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MASTER'S THESIS

IMPROVEMENT OF FOOD POWDER PACKAGING PROCESS WITH KAIZEN PROJECT

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Mahmut Hilmi GÖKÇE

ÖZET

Yüksek Lisans Tezi

Kaizen Projesi ile Gıda Toz Paketleme Sürecinin İyileştirilmesi

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Rekabet koşullarının giderek zorlaşması ve müşterilerin yüksek kalite düşük maliyet beklentileri üreticileri, müşterinin farkına varamadığı değerleri yada müşterilere değer katmayan faaliyetleri hassasiyetle analiz etme gerekliliğini ve proses geliştirme çalışmalarına önem vermek zorunda bırakmıştır. Bu bağlamda günümüzde, dünyada prosesin iyileştirilmesinde ve değer yaratmayan faaliyetlerin proseste önlenmesinde yalın üretim ve istatistiksel proses kontrol sıkça başvurulan yöntemlerdendir.

İstatistiksel kalite kontrolü, üreticilerin ve firmaların kalite hedeflerini tutturmaları ve kalite hedeflerini kontrol altına almakta kullanılan yöntemdirYalın üretim ise, müşteriyi odak noktasına yerleştirerek, maliyetleri ve israfı en alt noktaya çekmeyi, verimliliği arttırmayı ve kaliteli mamül üretip bunu sürdürmeyi amaçlayan bir yönetim felsefesidir. .

Uygulama kısmında Dr. Oetker Firmasının Türkiye Fabrikasında, kakao paketleyen hattaki Proses 3 (P3) makinesinde paketlenen paketlerin limitlerin üzerinde gramajlanmasından dolayı oluşan üretim kayıplarını minimize etmek için P3 makinasındaki helezon dolum sistemlerinde helezon ve dolum haznelerinin dizaynı yapılmış bu dizaynın hesaplamaları gösterilmiştir. Çalışmanın sonunda toplam prosese giren kakao miktarını baz alarak yüzde 6,59 oranında paketleme esnasında meydana gelen kayıp ve israfın önüne geçilmiştir.

Anahtar Kelimeler: Yalın Üretim, İstatistiksel Kalite Kontrol, Toz Gıda Karekteristiği, Mekaniksel Helezonik Dolum, Toz Gıda Akış Karakteristiği .

ABSTRACT

Master's Thesis

Improvement of Food Powder Packaging Process with Kaizen Project

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Competition conditions are getting tougher. Customers expect products with higher quality and lower price from manufacturers. For that reason, manufacturers should give more importance to process development activities. To analyze the values that customers could not realize and the activities that do not add value to products and customers have become a requirement for manufacturers. In this context, Lean production and Statistical Quality Control are frequently used systems in the industry for the improvement of the process and the prevention of non-value creating activities.

Statistical quality control method is used by manufacturers to control and meet quality objectives. Lean production is a management philosophy that aims to minimize costs and waste, increase productivity, and produce and maintain quality of goods by putting customers at the center. In addition to providing process improvement, the lean manufacturing techniques also aim to eliminate non-value-adding operations that the customer does not want to pay.

In this thesis, to minimize the production losses due to the over-dosing in cocoa packaging operations made in the Process 3 (P3) powder packaging machines at Dr. Oetker Turkish Factory, the helical screw and hoppers were redesigned in the P3 machines. The calculations based on design are reported extensively. End results of this implementation are reported as a percentage of the total amount of cocoa entering in the process. The losses incurred in the production process are decreased. More formally, excess weight in filling food powder package is decreased by 6,59% of total input of cocoa powder after the redesign of the helical screw.

Key Words: Lean Operations, Statistical Quality Control, Food Powder Characteristics, Mechanical Helical Dosing, Food Powder Flow Characteristics.

Improvement of Food Powder Packaging Process with Kaizen Project

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ABBREVIATIONS

JIT Just In Time

MRP Material Requirement Planning

PPM Parts Per Million

TPM Total Productive Maintenance

TPS Total Production System

QC Quality Control

UCL Upper Control Limit

LCL Lower Control Limit

PREN Pitting Resistance Equivalent Number

FFS Form/Fill/Seal type

HFSS Horizontal Form/Fill/Seal type

VFFS Vertical Form/Fill/Seal type

KAIZEN125B Before The Kaizen 125

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INTRODUCTION

In today's markets, companies should make innovation to able to withstand the competition in the market, and it becomes requirement to make customer-focused production by strictly relying on customers' needs and expectations. To ensure customer needs continuously – products with better quality and cheaper price –, the lean concept and statistical quality controls need to be introduced in all production processes.

Appropriate design of the equipment used in the storage, conveying and management of solid bulk require knowledge of certain bulk properties of the food powder material that is affected under static and dynamic conditions in production process. Many problems occur in this process. These problems lead to waste of temporal and financial resources for food powder industry.

In the first part of the study what is Lean Production, its historical development and techniques, in the second part, definition of quality, concept of Statistical Quality Control and control card. In application section, general information about the company and the products that are produced in the company are started with application studies. Firm is Dr. Oetker Turkey which produce ambient food powder. In the direction of the Lean operation improvement plan, steps were taken to implement the Lean manufacturing techniques in parallel with Statistical Quality Control Techniques are used in the application, Kaizen team is collected, this team is called kaizen 125 team and contains; Mechatronics Engineer, Food Engineer, Electronic Engineer and 2 experienced operators. Kaizen team has studied on P3 packaging machine for a one year. In production operation, P3 machine is operated for cacao 25 g product, project's aim is to analyze cacao food material in terms of powder flow characteristics, and design of auger screw is convenience to cacao food material and P3 machine design criteria. Food powder packaging operation is conducted using Statistical Quality Control and Control Chart. The implementation includes the necessary remedial actions to eliminate errors and waste in processes. In the last part, the results obtained in the study and the respective evaluations are shown.

FIRST CHAPTER

LEAN OPERATION CONCEPT

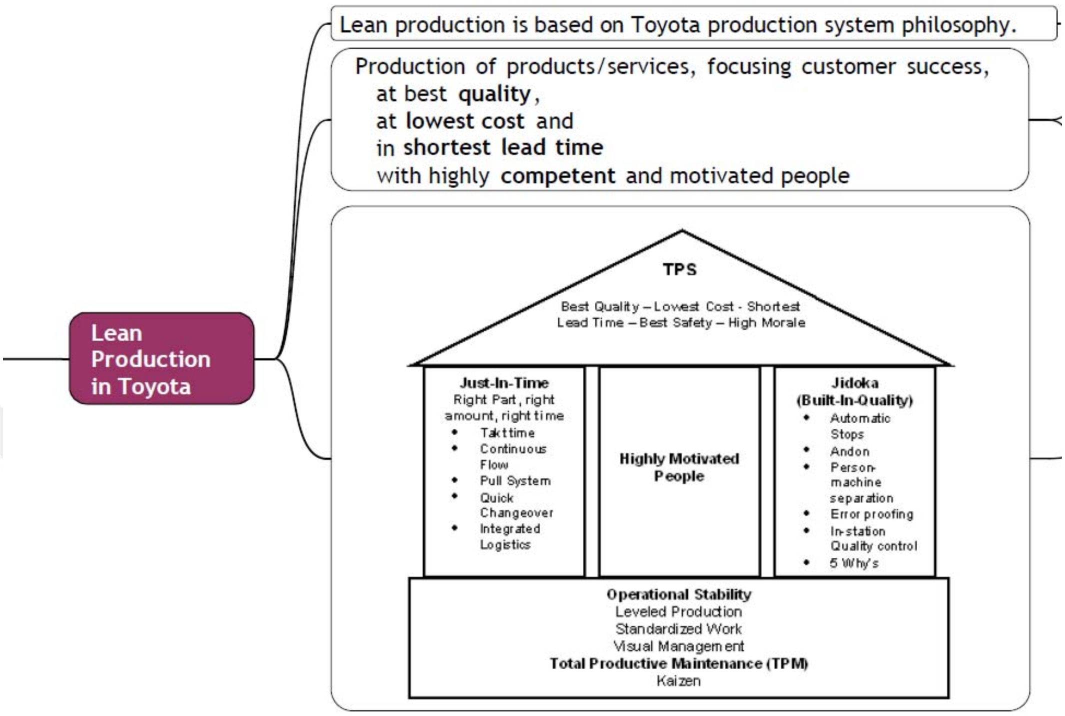
1.1. LEAN CONCEPT

Lean simply means the less of a thing and this thing, in terms of terminologies in industry, might be a waste of time, number of suppliers, the bureaucracy or production cycle time. Lean, as a concept, has a wide range intersectoral usage, such as aiming to inform worker of organization, providing increment of efficiency for operation function, and meeting expectations of consumers for marketing function at the organization. (Sayer and Williams, 2007: 12). Shortly, lean minimizes waste, maximizes value of corporation in the eyes of the client, thus, creates more value for customer by using less resource.

Lean Operation Concept, by definition, is to eliminate unnecessary steps during the production process, as well as minimizing mistakes, to keep customer satisfaction high. Several studies have shown that efficiency in organizations carrying out Lean Operation Concept increases their efficiencies, and consequently, so do their profits and the quality of their products (Okur, 1997: 28).

Even though Lean Production, as a term, has the common usage all over the world (Voss, 1995: 20), its naming might differ across different regions. Toyota is the pioneer to apply Lean Production Concept in their production process and observe decreases in “elapsed time from the beginning of production to the end consumer and the waste of resources" (Freeman & Soete, 2003: 176). Therefore, Lean Production is still called "Toyota Production System" in Japan. However, in Western countries, it is called "Just-in Time" or "Continuous Flow Production". Although it does not reflect the extensive meaning of the Lean Production, some experts use "Stockless Production" to name Lean Production (Shingo, 1985: 75).

Figure 1: Lean Production in Toyota



Source: Özdemir, 2017: 1

Due to its pioneering role in the industry, Toyota production system sets a basis for Lean production. Figure 1 gives Toyota Production System in detailed. Target of Lean Production is to minimize costs (i.e. temporal and financial waste), and thus, increase efficiency in all operation from production to delivery.

1.1.1. The Definiton of Waste and Its Types

Waste, in operational terminology, means everything that a customer is not willing to buy. Moreover, it might refer to a poor provision of goods or services not meeting customer satisfaction (Jones and Womack, 1996: 11). According to James Womack and Daniel Jones (1996), waste corresponds to activities not creating any value. Some operational, but necessary activities might cause partial waste, however, wastes to be abolished from each processes are the ones generated by unnecessary activities.

Figure 2: Taiichi Ohno's Seven Wastes

Source: Black and Miller, 2008: 8

Seven wastes (or muda, in Japanese) leading to increase in costs are determined by Toyota production system. Figure 2 depicts Taiichi Ohno's these seven wastes. Each of them are explained as follows:

- **Over Production:** Producing more than the demand of customers leads to over production. Products that are more than the demand of customers lead to increase in stock levels which, consequently, means expansion of a storage capacity beyond producers' long-term needs. Furthermore, producers might need to employ more labors that do not add any value to what customer buy.

- **Transportation:** Redundant transportation of goods and materials between different locations, not adding any value to a customer, is defined as another type of waste. Transportation activities use stocking areas where stocks are accumulated, and this situation hampers the ongoing value chain (Sayer and Williams, 2007: 44).

- **Stock on Hand:** Long production and cycle time operations cause extra stock on hand (Ünnü, 2003: 26).

- **Movements:** Unnecessary movements of non-value-adding capital and worker are waste. Unnecessary movements are defined as walking, carrying, or arriving these factors of production (Sayer and Williams, 2007: 44).

- **Defective Products:** Defective goods or products always increase costs, and thus wastes. To solve that problem, planning and controlling the production process are inevitable tools for organizations. Organization should adopt Total Quality Control, detect scrapped inputs both in material and labor, and analyze them thoroughly (Ohno, 1998: 38).

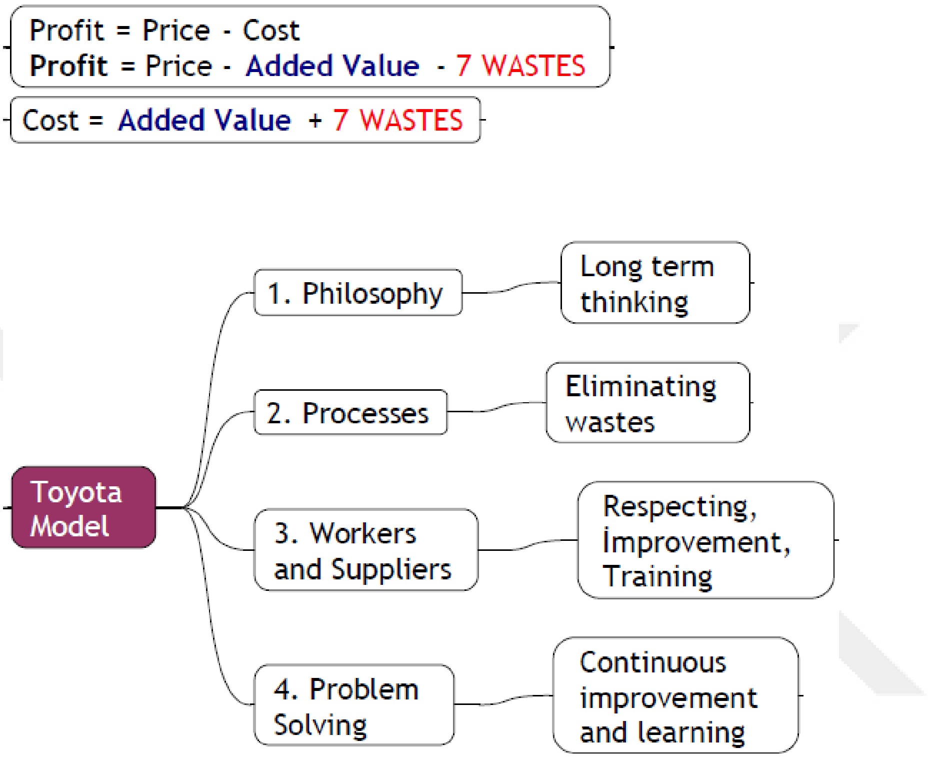
- **Processing and Complexity:** Competent specialist should analyze every stage in production processes, and detect unnecessary ones. Every non-value-adding process stages are waste. Job simplification and job description methods are the most important ways to minimize this waste (Çetinkaya, 2000: 296).

- **Time on Hand:** Waiting processing on work station does not generate any value for a product, and so do for a customer. To avoid that kind of a waste, experts should scrutinize stages in production process (Locher, 2008: 15).

To eliminate these different types of wastes, experts should get the bottom of case. Every problem gives an opportunity to come up with a solution in a process, and every solution, not temporary one, should be scrutinized in detail to reach and maintain success (Çetinkaya, 2000: 297).

1.1.2. New Approach to Cost-Profit Analyses

Figure 3: Toyota Model and Profit Concept



Source: Özdemir, 2017: 1

Up until very recently, profits gained out of sold goods and services are calculated based on Equation (1. 1) (Dennis, 2007: 14). With this approach organizations, firstly, determine their costs, and then, they add profit based on pricing of their products.

$$\text{Cost} + \text{Profit} = \text{Price} \qquad (1.\ 1)$$

Toyota Engineers, however, refuse this approach and embrace a new notion, "Unless cost decreases, organizations cannot make profits," formulated as in Equation (1.2) (Yamak, 2007: 316). Figure 3 demonstrates that cost, in fact, equals to added value plus seven wastes where these wastes are considered as an important component of the Toyota model.

$$\text{Price} - \text{Cost} = \text{Profit} \qquad (1.\ 2)$$

Due to unprecedented improvement in information and communication technology, customers have become more conscious than the past — they look for lower price with higher quality. According to the Toyota model, if organizations decrease their production cycle time and redundant costs, they can have bigger margins to adjust products' prices downward and opportunity to increase the demand of customers for their products which eventually might increase organizations' profits (Dennis, 2007: 14).

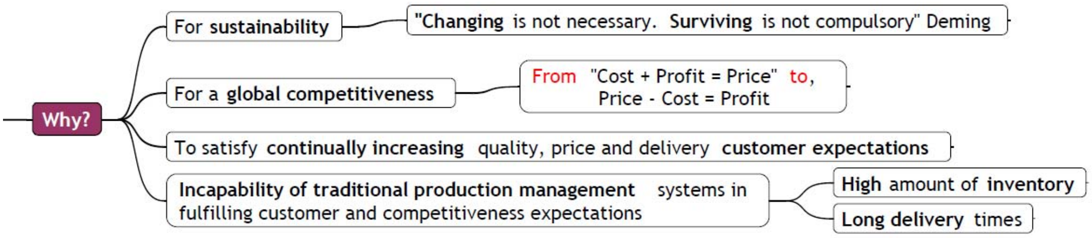
1.1.3. Success Factors in Lean Production

Quality intellection in Lean Production aims to meet customers' expectations and needs to the greatest possible extent. Lean Production achieves this by incorporating new dimensions to quality intellection (Akgeyik, 1998: 33).

To meet needs of the market in a shorter period of time, Lean Production incorporates all of elements of an organization from the top to the bottom within an organizational structure. In compliance with Lean Production, organizations employ educated workers, as well as use highly flexible and technologic automation machines. Moreover, required responsibilities are vested to these workers properly based on their competence levels, even at lower levels of the organizaional structure. This kind of responsibility structure promotes self-control mechanism within the organization.

Lean Production has six success factors — project leader, team work, information culture, integration of supplier, synchronous engineering, and integration of customer. Teamwork, project leader, and integration of customer make lean operation competitive vis-à-vis Tayloristic production management approaches (Karlsson and Ahström, 1996: 119).

Figure 4: Importance of Lean Operation



Source: Özdemir, 2017: 2

Toyota Production System aims to promote incorporation of labor-intensive inputs (i.e. flexible and trained worker teams) with mass production system (i.e. high-tech machines) in a costly efficient way (Özçelikel, 1994: 43). This aim, in fact, explains why we should apply lean production concept. Figure 4 shows prominent reasons of why Lean Operation is important — to achieve sustainability, to gain global competitiveness, to satisfy continually rising customer expectations in terms of quality, price and delivery, and to ameliorate incapability of traditional production management systems while fulfilling customer and competitiveness expectations, such as high amount of inventory, long delivery times.

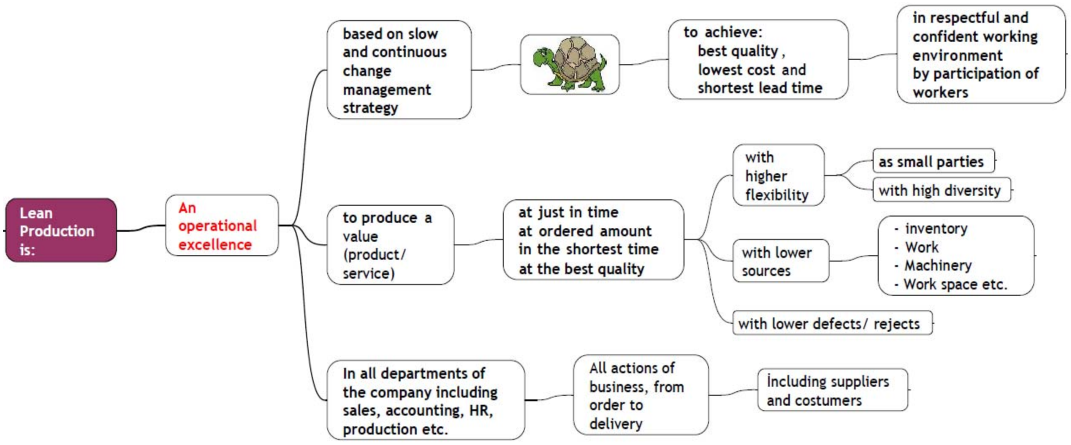
1.2.DEVELOPMENT OF LEAN MANUFACTURING

Until 1920s, labor-intensive system had been used all over the world. Well-trained workers were used in labor-intensive system. Expectations of consumers were met by using simple equipment or tools (Yeter, 2004: 4). After 1920s, Alfred Sloan and Henry Ford devised the mass production system, and Henry Ford was the first entrepreneur to carry out an assembly line. Henceforth, the mass production system is also known as "Fordism." The mass production was an innovative system at that time to produce cheap products in which unqualified workers in a partial-professional design and expensive and single-minded machines are harmoniously used in an operation area.

The mass production system is followed by the Lean Production in 1950s. Essential principles of the Lean Production was manifested by Eiji Toyota, one of the family members of Toyota Family, and Taiichi Ohno, an engineer in Toyota Corporation, for the first time in 1950s. Eiji Toyota and Taiichi Ohno considered Fordist production system as an inconvenient system for Japanese industry (Okur, 2000: 24). Problems that Eiiji Toyota and Taiichi Ohno confronted in the industry were (Dennis, 2007: 9);

- Tough competition conditions,
- Fixed or decreasing prices,
- Diversified markets demand with low-volume products,
- Rapidly changing technology.

Figure 5: Lean Operation Excellence



Source: Özdemir, 2017: 2

Figure 5 shows components of operational excellence based on Taiichi Ohno's approach aiming to solve problems faced in the industry. In late 1960s, this new production system was started to be carried out in Toyota production plants as the Lean Production. Since Fordism was not a convenient system for Japanese industry and had many drawbacks, Toyota's engineers scrutinized production stages studiously and made great contributions to improve production industry.

From the last months of 1973, oil crisis was broken out, all of the European countries were effected that situation. Oil crisis led to economic stagnation and economic crisis many countries. In 1974, Japan Economy was collapsed to "Zero Growth" level (Ohno, 1998: 39). Toyota which carried out Lean Production, held the line in terms of economic situation and made a profit in 1975, henceforth, Toyota succeeded to growth, at that rate, Toyota attracted attention between international platforms and Lean Operation was accepted and spread all over the world (Donnet, 1992: 60).

1.3. LEAN MANUFACTURING PRINCIPLES

Lean Manufacturing can be summarized in five fundamental principles shown in Figure 6.

Figure 6: Five Fundamental Principles of Lean Thinking

Source: Jones and Womack, 1996: 5

1.3.1. Value Definition

The critical starting point of Lean Production is a value, and only customer can define the value. Importance of the value definition is expressed as customers' needs that are met on time with the best price (Jones and Womack, 1996: 12-17). Value, in short, is based on customers' tastes and satisfactions.

1.3.2. Definition of Value Stream

The second step of Lean Thinking is the definition of value stream. Value stream is defined as the total of the value-adding and non-value-adding activities in production processes. Value stream has mainly three tasks (Jones and Womack, 1996: 17).

- **Problem solving task:** This task incorporates detailed design and engineering in theoretical aspects at the beginning of production processes.

- **Management of information technology task:** This task covers processes between getting and delivering orders of goods and services.

- **Physical conversion task:** This task covers processes of conversion of raw materials into a final product.

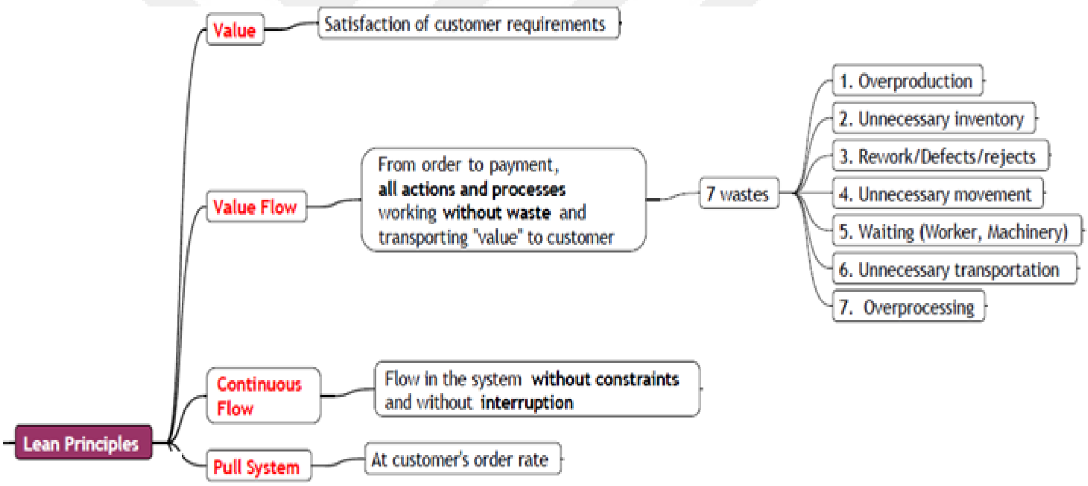
1.3.3. Creation of Flow

Classical mass production system consists of many actions, such as production, sales, or design, and these actions are separated into different departments of an organization. Keeping a product until it is sold might lead to time-consuming, unexpected problems, and many wastes. Instead of keeping, and then, pushing products to customers, organization can make their products to be pulled by customers which is more convenient according to Lean Thinking. Therefore, wastes can be minimized (Womack et al., 1990: 19).

1.3.4. Establishment of Pull

A product should be produced in an exact time and sent to an exact location when customers want that product. According to this condition, manufacturers do not produce unwanted products, and so, unnecessary stocks are not accumulated on value flows (Jones & Womack, 1996: 87-118). In the pull principle of Lean thinking, value is pulled by customers from sources of production. In compliance with pull principle, production starts from customers' demand, and continues until the product is delivered to the customers.

Figure 7: Lean Principles



Source: Özdemir, 2017: 2

1.3.5. Pursuit of Perfection

Lean principles are summarized in Figure 7 — value, value flow, continuous flow, and pull system. When Lean Operation is carried out, workforce efficiency increases, cycle time decreases, and defective products decrease. Therefore, diversified product is increased by minimal additional cost. Pursuit of perfection concept is inevitable for competitive and profit-making sectors and operation areas. In this way of production, organizations focus on expectations of consumers over desired products and they realize that the perfection is an endless process.

1.4. LEAN MANUFACTURING TECHNIQUES

Starting from 1950s, Lean Manufacturing, with its original philosophy, modern as well as advanced production techniques, has marked an era all over the world. Basically, the goal of Lean Manufacturing is the elimination of redundant waste in every stage of operations. To reach that goal, many methods have been developed by experts both in industry and academia (Akçagün, 2006: 12). Prominent techniques that have been established so far will be discussed in this subsection.

1.4.1. Just in Time Production (JIT)

Just in Time (JIT) means that ordered products are produced and dispatched with desired quantity on time. Through this process, the stock is minimized, production and transportation costs are reduced (Çetinkaya, 2000: 305). JIT approach is necessary to pursue perfection for each stage in operations. Moreover, JIT system can be employed to design non-defective production.

1.4.2. Zero Defect

Firms employing traditional manufacturing methods conceive of "Zero Defect" in its simplistic terms. However, according to Lean Operation Concept, defects and causes of these defects should be simultaneously controlled during operational processes. Eliminating defective products in production processes is the motto of this concept (Demir and Gümüşoğlu, 2003: 67).

1.4.3. Zero Stock

Another important objective of Lean Manufacturing is to reach "Zero Stock" level. This objective is not only carried out in production operations, but also in supply chain operations with a holistic approach. All departments of organizations must seek answers to following two questions: "Why do we work with that stock?" and "Why are we producing this product *now*, if it is unnecessary to produce now?” (Hutchins, 1999: 6)

1.4.4. Kanban System

One of the most importing qualifications of Lean Manufacturing is "Kanban System.” Kanban means “card” in Japan. Kanban is used in activities throughout production operations. Kanban card example is shown in Figure 8. Kanban should have following information;

- Part number,
- Part name,
- Kanban number,
- Descriptive Code number,
- Job station of Kanban.

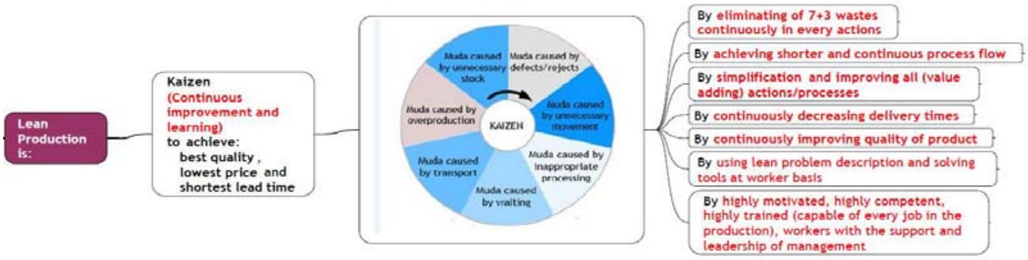
Figure 8: Kanban Card

Source: Özdemir, 2017: 2

1.4.5. Kaizen

Kaizen is a Japanese word meaning `continuous improvement'. The utmost purpose of Kaizen is, again, the elimination of waste on a value stream. Kaizen provides decrease in cost and increase in quality, and thus, quality assurance. Kaizen focuses on the satisfaction of customers' expectations. Process can be improved gradually by Kaizen philosophy (Sayer and Williams, 2007: 118). Figure 9 shows prominent purposes of Kaizen philosophy — best, quality, lowest price, and shortest lead time with eliminating of seven plus three wastes recursively in every stage of production operations.

Figure 9: Kaizen



Source: Özdemir, 2017:2

1.4.6. Total Productive Maintenance

The goal of Total Productive Maintenance is to eliminate waste in machines functioning in all production processes with participation of all personnel having operational responsibilities and workers. Wastes in machines might be potential machine breakdowns, waiting times in set-ups and/or settings of machines (Okur, 2000: 95). Therefore, overall equipment efficiency increases, and so does total productivity. (Görenes and Yenen, 2007: 48).

1.4.7. Poke- Yoke

Poke- Yoke is another Japanese word meaning `mistake-proofing’. In application, Poke- Yoke is a design tool to eliminate possibility of errors by, first, discovering, and then, ameliorating them. Poke- Yoke focuses on solutions of repetitive errors, such as physical and mental tiredness of worker. Some examples of repetitive errors are listed below:

- Process errors,
- Incorrect machining of parts,
- Lost parts,
- Incorrect parts,
- Incorrect processing of the part,
- Adjustment errors,

- Incomplete preparation of tools.

1.4.8. Jidoka

Jidoka's meaning is `to generate quality at its source'. In Jidoka practices, process mistakes should not be passed on to the next step (Sayer and Williams, 2007: 37). The basic principle of the Jidoka technique is simple — instead of letting mistakes determine the future processes, do determine mistakes at its source and solve them readily. If an error is faced during any process, first, production flow should be stopped, then, early response should be given to it and corrective actions should be taken, and lastly, repetitive mistakes on process should be prevented.

1.4.9. 5S Process (Seiri, Seiton, Seiso, Seiketsu, and Shitsuke)

5S process consists of five fundamental principles— sorting, setting in order, shining, standardizing, sustaining. If the Lean system is adopted, the most critical part of it is the sustaining cleanliness and discipline of working environment. Hereby, occupational health standards and high level of safety in the working environment can be achieved (Tapping, 2007: 1). Factors of discipline and cleanliness are comprised systematically in 5S, which is one of the Lean Manufacturing techniques.

The five steps of the 5S system are as follows:

- **1S- Sort**

Objects not contributing to a workplace are marked and removed.

- **2S- Set in Order**

Set in order is profoundly related to efficiency. Set in order means that a tool or equipment is placed quickly to a predetermined location in a very short period of time to make sure that employees can reach this equipment quickly, work stream is getting faster, and overall efficiency can increase.

- **3S- Shine**

The objective of shine is to create a clean workplace. Although it seems a quite easy objective, it might have many complexities in actions. Every cleaning process must be carried out carefully.

- **4S- Standardize**

The aim of standardization is to create a safe and well-organized environment. The best way is the sustaining of cleaning processes.

- **5S- Sustain**

The discipline stage is the most difficult one among other 5S principles because people tend to have low incentives, and thus, exert minimal effort to sustain established order. Only when 5S is carried out in a sustaining manner, 5S can be achieved wholly.

SECOND CHAPTER

STATISTICAL QUALITY CONTROL

2.1. QUALITY CONCEPT

2.1.1. Definition of Quality

Quality can be described based on various definitions or criteria. Quality is directly related to requirement of consumers, and because there is a divergence in expectations of consumers, quality cannot be defined uniformly by a set of objective criteria. Nature of quality is based on comparison (Doğan and Tütüncü, 2003: 27).

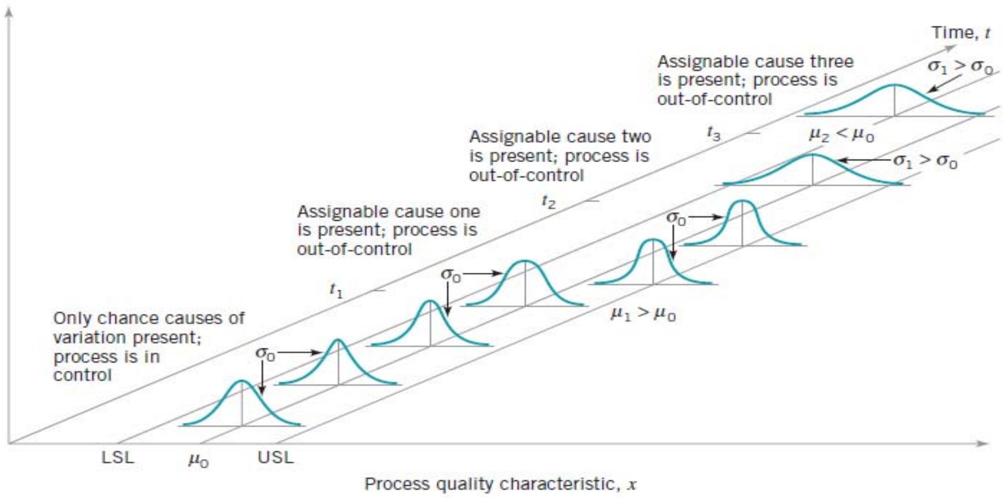
Quality can be defined as an ability to predict what the market is willing to buy with low cost and reliability (Doğan and Tütüncü, 2003: 27), a conformance to usability (Juran, 1989: 15) or requirement of a product (Doğan, 1991: 5), the sum of the properties of a product or service that has ability to meet specified or potential needs (Doğan, 1991: 3), or the minimal damage of product on society from delivery to distribution. Taking all these different definitions into considerations, quality can be defined as a conformity to desired characteristics (Bozkurt, 1997: 25).

2.1.2. Variation of Quality

- **Chance Causes:** Every process includes natural variations. These natural variations are the sum of all inescapable causes. Chance causes lead to a variation in processes, but these causes can be controlled statistically (e.g. variations in raw material and vibration of machines).

- **Assignable Causes:** Assignable causes might stem from three sources — machine, worker, or raw material. Variation in assignable causes might be large and this large amount in variation is not acceptable. Assignable causes might lead to variation in processes which might not be controlled statistically (e.g. a big mistake made by an untrained worker during operations).

Figure 10: Chance and Assignable Cause of Variation



Chance and assignable causes of variation.

Source: Montgomery, 2009: 186

Chance and assignable causes of variation are illustrated in Figure 10. The process until time t_1 can be illustrated as it is in control meaning that only chance causes of variation are possible to exist. As a result, both the mean and standard deviation of the process are at their levels of in-control values (m_0 and σ_0). Starting from time t_1, an assignable cause might exist. As shown in Figure 10, the effect of this assignable cause shifts the mean of the process from m_0 to m_1, where $m_1>m_0$.

At time t_2, another assignable cause might occur and result in at $\mu = \mu_0$, but now the standard deviation of the process shifts to a larger value of σ_1 from σ_0. At time t_3, another assignable cause might occur, leading to out-of-control values for both the mean and standard deviation of the process. From time t_1 onwards, the presence of assignable causes has resulted in an out-of-control process.

Processes will often operate in an in-control status for relatively longer periods of time. However, no process is truly stable forever and assignable causes might occur quite possibly, seemingly at random. These causes result in a shift to an out-of-control status where a larger proportion of the process output does not conform to requirements; for instance, recalling Figure 10, when the process is in control, most of the production will fall between the lower and upper specification limits (LSL and USL), whereas, when the process is out of control, a higher proportion of the process lies outside of these limits.

2.2. STATISTICAL QUALITY CONTROL CONCEPT

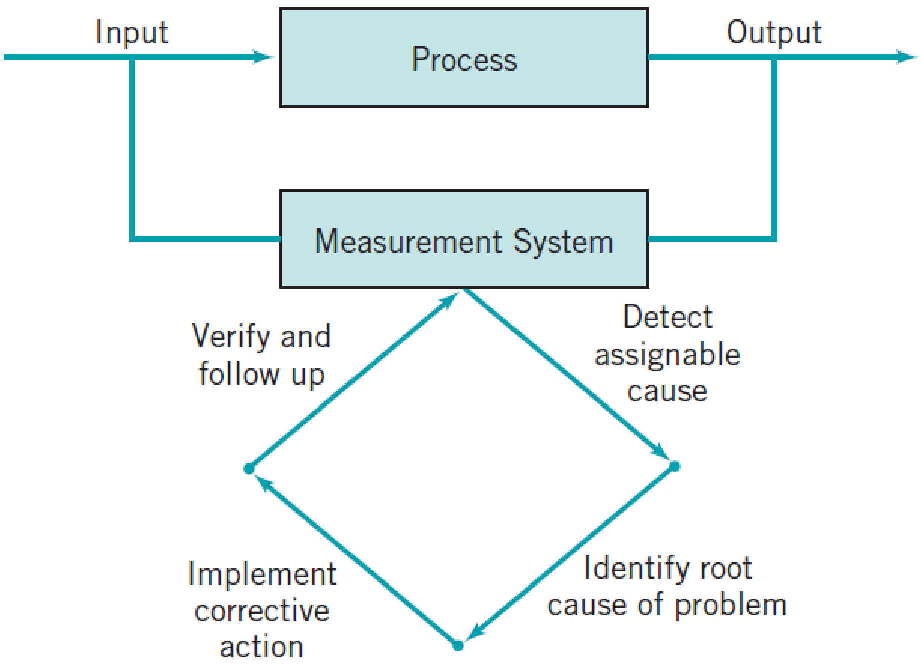
2.2.1. Control Charts

Main goal of Statistical Quality Control is to detect assignable causes as quickly as possible and ensure to take corrective actions before defective products are produced in large quantities. Control Charts are one of the most famous methods for production quality control. The reasons for why to use control cards can be listed as follows:

- Control charts are the tool for controlling process to improve productivity.
- Control charts are used in many ways, such as online statistical process control.
- Control charts provide historical information about the process and provide data for the analyses of current processes.
- Control charts are widely used for process improvement. Through minimizing assignable causes and decreasing process variations.

Control charts are an established technique for improvement in efficiency. A successful control chart program can reduce scrap and rework, which are the primary sources for decline in productivity, as well as increase in cost.

Figure 11: Process Improvement by Using Control Chart



Source: Montgomery, 2009: 160

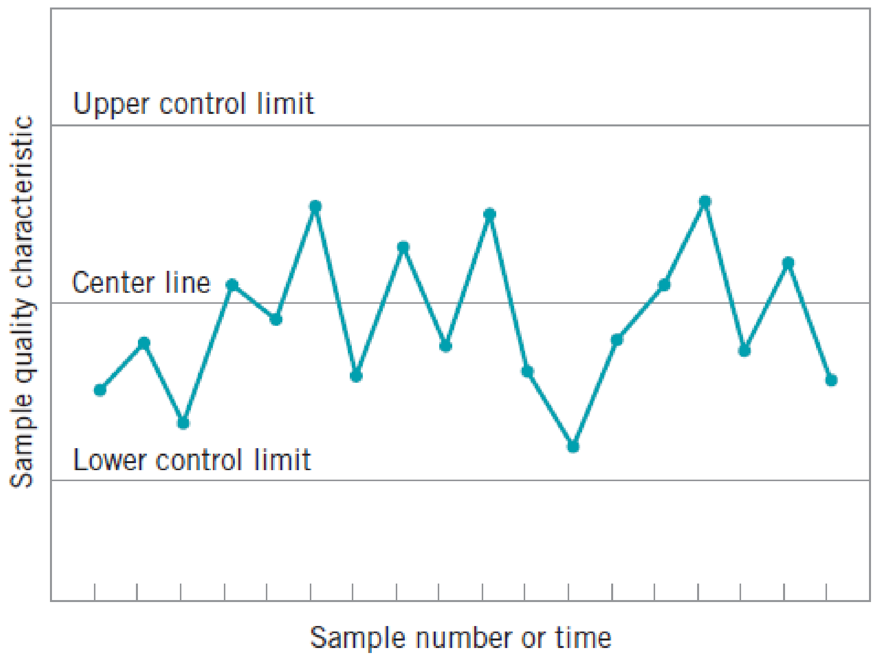
Process improvement is illustrated in Figure 11 by using control chart. Measurement system is critical for process. Before the verification and follow-up of data, measurement system should be set on process precisely. Then, sources of assignable causes are determined and corrective actions are implemented together with process engineers and operators (Montgomery, 2009: 185).

Control charts provide analytical information for operators or engineers by generating patterns out of data points. That provides invaluable repository of information for further improvements in the processes (Montgomery, 2009: 185).

Control charts provide information about the value of important process parameters and their stability over time. This information allows product and process designers to estimate their process capabilities (Montgomery, 2009: 186).

The motto of control charts is "Apply correctly at first time." Facing errors or mistakes, and avoiding them at the beginning is much cheaper than trying to overcome them at later stages on process line (Granth and Leavenworth, 1999: 88).

Figure 12: Sample Control Chart



Source: Montgomery, 2009: 183

Figure 12 shows a typical control chart. Basically, the control chart is a graphical image of quality characteristics that have been measured or estimated out of samples.

Center Line: Mean value for quality characteristics based on in-control condition.

Upper Control Limit (UCL): Maximum value for quality characteristics corresponding to the in-control condition.

Lower Control Limit (LCL): Minimum value for quality characteristics corresponding to the in-control condition.

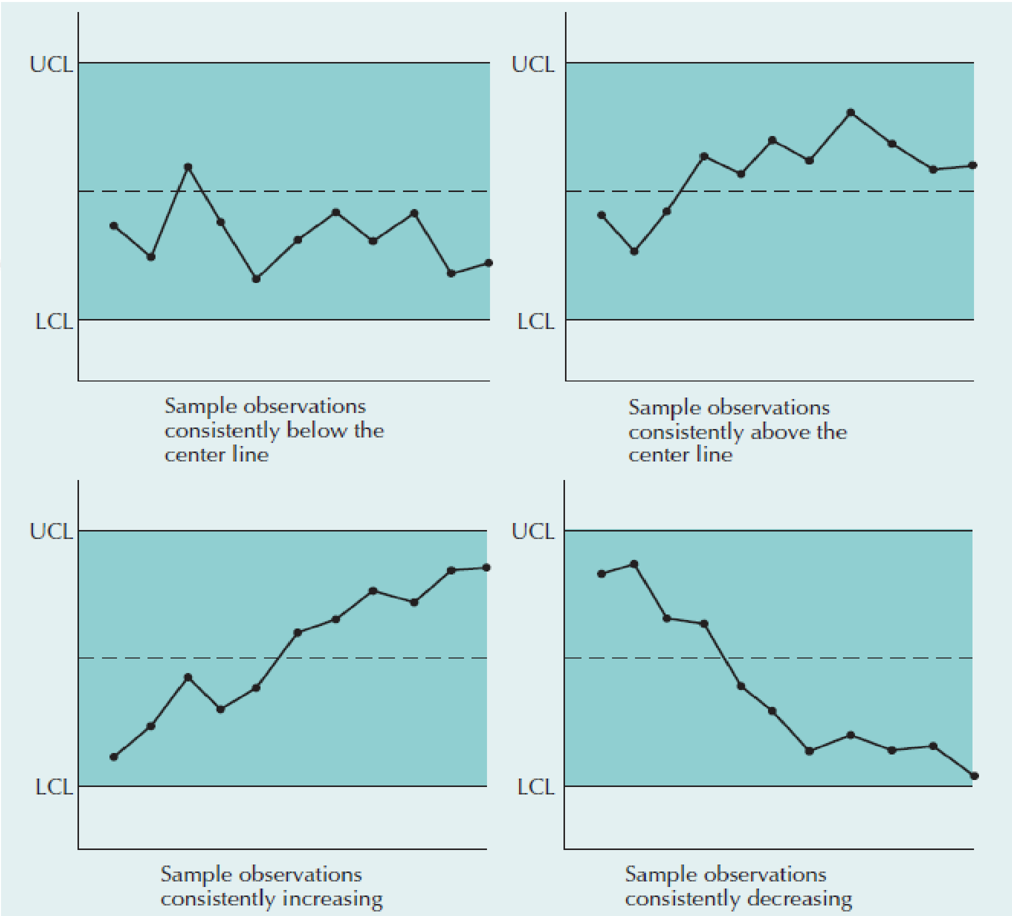
2.2.2. Selection of Control Limits and Control Chart Patterns

Choice of Control limits is very important subject for statistical quality control. If UCL and LCL move away from the center line, that means the risk decreases, but if mistakes fall beyond the control limits that indicates an out-of-control condition where no assignable cause is present. At the same time, if control limits are held widely, the risk might fall between the control limits when the process is, in fact, out of control (Taylor and Russell, 2011: 124).

Although control chart is a pointer of process and provides a sort of control over the process, variation might still occur in the process. When control chart is out of control limits, that means control limits may not be random (Atkins, 2013: 67). If the sample values display a consistent pattern, even within the control limits, this pattern seems to have a nonrandom cause that might warrant investigation. Control chart pattern is illustrated in Figure 13. Top-left hand corner of Figure 13 shows, sample observations consistently below the centerline. Top-right hand corner of Figure 13 shows that the sample observations are consistently above centerline, whereas, bottom-left hand of Figure 13 shows that the sample observations are consistently increasing. Bottom-right hand of Figure 13 shows that sample observations are consistently decreasing (Taylor and Russell, 2011: 125).

While analyzing control chart patterns, designers or engineers may encounter many troubles letting them detect systematic or unsystematic patterns and causes of these patterns (Banks, 1989: 41). At this point, designers or engineers should know precise information about all processes, as well as have statistical quality control knowledge.

Figure 13: Control Chart Pattern



Source: Taylor and Russell, 2011: 124

A pattern in a control chart is characterized by a sequence of sample observations that display the same characteristics. For example; the three values above the center line followed by the two values below the line represent two runs of a pattern. Another type of pattern is a sequence of sample values that consistently goes up or goes down within the control limits. Several tests are available to determine whether if a pattern is nonrandom or random (Taylor and Russell, 2011: 124).

Table 1: Factors for Determining Control Limits for $\bar{x}$ and R-Charts

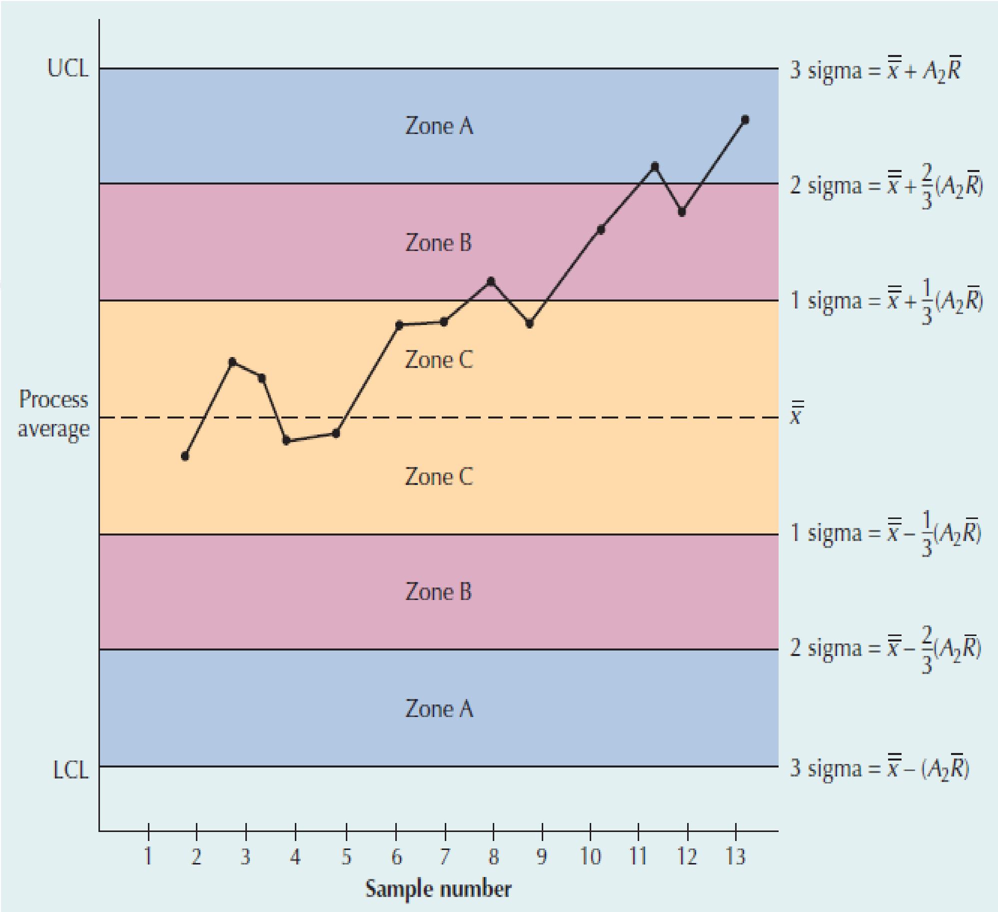
Sample Size	Factor For $\bar{x}$ Chart	Factors for R- Chart	Factors for R-Chart
n	A_2	D_3	D_4
2	1,88	0	3,27
3	1,02	0	2,57
4	0,73	0	2,28
5	0,58	0	2,11
6	0,48	0	2
7	0,42	0,08	1,92
8	0,37	0,14	1,86
9	0,34	0,18	1,82
10	0,31	0,22	1,78
11	0,29	0,26	1,74
12	0,27	0,28	1,72
13	0,25	0,31	1,69
14	0,24	0,33	1,67
15	0,22	0,35	1,65
16	0,21	0,36	1,64
17	0,2	0,38	1,62
18	0,19	0,39	1,61
19	0,19	0,4	1,6
20	0,18	0,41	1,59
21	0,17	0,43	1,58
22	0,17	0,43	1,57
23	0,16	0,44	1,56
24	0,16	0,45	1,55
25	0,15	0,46	1,54

Source: Reid and Sanders, 2011: 111

One type of pattern tests divides the control chart into three "zones" on each side of the center line where each zone has one-standard-deviation wideness. These zones are denoted as 1-sigma, 2-sigma, and 3-sigma limits (Reid and Sanders, 2011: 111). The pattern of sample observations in these zones is then used to determine if any nonrandom patterns exist. Recall that the formula for computing an $\bar{x}$–chart uses *A2* from Table 1, which assumes 3-standard-deviation control limits (or 3-sigma limits).

Thus, to compute the dividing lines between each of the three zones for an x̄-chart, we use $A2$. The formulas to compute these zone boundaries are shown in Figure 14.

Figure 14: Process Control Limits



Source: Taylor and Russell, 2011: 127

There are several guidelines associated to the zones to identify patterns in a control chart where none of the observations is beyond the control limits (Taylor and Russel, 2011: 128):

1. Eight consecutive points on one side of the center line

2. Eight consecutive points up or down

3. Fourteen points alternating up or down
4. Two out of three consecutive points in zone A (on one side of the center line)
5. Four out of five consecutive points in zone A or B on one side of the center line

If any of these guidelines is applied to the sample observations in a control chart, that would imply that a nonrandom pattern exists and the cause should be investigated.

2.2.3. Types of Control Charts

Control charts are one of the most commonly used tools in statistical process control. They can be used to measure any characteristic of a product, such as the weight of a cereal box, the number of chocolates in a box, or the volume of bottled water (Reid and Sanders, 2011: 188). The different characteristics that can be measured by control charts can be divided into two groups — variables and attributes. A control chart for variables is used to monitor characteristics that can be measured and have a continuum of values (Taylor and Russell, 2011: 127).

2.2.3.1. Control Charts for Variables

Control charts for variables monitor characteristics that can be measured and have a continuous scale, such as height, weight, volume, or width. When an item is inspected, the variable being monitored is both measured and recorded (Reid and Sanders, 2011: 190). When observed values go outside the control limits, the process is assumed not to be in control — production is stopped, and employees attempt to identify the cause of the problem and solve it.

2.2.3.1.1. Mean (x-Bar) Charts

A mean control chart (or x-bar chart) is used to monitor changes in the mean of a process. To construct a mean chart, we first need to construct the center line of the chart(Taylor and Russell, 2011: 126).

$$UCL = \bar{\bar{x}} + z\sigma_{\bar{x}}$$
$$LCL = \bar{\bar{x}} - z\sigma_{\bar{x}} \tag{2.1}$$

$\bar{\bar{x}} = process\ average = \frac{\overline{x_1}+\overline{x_2}+\ldots+\overline{x_n}}{k}$

$\sigma = process\ standard\ deviation$

$\sigma_{\bar{x}} = standart\ deviation\ of\ sample\ means = \sigma/\sqrt{k}$

$k = sample\ (number\ of\ subgroups)$

$n = sample\ size\ (number\ of\ observations\ in\ each\ subgroup)$

Secondly, to develop an $\bar{\mathbf{x}}$-chart, the following formulas are employed to measure the control limits:

$$UCL = \bar{\bar{x}}+A_2\bar{R} \tag{2.2}$$
$$LCL = \bar{\bar{x}} + A_2\bar{R}$$

$\bar{\bar{x}} = Average\ of\ sample\ mean$

$\bar{R} = Average\ range\ of\ samples$

$A_2 = Factor\ obtained\ from\ Table\ 1$

2.2.3.1.2. Range (*R*) Charts

Range (*R*) charts are another type of control charts for variables. Whereas *x*-bar charts measure a shift in the central tendency of the process, range charts monitor the dispersion or variability of the process. The method to develop and use *R*-charts is the same as to generate *x*-bar charts(Reid and Sanders, 2011: 200). The centerline of the control chart is the average range, and the upper and lower control limits are computed as follows (D_3 and D_4 are obtained from Table 1):

$$CD = \bar{R}$$

$$UCL = D_4\bar{R} \quad (2.3)$$
$$LCL = D_3\bar{R}$$

2.2.3.2. Control Charts for Attributes

Control charts for attributes are used to detect quality characteristics that are counted rather than measured. Attributes are discrete in nature and entail simple yes-or-no decisions; for example, the number of nonfunctioning light bulbs or the proportion of broken eggs in a carton. Control Charts for attributes are not used in this study, but examples are given to explain difference between control charts for attributes and variables (Reid and Sanders, 2011: 202).

P-charts: Used when observations are placed in either of two groups.

Examples:

● Defective or not defective

● Good or bad

● Broken or not broken.

C-charts: Used when defects can be counted per unit of a measure.

Examples:

● Number of dents per item

● Number of complaints per unit of time (e.g., hour, month, year)

● Number of tears per unit of area (e.g., square foot, square meter).

The primary difference between using a p-chart and *c*-chart is that the p-chart is used when both the total sample size and the number of defects can be computed whereas the c-chart is used when we can compute only the number of defects but cannot compute the proportion that is defective.

2.2.4. Process Capability Measures

2.2.4.1. Process Capability Ratio

The critical aspect of statistical quality controls is the evaluation of the production process's ability on meeting or exceeding preset specifications, which is called the process capability. Product specifications, or tolerance limits, are usually established by design engineers or product design specialists (Reid and Sanders, 2011: 202). One measure of the process capability to meet design specifications is the process capability ratio (**C_p**) defined as the ratio of the range of the design specifications (the tolerance range) to the range of the process variation that is typically $\pm 3\sigma$ or 6σ (Taylor and Russell, 2011: 122).

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$$C_p = \frac{Tolerance\ Range}{Process\ Range} = \frac{upper\ specification\ limit - lower\ specification\ limit}{6\sigma} \quad (2.4)$$

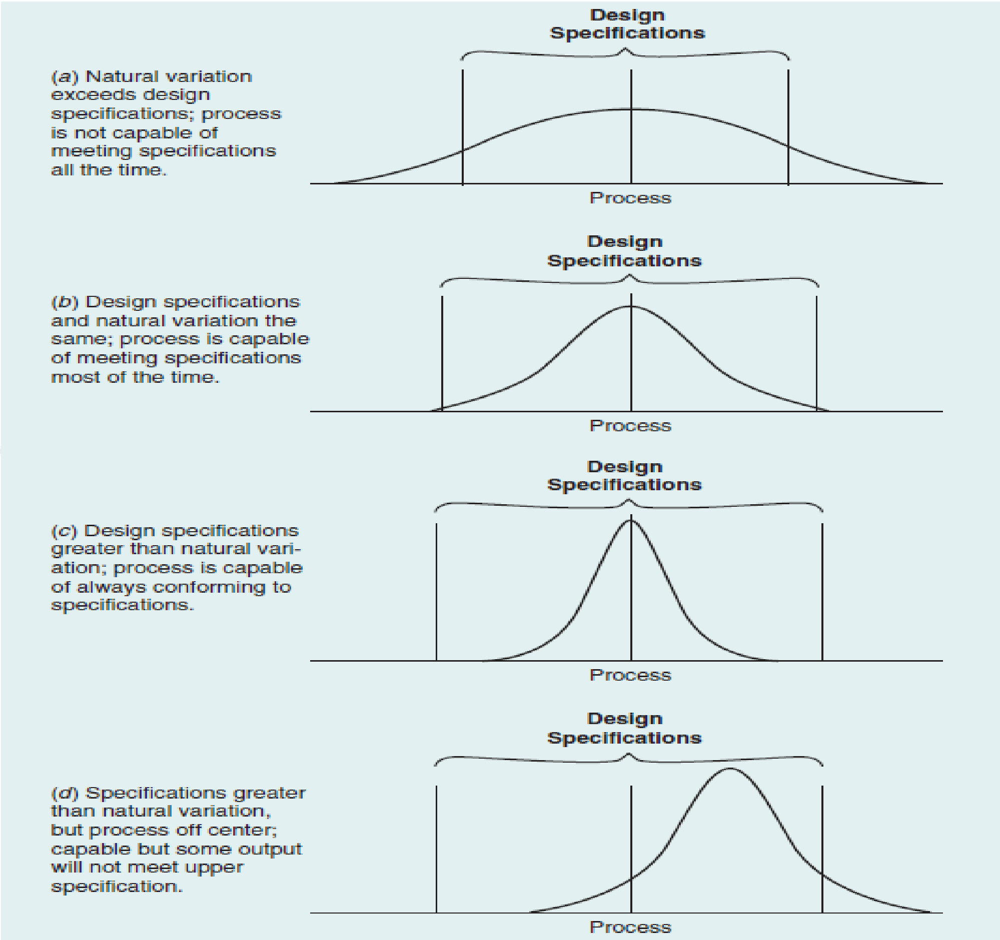
There are three possible ranges of values for C_p helping us interpret its value:

C_p=1: A value of C_p equals to 1 means that the process variability meets specifications — the process is minimally capable.

$C_p \leq 1$: A value of C_p is below 1 means that the process variability is outside the range of specification — the process is not capable of producing within preset specifications and needs improvement.

$C_p \geq 1$: A value of C_p is above 1 means that the process variability and the process exceeds minimal capability.

Figure 15: Design Specification on Process Capability



Source: Taylor and Russel, 2011: 122

Design specification on process capability is illustrated in Figure 15. Every process includes natural variations, but designers and engineers want to minimize these natural variations; for instance, (a) in Figure 15 shows that natural variation exceeds design specifications — process is not capable of meeting specifications all time. However, (c) in Figure 15 shows that design specifications greater than natural variation — process is capable of always conforming to specifications (Taylor and Russell, 2011: 122).

2.2.4.2. Process Capability Index

The second measure of process capability is the process capability index (C_{pk}). C_{pk} differs from C_p — C_{pk} indicates whether process mean shifts away from the design target, and reports the direction of this shift if it is off center. The process capability index specifically measures the capability of the process relative to the upper and lower specifications (Reid and Sanders, 2011: 205).

$$C_{pk} = minimum\left[\frac{\bar{\bar{x}}-lower\ specification}{3\sigma}, \frac{upper\ specification-\bar{\bar{x}}}{3\sigma}\right] \qquad (2.5)$$

If the C_{pk} index is greater than 1.00, then this means that the process is capable of meeting design specifications. If C_{pk} is less than 1.00, then the process mean seems to move closer to one of the upper or lower design specifications, and will generate defects. When C_{pk} equals C_p, this indicates that the process mean is centered on the design (nominal) targets (Reid and Sanders, 2011: 205).

THIRD CHAPTER

APPLICATION

3.1. COMPANY PROFILE

Dr. Oetker has a history of over 100 years. Its head quarter is in Bielefeld, Germany. All the other sub-entities of Dr. Oetker are controlled from this headquarter. While all Dr. Oetker establishments have similar management techniques in quality management systems, technology, and targets and strategies, product types and contents may vary across different Dr. Oetker establishments in different countries. Dr. Oetker, as a brand, appears in more than 35 countries all around the world with more than 3500 product types. German market is the first in ranking with 350 product types while Turkish market has 150. Dr. Oetker company provides job opportunities for almost 7000 people in the world.

This corporation is a family owned enterprise and Dr. August Oetker is the person who has developed the baking powder at his pharmacy in Bielefeld. Dr. Oetker's adventure in Turkey started in 1987 as a partnership with Maktaş Makarnacılık ve Ticaret T.A.Ş. Production was launched in 1988 with a capacity of 150 tonnes per month. In 2001, Dr. August Oetker A.G. took over Maktaş Makarnacılık ve Ticaret T.A.Ş's stakes and reached today's capacity of 1000 tonnes per month. Dr.Oetker also entered frozen food sector in 2001 and launched crust production in 2003.

The factory is in the outskirts of İzmir, Torbalı. There are many engineers working at the company right now. Production Director, Quality Control and R&D Chief of Powder Products, Quality Control and R&D Chief of Frozen Products, Sales Chief of Middle Anatolia Region are all food engineers. Logistics Director is an industrial engineer. General Manager is a chemical engineer with a Ph.D. Dr.Oetker's portfolio includes more than 80 types of powder products, 30 sorts of food service products, and 10 different sorts of frozen pizza

3.1.1. Processes

3.1.1.1. Manufacture of Powder Products

The factory operates two basic processes. One of them is for powder products. Manufacture process can be divided into 3 main parts — raw material acceptance, production, storing and transportation.

- **Raw Material Acceptance:** For raw material acceptance, there exists a procedure that should be followed by the vehicles carrying raw material. First, the vehicle is weighed on the weighbridge and the amount of load is calculated. Then, the worker, who is responsible for disinfections, carries out last controls before landing (e.g. match of orders from purchasing department). Finally, production/expiry date stickers and consignment numbers are searched on sacks, and landing permission is given if everything is proper. Afterwards, microbiologist takes raw material samples from different sacks. Physical and biological analyses are conducted in quality control laboratories and the results are sent back to logistics department. Colored labels, which represent the quality of the materials, are stuck on the sacks. Their meanings are as follows:

    - Yellow = waiting for control
    - Green = suitable
    - Blue = limited usage
    - Red = unsuitable

Green labeled material passes the tests while the one with red label fails and sent back to the supplier. The blue labeled sacks also pass from the analyses, but with a warning to the supplier.

Production warehouse and logistics warehouse are places where raw materials are stored. Approved raw materials (green & blue-labeled ones) are placed according to the production plan, which is prepared by the cooperation of the production director, the production chief, and the production planning & development manager. Raw materials to be used in that day are put into the production warehouse and the others are stored in the logistics warehouse based on the ‘first in, first out’ principle.

Packaging material acceptance also includes the same procedure and the quality control test results are compared with the information on packaging material specification cards. Materials are stored in the logistics warehouse, away from the other raw materials.

- **Production:** Powder production unit operates in a three-floored building. Sieves operate in the third floor while mixers run in the second floor and the packaging process takes place in the first floor.

- **Sifting:** Required raw materials are transported to the production warehouse relying on the daily production plan. For this purpose, there is a responsible worker.

Every morning the sifting operators are given the formula cards of the products to be produced. Operators weigh all the ingredients on electronic scales and keep the printings for later use. On printings, there exist the name of the product, the amount of the mixed ingredients in detail, the product consignment number, and the name of the operators.

After weighing, mixtures are poured into the sieves. All mixture types are sifted through different, but appropriate sieve caps so that they have the needed granulation. This operation also provides the removal of impurities. To guarantee the removal, machines are regularly controlled against tearing. Since sieves are connected to the mixers, everything that is sifted directly goes into the mixer.

- **Mixing:** Six different mixers with different volumes and capacities operate in the second floor. There also exist two sugar mills in a separate room — away from the production line. Sugar mills grind sugar, sodium bicarbonate, and some other ingredients, and then, the powder outputs are taken to the third floor after the approval of Quality Control Department.

When all the mixtures are inside the mixer, it is run. Each type of mixture has a different mixing procedure. Mixing period and amount of consignment for different mixtures are stated on a chart for the use of workers. Mixing periods were determined after various trials and vary from 20 to 50 minutes. Amount of consignment is also another project and it is determined after bulk density tests and quality control department’s sensorial tests. Data vary across different mixers and materials.

Once mixing operation finishes, mixtures are put into silos for their approval-waiting period. Samples taken from five different places inside the mixer are sent to the Quality Control laboratories. Having done their sensorial & other related tests, silos with green labels wait for their turn for packaging while the red-labeled ones are moved away till their problems are solved. If the problems cannot be solved, mixtures are set apart to be sold as animal feed additive. The silos of which packaging time comes are connected directly to the packaging machines.

- **Packaging:** The packaging operators and the workers are responsible for the torn open pouches, and for the pouches with wrong weigh or incorrect label information. They should check the pouches on the packaging line regularly. There are three types of packaging processes made by the machines — bagging (putting into pouches), cartooning, and over-packaging by using a flat film.

In bagging, two types of pouches are used according to mixture amount — small or big. Small pouches are for baking powder, vanillin with sugar, and tart jelly while big ones are for all other product types. Package weighs vary from 5 to 500 grams and packaging materials are made up of polyethylene, aluminum paper, Orientated Polypropylene *(OPP),* Bi-Orientated Polypropylene (BOPP), and paper. During bagging, samples from each consignment are sent to Quality Control laboratories for sensorial tests.

Grouping of previously bagged products by using a flat film is called over-packaging. This process provides mechanical protection during transportation, storage, and marketing. Products in small pouches are over-packaged and sold in groups of three or five. Sometimes different types of products can be over-packaged together for promotional purposes. The packaging material is transparent polyethylene flat film with printings on it.

After bagging, cartooning and over-packaging, workers put all products into corrugated cardboards. Corrugated cardboard is defined as cardboard consisting of one or several sheets of ridged paper glued onto sheets of flat paper. Two types of corrugated cardboards are used in the factory — displays and outboxes. Displays are small boxes made up of micro-corrugated cardboard used for marketing and transportation purposes. The factory operates its own display machine in the packaging floor. All products are put into displays, except carton ones and classical cake flour series. Outboxes are big large-corrugated boxes used for easy transportation of large groups of same kinds of products. Outboxes are put onto pallets when they are filled with packaged product. Palletization differs across each type of products.

- **Storing & Transportation:** Logistics & Production Departments are jointly responsible for the stocks, and employ SAP system (Company Operating & Source Planning Software) for this purpose. Dr. Oetker does not work with any marketing firm, and thus, relies on its own marketing process. For transportation, they have contracts with two big cargo firms in Turkey.

3.1.2. Equipment

Sugar Mill: Normal sugar may cause hardening, and its cooking time is longer than powdered one. Therefore, in most of the products powdered sugar is used instead of normal sugar.

Mill is used to grind sugar. It has a rotating wheel inside a pored cylinder. As the wheel turns, sugar is compressed between the wheel and the cylinder. Powdered particles get out and pass through the pores, and drop down to a tube which is in the exit. A sack is connected to the exit and powdered sugar is collected. This type of mill resembles the two cylinder mills in which as the two cylinders turn, the material is turned to powder form. However, in these types of mills, the two cylinders turn to different directions.

- **Sieves:** Sieves are used to quickly sift the materials into the desired granulation. There are 5 self-shaking sieves in the factory. The sieve pore dimensions vary from 800µ to 1400µ changing across materials; for instance, products including normal sugar are sifted through the largely pored sieve.
- **Mixers:** Different amounts of mixtures are prepared for different types of products, thus, there are 5 mixers in the factory with volumes varying from 600L to 2700L. Sugar and emulsifier including mixtures are required to be mixed quickly, so mixer rate is also important.

The mixers are specially designated with two screws inside and a horizontal tank. The screws revolve in different directions so that every region of the product is well mixed.

During mixing, segregation can occur due to the size of the particles. Even very small differences in the size of the particles affect the flow behavior and the degree of mixing achievable in the mixing process. For that purpose, all products are sifted before mixing. The mixers providing convective mechanism are less segregating.

A twin rotor mixer is an identical mixer to the ones used in the factory. It consists of two shafts with either paddles or screws encased in a cylindrical shell. Several levels are available in shaft speeds ranging from moderately low to relatively high which is useful for continuously mixing non-free-flow powder solids. The mixers in the factory also resemble to the horizontal through mixer including semi-cylindrical horizontal vessels designed with one or more rotating devices.

3.2. AIM of APPLICATION

Giant ambient food factory produces powder food for households and professional consumers, however it has some problems on filling packages in preset weights. Some packaging machines fill in excess weights and this situation constitutes cost problems for the company. Since the company produces millions pouch yearly, its aim is to eliminate filling excess weight problems in machines completely. When raw materials change, operator controls package weight, but overfill packages are being produced in ongoing process, and defective packages increase which leads to inefficient source problem. Muhsin Çömden, a managing director, assigns a task to standardize and measure dosing parameters of these machines.

These parameters are related to two important factors: The first factor is food powder flow characteristics because every powder shows different flow forms — while certain food powders have easy-flow characteristic some have poor-flow characteristics (e.g. cacao powder). Therefore, food material is very problematic on food packaging dosing system and one of the factors that we should consider. Auger screw conveyor, which is used to perform flowing and dosing powder in package as a volumetric, should fit into your food powder flow, otherwise you are likely to face excess weighting problems in filling packages.

Our main question in this project is “Which auger screw design is proper for product flow characteristics in packaging machines, and how can we control these issues?” To answer this question, Kaizen team was formed with a name, Kaizen 125, and one mechatronics engineer, one food engineer, one electronic engineer and two experienced operators were assigned to this team. We have studied on P3 packaging machine for one year. In production operations, P3 machine has been operated for cacao-25-gram product, and our task is to analyze cacao, as a specific food material, in terms of powder flow characteristics and a new design of auger screw. To minimize excess weight in filling powder packages, we employ statistical quality control systems and lean operation concept with an engineering approach. Appendix 15 shows Kaizen 125 project plan.

3.3. APPLICATION STUDY

In this study, helical screw dosing system and food powder flow characteristics are studied by Kaizen 125 team. Process variation characteristics are determined by statistical quality control for cacao-25-gram product produced in P3 machine. Data are acquired in accord with sampling instruction for establishing process variation. Before doing this implementation, first, we learnt cacao's chemical composition and the parameters affecting cacao flow characteristics. Then, practical powder flow tester (Angle of Repose tester) is drawn at DS Solid Works 2017, and then designed by Kaizen 125 team. Angle of Repose tester is manufactured by a subcontractor of Dr. Oetker. Secondly, we examined P3 machine mechanical dosing system having helical screw and hopper where helical screw is in hopper geometry. Helical screw is redesigned to increase efficiency of helical dosing system by using mechanical solid flow state designing phenomenon and mechanics of helical calculations. Thirdly, the following questions are answered:

- What is our loss?
- What is our gain?
- How much should we decrease process variation?

3.3.1. Project Charter

Considering the limited time, cost and technical situations, ee came up with a tentative plan and listed main tasks entailed by the project so that the project can be realized in the most efficient way. In this application, Gantt Chart is created by using task list and Kaizen 125 project charter is obtained to analyze each of the project stages and get information. Table 2 shows task list of the Kaizen 125 project and gives information about its stages (for detailed information see in Appendix 15).

Table 2: Kaizen 125 Project Task List

Task Name	Start	End	Duration (days)
Description of Food Powder	07.04.2016	07.05.2016	30
Determination of Helical Screw Parameter	07.05.2016	07.06.2016	31
Taking Measurement of Helical Screw on Machine	07.06.2016	14.06.2016	7
Description of Food Powder Flow Properties	14.06.2016	14.07.2016	30
Equipment Design For Determination of Cocoa Powder Flow Character	14.07.2016	14.10.2016	92
Taking Samples from Production Line Before Kaizen 125 Project	14.08.2016	14.09.2016	31
Application of Design	14.10.2016	02.01.2017	80
Taking Samples from Production Line After Kaizen 125 Project	02.01.2017	02.02.2017	31
Assessment of Statistical Results	02.03.2017	09.03.2017	7
Reducing Excess Weight	09.03.2017	30.03.2017	21
Improvements of Process and Benefits of Project	30.03.2017	30.04.2017	31
Completion of Project	30.04.2017	30.04.2017	0

In April 2016, we started to search for literature survey on food powder. Many academic publications have been scanned for a period of a month from this date. After this phase, the research for the design parameters of the helical screw has been started. While learning scientific knowledge on the helical screws, measurements were taken for the redesign of the helical screw. Afterwards, academic publications have been examined for the powder food flow characterization which is one of the most important parts of the project. The analysis was listed based on scientific findings where you can look at Appendix 10 for the list. The chemical and physical properties of the cacao were determined by the Quality department. We used these properties for the advanced stage of the redesign. At this stage, a presentation is prepared by the team leader to show progress in the projects.

In July 2016, a practical equipment design was started to determine the flow characteristics of cocoa on the cocoa product in the P3 machine. To save money and time for the redesign, Turkish supplier was commissioned to produce new equipment. Designs of equipment were designed by Kaizen 125 team engineers. Their drawings were made in DS Solid Work 2017. Technical drawings are illustrated in Appendix 6.

One hundred and sixty samples were taken from the production line in August 2016 with respect to sampling notification. Sampling paper was prepared to take samples. Appendix 8 and Appendix 9 include these papers. The same samples were taken from the same line and shift while the same operator was in operation. In this stage, two sampling groups were taken and processed under KAIZEN 125 B1 Pair 1 and KAIZEN 125 B2 Pair 2. KAIZEN 125 B1 Pair 1 data are illustrated in Appendix 11 and KAIZEN 125 B2 Pair 2 are illustrated in Appendix 13. Samples were taken from the production line for one month.

In October 2016, the technical drawings were given to the supplier to produce a prototype of the helix screws and hopper shown in Appendix 7. At this stage, a helical screw is redesigned for the cocoa product flow characteristics. Design of the helical screws and hopper were prepared based on the powder product flow angle. In January 2017, this designed equipment was employed in the machine dosing system. In this design, the carrying capacity of the helical screw was increased from 3,803 grams to 6,014 grams.

One hundred and sixty samples were again taken from the production line in January 2017 according to sampling notification. Sampling paper is prepared for sampling. Sampling papers are shown in Appendix 8 and 9. The same samples are taken from the same line and shift while the same operator was in operation. In this stage, a total of two sampling groups were taken and processed under KAIZEN 125 A1 Pair 1 and KAIZEN 125 A2 Pair 2. KAIZEN 125 A1 Pair 1 data are illustrated in Appendix 12, KAIZEN 125 A2 Pair 2 data are illustrated in Appendix 14. Sampling has been taken from the production line for one month.

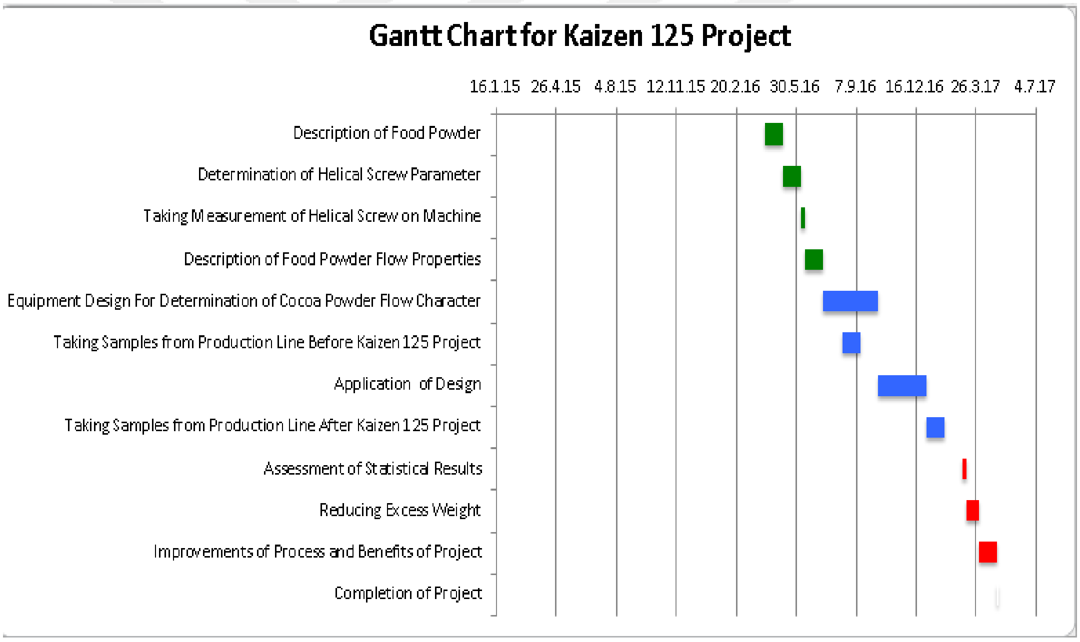
In March 2017, the new data were generated by closely examining production processes from 09.03.2017 to 30.03.2017. We observed reduction in excess weights. The cost of the project and the value that the project generated for the company were shown in the application part and are calculated in terms of unit input. The project was successfully culminated at the beginning of April 2017. At this stage, the final presentation was prepared by the team leader to show final results to a kaizen board — the general manager, the production manager, and technical service staff.

Gantt diagram for Kaizen 125 project are illustrated in Table 3. Gantt chart provides us to see the big picture and present stages of the project easily to the sponsor having limited knowledge about the stages and the progress of the project.

The Gantt diagram shows the followings as a bar graph:

- Current status of the project
- Estimated project duration
- Estimated duration of duty
- Completion of a task compared to the others.

Table 3: Gantt Chart for Kaizen 125 Project



3.3.2. Description to Chemical Composition and Flow Characteristic of Cocoa Powder

3.3.2.1. Chemical Composition of Cocoa

Cocoa beans are the seeds of *Theo broma* cacao tree. Foodstuffs are made up of oil, known as cocoa butter, and dry seeds are about half of the weight. Properties, such as the amount of fat, melting point and hardness, are dependent on the feature of the cacao and the environmental conditions. The seeds become fermented which causes chemical changes both inside and the surrounding of the seed. These changes affect the color of the seeds, as well as the flavor of the chocolate. Then, the seeds are dried and distributed to the processors so that cocoa mass, cocoa powder, and cocoa butter can be produced (Dand, 2013: 15).

Cocoa butter is obtained by crushing, grinding, and sifting of cocoa oil after pressing with cocoa. Cocoa and cocoa oil are used all over the world as well as in our country in the pastry sector, in the production of chocolate, and dairy products (Becketts, 1994: 27). Chocolate production is the most common use. Cocoa powder and cocoa butter, which are produced from cocoa beans and used in chocolate production, give a distinctive feature to the products because they have a high nutritional value, as well as a feeling of ease of consumption and psychological relief (Dand, 2013: 14).

3.3.2.2. Chemical Composition of Cocoa Powder

Standard cocoa powder has approximately 10-12 percent of a fat in its content. Cocoa bean has many by-products. Table 4 gives more information about chemical composition of cocoa powder and cocoa butter obtained by pressing the cocoa nib and brittle fracture below 20ºC where a melting point is about 35ºC with softening around 30-32ºC. It is basically made up of cocoa seeds, which is made into a very fine powder by taking up too much oil. Cocoa beans need to be fermented immediately after beaning, the outer shells must be picked and roasted. The duration of the roasting process determines the color and taste of the resulting cacao. After these preparatory steps, cocoa is processed in three main ways (Becketts, 1994: 27).

In the first method, the cores are milled until they become a brown fluid mass. The reason for their becoming this is the cocoa oil in them. This mass is then passed through the filter to remove excess oil. The product is ground and sieved into cocoa powder. The second method starts by soaking the seeds in alkaline solutions until they become soft and moist. The granules are then dried and passed through the processes described in the first method (Dand, 2013: 16). Depending on the alkalinity of the solution, the flavor and color of the cocoa may vary. It is also possible to obtain a darker color if desired. In the third method, the seeds are passed through a steam process to soften them without getting wet. It is easier to remove fat from the softening cores and larger. For that reason, the amount of fat in the cocoa is obtained by this method is much lower than that obtained by the other two methods. The last step in all three methods is the grinding of cocoa. When cocoa beans with low fat are very hard, they are processed through crackers with internal mill (Dand, 2013: 16).

Table 4: Chemical Composition of Cocoa Powder

Chemical Composition	Min	Max
Cocoa-Butter Content	10%	12%
Moisture Content (w/d)		4.5%
pH (10% suspension)	7,4	7,8
Ash Content		13.1%
Protein	21%	
Carbonhydrate	60%	

An indication of the composition of cocoa powder is in the following subsection, but note that this will be different depending on the roasting, alkalization, and pressing processes undertaken.

3.3.2.3. Flow Characteristics of Cocoa Powder

Cocoa powder has resistance to flow because of its cocoa butter content and particles size. Physical and flow properties of each cocoa powder particulate is measured. Table 5 shows cocoa powder physical and flow properties and followings give detailed information about cocoa powder's physical and flow properties.

Table 5: Physical and Flow Properties of Cocoa Powder

Physical and Flow Properties of Cocoa Powder	Values
Moisture Content (w/d)	% 4.5 (dried basis)
Cocoa-Butter Content	11%
Mean Particle Size	150 micrometer (μm)
Bulk Density	405,22 kg/m3 (ρ)
Voidage or Porosity	0,7 (ε)
Angle of Repose	58°

Moisture Content: Moisture content is important factor on flow characteristics. If moisture content is increased, resistance to flow raises flow of powder approach poor flow description. Moisture content does not directly affect flow characteristics, but it leads to adhesive force between particulate, hence, every particulate separation becomes so hard. In cocoa powder, moisture content is %4,5 in dried basis.

Cocoa- Butter Content: Butter content is primary chemical and flow properties for cocoa powder. Butter, in the cocoa powder, gives cohesive structure to cocoa powder. In this way, cocoa powder gains adherence property and cocoa powder is stick to stainless steel surface easily. Cocoa butter content in cocoa powder is 11%, and resistance to change is distinctive on flow characteristics.

Mean Particle Size: Particle size is one of the most significant properties of food powder. Particle size affects many features on particulate behavior characteristics. According to Schulze, the common experience with food bulk solids is that flowability increases with increasing particle size. Generally, it can be situated that, with decreasing particle size, the strength of a bulk solid becomes greater and, so its flowability decreases (Schulze, 2008: 111). Sieves measure mean of cocoa powder's particle size, and Appendix 3 shows sieves. Cocoa powder is 150 micrometer which is the smallest particle size in factory as a food material.

Voidage or Porosity and Bulk Density: Bulk density and voidage (or porosity) are basically used when conducting quality control in the food ambient industry. These parameters can assist to detect, for instance, whether a raw material can be mixed or a final product can be packed in a silo or container. Cocoa powder bulk density is 405, 2 kg/m^3. Container volume must be high when you stock cocoa powder for production operation activities. Porosity (or voidage) value of cacao powder is 0,7, and this value shows clearance in powder particulate. If you increase pressure on cocoa powder, porosity value increases, and thus, we expect that resistance to flow is high.

Angle of repose: There may be particulate systems of interest in different processing industries, which are free flowing, such as cereal grains, coarse sugar, etc. For these types of free-flowing materials, some characteristics angles can be used for calculations with considering aspects of storage and transport. This angle is the angle of repose (Arnold and Yu, 1997: 40). For measurement of angle of repose tester is designed for this application. Figure 16 shows angle of repose tester.

Figure 16: Angle of Repose Tester

Angle of repose tester is designed by Kaizen 125 team and each measurement is performed and drawn at DS Solid Work drawing program. Appendix 6 shows technical drawings. Description of flow is very complex study in engineering because practical and cost-friendly solutions are necessary to overcome problems. Figure 17 shows repose degree of cocoa which is measured very easily on repose tester and provides to describe flow characteristic of cocoa powder. Cocoa powder angle of repose degree is 58^0 and description of flow is very poor and very cohesive. Description of flow and angle of repose are illustrated in Table 6.

Figure 17: Angle of Repose Degree of Cocoa

Table 6: Description of Flow and Angle of Repose

Description of flow	Angle of repose (degree)
Excellent/very free flow	25–30
Good/free flow	31–35
Fair	36–40
Passable	41–45
Poor/cohesive	46–55
Very poor/very cohesive	56–65
Very very poor approx non-flow	>66

3.3.3. Optimization and Design Mechanical Helical Screw Dosing System on Packaging Machines with Engineering Approach

3.3.3.1. Powder Packaging Machines

All of the bagging machines used in the factory are form/fill/seal type. The term form/fill/seal means producing a bag or pouch from a flexible packaging material, inserting a measured amount of product, and closing the bag top. All the form/fill/seal type (*FFS*) machines available in the factory use gravimetric filling with changes in the filling equipment. Two distinct principles are utilized to form/fill/seal packaging — horizontal (HFSS) and vertical (VFFS).

The HFFS machines used in the factory can be classified as rotary or in-line with intermittent motion. Intermittent motion provides change of pouch size for these machines. This is a very good property for the factory since different sized pouches are used for different products.

There is one single in-line machine with the brand. This machine forms, fills, and seals the pouch on the same line. It produces three pouches together at every cycle. It operates at rates up to 120 pouches per minute. This machine is used for baking powder packaging, and since this product is sold out in groups of five, a photocell is added for counting. This photocell starts the conveyor band when the groups are formed.

In the rotary type machines, the pouch sides are sealed, the pouch is cut and transferred to an indexing wheel. Pouch opening, filling and top sealing take place at various conditions around the circumference of the indexing assembly. Vanillin with sugar and all other big pouched products are packaged in these machines.

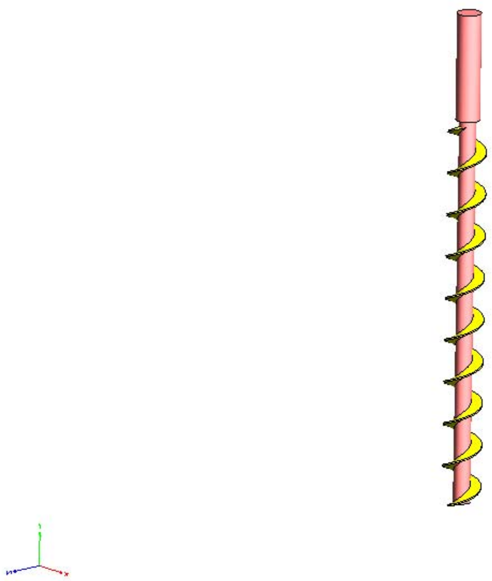
In both in-line and rotary type, the production date and the serial number are printed on the pouches before they are discharged. There is one VFFS in the factory and it is used for classical series cake flour packaging. This machine forms and fills vertically and is used to produce single-service pouches. It produces a flexible bag from flat roll-stock. Materials from a roll of a given web dimension is fed through a series of rollers to a bag forming collar/tube, where the finished bag is formed. The roller arrangement maintains minimum tension and controls the material as it passes through the machine preventing overfeed or whipping action. The bag forming collar receives the film web from the rollers, changes the film travel from a flat plane, and shapes it around a bag forming tube.

For filling, a spiral inside the tube is used. A spiral starting from the top lets the right amount of a product drop down. For sealing, two sealing tools are used — vertical and cross seals. The vertical seal turns the package material into a tube. The cross seal consists of a front and rear cross-sealing jaw that cuts the bottom and top of a bag. Another seal prints the production date and serial number. The filled bags fall onto a conveyor and move to a balance, which weighs them and eliminates the ones with wrong weight. The right weighed products are put into cardboards by the workers this machine is controlled by a computer. The amount of product, volume of the bag, the product density, and the jaw temperature values are uploaded to the computer.

3.3.3.2. Optimization and Design Mechanical Helical Screw Dosing System

There are various techniques used to increase the extraction capacity along the axis of a screw. The most influential technique is to increase the screw diameter (the cross-sectional area increases as square of this dimension). Other ways are to increase the pitch, reduce the center shaft diameter, or reduce the friction on the face of the screw flight. These variations can be made in almost any combinations, or independently. The effect of these changes will be examined in detail in Figure 20.

Figure 18: Helical Screw Feeder



A screw feeder or discharger is used to control the flow rate of a bulk material from a bin or hopper (Figure 18 shows helical screw feeder). Helical screw feeders are the ones that are used most commonly. The single screw feeder and hopper are separate units of powder dosing system. Helical screws are used for moving bulk materials in different ways (Beddow, 1981: 23). While the fundamental operating principle on which screws transport loose solids is based upon the rotation of an inclined face to promote the bulk material to move, screws work under different loading conditions, at various inclinations, and with many variations of functions. These different screw types may be broadly classified as conveyors, elevators, and feeders.

The class of feeders includes the use of discharge screws as an integral feature of a bulk storage facility, and as dispensing devices, where the prime function is to measure the feed at a controlled rate. The main distinction between the three main classes of screws for handling solids is based upon the mode of conveying of the material in transit (Bates, 2000: 46).

The selection criteria for these various modes of conveying are completely different. The capacity, power, and interfacing needs occupy distinctively separate considerations. For example, the nature of the material handled and the need to minimize wear may compromise the speed of operation of conveyors. The size of elevator may be determined more by the casing span than the handling capacity.

Figure 19: Dosing Hopper

Hopper outlet size is very important factor on dosing system. The design of a dosing hopper for bulk materials are taken in isolation (Figure 19 shows dosing hopper). The fixing of one key parameter tends to influence the rest (Bates, 2000: 47). For example, deciding an outlet size for flow considerations requires a width of feeder to serve the opening size selected. It is usually obvious whether a single screw can meet this task, and what speed it would have to run at to deliver the rated discharge. The section of a slot length to acquire a given storage volume without shallow end walls, puts a limit to the lowest size of central tube that can span between the end bearings. The tube size, then, sets a lower boundary for the size of screw, and may be used without creating a screw form out of normal proportions. The design of a feeder is affected by both the arching potential of a powder and the extraction pattern which are necessary to generate (Bates, 2000: 47).

Another crucial decision is on the shape of the outlet (Figure 19 shows flow pattern in hopper). This decision is made by the feeder connection with an extraction profile and inlet length as selected (Bates, 1994: 217). The interface connection for a screw feeder is usually a slot form with a length exceeding twice the width of the outlet. Shorter inlets are occasionally used, but they neglect to take advantage of the ability of screw feeders to serve slot outlets offering better flow prospects and greater storage capacity. The fixing of one key parameter tends to influence the rest. For example, deciding an outlet size for flow considerations requires a width of feeder to serve the opening size selected. It is usually obvious whether a single screw can meet this task, and what speed it would have to run at to deliver the rated discharge (Bates, 1986: 66).

3.3.3.3. Selection and Manufacturing Criteria of Screw Dosing System

The choice of standard equipment offers some advantages. The designs are complete and refined by experience. Cost is known and delivery will be shorter than custom-built products, possibly even ex-stock. Variants on standards, such as differing lengths, choice of drive and its position, and connection details can exist. The main drawback of selecting standard equipment is that construction and features special to the application cannot usually be included, except add-ons. When formulating the specification of a unit to offer features which is beneficial to the particular application, the first consideration is the screw construction (Bates, 2000: 48).

Wear resistance, the casing of a screw feeder, is not normally exposed to wear from the product sliding on the surface because the clearance between the screw flights and the casing usually allows a dead layer of product to isolate the inner casing surface (Ekaterina, 2016: 38). Flight tip wear is the most common form of wear afflicting screw feeders. As previously described, thicker flight forms do not reduce flight tip wear. In fact, the thickness detracts from an extended life because any product trapped between a thick flight tip and the bed of residue takes longer to clear as the screw rotates than it would from a thin flight. Counter to intuition, a flight chamfered on the trailing edge reduces tip wear and has the extra advantage of reducing the power needed to turn the screw. A narrow and hard weld deposit on the tip provides the same effect, and a better protection for abrasive duties. Face wear is not usually a problem, except with very abrasive materials (CEMA, 1980: 323)

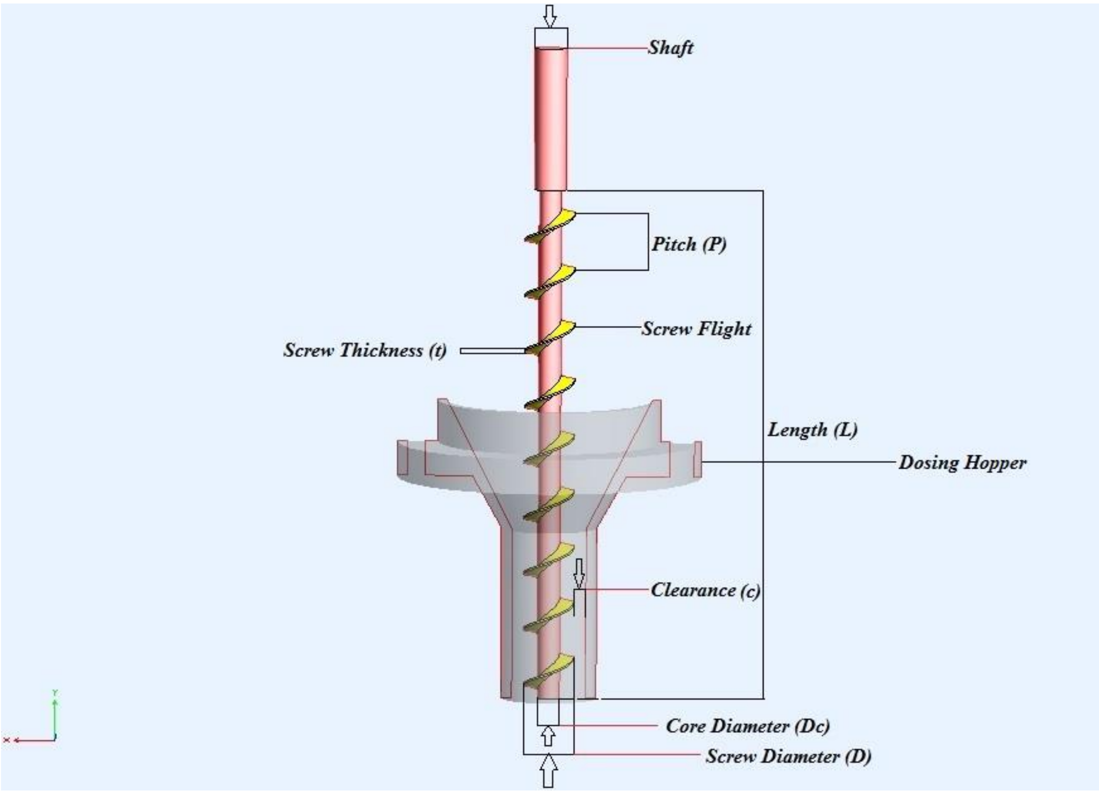
3.3.3.4. Performance of Screw Dosing System Capacity and Volumetric Efficiency

Many of researchers have showed that the volumetric capacity and volumetric efficiency most important parameter for screw dosing system. At each powder conveying, or dosing system, efficiency is the most important indicator in case of operations performance. The design of a helical screw feeder has a narrow connection with dosing hopper. First, the length and width of the hopper geometry is based on the food powder flow properties of the bulk solid hopper flow theory. Moreover, contemplating a helical screw feeder design includes;

- Capacity which is interested with helical screw geometry, the rotating speed of the helical screw and the volumetric efficiency.
- Even draw-down helical screw efficiency which is mainly couple with the geometry of the hopper outlet and helical screw feeder geometry in the dosing system.

The main aim for the effective design of helical screw dosing system can be abridged as determination of the capacity and volumetric efficiency. This objective requires dosing geometry to achieve the preferred hopper flow pattern. Theoretical modeling for the performance of screw dosing feeders are shown in Figure 20.

Figure 20: Helical Screw Capacity and Efficiency Parameters



Disregarding the thickness of the screw (t), the volumetric efficiency n_v of helical feeder at a given location along the screw can be formulated as the bulk volume V_{con} conveyed in one rotation, divided by the volume of one pitch *(P)* length at that location (Yu, 1997: 76).

$$n_v = \frac{V_{con}}{\pi P(R_o^2 - R_c^2)} \tag{3.1}$$

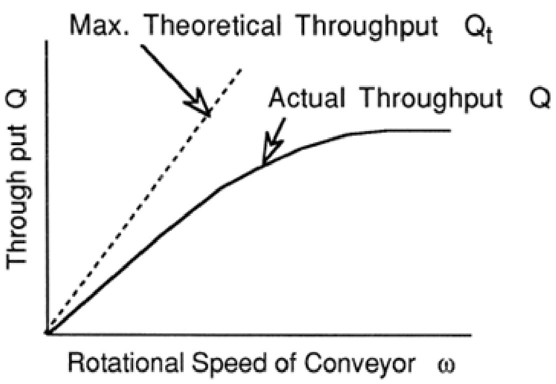
The volumetric efficiency of the material element conveyed can be figured out as:

$$n_v = \frac{Q_a}{Q_t} \tag{3.2}$$

$$Q = Q_t n_v \; ({m^3}/{s}) \tag{3.3}$$

The volumetric capability of a food powder helical screw is given by Roberts (1999: 59). Q is maximum theoretical capacity, when conveyor works 100% capacity.Figure 21 shows theoretical and actual throughput.

Figure 21: Theoretical and Actual Throughput



Source: Roberts, 1992: 11

The volumetric efficiency or capability comprises two elements — the rotational effect and the fullness effect. For helical screw feeder operating at low speed, the effectiveness of screw can be paid regard to be operating 100 percent full. The descent factor impressing the volumetric efficiency is the rotational motion which is a function of the screw dosing geometry, as well as the coefficient of friction between the bulk solid and the flight surface.

3.3.3.5. Effect on Clearance on Dosing Capability

A significant structural property affecting the capability of a helical feeder is the clearance (c) between the hopper and the screw diameter (D) in dosing system. Clearance is necessary to prevent metallic wearing from taking place during rotation due to various adverse factors, such as shaft deflection, faulty manufacturing eccentricity on machine integrity, and tolerance on the helical screw and the hopper. It can be exactly seen that the observed values have a good consistency with theoretical calculation and the increase of the capability is proportional to increase of the clearance (c) (k value equals to 0 because of draw-down axis).

The output per rotation of a single screw feeder can be calculates as (Bates, 2000: 90):

$$V_o = \pi n_v P[(R_O^2 - R_c^2) + (1-k)(2cR_o + c^2)] \tag{3.4}$$

A screw feeder or discharger is used to control the flow rate of a bulk material from a bin or hopper. Helical screw feeders are the ones that are use most commonly. According to Bates, the single screw feeder is a separate unit and hopper is separate unit of powder dosing system. Helical screws are used for moving bulk materials in different ways. While the fundamental operating principle on which screws transport loose solids is based upon the rotation of an inclined face to promote the bulk material to move, screws work under differing loading conditions, at differing inclinations, and with many variations of functions (Bates, 2000: 75). Helical screw and hopper designs before the Kaizen 125 Project are depicted in Figure 22.

Figure 22: Before the Kaizen 125 Project Helical Screw and Hopper

3.3.3.6. Engineering Calculations

Table 7: Before the Kaizen 125 P3 Machine Helical Screw and Hopper Design Parameter

(Before Kaizen 125 Projection) P3 Machine Helical Screw and Hopper Design Parameter	Values
Helical Screw Thickness (t)	0,0021 m
Pitch (P)	0,017 m
Helical Screw Length (L)	0,1 m
Core Diameter (Dc)	0,01403 m
Clearance (c)	0,0025 m
Screw Diameter (D)	0,0275 m

$V_o = \pi n_v P[(R_O^2 - R_c^2) + (1-k)(2cR_o + c^2)$ from equation (3.4)

$$Ro = \frac{D}{2},$$

$Rc = \frac{D_C}{2},$

$k\ values\ is\ 0\ because\ of\ dosing\ system\ \ is\ perpendicular\ x\ \ axis\ (\ down\ position\ ),$

$n_v\ is\ equal\ to\ 1\ , assumption\ is\ helical\ screw\ dosing\ system\ working\ \%100\ performance.$

According to design parameters shown in Table 7, the volumetric capacity of P3 machine's helical screw before Kaizen 125 Project is: $V_o = 9{,}3872 \text{ x } 10^{-6}\ m^3$. As you may realize, this value is volumetric parameter, but dosing system fills package gravimetric in kilograms, so we can reach the result by multiplying this capacity with bulk density of cacao powder, 405,22 kg/m^3:

$$\dot{m} = V_o \text{ x } \rho$$

$$9{,}3872 \text{ x } 10^{-6}\ x\ 405{,}22 = 3{,}803\ x10^{-3}\ kg$$

Unit analysis is equal to:

$$\frac{\cancel{kg}}{\cancel{m^3}}\ x\ \cancel{m^3}$$

At one rotation, helical screw is dosing 3,8 g cacao powder at %100 performance.

Another criterium of design is design ratios which are illustrated in Table 8. When you decided on helical screw and hopper design, you should take these ratios into consideration, because each ratio indicates important implications for designers, especially when they faced adhesive food material, such as cocoa powder.

Table 8: Before the Kaizen 125 P3 Machine Helical Screw and Hopper Design Ratios

(Before Kaizen 125 Projection) P3 Machine Helical Screw and Hopper Design Ratios	Values
(Dc/D)	0,5101
(P/D)	0,6181
(c/D)	0,0909

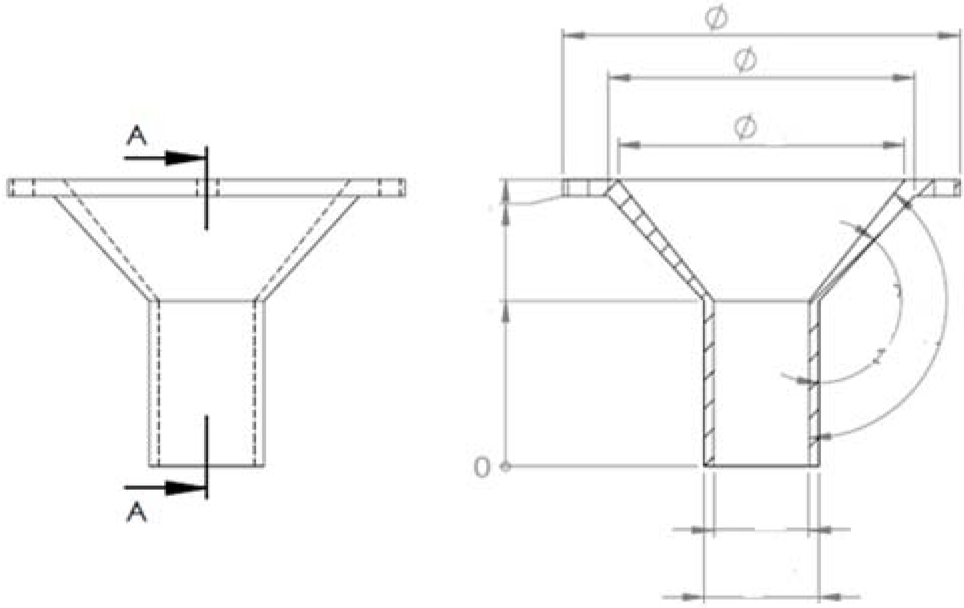
Influence of D_c /D: This ratio affects pressure point on helical and hopper surface. If this ratio increases, that means the volumetric capacity decreases. Sticky or adhesive material is influenced by pressure point because this pressure leads to undesired coating on helical screw and hopper surface, hereby, volumetric efficiency and capacity decreases.

Influence of P /D: This ratio is related to flow characteristics of food powder. If food material has poor flow characteristics, like cocoa powder, starch P/D ratio should be increased. Theoretically, if P/D ratio gradually increases, the volumetric capacity increases also.

Influence of c/D: Clearance in hopper, which is related to gravimetric dosing system, is the most important parameter on control of dosing system. If clearance is put largely with dosed food powder which is free-flow, the combination of these conditions is culminated in leakage between hopper and helical screw. This possibility effects designer's work negatively.

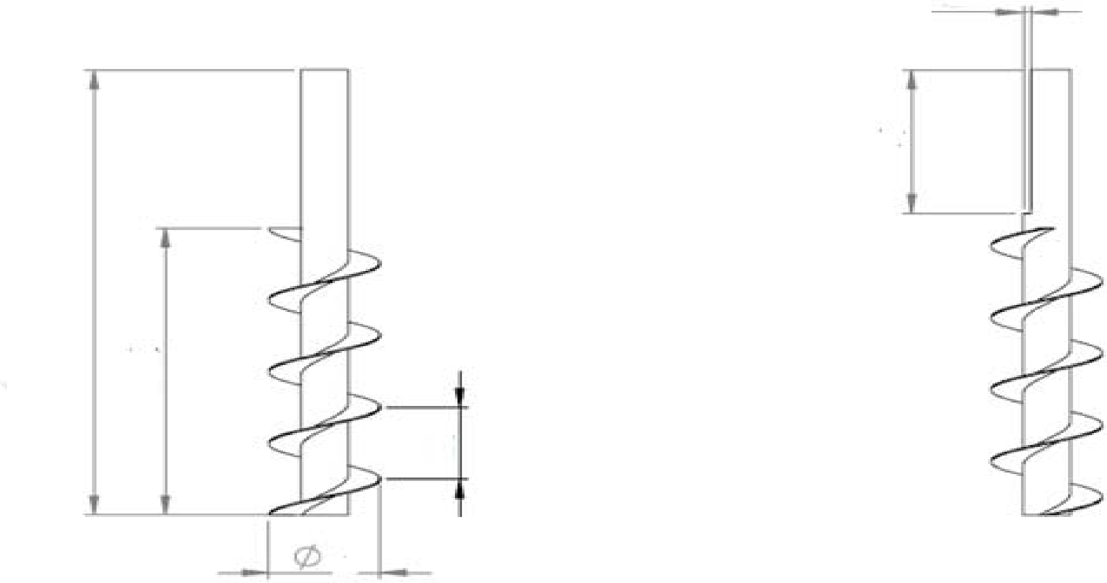
During the Kaizen 125 Project, we analyzed filling machine dosing system, as well as design new helical screw and hopper dosing system applicable to cocoa powder.

Figure 23: Before the Kaizen 125 Project Hopper Design and Optimization Technical Drawings



Hopper design is determined based on cocoa powder flow characteristics and Figure 23 shows the hopper design and optimization technical drawings before the Kaizen 125 Project.

Figure 24: After the Kaizen 125 Project Helical Dosing System Optimization and Technical Drawings



Helical screw dosing system is designed based on cocoa failure properties. The helical dosing system optimization and technical drawings after the Kaizen 125 Project are illustrated in Figure 24. Screw Thickness is designed more precisely and pitch of helical screw is designed longer than the previous screw. Diameter of helical screw is also gotten bigger. In addition, the clearance between helical screw and hopper is gotten smaller, so precision of dosing system is increased.

Table 9: After the Kaizen 125 P3 Machine Helical Screw and Hopper Design Parameters

(After Kaizen 125 Projection) P3 Machine Helical Screw and Hopper Design Parameter	Values
Helical Screw Thickness (t)	0,002 m
Pitch (P)	0,025 m
Helical Screw Length (L)	0,155 m
Core Diameter (Dc)	0,012 m
Clearance (c)	0,002m
Screw Diameter (D)	0,028 m

By this way, excess weight or fluctuation of filling package is decreased. At the same time, due to this design consideration, compaction problem is prevented where this problem exists between core diameter and hopper inner surface when cocoa powder is processes. P3 machine's helical screw and hopper design parameters and design ratios after the Kaizen 125 project are illustrated at Table 9 and Table 10, respectively.

Table 10: After the Kaizen 125 P3 Machine Helical Screw and Hopper Design Ratios

(After Kaizen 125 Projection) P3 Machine Helical Screw and Hopper Design Ratios	Values
(Dc/D)	0,428
(P/D)	0,892
(c/D)	0,071

$V_o = \pi n_v P[(R_O^2 - R_c^2) + (1-k)(2cR_o + c^2)$ from equation (3.4)

$$Ro = \frac{D}{2},$$

$$Rc = \frac{D_C}{2},$$

$k\ values\ is\ 0\ because\ of\ dosing\ system\ is\ perpendicular\ x\ axis\ (\ down\ position\ ),$

$n_v\ is\ equal\ to\ 1\ , assumption\ is\ helical\ screw\ dosing\ system\ working\ \%100\ performance.$

According to above design parameters, volumetric capacity of P3 machine's helical screw after the Kaizen 125 project is, $V_o = 1{,}48421 \text{ x } 10^{-5}\ m^3$. As you may realize, this value is volumetric parameter, but dosing system fills package gravimetric in kilograms, so we can reach the result by multiplying this capacity with bulk density of cacao powder, 405,22 kg/m^3:

$$\dot{m} = V_o \text{ x } \rho$$

$$1{,}48421 \text{ x } 10^{-5}\ x\ 405{,}22 = 6{,}014\ x 10^{-3}\ kg$$

Unit analysis is equal to:

$$\frac{kg}{\cancel{m^3}}\ x\ \cancel{m^3}$$

At one rotation, helical screw is dosing 6,014 g cacao powder at %100 performance.

With the Kaizen 125 project, volumetric capacity is increased, helical screw system is provided to fill cocoa powder packages easily, rotation per minute of helical screw is decreased, this leads to reduction in friction force on cocoa food material. Since cocoa powder contains cocoa butter and friction force generates heat, this improvement prevents increase in temperature of cocoa medium, so cocoa butter cannot be fluidized. Under these circumstances, volumetric capacity and control of dosing system decreases. Moreover, weight fluctuations in cocoa powder packaging occurred in production operation process is reduced by Kaizen 125 project. After this section, we can now answer the following question: "How can we decrease standard deviation or process variation in production of filled powder package weight process?"

3.3.4. Statistical Process Control on Dosing System

In this section, we are going to analyze process, and observe change in process standard deviation after the Kaizen 125 projection. Furthermore, the degree of improvement and significance will be tested by employing paired t-statistic using SPSS (Statistical Package for the Social Science).

Data are acquired by employing classical sampling methods. Appendix 13 and 14 show Kaizen 125 B2 Pair 2 Data and Kaizen 125 A2 Pair 2 Data, respectively. In this study, two paired data are represented:

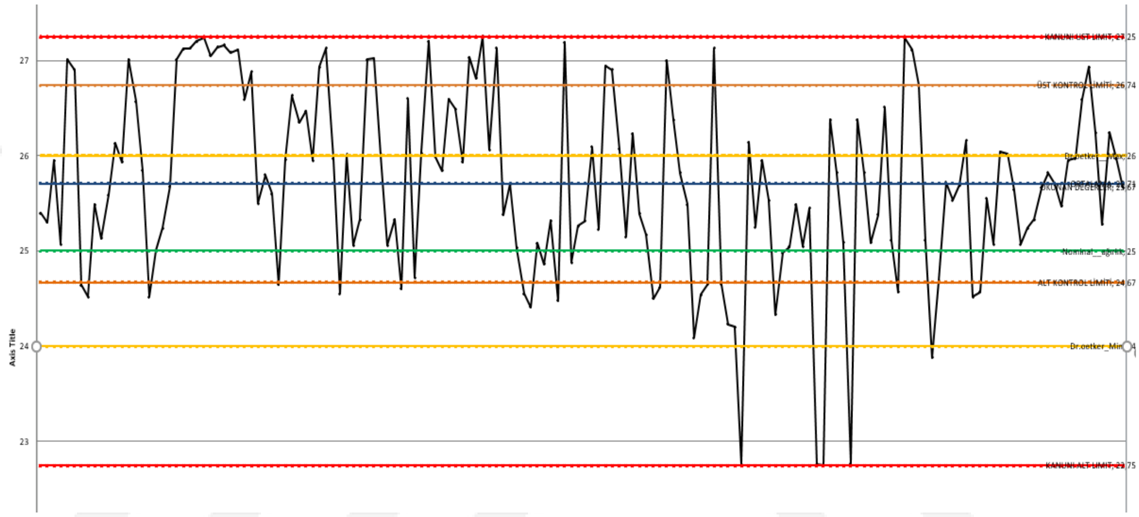
Before the Kaizen 125 is shortened to "KAIZEN125B",

After the Kaizen 125 is shortened to "KAIZEN125A".

3.3.4.1. Before the Kaizen 125 Projection Process Variation

Each sub-group has five samples, and 160 samples are randomly taken from process flow. Once every five-samples is taken, we stop sampling process in every minute because of sampling instructions. Sampling data list is provided in Appendix 8.

Figure 25: KAIZEN125B1 Pair 1 x̄-chart



KAIZEN125B1 Pair 1 x-chart shows us that majority of process samples are out of the process control. Process is realized within upper and lower Turkish standard control limits which are indicated with red lines. However, upper and lower World standard control limits indicated with yellow lines are not met. Calculated process mean is 25,71. Process Upper Control Limit is 26,74 and Process Lower Control Limit is 24,67. Upper and Lower Process Limits are calculated with equation (2.2) and A_2 factor for five sub-group is obtained from Table 1. Their lines (upper and lower process limits) indicated with brown color. As reported, process is not under control. Table 11 shows Before the KAIZEN125B1 Pair 1 Values and KAIZEN125B1 Pair 1 process capability is calculated from:

$$C_p = \frac{Tolerance\ Range}{Process\ Range} = \frac{upper\ specification\ limit - lower\ specification\ limit}{6\sigma} \quad \text{equation (2.4)}$$

Upper Turkish Standard Control Limit is 27,25

Lower Turkish Standard Control Limit is 22,75

Process Standard Deviation is 0,98

C_p is equal to (27,25-22,75)/(0,98x6)= 0,765 , $C_p \leq 1$:

So, process is not capable.

Figure 26: KAIZEN 125B1 Pair 1 R-chart

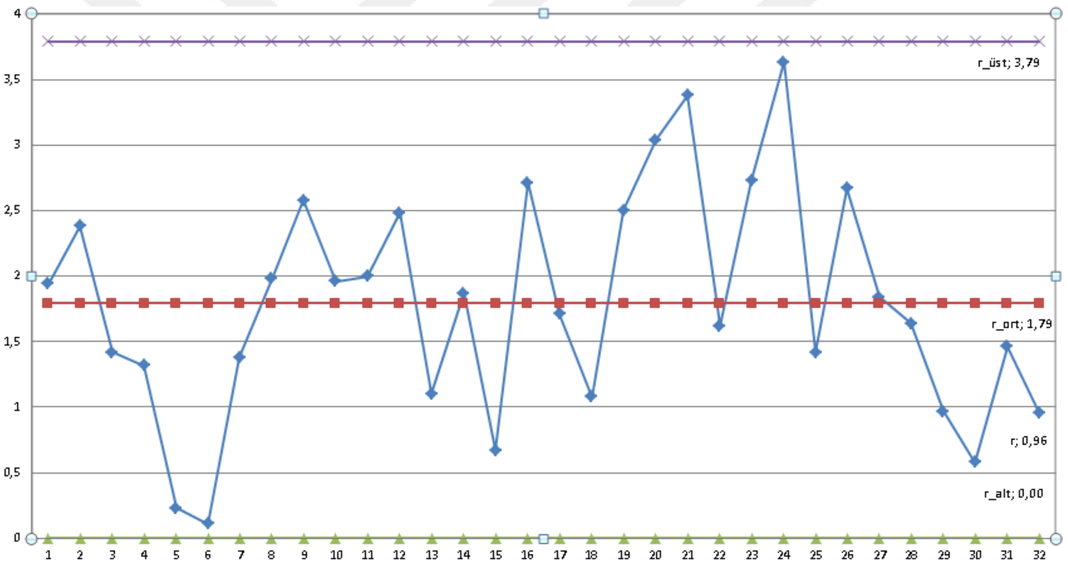


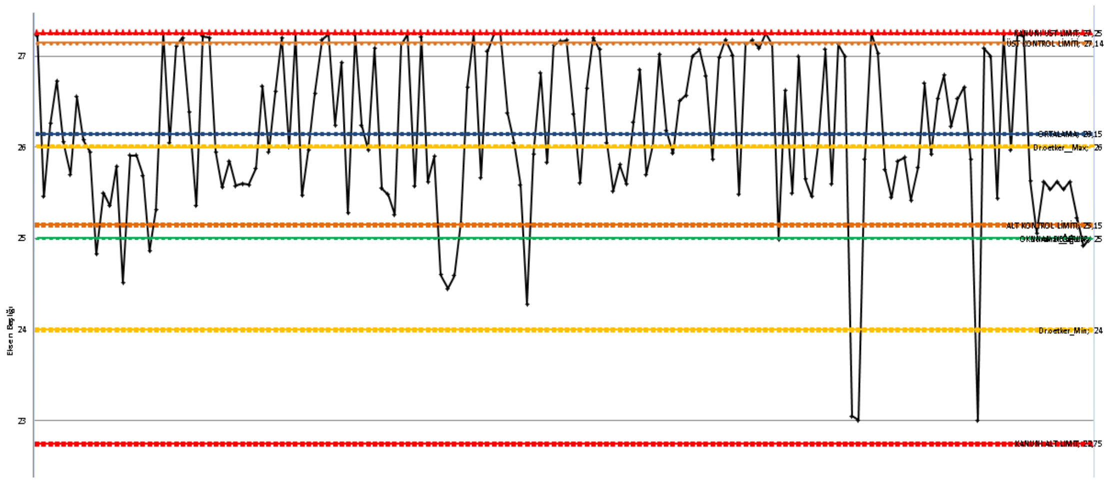
Figure 26 shows Kaizen 125B1 Pair 1 R-chart. R-chart formulas determined to control limits are calculated with equation (2.3) and D_3 and D_4 are obtained from Table 1. Lower Control Limit is zero because of D_3 factor for five sub-groups. Average or center line of R for the samples is 1,79. Upper Control Limit is 3,79 and D_4 factor for five sub-groups is 2,11. The R-chart suggests that the process is in control because samples are close to the control limits. However, the x-chart in KAIZEN125B1 Pair 1 suggests that the process is not in control. In fact, the ranges for samples 14 and 27 are relatively narrow. The comparison of both charts together provides a more complete picture of the overall process variability.

Table 11: Before the Kaizen 125B1 Pair 1

Before the Kaizen 125B1 Pair 1	Values
Process Standard Deviation	0,98
Process Variance	0,96
Upper Turkish Standard Control Limit	27,25
Lower Turkish Standard Control Limit	22,75
Upper World Standard Control Limit	26
Lower World Standard Control Limit	24
Process Upper Control Limit	26,74
Process Lower Control Limit	24,67
Net Package Weight (Nominal)	25
Process Mean	25,71

Each sub-group has five samples, and 160 samples are randomly taken from process flow. Once every five-samples is taken, we stop sampling process in every minute because of sampling instructions. Before the Kaizen 125B1 Pair1 data are illustrated in Appendix 11.

Figure 27: KAIZEN125B2 Pair 2 $\bar{\mathbf{x}}$- chart



KAIZEN125B2 x-chart shows us that majority of process samples are out of the control, and process is realized in Upper and Lower Turkish Standard Control Limits which are indicated in red lines. However, Upper and Lower World Standard Control Limits which are indicated in yellow lines are not met. Control limit and process mean is 26,15 where process upper control limit is 27,14 and process lower control limit is 25,15. Upper and Lower Process Limits are calculated with equation (2.2) and A_2 factor for five sub-group is obtained from Table 1. Their lines (upper and lower process limits) are in brown. As reported, process is not under control. Table 12 shows Before the KAIZEN125B2 Pair 2 Values. KAIZEN125B2 Pair 2 process capability is calculated from:

$$C_p = \frac{Tolerance\ Range}{Process\ Range} = \frac{upper\ specification\ limit - lower\ specification\ limit}{6\sigma} \quad \text{equation (2.4)}$$

Upper Turkish Standard Control Limit is 27,25

Lower Turkish Standard Control Limit is 22,75

Process Standard Deviation is 0,87

C_p is equal to (27,25-22,75)/(0,87x6)= 0,862 , $C_p \leq 1$:

So, process is not capable

Table 12: Before the Kaizen 125B2 Pair 2

Before the Kaizen 125B2 Pair 2	Values
Process Standard Deviation	0,87
Process Variance	0,76
Upper Turkish Standard Control Limit	27,25
Lower Turkish Standard Control Limit	22,75
Upper World Standard Control Limit	26
Lower World Standard Control Limit	24
Process Upper Control Limit	27,14
Process Lower Control Limit	25,15
Net Package Weight (Nominal)	25
Process Mean	26,15

Each sub-group has five samples, and 160 samples are randomly taken from process flow. Once every five-sample is taken, we stop sampling process in every minute because of sampling instruction. Before the Kaizen 125B2 Pair 2 data are illustrated in Appendix 13.

Figure 28: KAIZEN125B2 Pair 2 R-chart

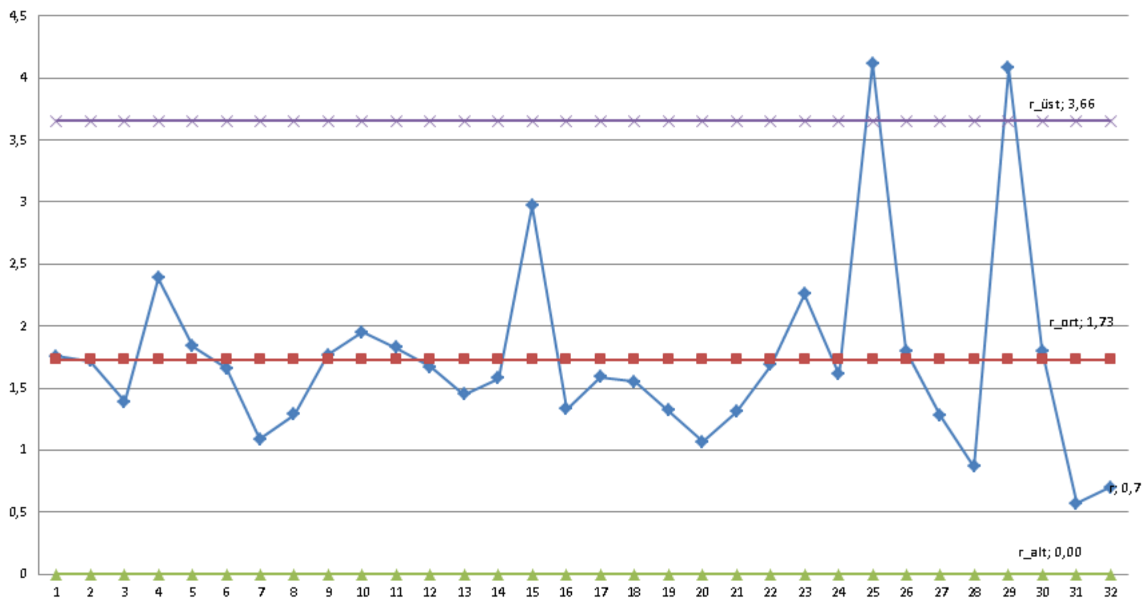
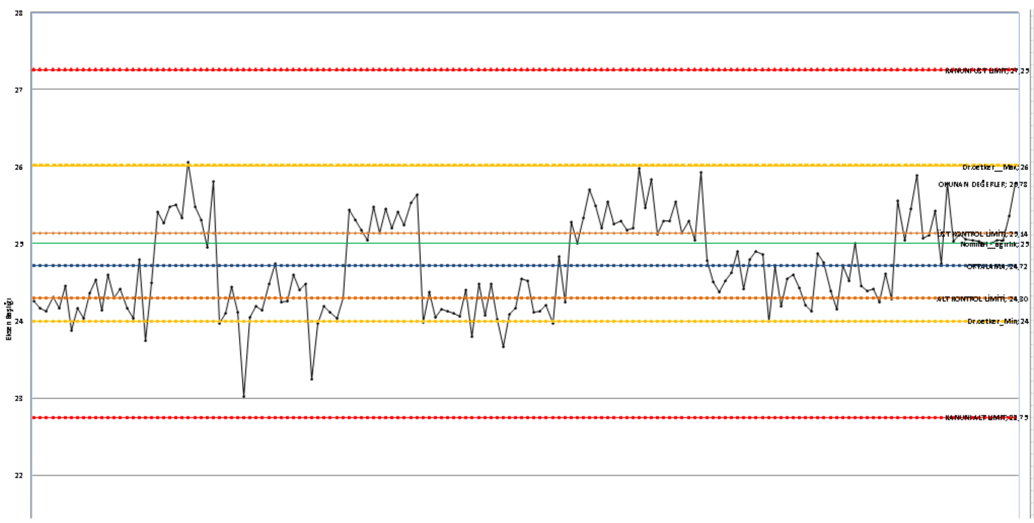


Figure 28 shows Kaizen 125B2 Pair 2 R-chart. R-chart formulas determined for control limits are calculated from equation (2.3) and D_3 and D_4 are obtained from Table 1. Lower control limit is zero because of D_3 factor for five sub-groups. Average or center line of R for the samples is 1,73. Upper control limit is 3,66 and D_4 factor for five sub-groups is 2,11. The R-chart suggests that the process is not in control because the ranges for samples 25 and 29 are out of upper control limit. In fact, the ranges for eleven samples are relatively narrow. The comparison of both charts together provides a more complete picture of the overall process variability.

3.3.4.2. After the Kaizen 125 Projection Process Variation

Each sub-group has five samples, and 160 samples are randomly taken from process flow. Once every five-sample is taken, we stop sampling process in every minute because of sampling instructions. Before the Kaizen 125A1 Pair 1 data are illustrated in Appendix 12.

Figure 29: KAIZEN125A1 Pair 1 $\bar{\mathbf{x}}$-chart



KAIZEN125A1 Pair 1 shows that after the Kaizen 125 project, process reaches Upper World Standard Control Limit, but some data show us that minority of samples still stay at Lower World Standard Control Limit. Still, process is not under control. Red lines are Turkish Standard Control Limits. Yellow lines are the World Standard Control Limits. Green line is net package weight (nominal). Upper and Lower Process Limits are calculated with equation (2.2) and A_2 factor for five sub-group is obtained from Table 1. Their lines (upper and lower process limits) are in brown. Process mean is 24,72 where process upper control limit is 25,14 and process lower control limit is 24,3. Table 13 shows KAIZEN125A1 Pair1 Values. KAIZEN125A1 Pair1 process capability is calculated from:

$$C_p = \frac{Tolerance\ Range}{Process\ Range} = \frac{upper\ specification\ limit - lower\ specification\ limit}{6\sigma} \quad \text{equation (2.4)}$$

Upper Turkish Standard Control Limit is 27,25

Lower Turkish Standard Control Limit is 22,75

Process Standard Deviation is 0,59

C_p is equal to (27,25-22,75)/(0,59x6)= 1,27 , $C_p \geq 1$: The value of C_p above 1 means that the process variability and the process exceeds minimal capability. So, process is capable.

Table 13: After the Kaizen 125A1 Pair 1

After the Kaizen 125A1 Pair 1	Values
Process Standard Deviation	0,59
Process Variance	0,35
Upper Turkish Standard Control Limit	27,25
Lower Turkish Standard Control Limit	22,25
Upper World Standard Control Limit	26
Lower World Standard Control Limit	24
Process Upper Control Limit	25,14
Process Lower Control Limit	24,3
Net Package Weight (Nominal)	25
Process Mean	24,72

Figure 30: KAIZEN125A1 Pair 1 R-chart

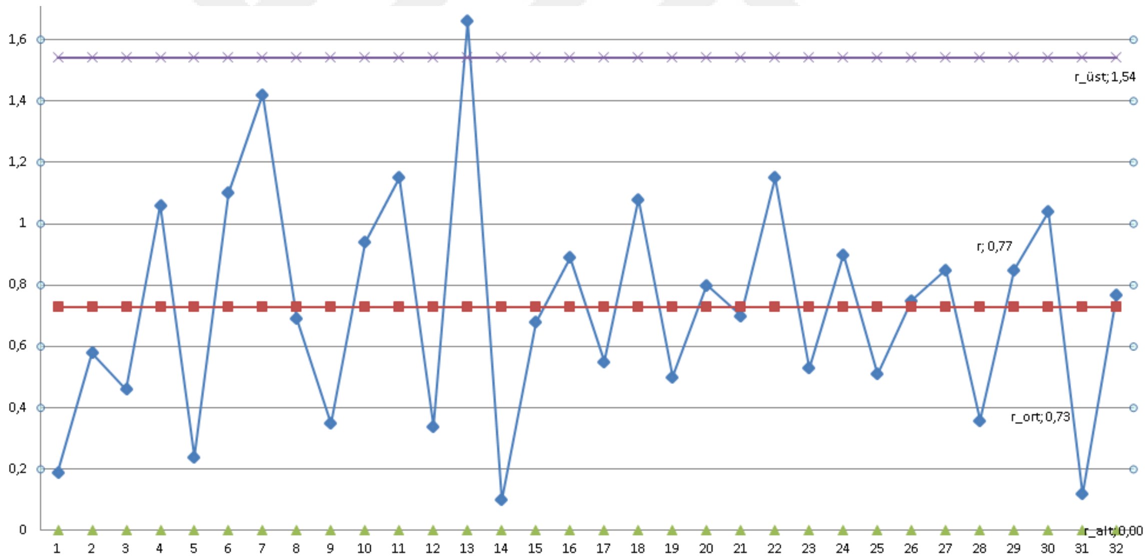
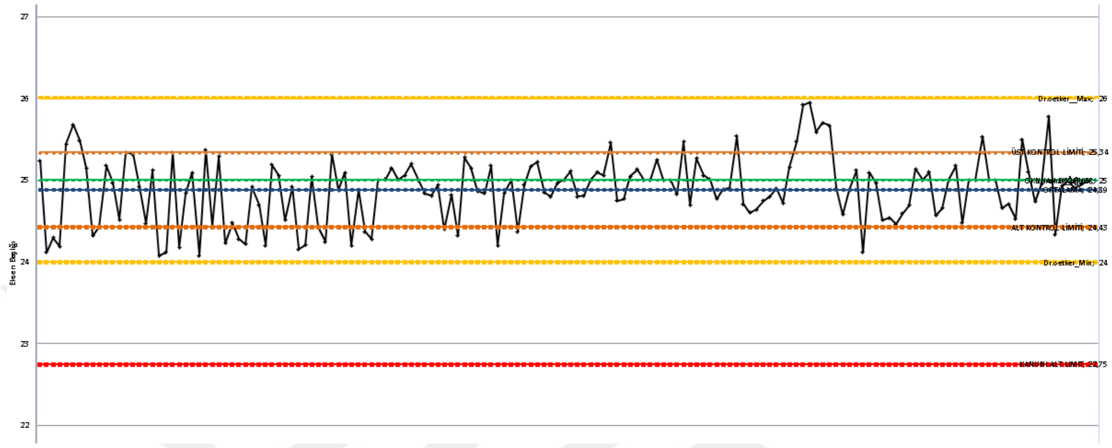


Figure 30 shows Kaizen 125A1 Pair 1 R-chart. R-chart formulas determined for control limits are calculated from equation (2.3) and D_3 and D_4 are obtained from Table 1. Lower control limit is zero because of D_3 factor for five sub-groups. Average or center line of R for the samples is 0,73, upper control limit is 1,54, and D_4 factor for five sub-groups is 2,11. The R-chart suggests that the process is out of control because the range for a sample 13 is out of upper control limit. In fact, the ranges for seven samples are relatively narrow. The comparison of both charts together provides a more complete picture of the overall process variability.

Figure 31: KAIZEN125A2 Pair 2 x̄-chart



Each sub-group has five samples, and 160 samples are randomly taken from process flow. Once every five-samples is taken, we stop sampling process in every minute because of sampling instructions. Appendix 14 shows KAIZEN125A2 Pair 2 data**.**

KAIZEN125A2 Pair 2 shows that after the Kaizen 125 project, process reaches World Standard Control Limits with the process variance of 0,15 and the process standard deviation of 0,39. Red lines are Turkish Standard Control Limits whereas yellow lines are World Standard Control Limits. Green line is net package weight (nominal). Upper and Lower Process Limits are calculated with equation (2.2) and A_2 factor for five sub-group is obtained from Table 1. Their lines (upper and lower process limits) are in brown. Process mean is 24,89, where process upper control limit is 25,34 and process lower control limit is 24,43. Table 14 shows KAIZEN125A2 Pair 2 Values. Loss in process is decreased by Kaizen 125 project, however, process is not under control. KAIZEN125A2 Pair 2 process capability is calculated from:

$$C_p = \frac{Tolerance\ Range}{Process\ Range} = \frac{upper\ specification\ limit - lower\ specification\ limit}{6\sigma} \quad \text{equation (2.4)}$$

Upper Turkish Standard Control Limit is 27,25

Lower Turkish Standard Control Limit is 22,75

Process Standard Deviation is 0,39

C_p is equal to (27,25-22,75)/(0,39x6)= 1,92 , $C_p \geq 1$: The value of C_p above 1 means that the process variability and the process exceeds minimal capability. So, process is capable.

Figure 32: KAIZEN125A2 Pair 2 R-chart

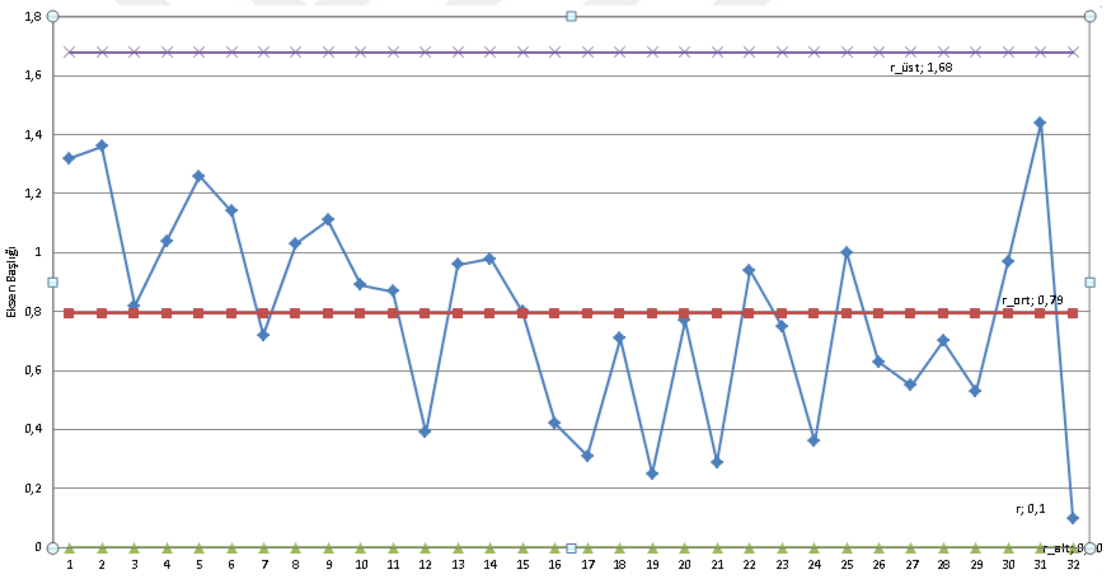


Figure 32 shows Kaizen 125A2 Pair 2 R-chart. R-chart formulas determined for control limits are calculated from equation (2.3) and D_3 and D_4 are obtained from Table 1. Lower control limit is zero because of D_3 factor for five sub-groups. Average or center line of R for the samples is 0,79, upper control limit is 1,68, and D_4 factor for five sub-groups is 2,11. The R-chart suggests that the process is in control. In fact, the ranges for nine samples are relatively narrow. The comparison of both charts together provides a more complete picture of the overall process variability.

Table 14: After the Kaizen125A2 Pair 2

After the Kaizen 125A2 Pair 2	Values
Process Standard Deviation	0,39
Process Variance	0,15
Upper Turkish Standard Control Limit	27,25
Lower Turkish Standard Control Limit	22,75
Upper World Standard Control Limit	26
Lower World Standard Control Limit	24
Process Upper Control Limit	25,34
Process Lower Control Limit	24,43
Net Package Weight (Nominal)	25
Process Mean	24,89

The results shown in process $\bar{x}$-charts and R-charts are to be verified by employing statistical tests. We should as the following question: "Is this application significant statistically?" Paired t–statistics are employed on as before- and after-treatment values by using SPSS Program. We tested the following hypothesis:

H_0 = At 5% significance level, there is no statistically significant difference between the packet weight average before and after the helical and hopper design.

H_a = At 5% significance level, there is statistically significant difference between the packet weight average before and after the helical and hopper design.

If P value is found to be smaller than the level of significance we can reject H_0 in favor of H_a.

Table 15: Pair 1 Statistical Analysis

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	KAIZEN125B - KAIZEN125A	,98806	1,12067	,08860	,81308	1,16304	11,152	159	,000

T-Test

[DataSet0]

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	KAIZEN125B	25,7059	160	,98125	,07757
	KAIZEN125A	24,7178	160	,59747	,04723

Table 16: Pair 2 Statistical Analysis

Paired Samples Statistics

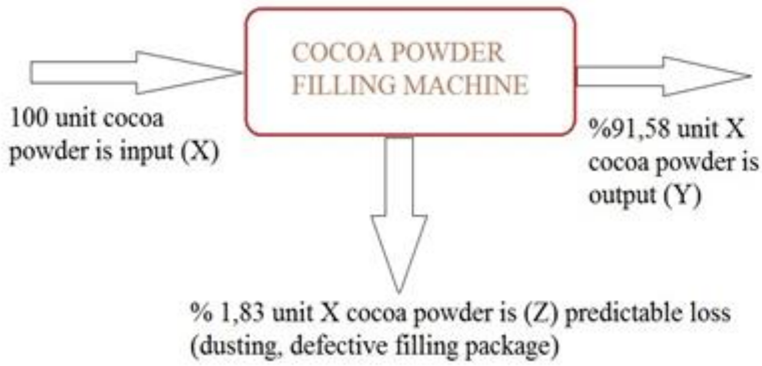
		Mean	N	Std. Deviation	Std. Error Mean
Pair 2	KAIZEN125B	26,1457	160	,87737	,06936
	KAIZEN125A	24,8850	160	,39923	,03156

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 2	KAIZEN125B - KAIZEN125A	1,26069	,94489	,07470	1,11316	1,40822	16,877	159	,000

According to Pair 1 and Pair 2 paired sample tests *p*-value is found to be lower than 0.05 meaning that we can confidently reject the null hypothesis at 5% significance level. Therefore, there is statistically significant difference between the packet weight averages before and after the helical and hopper design.

3.3.5. Improvements of Process and Benefits of Project



Mass balance is calculated based on saved cocoa powder from cocoa powder input, by applying Kaizen 125.

$$X = Y + Z + Excess\ Food\ \ Powder\ Filling\ Package\ Weight \tag{3.5}$$

$$Excess\ Food\ \ Powder\ Filling\ Package\ Weight = X - (Y + Z) \tag{3.6}$$

$$= \%100 - (\%91{,}58 + \%1{,}83)$$

$$Excess\ Food\ \ Powder\ Filling\ Package\ Weight = \%6{,}59$$

By applying Kaizen 125 project, excess food powder filling package weight is decreased to 6,59 percentage of total input of cocoa powder.

CONCLUSION and RECOMMENDATIONS

Recent improvements in life standards and communication technology, increase in the levels of education, and the changes in the social and cultural structure have greatly risen the expectations of consumers. For that reason, businesses have prioritized satisfaction of consumers' expectations to be able to compete and sell their products. In the first part of the study, we discussed concept of lean production, its historical development, as well as techniques and contributions to the production industry. Equally importantly, we explained Lean Tools in detail, and argued how Lean Manufacturing and Lean Techniques can be used together. Increasing competition in the market requires businesses to pay more attention to quality. Businesses should meet customers' needs with cheaper and better-quality products to increase their share in the market. Therefore, it is a requirement to use quality control methods which enable the detection of the errors during production processes, and thus, help us determine the causes of these errors, and take corrective actions to improve these processes.

The most important and innovative part of this research endeavor is the application part. In this part, the food powder production processes in Dr. Oetker company were subject to our examination. The Lean manufacturing techniques with Statistical Quality Control Techniques were implemented to reduce excess food powder filling package weight for cacao 25-gram product. We relied on powder flow characteristics and design of auger screw to provide compatibility with P3 machine design criteria. Helical screw dosing system and food powder flow characteristics were studied, and helical screw was redesigned. According to data and statistical test based on the data, loss in process, in other words excess weight in filling food powder package is decreased by 6,59 percentage of total input of cocoa powder as a result of the redesign of the helical screw.

In this study, the conclusions of the previous studies are verified and the results that they found are closely estimated. In the assessment, the results of the implementations and outcomes of reported in statistical control charts of cocoa powder packaging processes are interpreted. Our results indicated that before our improvement implementation cocoa powder was packaged within Turkish Standard Control Limits, but not within World Standard Control Limits. After the improvement application, results reported from packaging process showed that packaging limits became closer to World Standard Control Limits, but the process is still out of control. In this process, further research and improvements are necessary on the characteristics of food powder. Other variables on this subject should be examined in detail and helical design experiments should continue. For researchers working on this subject, it is recommended to use more precise measurement equipment to analyze powder flow characteristics. Improvement implementations should continue until the process is fully controlled.

REFERENCES

Akçagün, E. (2006). Hazır Giyim İşletmelerinde Yalın Üretim Tekniklerinin Araştırılması. *Marmara Üniversitesi Fen Bilimleri Enstitüsü Yüksek Lisans Tezi*.

Akgeyik, T. (1998). *Stratejik Üretim Yönetimi.* İstanbul: Sistem Yayıncılık.

Arnold, P., and Yu, Y. (1997). The influence of Screw Feeders on Bin Flow Patterns. *Centre for Bulk Solids and Particulate Technologies*. 27(2): 40-44.

Association, C. E. (1980). *Screw Conveyors.* CEMA.

Atkins, T. (2013). *A Dictionary of Mechanical Engineering.* Oxford: Oxford University Press.

Banks, J. (1989). *Principles of Quality Control.* New York: John Wiley and Sons.

Bates, L. (1986). Intefacing Hoppers with Screw Feeders. *Bulk Solids Handling*. 37(1): 65-78.

Bates, L. (1994). The Storage, Feed and Collection of Loose Solids. *Powder Handling and Processing*. 105(4): 215-221.

Bates, L. (2000). *Guide to the Design Selection and Application of Screw Feeders.* London: London Professional Engineering Publishing.

Becketts, T. (1994). *Industrial Chocolate Manufacture and Use.* Blackie Academic and Professional.

Beddow, J. (1981). *Particulate Science and Technology.* New York: Chemical Publishing.

Black, J., and Miller, D. (2008). *The Toyota Way to Healtcare Excellence: Increase Efficiency and Improve Quality with Lean.* Boston: Foundation of the American College of Healtcare Executives.

Bozkurt, R. O. (1997). *ISO 9000 Kalite Güvence Sistemleri.* Ankara: MPM Yayınları.

Çetinkaya, K. (2000). *Toplam Tasarım.* Ankara: Gazi Büro Evi.

Dand, R. (1993). *The International Cocoa Trade.* Woodhead Publishing.

Demir, H., and Gümüşoğlu, Ş. (2003). *Üretim Yönetimi İşlemler Yönetimi.* İstanbul: Beta Basım.

Dennis, P. (2007). *Lean Production Simplified a Plain Language Guide to the World's Most Powerful Production System.* New York: Productivity Press.

Doğan, Ö., and Tütüncü, Ö. (2003). *Hizmet İşletmelerinde Toplam Kalite Yönetimi Kapsamıda ISO 9001 ve Bilgisayar Destekli Bir Uygulama.* İzmir: DEÜ Rektörlük Matbaası.

Doğan, Ü. (1991). *Kalite Yönetimi ve Kontrolü.* İzmir: İstiklal Matbaası.

Donnet, P. (1992). *Japonya Dünyayı Satın Alıyor.* İstanbul: Varlık Yayınları.

Ekaterina, K. (2016). *Food Quality Management(*pp.38-45). Hamburg: European Parlimentary Research Service.

Freeman, C., and Soete, L. (2003). *Yenilik İktisadı.* Ankara: Tübitak Yayınları.

Görenes, A., and Yenen, V. (2007). İşletmelerde Toplam Verimli Bakım Çalışmaları Kapsamında Yapılan Faaliyetler ve Verimliliğe Katkıları. *İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi*. 11(8): 47-65.

Granth, E., and Leavenworth, R. (1999). *Statistical Quality Control (7th Edition).* New York: McGraw Hill.

Hutchins, D. (1999). *Just in Time.* New York: Gower Publishing Company.

Jones, D., & Womack, J. (1996). *Yalın Düşünce.* İstanbul: Sistem Yayıncılık.

Juran, J. (1989). *Juran on Leadership for Quality: An Executive Handbook.* New York: The Free Press.

Karlsson, C., and Ahström, P. (1996). The Diffucult Path to Lean Product Development. *Product Innovation Management*.

Kobu, B. (1987). *Endüstriyel Kalite Kontrolü.* İstanbul: İstanbul Üniversitesi Yayınları.

Locher, D. (2008). *Value Stream Mapping the Development Process: A How to Guide for Streamlining Time to Market.* New York: Productivity Press.

Montgomery, D. (2009). *Introduction to Statistical Quality Control (Fourth Edition).* New York: John Wiley and Son.

Oakland, J. (2008). *Statistical Process Control (Sixth Edition).* Oxford: Elsevier.

Ohno, T. (1998). *Toyota Ruhu: Toyota Üretim Sisteminin Doğuşu ve Evrimi.* İstanbul: Scala Yayıncılık.

Okur, A. (2000). *Yalın Üretim: 2000' li Yıllara Doğru Türkiye Sanayisi İçin Yapılanma Modeli.* İstanbul: Söz Yayın.

Özçelikel, H. (1994). *Japon Yönetim Sistemleri.* İstanbul: MESS Eğitim Vakfı.

Özdemir, M. (16. 06. 2017). *Japan Institute of Plant Maintenance.* Retrieved from Japan Institute of Plant Maintenance: http://www.jipm.or.jp/, (16. 06. 2017).

Reid, D., and Sanders, N. (2011). *Operations Management An Integrated Approach(Second Addition).* Wiley.

Roberts, A. (1992). Determining Screw Feeder Geometry for Specified Hopper Draw-Down Performance. *Workshop Seven at the Powder and Bulk Solids Conference* (pp. 1-15). Australia: Powder Technology.

Roberts, A. (1999). The Influence of Granular Vortex Motion on the Volumetric Performance of Enclosed Screw Conveyors. *Powder Technology*. 11(9): 56-67.

Sayer, N., & Williams, B. (2007). *Lean For Dummies.* New York: Wiley Publishing.

Schulze, D. (2008). *Powders and Bulk Solids Behaviour Characterization Storage and Flow.* Berlin: Springer Science.

Shingo, S. (1985). *A Revolution in Manufacturing- the SMED System.* Cambridge: Productivity Press.

Tapping, D. (2007). *The Lean Pocket Guide Tool for Elimination of Waste.* Chealse: MCS MEDIA.

Taylor, W., & Russell, S. (2011). *Operations Management Creating Value Along The Supply Chain(Eight Edition)*. New York: Wiley.

Ünnü, K. (2003). *Yalın Üretim Sistemi ve Yardımcı Teknikleri*. Master Thesis. İzmir: Dokuz Eylül Üniversitesi Sosyal Bilimler Ensitüsü.

Voss, C. (1995). *Operations Management Fom Taylor To Toyota And Beyond.* New York: British Journal Of Management.

Womack, J., Roos, D., & Jones, D. (1990). *Dünyayı Değiştiren Makine.* İstanbul: Sistem Yayıncılık.

Yamak, O. (2007). *Üretim Yönetimi: Sistemsel Bir Yaklaşım.* İstanbul: Türkmen Yayıncılık.

Yeter, S. (2004). Transfer Sistemli Son Montaj Üretim Bandı Tasarımı, Kurulumu ve İşletilmesi. *Trakya Üniversitesi Fen Bilimleri Enstitüsü*.

Yu, Y. (1997). Theoretical Modelling and Experimental Investigation of the Performance of Screw Feeders. *University of Wollongong Thesis Collection*.

Yüksel, H. (1998). Toplam Kalite Yönetiminde İstatistiksel Kalite Kontrolü ve Bir İşletmede Uygulanması. *Yüksek Lisans Tezi, Dokuz Eylül Sosyal Bilimler Enstitüsü*.

APPENDICES

Appendix 1: Specification of MA15

Specifications
MA35 | MA100 | MA150

	MA35	MA100	MA150
Max. weighing capacity (g)	35	100	150
Accuracy of the weighing system (mg)	1	0.1	1
Weighing system with EC type-approval certificate		•	
Repeatability, average (%)			
– for initial sample weight approx. > 1 g	± 0.2	± 0.1	± 0.2
– for initial sample weight approx. > 5 g	± 0.05	± 0.02	± 0.05
Readability (%)	0.01	0.001	0.01
Display mode for results			
– % moisture	•	•	•
– % dry weight	•	•	•
– % RATIO	•	•	•
– g residue	•	•	•
– g/kg residue		•	•
– g/l residue			•
– mg weight loss		•	•
– Calculated value (measured value × factor)		•	
Temperature range and settings			
– 40°C–160°C, adjustable in 1-degree increments	•		
– 30°C–230°C, adjustable in 1-degree increments		•	
– 40°C–220°C, adjustable in 1-degree increments			•
Heating mode			
– Standard drying	•	•	•
– Quick drying		•	
– Gentle drying		•	•
– Phase drying		3 × 0.1–999 min.	1 × 0.1–999 min.
Analysis mode			
– Fully automatic	•	•	•
– Semi-automatic		1–50 mg/5–300 sec. 0.1–5.0%/5–300 sec.	1–50 mg/5–300 sec. 0.1–5.0%/5–300 sec.
– Timer settings	1 × 0.1–99 min.	3 × 0.1–999 min.	1 × 0.1–99 min.
– Timer mode × fully/semi-automatic		2 × 0.1–999 min. + automatic	
SPRM® mode for parameter recognition		•	
Heating unit			
– Ceramic IR heating element (infrared)		•	•
– Halogen lamp (infrared)		•	
– CQR heater (coiled quartz radiator)		•	•
– Metal tubular-shaped heating element (infrared dark radiator)			
Later exchange of the heating unit by Plug & Dry®*		•	
Access to the sample chamber			
– via hinged, flip-up cover	•		•
– via motorized cover		•	

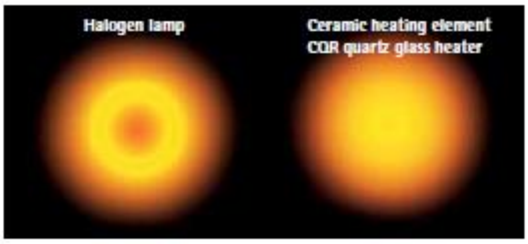
Appendix 2: Description of MA150

Sartorius MA150
The compact class featuring maximum performance with minimum space requirements

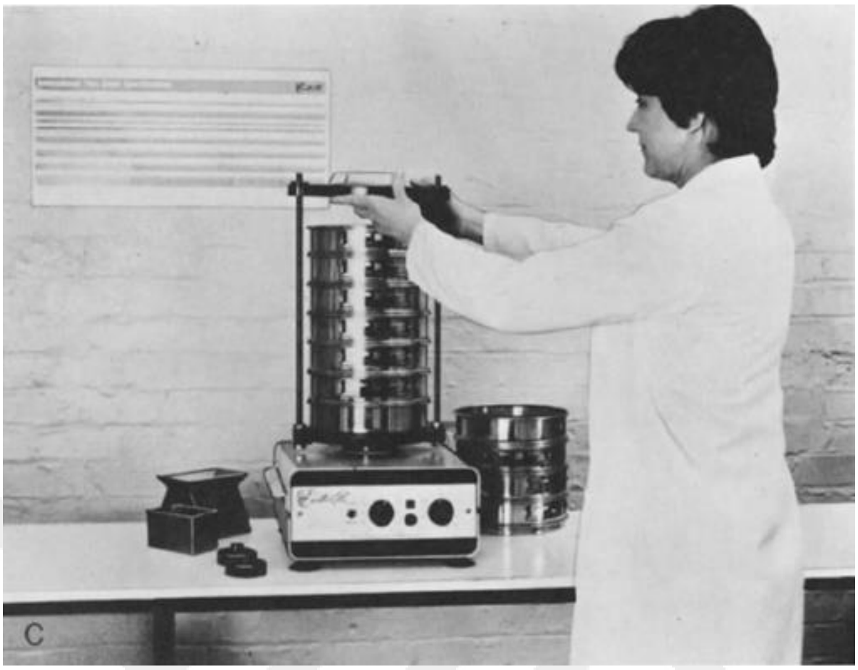
For routine operation
A rugged design with low space requirements and easy operation are the major features of the MA150. Fully automatic drying of a sample until a constant weight is reached eliminates the need for programming an endpoint shutoff parameter. Twenty drying routines can be saved to give you the flexibility you need when the moisture content of additional, "out-of-the-ordinary" samples of material has to be measured.

Customizable and fast
Sartorius offers you a choice of two different moisture analyzers that cover diverse requirements on moisture measurements. Whichever heat source you opt for, both analyzers deliver results within just minutes. For temperature-sensitive samples, a ceramic heating element ensures especially gentle heating over the entire surface. The other choice, a CQR quartzglass heater, optimizes the analysis time even further, which is already ultrafast for the analyzer featuring the ceramic heater.

Application-specific solutions
Practical accessories round off the entire line-up of Sartorius moisture analyzers. These include, for instance, an in-use dust cover that is included with the standard equipment supplied and a special version of the moisture analyzer without openly accessible glass components in compliance with the stringent FDA and HACCP requirements that ban the use of glass in production.

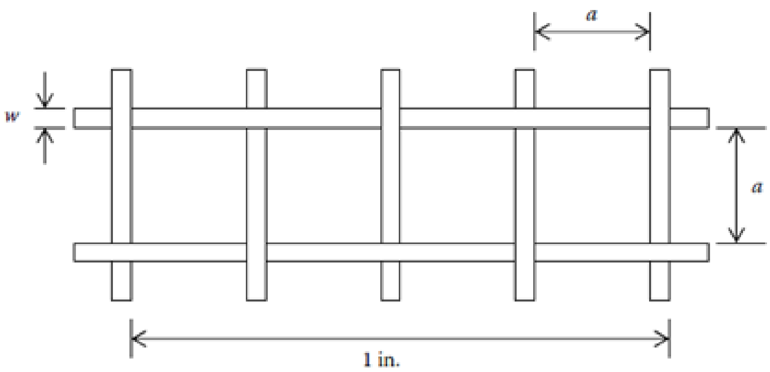


Appendix 3: Measurement of Powder Particles by using sieves



Source: (Woodcock and Mason, 1995)

Appendix 4: Dimensions of sieve on a screen



Source: (Ortega- Rivas, 2012).

$$M = \frac{1}{a + w}$$

$$M = \frac{1}{M} - w$$

Mesh size M, screen aperture a, and wire diameter

Appendix 5: Products Produced in Dr. Oetker

The products that are produced in this plant is given below;

Desserts

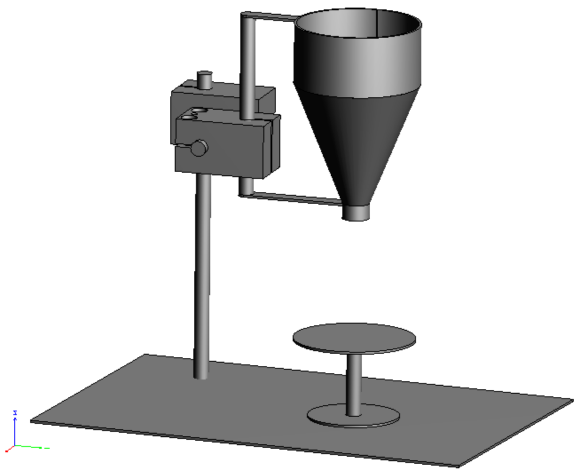
- Puddings
  - Chocolate Flavored Pudding
  - Bitter Chocolate Flavored Pudding
  - Vanilla Flavored Pudding
  - Strawberry Flavored Pudding
  - Banana Flavored Pudding
  - Chocolate-Pistachio Flavored Pudding
  - Chocolate-Coconut Flavored Pudding
  - Chocolate-Almond Flavored Pudding
  - Nut Aromatized Chocolate Flavored Pudding
  - Coconut Flavored Pudding
  - Pistachio Pudding
  - Chocolate Pieced Pudding
  - Pudding with Pieced Vanilla
  - Cacao Flavored Light Pudding
  - Vanilla Flavored Light Pudding
  - Light Whipped Cream
- Creamy Desserts
  - Mole Cake

- Crème Ole

- Turkish Dessers
    - Tavukgöğsü
    - Kazandibi
    - Krem Şokola
    - Sütlaç
    - Supangle
    - Sakızlı Muhallebi
    - Çikolatalı Muhallebi
    - Muhallebi
    - Keşkül
    - Sütlaç
    - İrmik Tatlısı
    - Aşure
    - İrmik Helvası
- Drinks
    - Ice Tea Peach
    - Ice Tea Lemon
    - Chocolate Drink
    - Chocolate Milkshake
    - Strawberry Milkshake
    - Banana Milkshake
    - Chocolate-Strawberry Milkshake

- Vanilla Aromatized Milkshake
- Express Salep
- Hot Chocolate

Appendix 6: Designed Angle of Repose Tester



Appendix 7: After kaizen 125 project Helical screw

Appendix 8: Sampling Sheet

		Parti büyüklüğünü giriniz.		Nominal ağırlığı giriniz.									
	Örnek Nr:	Net Okunan Değer (g)	Tarih	Vardiya 1/2/3/N	Operatör	Makine Adı	Parti No	(Operatörün girdiği) Alt Limit (g)	(Operatörün girdiği) Üst Limit (g)	X	R	Xort	Rort.
	1												
	2												
1	3												
	4												
	5												
	6												
	7												
2	8												
	9												
	10												
	11												
	12												
3	13												
	14												
	15												

Appendix 9: Sampling Instructor

Numune Alma Talimatı

- Operatöre çalışma hakkında bilgi veriniz. (Ürünlerin dolum miktarındaki sapmaları görmek.)
- Ürünün kampanya için çalışılan ürün olmamasına dikkat ediniz.Ürünlerin tartımını, Üretim Gramaj Listesi'nde bulunan mevcut hallerini dikkate alarak gerçekleştiriniz.
- Çalışılan herbir üründen 160 adet (aynı partiden) numune alarak bunları tartınız.
- Ölçüm esnasında silo başlangıcı,bitişi ve değişimi olmamasına dikkat ediniz.Bu konuda makine operatöründen bilgi alınız.
- Her 5 ölçümde bir 1 dakika bekleyiniz.
- Numune alımı esnasında operatörü gramaj ayarı yapmaması konusunda uyarınız.
- Çalışılan partinin 160 adet numuneyi almaya yetecek kadar devam edip etmeyeceğini operatörden öğreniniz.
- Tartım esnasında ürünün darasını teraziden düşünüz. (Örneğin 5'li şekerli vanilin için 5 adet boş pakedin ağırlını teraziden düşünüz.)
- Ölçüm esnasında, ürünün nominal dolum miktarından aşırı miktarda sapma gösteren ölçümleri dikkate almayınız. (Örneğin nominal dolum miktarı 20 gram iken tartım esnasında 15 gram gelen bir ölçümü dikkate almayınız.)
- Ölçümleri Gramaj Kontrol Çalışması için hazırlanan forma giriniz.Formda bulunan operatörün adı, tarih, makine adı,ürünün adı (Üretim Gramaj Listesi'ndeki adıyla), parti no, vardiya, nominal dolum miktarı, operatörün makineye girdiği alt ve üst limit bilgilerini eksiksiz doldurunuz.
- Parti no'nun yanına parantez içerisinde silo numarsını belirtiniz.(Örneğin; 1500831(1) gibi. Burada ki 1; numune olarak alınan verilerin 1500831 partisine ait 1. silodan alındığını belirtmektedir.
- Tarih bilgisinin yazıldığı bölüme, ölçümün başlangıç saatini de belirtiniz.

Appendix 10: Analyze Sheet

Ham madde:	**Nem Değeri:**
	Partikül Yoğunluğu:
	Yığın Yoğunluğu:
	Boşluk Değeri:
	Elek Analizi(Çap):
	Hausner Oranı:
	Carr's İndeksi:
	Yığın Açısı: **Akış İndeksi:**
	Açıklama:

Dr. Oetker İzlenebilirlik:	**Tarih:**
	Parti Numarası: **Operatör İsmi:** **Operatör Tecrübe(Yıl):** **Vardiya:**

Helezon Dizaynı Hesap Parametreleri (mm):	**Makine:** **Motor hızı (rpm):** **Açısal Hız:** **Paket/dakika:**
L/D:	**Helezon Kalınlık (t)1:** **Helezon Kalınlık (t)2:**
P/D:	**Hatve (P)1:** **Hatve (P)2:**
d/D:	**Helezon Uzunluğu (L):** **Helezon Çapı (D):**
c/D:	**İç Çap Şaft(d):** **Kovan Çapı (Do):**
Do/D:	**Kovan Boşluğu(c):** **Helezon Sayısı:**
Helezon Yönü:	**Helezon Açısı:**

Appendix 11: KAIZEN125B1 Pair 1 Data

	x	x_ort	Kanuni alt_sınır	Kanuni ust_sınır	AKS	UKS
1	25,4	25,71	22,75	27,25	24,67	26,74
2	25,3	25,71	22,75	27,25	24,67	26,74
3	25,95	25,71	22,75	27,25	24,67	26,74
4	25,07	25,71	22,75	27,25	24,67	26,74
5	27,01	25,71	22,75	27,25	24,67	26,74
6	26,9	25,71	22,75	27,25	24,67	26,74
7	24,64	25,71	22,75	27,25	24,67	26,74
8	24,52	25,71	22,75	27,25	24,67	26,74
9	25,49	25,71	22,75	27,25	24,67	26,74
10	25,13	25,71	22,75	27,25	24,67	26,74
11	25,59	25,71	22,75	27,25	24,67	26,74
12	26,13	25,71	22,75	27,25	24,67	26,74
13	25,93	25,71	22,75	27,25	24,67	26,74
14	27,01	25,71	22,75	27,25	24,67	26,74
15	26,57	25,71	22,75	27,25	24,67	26,74
16	25,84	25,71	22,75	27,25	24,67	26,74
17	24,52	25,71	22,75	27,25	24,67	26,74
18	25	25,71	22,75	27,25	24,67	26,74
19	25,24	25,71	22,75	27,25	24,67	26,74
20	25,68	25,71	22,75	27,25	24,67	26,74
21	27,01	25,71	22,75	27,25	24,67	26,74
22	27,12	25,71	22,75	27,25	24,67	26,74
23	27,13	25,71	22,75	27,25	24,67	26,74
24	27,2	25,71	22,75	27,25	24,67	26,74
25	27,24	25,71	22,75	27,25	24,67	26,74
26	27,05	25,71	22,75	27,25	24,67	26,74
27	27,14	25,71	22,75	27,25	24,67	26,74
28	27,16	25,71	22,75	27,25	24,67	26,74
29	27,08	25,71	22,75	27,25	24,67	26,74
30	27,11	25,71	22,75	27,25	24,67	26,74
31	26,59	25,71	22,75	27,25	24,67	26,74
32	26,88	25,71	22,75	27,25	24,67	26,74
33	25,5	25,71	22,75	27,25	24,67	26,74
34	25,8	25,71	22,75	27,25	24,67	26,74
35	25,6	25,71	22,75	27,25	24,67	26,74
36	24,65	25,71	22,75	27,25	24,67	26,74
37	25,96	25,71	22,75	27,25	24,67	26,74
38	26,63	25,71	22,75	27,25	24,67	26,74
39	26,35	25,71	22,75	27,25	24,67	26,74
40	26,47	25,71	22,75	27,25	24,67	26,74
41	25,95	25,71	22,75	27,25	24,67	26,74
42	26,93	25,71	22,75	27,25	24,67	26,74
43	27,13	25,71	22,75	27,25	24,67	26,74
44	25,97	25,71	22,75	27,25	24,67	26,74
45	24,55	25,71	22,75	27,25	24,67	26,74
46	26,01	25,71	22,75	27,25	24,67	26,74
47	25,06	25,71	22,75	27,25	24,67	26,74
48	25,33	25,71	22,75	27,25	24,67	26,74
49	27,01	25,71	22,75	27,25	24,67	26,74
50	27,02	25,71	22,75	27,25	24,67	26,74
51	26,01	25,71	22,75	27,25	24,67	26,74
52	25,06	25,71	22,75	27,25	24,67	26,74
53	25,33	25,71	22,75	27,25	24,67	26,74
54	24,6	25,71	22,75	27,25	24,67	26,74
55	26,6	25,71	22,75	27,25	24,67	26,74
56	24,72	25,71	22,75	27,25	24,67	26,74
57	26,03	25,71	22,75	27,25	24,67	26,74
58	27,2	25,71	22,75	27,25	24,67	26,74
59	25,99	25,71	22,75	27,25	24,67	26,74
60	25,84	25,71	22,75	27,25	24,67	26,74
61	26,59	25,71	22,75	27,25	24,67	26,74
62	26,49	25,71	22,75	27,25	24,67	26,74
63	25,93	25,71	22,75	27,25	24,67	26,74
64	27,03	25,71	22,75	27,25	24,67	26,74
65	26,81	25,71	22,75	27,25	24,67	26,74
66	27,25	25,71	22,75	27,25	24,67	26,74
67	26,06	25,71	22,75	27,25	24,67	26,74
68	27,13	25,71	22,75	27,25	24,67	26,74
69	25,38	25,71	22,75	27,25	24,67	26,74
70	25,7	25,71	22,75	27,25	24,67	26,74
71	25,03	25,71	22,75	27,25	24,67	26,74
72	24,55	25,71	22,75	27,25	24,67	26,74
73	24,41	25,71	22,75	27,25	24,67	26,74
74	25,08	25,71	22,75	27,25	24,67	26,74
75	24,86	25,71	22,75	27,25	24,67	26,74
76	25,32	25,71	22,75	27,25	24,67	26,74
77	24,48	25,71	22,75	27,25	24,67	26,74
78	27,19	25,71	22,75	27,25	24,67	26,74
79	24,88	25,71	22,75	27,25	24,67	26,74
80	25,26	25,71	22,75	27,25	24,67	26,74
81	25,31	25,71	22,75	27,25	24,67	26,74
82	26,09	25,71	22,75	27,25	24,67	26,74
83	25,23	25,71	22,75	27,25	24,67	26,74
84	26,94	25,71	22,75	27,25	24,67	26,74
85	26,9	25,71	22,75	27,25	24,67	26,74
86	26,07	25,71	22,75	27,25	24,67	26,74
87	25,15	25,71	22,75	27,25	24,67	26,74

88	26,23	25,71	22,75	27,25	24,67	26,74
89	25,39	25,71	22,75	27,25	24,67	26,74
90	25,17	25,71	22,75	27,25	24,67	26,74
91	24,5	25,71	22,75	27,25	24,67	26,74
92	24,62	25,71	22,75	27,25	24,67	26,74
93	27	25,71	22,75	27,25	24,67	26,74
94	26,38	25,71	22,75	27,25	24,67	26,74
95	25,82	25,71	22,75	27,25	24,67	26,74
96	25,49	25,71	22,75	27,25	24,67	26,74
97	24,09	25,71	22,75	27,25	24,67	26,74
98	24,54	25,71	22,75	27,25	24,67	26,74
99	24,65	25,71	22,75	27,25	24,67	26,74
100	27,13	25,71	22,75	27,25	24,67	26,74
101	24,65	25,71	22,75	27,25	24,67	26,74
102	24,23	25,71	22,75	27,25	24,67	26,74
103	24,2	25,71	22,75	27,25	24,67	26,74
104	22,76	25,71	22,75	27,25	24,67	26,74
105	26,14	25,71	22,75	27,25	24,67	26,74
106	25,25	25,71	22,75	27,25	24,67	26,74
107	25,95	25,71	22,75	27,25	24,67	26,74
108	25,53	25,71	22,75	27,25	24,67	26,74
109	24,33	25,71	22,75	27,25	24,67	26,74
110	24,98	25,71	22,75	27,25	24,67	26,74
111	25,04	25,71	22,75	27,25	24,67	26,74
112	25,49	25,71	22,75	27,25	24,67	26,74
113	25,05	25,71	22,75	27,25	24,67	26,74
114	25,45	25,71	22,75	27,25	24,67	26,74
115	22,76	25,71	22,75	27,25	24,67	26,74
116	22,75	25,71	22,75	27,25	24,67	26,74
117	26,38	25,71	22,75	27,25	24,67	26,74
118	25,82	25,71	22,75	27,25	24,67	26,74
119	25,09	25,71	22,75	27,25	24,67	26,74
120	22,77	25,71	22,75	27,25	24,67	26,74
121	26,38	25,71	22,75	27,25	24,67	26,74
122	25,82	25,71	22,75	27,25	24,67	26,74
123	25,09	25,71	22,75	27,25	24,67	26,74
124	25,38	25,71	22,75	27,25	24,67	26,74
125	26,51	25,71	22,75	27,25	24,67	26,74
126	25,11	25,71	22,75	27,25	24,67	26,74
127	24,57	25,71	22,75	27,25	24,67	26,74
128	27,24	25,71	22,75	27,25	24,67	26,74
129	27,11	25,71	22,75	27,25	24,67	26,74
130	26,74	25,71	22,75	27,25	24,67	26,74
131	25,11	25,71	22,75	27,25	24,67	26,74
132	23,88	25,71	22,75	27,25	24,67	26,74
133	24,68	25,71	22,75	27,25	24,67	26,74
134	25,72	25,71	22,75	27,25	24,67	26,74
135	25,53	25,71	22,75	27,25	24,67	26,74
136	25,69	25,71	22,75	27,25	24,67	26,74

136	25,69	25,71	22,75	27,25	24,67	26,74
137	26,16	25,71	22,75	27,25	24,67	26,74
138	24,52	25,71	22,75	27,25	24,67	26,74
139	24,57	25,71	22,75	27,25	24,67	26,74
140	25,55	25,71	22,75	27,25	24,67	26,74
141	25,07	25,71	22,75	27,25	24,67	26,74
142	26,04	25,71	22,75	27,25	24,67	26,74
143	26,02	25,71	22,75	27,25	24,67	26,74
144	25,64	25,71	22,75	27,25	24,67	26,74
145	25,07	25,71	22,75	27,25	24,67	26,74
146	25,24	25,71	22,75	27,25	24,67	26,74
147	25,33	25,71	22,75	27,25	24,67	26,74
148	25,66	25,71	22,75	27,25	24,67	26,74
149	25,82	25,71	22,75	27,25	24,67	26,74
150	25,7	25,71	22,75	27,25	24,67	26,74
151	25,47	25,71	22,75	27,25	24,67	26,74
152	25,95	25,71	22,75	27,25	24,67	26,74
153	25,97	25,71	22,75	27,25	24,67	26,74
154	26,59	25,71	22,75	27,25	24,67	26,74
155	26,93	25,71	22,75	27,25	24,67	26,74
156	26,24	25,71	22,75	27,25	24,67	26,74
157	25,28	25,71	22,75	27,25	24,67	26,74
158	26,24	25,71	22,75	27,25	24,67	26,74
159	25,97	25,71	22,75	27,25	24,67	26,74
160	25,67	25,71	22,75	27,25	24,67	26,74

Appendix 12: KAIZEN125A1 Pair 1 Data

	x	x_ort	Kanuni alt_sınır	Kanuni ust_sınır	AKS	UKS
1	24,26	24,72	22,75	27,25	24,30	25,14
2	24,17	24,72	22,75	27,25	24,30	25,14
3	24,12	24,72	22,75	27,25	24,30	25,14
4	24,31	24,72	22,75	27,25	24,30	25,14
5	24,17	24,72	22,75	27,25	24,30	25,14
6	24,46	24,72	22,75	27,25	24,30	25,14
7	23,88	24,72	22,75	27,25	24,30	25,14
8	24,16	24,72	22,75	27,25	24,30	25,14
9	24,03	24,72	22,75	27,25	24,30	25,14
10	24,36	24,72	22,75	27,25	24,30	25,14
11	24,53	24,72	22,75	27,25	24,30	25,14
12	24,14	24,72	22,75	27,25	24,30	25,14
13	24,6	24,72	22,75	27,25	24,30	25,14
14	24,29	24,72	22,75	27,25	24,30	25,14
15	24,42	24,72	22,75	27,25	24,30	25,14
16	24,16	24,72	22,75	27,25	24,30	25,14
17	24,03	24,72	22,75	27,25	24,30	25,14
18	24,8	24,72	22,75	27,25	24,30	25,14
19	23,74	24,72	22,75	27,25	24,30	25,14
20	24,5	24,72	22,75	27,25	24,30	25,14
21	25,41	24,72	22,75	27,25	24,30	25,14
22	25,27	24,72	22,75	27,25	24,30	25,14
23	25,48	24,72	22,75	27,25	24,30	25,14
24	25,51	24,72	22,75	27,25	24,30	25,14
25	25,34	24,72	22,75	27,25	24,30	25,14
26	26,06	24,72	22,75	27,25	24,30	25,14
27	25,48	24,72	22,75	27,25	24,30	25,14
28	25,31	24,72	22,75	27,25	24,30	25,14
29	24,96	24,72	22,75	27,25	24,30	25,14
30	25,81	24,72	22,75	27,25	24,30	25,14
31	23,97	24,72	22,75	27,25	24,30	25,14
32	24,1	24,72	22,75	27,25	24,30	25,14
33	24,44	24,72	22,75	27,25	24,30	25,14
34	24,11	24,72	22,75	27,25	24,30	25,14
35	23,02	24,72	22,75	27,25	24,30	25,14
36	24,05	24,72	22,75	27,25	24,30	25,14
37	24,19	24,72	22,75	27,25	24,30	25,14
38	24,14	24,72	22,75	27,25	24,30	25,14
39	24,48	24,72	22,75	27,25	24,30	25,14
40	24,74	24,72	22,75	27,25	24,30	25,14
41	24,25	24,72	22,75	27,25	24,30	25,14
42	24,26	24,72	22,75	27,25	24,30	25,14
43	24,6	24,72	22,75	27,25	24,30	25,14
44	24,4	24,72	22,75	27,25	24,30	25,14
45	24,48	24,72	22,75	27,25	24,30	25,14
46	23,25	24,72	22,75	27,25	24,30	25,14
47	23,97	24,72	22,75	27,25	24,30	25,14
48	24,19	24,72	22,75	27,25	24,30	25,14
49	24,11	24,72	22,75	27,25	24,30	25,14
50	24,03	24,72	22,75	27,25	24,30	25,14
51	24,29	24,72	22,75	27,25	24,30	25,14
52	25,44	24,72	22,75	27,25	24,30	25,14
53	25,31	24,72	22,75	27,25	24,30	25,14
54	25,18	24,72	22,75	27,25	24,30	25,14
55	25,05	24,72	22,75	27,25	24,30	25,14
56	25,48	24,72	22,75	27,25	24,30	25,14
57	25,14	24,72	22,75	27,25	24,30	25,14
58	25,45	24,72	22,75	27,25	24,30	25,14
59	25,2	24,72	22,75	27,25	24,30	25,14
60	25,42	24,72	22,75	27,25	24,30	25,14
61	25,24	24,72	22,75	27,25	24,30	25,14
62	25,53	24,72	22,75	27,25	24,30	25,14
63	25,64	24,72	22,75	27,25	24,30	25,14
64	23,98	24,72	22,75	27,25	24,30	25,14
65	24,37	24,72	22,75	27,25	24,30	25,14
66	24,05	24,72	22,75	27,25	24,30	25,14
67	24,15	24,72	22,75	27,25	24,30	25,14
68	24,13	24,72	22,75	27,25	24,30	25,14
69	24,1	24,72	22,75	27,25	24,30	25,14
70	24,06	24,72	22,75	27,25	24,30	25,14
71	24,4	24,72	22,75	27,25	24,30	25,14
72	23,8	24,72	22,75	27,25	24,30	25,14
73	24,48	24,72	22,75	27,25	24,30	25,14
74	24,07	24,72	22,75	27,25	24,30	25,14
75	24,48	24,72	22,75	27,25	24,30	25,14
76	24,02	24,72	22,75	27,25	24,30	25,14
77	23,66	24,72	22,75	27,25	24,30	25,14
78	24,08	24,72	22,75	27,25	24,30	25,14
79	24,17	24,72	22,75	27,25	24,30	25,14
80	24,55	24,72	22,75	27,25	24,30	25,14
81	24,52	24,72	22,75	27,25	24,30	25,14
82	24,11	24,72	22,75	27,25	24,30	25,14
83	24,13	24,72	22,75	27,25	24,30	25,14
84	24,21	24,72	22,75	27,25	24,30	25,14
85	23,97	24,72	22,75	27,25	24,30	25,14
86	24,83	24,72	22,75	27,25	24,30	25,14
87	24,25	24,72	22,75	27,25	24,30	25,14

88	25,28	24,72	22,75	27,25	24,30	25,14
89	25,01	24,72	22,75	27,25	24,30	25,14
90	25,33	24,72	22,75	27,25	24,30	25,14
91	25,7	24,72	22,75	27,25	24,30	25,14
92	25,49	24,72	22,75	27,25	24,30	25,14
93	25,2	24,72	22,75	27,25	24,30	25,14
94	25,55	24,72	22,75	27,25	24,30	25,14
95	25,26	24,72	22,75	27,25	24,30	25,14
96	25,3	24,72	22,75	27,25	24,30	25,14
97	25,18	24,72	22,75	27,25	24,30	25,14
98	25,2	24,72	22,75	27,25	24,30	25,14
99	25,98	24,72	22,75	27,25	24,30	25,14
100	25,47	24,72	22,75	27,25	24,30	25,14
101	25,83	24,72	22,75	27,25	24,30	25,14
102	25,13	24,72	22,75	27,25	24,30	25,14
103	25,3	24,72	22,75	27,25	24,30	25,14
104	25,3	24,72	22,75	27,25	24,30	25,14
105	25,55	24,72	22,75	27,25	24,30	25,14
106	25,14	24,72	22,75	27,25	24,30	25,14
107	25,3	24,72	22,75	27,25	24,30	25,14
108	25,05	24,72	22,75	27,25	24,30	25,14
109	25,93	24,72	22,75	27,25	24,30	25,14
110	24,78	24,72	22,75	27,25	24,30	25,14
111	24,51	24,72	22,75	27,25	24,30	25,14
112	24,37	24,72	22,75	27,25	24,30	25,14
113	24,52	24,72	22,75	27,25	24,30	25,14
114	24,62	24,72	22,75	27,25	24,30	25,14
115	24,9	24,72	22,75	27,25	24,30	25,14
116	24,42	24,72	22,75	27,25	24,30	25,14
117	24,8	24,72	22,75	27,25	24,30	25,14
118	24,9	24,72	22,75	27,25	24,30	25,14
119	24,86	24,72	22,75	27,25	24,30	25,14
120	24	24,72	22,75	27,25	24,30	25,14
121	24,7	24,72	22,75	27,25	24,30	25,14
122	24,19	24,72	22,75	27,25	24,30	25,14
123	24,55	24,72	22,75	27,25	24,30	25,14
124	24,6	24,72	22,75	27,25	24,30	25,14
125	24,43	24,72	22,75	27,25	24,30	25,14
126	24,2	24,72	22,75	27,25	24,30	25,14
127	24,13	24,72	22,75	27,25	24,30	25,14
128	24,88	24,72	22,75	27,25	24,30	25,14
129	24,75	24,72	22,75	27,25	24,30	25,14
130	24,39	24,72	22,75	27,25	24,30	25,14
131	24,15	24,72	22,75	27,25	24,30	25,14
132	24,72	24,72	22,75	27,25	24,30	25,14
133	24,52	24,72	22,75	27,25	24,30	25,14
134	25	24,72	22,75	27,25	24,30	25,14
135	24,46	24,72	22,75	27,25	24,30	25,14
136	24,39	24,72	22,75	27,25	24,30	25,14
137	24,41	24,72	22,75	27,25	24,30	25,14
138	24,25	24,72	22,75	27,25	24,30	25,14
139	24,61	24,72	22,75	27,25	24,30	25,14
140	24,28	24,72	22,75	27,25	24,30	25,14
141	25,56	24,72	22,75	27,25	24,30	25,14
142	25,04	24,72	22,75	27,25	24,30	25,14
143	25,45	24,72	22,75	27,25	24,30	25,14
144	25,89	24,72	22,75	27,25	24,30	25,14
145	25,07	24,72	22,75	27,25	24,30	25,14
146	25,11	24,72	22,75	27,25	24,30	25,14
147	25,43	24,72	22,75	27,25	24,30	25,14
148	24,74	24,72	22,75	27,25	24,30	25,14
149	25,78	24,72	22,75	27,25	24,30	25,14
150	25,03	24,72	22,75	27,25	24,30	25,14
151	25,12	24,72	22,75	27,25	24,30	25,14
152	25,06	24,72	22,75	27,25	24,30	25,14
153	25,05	24,72	22,75	27,25	24,30	25,14
154	25,03	24,72	22,75	27,25	24,30	25,14
155	25	24,72	22,75	27,25	24,30	25,14
156	25,01	24,72	22,75	27,25	24,30	25,14
157	25,05	24,72	22,75	27,25	24,30	25,14
158	25,04	24,72	22,75	27,25	24,30	25,14
159	25,36	24,72	22,75	27,25	24,30	25,14
160	25,78	24,72	22,75	27,25	24,30	25,14

Appendix 13: KAIZEN125B2 Pair 2 Data

	x	x_ort	Kanuni alt_sınır	Kanuni ust_sınır	AKS	UKS
1	27,22	26,15	22,75	27,25	25,15	27,14
2	25,46	26,15	22,75	27,25	25,15	27,14
3	26,26	26,15	22,75	27,25	25,15	27,14
4	26,73	26,15	22,75	27,25	25,15	27,14
5	26,06	26,15	22,75	27,25	25,15	27,14
6	25,7	26,15	22,75	27,25	25,15	27,14
7	26,55	26,15	22,75	27,25	25,15	27,14
8	26,08	26,15	22,75	27,25	25,15	27,14
9	25,95	26,15	22,75	27,25	25,15	27,14
10	24,83	26,15	22,75	27,25	25,15	27,14
11	25,5	26,15	22,75	27,25	25,15	27,14
12	25,36	26,15	22,75	27,25	25,15	27,14
13	25,79	26,15	22,75	27,25	25,15	27,14
14	24,52	26,15	22,75	27,25	25,15	27,14
15	25,91	26,15	22,75	27,25	25,15	27,14
16	25,91	26,15	22,75	27,25	25,15	27,14
17	25,69	26,15	22,75	27,25	25,15	27,14
18	24,86	26,15	22,75	27,25	25,15	27,14
19	25,32	26,15	22,75	27,25	25,15	27,14
20	27,25	26,15	22,75	27,25	25,15	27,14
21	26,05	26,15	22,75	27,25	25,15	27,14
22	27,11	26,15	22,75	27,25	25,15	27,14
23	27,2	26,15	22,75	27,25	25,15	27,14
24	26,39	26,15	22,75	27,25	25,15	27,14
25	25,36	26,15	22,75	27,25	25,15	27,14
26	27,22	26,15	22,75	27,25	25,15	27,14
27	27,2	26,15	22,75	27,25	25,15	27,14
28	25,95	26,15	22,75	27,25	25,15	27,14
29	25,56	26,15	22,75	27,25	25,15	27,14
30	25,85	26,15	22,75	27,25	25,15	27,14
31	25,58	26,15	22,75	27,25	25,15	27,14
32	25,6	26,15	22,75	27,25	25,15	27,14
33	25,59	26,15	22,75	27,25	25,15	27,14
34	25,77	26,15	22,75	27,25	25,15	27,14
35	26,67	26,15	22,75	27,25	25,15	27,14
36	25,95	26,15	22,75	27,25	25,15	27,14
37	26,61	26,15	22,75	27,25	25,15	27,14
38	27,2	26,15	22,75	27,25	25,15	27,14
39	26	26,15	22,75	27,25	25,15	27,14
40	27,24	26,15	22,75	27,25	25,15	27,14
41	25,47	26,15	22,75	27,25	25,15	27,14
42	25,97	26,15	22,75	27,25	25,15	27,14
43	26,59	26,15	22,75	27,25	25,15	27,14
44	27,18	26,15	22,75	27,25	25,15	27,14
45	27,24	26,15	22,75	27,25	25,15	27,14
46	26,24	26,15	22,75	27,25	25,15	27,14
47	26,93	26,15	22,75	27,25	25,15	27,14
48	25,28	26,15	22,75	27,25	25,15	27,14
49	27,23	26,15	22,75	27,25	25,15	27,14
50	26,24	26,15	22,75	27,25	25,15	27,14
51	25,97	26,15	22,75	27,25	25,15	27,14
52	27,09	26,15	22,75	27,25	25,15	27,14
53	25,55	26,15	22,75	27,25	25,15	27,14
54	25,48	26,15	22,75	27,25	25,15	27,14
55	25,26	26,15	22,75	27,25	25,15	27,14
56	27,13	26,15	22,75	27,25	25,15	27,14
57	27,24	26,15	22,75	27,25	25,15	27,14
58	25,57	26,15	22,75	27,25	25,15	27,14
59	27,21	26,15	22,75	27,25	25,15	27,14
60	25,62	26,15	22,75	27,25	25,15	27,14
61	25,9	26,15	22,75	27,25	25,15	27,14
62	24,6	26,15	22,75	27,25	25,15	27,14
63	24,45	26,15	22,75	27,25	25,15	27,14
64	24,59	26,15	22,75	27,25	25,15	27,14
65	25,17	26,15	22,75	27,25	25,15	27,14
66	26,66	26,15	22,75	27,25	25,15	27,14
67	27,25	26,15	22,75	27,25	25,15	27,14
68	25,67	26,15	22,75	27,25	25,15	27,14
69	27,05	26,15	22,75	27,25	25,15	27,14
70	27,24	26,15	22,75	27,25	25,15	27,14
71	27,25	26,15	22,75	27,25	25,15	27,14
72	26,37	26,15	22,75	27,25	25,15	27,14
73	26,05	26,15	22,75	27,25	25,15	27,14
74	25,59	26,15	22,75	27,25	25,15	27,14
75	24,28	26,15	22,75	27,25	25,15	27,14
76	25,92	26,15	22,75	27,25	25,15	27,14
77	26,81	26,15	22,75	27,25	25,15	27,14
78	25,83	26,15	22,75	27,25	25,15	27,14
79	27,12	26,15	22,75	27,25	25,15	27,14
80	27,16	26,15	22,75	27,25	25,15	27,14
81	27,17	26,15	22,75	27,25	25,15	27,14
82	26,36	26,15	22,75	27,25	25,15	27,14
83	25,61	26,15	22,75	27,25	25,15	27,14
84	26,65	26,15	22,75	27,25	25,15	27,14
85	27,2	26,15	22,75	27,25	25,15	27,14
86	27,07	26,15	22,75	27,25	25,15	27,14
87	26,05	26,15	22,75	27,25	25,15	27,14

88	25,52	26,15	22,75	27,25	25,15	27,14
89	25,81	26,15	22,75	27,25	25,15	27,14
90	25,6	26,15	22,75	27,25	25,15	27,14
91	26,27	26,15	22,75	27,25	25,15	27,14
92	26,85	26,15	22,75	27,25	25,15	27,14
93	25,7	26,15	22,75	27,25	25,15	27,14
94	26,02	26,15	22,75	27,25	25,15	27,14
95	27,02	26,15	22,75	27,25	25,15	27,14
96	26,18	26,15	22,75	27,25	25,15	27,14
97	25,93	26,15	22,75	27,25	25,15	27,14
98	26,51	26,15	22,75	27,25	25,15	27,14
99	26,57	26,15	22,75	27,25	25,15	27,14
100	27	26,15	22,75	27,25	25,15	27,14
101	27,07	26,15	22,75	27,25	25,15	27,14
102	26,78	26,15	22,75	27,25	25,15	27,14
103	25,87	26,15	22,75	27,25	25,15	27,14
104	26,98	26,15	22,75	27,25	25,15	27,14
105	27,18	26,15	22,75	27,25	25,15	27,14
106	27,01	26,15	22,75	27,25	25,15	27,14
107	25,48	26,15	22,75	27,25	25,15	27,14
108	27,13	26,15	22,75	27,25	25,15	27,14
109	27,17	26,15	22,75	27,25	25,15	27,14
110	27,09	26,15	22,75	27,25	25,15	27,14
111	27,25	26,15	22,75	27,25	25,15	27,14
112	27,13	26,15	22,75	27,25	25,15	27,14
113	24,99	26,15	22,75	27,25	25,15	27,14
114	26,62	26,15	22,75	27,25	25,15	27,14
115	25,5	26,15	22,75	27,25	25,15	27,14
116	26,99	26,15	22,75	27,25	25,15	27,14
117	25,65	26,15	22,75	27,25	25,15	27,14
118	25,46	26,15	22,75	27,25	25,15	27,14
119	26,02	26,15	22,75	27,25	25,15	27,14
120	27,07	26,15	22,75	27,25	25,15	27,14
121	25,6	26,15	22,75	27,25	25,15	27,14
122	27,13	26,15	22,75	27,25	25,15	27,14
123	27	26,15	22,75	27,25	25,15	27,14
124	23,05	26,15	22,75	27,25	25,15	27,14
125	23,01	26,15	22,75	27,25	25,15	27,14
126	25,87	26,15	22,75	27,25	25,15	27,14
127	27,25	26,15	22,75	27,25	25,15	27,14
128	27,03	26,15	22,75	27,25	25,15	27,14
129	25,76	26,15	22,75	27,25	25,15	27,14
130	25,45	26,15	22,75	27,25	25,15	27,14
131	25,85	26,15	22,75	27,25	25,15	27,14
132	25,89	26,15	22,75	27,25	25,15	27,14
133	25,42	26,15	22,75	27,25	25,15	27,14
134	25,78	26,15	22,75	27,25	25,15	27,14
135	26,7	26,15	22,75	27,25	25,15	27,14
136	25,92	26,15	22,75	27,25	25,15	27,14
137	26,53	26,15	22,75	27,25	25,15	27,14
138	26,79	26,15	22,75	27,25	25,15	27,14
139	26,23	26,15	22,75	27,25	25,15	27,14
140	26,53	26,15	22,75	27,25	25,15	27,14
141	26,66	26,15	22,75	27,25	25,15	27,14
142	25,87	26,15	22,75	27,25	25,15	27,14
143	23	26,15	22,75	27,25	25,15	27,14
144	27,08	26,15	22,75	27,25	25,15	27,14
145	27	26,15	22,75	27,25	25,15	27,14
146	25,44	26,15	22,75	27,25	25,15	27,14
147	27,23	26,15	22,75	27,25	25,15	27,14
148	25,97	26,15	22,75	27,25	25,15	27,14
149	27,24	26,15	22,75	27,25	25,15	27,14
150	27,22	26,15	22,75	27,25	25,15	27,14
151	25,63	26,15	22,75	27,25	25,15	27,14
152	25,06	26,15	22,75	27,25	25,15	27,14
153	25,62	26,15	22,75	27,25	25,15	27,14
154	25,54	26,15	22,75	27,25	25,15	27,14
155	25,62	26,15	22,75	27,25	25,15	27,14
156	25,54	26,15	22,75	27,25	25,15	27,14
157	25,62	26,15	22,75	27,25	25,15	27,14
158	25,23	26,15	22,75	27,25	25,15	27,14
159	24,92	26,15	22,75	27,25	25,15	27,14
160	25	26,15	22,75	27,25	25,15	27,14

Appendix 14: KAIZEN125A2 Pair 2 Data

	x	x_ort	Kanuni alt_sınır	Kanuni ust_sınır	AKS	UKS
1	25,24	24,89	22,75	27,25	24,43	25,34
2	24,12	24,89	22,75	27,25	24,43	25,34
3	24,3	24,89	22,75	27,25	24,43	25,34
4	24,19	24,89	22,75	27,25	24,43	25,34
5	25,44	24,89	22,75	27,25	24,43	25,34
6	25,68	24,89	22,75	27,25	24,43	25,34
7	25,49	24,89	22,75	27,25	24,43	25,34
8	25,15	24,89	22,75	27,25	24,43	25,34
9	24,32	24,89	22,75	27,25	24,43	25,34
10	24,43	24,89	22,75	27,25	24,43	25,34
11	25,18	24,89	22,75	27,25	24,43	25,34
12	24,97	24,89	22,75	27,25	24,43	25,34
13	24,52	24,89	22,75	27,25	24,43	25,34
14	25,34	24,89	22,75	27,25	24,43	25,34
15	25,32	24,89	22,75	27,25	24,43	25,34
16	24,92	24,89	22,75	27,25	24,43	25,34
17	24,47	24,89	22,75	27,25	24,43	25,34
18	25,12	24,89	22,75	27,25	24,43	25,34
19	24,08	24,89	22,75	27,25	24,43	25,34
20	24,12	24,89	22,75	27,25	24,43	25,34
21	25,34	24,89	22,75	27,25	24,43	25,34
22	24,18	24,89	22,75	27,25	24,43	25,34
23	24,84	24,89	22,75	27,25	24,43	25,34
24	25,09	24,89	22,75	27,25	24,43	25,34
25	24,08	24,89	22,75	27,25	24,43	25,34
26	25,37	24,89	22,75	27,25	24,43	25,34
27	24,44	24,89	22,75	27,25	24,43	25,34
28	25,29	24,89	22,75	27,25	24,43	25,34
29	24,23	24,89	22,75	27,25	24,43	25,34
30	24,48	24,89	22,75	27,25	24,43	25,34
31	24,28	24,89	22,75	27,25	24,43	25,34
32	24,22	24,89	22,75	27,25	24,43	25,34
33	24,92	24,89	22,75	27,25	24,43	25,34
34	24,7	24,89	22,75	27,25	24,43	25,34
35	24,2	24,89	22,75	27,25	24,43	25,34
36	25,19	24,89	22,75	27,25	24,43	25,34
37	25,06	24,89	22,75	27,25	24,43	25,34
38	24,51	24,89	22,75	27,25	24,43	25,34
39	24,92	24,89	22,75	27,25	24,43	25,34
40	24,16	24,89	22,75	27,25	24,43	25,34
41	24,21	24,89	22,75	27,25	24,43	25,34
42	25,04	24,89	22,75	27,25	24,43	25,34
43	24,43	24,89	22,75	27,25	24,43	25,34
44	24,25	24,89	22,75	27,25	24,43	25,34
45	25,32	24,89	22,75	27,25	24,43	25,34
46	24,88	24,89	22,75	27,25	24,43	25,34
47	25,09	24,89	22,75	27,25	24,43	25,34
48	24,2	24,89	22,75	27,25	24,43	25,34
49	24,88	24,89	22,75	27,25	24,43	25,34
50	24,37	24,89	22,75	27,25	24,43	25,34
51	24,28	24,89	22,75	27,25	24,43	25,34
52	25	24,89	22,75	27,25	24,43	25,34
53	25,01	24,89	22,75	27,25	24,43	25,34
54	25,15	24,89	22,75	27,25	24,43	25,34
55	25,01	24,89	22,75	27,25	24,43	25,34
56	25,06	24,89	22,75	27,25	24,43	25,34
57	25,2	24,89	22,75	27,25	24,43	25,34
58	25	24,89	22,75	27,25	24,43	25,34
59	24,84	24,89	22,75	27,25	24,43	25,34
60	24,81	24,89	22,75	27,25	24,43	25,34
61	24,94	24,89	22,75	27,25	24,43	25,34
62	24,4	24,89	22,75	27,25	24,43	25,34
63	24,82	24,89	22,75	27,25	24,43	25,34
64	24,32	24,89	22,75	27,25	24,43	25,34
65	25,28	24,89	22,75	27,25	24,43	25,34
66	25,15	24,89	22,75	27,25	24,43	25,34
67	24,87	24,89	22,75	27,25	24,43	25,34
68	24,84	24,89	22,75	27,25	24,43	25,34
69	25,18	24,89	22,75	27,25	24,43	25,34
70	24,2	24,89	22,75	27,25	24,43	25,34
71	24,84	24,89	22,75	27,25	24,43	25,34
72	25	24,89	22,75	27,25	24,43	25,34
73	24,37	24,89	22,75	27,25	24,43	25,34
74	24,94	24,89	22,75	27,25	24,43	25,34
75	25,17	24,89	22,75	27,25	24,43	25,34
76	25,22	24,89	22,75	27,25	24,43	25,34
77	24,85	24,89	22,75	27,25	24,43	25,34
78	24,8	24,89	22,75	27,25	24,43	25,34
79	24,97	24,89	22,75	27,25	24,43	25,34
80	25	24,89	22,75	27,25	24,43	25,34
81	25,11	24,89	22,75	27,25	24,43	25,34
82	24,8	24,89	22,75	27,25	24,43	25,34
83	24,81	24,89	22,75	27,25	24,43	25,34
84	25	24,89	22,75	27,25	24,43	25,34
85	25,1	24,89	22,75	27,25	24,43	25,34
86	25,06	24,89	22,75	27,25	24,43	25,34
87	25,46	24,89	22,75	27,25	24,43	25,34

88	24,75	24,89	22,75	27,25	24,43	25,34
89	24,77	24,89	22,75	27,25	24,43	25,34
90	25,05	24,89	22,75	27,25	24,43	25,34
91	25,13	24,89	22,75	27,25	24,43	25,34
92	25	24,89	22,75	27,25	24,43	25,34
93	25	24,89	22,75	27,25	24,43	25,34
94	25,25	24,89	22,75	27,25	24,43	25,34
95	25	24,89	22,75	27,25	24,43	25,34
96	25	24,89	22,75	27,25	24,43	25,34
97	24,83	24,89	22,75	27,25	24,43	25,34
98	25,47	24,89	22,75	27,25	24,43	25,34
99	24,7	24,89	22,75	27,25	24,43	25,34
100	25,27	24,89	22,75	27,25	24,43	25,34
101	25,06	24,89	22,75	27,25	24,43	25,34
102	25,01	24,89	22,75	27,25	24,43	25,34
103	24,77	24,89	22,75	27,25	24,43	25,34
104	24,89	24,89	22,75	27,25	24,43	25,34
105	24,9	24,89	22,75	27,25	24,43	25,34
106	25,54	24,89	22,75	27,25	24,43	25,34
107	24,71	24,89	22,75	27,25	24,43	25,34
108	24,6	24,89	22,75	27,25	24,43	25,34
109	24,64	24,89	22,75	27,25	24,43	25,34
110	24,75	24,89	22,75	27,25	24,43	25,34
111	24,8	24,89	22,75	27,25	24,43	25,34
112	24,9	24,89	22,75	27,25	24,43	25,34
113	24,72	24,89	22,75	27,25	24,43	25,34
114	25,16	24,89	22,75	27,25	24,43	25,34
115	25,47	24,89	22,75	27,25	24,43	25,34
116	25,92	24,89	22,75	27,25	24,43	25,34
117	25,95	24,89	22,75	27,25	24,43	25,34
118	25,59	24,89	22,75	27,25	24,43	25,34
119	25,7	24,89	22,75	27,25	24,43	25,34
120	25,67	24,89	22,75	27,25	24,43	25,34
121	24,9	24,89	22,75	27,25	24,43	25,34
122	24,58	24,89	22,75	27,25	24,43	25,34
123	24,88	24,89	22,75	27,25	24,43	25,34
124	25,12	24,89	22,75	27,25	24,43	25,34
125	24,12	24,89	22,75	27,25	24,43	25,34
126	25,09	24,89	22,75	27,25	24,43	25,34
127	24,97	24,89	22,75	27,25	24,43	25,34
128	24,51	24,89	22,75	27,25	24,43	25,34
129	24,54	24,89	22,75	27,25	24,43	25,34
130	24,46	24,89	22,75	27,25	24,43	25,34
131	24,59	24,89	22,75	27,25	24,43	25,34
132	24,69	24,89	22,75	27,25	24,43	25,34
133	25,14	24,89	22,75	27,25	24,43	25,34
134	25	24,89	22,75	27,25	24,43	25,34
135	25,1	24,89	22,75	27,25	24,43	25,34
136	24,57	24,89	22,75	27,25	24,43	25,34
137	24,66	24,89	22,75	27,25	24,43	25,34
138	25	24,89	22,75	27,25	24,43	25,34
139	25,18	24,89	22,75	27,25	24,43	25,34
140	24,48	24,89	22,75	27,25	24,43	25,34
141	25	24,89	22,75	27,25	24,43	25,34
142	25	24,89	22,75	27,25	24,43	25,34
143	25,53	24,89	22,75	27,25	24,43	25,34
144	25	24,89	22,75	27,25	24,43	25,34
145	25	24,89	22,75	27,25	24,43	25,34
146	24,66	24,89	22,75	27,25	24,43	25,34
147	24,71	24,89	22,75	27,25	24,43	25,34
148	24,53	24,89	22,75	27,25	24,43	25,34
149	25,5	24,89	22,75	27,25	24,43	25,34
150	25,1	24,89	22,75	27,25	24,43	25,34
151	24,74	24,89	22,75	27,25	24,43	25,34
152	24,96	24,89	22,75	27,25	24,43	25,34
153	25,78	24,89	22,75	27,25	24,43	25,34
154	24,34	24,89	22,75	27,25	24,43	25,34
155	24,93	24,89	22,75	27,25	24,43	25,34
156	24,99	24,89	22,75	27,25	24,43	25,34
157	24,9	24,89	22,75	27,25	24,43	25,34
158	24,95	24,89	22,75	27,25	24,43	25,34
159	25	24,89	22,75	27,25	24,43	25,34
160	25	24,89	22,75	27,25	24,43	25,34

Appendix 15: Kaizen 125 Project Plan

Dr. Oetker Turkey

Proje Yöneticisi	Mahmut Hilmi Gökçe		Turkish
Proje Başlığı	Kaizen 125	Güncellendi	Tarih

PROJE BERATI

Proje Numarası	*Opsiyonal*	**Versiyon**	*Opsiyonal*
Proje Başlagıcı	31.05.2016	**Proje Bitişi**	31.11.2017

Proje Açıklaması

Sorun açıklaması / arka plan / fiili durum	Toz gıda ürünlerinin akış özellikleri her ürün grubu için farklıdır ve helezon üzerinde farklı özellikte akış karekteristiği göstermektedir,ayrıca modern kontrol sistemlerindeki hassas olmayan durumdan dolayı toz gıda paketlerinde gramaj sapmalarına neden olmaktadır
Projenin amacı (Hedef durum)	Gramaj sapmalarını minimize etmek
Kilometre Taşları/Alt Hedefler	*Ürüne göre helezon dizayn etme,ürün akış özelliklerinin belirlenmesi ,akış özelliklerinin modellenmesi ve devir sayılarının standart duruma getirilmesi*
Göstergeler	Devir,Helezon parametreleri,Toz Akış İndeksi,İstatiksel Proses Kontrolü,Fayda-Maliyet Analizi
Proje istemcileri/müşterileri	Üretim Departmanı,Teknik Servis

Faydaları & Maliyetleri

Faydaları (nicel / nitel)	Kalitede ve Zamanlamada kesinlik,Maliyette verimlilik,Üretimde esneklik.

HEDEF:
Aşağıdaki maddeler ile ekip üyelerinin projenin ortak bir çıktısını oluşturması gerekir:
- Neden böyle bir proje gereklidir?
- Mevcut sorunları (fırsatları) nelerdir?
- Projenin amacı nedir?
- Hangi kaynaklar söz konusu?
- Beklenen kapsamı ve zamanlaması nedir?

İyi bir Proje çıktısının hazırlanması dış gözlemcilerin projeye bakışını güçlendirir.

NOT (LAR)
Sorunlar ve hedefler için S-M-A-R T-kurallar koymayı unutmayın.

Proje Beratı "yaşayan" bir belgedir. Güncelleme proje boyunca mümkündür, ama her zaman proje ekibi ve / müşteri ile koordine edilmelidir. "

Proje Yöneticisi Mahmut Hilmi Gökçe

Proje Başlığı Kaizen 125

Güncellendi Tarih

PROJE PLANI

Çizgi/Satır/Hat Ekle | Çizgi/Satır/Hat Sil | Zaman Alanını Güncelle | Start Projekt ⇉ | Bugün

Hayır	Proje Aşaması Calisma Paketi Görev Uzman	Yorum/Açıklama	Sorumlu Name	Planllanan Başlangıç Tarihi Tarih	Planlanan Bitiş Tarihi Tarih	Brüt Zaman Günler	Gerçekleşen Başlangıç Tarihi Tarih	Gerçekleşen Bitiş Tarihi Tarih	Brüt Zaman Günler	Durum % Tamamlandı	Haftalık Ajanda Yıl Proje Haftası
1	**Ürün Akış Karekteristikleri ve Hatalı Akış Özelliklerinin Belirlenmesi**		**Mahmut Hilmi Gökçe**	**7.04.2016**	**7.05.2016**	**31**	**7.04.2016**	**7.05.2016**	**31**		Planlı Fiili
1.1.	Yığın Açısı										Planlı Fiili
1.2.	Silo ve Hazne Dizaynı Parametreleri										Planlı Fiili
1.3	Ürünün Yüzey ile Yaptığı Akış Özelliklerinin Belirlenmesi										Planlı Fiili
2	**Helezon Dizayn Paremetrelerinin Belirlenmesi**		**Mahmut Hilmi Gökçe**	7.05.2016	7.06.2016	32	7.05.2016	7.06.2016	32		Planlı Fiili
2.1	Hatve,Çap,Helezon Açısı										Plan Ist
2.2	Helezon Veriminin Teorik İspatı										Plan Ist
3	**Makinaların Helezon Ölçülerinin Alınması**		**Mahmut Hilmi Gökçe**	7.06.2016	28.06.2016	22	7.06.2016	28.06.2016	22		Planlı Fiili
3.1	Üretim 1										Planlı Fiili
3.2	Üretim 2										Planlı
4	**Modern Kontrol Sistemlerinin Gramaj Kontrolünde İşleyişinin Kavranması**		**Mahmut Hilmi Gökçe**	29.06.2016	30.08.2016	63	29.06.2016	30.08.2016	63		Planlı Fiili
4.1	PLC										Planlı Fiili
4.2	Servo Kontrol Sistemleri										Planlı Fiili
4.3	Devir (Revolution per Minute)RPM										Plan Ist
4.4	Elektriksel Motorların Kavranması										Plan Ist
5	**Ürün Akış Özelliklerinin Belirlenmesi İçin Ekipman Tasarımı**		**Mahmut Hilmi Gökçe-Mert Ün**	1.09.2016	1.10.2016	31	1.09.2016	1.10.2016	31		Plan Ist
5.1	İç Sürtünme Açısı										Plan Ist
5.2	Yüzey Sürtünme Açısı										Plan Ist
6	**Ürün Akış Özelliklerinin Belirlenmesi**		**Mahmut Hilmi-Güneş Özgür**	1.10.2016	8.10.2016	8	1.10.2016	8.10.2016	8		Plan Ist
7	**Belirlenen 'Makinaların Operatör Panelindeki Gramajı Yöneten**		**Mahmut Hilmi-Bilge Karaman**	10.10.2016	21.10.2016	12					Plan Ist
7.1	HMI (Human Machine Interface)										Plan Ist
7.2	Devir (RPM) in servo kontrol sisteminde de hassasiyetinin artırılması										Plan Ist
8	**Belirlenen Makinalarda Ürüne göre Helezonların Dizaynı**		**Mahmut Hilmi-Mert Ün**	1.11.2016	1.12.2016	31					Plan Ist
8.1	Dizayn Edilen Helezonların Denenmesi										Plan Ist
8.2	Uygun Helezonun Ürüne göre Saptanması										Plan Ist
9	**Fayda-Maliyet Analizi**		**Mahmut Hilmi-Tuba Alkan**	1.11.2016	1.12.2016	31					Plan Ist
											Plan Ist
10	**Sapmaların Düşürülmesi**		**Kaizen 125 Takımı**	1.12.2016	31.11.2017	#VALUE!					Plan Ist Planlı