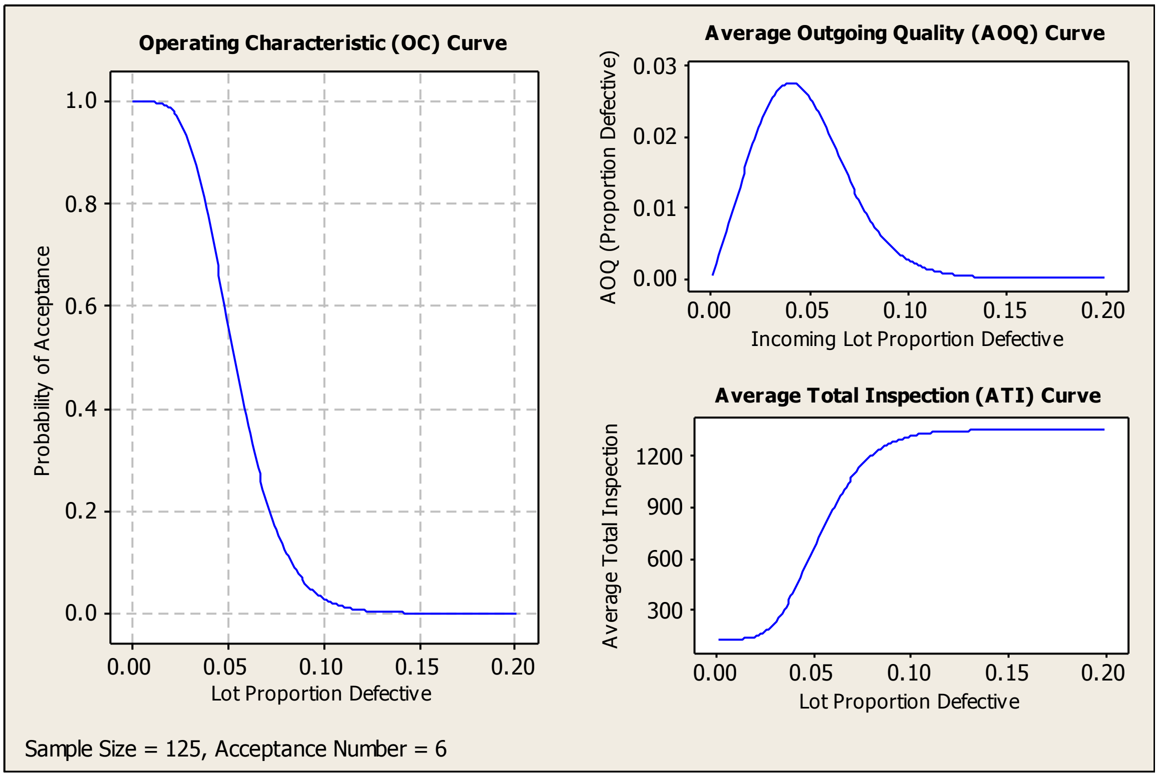
The sampling plan 2 result reported that the probability of rejecting the manufacturers product of good quality by the consumers is about 0.235 (producers risk, α=0.235). This probability is nearly uncertain because of its weak nature and by so, nearly all of the goods produced will be considered accepted in the market and hence, the producer will experience a greater power with the plan on acceptable number of defects as 6. The estimated average outgoing quality is quite encouraging and that decreases the corresponding value of the average total inspection number.

Figure 3



For the second plan, the reporting operating characteristic curve for acceptance number as 6 and computed AQL as 0.04, indicated that the probability of acceptance has relatively risen as supported by the result in table 2 above. From the above, the average outgoing quality limit is 2.8% for the given sampling plan. From figure 3 above, the average number of items inspected per lot using the second plan reduced to 412.6.

Conclusion

Acceptance sampling has gained wide acceptance in many industries around the world, yet some industries undermine its usefulness. This study therefore designed two acceptance sampling plans in order to compare which one will minimize the producer's risk more. Of the two sampling plan intended, the plan with allowable number of defects as 6 and sample size of 125 proved more efficient with α =0.235 about 23.5% of goods of with good quality will be rejected by consumers as a result of the number of allowable defect per sample of size 125. In conclusion, manufacturers are advised to develop acceptance sampling plan to internally monitor the quality of their products before marketing so as to increase their reputation in the market place.

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