Application of Acceptance Sampling Technique in Paper Converting and Finishing Sections

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Attempt has been made to view the problems encountered in the Converting Section of Paper industry through Acceptance Sampling Plans, a technique exposed under the application of Statistical Quality Control. Amount the two classifications of sampling plans, namely, sampling plans for lot by lot quality and sampling plans for continuous production, the former technique was utilised for this purpose. Further, it was attempted to answer the genuine doubt to what extent this technique is applied in the particular context with meaningful results. It was observed that Sampling Plans injected with suitable modifications to suit the conditions in Paper industry yielded encouraging results by way of :

(i) reduction in the work load and

(ii) increase in the productivity.

I. Introduction

Among the various techniques exposed under the application of Statistical Quality Control (SQC) Acceptance Sampling Plans cover the major field. The significance of the sampling plans is characterised by its simplicity in application and effectiveness in digging out result-oriented informations from the experimental area.

These plans are essentially based on certain simple principles of Statistics such as the distribution pattern of an event, the probability of occurrence of events and so on. The sampling plans contend to pass judgement on the lot submitted for Acceptance or Rejection Decision, taking into account the vital details such as the risk taken by the manufacturer of a product and the risk taken by the consumer. It is to be noted that the purpose of these plans ends at determining a course of action, and not to estimate the lot quality. (2).

We assume that the lots submitted for decision are homogeneous in nature and occurrence of a specific defect or combination of several objectionable defects in a sheet has got equal chance. We also assume that the process is operating in a random manner.

Without going into the details of statistical theory behind these sampling plans, an attempt has been made here to view the problems in a paper industry through SQC technique and to answer the genuine doubt as to what extent this technique is applicable with meaningful results.

II. Problem

The favourable point in the Paper industry where one can concentrate for application of these plans is the converting Section. We will restrict ourselves to this vital unit of a paper industry throughout the discussion.

Imagine a whole lot of homogeneous planks filled with the paper of a particular quality. Supposing that an order of 100 tonnes is converted to sheets and to be finished by the skilled men. A progressive mill is likely to obtain enormous orders for sheets as well as reels. Even though the Sales Department takes care as far as the distribution of orders is concerned in the light of the existing personnel in Finishing House and the capacity of the converters, such a big industrial complex has to meet erratic situations now and then. On such occasions manipulations become simply impossible. Besides, either finishers are laid off for some days or the converters are kept idle.

The main reasons for such situation are (i) Technical in nature (ii) Lack of adequate orders to keep all the personnel engaged besides inadequate planning in taking up the production.

The sampling plan for attributes (by which we refer to the classification of quality of paper in terms of well-defined defects) will help speeding up of the despatch of the incoming quality based on simple sampling theory.

Let us consider a mill turning out 75 tonnes in form of sheets on an average per day, the maximum being 100 tonnes. If the quality is Creamwove or Printing paper, the finishers (say, 40 in number) manage to complete this order with ease. If the quality is Maplitho Printing of Magazine Printing they are expected to take care of all sides of the sheets so that defects such as Dandy marks, Holes or Calender marks do not escape their attention. Similarly, in Board varieties attention should be paid by the finishers to finish the maximum quantity of paper with the fixed time available to his credit to meet the target rate based on which he is paid.

III. Procedure

Consider a simple Single Sampling Plan for Attributes characterised by the following informations :

N (Total sheets in a plank)=25 Reams
(1 Ream=500 sheets)
n (Sample Number) =2 Reams
c (Acceptance Number) =8

The experimental Unit will be a plank consisting of 25 Reams of sheets approximately. The Sample Number has been fixed at 2 Reams. These 2 Reams (Amounting to 1000 sheets in case of paper and 288 in case of Boards) will be collected from different locations during the build-up of the planks. Sample thus collected will be arranged neatly by the apprentice finisher. He will see that there are exactly 2 Reams. He is given a free hand to make the Sample Number exactly 2 Reams by adding or removing some sheets as situation demands. The Reams, then, will be subjected to thorough finishing.

The Decision - Criteria in the above sampling Plan is as follows :

Lot (Plank in this case) will be accepted if the number of defective sheets in the two reams are either 0, 1, 2, 3... or 8. The lot is rejected if the defective sheets are 9 or above 9. The first decision is branded as Grade I and the second as Grade II.

IV. The Sampling Plan as Adoptable in a Paper Industry.

The above procedure in Para III is a general one adopted for a Single Sampling Plan. When this sampling plan is tried in a paper industry, we face certain difficulties. Experience in application of this plan in a converting section has made us to realise the necessity of inserting few modifications to make it effective. First of all occurrence of a specific defect in this process say Crease (Cutter crease or Machine crease) is highly irregular (see Graph I).

This defect crowds a plank when the cutter starts operating or when there is breakage, wrinkles or uneven caliper along deckle. Besides, we are aware that the fixing of parent rolls in the Brake Pockets should be so done that there is no chance for irregular stretch while feeding the rolls to cutters. Hence, there are two main ways in which creases form in the planks, namely;

(i) Concentration on a particular location in the plank.

(ii) Or occurrence of this defect at different locations during the build-up of this plank.

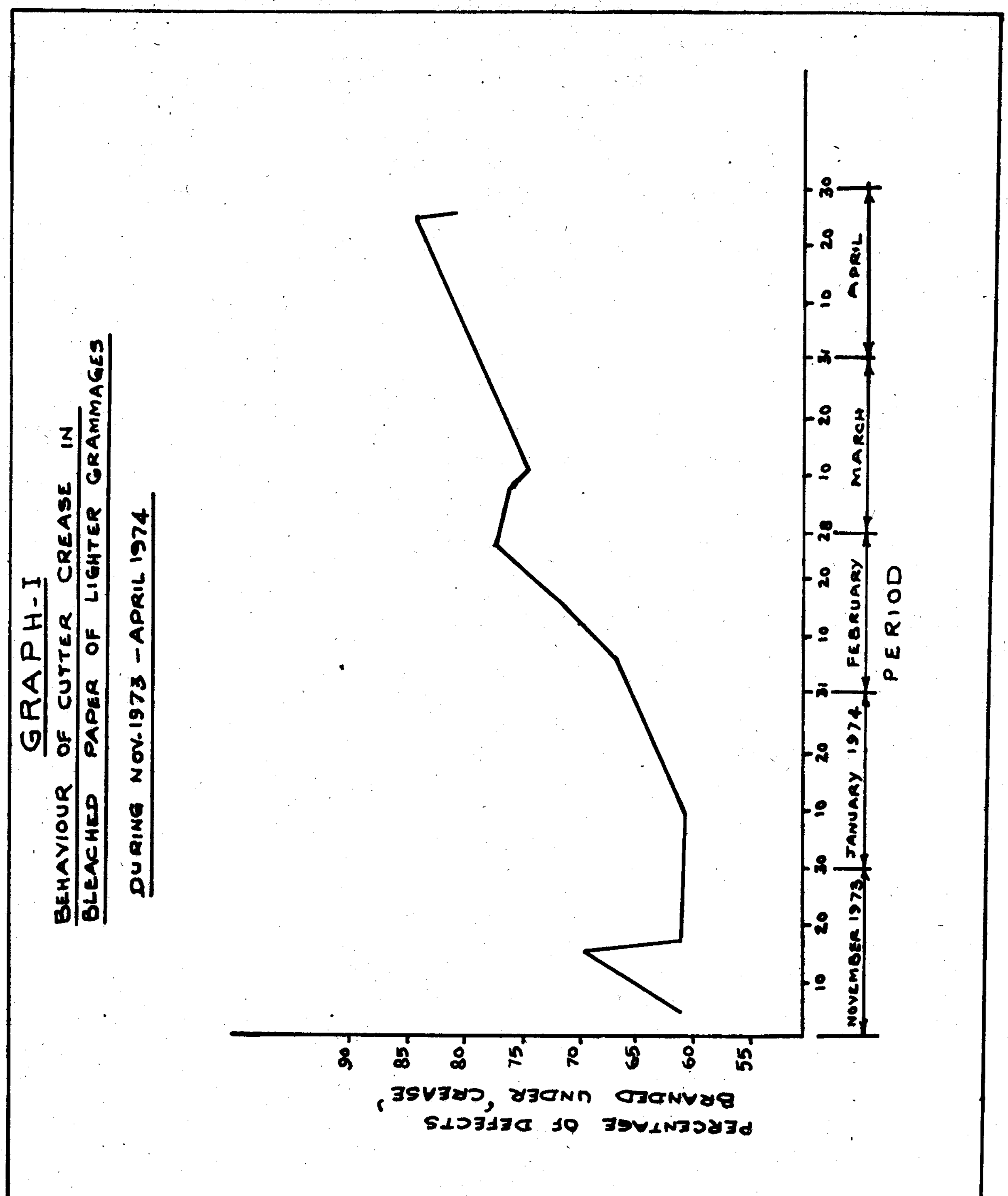
While grading the planks there is a specific need to be conscious of the above facts.

Let us assume that a plank (Graded as I in the usual sense, over looking the above facts) is subjected to thorough finishing. You will find a portion of the plank adhering to the grade given, another portion fits enough to be under the other grade.

II Grade	
I Grade	Plank
II Grade	

This discrepancy in the gradation of the plank is very much due to the indifferent attention to the types of defects, that the finisher gives while allotting the grade, plus the working of random causes resulting in concentration of defects as mentioned above. Instead the gradation of the plank will be working well if the following points are also kept in mind:

(i) Those locations where the particular defect crowd-in will be chalk-marked and not considered for the grading of the plank. Also the apprentice finisher will



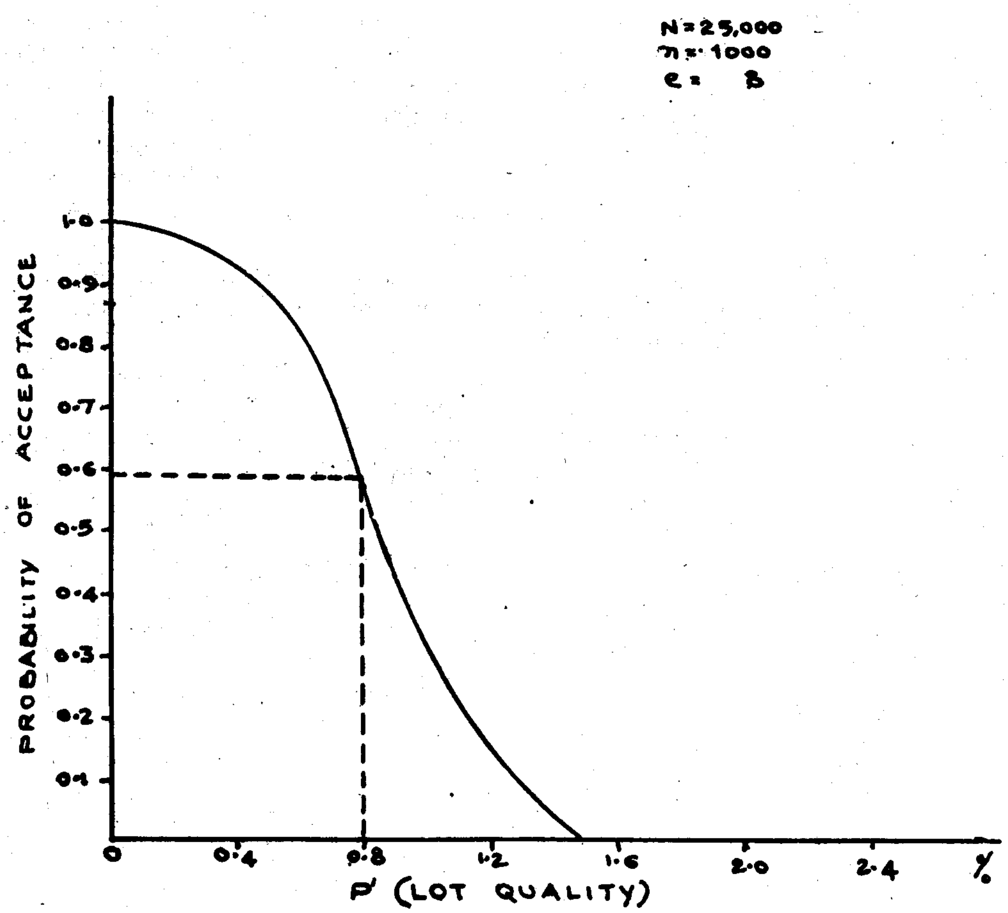
not collect his samples from that location.

(ii) Neither will he do the sampling when a specific defect say dandy mark or calender mark or holes appear throughout in the plank. Since single sheet finishing becomes unavoidable in such occurrence, he will grade such planks under Grade III.

(iii) There is considerable

GRAPH-II

OC CURVE FOR SINGLE SAMPLING PLAN



amount of regularity in the irregular appearance of these defects. The finisher will essentially mark those locations.

V. Discriminating power of a Sampling Plan :

The discriminating power of any sampling plan is denoted by what is called the Operating Characteristic Curve (OC Curve). The OC Curve for the above mentioned plan is given in Graph II.

Computations for the construction of an OC Curve are based on the assumption that the Probability of Acceptance of Lots is given by Hypergeometric Distribution. In many instances the type of sampling performed in Industrial applications is the selection of a sample of 'n' items out of a lot of 'N' items. The Lot is considered to be Homogeneous in all respect. This selection is usually done in such a manner that the sampling is WITHOUT REPLACEMENT. Thus we have a 'random' sample only in the specialised sense that every possible group of 'n' items in the sample, the Hypergeometric Distribution is suggested by the density function.

$$\frac{(D)}{(X)}\ \frac{(N-D)}{(n-x)} \div \frac{(N)}{(x)}$$

where 'D' represents the number of defective items in the Lot. The defects are well defined. (1)

It is preferred to make use of the Poison approximation to Hypergeometric Distribution when 'N' is large and 'x' is smaller. The Density Function of a Poison Distribution is given by :

$$e^{-\lambda}\ \frac{\lambda x}{x^{1}_{0}}$$

λ being the Parameter. 'x' represents the number of defective items in a sample number of 'n' items. An unbiased estimate to determine is achieved with the knowledge of 'n' and 'P' (lot Quality).

This Curve helps us to arrive at a reliable estimate of the number of planks acceptable against the specific lot quality.

For instance a homogeneous group of lots with a lot quality of say 0.8% (i.e. 4 defective sheets in a ream) may have I-Grade planks upto 60% in maximum while this particular sampling plan operates. Thus for various lots of different quality, acceptable quality is determined with the help of the Operative Characteristic Curve.

The annexed Tables I and II give a detailed picture of :

(i) the expectation of a manufacturer as regards to the acceptability of his products.

(ii) the average Quality Level of the reams despatched from Finishing House (Graph III)

We can be rest assured of the smooth functioning of the sampling plan when the points discussed above are kept in mind.

Now let us go back to the original problem posed earlier as to how the situation developed due to increase in capacity of the Mills will be met by the SQC Technique.

A conservative computation, based on our observations, will make clear that 100 Tonnes of sheets are directed to finishing with the existing terms of say 40 Finishers, they will be facing about 60% of 100 Tons (i.e. approximately 60 tonnes) in I-grade, the rest in II-Grade.

The same team is capable of handling 70 tonnes with the existing capacity taking for granted different qualities of paper ranging from Board to Writing paper are made available for finishing. Hence in the light of this fact, a 50% increase in the sheet order will be squarely and efficiently met without extra burden, and without addition in man power.

VI Conclusions :

(a) Any Sampling Plan—let it be the one designed by an expert will never guarantee

ANNEXURE I AND II

Computations for Constructing an 'OC' Curve

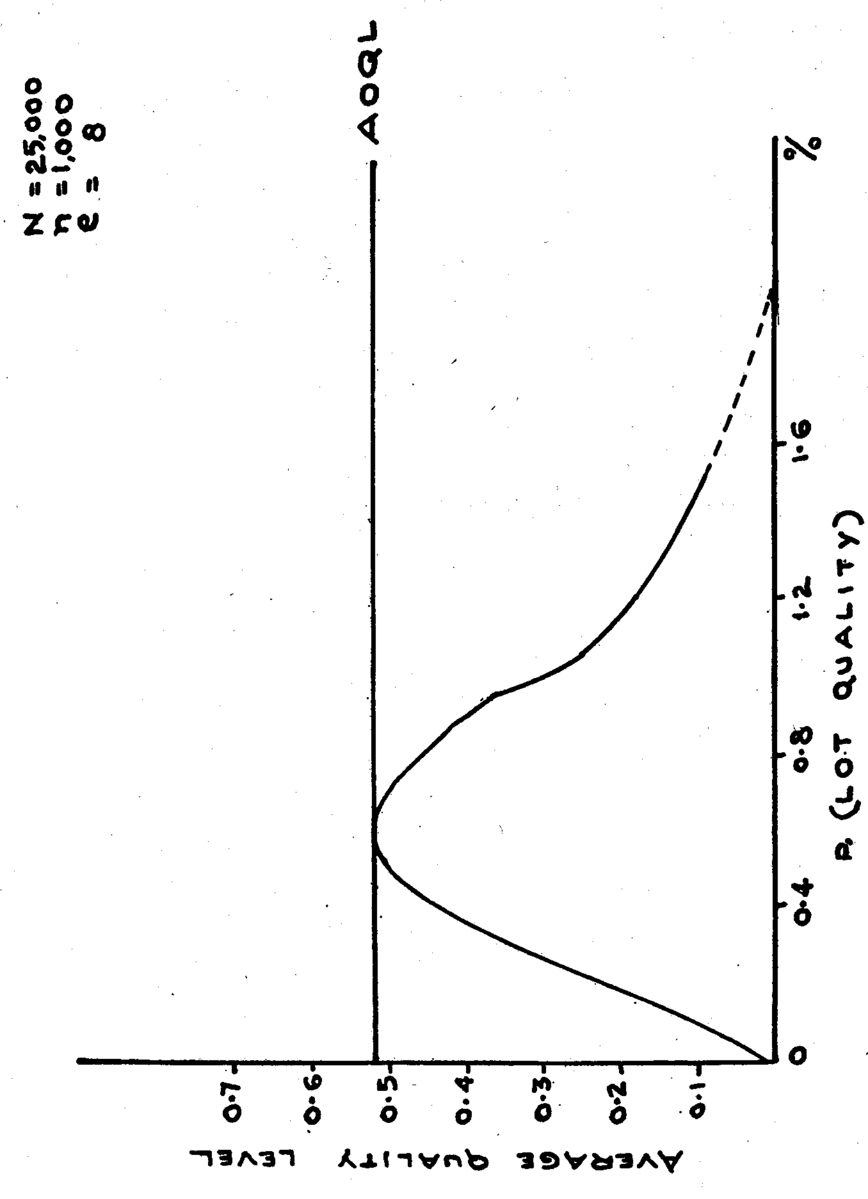
Sampling Plan : N=25,000; n=1000; e=8.

Submitted lot Quality (P)	*nP (n=1000)*	*Pa* (Probability of Acceptance)*	*P. Pa (Average Quality Level)*
0.001	1	1.000	0.0010
0.005	5	0.932	0.0050
0.006	6	0.847	0.0051
0.007	7	0.729	0.0051
0.008	8	0.593	0.0047
0.009	9	0.456	0.0041
0.0095	9.5	0.392	0.0037
0.010	10	0.333	0.0030
0.012	12	0.155	0.0019
0.015	15	0.037	0.0010
0.020	20	0.002	0
0.025	25	0	0

***Ref :** Molina's Table for Poison Probabilities.

GRAPH-III

AQL CURVE FOR SINGLE SAMPLING PLAN



100% acceptance results. At the most, a liberal SQC man will design a plan so that he confines himself to process about 70% of the total lot subjected for post-martem. Hence implementation of this scientific technique necessitates a cleverly systematised distribution of the lot assuring the optimum output adhering to Average Outgoing Quality Limit (AOQL).

(b) Implementation of the Single Sampling Plan for attributes in the Works will ease the functioning of the Finishing Section. It is possible to seggregate the major production of cut sheets for direct counting and finishing. Hence, it is suggested that, if application of the sampling plan goes hand in hand with installation of a Ream-counting machine, the efficiency of the Finishing Section can easily be doubled. The Ream counting machine counts the sheets in the individual stacks into reams at a faster rate (about 1500 sheets per minute). The counted reams can be packed in a single or in multiple numbers whichever is possible/desirable.

By adopting this method, It is possible to cope up with more of sheet production without increasing the existing number of Finishers. Also, better finishing efficiency among the Finishers will be a consequent effect as work-load is considerably reduced.

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