(REFEREED RESEARCH)

THE APPLICATION OF 'p' AND 'p-CUSUM' CHARTS INTO TEXTILE SECTOR IN THE STATISTICAL QUALITY CONTROL PROCESS

İSTATİSTİKSEL KALİTE KONTROL SÜRECİNDE p VE p-CUSUM GRAFİKLERİNİN TEKSTİL SEKTÖRÜNDE UYGULANMASI

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ABSTRACT

As in every sector, in textile sector, quality is of great importance for consumers and producers. Thus, this study is carried out to increase level of quality. In this study, it is analyzed the errors, the reasons and the results during the production process in a textile company in Denizli. The data on errors are obtained from check reports of the Quality Department. Technical features of production process are presented in control charts. Thanks to data on products in certain and equal time periods, control charts such as 'p' (Defect Percentage of Charts) and 'p-CUSUM' (The Cumulative Sum Of Charts) are used to research whether or not the production is suitable for the standards or desired quality level. Data on production in July 2012- June 2013 are analyzed by comparing different methods. Through the use of two different control charts, it is both compared different methods and obtained feddback about quality level. IBM SPSS Version 21 and Microsoft Excel 2007 programs are used during the prepartion of control charts. Quality control level of error rates is identified as different and inconsistent. In the end of this study, it is appropriate to use both control chart methods together.

Key Words: Quality, Statistical quality control, p-Chart, p-CUSUM chart, Pareto analysis.

ÖZET

Her sektörde olduğu gibi tekstil sektöründe de kalite müşteriler ve üreticiler için büyük önem taşımaktadır. Bu yüzden kalite düzeyinin arttırılması amacıyla bu çalışma yapılmıştır. Bu çalışmada Denizli'de faaliyet gösteren bir tekstil şirketinin üretim sürecindeki hatalar, nedenleri ve sonuçları incelenmiştir. Hata verileri kalite bölümünün kontrol raporlarından elde edilmiştir. Üretim sürecinin sahip olduğu teknik özelliklerin durumu kontrol grafikleri ile sunulmuştur. Ürünlerin belirli ve eşit zaman periyotlarında elde edilen verilerle p (Kusur yüzdesi grafikleri) ve p-CUSUM (Kümülâtif toplam) kontrol grafikleri yardımıyla üretimin hedeflenen kalite düzeyinde veya standartlara uygun olup olmadığını araştırmak için kullanılmıştır. Üretimin Temmuz 2012 - Haziran 2013 arası verileri farklı yöntemlerle kıyaslanarak incelenmiştir. İki farklı kontrol grafiği yöntemi kullanılarak hem farklı yöntemler karşılaştırılmıştır, hem de kalite düzeyi hakkında görüş belirtilmiştir. Kontrol grafikleri hazırlanırken, IBM SPSS Version 21 ve Microsoft Excel 2007 programları kullanılmıştır. Hata oranlarının kalite kontrol seviyesi p-kontrol ve p-CUSUM grafiklerinde farklı ve tutarsız olduğu tespit edilmiştir. Bu çalışmanın sonucunda uygun olan her iki kontrol grafiği yönteminin birlikte kullanılmasıdır.

Anahtar Kelimeler: Kalite, İstatistiksel kalite kontrol, p-Grafiği, p-CUSUM grafiği, Pareto analizi.

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1. INTRODUCTION

Nowadays, the concept quality has an important place with widespread use. Quality is one of the indispensable elements of human life. It's closely related to the concept quality to keep the continuity and profitability of companies in the global competitive markets.

No matter how far technology goes a head, in practice products don't indicate a 100% compliance with required standards (1). Continuous improvement is essential to ensure superior quality.

In this study, errors and results during the production period are analyzed in a textile business operating in Denizli with a wide range of products. The data on errors are obtained from check reports of the Quality Department Employees. Whether or not the production has got identified technical qualifications are presented in control charts. The data within one year are included in the study. This study is conducted to ensure the improvement of quality and utility for production.

2. STATISTICAL QUALITY CONTROL

Deming W.E. describes Statistical Quality Control like that 'Statistical Quality Control covers all application stages in production of statistical principles and methods in order to ensure the production of a product the most economically and the highest usefully and also in the way of having a market' (2).

Statistical process control is a tool used for minimizing the production of defective products and a tool which aims at adherence to the standarts, also enables production to comply with expected quality specifications (3).

Reasons of variability for quality is divided into two groups as general and specific reasons. General reasons are random impairments existing in process functions and the ones which consist of natural reasons. These mentioned impairments cause predictable variabilities in process characteristics of products and they can't be destroyed unless there isn't variability in the business. Whereas, variability often needs important expenses and large investments. General reasons ocur based on some factors like working conditions, technological levels of machines, the nature of quality program, the determination of raw materials features. Specific reasons cause unexpected impairments in the process and in the product variability. Specific reasons aren't related to the characteristics of process; they are impairments resulting from a certain reason like workers position, raw material noncompliance, distortions of machine settings. The presence of specific factors is immediately understandable in a well-designed process control. The presence of change because of specific reasons can only be determined by statistical process control (4).

The most important aim of statistical process control is to keep process under control by destroying specific reasons of process change (5). Thus, errors and their reasons are analyzed by checking process output.

Prof. Dr. Kaoru İshikawa claims that 95% of an enterprise problems can be solved seven quality control methods (6). Statistical process control tools are process flow diagrams, control charts, histograms, pareto analysis, cause-effect diagrams, scatter diagrams, control cards. Control charts and pareto analysis are included in the study.

3. CONTROL GRAPHS

Dr. Walter A. Shewart found the difference between controlled and uncontrolled changes related to general and specific reasons. Therefore, control charts are also called as 'Shewart Control Charts' (5).

Control charts are important tools for process development. The use of control charts is a step to be taken previously to destroy determinable reasons to minimize the process variability and to stabilize the process performance (7).

Quality control has been defined as an effective systems to integrate quality improvement, quality maintenance, quality improvement efforts of the various groups in an organization, to enable production and service at the most economical levels for a full customer satisfaction. According to this definition, quality control must be cover the entire organization (8).

W.A. Shewart points out that control schemes help for firstly indicating the target, secondly being used as a tool to reach an aim, thirdly measuring whether or not to reach an aim (9).

Changes from non-natural causes affect the process adversely, thus these causes should be identified, researched and kept under control. A control scheme is a significant tool to distinguish whether changes in the process consist of natural or non-natural causes (2).

The benefits of quality control charts:

- Introducing basic changes of quality features,
- Measuring the quality change performance,
- Determining the average level of quality features (10)

Control charts are divided into two parts as qualitative and quantitative control charts. Other control charts based on individual observation; Cumulative Total (CUSUM) Control Charts, Moving Average (MA) Control Charts, Exponentially Weighted (EWMA) Control Charts and Regression Control Charts.

The following steps are suggested for the process stability analysis and control charts;

- Determining the quality property to be analyzed.
- Sampling based on rational subgroups.
- Determining control scheme and control limits.
- Drawing charts by pointing the marks about the production related to time.
- Identifying points which may be off limits and abnormal movements, researching their causes and taking corrective measures (11).

Control charts will only identify assignable causes of variation. Management must then authorize action to eliminate the assignable causes (12).

3.1. p Control Chart

Let us consider the case where the output quality is measured in term of the items being either nondefective or defective. The decision to continue or to adjust the production process will be based on p, the proportion of defective items found in a sample of the output. The control chart used for proportion defective data is called a p chart (12).

P (Defect Percentage) Control Chart method which is one of quantitive control charts is used to research whether products obtained in certain and equal time period are defective or not instead of researching the products whether suitable or not to the standards.

Table 1. Notations used in study for p- Control Charts

	p- Control Charts (The situation of unknown standards)
UCL	$\overline{p} + 3\sqrt{\overline{p}\overline{q} / n}$
CL	$\overline{p}$
LCL	$\overline{p} - 3\sqrt{\overline{p}\overline{q} / n}$

The possible reasons of being out of control of the process;

- Extreme Points: The situation of one or more points above or below of control limits.
- 2 of 3 points are inside or outside of A region: Two of three consecutive points are near the control limits.
- 4 of 5 points are inside or outside of B region: The situation of being close to warning borders of 4 of 5 consecutive points.
- 7 or more consecutive points are on the same side of centrel line: The situation of on the one side of the center line (above or below). (This situation is called Run.)
- Linear Trend: 7 or more points raise continuously or lower. (This situation is called a trend.)
- Unstable Trend: 10 of consecutive 11 points (12 of 14 points, 14 of 17 points or 16 of 20 points) are on the one of center line.
- The avoidance test from C-zone which is near the center line: In the 1/3 section which remains the middle of control limits, the situation of being less points than 2/3 of total points.
- The situation of collecting in C zone near of the centrel line: Very close to the center line of all points (satisfaction) status.

These mentioned situations are interpreted as an unusual trend in the course of process (5). When looking at p-Control Chart included in the study, more or seven consecutive points are on the same side of the center line and it's understood as condition of unstable trend.

3.2. p-Cusum Control Chart

By observing cumulatively the difference between Cumulative Sums Method developed as an alternative to Shewart diagrams, the actual performance and target strenght, it is researched whether the process is under control or out of control (13).

The use of The Cumulative Sum (CUSUM) has been suggested for both surveillance and quality control. Its use for examining sequential measures or for looking for changes over time has recently been described (14).

Cusum (The Cumulative Sum) Control Chart is a graphical representation of the variable resulting from series of consecutive transactions based on time basically. Cusum or as Turkish Cumulative Sum Technique is first discovered by Page in 1954. This chart is designed to reveal the ratio of unfavorably produced products and its related performance. In acceptable level of performance, Cusum curve lies on or above the horizontal line randomly. However, if it is at on unacceptable level of performance, the curve Cusum indicates an upward slope and as a result, a decision interval occurs. In this way, Cusum Control Chart enables to determine unfavorable production level (15).

It may occur positive or negative shifts from a targeted certain value in a process. According to Cusum Control Charts, a method named 'V-mask' is used to determine whether possible shifts in the process average are under control or not (16).

Table 2. Used in study the notation for p-Cusum Control Chart of V-mask

$X_m = \sum_{i=1}^{m} \left(\overline{X}_i - \mu_0\right)$	$\theta = \tan^{-1}\left(\frac{D}{2\sigma_{\bar{x}}}\right)$	$d = \sqrt{\frac{R\sqrt{n}}{\sigma_{\bar{x}}}}$

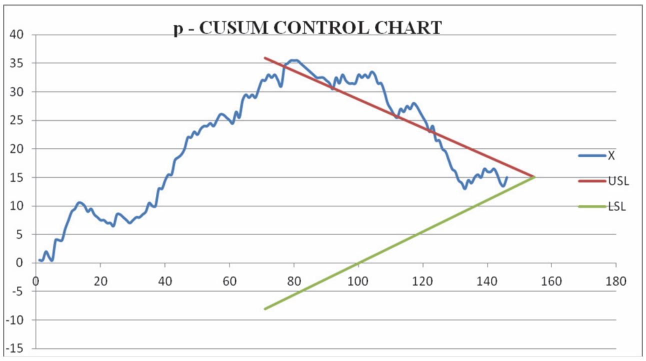

Figure 2. p-Cusum Control Chart

3.3. Pareto Analysis

Named by Italian economist Wilfredo Pareto, this tool is also known as the rule of 80-20. The problems and reasons are degreeded with the logic like that; '80% of analysis problems is based on 20% of the transactions carried out.' So, this way enables to focus on the most important causes. Therefore, cumulative frequency values are obtained by the frequencies identified for histograms. These values are placed into the x axis as the most used ones on the most left and least seen on the most right (17).

In the study, the errors are cared as four factors like presentation, fabric, make-up and componentry. These are divided into 44 sub-factors. Presentation errors are evaluated as pressing defects, soiled-stained, chemical odour, hanger appeal crushing, packaging incorrect and other presentation errors. Fabric errors are evaluated as flews-faults-holes-contemination in fabric-lining, uneven yarn or fabric surface, fabric handle-drape outside specification, snagging plucks, floats on embroidery outside specification, poor transfer of rib to well body, sewing out of wale, leather of unacceptable quality outside specification, printing or dyeing faults, washing abrasion, shading within product outside specification, shading between products outside specification, yellowing, poor temination of components and other fabric errors. Make-up errors are evaluated as seam breakdown (non-inclusion/ insecure/ cracking), seams tension incorrect (puckered/ grinning/ roping), seam position incorrect (twisting/ stretches), linking-bind off breakdown, poor trimming, needle damage (including laddering), uneven panels (fronts, vents, cuffs, pleats), uneven hems (dipping/ uneven/ roping), uneven welts (uneven/ flipping up), incorrect garment balance (presentation or fabric), product features insecure or misaligned, fastenings insecure or misaligned, pockets or flap not level, incorrect pocket finish (bagging/ pulling in), incorrect elastication, hem attachment and other make-up errors. Componentry errors are evaluated as incorrect attachment, poor component apperance, damaged component, non-operational fastening, button attachment and other componentry errors. However in the study, data of 12 months in various amounts are used. In the table below, it is given faulty products numbers and error causes in the selected sample for only June the month.

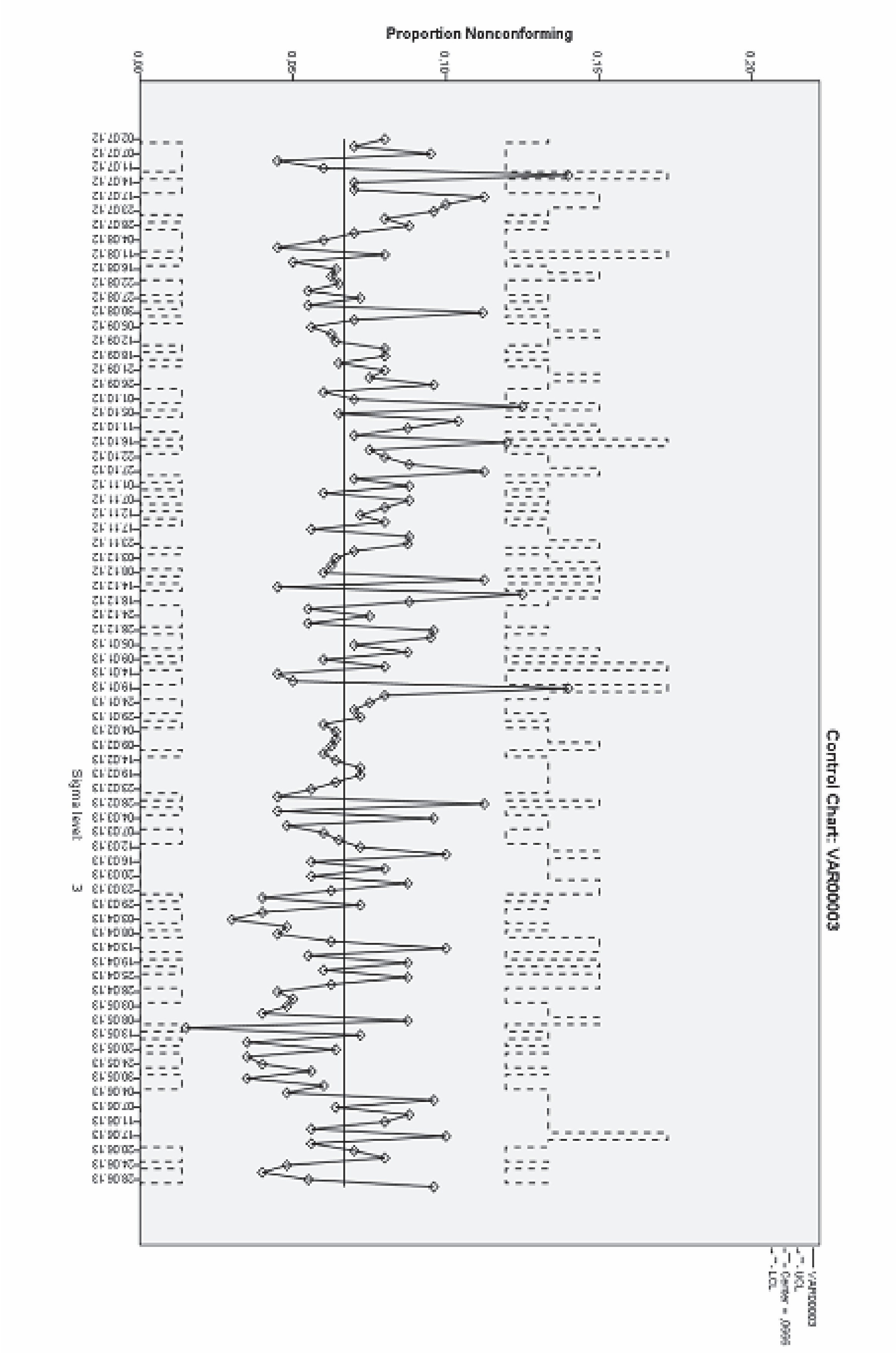

Figure 1. p Control Chart

Table 3. Causes and numbers of errors for June 2013

	The Sample														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
The Main Mass	3159	1132	2332	2093	1870	1555	1454	998	1506	8000	4503	1357	2560	200	125
The Sample	200	125	125	125	125	125	125	50	125	200	200	125	200	200	125
Number of errors	12	6	12	8	11	10	7	5	7	14	16	6	8	11	12
Presentation errors	3	2	2	3	2	5	1	2	2	6	4	2	2	3	6
Fabric errors	0	4	0	2	0	0	0	0	0	0	7	0	0	0	2
Make-up errors	9	0	8	3	9	5	6	3	5	8	2	4	6	8	4
Componentry errors	0	0	2	0	0	0	0	0	0	0	3	0	0	0	0

The classification of production error types will help for improving the quality and so it will be clear to understand which errors are of more importance. In this way, fixing costs will be minimized and performance will be improved in the most profitable way. Pareto diagrams are given in order to stress the importance degrees of errors and to make accurate and timely arrangements. According to Pareto principle, a very large part of nonconformities are based on a few certain reasons and the determination of these reasons plays a key role in problem solving (18).

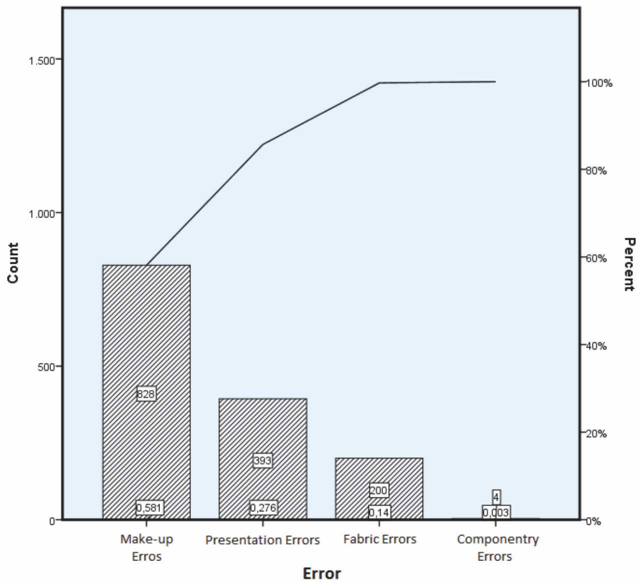

Figure 3. Pareto analysis kind of defect

4. CONCLUSION

In the application, it is evaluated data on quality control reports of orders in July 2012- June 2013 in a textile company operating for producing various productions. Research reports are taken into consideration under the quality control of the 21,445 product for 1 year.

During the production significant differences about inspection measurements of the people working in the control department cause lack of information about error types. Part of this study original proposal can be made to perform a new regulation on the quality control department. Accurate identification of errors is the first step in improving quality.

The errors in Pareto analysis are found to be 86% of errors in make-up and presentation. This rate can be reduced to a minimum level by better identification of error types.

According to the findings of the study, the results of p-Cusum Control Chart and p Control Chart are inconsistent.

P Control Chart prepared for error rates of analyzed samples shows the production in control. The quality level of textile firm is at the level of 0,07% per annum, but it can't be reached to the aimed control level of 0,05% the aimed control level of 0.005 % is approached more in the last six-month period. Considering the whole year, a declining trend in error rates is observed based on p control chart. However, instability in p rates shows the discrepancy between products of the firm. The changes by the firm since January 2013 influence the firm positively. It is necessary that the positive changes for the aimed quality level must be permanent and increased.

Although the error rate in production is at the control level in p Control Charts, when V mask is applied according to 1σ deviations in p-Cusum Control Charts, it is concluded that error rate isn't at control level. The error rates in produciton are at the control level since 10 May, 2013. Therefore, the remarkable declining trend in p Control Charts gains a clearer view p-Cusum Control Charts.

Shewart p Control Chart gives better results while identifying larger deviations then average. But productions in the process is evaluated independently from each other. But p-Cusum Control Chart gives better results in the determination of smaller deviations than average. However, evaluating the production of p-Cusum Charts cumulatively and completely provides more coherent information about production process.

Results are evaluated with different graphics models used in application. When evaluating with different graphics models and in similar ways, the comparison of the results and the evaluation together make the information more coherent and more accurate. It is suggested to use more than one method of quality control charts instead of a single quality control graphics for similar quality control proccess studies.

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