(REFEREED RESEARCH)

REDUCING PRODUCT DEFECTS IN APPAREL MANUFACTURING BY USING THE SIX SIGMA METHODOLOGY: A CASE STUDY

HAZIR GİYİM ÜRETİMİNDE ALTI SİGMA YÖNTEMİNİ KULLANARAK ÜRETİM HATALARININ AZALTILMASI: BİR ÖRNEK ÇALIŞMA

Kürşat ÖNCÜL[1], M. Çetin ERDOĞAN[2], Mustafa GÜNEŞ[3]

[1]Ege University, Emel Akın Vocational Training School, İzmir, Turkey
[2]Ege University, Department of Textile Engineering, İzmir, Turkey
[3]Gediz University, Department of Industrial Engineering, İzmir, Turkey

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ABSTRACT

Six Sigma is a statistical methodology aiming to reduce and preclude failures in business processes. Its the foremost principle is that once the number of refuses in any process is discernible, the procedures can be established to systematically prevent them. This paper reports a performance of an implementation of the Six Sigma Methodology in an apparel plant, that has provided an increase of 13% in the manufacturing productivity of trousers by minimization of sewing thread breakage. This accomplishment has been obtained by reducing the thread breakages in the process of the sewing trademark label to the rear center of a trouser.

Key Words: Six Sigma, Apparel manufacturing, Productivity, Quality, Process management, Process improvement.

ÖZET

Altı Sigma, çalışma ortamlarında ortaya çıkan hataların azaltılması ve önlenmesini amaçlayan istatistiksel bir metodolojidir. Herhangi bir işlemde istenmeyen durumları sistemli bir şekilde önleyecek yöntemlerin geliştirilebilmesinin bu olumsuzlukların sayılarının ortaya çıkarılmasına bağlı olduğunu temel bir esas olarak kabul etmektedir. Bu yazıda, bir konfeksiyon işletmesinde dikiş ipliği kopuşlarını en aza indirme çalışmasıyle pantolon üretimi verimliliğinde %13 artış sağlayan Altı Sigma Yöntemi'nin bir uygulaması gösterilmektedir. Bu verimlilik artışı, pantolonun arka ortasına marka etiketi dikim işleminde dikiş ipliği kopuşlarının azaltılması ile elde edilmiştir.

Anahtar Kelimeler: Altı Sigma, Konfeksiyon, Verimlilik, Kalite, Süreç yönetimi, Süreç iyileştirme.

Corresponding Author: Kürşat Öncül, kursat.oncul@ege.edu.tr, Tel: +90.232.342 60 53

1. INTRODUCTION

Today, with the development of industrial applications and technologies, the manufacturing industry has begun to work on machines with more advanced configuration and higher production performance than it was 20 or 30 years ago. However, incessant errors and cessations in production processes have continued to compel researchers to design new solutions.

The introduction of wide range of innovative methods for process quality control has ultimately provided the constitution of various methodologies on quality and productivity. For example, the implementation of Six Sigma has been abundantly affirmed as one of the most adequate and productive problem-solving methods for quality concerns. The DMAIC (the acronym for define – measure – analyze – improve - control) perspective has been very influential for diagnosing and solving a problem, and sustaining the resolution (1).

In a study carried out by Kerekes and Johanyák (2), the formulation of eleven suggestions for constructive modifications was concluded by the application of the FMEA for different elements and parts that frequently subjected to failure. The economical analysis showed that the adoption of the suggested modifications can contribute to a 19% decrease in material costs and 24% in production costs.

Yucel (3) carried out an application of FMEA for defining the potential fault types and decreasing the negative effect on production systems in a clothing factory. A team was set up to determine the causes of the faults. In conclusion, it was obtained 4.1% decrease of seam fault in the trouser production line and 5.2% in the shirt production line. Additionally, 966.3 minutes reduction time was achieved in the fault correction.

Academic research into this management approach has been circumscribed whereas many books and papers on Six Sigma have come up in the professional literature. Scholarly inquiry is necessary to acquire an comprehensive and scientific understanding of Six Sigma and distinguish reality from imagination (4).

This paper reports a Six Sigma project on the reducing the sewing thread breakages in sewing trademark label to the rear center of trouser by implementing the Six Sigma Methodology at an apparel manufacturing plant (5). The breakages at the level of approximately 10% adversely affect the workflow and the cost level. Since the replacement of the thread on the sewing machine before resuming the sewing process takes away valuable time, frequent breakages induce decrease in the productivity of both the process operator and the company, and therefore the process is subject to be improved.

2. MATERIAL AND METHOD

Company’s trademark label is sewn to the rear center of trouser on a few models that correspond approximately 80% of the plant's daily trouser production. The Six Sigma Methodology was deployed to solve the problem of the thread breakages. Minitab, a statistical and process management software, was used for statistical calculations.

2.1 The Define Phase

The first step at the beginning of the project was to build a Six Sigma Team. The team is made up of the personnel as follows:

- Champion (General Manager of the firm)
- Master Black Belt (External Project Consultant)
- Black Belt (Project Executive: The corresponding author of this paper)
- Green Belt (Technical Manager of the firm)
- The other personnel:
  - Shift engineer
  - Quality Control operators

An IPO Diagram and a Cause and Effect Diagram of the problem were developed through the initial brainstormings of the team members. The followings are the process information in the IPO Diagram designed by the Six Sigma Team:

- Input:
  - Trouser on which the belt was sewn (100% wool)
  - Belt interlining
  - Muslin
  - Trademark
  - Sewing needle (DPx5, No:12, No:14)
  - Sewing yarn (100% pes, 30 tex, 20 tex)
  - Stopstitch machine
- Process
  - Sewing treademark label to the rear center of trouser.
- Output
  - Trouser on which treademark label sewn to the rear center.

The Table 1 shows the probable factors (including the noise factors, the procedure factors, and the process parameters) affecting the sewing trademark label to the rear center of trouser, in the form of Cause and Effect Diagram built by the Six Sigma Team:

The trademark label is fixed with a total of four stopstitches, one in every corner of the label by the sewing needle coming back and forth in 2 mm distance between two points in the process of the sewing label on the stopstitch machine (Figure 1).

Figure 1. The Display of a Sewed Trademark Label to the Rear Center of a Trouser.

Table 1. Cause and Effect Diagram of Probable Factors.

Material	Machine	Environment
-Type of the interlining -Unit weight of the interlining -Type of the muslin -Unit weight of the muslin -Friction resistance of the sewing yarn -Tensile strength of the sewing yarn -Type of the sewing yarn -Number of the sewing yarn -Type of the fabric -Weaving design of the fabric -Unit weight of the fabric	-Production date of the machine -Type of the machine -Sewing speed of the machine -Tension of the lower sewing yarn -Tension of the upper sewing yarn -Temperature of the sewing needle -Number of the sewing needle -Attribute of the sewing needle	-Moisture of the environment -Temperature of the environment

The time duration required is 37 seconds for sewing a trademark label, 32 seconds for resuming the process after a sewing thread breakage occures, and 45.21 minutes for sewing an entire pant. The data are collected in the time studies carried out in the manufacturing plant.

The team brainstormed about which factors could be changed by levels to solve the problem after the determination of factors in the Cause and Effect Diagram. As a result of the brainstorming a few factors come into prominence such as number of the needle, number of the sewing yarn, and the machine speed.

2.2 The Measure Phase

In the Measure Phase, firstly the sample data of the sewing yarn breakages was collected without any change in the presence of the problem. The p-value of 0.192 (greater than 0.05) indicates that the examined distribution of the data is not statistically different from the normal distribution.

A retrospective study was carried out to determine what the acceptable values for power and sample size of the data. According to the results, when a sample of eight sewings is taken, the actual power for the test is approximately 0.94; for a sample of sixty sewings which is our real value, the power is 1.

Here, the Ppk index is 0.00, indicating that the process must be improved by reducing variability and centering the process on the target. Apparently high value in the number of the present breakages in the process is a much more severe problem for this production line compared to the process having normal flow.

2.3 The Analyze Phase

In the Analyze Phase, as obtained already the number of breakages and the number of the sewings, the relatedness of these variables was calculated. In the results, the Pearson correlation between the number of breakages and the number of the sewings is 0.209. Since the p-value of 0.455 is greater than 0.05, there is adequate indication at a = 0.05 that the correlation is zero.

2.4 The Improve Phase

In the Improve Phase, the process parameters (or factors) were chosen from the probable factors descripted in the Define Phase. These factors and their levels are shown in Table 2.

Table 2. The Factors and Their Levels in the First Factorial Analysis.

Factors	Levels	
	(-)	(+)
Yarn Number (tex)	20	30
Needle Number (DPx5)	12	14
Machine Speed (rpm)	1800	2600
Lower Yarn Tension (cN)	50	150

The center points were included in the design. Adding center points to a design checks for curvature in the response surface. However it was observed that the central points have a small effect (p-value = 0.581) on the first model of the design, and they are not present in the final model, indicating that they have no effect on the process.

The p-values from the sublimated state were evaluated to determine if there is any significant effect. The p-values for the number of the needle, the tension of the lower yarn and the machine speed are significant at alpha = 0.05 significance level. The number of the needle is kept significant because of being a prominent factor.

In the results of the normality test for residuals, the p-value of 0.091 indicates that the normal distribution fits the data well. In the test for equal variances, the data provide enough information (p-value = 0.070) to claim that the populations have equal variances. That is, the values in the ANOVA table of the factorial design can be considered to provide a reasonable information.

The verification experiments on the combinations that were chosen at random were implemented to check whether the results of the factorial analysis were reliable. The results were evaluated by using a Chi-Square Test. P-value smaller than 0,05 indicates that the evidence is enough to admit the results of the verification experiments.

This consequence made us think that the experiments of the verification and the factorial analysis were implemented under different conditions, because the verification experiments were carried out a few days after the factorial analysis experiments.

Evaluating which factor or factors might be changed, the team reached a conclusion that the sewing yarns used on different days were probably not the same yarns. Based on the conclusion, it was decided that the factorial analysis experiments would be implemented again so that the same sewing yarns chosen for their greater strength of breakage would be used in both the factorial analysis experiments and the verification experiments.

The sewing yarns were chosen as 3 yarn coils in each of 3 different production units. 16 samples data of breakage strengths were collected. Tensile strength tests were carried out on a Lloyd Instruments machine together with NEXYGENPlus data analysis software.

According to the results of the Power and Sample Size Test, when a sample of three sewings with the average value of 7 is taken, the actual power for the test is approximately 0.999; for a sample of sixteen sewings which is our real value, the power is 1.

When we reverted back to the Improve Phase, the team decided to include the yarn attribute into the experiments as a process parameter in the factor list. The sublimated model of the factorial analysis gave the results with effective binary and ternary interactions.

In the results of the normality test for residuals, the p-value of 0.005 indicates that the normal distribution doesn't fit the data well. In the test for equal variances, the data provide enough adequacy (p-value = 0.830) to agree that the populations have equal variances. That is, the values in the ANOVA table of the factorial design can be considered to provide a reasonable information.

The result in the verification experiments of the factorial analysis implemented for the second time (Chi-Sq=2) indicates that the output is enough to regard the results of the verification experiments and the factorial analysis experiments as the same. According to the results, the factor combination that causes the less breakage is the combination of yarn number of 20 tex and the machine speed of 1800 rpm.

2.5 The Control Phase

The factor combination setting that causes the less breakage was implemented to the process of the sewing trademark label. The process was controlled by collecting the data of the sewing yarn breakages to stabilize the solution on the production.

In the Distribution Identification, the data collected from the experiments is not distributed normally. But in comparison to other distribution types, the normal distribution was accepted as the most convenient type.

3. RESULTS

In the results of the experimentation, the Process Capability Analysis gave a ZB value of 3.2 and a Ppk value of 1.08, indicating that the process was improved.

Minimum yarn breakage responses after the factorial analysis are achieved in more than one combination. This provides flexible production settings to the management.The average value of the yarn breakages were reduced from 4.6 to 0.2.

The productivity gain achieved from the improvements in the process investigated is 57.38 € per 100 parts. Because each of the models is produced by using different processes, the calculations of the productivity gain are made per 100 parts. The daily production target for the trouser is 750 trousers, and the production rate of the process investigated on the pants is approximately 80%.

4. CONCLUSION

The followings indicate that the Six Sigma Methodology can be applied to apparel manufacturing plants:

- The firm that is subject to the application of Six Sigma has been able provide requirements for the implementation of the method,
- A significant level of productivity gain has been achieved via the improvements in the process.

There should be as much factors as possible in the problem solving technique in the Six Sigma Methodology in order to increase the power of solution. The determination of factors largely depends on the brainstorming performance of the Six Sigma Team. Thus the effort of including at least one representative personnel from each department into the Six Sigma Team becomes one of the most important issues about the building an effective Six Sigma Team.

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