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Impact of Sample Size on Determination of Yarn Quality

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ABSTRACT

This paper will deal with the accurate sample size and statistical process that could be used quality control methods in inspecting the yarn quality. This study was conducted in an elastomeric covered yarn production company located in Sri Lanka which is producing 312 yarn cones per day using one yarn machine. They did not have accurate sample size and statistical process control methods for inspecting the yarn quality. Therefore the company's production failure rates were very high and it has affected the overall profit as well as the time management in production. Statistical quality control methods were used to identify the correct sample size. Sample data of defects of yarn come in consecutive days can be used in the p-chart to determine whether the process in expected level and determine the sample size. Each sample had 100 yarn cones. As well as an identified way of the machine adjustments based on operating characteristic functions. According to the result of the sample size calculation, it was found that 104 yarn cones should be selected per day.

KEYWORDS: *Defects, Operating Characteristic Function, P-Chart, Sample Inspection, Yarn*

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1. Introduction

Quality is an important factor to be considered in all industries. Quality of textile is based on the type of yarn used. So that, all manufacturers of yarn concentrate more on quality so that they can withstand in the market.

This paper is related to textile industry, especially to Yarn developing process. The process of conversion of elastic yarn into covered elastomeric yarn. There are various operations takes place in spinning Fig.1 shows the flow diagram of the manufacturing process. This paper identifies the problems occurring during the quality of yarn in different processes. It also describes the preventive action against any failure. In order to tackle the complex problems, the first thing is to construct a well-structured problem formulation a good representation. How to solve the problems from different actions and implementation some rules in the process In this paper and identifies the reason for these problems due to carelessness of employees during manufacturing.

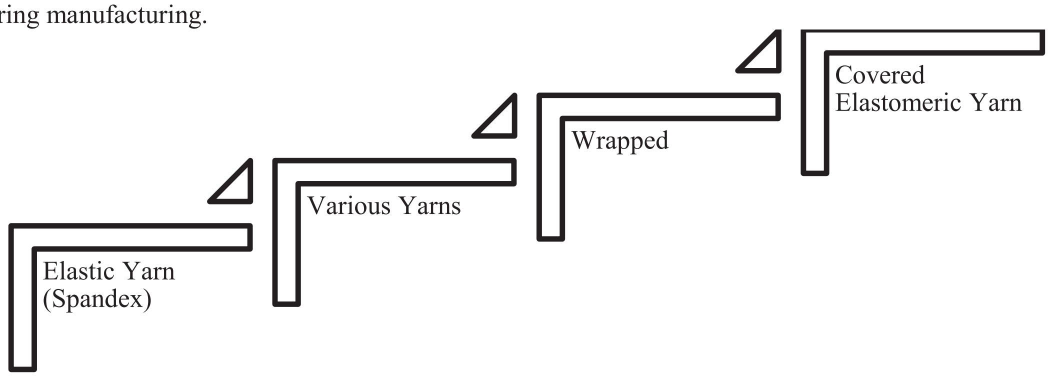

Figure 1: Manufacturing process

2. Statement of the problem

Toady warehouse checks quality of yarn using a random sample. 150 yarn cones have been checked daily. They do not have the exact sample size and machine adjustment date. When products delivered to the customer most of the products gets rejected and quality is re-checked.This is not an efficient method to practice due to the time wastage and the costs of quality re-checks. Therefore, having an exact sample size leads to less product wastage.

3. Objectives of the study

To determine sample size for elastomeric covered yarn.
To identify significant differences of the process.
To identify the machine adjustment date.

4. Review of literature

A research article by Stephanie J. Reed introduces the use of statistical quality control charts in monitoring interviewers.

As a result of that study, he had identified statistical process control charts $\bar{X}$ Chart and R Chart can be very useful in monitoring survey data quality and interviewer productivity.

C.W. Kan and M.P.Lauhave done a research on effect of sampling methods on detection of Yarn Quality. Most of which are based on current research.

The test results obtained from the local spinning mill and the PolyU's spinning workshop show that data obtained by random sampling are more revealing about the reality of a spinning process (whether it is in control or out of control) than fixed samples.

A research article by A. Das &R. chakraboorthi (2012) had studied on elastane-cotton core- spun stretch yarn and fabrics.

This paper is confined to the characterization of yarn properties based on the selected factorial design. They had identified tenacity and breaking elongation of Yarn. With the increase in elastin stretch the yarn tenacity initially increase and the drop. The elastic recovery of elastane core-spun yarn is much higher than the normal cotton yarn. The increase in the level of twist reduces the hairiness of elastane core-spun yarn, but the increase in elastane stretch and the proportion of elastane core component increase the hairiness of yarn.

J. F. Kennedy has been Studying an OC Curve of an Acceptance Sampling Plan. The research problems under consideration are relationships between sampling risks and other elements inbuilt in a single acceptance sampling plan. Two levels of quality are considered. First, the average quality level desired by the consumer AQL, and second, quality level called lot tolerance percent defective LTPD, or the worst level of quality that the consumer may tolerate. The producer's risk α is the risk of incorrect rejection is the risk that the sampling plan will fail to verify an acceptable lot's quality set by AQL and, thus, reject it. The probability of acceptance a lot with LTPD quality is the consumer's risk β or the risk of incorrect accepting. Operating characteristic (OC) curve describes how well an acceptance plan discriminates between good and bad lots. Acceptance sampling plan consists of a sample size n, and the maximum number of defective items that can be found in the sample c. The OC curve pertains to a specific plan, i.e. to a combination of the sample size n and the acceptance criterion.

In this research area they acceptance sampling was concerned with the decision to accept or reject a lot (or batch) of goods. The design of the acceptance sampling process includes decisions about sampling versus complete inspection, attribute versus variable measures, AQL, α ,LTPD, β , and sample size. Management can select the best plan (choosing sample size n and acceptance number c) by using an operating characteristic (OC) curve. If the sample size n is increased, with c, AQL and LTPD fixed, the OC curve would change so that the producer's risk α increases while consumer's risk β decreases. Further, with increasing the critical value c, and with n, AQL and LTPD fixed, the probability being the producer's risk α would decrease, but the probability for consumer's risk β would increase.

5. Methodology

Identify the specific Machine no 4.Thatmeachine's more production were failures.In a day (24 hours) Machine no 4 produces at least 312 yarn cones. Normally weights of yarn cone is approximately 0.5, 1.0, 1.2 kg. Because yarn has different size length.Collect 20 samples in 20 consecutive days in randomly. Each sample has 100 yarn cones. By inspecting of yarn cone in each day it is possible to whether, yarn cone was useful or not. Identify the number of defects of yarn cones. Defect as yarn did not properly covered, the yarn has some thick and thin places, when tension, stretch and modulus of covered yarn have been changed.

Using fraction non-conforming chartrepresent defects of each sample.(Duclos and Voirin, 2010). If the processis out of control, then omitted the out of bound sample and again check whether process is in control or out of control. When the process is in control and lower control limits at least equal zero we can find the proper sample size using below equation.(Montgomery, 2008, p. 274)(Noordzij et al., 2010)

$$n > \left[\frac{1-P}{P}\right] * K^2 \qquad (1)$$

Where k=3 sigma limits

During the next 10 days adjust the machine and get new 10 samples. Test the hypothesis that the process fraction non-conforming in this current ten day period differs from the process fraction non-conforming in the preliminary data.

Calculated the probability of type II error in the fraction nonconforming control chart may be computed from

$$\beta = P\{D < n\ UCL|\ P\} - P\ \{D \leq n\ LCL|P\} \qquad (2)$$

and calculating average run lengths (ARLs)for the fraction nonconforming control charts using Eq-3 (Montgomery, 2008, p. 257)

Thus, if the process is out of control then

$$ARL = \frac{1}{1-\beta} \qquad (3)$$

6. Results and Discussion

20 samples from 20 consecutive days from the production and each were consisting with 100 yarn cones.

Table 1: Number of Defects of 100 yarn cones

Sample number	Number of defects of yarn cones	Sample number	Number of defects of yarn cones
1	12	11	2
2	15	12	9
3	8	13	17
4	10	14	8
5	4	15	15
6	3	16	10
7	1	17	11
8	0	18	0
9	5	19	18
10	13	20	5

The sample fraction non-conforming from each preliminary sample is plotted on figure 2.

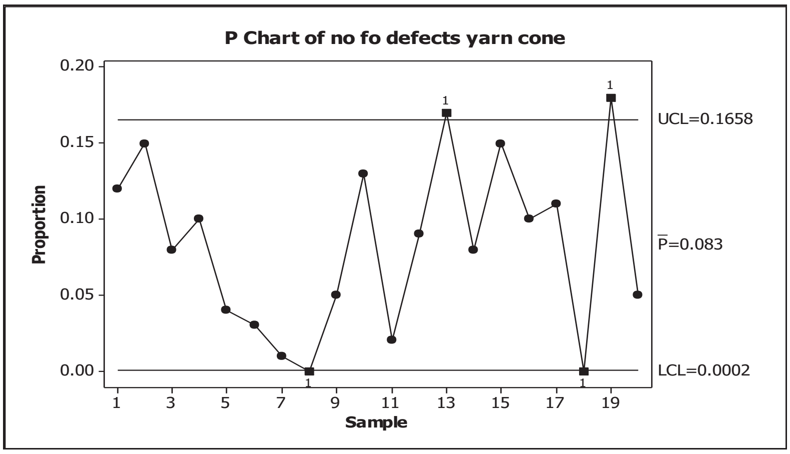

Figure 2: Initial Fraction non-conforming control chart for the data in Table 1

In figure 2, there are four samples 8, 13, 18, 19 are plotted in out of control limits. These points must be investigated to see whether an assignable cause can be determined.

Then consequently samples 8, 13, 18 and 19 are eliminated. The revised center line and control limits are shown in the figure below.

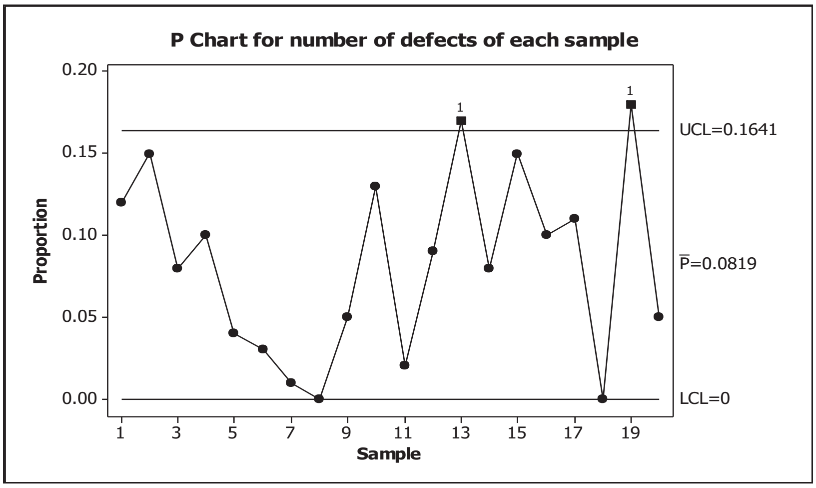

Figure 3: Revised control limits for the data in Table 1

Figure 4 not dropped samples 8, 13, 18, 19 from the chart, but they have been excluded from the control limit calculations. Comparing these two charts we can see the process is in control at the level P=0. 0819 and that the revised control limits should be adopted for monitoring current production.

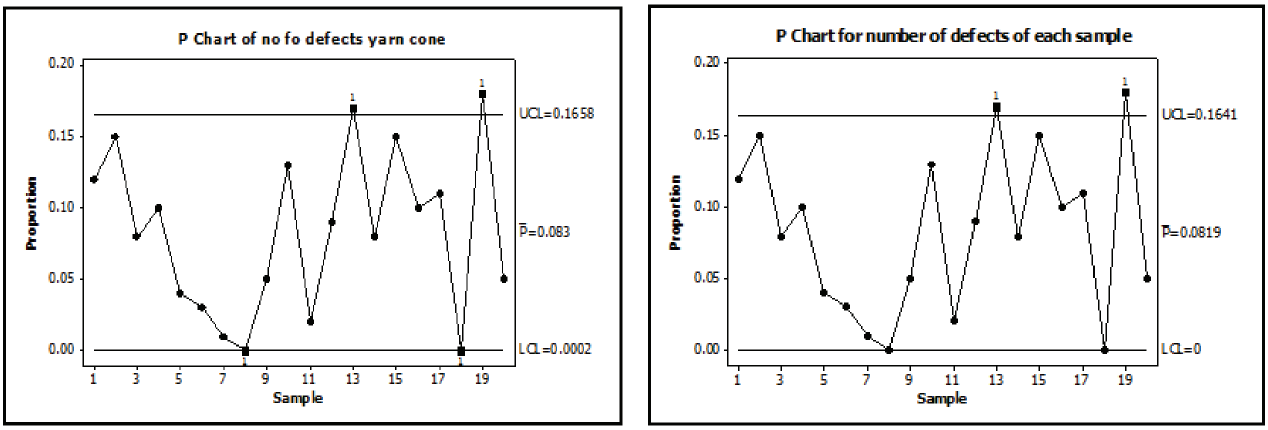

Figure 4: Comparing Control Charts

Considering the above results next we calculate the proper sample size that they can use to keep the quality of products.

According to the figure 4.2 we can observe that lower control limit at least equal zero and proportion defective is P=0. 08. Therefore, using the Eq.(1) we can find the proper sample size as below.

$$n > \left[\frac{1-P}{P}\right] * K^2$$

$$n > \left[\frac{1-0.08}{0.08}\right] * 3^2$$

$$n > 103.5$$

$$104\ samples$$

Next we are focusing to analyze how machine adjustment effects to keep the quality of product which is doing at the each month. Therefore, after the machine adjustment collected another ten samples during the next 10 days. These data are shown in Table 2, and the sample fraction nonconforming is plotted on the control chart in Figure 5.

Table 2: Number of defects of Yarn cone in 10 samples

Sample number	Number of defects
21	3
22	4
23	7
24	3
25	9
26	4
27	0
28	1
29	2
30	6

The figure 6 shows the control chart develops for above data with centerline at $\bar{P} = 0.0654$ .We can see sample no 21-30 are in the inside of the control limits. Now, we identify new quality level that is substantially better than the center line of $\bar{p}$=0.083.

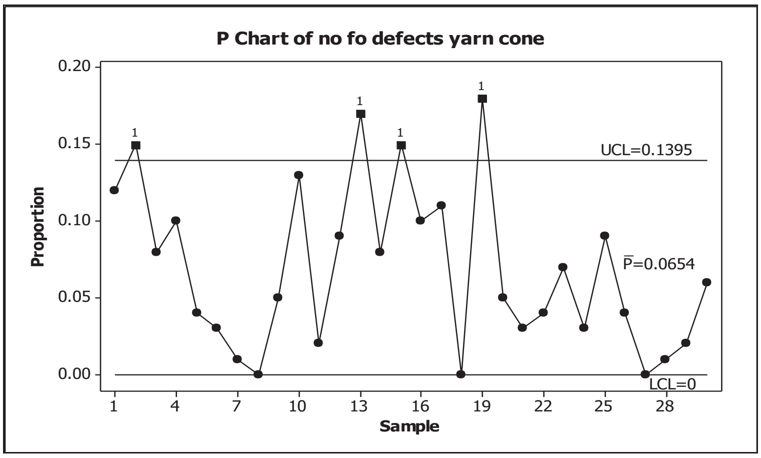

Figure 5: Continuation of the fraction nonconforming control chart

When we observed the data we can see the difference between before and after the machine adjustment.

Test the hypothesis that the process fraction Nonconforming in this current three-shift period differs from the process fraction nonconforming in the preliminary data.

The hypotheses are

$H_0 : P_1 = P_2$
$H_1 : P_1 > P_2$

P_1- Process fraction nonconforming from the preliminary data

P_2 - Process fraction nonconforming in the current period.

We may estimate P_1 by $\widehat{P_1} = \bar{P} = 0.0819$ and P_2 by

$$\widehat{P_2} = \frac{\sum_{i=21}^{30} Di}{100 * 10} = \frac{39}{100 * 10} = 0.039$$

The approximation

$$Z_0 = \frac{\hat{P}_1 - \hat{P}_2}{\sqrt{\hat{P}(1-\hat{P})\left[\frac{1}{n_1} + \frac{1}{n_2}\right]}}$$

Where $\hat{P} = \frac{n_1\hat{P}_1 + n_2\hat{P}_2}{n_1 + n_2}$

$$\hat{P} = \frac{1600 * 0.0819 + 1000 * 0.039}{2600}$$

$= 0.0654$

$$Z_o = \frac{0.0819 - 0.039}{\sqrt{0.0654(1-0.0654)\left[\frac{1}{1600} + \frac{1}{1000}\right]}}$$

$= 4.3046$

Commonly this to the upper 0.05 point of the standard normal distribution.

$Zo = 4.3046 > Z_{0.05} = 1.645$

Consequently, we reject H_o and conclude that there has been a significant decrease in the process fallout.

Based on the apparently successful process adjustments, it seems logical to revise the control limits again, using only the most recent samples (numbers 21–30).

This results in the new control chart parameters:

Center line $(\bar{P}) = 0.039$

$$UCL = \bar{P} + 3\sqrt{\frac{\bar{P}\,(1-\bar{P})}{n}}$$

$$= 0.039 + 3\sqrt{\frac{0.039(1-0.039)}{100}}$$

$$= 0.097078$$

$$LCL = \bar{P} - 3\sqrt{\frac{\bar{P}\,(1-\bar{P})}{n}}$$

$$= 0.039 - 3\sqrt{\frac{0.039(1-0.039)}{100}}$$

$$= -0.019078$$

$$= 0$$

Figure 7shows the control chart with these new parameters. Note that since the calculated lower control limit is less than zero, we have set LCL = 0. Therefore, the new control chart will have only an upper control limit. From inspection of Figure 6, we see that all the points would fall inside the revised upper control limit. Therefore, we conclude that the process is in control at this new level.

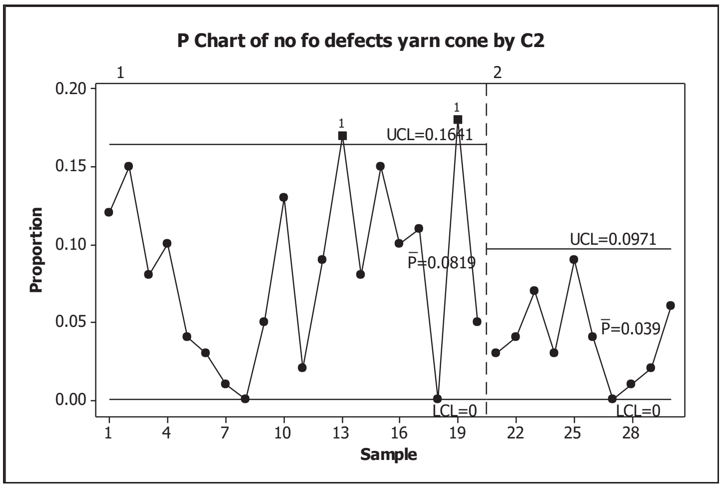

Figure 6: Completed Fraction non-conforming chart

The calculation required to generate the OC curve for a control chart or fraction nonconforming with parameters n=100, LCL=0. 0, UCL = 0.0971.using these parameters Eq.(2) becomes

$$\beta = P\{D < (100)(0.0971)|\, P\} - P\,\{D \leq (100)(0)|P\}$$

$$= P\{D < 9.71|\, P\} - P\,\{D \leq 0|P\}$$

Table 3:Type II error

P	P{D<=10|P}	P{D<=0|P}	β
0.01	1	0.366	0.634
0.03	0.9991	0.0476	0.9515
0.05	0.9718	0.0059	0.9659
0.1	0.4513	0	0.4513
0.15	0.0551	0	0.0551
0.2	0.0023	0	0.0023
0.25	0	0	0
0.3	0	0	0
0.35	0	0	0
0.4	0	0	0
0.45	0	0	0
0.5	0	0	0

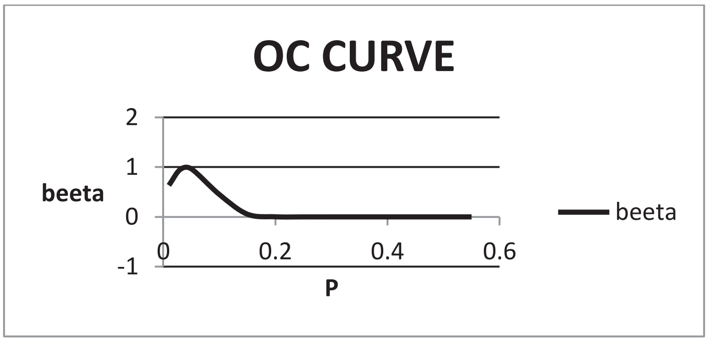

Figure 7: Oc curve in the p chart with $\bar{P} = 0.039$, $LCL = 0.0$, $UCl = 0.0971$

If the process is in control with $= \bar{P}$, the probability of a point plotting in control is = 0.9515.

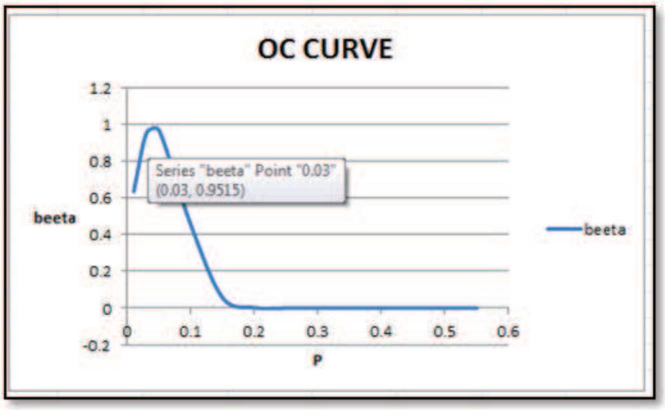

Figure 8 : OC curve for finding the β value

Thus, in this case $1 - \beta = 0.0485$, and the ARL is using Eq.(3) $\frac{1}{0.0485} = 20.62$
Using figure 8 if the process is really in control, it will experience a "False alarm" out of control signal about every 21 samples. Adjust the machines after getting 21 samples.

Conclusions

The Conclusion could be drawn that the process was going to in control and lower control limit was equal to the zero value. So in this research more work done to identify defect samples and did a literature based evaluation on those techniques. At least 104 samples should be inspected per day.

As the yarn is a base material for textile manufacturing concentrated on improving the quality of yarn. By removing the accumulated waste automatically at a periodic interval of time, working efficiency of suction motor is improved; this in turn improves the operation of autoconer and thus the quality of yarn. Though the winding process stops for a few minutes it does not affect productivity.

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