Basics of Acceptance Sampling Procedures

In this session we discuss the basics of Acceptance Sampling Procedures (Product Control). The entire topic is subdivided in to 7 sub divisions.

1. Product control and the role of acceptance sampling
2. Advantages and disadvantages of sampling plan
3. Some terminologies
4. Consumers risk and producers risk
5. OC function and its properties
6. AOQ Curve and AOQL
7. Designing a sampling Plan
8. Conclusion.

1. Product control and the role of acceptance sampling

In the construction of control charts, we were dealing with the problem of process control. If the control charts indicate that if the process is going out of control, we look for assignable causes. By eliminating assignable causes of variations as indicated by control charts we bring the process under control. Even when the process is under control, there is no guarantee that all the items produced are good. We only guarantee that the probability that the defective item will be produced is too small. In large scale production, produced items are delivered in lots. The items are also purchased in lots. Usually lot sizes are very large.

Foe economic considerations and nature of products, it is not practicable to inspect cent percent all items in the lot; one has to take fewer units from the lot and inspect the units selected. Based on the information from sampled units the disposition of as good or bad is decided.

Definition: Acceptance Sampling is a technique which deals with acceptance or rejection of a lot or process based upon the results obtained from a random sample or samples taken randomly from the lot.

If the items are judged good or bad by inspection of presence or absence of some attribute characteristics, the inspection is called attribute inspection. In this case the quality of a lot is defined by the sample fraction nonconforming (fraction defective).

The acceptance sampling is preferred to 100% inspection in the following cases.

1. When the cost of the inspection is high and loss that arises from the passing out defective items is not too much
2. When the inspection units are costly or destructive
3. To maintain good quality: If the lots are rejected often the producer is forced to improve the production process. Hence acceptance sampling indirectly improves the quality of the products.
4. To give protection to the consumer against the acceptance of bad lots. It also gives protection to the producer against the rejection of good lots. The consumer is given long

run protection against the product. It minimizes the cost of inspection and administration. It provides a basis for action with regard to the production of units in future course.

Comparison between 100% inspection and sampling inspection

100% inspection	Sampling inspection
1. 100% inspection is not efficient	1. Because of low quantities involved inspection will be efficient
2. it is subject to human errors arising out of fatigue and monotony. These errors cannot be quantified	2. It is subject to sampling errors which can be quantified and controlled
3. It is not practicable for mass-production components	3. It is practicable for mass production components.
4. It is not feasible where destructive testing is involved	4. It is only alternative where destructive testing is involved
5. It is costly, time consuming and effort some.	5. It is cheap ' quick and easy
6. It does not develop an attitude of quality or pressure for quality	6. It develops pressure for quality improvement by rejection of entire lots on the basis of findings in samples

2. Advantages and disadvantages of sampling plan

Advantages of Acceptance Sampling

1. Less expensive because of less inspection compare to entire lot.
2. Less handling of product and hence reduce damage
3. Applicable to destructive testing
4. Fewer personnel are involved in inspection activities
5. Reduces the amount of inspection error
6. The rejection of lot motivate the vendor for quality improvement

Disadvantages of Acceptance Sampling

1. Risk of accepting a bad lots and rejecting a good lots
2. Less information about the product
3. Need some plan and formulation compare to 100% inspection

3. Some terminologies

Sampling plan: A sampling plan prescribes the sample size N, that is the number of units to be taken from the lot for purpose of sampling inspection and acceptance criteria for accepting or rejecting the lot or for taking one more sample and inspect.

Operating Characteristic Function (OC Function): The operating characteristic function is the mathematical expression giving the probability of acceptance of a lot as a function of p, the fraction defective of the lot.

Operating Characteristic Curve (OC Curve):
Given a sampling plan an Operating Characteristic Curve (OC) is a probability curve for a sampling plan that shows the probabilities of acceptance of lots with various lot quality levels (% defectives). Shows probability of lot acceptance Pa as function of lot quality level (p).

Acceptable Quality Level (AQL)
The fraction nonconforming units (proportion defective) at which a customer is willing to accept a lot with a stated high probability is called AQL. The probability of rejection at this quality level is very small which is denoted as α. A lot with this fraction nonconforming is considered as a good lot. The producer is expected to manufacture to ensure this acceptable quality. AQL is denoted by p_1.

Limiting Quality Level (LQL):
This is the maximum percent defective (or the maximum number of defects per 100 units or maximum fraction nonconforming) for purposes of sampling inspection that can be tolerated and above which the lot will be rejected. This is a bad quality level that one may not wish to accept the lots with this quality more often than a small specified percent of the times. . The probability of acceptance at this quality level is very small which is denoted as β. That is the probability of acceptance at LQL is β. LQL also called as Lot Tolerance proportion defective (LTPD). LQL is relatively large fraction defective compared to AQL. A lot with this fraction defective is considered as a bad lot by the consumer. It is denoted by P_2.
Average Sample Number (ASN): The expected value of the sample size required for coming to a decision of accepting or rejecting a lot, under the sampling inspection plan, is called the average sample number. This is the average number of units inspected on sampling basis, which is applicable for double or multiple sampling plans only. In single sampling this is the same as the sample size.

Average Total Inspection (ATI): The average number of units inspected in total in a lot is called the average total inspection. This is based on the units inspected on sampling basis for accepted lots and inspected on 100% basis for rejected lots.

4**. Consumers and producers risk**

Producer's risk (α): By a producer we mean a person, a company or a firm that manufactures or sells articles to the consumer. Even if the lot is good the producer may have to face a risk of rejecting his product. This happens because of random sampling. There are chances of a good lot getting rejected by the sampling inspection, in which case the producer suffers a loss of rejecting a lot of good quality say p_1. The probability of rejecting a lot of quality p_1 is called producer's risk, and is denoted by α.

i.e., α = P (rejecting a good lot) = P (rejecting a lot of quality p_1)

In practical situations α is always be less than or equal to 0.05.

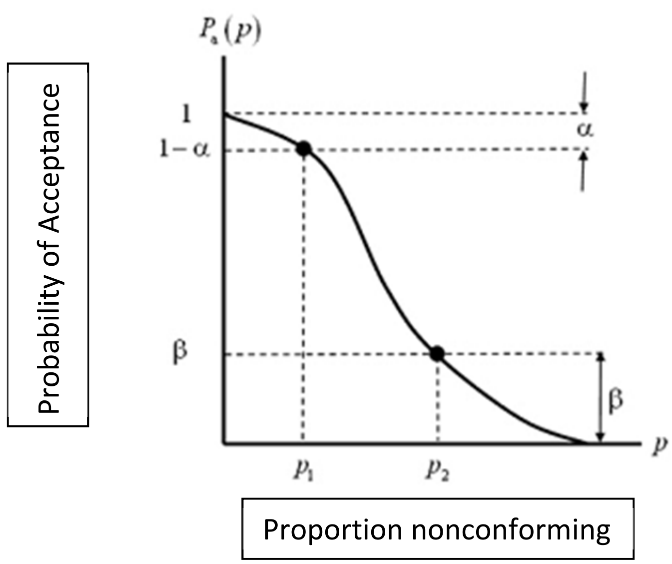
Consumer's Risk (β): By consumer we mean, a person, a department or a company that receives the items from a producer. In the case of sampling inspection a lot is declared acceptable or not on the basis of the quality of the sample. Sometimes even if the lot is bad the sampling results may lead to acceptance of the lot. There are chances of a bad lot getting accepted by the sampling inspection, in which case the consumer suffers a loss of rejecting a lot of good quality say p_2. The probability that a consumer accepts a lot of quality p_2 is called consumer's risk denoted by β.
i.e. β = P(accepting a bad lot) = P(accepting a lot of quality p_2)

The consumer's risk gives the percentage of lots of quality p_2 that are accepted in the long run. In practical situations β is always be less than or equal to 0.10.

Indifference Quality Level (IQL): The proportion defective (or the number of defectives per 100 units or the fraction nonconforming) at which the probability of acceptance is equal to probability of rejection [i.e., P (p) =0.5] is called indifference quality level (IQL). This is the quality level at which the consumer and the producer share equal risks of 0.5. IQL is denoted by p_0.This point on the OC Curve (p_0, 0.50) is called point of control.

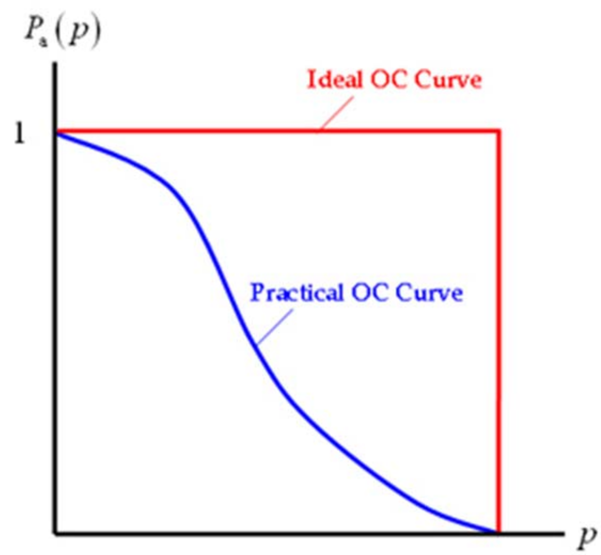
5. OC function and its properties

Five important points on the OC Curve:



- (0,1) is the starting point on the OC curve.
- (p_1, 1- α) is the point corresponding to AQL and producers risk
- (p_0, 0.5) is the point corresponding to indifference quality of the lot.
- (p_2, β) is the point corresponding to LTPD and consumers risk
- (1, 0) is the ending point of the curve.

Ideal OC curve: Suppose a sampling plan is designed such that, p' is the desirable and stable nature of lot quality or product quality or process quality. A lot will be accepted whenever the sample proportion defective from the lot $p \leq p'$. Otherwise the lot will be rejected. That is, whenever $p > p'$ the lot will be rejected. The sampling plan which discriminates perfectly between good and bad lots is called ideal sampling plan. In this case, for all values of $p \leq p'$ the probability of Acceptance P_a will be equal to 1 and for all values of $p > p'$, Pa will be equal 0. Thus the curve of the ideal sampling plan will have Z shape as shown below.



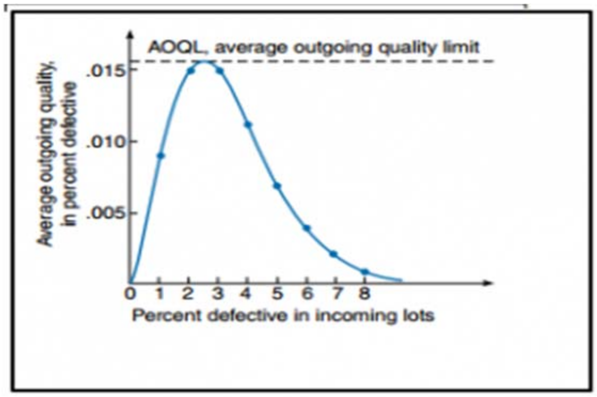
Usually p' is a value very close to zero. Though it is desirable to have sampling plans which yield OC curves equal to ideal OC curve, it is impossible to have such plans in practical situations because of the chance causes which is unavoidable in any production process. Therefore it is usually desirable to have samplings plans which would give high probability of acceptance at lowest proportion defectives and very low probability of acceptance at larger proportion defectives.

6. **AOQ Curve and AOQL**

Average Outgoing Quality (AOQ): In sampling inspection of lots, there is a likelihood of accepting lots inferior to a specified quality and rejecting lots superior to this quality. However in many situations lots rejected are screened and inspected cent percent. The accepted lots will have a fraction defective p that is equal to the incoming quality. The lots rejected, under rejection rectification scheme will have fraction defective equal to zero. In the long run the average value of these fraction defectives is called as the average outgoing quality. Thus the points whose coordinates are p and corresponding AOQ value lie on a unimodel curve starting from (0, 0) rising to a maximum at $p=p_m$ and terminating at (1, 0). The proportion defective p_m corresponding to the maximum ordinate is the average outgoing quality limit (AOQL).

AOQL

The AOQL of a sampling plan is the maximum value (peak point) on the AOQ curve. The AOQ curve gives the average outgoing quality (left axis) as a function of the incoming quality (bottom axis). The AOQL is the maximum or worst possible defective or defect rate for the average outgoing quality. Regardless of the incoming quality, the defective or defect rate going to the customer should be no greater than the AOQL over an extended period of time. Individual lots might be worse than the AOQL but over the long run, the quality should not be worse than the AOQL. The AOQ curve and AOQL assume rejected lots are 100% inspected, and is applicable only to this situation.



7. **Designing a Sampling Plan:**

Designing a sampling plan would mean obtaining the parameters of the sampling plan namely, the sample size and acceptance criteria satisfying some stated conditions, usually, on the points on the OC Curve.

A sampling plan is designed to accomplish a number of different purposes, the most important of which are:

1. to strike a proper balance between the consumers capacity and the producers capacity
2. to separate bad lots from good
3. simplicity of procedures and administration
4. economy in number of observations inspected
5. to reduce the risk of wrong decisions with increase in the size
6. to use accumulated sample data as a valuable source of information
7. to exert pressure on the producer or supplier when the quality of lots received is unreliable or not up to standard.
8. to reduce the sample size of the qualities of reliable and satisfactory.

Characteristics of a good acceptance sampling plan:

1. It should be simple to understand and implement
2. It should minimize total inspection at process average quality
3. It should regulate/ minimize consumer’s risk and producer’s risk to acceptable values.
4. It should guarantee specified AOQL.
5. It should effectively assist in estimating lot quality if required.
6. It should be acceptable to both consumer and producer.

Summary: In this lecture we discussed the product control and importance advantages and disadvantages of acceptance sampling. We discussed some importance definitions-OC function and OC curve, AOQ and AOQ curve, good and bad lot, risks in accepting/rejecting a bad/good lot and an ideal OC curve.