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Analysis of Reasons of Breakage in Bag Production Machine for Agricultural Materials

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Abstract: In a globalizing world, the borders on the map have started to disappear economically and customers in the world economy expect high levels of quality from their suppliers. Only companies that can respond to customer expectations in the most accurate way will be able to survive in the future. One of the main goals of today's companies is to offer the best quality product at the most affordable price in line with the needs of customers. At this point, the Six Sigma approach is one of the most effective methods that companies can try.
In this study, by applying the Six Sigma methodology, the root causes of PE (Polyethylene) film breaks in plastic bags were investigated by taking plastic bag production machines, processes and control steps as an example, necessary measurements were made by considering the production lines in a sample company and improvements were made in the production process by analyzing with Minitab program. At the end of the study, 24.012 TL/year savings were achieved by reducing downtime due to film breaks in the PE Film line, and 13.938 TL/year savings were achieved financially by reducing the amount of waste.
In this way, the plastic bag industry benefited. In six sigma projects, it has been determined once again that the only element that is as important as making the change is that all the personnel of the company should keep up with and support this change.

Keywords:, 6 Sigma, plastic fertilizer bag, production line

Tarımsal Materyaller İçin Torba Üretim Makinesinde Kopma Nedenlerinin Analizi

Öz: Globalleşen dünyada haritadaki sınırlar ekonomik anlamda yok olmaya başlamıştır ve dünya ekonomisinde müşteriler, tedarikçilerinden yüksek düzeyde kalite beklentisi içerisindedir. Müşterilerin beklentilerine ancak en doğru şekilde cevap verebilen şirketler, gelecekte varlıklarını sürdürebileceklerdir. Müşterilerin ihtiyaçları doğrultusunda en kaliteli ürünü en uygun fiyattan piyasaya sunabilmek, günümüz şirketlerinin temel hedeflerinden biridir. İşte tam da bu noktada Altı Sigma yaklaşımı, şirketlerin deneyebilecekleri en etkili yöntemlerden biridir.
Bu çalışmada, altı sigma metodolojisi uygulanarak, plastik torba üretim makineleri, prosesleri, kontrol adımları örnek alınarak, torbadaki PE (Polyetlen) film kopmalarının kök nedenleri araştırılmış, örnek bir firmadaki üretim hatları dikkate alınarak gerekli ölçümler yapılmış ve Minitab programı ile analizler yapılarak, üretim prosesinde iyileştirmeler yapılmıştır. Çalışmanın sonunda, PE Film hattı film kopmaları kaynaklı duruş sürelerinin azaltılarak 24.012 TL/yıl tasarruf sağlanmış, telef miktarının azaltılması ile mali yönden 13.938 TL/yıl tasarruf elde edilmiştir.
Bu vesileyle plastik torba sektörüne fayda sağlanmıştır. Altı sigma projelerinde, değişimin yapılması kadar önemli olan yegane unsurun şirketin tüm personeli tarafından bu değişime ayak uydurulması ve desteklenmesi gerekliliği bir kez daha tespit edilmiştir.

Anahtar Kelimeler: 6 Sigma, plastik gübre torbası, üretim hattı

1. Introduction

In today's increasingly competitive market conditions, there is only one solution for businesses to survive, which is to listen to their customers, in other words, to understand the real and current needs of the customer correctly and to produce quality products with optimum cost. Accordingly, it is aimed to produce products that meet the criteria and relevant standards that meet customer needs, on the specified date, at the appropriate quality, at the appropriate cost. Although it seems very simple at the basic point, one of the most critical parameters that especially large enterprises miss in their daily work intensity is the opinion and satisfaction level of their customers about the service or product they receive. Customers are like a mirror held up to the company itself. In line with the recommendations or criticisms from their customers, companies may realize a feature that they have never

seen before or close their missing points. Although there are methods such as Benchmark product price comparisons, Six Sigma methods are a powerful way of listening to the voice of the customer, which provides effective success in this part. In this way, companies have the opportunity to examine, reorganize and reorganize their processes based on the basic points that their customers need and move to a much better stage.

The most important criterion for the implementation and success of the six sigma perspective in a business is the support of the top management, the establishment of a team with relevant critical personnel, the belief of all employees and their best efforts. When brainstorming and improvements are made, it is of great importance that they become widespread and sustainable. The idea of change often scares people and causes resistance. However, if one employee in the team or even in the company does not believe in this approach and change, it negatively affects the whole system. In addition, although the cost of implementing a six sigma approach is not so critical, it is very important to choose logical projects that fit the economic structure of the company and respond directly to customer demand.

Of course, it is not easy to survive in the globalized competitive market and to be preferred. Companies that make a difference in every sector have a say. Being able to manufacture more products at once, using less data, at a rate closest to zero error, means more profit for companies and more resources for the next generation. There are many methods to improve processes. The Six Sigma approach is one of the methods that has been applied by many companies around the world and has been recognized as effective. The goal of the Six Sigma approach is to minimize the defect rate in a company's products or services as much as possible and to ensure sustainability. Six Sigma is a set of customer-oriented methods that takes into account the primary needs of the customer and selects them as the most effective parameter for solving the problem and analyzes them according to these assumptions. With the help of improvement steps and approach, it performs a radical revision by re-evaluating and questioning the existing processes and workflow within the company (Avunduk, 2019).

In this research, how businesses can solve problems within the framework of six sigma methods is investigated, and the concepts of identification, i.e. identifying the problem, measurement, analysis, development, validation and control, which are the stages of this methodology, are evaluated. This is also referred to as the Shewhart Cycle or the Deming Cycle. According to this cycle, it consists of these four stages that enable the elimination of recurring errors and the improvement of processes: (Işığıçok, 2005)

Plan: Identifying a problem or opportunity for improvement, understanding the opportunity/risk and developing a plan to achieve the goal.

When planning the problem, the possible causes of the problem are considered. The most important goal of the step is to identify the root causes of the problem in the process and to eliminate them. Various statistical methods to be used in analyzing the problem must be fast, effective and reliable. As a result of the analyses, the parts to be improved are clarified and changes are made in production. With the help of changes in operations, equipment or materials, products can be manufactured with less cost, minimum defects and high quality.

Implement: This is the stage where the plan is implemented.

Check: Measure the end products or service to understand whether the plan has achieved the objective and report the results.

Take Measures: This is the stage of re-planning and implementing the necessary changes to improve performance based on data analysis. After this stage, the Plan-Implement-Check-Take Measures cycle starts again.

In addition, 5S (Seiri (sorting), Seiton (order), Seiso (cleanliness), Seiketsu (standardization), Shitsuke (discipline)), a business philosophy that focuses on improving working conditions in terms of safety, cleanliness, comfort and performance, is one of the process improvement methods. It is used to prevent or minimize clutter, damage and accidents in a business (Lınderman, 2003).

Gemba, which in Japanese means the real place or the place where the work is done, is another continuous improvement technique. Accordingly, managers make visits to the workplace. The aim is for managers to see what is going on in the real work environment, to develop trust-based communication with field workers and to discuss current problems.

Value stream mapping is a method that mirrors processes by visually depicting a business process from start to finish.

In addition, customer satisfaction surveys, when conducted at the right time and in the right way, contribute greatly to the process by providing a clearer view of customer expectations and criticisms. In addition, the Benchmarking method gives the company an idea about that product by comparing it with the best

in the sector.

There are articles and theses about 6 sigma methodology in the literature. A few of these are described below. Improvements in production and process improvements have been made using this approach. However, there are no 6 sigma studies on plastic bags. It is necessary to prevent polyethylene film breaks, which is a major problem especially for companies producing plastic bags.

Ozveri and Cakır (2012) made improvements in the pulley production process, which has the highest number of errors, taking into account the project prioritization structure of Six Sigma. As a result of the improvements, it was observed that other problems were encountered within the scope of percentage inaccuracy in the pulley production process. At the end of the measurements, based on the results such as the inaccuracies caused by calibration decreased and the inaccuracies caused by the relay increased, it was determined that the next project role would be on improvement in the operation. Customers were asked to make pairwise comparisons in the identified demands. He concluded that companies should listen not only to the voices of the customers but also to the voices of the business within the scope of project selection and implementation.

Evren (2006), in his thesis on six sigma methods and its application in a selected company, examined the six sigma approach and the development actions it suggests in detail and clearly revealed the issues to be encountered in the process and the preparation of companies for six sigma steps. He summarized the framework picture of the related methodology through the six sigma applications he sampled.

Ozkan (2006), in his thesis on six sigma applications in industry, has seen in his studies that companies applying six sigma methods analyze their errors better, keep their processes under control and ensure customer satisfaction by producing better quality products.

Altuğ (2010), in his comparative analysis study in terms of the gains of companies in six sigma project implementation, the six sigma project implementation examples of 11 companies operating in the manufacturing industry were examined through a survey and the analysis of these examples were included. As a result of these analyzes, it was determined that the companies gained economically and technically by making a comparison before and after the six sigma project implementations. The finalization times of the projects implemented in the companies, the measurement of the gains from the project in the balance sheet and whether there are independent departments that advance the six sigma activities are also examined. In this context, it was concluded that the ability to meet the expenses of the project, to bring profit, and the measurability of these results in the balance sheet are strictly related to the completion of the relevant projects within the estimated time. Taking into account the top management's perspective, the relationship between six sigma activities and strategic business objectives was evaluated and it was concluded that the most critical objectives would be to satisfy the customer and to gain profit and benefit.

Pande and Holpp (2002) list the Six Sigma itinerary in five points as follows:

- Identifying the main workflow and the most important customer
- Correct identification of buyer requirements
- Measuring the performances that are possible
- Prioritization of improvements
- Integrating the idea and belief of six sigma to all employees, adapting it to the whole project, verifying it through analysis and ensuring its sustainability

In this study, plastic bag production lines and process stages are detailed. How businesses can solve problems within the framework of six sigma methods has been investigated, and the concepts of identification, i.e. identifying the problem, measurement, analysis, development, validation and control, which are the stages of this methodology, have been evaluated.

In the Toros Tarım company, which was taken as a case study, the factors that caused major losses in the production of the fertilizer and bag factory were investigated using the Six sigma method. In addition, a problem that directly affects the wastage rate and profit margin in production was addressed and analyzed in Minitab program by going down to the root causes, and improvements in production were implemented. With the improvements made, the PE (Polyetlen) film rupture error, which is a common chronic problem of plastic bag manufacturers, has been eliminated and taken under control.

2. Materials and Methods

The commercial success of plastic as a packaging product is the result of its combination of flexibility (from film to rigid applications), durability, light weight, stability, impermeability and easy sterilization. These properties make plastics an ideal packaging material for all kinds of commercial and industrial users. In this study, a woven plastic bag product and plastic (polypropylene and polyethylene) materials were used.

Woven (knitted) plastic bags are bags made of polypropylene plastic material called jute on the outside and polyethylene plastic film on the inside. These bags play a major role in the transportation of fertilizer, which is the lifeblood of agriculture. As with any packaging, sealing and product protection are very important in this type of packaging. The woven plastic production process consists of yarn production line, weaving loom, flexographic printing machine, cutting sewing machine, warp and weft tapes, drafting cylinder, hot cutting, PE (Polyetlen) film line, PE (Polietylen) bag line, winding unit and granulator machine.

In the study, the brainstorming method and six sigma methodology were actively used, which is a general method used to generate a large number of creative and effective ideas on a given topic. In this way, the imagination of the people doing the work can be used to use their ideas generated during their work related to improvement, and their imaginative suggestions can be used for the success of the project as much as possible without any hindrance. Team members were able to develop and suggest improvements and recommendations without any pressure. The six sigma project team included the company's manufacturing engineer, quality engineer, manufacturing manager, quality manager, relevant production line operators, general manager.

The product life for knitted plastic bag is described in Figure 1:

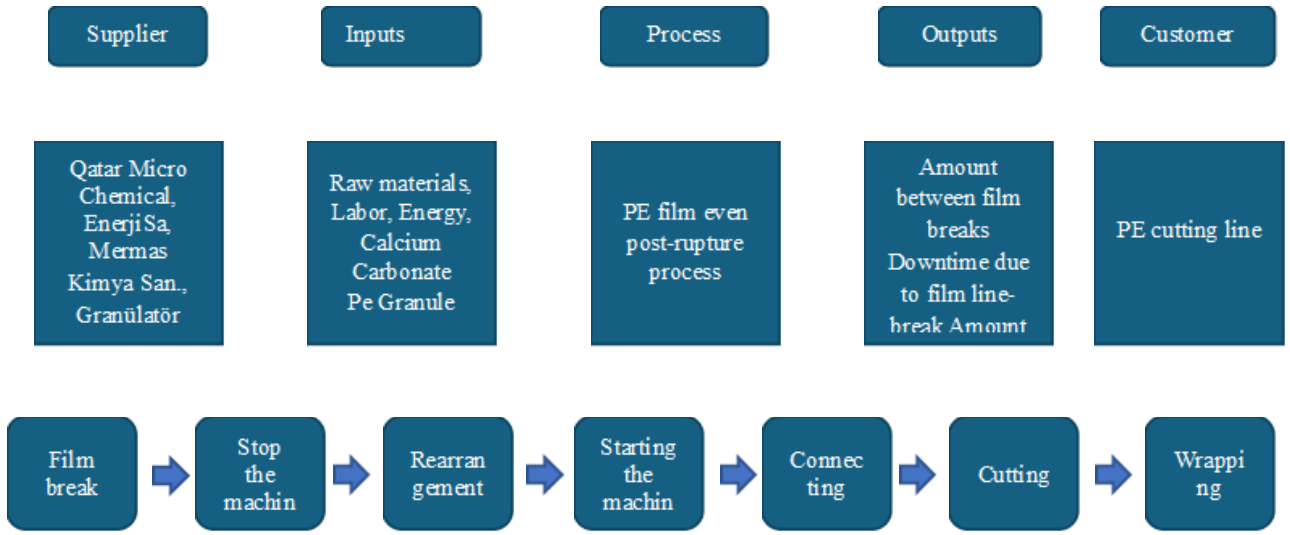

Figure 1. Product Life
Şekil 1. *Ürün Yaşamı*

In order to prevent PE (Polyetlen) film ruptures in the production of woven plastic bags, which are frequently used in fertilizer transportation, the problem was defined correctly in this project, and data were collected from the production lines with root cause analysis and fishbone methods. In the fishbone diagram in Figure 2 all possible causes of the problem are categorized.

According to the following chart, the polyethylene film breaks in the plastic bag are rated according to their importance for the customer and the possible causes of the problem are clearly indicated in the inputs section. The possible causes were prioritized and the number of film breaks, machine downtime, potential impact value and amount of lost product were scored.

When Pareto analysis, in other words prioritization analysis, cooling-related problems, transmission-related malfunctions, electrical fluctuations, resistance temperatures, speed difference between motors are in the top 5. For this reason, all these factors were analyzed one by one.

There are 4 resistances below and 2 resistances above the machine benches in the sampled company. While collecting the data, a large number of measurements were taken by different operators at various times from three shifts. The hours of PE (Polyetlen) film breakage and resistance temperatures were also recorded. The cooling temperature in the machine and the winding motor speeds were measured. Break frequencies were monitored before and after the retrofit, taking into account the total equipment efficiency.

In this study, methods such as Anova, S&S matrix, CTQ (Critical to Quality) quality requirements, voice of the customer were applied in Minitab program before and after process analysis and improvement. With these methods, the problem was accurately defined and a road map for the solution was drawn. Possible causes of the problem with high standard deviations were investigated and the factor that affected the result the most and had the highest deviation was emphasized.

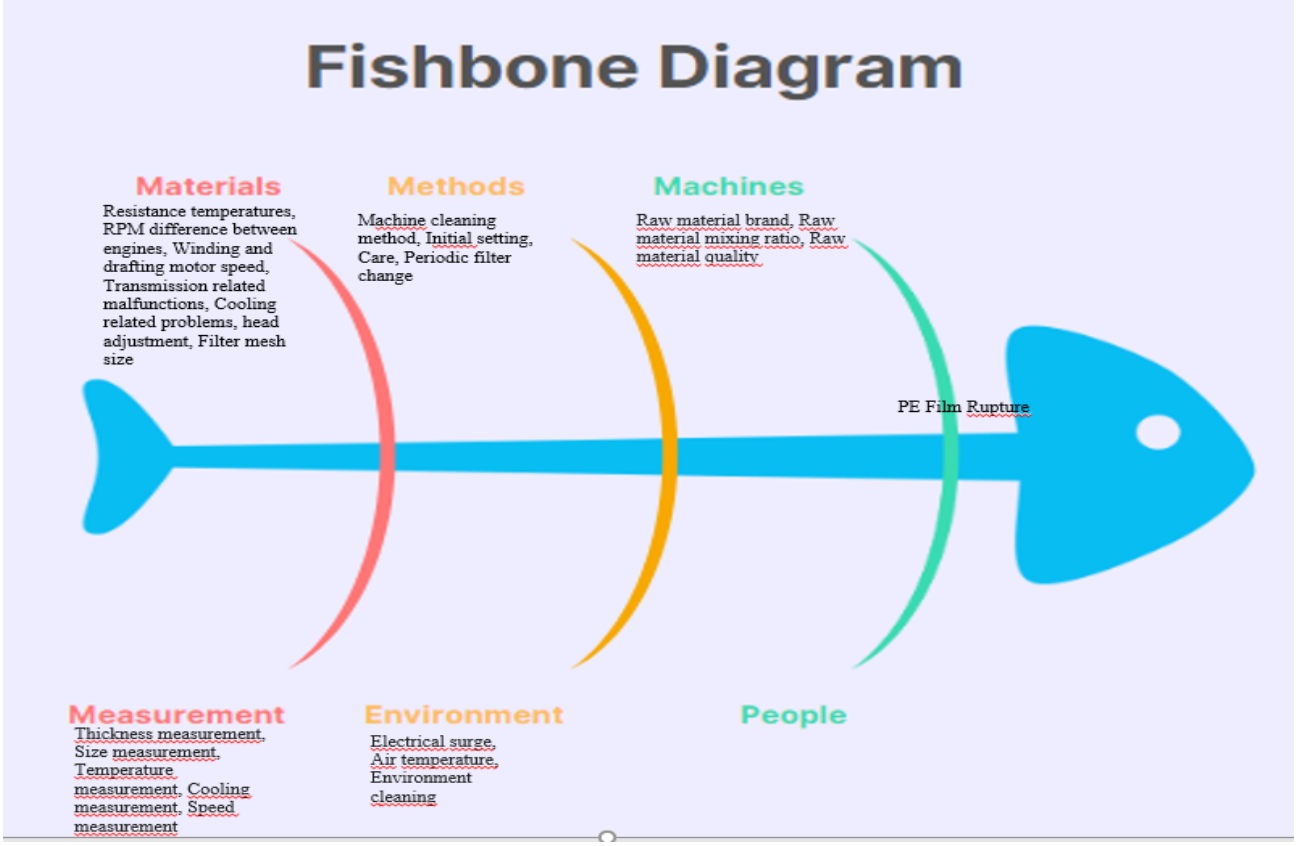

Figure 2. Illustration of possible causes of PE film rupture in a fishbone diagram
Şekil 2. PE film kopmasının olası nedenlerinin balık kılçığı diyagramında gösterimi

Table 1. Cause and effect matrix and prioritization
Çizelge 1. *Neden-sonuç matrisi ve önceliklendirme*

	Importance level for the customer		**8**	**9**	**7**	**10**		
	Process Factor	**Outputs** **Inputs**	**Number Of Film Breaks**	**Downtime Due To Rupture**	**OEE Value**	**Amount Of Lost Product**	**Total Value**	**Pareto**
8	Machine	Cooling related problems	9	9	9	9	306	**7%**
7	Machine	Gearbox related malfunctions	5	9	9	9	274	**13%**
17	Enviroment	Electrical surge	9	5	5	9	242	**19%**
4	Machine	Resistance temperatures	9	9	5	5	238	**25%**
5	Machine	Speed difference between engines	9	9	5	5	238	**30%**
6	Machine	Winding and drafting motor speed	9	9	5	5	238	**36%**
15	Method	Maintenance	9	5	5	9	238	**41%**
22	Measurement	Temperature measurement	5	9	9	5	238	**47%**
23	Measurement	Cooling measurement	9	9	5	5	238	**52%**
24	Measurement	Speed measurement	9	9	5	5	238	**58%**
14	Method	Initial setting	5	9	5	5	206	**63%**
16	Method	Periodic filter change	9	5	5	5	202	**67%**
9	Machine	Head setting	5	5	9	5	198	**72%**
10	Material	Raw material brand	5	5	5	5	154	**76%**
13	Method	Machine cleaning method	3	5	5	5	154	**79%**
12	Material	Raw material quality	3	5	5	3	152	83%
20	Measurement	Thickness measurement	3	5	5	3	134	86%
21	Measurement	Size measurement	3	5	3	3	134	89%
18	Enviroment	Air temperature	3	3	3	3	120	92%
11	Material	Raw material mixing ratio	3	1	3	3	102	94%
2	People	Experience	3	3	1	1	68	96%
3	People	Competence	3	1	3	3	68	98%
19	Enviroment	Environment cleaning	1	1	3	3	68	99%
1	People	Education	1	1	1	1	34	100%
Totaly Value for Outputs			**0**	**0**	**0**	**0**	**4298**	

3. Results and Discussion

3.1. Resistance Temperature Values before optimization

Before the retrofitting of the machine tools, the resistance temperature values of the thermocouples were measured periodically. The minimum, maximum and average values of Z1, Z2, Z3, Z4 and D1, D2, D3 resistance temperature values are given in table 1. It was observed that D1, D2 and D3 head resistances dramatically exceeded the upper limit (190°C).

Table 2. Resistance temperature values before ımprovement
Çizelge 2. *İyileştirme öncesi rezistans sıcaklık değerleri*

Resistance	Average Temperature Value (°C)	Min. Measured Value (°C)	Max. Measured Value (°C)
Z1	156,20	145	170
Z2	155,12	132	172
Z3	156,30	140	170
Z4	154,27	140	172
D1	165,96	142	190
D2	167,03	152	190
D3	157,09	145	180

Table 3. Improvement action and responsible table
Çizelge 3. *İyileştirme aksiyon ve sorumluları tablosu*

Actions	Responsable
The problem of overheating (temperature volatility) was discussed with the thermostat supplier company and the recommended thermostat adjustments were made.	Quality control supervisor, production operator
At the end of the recommended settings, the thermostats are deactivated when the thermostats are close to reaching the set temperature (2-3 degrees) and are activated again at the end of the set time and the heating is slowed down and the temperatures are increased to minimum levels above the set values.	Quality control supervisor, production operator
Since the thermocouple (thermocouple, temperature sensor) bearings of the thermostats were deformed, they were renewed to feel the heat more sensitively.	Quality control supervisor, production operator

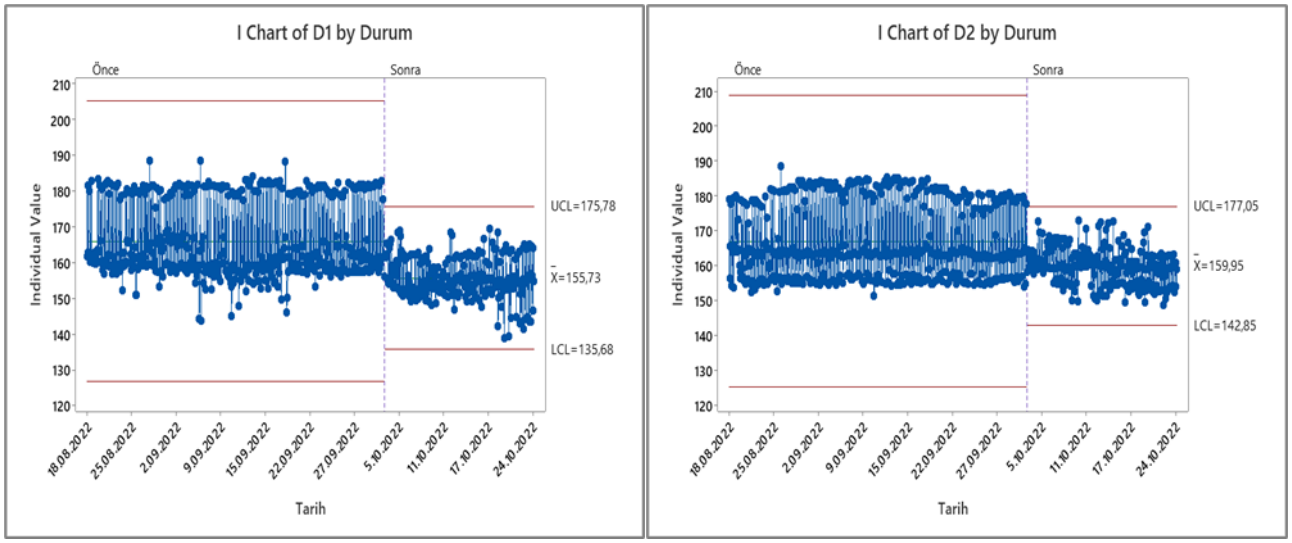

Figure 3. D1-D2 ımprovement before-after distribution between lower and upper limits
Şekil 3. *D1-D2 iyileştirme önce-sonra alt ve üst limitler arasındaki dağılımı*

3.2. Improvement actions

In order to improve this situation, the actions given in Table 2 were implemented by the responsible staff.

3.3. D1-D2 Temperature Values Before-After Improvement

As can be seen in Figure 1, while the upper and lower control limit range of D1 and D2 resistances was wider in the previous case, after the improvements, the variability decreased and the limits narrowed and their averages approached the desired set value of 160 °C.

3.4.Resistance Temperature Values - One Way Anova Table

As can be seen in Figure 2, when the analysis was performed using the Interval Plot module for 7 resistors from the Minitab program, it was seen that before the

improvement, especially the D1-D2 resistance temperatures were higher than the others, while after the improvements made, all resistance temperature values were brought to the set value levels.

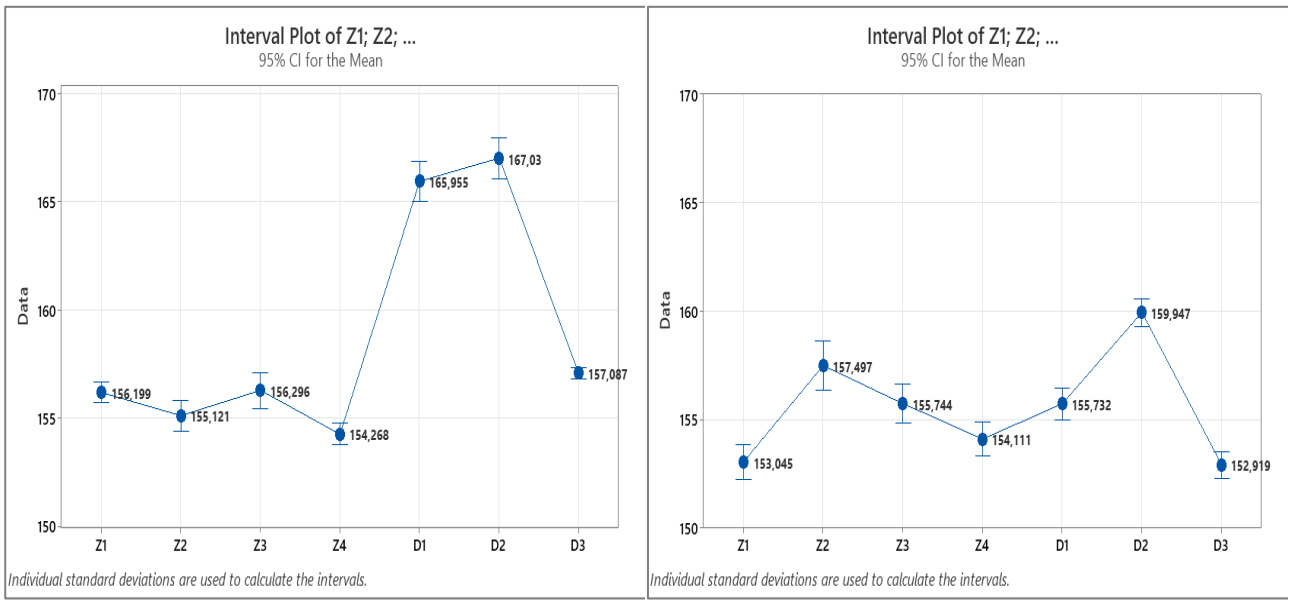

Figure 4. Interval Plot Distribution of Z1, Z2, Z3, Z4 and D1, D2, D3 Resistance Temperatures
Şekil 4. Z1, Z2, Z3, Z4 ve D1, D2, D3 Rezistans Sıcaklıklarının Interval Plot Dağılımı

3.4. Breakage Frequency - Before-After One Way Anova Test Result

As seen in Figures 3 and 4, when the rupture frequency and conditions of PE (Polyetlen) films were analyzed using the I Chart module, Interval Plot and Welch's test from the Minitab program, the monthly rupture conditions and standard deviations before and after the improvement were examined.

The alternative hypothesis was accepted (P-Value: 0,001) and it was accepted that there was a significant difference in the frequency averages after the improvement, i.e. the frequency decreased significantly after the improvement.

The confidence interval for the mean breaking amount is between 70.0-143.7 in the first case and 22.99-50.35 in the second case.

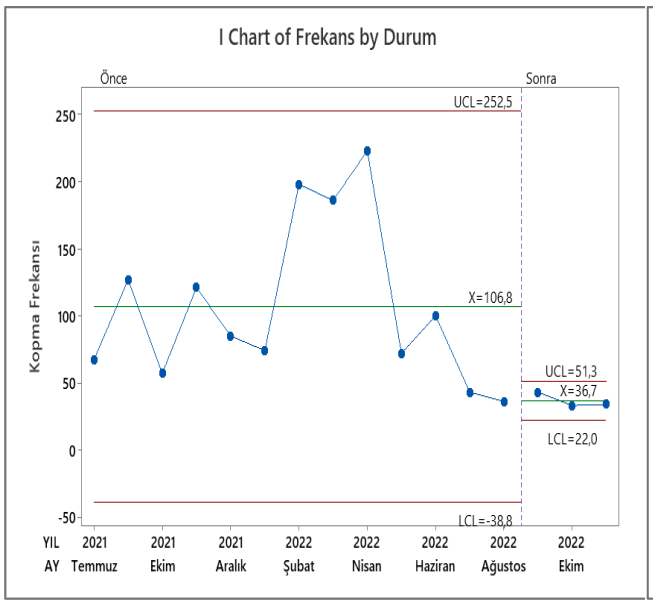

Figure 5. I Chart Distribution of Rupture Frequencies on a Monthly Basis
Şekil 5. *Aylar Bazında Kopma Frekanslarının I Chart Dağılımı*

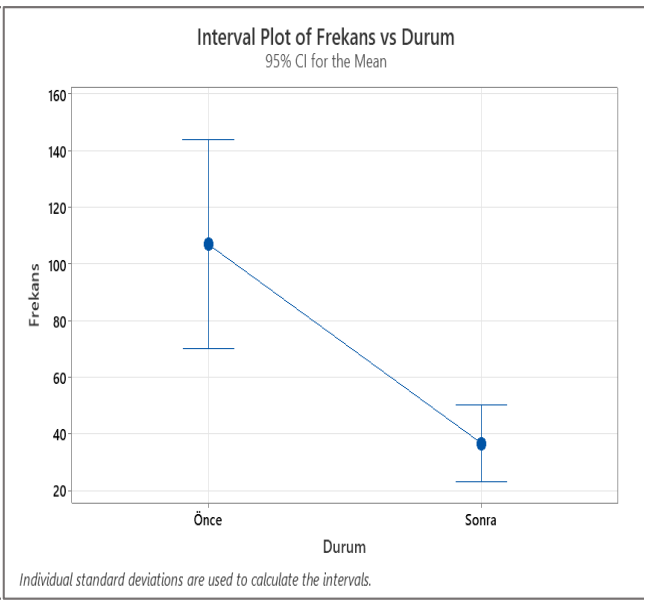

Figure 6. Interval Plot Distributions of Rupture Frequencies
Şekil 6. *Kopma Frekanslarının Interval Plot Dağılımları*

Means

Durum	N	Mean	StDev	95% CI
Önce	13	106,8	61,0	(70,0; 143,7)
Sonra	3	36,67	5,51	(22,99; 50,35)

Method

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are eq
Significance level	α = 0,05

Equal variances were assumed for the analysis.

Welch's Test

Source	DF Num	DF Den	F-Value	P-Value
Durum	1	12,7671	16,62	0,001

4. Conclusion and Discussion

The Six Sigma kaizen approach is a customer-oriented methodology based on numerical data and statistical analysis that aims to achieve consistent improvement. The success of the Six Sigma project is ensured by the progress of the work flow, the appropriate response to buyer expectations, the reduction of inappropriate issues and deficiencies in the product or service, the creation of processes and services to best meet business needs, the implementation of the infrastructure and the appropriate team and leadership system to keep the gain and progress continuous.

This was the case in the production of plastic bags. Periodically, these methods were applied every week as non-conforming products increased in the bag production machines and various analyzes were made in the Minitab program, different operators were made to work on the machines at different time intervals and different personnel took measurements from the products. The distribution of the inter-break quantities (mt) in PE (Polyetlen) films was analyzed month by month, and the resistance temperature values before and after the remediation, the monthly breakage rates and their standard deviations were analyzed. The causes of film breakage were analyzed as human, machine, dimension, material and environmental by using fishbone diagram and 5 cause analysis methods and the root cause was tried to be found.

In the chronic problem of the enterprise, statistical methods and Minitab tools where the most effective results are obtained; S&S matrix, pareto diagram, cause-effect diagrams, ANOVA, Interval plot, Box Plot and I Chart analyzes come to the fore.

In order to prevent PE (Polyetlen) film breaks in the production of woven plastic bags, which are frequently used in fertilizer transportation, the distribution of cooler temperatures, which is one of the prominent factors in PE (Polyetlen) film breaks as a result of pareto analysis, was examined. It was observed that there was not a very large variability. Similarly, engine and transmission speeds were analyzed. Again, it was observed that the deviation in the number of revolutions was not high. There are 4 resistances below and 3 resistances above the machine benches. It was observed that the deviations in the resistance temperatures were high and the temperature values exceeded the lower and upper limits. In this case, new optimal lower and upper limits were determined. In each shift, the resistance temperatures in the lines were recorded and accordingly the set values in the resistance were determined. The upper limit was set for the first resistance to stop as Z1 approaches 165. In this case, the other resistance was allowed to increase, and then when the temperature reached the upper limit, it was again switched to the other resistance. It was found that the resistances could not take accurate readings due to dirt getting into the resistances and the resistances were replaced with thermocouples. As a result of the improvements, a radical reduction in the amount of PE (Polyetlen) film breakage in the bag was observed.

As a result of the analyses, necessary changes were made in the quality control plan and related forms used to check the conformity of the products coming out of production, and trap samples were sent to production, and validation activities were carried out by adding regular measurements (break frequency, resistance temperatures, etc.) to the forms. In addition, 24,012 TL/year savings were achieved by reducing downtime due to film breaks in the PE (Polyetlen) Film line, and 13,938 TL/year savings were achieved financially by reducing the amount of waste.

Awareness and practical trainings were provided to the personnel. In six sigma projects, it has been determined once again that the most important issue, as important as making the change, is the adaptation and support of this change by the entire staff of the company.

In the future, it is thought that by making use of this article, improvements can be made in production processes or machines in plastic bags or in another sector by using 6 sigma methodology and statistical analysis methods applied in the thesis.

Conflıct of Interest

The article is a research study within the scope of PhD and was carried out under the supervision and supervision of the advisor Prof. Dr. Recai GÜRHAN and there is no conflict of interest in terms of name priority.

Author Contrıbutıon

Burcu ER was responsible for the preparation of the article and the conduct of the research as the corresponding author. Prof. Dr. Recai GÜRHAN was the supervisor of the article and the research.

Thank You

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