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**LEAN MANUFACTURING, VALUE STREAM MAPPING A CASE
STUDY IN A PRODUCTION COMPANY**

M.S. Thesis In Industrial Engineering

by

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APPROVAL PAGE

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

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ABSTRACT

Lean production is a production model which comes about the pursuit of companies to be able to meet competition and make effective production. At lean production the main purpose is to get control about the wastage. This study includes the requirements for the success of the lean production and how the lean production system can be established.

The method of value stream mapping was revealed by literature investigation and an application in a lean manufacturer firm. It is shown that efforts on effective use of source with prevention of waste source in production and increasing value added procedures.

In first four chapters of this study, lean thinking, lean concepts and definitions, lean production techniques, value stream mapping were defined and explained. In the fifth chapter which includes the application study and all knowledge that were explained in the previous sections applied in a factory producing household appliances. In this study lean production techniques were applied to the electric water heater line.

Measurements were made, operation cycle times were determined, Kaizen improvement methods and line balancing methods were applied according to the results. Value stream maps were drawn and therefore non value-added works were determined and they had been eliminated in improved case. And last chapter of the study showed conclusion of lean implementation.

Keywords: Lean, Lean Manufacturing, Value Stream Mapping, Kaizen

YALIN ÜRETİM, DEĞER AKIŞ HARİTALAMA VE BİR ÜRETİM FİRMASINDA YAPILAN UYGULAMA

Hümeysra BAŞER

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ÖZ

Yalın Üretim işletmelerin rekabet edebilir ve verimli üretim yapabilme arayışları sonucunda doğmuş bir üretim modelidir. Yalın üretimde temel amaç israfı önlemektir. Bu çalışmada, yalın üretim uygulamalarının başarılı olabilmesi için gerekenler ve bir yalın üretim sisteminin nasıl oluşturulabileceği yer almaktadır.

Değer akış haritalama yöntemi, literatürden ve yalın bir şirkette uygulama örneği ile açıklanmıştır. Üretimdeki israf kaynaklarının önlenmesi ve değer katan işlemlerin artırılarak kaynakların etkin kullanılmasındaki çabalar gösterilmiştir.

Çalışmanın ilk dört bölümünde yalın düşünce, yalın kavramları ve tanımları, yalın üretim teknikleri, değer akış haritalama tanımlanmış ve açıklanmıştır. Beşinci bölüm de daha önceki bölümlerde açıklanmış olan tüm bilgilerin ev aletleri üreten bir fabrikada uygulanmasıdır. Bu çalışmada fabrikada üretilen elektrikli şofben hattı yalın üretim tekniklerine göre analiz edilmiştir. Uygulamada zaman ölçümleri yapılmış, operasyonların çevrim süreleri belirlenmiş, elde edilen sonuçlara göre Kaizen

iyileştirme yöntemleri ve hat dengeleme metotları uygulanmıştır. Değer akış haritaları çizilmiş ve bu sayede katma değer oluşturmayan işler belirlenerek, iyileştirilmiş durumda bu işler yok edilmiştir. Çalışmanın son bölümü ise yalın uygulamanın sonuçlarını göstermektedir.

Anahtar Kelimeler: Yalın,Yalın İmalat, Değer Akış Haritalama, Kaizen.

DEDICATION

To my daughter

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My thanks first go to my wonderful parents, for providing me with the opportunity to be where I am and my husband Ömer Faruk Başer for all his love and support during this work.

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LIST OF SYMBOLS AND ABBREVIATIONS

CO	Change-over Time
CT	Cycle Time
EPE	Every Part Every
IMVP	International Motor Vehicle Project
JIT	Just In Time
LT	Lead Time
PDCA	Plan Do Check Act
SMED	Single Minute Exchange of Die
TPM	Total Productive Maintenance
TPS	Toyota Production System
TT	Takt Time
VA	Value Added
VSM	Value Stream Mapping

CHAPTER 1.

INTRODUCTION

In today's competitive environment, firms to protect location and grow in the market must produce wide variety of products depending on customer demand that delivered in the shortest time, excellent quality and low price. Production activities are focused on the customer, must be fast and good quality. In addition, if firms can make an efficient production, they will provide competitive advantage as well as cost savings and investment.

Ensuring a competitive environment, increasing productivity can be possible with the implementation of current production methods and a number of possible productivity management instead of purchasing new machines or existing workforce to increase workers' purchasing methods such as product cost increases. The search for a competitive and efficient production of enterprises, led to the emergence of a production model known as lean manufacturing.

Before, lean production reveals all the disruptions and problems within the current existing system. Then to better for the future, lean production includes following the path of continuous improvement and never stops chasing the perfection of production techniques, management principles and lean thinking. The other businesses implementing lean manufacturing production, the required amount of production can be perfect and without waste, at the designated time. In non wasting production, cost and investment is saved. Therefore, enterprises should be adopted as a model for efficient production of lean manufacturing.

Re-evaluate the production system and to purify wastes, very effective tool value stream mapping is a used in the lean production. Value stream mapping is a technique

used for understand the shape of the current functioning of the enterprise, wasted resources and see lean practices to plan.

A continuous improvement, development and harmonization should be existing processes and systems to fight with waste. To ensure this, the philosophy of Kaizen can be used.

In this study, the definition of lean production systems, principles, ideas and techniques used is discussed, selected a process in a company producing household appliances and situations encountered during the transition to lean production in the classic production, switching stages and according to the current situation with the transition from the gains in the lean is shown.

This study is made up 6 parts.

In the first part, the objective of the study is explained. In the second part, lean thinking, lean concepts and definitions are explained. In the third part, the notions of lean manufacturing techniques are clarified. In the fourth part, value stream mapping's definition, techniques, drawing methods and purposes were defined.

In addition to this, a case study was analyzed. A case study is an application that takes place in a factory. This application was started as a pilot scale test works at first. Then, amendment and improvement works have been started in real when effective outcomes were gained. The improvement works have been started from main assembly line and spread to the other lines of the company. In today, these works still continue.

When visiting in the production area, hundreds of people were working. It soon became obvious that there were about twice the people required, twice the required space, and far too much inventory and scrap. There were good and new equipment but somehow things were not coordinated well. In fact, there was clearly lot of waste. So, the company decided to implement the lean production techniques to eliminate the wastes.

Depending on the application, in the production area measurements were made, operation cycle times were determined, Kaizen improvement methods and line balancing methods were applied according to the results. Value stream maps were

drawn and therefore non value-added works were determined and they had been eliminated in improved case.

CHAPTER 2.

LEAN PRODUCTION

2.1 Simple Approach

The main objective of lean thinking is transferring the value to the customer during value forming process starting from the first raw material. To achieve this objective, viewing the value chain from an integral framework, eliminating wastes, and directing all operations to the purpose of creating excellent value for customers are necessary. “Waste” in lean thinking means everything which does not offer benefit to the user of the product or the service and for which the customer will not accept to pay any excessive money.

From design to delivery, to increase the profitability of company, it needs to reduce waste in all areas of production (mistakes, over productions, unnecessary work, unnecessary movement, unnecessary storages). Reducing costs, increasing customer satisfaction, gaining adaptation flexibility to market conditions, accelerating cash flow and thus increasing company profitability are aimed (Shah & Ward, 2007).

2.1.1 The Production System of Toyota

Toyota is the first and the best implementer of lean production. The basis of this approach appeared in Taiichi Ohno’s trip to America with executives. Ohno has formed a basis for Toyota system. Their purposes were to improve production systems which could compete against American companies. At that time, there were mass production systems which are still used at the present day, developed by Henry Ford in America. This system makes mass production according to forecast. After the mass production, the goods were subjected to quality control. This system has not been adopted by Taiichi Ohno. At the result of this review, Eiji Toyota the youngest and the most

successful engineer of Toyota motor company and Taiichi Ohno decided that the mass production system which was applied by Ford was not appropriate for Japan. Instead of this they have begun to work on “Toyota Production System” as called in Japan.

In the 1950s in The United States, to make mass production was not a problem. Because competition was low in the market, there was an unsaturated market in which large amounts of differentiated products could be sold. Therefore, mass production system which depended on excessive work sharing and in which a higher profit level was obtained as a result of a higher production level, and the waste resulting from this system were not considered as a problem. But in Japan this situation was so different in the same years. The market was small and national income per capita was low, accumulation of funds was not enough. There was demand to different quality products and competition was too much. Toyota and Ohno analyzed the mass production system by critical eyes cause of all these constraints. At the beginning of 1980s, Toyota Motor Company putted 3,5 million cars on market and thus ranked to second among the manufacturers in the world. (Ohno, 1996)

The following is some numeric information about Toyota Production System. An employee was working 2150 hours per year in Toyota, but in the United States, an employee was working 1920 hours per year in 1980s. An employee was producing 16 automobiles per year in Chrysler which was one of the leading firms in America in 1982, but in Toyota an employee was producing 56 automobiles. In 1987, installation of a car was taking 31 hours in General Motors, but in Toyota an automobile installation was being done every 16 hours. The most important success was reducing the time of changing the dies were reduction to an incredible level of time. This time was reduced from 8 hours to 3 minutes. (Ohno, 1996)

The most basic principle that Toyota Production System has integrated to industrial world that to produce everything at anytime and in any quantities according to customer's requires and to eliminate unnecessary inventories completely. The inventory was perceived as a waste, and any kind of waste was not allowed in this system. Every step of production was only taken according to the time and quantity needed by the next step. These steps were triggered by cards called Kanban. By applying this logic in the

chain of other suppliers, a system was established which had minimized stocks and which could use its sources much more effectively.

Toyota Production System has two basic principles. These are just-in-time and automation. Just-in-time and automation are primitives intended for overcoming mass production system's structural barriers and limitations. Both of them emphasize the human factor in business process. Just-in-time aims to reduce high inventory cost which is the most important issue of mass production system, and activate the activities of production system by adding value to the product. Automation prevents the faulty production and allows the identifications of abnormalities which are emerging on the production line.

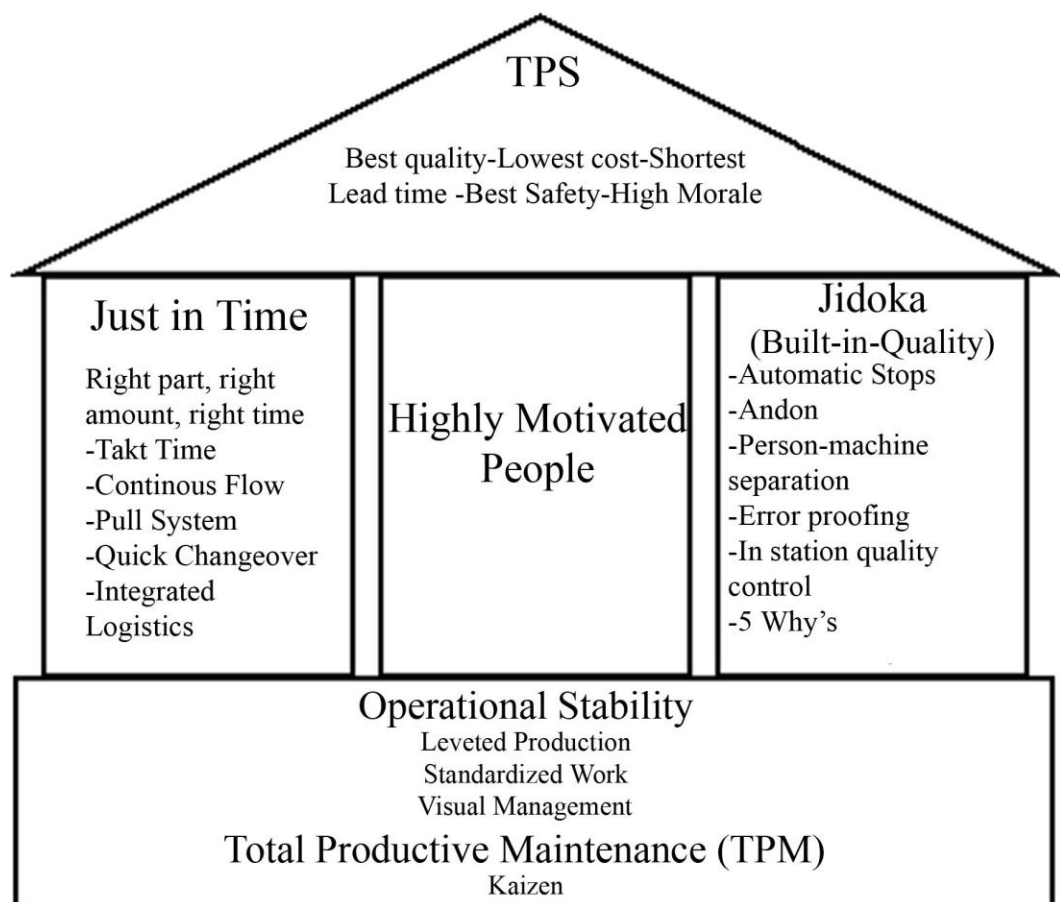


Figure 2.1 Toyota Production System House (Ohno, 1996)

One of the key features of Toyota Production System was the respect for the people. Safety and security of employees, tidiness and cleanliness of working

environment, to make the workers to work according to standards and ergonomics are the impressive elements. Everything is done to make the workers to do their jobs completely and to take part in development activities. (Liker J. , 2004)

Toyota Production System is a different approach to production management. It was emerged after the Second World War as a result of Japan's economic conditions. Japan had to learn to use scarce natural resources, funds and labors on the most rational way. This obligation caused emerge a new production and management understanding which is used in various production areas today.

2.2 Lean Production

In 1927, Henry Ford created his own production philosophy for today and tomorrow. He established a revolution with basic principles under the name of Ford Production System. Toyoda (later with the name of Toyota) Motor Company was established in Japan, Koroma. The cousins Kiichiro and Eidji formed the TPS (Toyota Production System) by working on FPS (Ford Production System) with Taichi Ohno. TPS's key function was also JIT (just-in-time production). In 1978, Taichi Ohno issued "Toyota Production System" in Japanese. According to Ohno, the sole purpose of priority of TPS was reducing costs, so eliminating wastes, and it would be succeed by controlling of quantities, quality assurance and respecting for human rights. Ohno was proposing to produce only the required product varieties in required time and in required quantities. In 1973, the oil crisis which hit the North America brought a great interest in Japan manufacturing and management applications and these events continued with many numerous of articles and books.

The first academic article was issued by Sugimori Et AL, In 1977. The articles focused on Kanban and just-in-time production. The production adjustment and level increment were written first. In 1984, Toyota Motor Company and General Motors attempted as copartner in California. In the middle of 1980s, some of notable books such as Toyota production Systems by Taichi Ohno (1988) and Toyota Production Systems by Yasuhiro Moden (1983) were issued in English language. (Shah & Ward, 2007)

At the beginning of 1980s, Toyota Motor Company putted 3,5 million cars on market and thus ranked to second among all manufacturers in the world. At the same time, it is the historic moment of Japan automobile industry passed beyond the American automobile industry. Response to America's 8 million pieces automobiles, Japan automobile industry, with the 11 million cars, was exceptional performance and Toyota Motor Company was the biggest contributor to this success. (Ohno, 1996)

Lean production appears as a term by John Craftik who is a researcher on the subject of International Motor Vehicle Project (IMVP) by Massachusetts Institute of Technology University of USA (Womack, Daniel J.T., & Ross, 1990). This term won world-wide validity through James P. Womack, Daniel T. Jones and Daniel Roos's book *The Machine That Changed The World*, that came out in 1990. The authors saw on the travel for promotion of book that the world was willing to try on Lean production but they faced with the question that how to produce in lean production (Womack & Daniel, 1998). The articles about just-in-time production, values of total quality management measures were published in the middle of 1994. In 1994, the "Lean Thinking" published by Womack and Jones. The book was improving lean philosophy. Many books and articles were written by advisers and supporters and some academic concepts were created. In 2006, the Toyota Motor Company has become the number one automobile manufacturer in North America (Shah & Ward, 2007).

2.3 The Definition of Lean Production

To understand the lean production easily and in detail lean production definitions and the basic lean concepts should be known. In the lean production system; there is no any unnecessary element and this system is a manufacturing system that reduces failure cost, stocks, labors, development process, production area, waste and customer dissatisfaction to a simpler state (Herron & Hicks, 2008).

With a simple definition the lean production based on to make less storage quantities in less time and to use less capitals and thus to manufacture more much. The lean production system is also known as a comprehensive production system including just-in-time production. If we decelerate it with more wide expression, we can describe

lean production as it uses the minimum resource, produces the cheapest and perfect according to customer's request completely, produces with the least waste and finally this system uses all the production factors so flexible that it benefit of all potencies. This system has borne as a result of a philosophy or skeptical approach, that questions absolutely accepted all rules and, that doesn't accept any kind of established principles (Liker J. , 2004). The main strategy of lean production is to improve quality cost and delivering performance contemporaneously by increasing speed and reducing flow time. Lean production distinguishes the activity that transforms or shapes material and information through customer's needs from the activity that uses time and source but that doesn't any value to the product matching with customer's needs. Zero defect and just in time production in small batches is envisaged (Rivera & Chen, 2007).

To have sustainable competitive environment, the companies should improve especially their quality, cost and shipment. The main aims of lean thinking is to make efficiency and productivity analysis of excellent process quits the wastes, so then it reduce the cost and offers a perfect values to the customer. Both of basic concept value and waste should be known to understand these definitions.

2.3.1 The Value

The specific starting point for lean thinking is value. Value can only be defined by the ultimate customer. And it's only meaningful when expressed in terms of a specific product (a good or a service, and often both at once) which meets the customer's needs at a specific price at a specific time (Womack & Daniel, 1996)

2.3.2 The Waste

“Muda” means waste in Japanese, specifically any human activity which absorbs resources but creates no value: mistakes which require rectification, production of items no one wants so that inventories and remaindered goods pile up, processing steps which aren't actually needed, movement of employees and transport of goods from one place to another without any purpose, group of people in a downstream activity standing

around waiting because an upstream activity has not delivered on time, and goods and services which don't meet the needs of the customer (Womack & Daniel, 1996).

Fujio Cho of Toyota defines waste as “anything other than the minimum amount of equipment, materials, parts, space, and workers time, which are absolutely essential to add value to the product”. As early as the 1920's Henry Ford was concerned with the problem of waste. He discussed it specifically in his book *Today and Tomorrow*, which Toyota people diligently studied later. Put it simple terms, “If it doesn't add value, it's waste” (Suzaki).

2.3.3 The Basic Seven Wastes in Lean Production

Toyota defines waste as anything other than the minimum amount of materials, equipment, parts, space, or time which are essential to add value to the product. Though sources of waste vary within and across organization, the similarities are great (Nicholas.J.M., 1998). Taiichi Ohno, the Toyota executive who was the most ferocious foe of waste human history has produced, identified the seven types of waste and P.J Womack and D.T Jones issued them in a book first. (Hicks, 2007)

The seven wastes;

- Overproduction
- Wait time
- Transportation
- Processing methods
- Inventory
- Motion
- Defects

2.3.3.1 Overproduction

Overproduction is the result of producing more product than the market requires and represents one of the greatest wastes in manufacturing operations. When the market is strong, this waste might not be noticeable, but, when demand drops, overproduction produces serious problems with unsold inventory and wasted by-products. Wasted by-products include material handling, storage space, inventory interest charges, machinery and equipment, defects, overhead, workers and paperwork.

Overproduction generates difficulties that often obscure more fundamental problems. A key element for eliminating overproduction lies in the understanding that machines and operators don't have to be fully utilized to be cost efficient, as long as customer demands are met. This concept is difficult for many plant professionals to grasp. It's helpful for any worker to think of the next downstream operation as the "customer" and produce only the quantity of product the customer actually requires.

Extra inventory results when more raw materials are consumed and more wages than necessary are paid. Extra inventory leads to additional material handling, storage space and interest paid on money used to carry the extra inventory. Additional staff, computers and equipment might be needed to monitor the extraneous goods. As serious as these problems are, even more critical is the confusion about what the priorities are, or should be. When people get distracted, they can't focus on meeting the customer's requirements of high quality, lowest cost and correct timing.

Overproduction waste can be reduced significantly or completely eliminated by a material handling system that controls material flow through production to match material supply to customer demand. One effective control is to use the material handling system as a tollgate that won't let anything move until it's pulled by a customer order. (Leimbach. W.)

2.3.3.2 Wait time

Unlike overproduction, waste from waiting usually is readily identifiable. Idle workers (who have already completed the required amount of work) or employees who

spend much time watching machines but are powerless to prevent problems are two examples of the waste of waiting. A material handling system that regulates the work flow at an efficient pace (small buffer queues may be necessary) minimizes or eliminates wait time waste.

Weak links in the material handling system that cause wait time include engineering drawings, gauging and equipment/tooling defects.

Evaluate each of these work elements during design of the material handling system with a process failure mode and effect analysis to identify and eliminate these problems. Ideally, use only the machinery and personnel for the time required by the pace of work that meets the production demand (Leimbach. W.).

2.3.3.3 Transportation

Transportation, including double or triple handling of raw and finished goods, is another commonly observed waste. Often the root cause of this waste is a poor layout of the factory floor and storage facilities, which can mean long- distance transportation and over-handling materials. Temporary storage and frequent changes of storage locations aggravate the situation. Transportation waste can be eliminated by minimizing the distances materials must travel, better process coordination, better transportation methods and general organization of the operation.

A material handling system focused on optimum product movement minimizes transportation waste. To achieve optimum product movement, use computer simulation on the plant layout to determine which configuration is most effective. Using the material handling system as a band-aid to cover over other problems only adds cost with no value and perpetuates the underlying problems (Leimbach. W.).

2.3.3.4 Processing methods

Maintenance and manufacturability are keys to eliminating waste from process methods. Well-maintained fixtures and machinery require less operator labor to produce

a quality product. Regular preventive maintenance, including total preventive maintenance, also reduces defective pieces produced. Using the principles of design for manufacturing and taking into account manufacturability during product design reduces or eliminates processing waste before production even begins.

Material handling systems that control material and orientation while identifying parts using RFID and barcodes best accommodate automated material loading and unloading as well as the other process improvements, which will minimize wastes. Don't install a material handling system for an inherently faulty process. Evaluate work processes proactively using process failure modes and effects analysis to identify failure modes for corrective actions. In addition, institute procedures that continuously improve and upgrade process control and monitoring equipment to further identify and reduce processing wastes (Leimbach. W.).

2.3.3.5 Inventory

Inventory waste is closely connected with overproduction. Excess inventory requires extra handling, storage space, interest charges, people and paperwork. Because of the substantial cost associated with excess inventory, you should be taking rigorous measures to reduce inventory to minimum levels.

It's essential to dispose of obsolete materials and produce only the number of items the next process requires. Purchase only the required amounts of materials, but be sure to weigh carefully any savings achieved through volume discounts against inventory and storage costs. Manufacture products only in optimum lot sizes. If you desire a material handling system that can handle orders of variable size, you must have very low setup and changeover costs to ensure that variations in customer order size don't have a meaningful economic impact.

In many operations, inventory can hide a myriad of other problems. As inventory levels drop, you'll need to address certain problems. These include poor scheduling, machine breakdowns, quality problems, long transportation times, vendor delivery times, line imbalance, lengthy setup time, absenteeism, lack of housekeeping or factory organization, and communication problems within the organization, with

suppliers and with customers. Material handling systems that control production flow help reduce inventory levels to an optimum (Leimbach. W.).

2.3.3.6 Motion

Waste motion is defined as time spent not adding value to the product or process. Movement doesn't equal work.

Motion waste is most often revealed in the actions of workers as they search for tools, how they pick and place tools and parts that are kept out of immediate reach of the workstation, and the time spent walking among machines if they are responsible for several workstations. A carefully planned layout and fixture selection can eliminate motion waste.

Material handling system changes that improve the material flow through value-added operations are a major opportunity to reduce motion wastes. Implementation of 5S when changing or installing new material handling systems can identify and eliminate or minimize many of the motion wastes. Be sure to include the process engineers in any material handling system design changes (Leimbach. W.).

2.3.3.7 Defects

Product defect wastes aren't simply those items quality control rejects before shipment. Instead, product defect waste actually causes other types of waste throughout the manufacturing process.

These other wastes include wait time that increases costs and lead times for subsequent processes, rework that increases labor costs to make parts usable, additional labor required for disassembly and reassembly, additional materials needed for replacement parts, the extra labor involved in sorting defective from acceptable parts, and scrapping defective pieces, which wastes both materials and work already performed.

In many cases, defective material handling procedures can scrap or damage materials. Defective material handling systems can be improved by performing process failure mode and effects analysis to identify operating procedures required to reduce or eliminate the defects. When designing new material handling systems, perform a design failure mode and effects analysis on the equipment to identify and eliminate sources of damage.

As bad as they might be, the previous are insignificant in comparison to a customer discovering your defects for you. Not only are extra warranty and delivery costs involved, but customer dissatisfaction might result in loss of future business and market share.

Eliminate defect waste at the source by establishing a system to identify defects (or the conditions that cause defects) as they occur. Authorize anyone on the plant floor to take corrective action. Without this preventive system in place, other time-saving efforts are futile. There's no advantage to using highly automated machinery to make defective parts faster.

The first step to eliminating the seven deadly wastes is to understand and identify each one within the operation. After that, take corrective measures to reduce, control or eliminate the problems. Such action may require simple, inexpensive solutions to a single workstation or changes as massive as a new factory floor layout and more efficient machinery. Appropriate solutions require careful study of the operation, clearly defined objectives, a thorough investigation of the benefits to be gained by each change (Leimbach. W.).

2.4 Lean Production Principles

The lean production is a five-step process (Womack & Jones, 2007):

- Value
- The Value Stream
- Flow
- Pull

- Perfection

Value: The critical starting point for lean thinking is value. Value can only be defined by the ultimate customer. Precisely defining value is in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers. The way to do this is to ignore existing assets and technologies and to rethink firms on a product-line basis with strong, dedicated product teams. (Womack & Daniel, 1996)

Value Stream: The value stream is the set of all the specific actions required to bring a specific product. It is also defines as sequence of activities required to design, produce a specific good or service, and along which information, materials and worth flows. (Womack & Daniel, 1996)

Flow: It is movements of goods or services along the value stream from raw materials to the customer without backflow, stoppages, or waste. It means to consider to take customer's offers when shaping the product. (Womack & Daniel, 1996)

Pull: It means generation of orders for inputs (material or parts) on the basis of their requirement (demand) created by the product as it is sold in the market. (Womack & Daniel, 1996)

Perfection: As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced, begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste. (Womack & Daniel, 1996)

2.5 Reasons for Lean Production Applying

Today, in global competitive environment, businesses services to customers who are more demanding gradually. The businesses have to meet costumer's (who are whether individual consumer or another product firm) demands as good quality, low cost and quick shipment to being survive corporation. They have to accommodate to orders that in a small quantities and changing transiently.

At this point to meet the different requirements is not possible with a few kinds of products in market. To expand the sales area, private products are needed to be generate and this should be made with low cost and fast. Product life is getting shorter more. To make an investment to a product which is intended even spent, product development time has to be developed.

Lean production has to be dwelled on to understand why it is different and excellent. In all process about lean production, almost everybody make leaned production to be organized and everybody likes minded the lean production need to be accepted as a best process in the world. However when the lean production is accepted as a best process in the world, the lean production came to the fore of field production techniques gained in a limited sense and this system is presentational as a set of techniques. Definitely, the most important factor that makes the lean production is to bring original techniques in production area.

As the famous Japan experts Shingo and Monden emphasize, lean production has another no ignorable dimension that the central pillar of the system is hidden in this dimension. That important point is the lean production pleases all walks of process, every actor or every part, that take part in the system, at the same time. Backward mass production, lean production has a potentially powerful which allows everyone to win.

2.6 Lean Production Techniques

Ten techniques are based on lean production will be examined in this section.

- JIT (Just-in-Time)
- Kanban
- SMED (Single Minute Exchange of Dies)
- Poka-Yoke
- 5S
- TPM (Total Productive Maintenance)
- Kaizen

- Jidoka
- Heijunka
- One Piece Flow

2.6.1 JIT (Just in Time)

Just in time production means producing required parts, at the required time, in the required amount, at each step of the production process in the most economical manner (Suzaki).

In the beginning, JIT was a technique used by Toyota for the purpose of controlling production and reducing inventory. From there, it evolved to include techniques for setups, maintenance, worker participation, supplier relations, and so on. When JIT was then introduced to the rest of the world in the 1970s, it began as a manufacturing technique centered on the kanban method and pull production. Over time, JIT has involved into a complete management philosophy driven by waste reduction and continuous improvement (Nicholas.J.M., 1998).

2.6.1.1 JIT Principles

Decisions and actions in JIT organization are guided by a set of principles:

- Simplification
- Cleanliness and Organization
- Visibility
- Cycle Timing
- Agility
- Variation Reduction
- Measurement

2.6.1.2 The Aim of Just in Time

Eliminating waste means that not add value to the customer service or product directly to minimize all activities. The sources of stocks are all kind of waste. In this

context, at every stage of production, inventories (raw materials, intermediate products, goods stocks) and the coarseness of the most basic elements of wastes would be reduced (Karlsoon & Ahlstrom, 1996).

Here are the basic objectives of the JIT (Browne, Harjen, & Shivan, 1998).

- Zero defect
- Zero inventory
- Zero set up time
- Zero deliver time
- Zero shipment

2.6.1.3 The Advantages of Just in Time

Reduction party production amount, lowering inventory, improving quality, less waste and re-processing, advancing motivation, increasing productivity and flexibility, the plant needs less pace placement, reducing manufacturing costs, reducing manufacturing time and advanced problem solving techniques the plant according to the multiple processes changes in placement, using the work control tools at full capacity, are the benefits the first that comes to mind in JIT production.

In addition, by using advanced quality techniques to minimize the time spent to find the error, fault finding and eliminating the cause of the error, rather than the description as there are benefits in terms of quality and also an acceptable level of fault is always assumed to be zero (Mchlachlin, 1997)

2.6.2 Kanban

Kanban is a Japanese word meaning “display” or “instruction” card. In a factory setting, it is a card describing the part number, the quantity of parts, where they are from, to where they are to be delivered, and so on (Suzaki).

Kanban is quite eye-catching, simple, effective and visual. Kanban system is a scheduling approach that controls the movement of material in lean manufacturing system. The most important feature of this system, traction system is according to the

principles of the work. Pull system and anti-thrust push system is the classification of a production system.

2.6.2.1 Push System

In push production system, materials are processed in batches to a schedule for each workstation, and then moved (pushed) downstream to the next workstation where they are processed according to another schedule. The materials must usually wait until the workstation completes earlier jobs, change over, and is ready to process them.

The properties of this system are as follows sort (Monden):

1. Push system begins with a master plan based on demand. Material is pushed according to this plan to meet demand.
2. Push system has a plan showing the development of inventories over time.
3. Estimated demand values stimulate the system.
4. The system's material needs are met sorted and properly.
5. Push system cannot respond quickly to changes in demand.
6. Demand structure is suitable if it is dependent.
7. Ensuring coordination is easy.

2.6.2.2 Pull System

Pull production is a way of controlling a process and reacting quickly to changes without relying on inventory. In a pull system, each stage of a process produces exactly what the immediate downstream stage requests; in effect, material is pulled through the process by each stage producing only what is demanded of it from the next stage.

Production and movement of material through a pull process are contingent on signals coming from downstream. No material is moved downstream, and nothing is produced unless a signal comes from downstream. The most familiar kind of signal system uses cards and is called Kanban.

A pull system reacts immediately to changes or problems anywhere in the process. If a stage faces a problem and ceases to send signals upstream, the upstream stages also cease, at least until the signal resume. A small amount of inventory called a

buffer is held between stages to allow downstream demand to be filled immediately while upstream operations work to meet requests for more. The amount held in the number of containers corresponds to the number of cards (kanban) deemed adequate for the system to meet demand. Because, the number of cards is regulated, the amount of in-process inventory required for a process to function smoothly can be held to a small quantity.

Pull production should be introduced in stages, starting with the last stage of the process and working upstream. Pull production requires commitment and resources from top management, and a shift of most responsibility for production control to worker team.

2.6.2.2.1 Pull Production Requirements

1. Continuous, somewhat stable product demand
2. Uniform (level) production plans and schedules
3. Short setup times
4. Limited product variety
5. Continuous flow: Few interruptions from equipment, quality, setup, and other problems

2.6.2.2.2 Rules of Pull Production

1. Downstream operations withdraw only the quantity of items they need from upstream operations. The quantity is controlled by the number of cards.
2. Each operation produces items in the quantity and sequence indicated by the cards.
3. A card must always be attached to a container. No withdrawal or production is permitted without a kanban.

4. Only no defective items are sent downstream. Defective items are withheld and the process is stopped until the source of defect is remedied.
5. The production process is smoothed to achieve level production. Small demand variations are accommodated in the system by adjusting the number of cards.
6. The number of cards is gradually reduced to decrease WIP and expose areas that are wasteful and in need of improvement.

2.6.2.3 Types of Kanban

There are various Kanbans depending on the needs. The main types of kanban are as follows:

Withdrawal Kanbans: Withdrawal kanbans, also called conveyance kanbans or "move cards" are used to signal when a part is ready to move from one part of the production process to another. The card is attached to a prescribed number of parts, which are moved to the work area that requires them. Once the parts are used, the card is returned as a signal to send the same number of the same part back.

Production Kanban: A production kanban contains a comprehensive list of everything the part requires in order to be completed. This includes the materials required, the parts required and the information included upon a withdrawal kanban. Essentially, a production kanban orders the production system to get started with production, as well as explaining what must be produced.

Supplier Kanban: A supplier kanban is a kanban that goes directly to a supplier a company that sells materials to the manufacturer -- and enters the supplier's kanban system as a representative of the manufacturer.

Also, there are express kanban, emergency kanban, job-order kanban, through kanban etc. (Monden).

Kanban implementation phases are as follows;

1. Carrier of the next production process goes to the stock point of previous process with sufficient number of traction kanban and forklift or a blank pallet.

This process is predetermined time intervals or a kanban box drawing accumulate a certain number is repeated.

2. When process the next of the carrier, tries to pull parts from inventory, the first-order kanbans glued to the pieces pallets by removing (each pallet attached to a kanban) leaves to the accept kanban box. In addition, empty pallets leave the station in a predetermined location.
3. A pull kanban is pasted instead of each issued production-order kanban.
4. In the next production when process starts to work, pull kanban is dropped in pull box.
5. At previous production process production-order kanbans, in kanban accept box after make a particular point in time or a certain number of manufacturing, are collected and these cards are left in production-order kanban box.
6. Track production is performed in order of the production-order kanbans box.
7. When previous physical production process is completed, parts and production-order kanban is placed inventory point. Thus, the next carrier of the manufacturing process at any time to come and be able to get parts.

2.6.2.4 The Advantages of Kanban

Here are the advantages of Kanban (www.lean.org) :

- Information flow and the product are handled together.
- Does not require a separate inventory management.
- Allows for visual control.
- Factory production operations and intermediate stocks are managed together.
- Fast and accurate flow of information provided.
- Provides to give the quick reply to changes.
- Prevents the production of excess.
- To minimize wastes.
- Responsibility of the operators will work.

2.6.3 SMED (Single-Minute Exchange of Dies)

Shigeo Shingo, over many years working as a consultant to Toyota and other Japanese manufacturers, developed a methodology and reduces the changeover time for dies known as the “Single-Minute Exchange of Dies (SMED)” technique is based on very simple grounds (Okur, 2005).

Shingo primarily devoted to two die-change operations as internal and external operations (Shingo, 1989).

An internal setup is a step that must be performed while the machine or operation is stopped; internal setup time is the same as downtime.

An external setup is a step that can be performed while the operation is running.

The most common mistake made by people is unable to distinguish between internal and external change. On the contrary, both of them mixed together and they are treated as internal change.

Therefore, the first step in the process of changing the total pattern is to measure the time to review and process of each component. After that, the internal and external processes can be distinguished from each other (Suzaki). 4 main concepts are important to understand for the reduction of change time.

Concept 1: The separation internal operation from the external operation: After the machine has stopped, external operations are provided to prevent workers realize. In external operation, tools and materials keep available near the machine so as be possible to intervene when there is a need.

Concept 2: The conversion internal operations to the external operations as much as possible: The initial principal objective of setup improvement is to reduce internal setup time. The more setup steps, decisions, adjustments, whatever tat can be done on external time, the better.

Concept 3: Elimination of the adjustments: Converting internal steps to external steps reduces setup time considerably, although usually not to enough to be in the single minute range.

Concept 4: The elimination of exchange completely: There are two approaches to this. The first one is to generate standard product and the second is to generate products which have different standards at the same time.

While earnings are being provided from the periods of changing, effectiveness of SMED increases. SMED system for the producers to adapt wills product basic strategic advantages with changing in the concept of production and elimination of the stock (Shingo, 1988).

2.6.4 Poka-Yoke

Poka-yoke is a Japanese word translated as “foolproof mechanism”. Poka- yoke helps operators work easily, and at the same time it eliminates troubles associated with defects, safety, mistakes in operation, and so on without requiring the operators’ undue attention.

Poka-yoke elements terminating switches, warning lights, templates, guides, sensors, pressure switches, tuning pins, timers, and so on consists of hardware, Basic functions are off, stop, control and warning.

Poka yoke’s implementation is extremely simple. All of the machine automatically detects a faulty state agency and in this case, the machine automatically stops again to place the devices. The machine stops later, a bell rings or the light is on, so the machine tells the failure to workers instantly.

At this point, workers and engineers should work together to determine the reason for the failure and immediately make the necessary corrections. Thus, the incorrect track passes to the next process 100 % to prevent. Also, by eliminating one more reason not will repeat and the error can be ensured (Askın & Goldberg, 2001).

2.6.5 5S

5S is a system to reduce waste and optimize productivity through maintaining an orderly workplace and using visual cues to achieve more consistent operational results. Implementation of this method "cleans up" and organizes the workplace basically in its

existing configuration, and it is typically the first lean method which organizations implement.

There are 5 primary phases of 5S:

Sort (Seiri)

Eliminate all unnecessary tools, parts, and instructions. Go through all tools, materials, and so forth in the plant and work area. Keep only essential items and eliminate what is not required, prioritizing things as per requirements and keeping them in easily-accessible places. Everything else is stored or discarded (Hamkewicz.A., 2004).

Set in Order (Seiton)

There should be a place for everything and everything should be in its place. The place for each item should be clearly labeled or demarcated. Items should be arranged in a manner that promotes efficient work flow, with equipment used most often being the most easily accessible. Workers should not have to bend repetitively to access materials. Each tool, part, supply, or piece of equipment should be kept close to where it will be used – in other words, straightening the flow path. Seiton is one of the features that distinguish 5S from "standardized cleanup" (Hamkewicz.A., 2004).

Shine (Seiso)

Keep the workplace tidy and organized. At the end of each shift, clean the work area and be sure everything is restored to its place. This makes it easy to know what goes where and ensures that everything is where it belongs. A key point is that maintaining cleanliness should be part of the daily work – not an occasional activity initiated when things get too messy (Hamkewicz.A., 2004).

Standardize (Seiketsu)

Work practices should be consistent and standardized. All work stations for a particular job should be identical. All employees doing the same job should be able to work in any station with the same tools that are in the same location in every station.

Everyone should know exactly what his or her responsibilities are for adhering to the first 3 S's (Hamkewicz.A., 2004).

Sustain (Shitsuke)

Maintain and review standards. Once the previous 4 S's have been established, they become the new way to operate. Maintain focus on this new way and do not allow a gradual decline back to the old ways. While thinking about the new way, also be thinking about yet better ways. When an issue arises such as a suggested improvement, a new way of working, a new tool or a new output requirement, review the first 4 S's and make changes as appropriate.

In the daily work of a company, routines that maintain organization and orderliness are essential to a smooth and efficient flow of activities. This lean method encourages workers to improve their working conditions and helps them to learn to reduce waste, unplanned downtime, and in-process inventory (Hamkewicz.A., 2004).

2.6.5.1 The Benefits of 5S

- To notice errors more quickly and easily to the improvement of quality,
- To elimination of wastes via reducing of costs,
- The realization of just in time deliveries
- Reduction in work-related accidents and occupational diseases
- Shortening the duration of preparation tools and equipment thanks to the team placement arrangement (Hirano, 1990).

In production flow benefits (Demirkır.M.S., 2008);

-The elimination of unnecessary materials and where appropriate due to the presence of materials needed, the decrease in times to ensure their presence investigated.

- Reduces downtime is unpredictable
- Because of pollution that may occur on the product prevents shoddiness's.
- By decontamination, minimizing the number of faulty products.

- Provides a business center has been organized.
- A more secure means of a business center.

2.6.6 TPM (Total Productive Maintenance)

Total productive maintenance as the simplest definition that instruments, equipment and machinery, and it aims to provide the most efficient use of effort to put forward to set off (Askin & Goldberg, 2001)

The purpose of the TPM is ensuring that an effective production system in general with the participation of employees'. The emphasis, as well as total quality control, is respect for individual and the key to success is participation of employees. Lean manufacturing supports team members in carrying out the process. Everything is known by them who manufactured the product for that. Thus, members of the team that know they are included in TPM program and can lead to equipment in good condition with visual control system (Liker K. , 2005).

Operators must be trained to detect machines abnormal conditions. Mechanical failures' 5 main reasons are (Suzaki):

1. Unable to meet the basic needs of the machine; maintenance, lubrication, compression bolt, etc.
2. Unable to protect the right operating status; temperature, vibration, pressure, velocity, force, etc.
3. Lack of skills; poor use of the operator, maintenance staff errors, etc.
4. Dilapidation; wear of bearings or gears etc.
5. Design flaws: material dimensions, etc.

There are four phases of machine maintains to eliminate the machine failure problems. The first, depending on the strain is a tear. A repair is required to bring the first level of the performance of the machine again.

In the second stage, the machine there is only natural aging and can be corrected periodic maintenance. The third stage, there are efforts to repair according to the state on an ongoing basis of the machines. The fourth stage, there is a maintenance due to the situation. Continuously it is observed in the machine status. By diagnostic

equipment using, predictable life of machine parts and quality level of processed work piece due to reduced maintenance costs (Suzaki).

The basic purpose of the TPM is providing protection and continuation of production quality. If applied regular and correctly maintenance, the replacement of old equipment that is not productive. To be competitive in manufacturing, the whole machine distortions and failures must be eliminated (Suzaki). Standardization, kaizen, heijunka, dies changeover, visual control applications of lean tools cannot be successful where the machine malfunctions.

2.6.7 Kaizen

In Japanese ‘kai’ means change, ‘zen’ means well, better. Based here, Kaizen is achieving better development or general use means continuous improvement.

Kaizen is a Japanese philosophy and tells the lifestyles should improvement continuously. According to the philosophy of kaizen, should not be even a single day without any development in any unit of company (Imai, 1994). Improvements are like the inventions. Improvement of %90 is said to be due to common sense. Many improvements will appear so simple after the work finished that people are surprised why they do not think it previously (Suzaki).

Kaizen is a continuous improvement with everyone from administrators to workers (Imai, 1994). The key to creating a better work place and something that triggered the better improvements is participation of operators (Suzaki). A permanent improvement in the process requires everyone involved in the process to understand and believe new logic of process (Womack & Jones, 2006). Lean production pay attention to formation of the people, recovery teams are directly affected by the change and responsible for oversight of the production (Spear, Steven, & Bowen, 1996). One of the factors contributing to continuous improvement is "suggestion system". With suggestion system, targeted to increase the system and employees' commitment to the institution

(Monden). Suggestions should evaluate timely, suggestion owners should inform and proper suggestions should put into practice absolutely (Ozcelikel, 1994).



Figure 2.2 Kaizen Umbrella (Imai, 1994)

2.6.7.1 Four Basic Approach of Kaizen

1. Focuses on employees: Production process workers are encouraged to find methods to do their jobs more efficiently and effectively.
2. Focuses on equipment improvements: Accordingly, workplace regulations, equipment upgrading of the quality work done.
3. Focuses on the processes and procedures required for production: Restricting training and development policies not apply.

4. Combination of the first three stage: This stage, the results of previous levels engaged when had reached maximum value and focuses on innovations.

2.6.7.2 Kaizen Processes

Shigeo Shingo, a leading expert on manufacturing improvement, has said that improvement requires continuous cycle of perceiving and thinking. A structured way to apply this perceiving-thinking process is PDCA, which stands for plan-do-check-act.

Kaizen process consists of four steps;

Plan:

It has four subsets:

1. Collecting data: Improvement is always instigated by dissatisfaction, the perception that a problem exists or that things are not as good as they might be. Data collection involves systematic observation, documentation, and analysis of data for purposes of verifying, understanding, and getting to the root cause of a problem.
2. Defining the problem: The source of dissatisfaction is understood and its causes are known, the problem can be defined unambiguously.
3. Stating the goal: A goal is specified as the desired target of the improvement.
4. Solving the problem: Multiple ways of achieving the goal should be considered as well as cost and benefits of each.

Do: Weak or ineffective portions of the plan are sifted out and only beneficial parts are retained.

Check: Status should be examined completely and issues should be revealed. Placed in the previous status of implementation of the plan compared to the situation after practice.

Act: Against provisions should be made to solve the problems.

2.6.7.3 The Benefits of Kaizen

Kaizen benefits are as follows;

- Creates vitality in all activities of the organization.
- Provides to work community in line with the same objectives and aim.
- Solves the common problems of interaction with departments, shortly and permanently.
- Employees' knowledge and skill level rises and increases motivation.
- Efficiency and other basic elements of the competition show a better development.

Facilities are provided with this development benefits the entire society through the volume of employment.

2.6.8 Jidoka

Jidoka is equivalent of the word “autonomation” in Japanese. A principle of the Jidoka is right to use the machines. Jidoka is based on ensure maximum work activity of human-machine relationship (Ohno, 1996). Jidoka is a dictionary that designed for machines to stop automatically when occurred any error (Imai, 1994). When a process goes wrong, the process should be stopped and the problem should be determined and solved the problem as soon as possible to achieve efficient flow again. Lean manufacturing strength is provided by regarding the prevention, not therapeutic processes (Ohno, 1996).

Foremen and supervisors must teach first of all determination faulty parts and stopping the route to workers. After that they must teach find and fix the cause of the fault (Acar, 2003) .

Stopping an assembly line is as follows (Suzaki, The New Manufacturing Challenge: Techniques for Continuous Improvement):

1. The operator will print the button to get help from supervisor when he sees a problem or cannot finish the work in time.

2. If supervisor succeeds to solve the problem in time, the line will continue to process. However, the problem is not resolved in time; the line will stop the point of impact at the other operators to a minimum.
3. If the line stopped, duration of making the line functional again will change depend on the degree of the problem.

Jidoka leads to large productivity gains by eliminating the need for continuously surveillance of machines (Marchwinski & Shook, 2008). This system leads to important developments of worker's responsibilities and skills because of workers manage many different machines at the same time (Imai, 1994).

2.6.9 Heijunka (Mixed Loaded)

Primary and most important function of the mixed installation is to provide without making computation with finished or being processed product stock can adapted easily to changes demand of production.

In addition, to be installed more than one model or product on the same line reduces the total required number of lines and therefore the total factory area.

A third function of mixed installation is to save the manufactures the obligation of keeping unnecessary inventory space by providing forward the products after reached the desired order composite to customers. The amount and combination of customer demand which came from dealers determine what will be order of the mixed installation (Okur, 2005).

2.6.10 One Piece Flow

Workers and finished or being tracked parts in the flow of production should not lose time with waiting to have a very high productivity and short production time. Works continue compulsory with duration at works with stock.

One of the solutions for wasting time have founded by lean production is based on the processing flow of parts, all the machines needed to receive the final version of a part in any workshop, placed one after another. And the part should go through from the machine required for previous process to machine will use in the next process. Placement of machines in this way "process-based placement" "or "process-based line",

and transmission of parts one by one without waiting between processes the "one-piece flow" is called one-piece flow and define them as zeroing in stock (Cesur, 1997).

One-piece flow is one of the basic conditions of working without stocks; takes place according to lean manufacturing at workshops of working factories as well as side-industries at the same time synchronously. According to the mixed installation, regularity of production and traction system with kanban cards, all parts to be installed to the next production are produced at the same time or at short intervals required to ideally implement.

One-piece flow is the work of Toyota's genius engineer Taiichi Ohno. Ohno decides that in the most effective element of the system is the final assembly line, when he is reweaving the Ford production system. In broad sense, the one-piece flow is a system that includes all production stations of the finally assembly line application and that interlocks the all production stations with the final assembly line approach.

CHAPTER 3.

VALUE STREAM MAPPING

Value Stream Mapping (VSM) is one of the many tools, working methods and concepts in the Lean environment. Other familiar tools are Just-in-Time (JIT), Single Minute Exchange of Die (SMED), 5S and Kanban. VSM can be and is used in all different kinds of manufacturing and can easily be learned and then used by just about every-one. In a VSM a team walk through the manufacturing system and documents facts such as cycle times, buffer sizes and personnel requirements. The facts are then turned into a map which describes the system with standardized icons. When a map of the current situation is documented a parallel map is developed within the team which instead describes the ideal future state. This future state is used as a base for prioritizing improvement activities, so called kaizen events (Solding & Gullander, 2009).

3.1 Overview of VSM

A value stream is a collection of all actions (value-added as well as non-value-added) that are required to bring a product (or a group of products that use the same resources) through the main flows, starting with raw material and ending with the customer. These actions consider the flow of both information and materials within the overall supply chain.

The ultimate goal of VSM is to identify all types of waste in the value stream and to take steps to try and eliminate these. While researchers have developed a number of tools to optimize individual operations within a supply chain, most of these tools fall short in linking and visualizing the nature of the material and information flow throughout the company's entire supply chain.

Taking the value stream viewpoint means working on the big picture and not individual processes. VSM creates a common basis for the production process, thus

facilitating more thoughtful decisions to improve the value stream (Abdulmalek & Rajgopal, 2007)

When one member of the supply chain becomes lean, other members in the process also have to be lean, in order to reap the benefits. Thus VSM is a powerful tool to spot where the waste is and where in the supply chain the actions have to be taken to be efficient. Few advantages of VSM are (Chitturi, Glew, & Pauls, 2007)

- It helps to see more than waste. It helps to see the sources of waste in the value stream
- It provides a common language for talking about the manufacturing process
- It makes the decision about flow apparent
- It ties together lean concepts and techniques, which helps avoid cherry picking
- It forms the basis of an implementation plan by designing the whole door-to-door flow

However, since VSM is a paper and pencil method, it is limited in its modeling power. VSM is also a static tool that cannot describe dynamic behavior and cannot handle either complexity or uncertainty. Moreover, we might need at least a few months of a continued monitoring to observe the effects of changes and improvements. On the other hand, we would like to preserve the VSM modeling language, because of its ease of use and its widening dissemination within the manufacturing community. Moreover, VSM also includes a step by step approach to transform a current manufacturing state into a Lean Future State, which is the basis of its success in practice (Lian & Landeghem, 2011).

3.2 Value Stream Mapping Techniques

There are four levels for a product family value stream mapping. These are the level of the process, a single business, more than one in operation and between different businesses mapping methods.

Process level: Pacemaker process mapping to create a continuous flow process. Pacemaker process for a particular product family meets the first step of the incoming orders and foreign customers. This level is usually at the level of cell mapping. Cell, the parts are processed in a continuous flow of each process step are arranged one after the other, human, machine, an arrangement of materials and methods. The best known form of physical cell "U" shape, but many other shapes are also possible.

In a single business: The factory in the "door-to-door" deals with the production flow. This flow factory delivery to its customers and the supply side of industrial parts and materials are included. Value stream mapping, door-to-door in the factory for a single product family, material and information flow and to walk through the steps of the process and means to draw them.

More than one in operation and between different businesses: These methods are generally regarded as the extended value stream map. Extended value stream map, a product state of the raw materials into the hands of the customer as the final product includes all activities in the period up to achieve. Extended value stream map among the firms, the common problems of cost, quality, customer responsiveness and communication problems can make on the open exchange of information and provides a consistent language.

3.3 Strengths With Value Stream Mapping

VSM is a valuable tool for analyzing value flows and the most obvious strengths are (Solding & Gullander, 2009):

- Fast and easy to carry out.
- Cheap, since no special tools or computer programs are needed. Only man hours are spent during initial work.
- Simple – Easy to learn and understand.
- All tools needed are pen and paper
- Gives a good basis for discussions and decisions.

- Increases the understanding for the customer, the product and information flow and losses.
- Can often be performed with people directly involved in the system with aid from a VSM experienced person.

3.4 Weaknesses with Value Stream Mapping

There are also some weaknesses with VSM as it is normally used (Solding & Gullander, 2009):

- Only the flow of one product or product type is analyzed per VSM analysis.
- The VSM gives only a snapshot of the situation on the shop floor at one specific moment.
- The VSM map is a rough simplification of the real situation.
- It is difficult to experiment with suggested new systems and layouts.

3.5 Value Stream Mapping Criteria

Takt Time (T/T): "Takt" is the German word for the baton that an orchestra conductor uses to regulate the speed, beat or timing at which musicians play. Lean terminology uses Takt Time as the rate at which a completed product needs to be finished in order to meet customer demand. Takt time is determined according to the following account:

$$\text{Takt time} = \frac{\text{Production Time Available}}{\text{Customer Demand}}$$

Cycle Time(C/T): Cycle time is the total time from the beginning to the end of your process, as defined by you and your customer. Cycle time includes process time, during which a unit is acted upon to bring it closer to an output, and delay time, during which a unit of work is spent waiting to take the next action. Cycle Time is the total elapsed time to move a unit of work from the beginning to the end of a physical process.

Lead Time (L/T): The amount of time, defined by the supplier that is required to meet a customer request or demand. Lead time is the commitment to deliver final product to your customer.

Value added time(V/A): Cumulative time of all the value added activities in a process. Value added time is an activity for which the customer is actually paying for.

Non Value added time: Cumulative time of all the non-value added activities in process. Non value added time is an activity for which the customer is not actually paying for.

Every Part Every (EPE): For example, every three days, a product from one production lot size model, replacing the "three-day track "means.

Change Over Time (C / O): A period of transition from one model.

Uptime: The machine utilization rate.

Operator Number: The number of employees in the process.

Available working time: Times are removed from the total production time. Break time, meeting time etc.

3.6 Drawing the Standard Value Stream Mapping

VSM is a pencil and paper tool, which is created using a predefined set of standardized icons (Sullivan & McDonald, 2002). The most common icons for use in a value stream map are indicated in Figure 3.1.

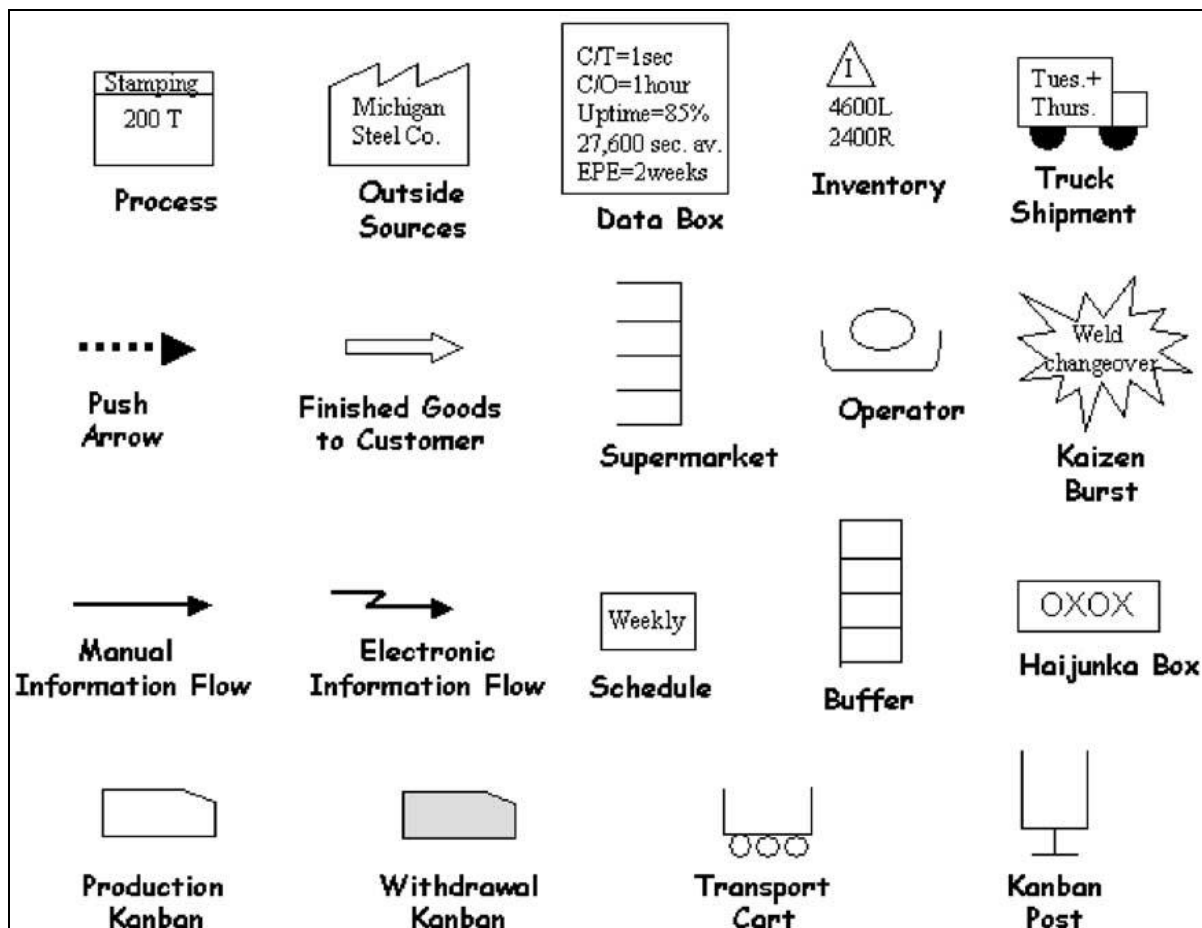


Figure 3.1 VSM icons (Sullivan & McDonald, 2002)

The first step is to choose a particular product or product family as the target for improvement. The next step is to draw a current state map that is essentially a snapshot capturing how things are currently being done. This is accomplished while walking along the actual process, and provides one with a basis for analyzing the system and identifying its weaknesses. The third step in VSM is to create the future state map, which is a picture of how the system should look after the inefficiencies in it have been removed. Creating a future state map is done by answering a set of questions on issues related to efficiency, and on technical implementation related to the use of lean tools. This map then becomes the basis for making the necessary changes to the system (Sullivan & McDonald, 2002).

Value stream mapping is used when creating shapes are specified as shown figure 3-2 pre-qualification phase. These figures are drawn using the method of pen and paper production. Production of materials, information and process flow is expressed by each of these shapes. Such as electronic or computer with an automated way to ensure the flow of information between processes and also such as work orders on paper that

the provision of communication between processes can be seen on the drawn value stream mapping. Also using these universal shapes provides that all employees understand the same things when you look at the map and this feature of VSM is very useful for employees of international companies.

A value stream map provides a blueprint for implementing lean manufacturing concepts by illustrating how the flow of information and materials should operate. VSM is divided into two components: big picture mapping and detailed mapping. Before starting detailed mapping of any core process, it is useful to develop an overview of the key features of that entire process. The overview will help accomplish the following:

- Visualize the flows.
- Identify where waste occurs.
- Integrate the lean manufacturing principles.
- Decide who should be on implementation teams.
- Show relationships between information and physical flows.

Visualizing the flow creates the ability to see where, when, and how both the information and product flows through the organization.

To describe and create an overview of a production process, “big picture” mapping is used. Fig. 3-2 is a generic example of a big picture map for current state situation in a hypothetical transfer line. Fig .3- 2 encapsulates the five basic phases in the big picture mapping exercise:

- Define customer requirements.
- Map information flows.
- Map physical flows.
- Link physical and information flows.
- Complete the map by making the above information visual and include a timeline of total lead-time vs. the value-added time.

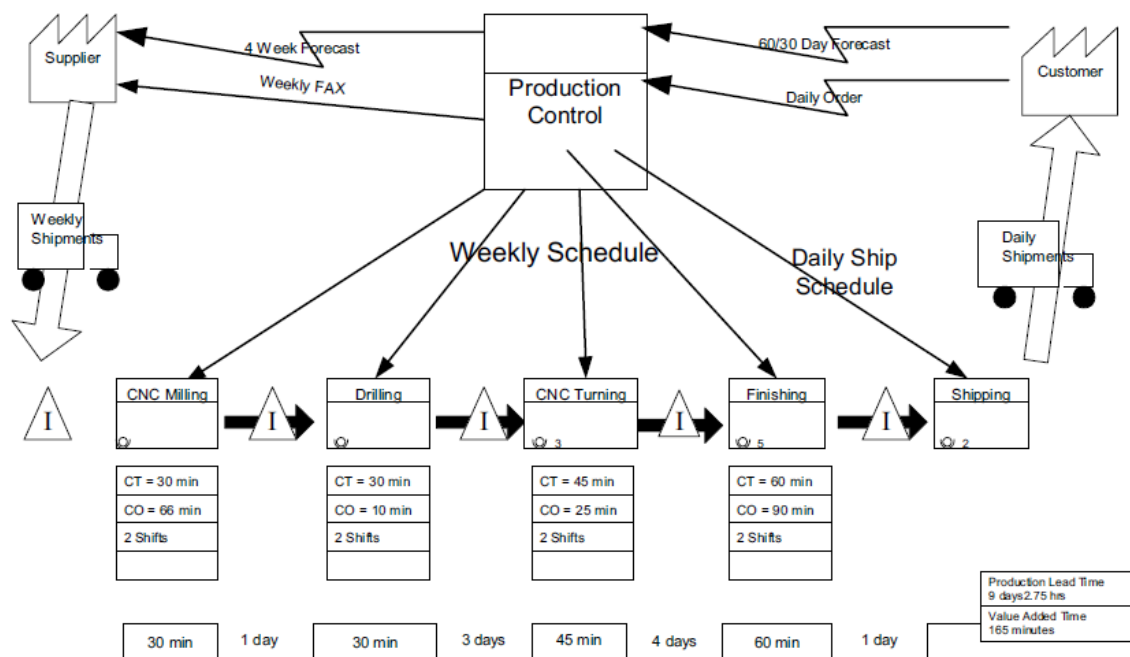


Figure 3.2 Current State VSM (Sullivan & McDonald, 2002)

VSM is completed with total production time and value added time by adding below the map.

Information concerning product family, customer demand (when, where, how many, and how often), parts to be manufactured, packaging requirements, and customer stock to be held are gathered during the customer requirements phase. The information flow phase gathers data on the customer forecast and how this information is processed within the organization as well as forecast information given to suppliers. Physical flows are concerned with inbound raw materials/ components and internal processes. For incoming raw materials information on demand, number of deliveries, delivery quantities, packaging, and lead-times is collected. Internal processes use information concerning the key steps within the organization, processing time of each step, machine downtime for each process, inventory storage points, inspections, rework loops, cycle time, set-up time, number of workers, and operation hours per day. Linking the physical and information flows is concerned with the type of scheduling information used, work instructions, and what is done when problems arise. To complete the map, a time line is added at the bottom of the map recording the production lead-time and the value added time.

Detailed mapping is done after the big picture map is complete. Detailed value stream mapping as part of the seven standard vehicles described below. These tools are for identification purposes were put into the system any waste (Sullivan & McDonald, 2002).

3.6.1 Detailed VSM Seven Standard Tools

Process activity mapping: This classifies processes as operations, transports, inspections, delays, storages, and where communications occur. Process activity mapping focuses on the wastes of waiting, transportation, inappropriate processing, unnecessary motion, and unnecessary inventory.

Supply chain response matrix: This evaluates and portrays inventory levels and critical lead-time constraints and also evaluates the need to maintain stock within the context of short lead-time replenishments by identifying large sectors of time and inventory.

Production variety funnel: The production variety funnel 'is a visual mapping technique that plots the number of variants at each stage of the manufacturing process. It provides understanding of how the supply chain operates and the accompanying complexity that needs to be addressed. It helps identify where buffer stocks may be held prior to customization, where to target to inventory reductions, and where to make changes in the processing of products.

Quality filter mapping: Identifies where quality problems exist. It classifies defects as product, service, or internal scrap. Each defect is mapped along the supply chain. Establishes are both internal and external quality levels.

Demand amplification mapping: The demand amplification map is a graph of quantity against time. It shows the batch sizes of a product at different stages of the production process. This are used either within an organization or along the supply chain. Highlights the bullwhip effect and again used to see the extent of amplification as orders move up stream, gain insight into batch scheduling policies, and analyzing inventory decisions.

Decision point analysis: The decision point is the point in the value stream where demand pull gives way to forecast-push. Aids in the assessment of processes that

operate both upstream and downstream from the decision point. Allows develop of “what if” scenarios to view the operation of the value stream if the decision point is moved.

Physical structure mapping: Physical structure mapping is used to obtain an overview or industry level view of the value stream. This overview is helpful in determining what the industry looks like, how it operates, and in focusing attention to areas that are not receiving sufficient (Sullivan & McDonald, 2002).

The next step in the VSM process is to map the proposed future state. This is shown in Fig. 3-3. The eight questions that must be answered to construct the future state map are listed below. The five first questions are concerned with basic issues related to the construction of the future state map. The next two questions deal with technical implementation details such as the details of the control system (e.g., “heijunka”). Finally, the last question is related to the definition of effort or actions needed (“kaizen”) to migrate from the current to the future situation.

Future state questions: (Abdulmalek & Rajgopal, 2007)

Basic

1. What is takt time?
2. Will finished goods will be built to replenish in supermarket or will they be built and directly shipped to clients?
3. Where can continuous flow processing be utilized?
4. Is there a need for a supermarket pull system within the value stream?
5. What single point in the production chain will be used to Schedule production?

Heijunka

6. How will the production be leveled at the pacemaker process?
7. What increment of work will be consistently released from the pacemaker process?

Kaizen

8. What process improvements that can be done?

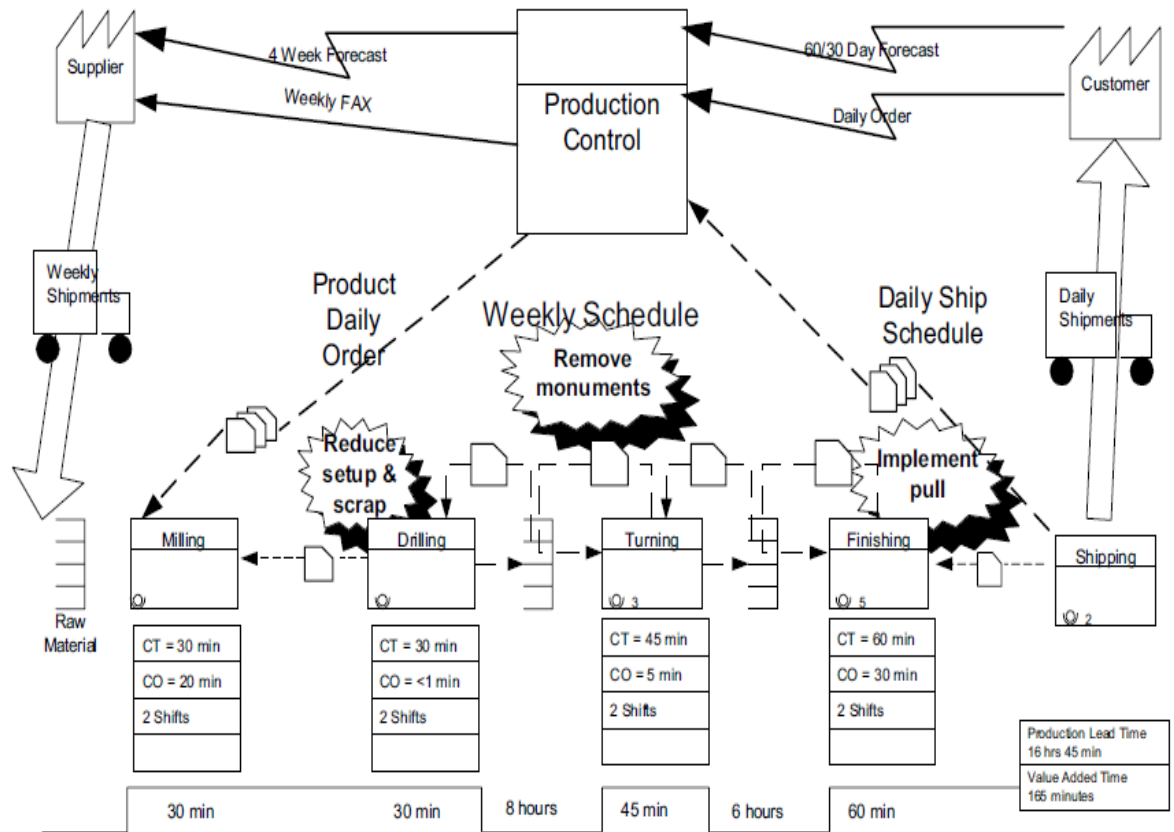


Figure 3.3 Future State VSM

3.7 Purpose of Value Stream Mapping

The purpose of value stream mapping, which will be held as soon as possible to uncover the sources of waste to the implementation of future state value stream and eliminate them. The aim of the process to its customers each and every process is connected with continuous flow or pull system only needs time to produce what the customer needs establish a production chain works.

CHAPTER 4.

AN APPLICATION OF LEAN PRODUCTION IN A COMPANY

4.1 About Application

This section of thesis is about a case study. The case study is a lean production application that applied in a factory. This application was started as a pilot scale test works at first. Then, amendment and improvement works have been started in real when effective outcomes were gained. The improvement works have still been applied to other lines of the company as from main assembly line.

All knowledge that was explained in the previous sections applied in a factory producing household appliances. In this study lean production techniques were applied to the electric water heater line. Measurements were made, operation cycle times were determined, Kaizen improvement methods and line balancing methods were applied according to the results. Value stream maps were drawn and therefore non value-added works were determined and they had been eliminated in improved case.

4.2 A Brief Information about The Company

Established in 1975 and started to production, “Ihlas Domestic Appliances Production Industry and Trade Incorporated Company” (IHEVA) presented its small appliances, which takes human health as a priority and facilitates the domestic life from the very beginning, to the consumers. Situated with its energetic coaching staff in Beylikduzu Organized Industrial Zone (BOSB) in a closed area of 21,175 m² which employs 300 personnel composed of 220 assembly staff and 80 administrative staff, the company continues its production in Cleaning Robots Factory, Water Heaters and RO Water Purifiers Factory, Carpet Washing Machine Factory and Plastically Injection Printing Plant.

In this part of the thesis, an example of application of lean production that has been discussed in the previous parts will be presented in Ihlas Domestic Appliances Company. Respectively process methodology of the application, problems in the application that needs to be straightened, solutions introduced to overcome these problems, and benefits to be gained with the overcoming of the problems will be discussed.

The principles of lean production (value, value stream, flow, pull,) will be the founding ground in all the works to be done in this application.

To start the application by picking a department which is a bottleneck in the factory and has plenty of inventories will be the first criteria to choose the place. Later, it will be better to choose a place to start the application where getting better results and benefits of the new system can be observed. Because of this, a good reason is wanted to be given both to the administrative staff and the workers to accept the new system. Due to all these reasons, the application place will be accepted the production line of electrical water heaters.

In the amendment application in the production line of electrical water heaters, all the components were considered as a whole. There was continuous information sharing between the workers, personnel and managers. The idea of qualified stream was always the main concern in order to achieve a consistency with the amendment plans of the department. JIT (just in time production), one piece flow, 5S and Kaizen were applied among the lean production methods. At the same time, time measure method has been evaluated in order for analyze existing situation and the results of amended situation.

Time measuring consists of defining the working system, methods and conditions and determining base amounts for one by one stream slices, factors, performance level and real times.

In this study time survey forms were used. Accordingly, the standard working time was determined by measuring three circular times for each production process of the study.

4.3 The Analysis Of The Current Situation

There are 31 workers in the production line of the electrical water heaters. The working hours for them are from 08.05 to 18.25.

The distribution of the working hours is as follows:

Table 1.1 The distribution of the working hours is as follows

08.05 - 09.45	Working Hours
09.45 – 10.00	Break
10.00 – 12.30	Working Hours
12.30 – 13.30	Lunch Break
13.30 – 16.00	Working Hours
16.00 – 16.30	Break
16.30 – 18.25	Working Hours

Briefly sum up the work done in the factory in this department, parts produced by the company and the pieces such as cables, screws, etc. which are coming from the supplier industry are combined together and packed after quality control and served to the market. All the works under the production process is labor intensive. In the workplace, there are three control machines and a U-shape assembly line on that the production is made.

Currently, the total area of the workplace is 100 m². The 25,6 m² part of the this area is for the assembly line and the remaining 74,4 m² part is for workers and buffer stocks.

The settlement plan of the production line of electrical water heater is given in figure 4.1.

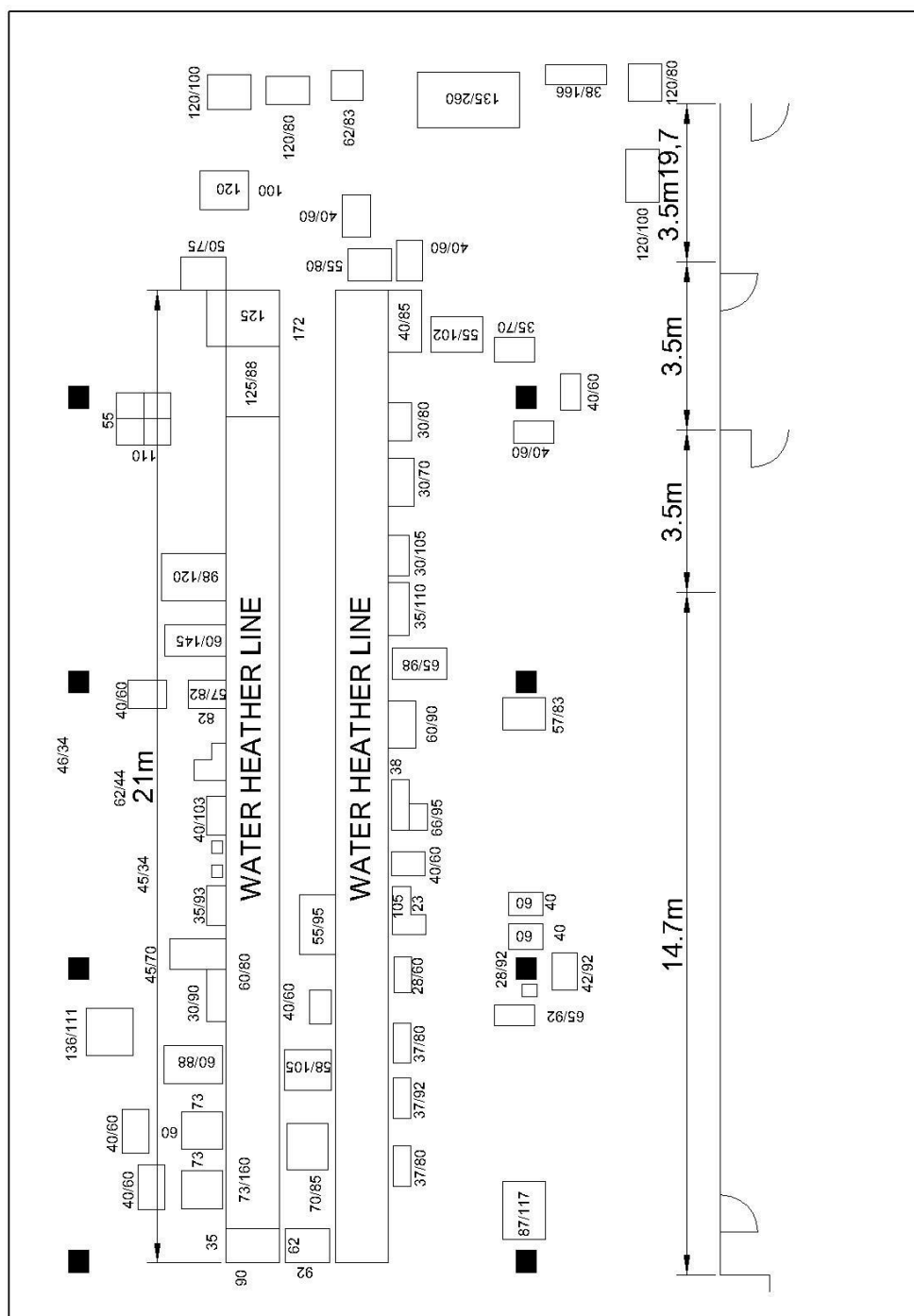


Figure 4.1 The settlement plant of the production line

In current settlement the following non-value-added streams were determined trailing the order of the material and assembly process.

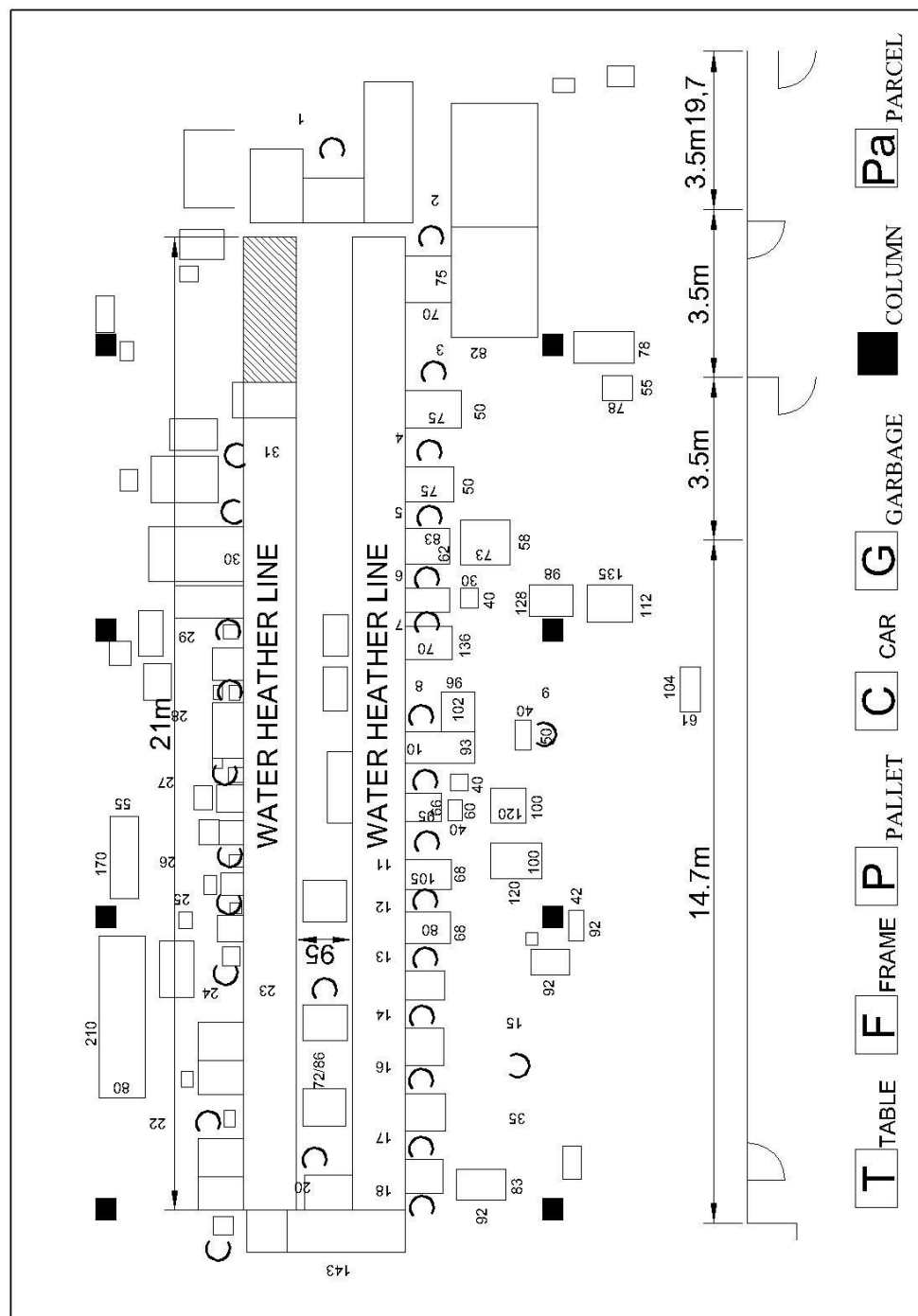
➤ **ERGONOMICS:** Workers are working under ergonomically unfavorable conditions. The sitting workers work from 90° angle to the assembly line. For this reason, they are often faced with different diseases. Hernia is among the most frequent diseases. Problems related to ergonomics led to work loss, as well. This is because due to these problems work efficiency decreases and inefficiency becomes the trend.

➤ **WORKER INEFFICIENCY:** There are abeyance periods for the workers. This is due to unequal distributions of operations to the operators. While some workers get behind their schedule, others are early to finish and wait.

➤ **LINE EQUALIZING IS NOT IDEAL:** The unequal distribution of works to operators brings about an imbalanced line. For this reason, workers become inefficient and products become less qualified.

➤ **STREAM OF WORK AND MATERIALS IS NOT ORDERLY:** In the production area walking roads are long and transportation is a lot. Not being on time to replace run out materials causes suspensions and breaks the work stream. For this reason, while production stock accumulates there remain assembly lines flowing in vain.

The existing operator settlement plan is given in figure 4.2.



➤ **BUFFER STOCKS:** Because of mass production there is no one piece flow. Desultory impediments in production timing create lots of semi-finished buffer stocks. These buffer stocks not only block workers' work space and time but also elongate walking paths for material flow.

The transportation of materials used in a workplace from the warehouse by a vehicle is called combinationization.

In the production line of water heater, materials are demanded as mass orders instead of combinationization. This makes it hard to control the stocks and creates an unnecessary material stock.

➤ **THE PLACEMENT OF MATERIALS IS NOT IN ORDER:** The place of the hand tools used in the assembly process is not ergonomically designed. Because the operator does not a line assembly tools orderly, it causes the production process to prolong and increases the work burden for itself.

4.3.1 Current Production Time For The Water Heaters

The production of a water heater occurs in 31 steps and each step is taken by a different operator. The survey form for time measurement is given in the table 4.2. All of the other time measurements take place in Appendix A.

Table 4.2 Time Survey Form for Operation 1

TIME SURVEY FORM						
Work: Tank Control and nut fastening				Date: 22.02.2011		
Worker: Hidayet Basyesil				Surveyor: Erkan Adiguzel		
Step no:	Work step:	Measurement 1	Measurement 2	Measurement 3	Work Time	Remarks
	Starting time	00:12	00:26	01:40		Taking place of the tank is not suitable
1	Taking the tank from the box	00:14	00:27	01:42		
		2 sec.	1 sec.	2 sec.	2 sec.	
2	Visual inspection of the tank	00:15	00:29	01:43		
		1 sec.	2 sec.	1 sec.	1 sec.	
3	Combining the security piston, gasget and bow	00:20	00:33	01:47		
		5 sec.	4 sec.	4 sec.	4 sec.	
4	The placement of the bow into the slot	00:21	00:34	01:48		
		1 sec.	3 sec.	1 sec.	1 sec.	
5	Attaching the security nut ti the tank	00:23	00:36	01:50		
		2 sec.	2 sec.	2 sec.	2 sec.	
6	Fastening it by a pistol	00:24	00:37	01:52		
		1 sec.	1 sec.	2 sec.	1 sec.	
7	Putting the tank onto the line	00:25	00:39	01:53		
		1 sec.	2 sec.	1 sec.	1 sec.	
8						
9						
10						
11						
12						
13						
14						
	Time necessary of 1 turn	13 sec.	15 sec.	13 sec.	?=11sn	

Operations:

1. Tank control and nut fastening
2. Attaching the oring kit and resistor to the tank
3. Flange screwing
4. Flange screwing
5. Assembly of reset thermostat
6. Flange screwing
7. Back cover assembly
8. Connector screwing
9. Diaphragm grouping
10. Diaphragm body assembly
11. Cable assembly
12. Switch screwing
13. Cable assembly to the resistor
14. Attaching clamp and socket
15. Thermostat screwing
16. Limit thermostat assembly
17. Key screwing
19. Checking before closing the front box
20. Checking before closing the front box
21. Mostec control
22. Hand-eye control and closing the front box
23. Attaching the screw and tag to the front box

24. Attaching the button and the stage tag
25. Attaching the barcode and front panel tag
26. Packaging and putting in the operating manual
27. Putting the product into the box
28. Separator and assembly
29. Closing the box, sticking the barcode and warning label
30. Product installation and sticking the barcode onto the box
31. Packaging

In time survey forms, there are different turn times for each operation. This means that working time for each operator is different. Deducing from these data, it is obvious that under the existing circumstance capacity-use rate and waiting times are imbalanced.

In figure 4.3. shows the map that the value flows of current production of electrical water heater.

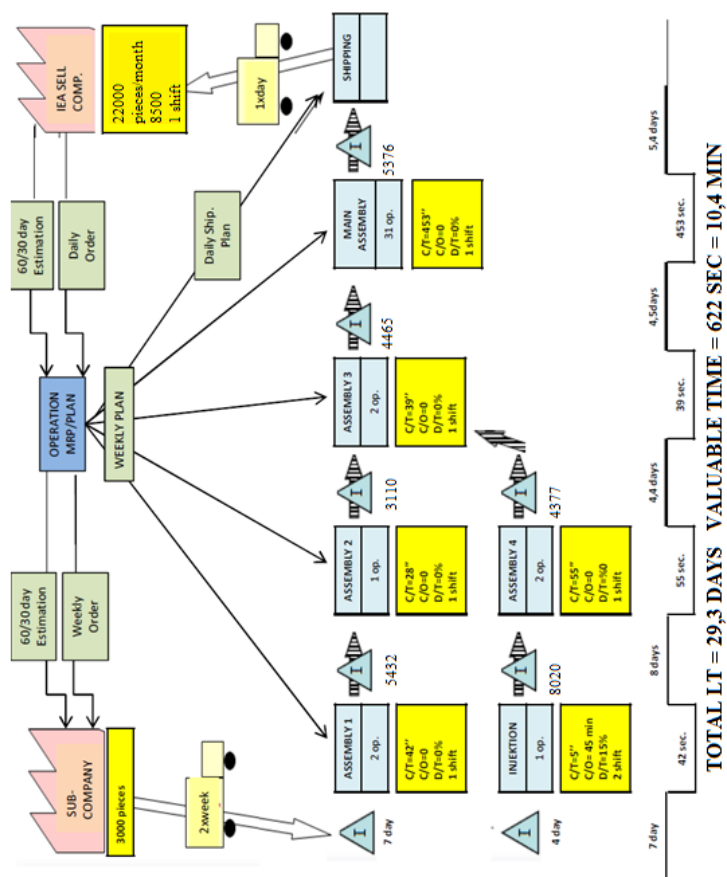


Figure 4.3 Current State Value Stream Mapping

The current situation and existing problems are defined in the production line of electrical water heaters as follows:

The company determines the number of water heater to be produced on a monthly base. The number is between maximum 31000 piece and minimum 9000 piece of water heaters. The water heaters are produced according to the demand. Generally, the company produces on alternate days and workers produce different products when not producing water heaters. This is the first and the most important problem. For this reason, sometimes producing on time becomes a problem. While sometimes there is overproduction leading the excess to product to wait, in other days there is overtime because the product does not match up. In addition, another important thing to mention is that the company is not able to have production breaks in order to decrease its financial expenses and make the maintenance for the assembly line.

The annual number of water heater product is given in table 4-3.

In addition to these, disorderliness is obvious in the work environment. Although the work place is clean, forming material stocks, putting the workers working tables to the assembly line in an inconvenient way, placing the hand tools disorderly and the other similar factors unnecessarily occupies a lot of space.

Table 4.3 Annual Number of Water Heater Product

Product	January	February	March	April	May	June	July	August	September	October	November	December	Total
Water Heater 2006	11.980	9.960	18.113	22.693	17.384	28.376	24.700	26.400	27.748	25.100	34.116	27.612	274.182
Water Heater 2007	9.500	21.938	17.934	9.819	17.718	25.284	18.596	19.841	15.108	22.929	22.838	19.752	221.257
Water Heater 2008	19.419	15.523	9.973	13.926	27.763	27.576	25.187	22.056	18.109	15.173	33.255	19.975	247.935
Water Heater 2009	33.405	25.793	22.426	15.215	17.442	26.416	21.957	21.435	19.601	24.533	30.457	34.989	293.669
Water Heater 2010	27.356	19.509	22.429	13.261	16.578	13.872	19.025	17.360	22.918	22.530	28.975	31.161	254.974
Water Heater 2011	26.023	20.000	25.000	20.000	25.000	20.000	25.000	20.000					181.023

4.4 The Method to be Applied in Order to Regulate The Problematic Area

The first method to be applied to regulate the problematic area is the establishment of a lean team.

Transition from a years-long production process to a new one will be difficult for both managers and workers. After the transition to a new project, in order to show the determination of lean production and get efficient results it is necessary to include a department which will both do the works to be done in the transition process and do the monitoring job after the transition is complete.

Generally, the most salient thing to the in forming a lean team is to choose engineers for the engineering department in line with lean production techniques that the whole staff adopts and the existing production process.

In the lean team formed for this application, in addition to product and quality control engineers, journeymen working in the production line of the electrical water heaters have a part in the team.

The team to be in the application process of lean production is composed of one advisor, one group spokesman, one vice group spokesman and 7 members, adding up to 10 in total.

The first step after forming the team is to give an education of the application of lean production. Workers are needed to refrain from all kind of wastes and act in a lean thinking in each process of their work. This consciousness in lean production comes with educations that encourages each worker to adopt lean working style rather than with a pressure coming from above in a hierarchical order. Lean education is given to all the workers, both to blue collar employee and a white collars employee in the company.

The following objectives have been identified in order to eliminate the problems that are currently existing after the forming the lean team and the giving the necessary education.

Objectives:

1. To increase the efficiency by 25 %.
2. To gain a 30% profit in the assembly corridor by decreasing the surplus stock in the work area and bringing the materials in time through a system of combinationization in the warehouse.
3. To increase the efficiency 20% by regulating orderly arranging the positions of the workers and the places of the materials. To make and supply the necessary equipments to achieve this.
4. To decrease the working time by 30 % by determining the takt time and decrease the waiting time.
5. To re determine the number of the workers by balancing the work load and flow.
6. To re determine the number and working hour of the controlling machines.
7. Preparation for the transition to Kanban in order to regulate the transportation system in the warehouse and production departments.

4.5 Amendments Achieved in the Production of Water Heaters

4.5.1 The First Application of Kaizen

Continuously improving a single process and a value stream by creating more value with less wasting is called Kaizen. The value stream mapping is a perfect tool in defining a whole value stream and determines where the appropriate value process kaizen is.

The first application have been made is a five day kaizen group activity. The aim is to create a continuous stream cell in a week. The lean team members were previously selected firstly learned the principles of continuous stream and then re planed the necessary changes by going to the production area in order to evaluate the real conditions there. Then, the production was tested by the team via placing the necessary machine, material and operator. After these amendments, production was controlled by standardization.

4.5.1.1 Assembly Line Balancing Method

In the industrialization process, it is discovered that dividing the work into pieces and assigning each work to different workers instead of making one worker to do the entire job will speed up the production process and decrease the production cost. With this discovery, the production started to be made on line on which different work stations are arranged.

Balancing the assembly line is the most important problem to be solved by mass production companies. The main aim in balancing work to design assembly lines is to maximize the utilization of existing resources. In line with this aim, work items are distributed among the stations by assigning the station times equal or very close.

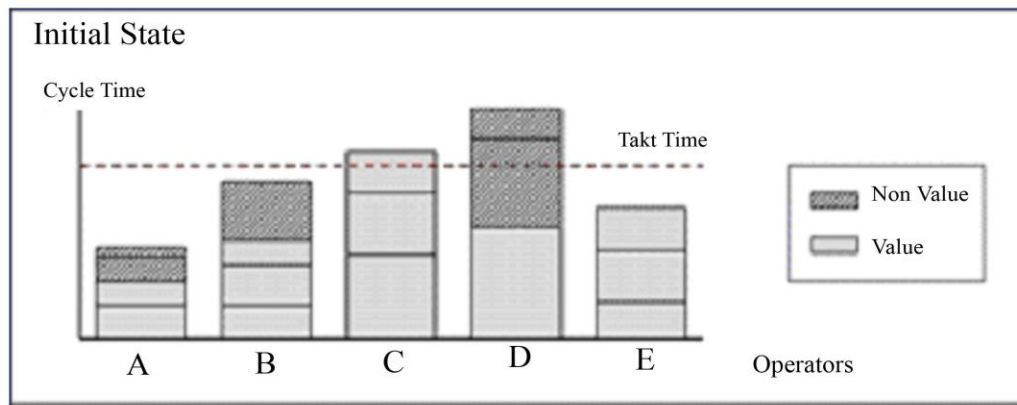
By assembly line balancing, works are categorized and stations are established accordingly. Operation times of these stations are made close to each other. And under these circumstances assembly line is made to work without a hitch. Hence, the maximum benefit is achieved.

Objectives of line balancing:

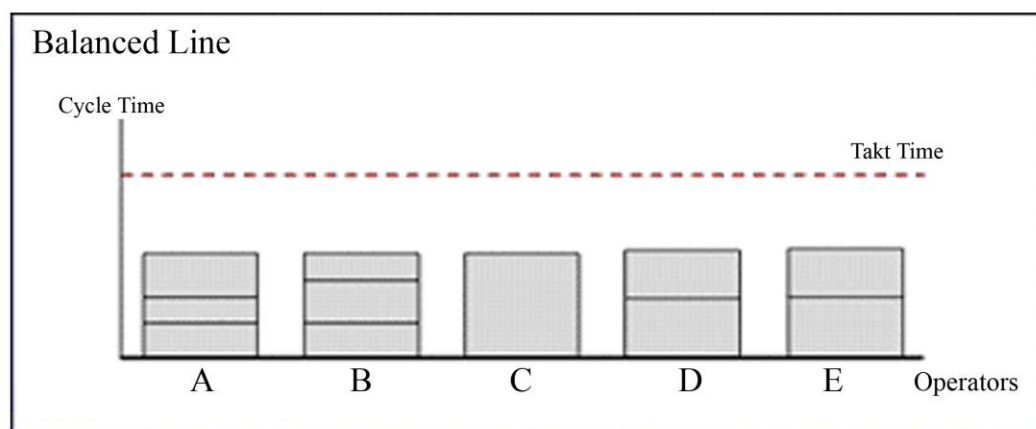
- Regular material flow,
- Utilization of human power and machine capacity at a maximum level,
- Minimum operation times,
- Minimum stationary times,
- Minimization of the work stations,
- To distribute idle times among work stations,
- To decrease the production cost

To minimize the processing time differences depends on the takt time. In line with the determined takt time turn times of the operations and the number of the operators is re determined. This is explained in the following example:

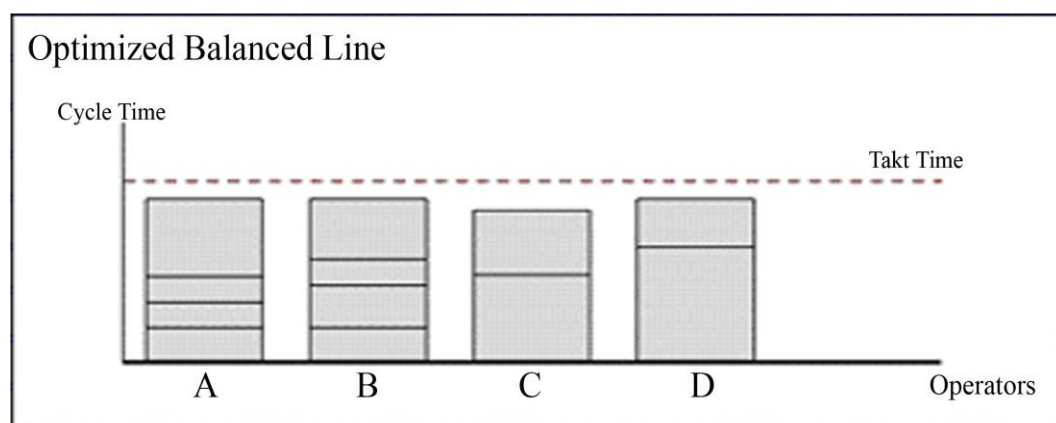
Starting with implementing takt time by first measuring individual cycle times. To begin aligning your process to the takt time, start dividing the work that goes into the process into value adding and non-value adding activity.



Eliminate the non-value adding time and balance the workload of the operators.



Bring the individual cycle times closer to the takt time. Keep the line balanced. In this case you will need fewer operators.



In the firm, on this application one of the line balancing study explained below example:

Firstly, 5th, 6th, 7th, and 8th operators, who works on the water heater line, are considered.

Each operator's works are called separately a, b, c, d, e, etc.

5th. operator completes his works at total 15 second time and each work respectively is 5a (2sec.), 5b(3sec.), 5c(4sec.), 5d(4sec.), 5e(2 sec.).

6th. operator completes his works at total 14 second time and each work respectively is 6a (1sec.), 6b (12sec.), 6c (1sec.).

7th. operator completes his works at total 14 second time and each work respectively is 7a (1sec.), 7b (2sec.), 7c (3sec.), 7d (7sec.), 7e (1 sec.) .

8th. operator completes his works at total 12 second time and each work respectively is 8a (1sec.), 8b (3sec.), 8c (6sec.), 8d (2sec.).

Takt time is 20, 8 sec. in current state. In this case the whole operations cycle times remain under the takt time. Now, we should share some operations between operators to re-create a workflow. The main goal of that to closing the operation cycle times, upward to takt time.

Every operation in the water heater does not require much skill. Thus, each operator can do all the work. So, we start sharing in the operator's work backwards. Leaving the 8th operator to off-line is the first goal. For that, operation 8c (6 sec.) and 8d (2 sec.) are added to 7th operator. So, 7th operators cycle time is completed 22 sec. time. Then, operation 5c (4 sec.) and 5d (4 sec.) are added to 6th operator and now his total cycle time is 22 sec. After, 8a and 8d operations are added to 10th operator. At the same time, 5a and 5b operations are added to operator 4. So on 8th and 5th operators would be off-line.

All operations are not sharing only the both of 6th and 7th operators according to the explanations above. As a result of those things, it is shown that the line balancing may not be exactly made. But if the rest of the line balancing process would be searched, we just observe the full balanced line. All of the processes are shown step by step in Appendix B.

4.5.1.2 The Application

In line with the value stream map and enumerated objectives mentioned before, the following changes in the production process are made in order to improve the existing conditions:

Takt time is determined: The time obtained by dividing the available production time to the consumer demand is called takt time. Takt is a German word used to define an exact time period just like a musical measure. The aim of takt time is to achieve an exact overlap of production and demand.

$$\text{Takt time} = \frac{\text{Production Time Available}}{\text{Customer Demand}}$$

As a result of the lean work that have been done, it is determined that the average of monthly production is 33000 and monthly work day is 22. This means that the average number of daily production is 1500.

The average of daily working time of the factory is 33600 seconds. Out of this time, 2400 is spared for tea breaks and the remaining 31200 seconds is pure working time. The daily demand of the product by customer is 1500. So, the takt time is $31200/1500 = 20,8$ seconds. In other words, customer demand a product in each 20,8 seconds.

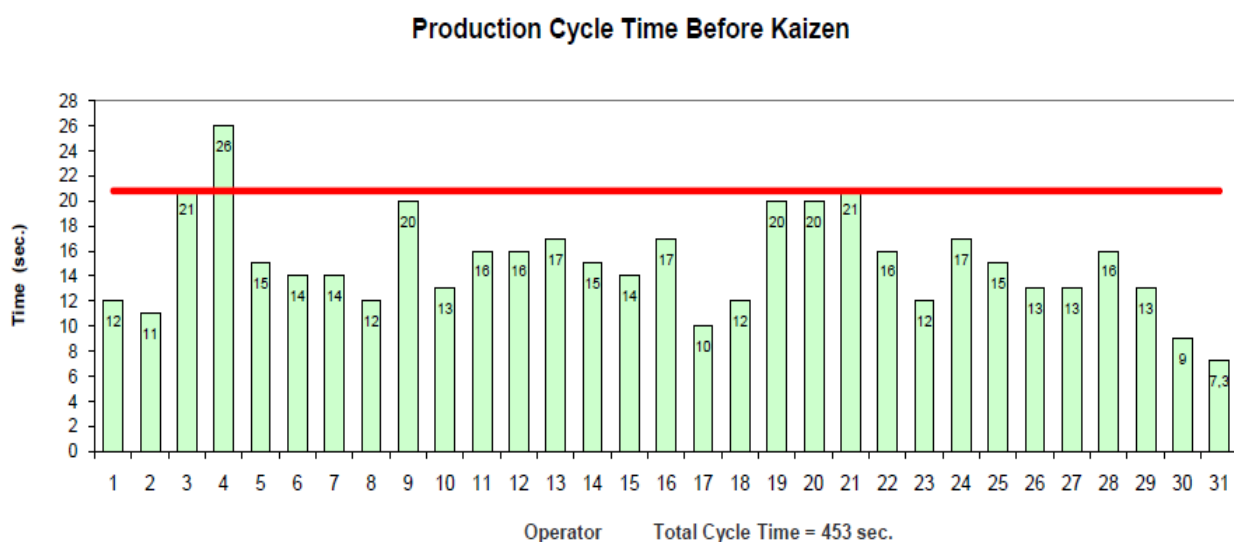
$$\text{Takt Time} = \frac{31200}{1500} = 20,8 \text{ sec.}$$

Job-step sequence is determined: The distribution of a particular work to a single worker in a constant sequence and the adaptation of this to the takt time is called job-step sequence.

In this part, the working time of the operators is determined and cycle times for each operator are recalculated. The deviations in workers' work are determined. In these calculations, it was observed that the cycle time of operations is below the takt. For this reason, with drawing the work sequence and time towards the takt time by the method of balancing the assembly line, the work division among the operators is rearranged.

An analysis of takt time and cycle times of the operations before kaizen are shown table 4-4.

Table 4.4 Production Cycle Time Before Kaizen



apply JIT principles in a lean style. The waiting times should be minimizing that cause some loss and decrease the cycle times of the workers as much as possible. At the same time, it is necessary to have a labor force that can easily adapt different works and responsibility and is multidimensional. As a result, taking all these points into consideration, the production line is divided in three parts as A, B and C. Part A deals with assembly work; Part B deals with control work; and Part C deals with packaging work. This division is done just on paper in order to arrange the placement of the operator and regulate the works easily. In reality, the line is united.

In Part A, 18 operators work at first. With the new work distribution and newly calculated cycle times, the number of operators' decreases to 12 and 6 operators is left idle. As a result, 33.3% efficiency is obtained from this part.

$$\text{Efficiency of part A} = \frac{6}{18} \times 100 = 33.3$$

B is the control part. This is the automatic operation region. There are 2 controlling machine working in each 30 seconds and two operators are leading them. The working time of the machine is standardized; it does not depend on the operator. The duty of the machine is to checks whether the water heater leaks water or not. In the same region, there is a high-voltage control machine which checks whether there is any electricity leakage in a water heater. This machine is also led by an operator and an operation takes 30 seconds here. In the first application, any changes have not been made in this region but the usage time of the machine was aimed to decreased. 3 operators still continue to work.

In Part C, 12 operators work. With new regulations an work distribution, 8 people continue to work while 4 people remain idle. The increase in effectiveness in this region is 30%.

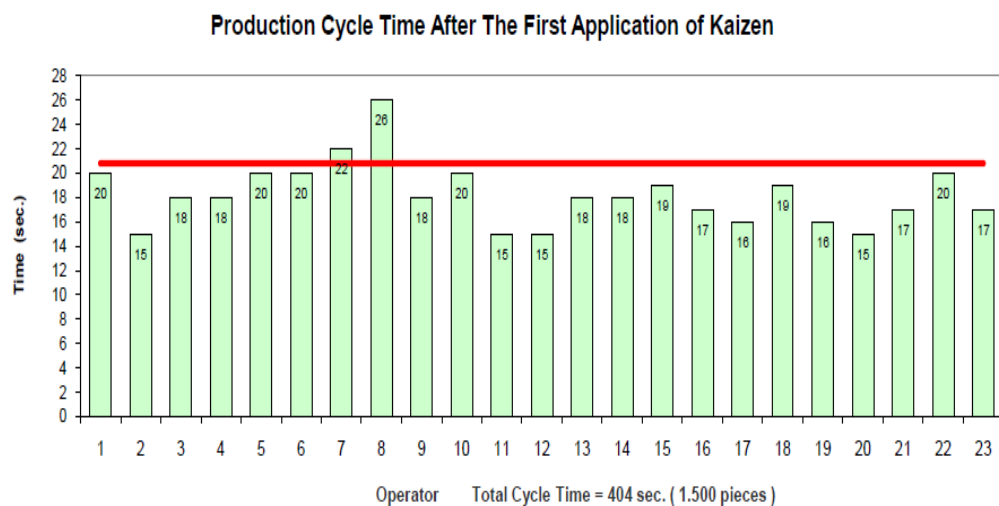
$$\text{Efficiency of part C} = \frac{4}{12} \times 100 = 30$$

Table 4.5 Efficiency

	OperatorNumber	Per Capita Production (Number/Day)
Before Kaizen	31	48,4
After the First Application of Kaizen	23	65,2
Variation	8	16,8
Increase in Efficiency : 35 %		

In table 4-6, new cycle times for the operators are assigned after first application of Kaizen as a result of new improvements.

Table 4.6 Production Cycle Time After The First Application of Kaizen



An ergonomical work environment is created: Because the operators work while seated, their body is under more pressure and burden. For this reason, if they take an adverse movement, the injury risk is quite. Operators' working desks are placed in a 90° angle towards the production line and the materials are placed on it randomly. These

work desks takes a lot of unnecessary space and create a difficulty for the operator to reach the line. For this reason, working area and working style of the operators are rearranged and as in any other places Kaizen improvements are made in this area too. The working environment of the operators is redesigned according to main principles of ergonomic. In these regulations desks are situated in parallel to the line and remade according to the height of the operator. As a result, it is prevented for worker to take adverse movements, to stretch and to turn. By rearranging the placement of materials and hand tools of the worker in line with their usage, either with left or right hand, the decrease in performance and bodily stress is prevented. Moreover, the height of the production line is taken to the standard level.

**Before Kaizen****After Kaizen**

Kanban system is established: As a result of the new improvements, it is observed that there are some problems in the production because the system of combinationization is weak and there is waiting times for the finished materials of the operators to be supplied. To prevent this, the kanban system has been established. The materials used were established one by one. The backup times of each material were determined according to size of the parts and the frequency of use. The name and number of the material used is enumerated in the Appendix C named ‘assembly operation phases’. Kanban boxes are made according to the number of the materials. Because ‘pulling system’ is aimed and installed in each works, thus pulling kanban cards were prepared.



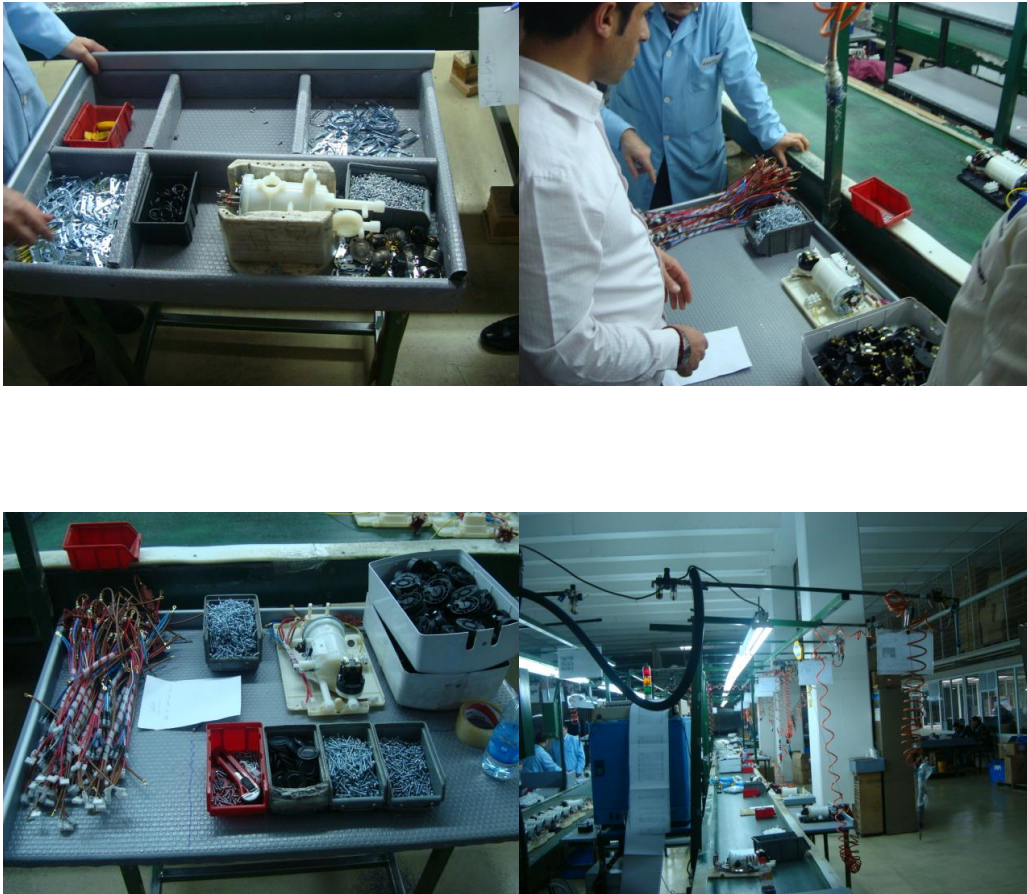
Spiderman is determined: Spiderman is a name given to the person who checks the production environment and transports the necessary materials to the operator in a lean production. This concept is not among the standardized lean concepts. All the materials, used to prevent unnecessary material stock and create the necessary environment for operator to work conveniently, exist equally in the production area in

parallel with their sizes and usage frequency. For example, there are 100 water heaters' heads ready near the line before the production starts. Spiderman has to transport material stock in each 100 products by following the product number from the scoreboard in the production area. This transportation work is maybe a hourly duty. For example, there is a 6-hours stock for the screws used in the assembly process. Spiderman has to work according to the hour again and in each 6-hour, he has to check the production area a supply necessary materials. All the finished and nearly-finished materials in the production area have to be under the responsibility of the spider man. The operator must not do any other work that does not bring value. He must never go and bring the finished materials and make the production wait for this.

The car for combinationization is made: Hand cars are designed to carry materials from the stock in order to supply kanban boxes.



The work environment is regulated: In order to create an organized, clean and high efficiency work environment, 5S method which is a work description and a process has been utilized in the production area. The materials that are disorderly and occupy unnecessary space are removed. Chairs and junks are removed, too. The places and the sizes of the desks are changed. By creating a evaluation measure, the materials used in the production is rearranged. Only the materials necessary in a day or an hour are allowed to be present in the work area. The unnecessary space usage in the production area is prevented.



As a result, the initial 100m² work environment composed of a line of 25.6 m² and a remaining part of 74.4 m² is decreased to a 60.5 m² area, composed of a 25.6 m² line and a 34.9 m² remaining part, as a result of the improvements made.

Table 4.7 Space saved table before kaizen

	Line(m ²)	Others (m ²)	Total(m ²)
Before Kaizen	25,6 m ²	74,4 m ²	100 m ²
After the First Application Of Kaizen	25,6 m ²	34,9 m ²	60,5 m ²
Pure Amount Of Space Saved = 39,5 %			



Before Kaizen

After Kaizen



Wasted Band

4.5.2 The Second Application of Kaizen

The aims are achieved as a result of the first application of Kaizen. The application of first Kaizen has lasted 5 days. During this process, operators have tried to become accustomed to the new order. At the end of five following days, operators have become accustomed to the distribution of new tasks and production field, and they have increased the tempo even more.

As a result of the obtained results and observations, it was revealed that the second kaizen study can be made in this production field. Reduction of wastes and increase in tempo, production of quality and correct product was made possible. As a result of this, the stock of finished products is formed.

In this application, firstly units of production were considered. In order to make improvements in production, there is a stock of finished products for immediate demands. To reduce or if possible to destruct stockpiles of finished product without disturbing the smoothness of production, new targets were determined.

Objectives:

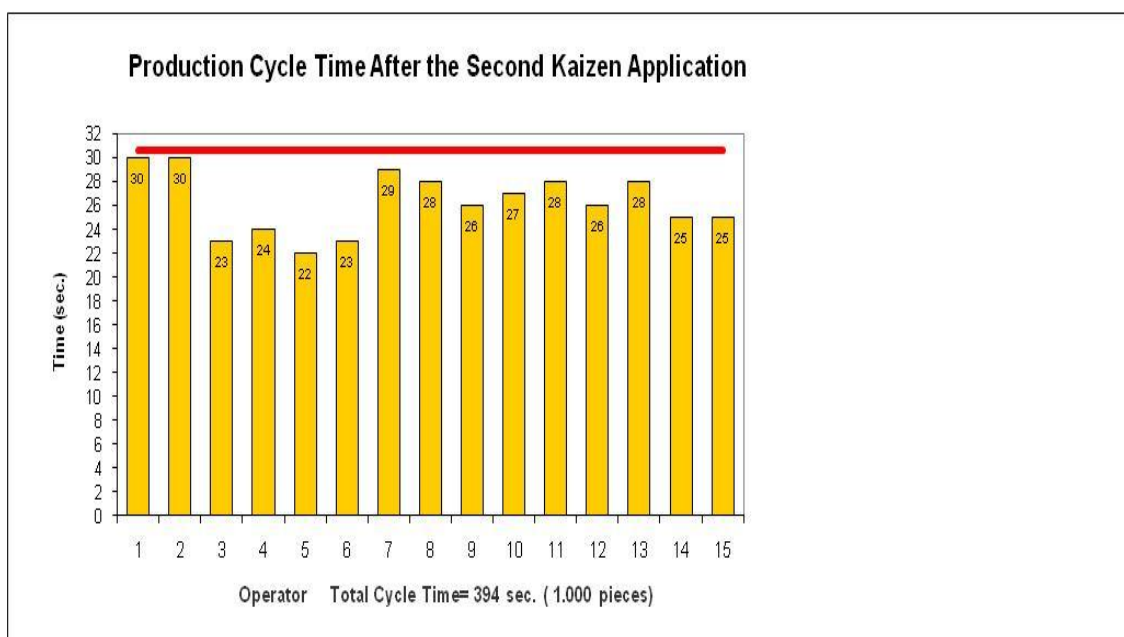
1. To increase the efficiency by 30 %,
2. To gain a 30% profit by decreasing the stocks in the work area,
3. To achieve a space saving of 20%,
4. To decrease the production time by 30% by determining the takt time and decreasing the waiting time,
5. To re determine the number of workers by balancing the work load and flow.

In line with the before mentioned objectives, firstly the monthly production demand has been standardized to 22000 from 33000 and monthly working day is again 22. Hence, the average of daily production becomes 1000. In terms of working time and labor force, the factory is able to produce at this amount. Under the circumstances of production delay, this problem will be handled by overwork. The pure working time remained 30600 seconds. As a result, the new takt time became 30.6 seconds.

$$Takt\ Time = \frac{30600}{1000} = 30,6\ sec.$$

With this new takt time, work distribution and operator numbers are re determined as in the previous application. The existing operator number is decreased to 15 from 23. Because 15 people started to work on the production line, instead of 31 people, thus production area saved up from the line. The initial 25.6 m² line decreased to 22.19 m². The remaining part was 34.9 m² after the first application, now it became 21.51 m².

Table 4.8 Production Cycle Time After the Second Kaizen Application



The new results are obtained after the second Kaizen application, is given table 4-8. and table 4-9.

Table 4.9 The efficiency in the line for the water heaters.

	Operator Number	Daily Production	Per Capita Production (Number/Day)
Before Kaizen	31	1500	48,4
After the First Application of Kaizen	23	1500	65,2
After the Second Application of Kaizen	15	1000	66,7
Increase in Efficiency: 38%			

Table 4.10 The pure usage in the line for water heaters.

	Line (m ²)	Other (m ²)	Total (m ²)
Before Kaizen	25,6 m ²	74,4 m ²	100 m ²
After the First Applicati on of Kaizen	25,6 m ²	34,9 m ²	60,5 m ²
After the Second Applicati on of Kaizen	22,19 m ²	21,51 m ²	43,7 m ²
Pure amount of space saved: % 56			

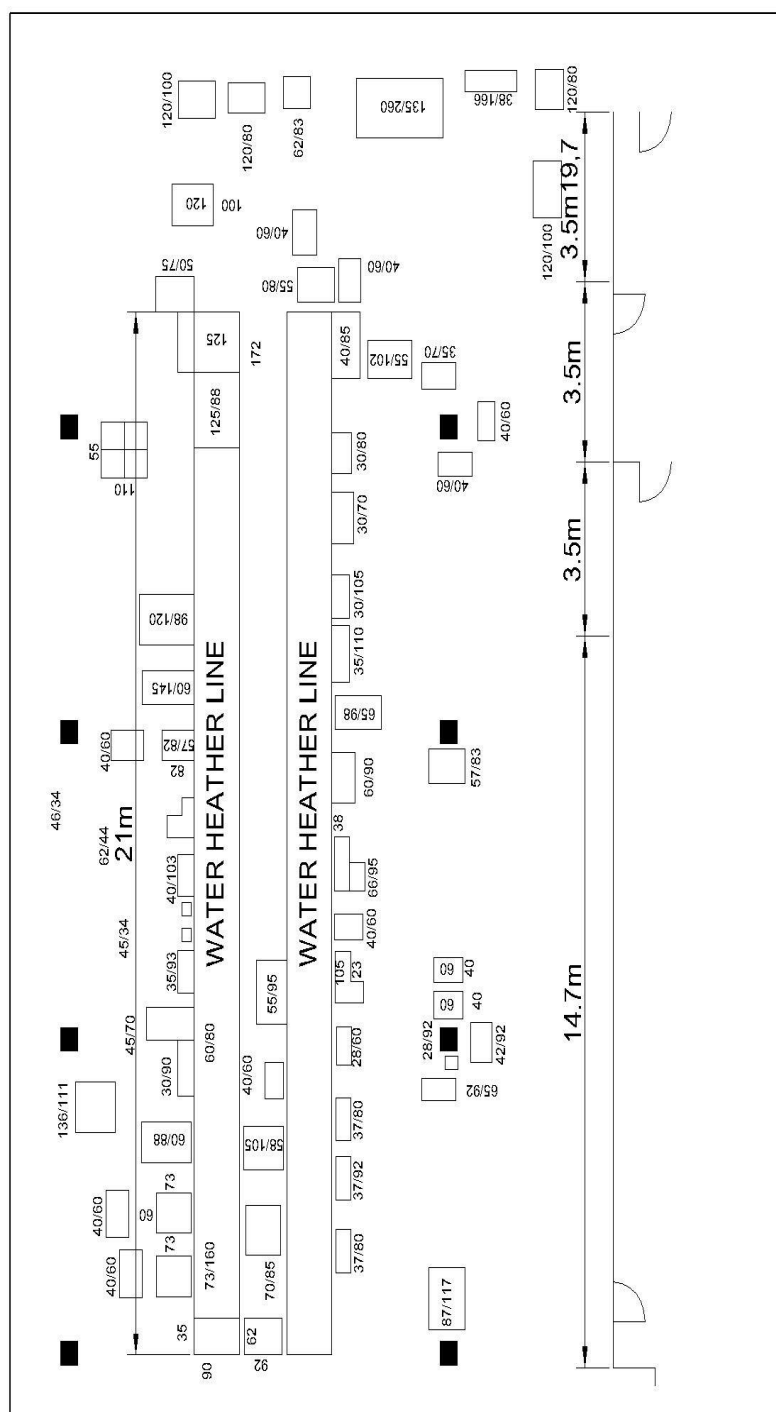


Figure 4.4 The settlement plan of the production line after the first kaizen application

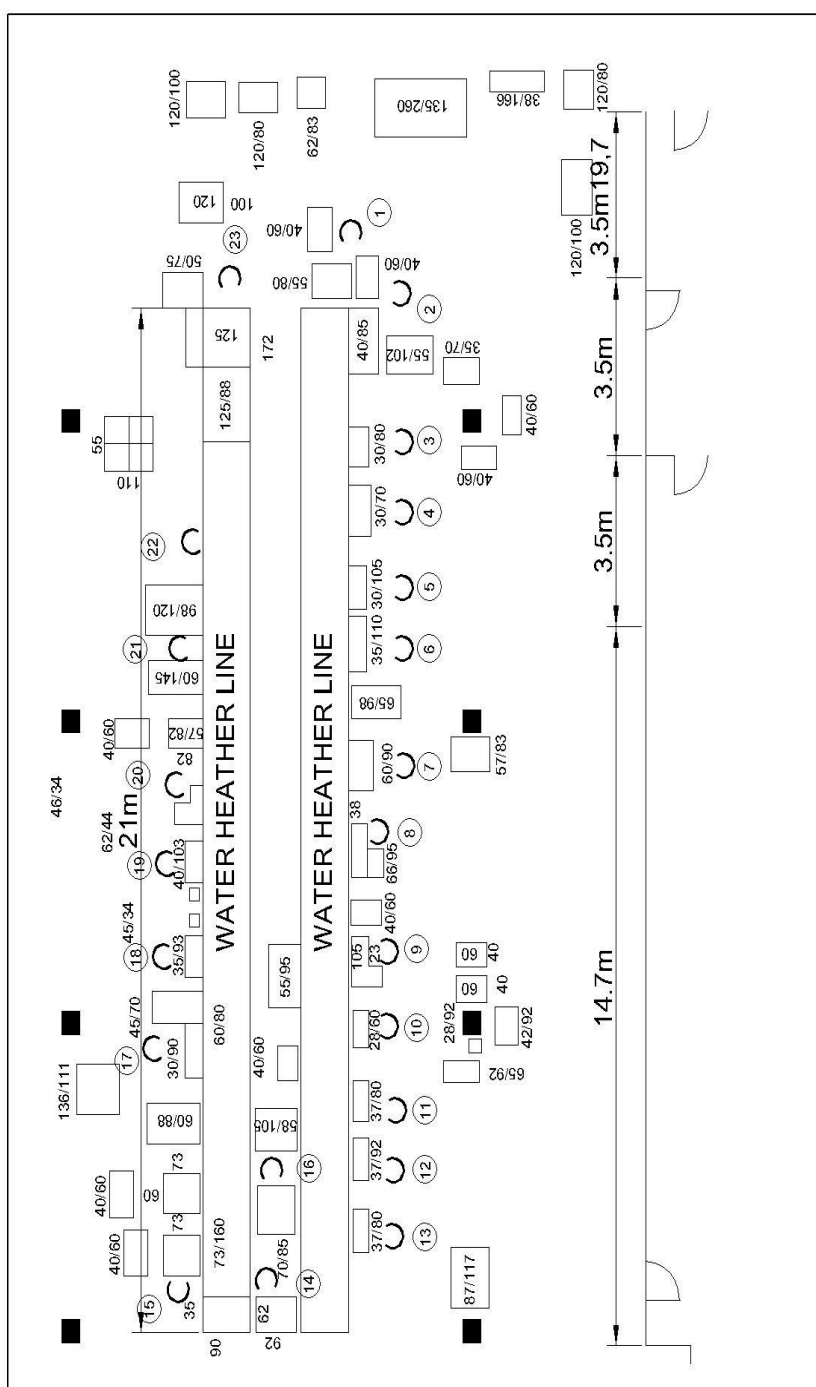


Figure 4.5 Operator settlement plan of the production area after the first kaizen application

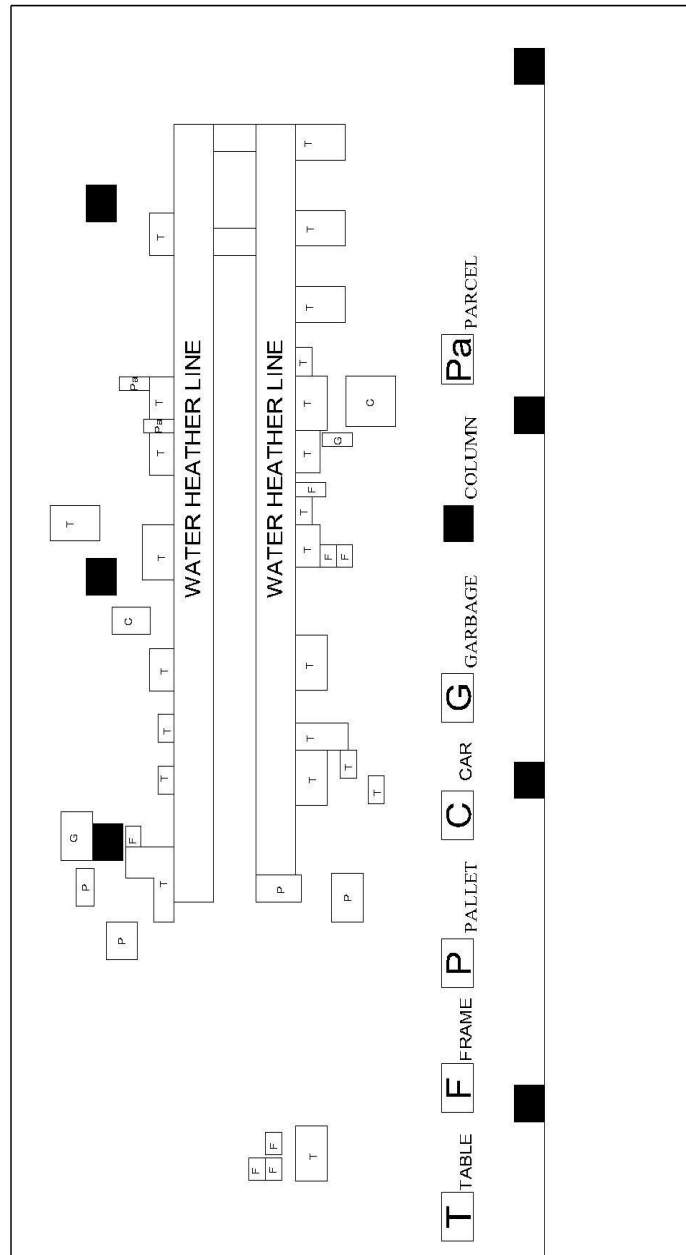


Figure 4.6 The settlement plan of the production area after the second kaizen application

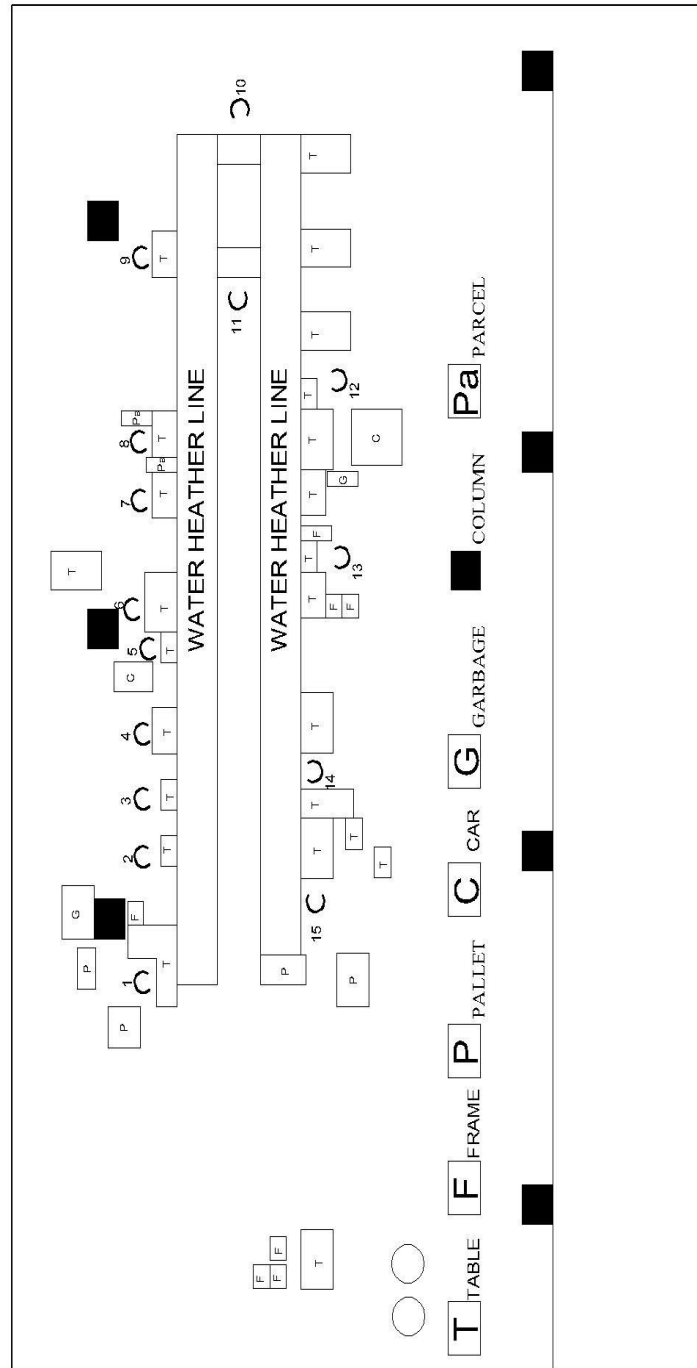


Figure 4.7 Operator settlement plan of the production area after the second kaizen application

4.6 Recent Situation Analysis

The future state value stream mapping is drawn in figure 5-4 after the application of lean techniques to the existing system.

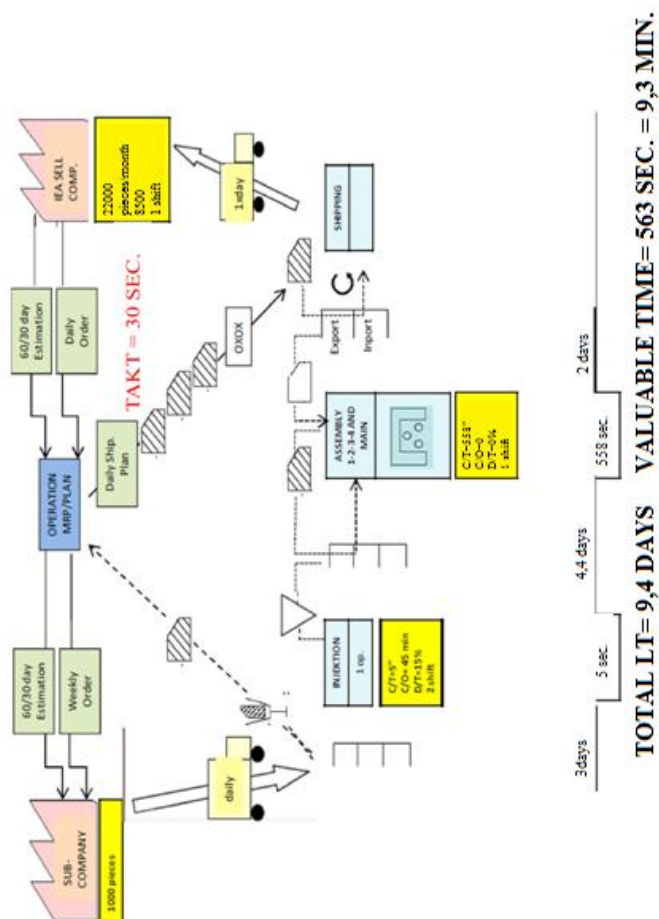


Figure 4.8 Future State Value Stream Mapping

4.7 Challenges in the Application and Solution Methods

In the process of the applications of the improvement methods, the lean team has faced with dramatic reactions from the workers. Workers accustomed to work while seated could not adopt the idea to work while standing. They reacted dramatically against both to the lean team leading the application and to the gangers. In order to stop these reactions, brochures explaining the ergonomically working principles are posted around. In order to raise workers' awareness, a series of seminars are given by expert doctors.

Another problem faced during the application is frequent worker absence. The operators can take a day off by presenting an excuse or due to health problems. This, however, causes some problems in an assembly line production system balanced according to the number of operators. In order to prevent these problems, the lean team spares two more workers to work in the production line. Because the production line of electrical water heaters is not a complex production line, almost every worker can do every work on it. For this reason, the substitute two workers are educated to handle every operation. They can be used in the case of the absence of any operator. When there is no operator absence, these two workers help other operators in case if any defect or other problems in the production process.

4.8 Financial Improvements as a Result of the Application of Lean Production

The benefits were gained as a result of the improvement work done in the company by using the philosophy and method of the lean production, work study and kaizen improvement methods.

Take the monthly production capacity of the company as 1500 water heaters, monthly labor cost as 1800 TL and monthly working time as 22 days, the profit the company gain after a year's work will be as follows:

The daily cost of a worker:

$$(1800 \text{ TL}) : (22 \text{ day}) = 82 \text{ TL/day}$$

Before Kaizen:

Monthly cost of workers:

$$(31) \times (82 \text{ TL}) = 2542 \text{ TL}$$

Monthly labour cost:

$$(2542 \text{ TL}) : (1500 \text{ piece}) = 1,6 \text{ TL/day}$$

After Kaizen:

Monthly cost of workers:

$$(15) \times (82 \text{ TL}) = 1230 \text{ TL}$$

Monthly labour cost:

$$(1230 \text{ TL}) : (1000 \text{ piece}) = 1,2 \text{ TL/day}$$

Gains:

$$\text{Difference: } 1,6 - 1,2 = 0,4 \text{ TL/day}$$

Daily gains:

$$(0,4 \text{ TL/day}) \times 1000 \text{ piece/day} = 400 \text{ TL/day}$$

Annual gains:

$$(400 \text{ TL/day}) \times 250 \text{ day/year} = 100.000 \text{ TL/ year}$$

After these improvements the company will gain 100.000 TL only from the labor cost. In addition to this, there are many gains not included into the calculations. As a result of improvement in space and technical materials, lots of gains are achieved.

The gains from space can be examined under two headings, as gains in construction and management. The company saves up from space and utilizes this idle space in the production of other goods. Instead of establish in another factory in a different place, the company utilized this idle space to produce a different product. This is the main gain in construction.

In addition, the company saves up from other costs like lightening, heating, cleaning, and etc.

In the process of improvements, there was a necessity for new working desks, kanban boxes, and cars for transporting the materials. Because the company is able to produce all these, there was a not additional cost for these materials.

CHAPTER 5.

CONCLUSION

In this thesis, in a company producing home appliances, value stream mapping has been utilized as one of the founding stones of lean production and analyzed the techniques of Kaizen continuous improvement. The extravagancies have been observed by the methods of time measurement and the value stream mapping. The deficiencies in the work flow, placement of material and production planning have been determined.

The most salient problem under the existed circumstances was the differences in cycle times and remaining below the takt time of these. The main source of the problem is unequal distribution of work load and flow among the operators and unnecessary waiting time. The other problem is the changing nature of production demand and time.

In line with the changes in demand for production, monthly plans for production changes, too. In order to balance the production the factory was producing on alternate days. For this reason, while determining the future map of production under the pulling system, a continuous production plan has been designed. With time measurement, cycle times were drawn towards takt time. Waiting times and other extravagancies have been revised one by one and re determined the work flow and capacity of the operators.

In order to increase work efficiency, the work environment has been regulated and the workers have been encouraged to work while standing. The hand tools and other materials have been situated an easily reachable place and designed an ergonomically work environment. The working desks have been redesigned suitable for the nature of the work and standardized the size of the assembly line. The existing work environment has been regulated, the work area has been standardized and the system of in-time production has been established. In parallel to the objectives determined, Kaizen improvements have been implemented and great deal of benefits have been gained.

During the improvement process, both from production and from operators' material usage have been saved up. Before the first application, there were 31 operators producing 1500 water heaters daily. Per capita production was 48.4. After the first application of Kaizen, the production of 1500 water heaters has been achieved by 23 operators in a day. Per capita daily production was 65.2. After the second improvement, the production process has been re planned. Now the daily production was 1000 water heaters by 15 operators. Per capita daily production is 66.7. The increase in water heater line is 38%.

As a result of improvements, the total space, used in line with the location of operators and production flow, decreased from 100 m² to 60.5 m². The gain from space after the first application of Kaizen is 34.9%. After the second application of Kaizen, the size of the line decreased from 25.6 m² to 22.19 m²; and the remaining part decreased from 34.9m² to 21.5 m², So, the total areas used becomes 43.7m². After the all improvements, the total gain from space is 56%

The application of lean production in Ihlas Domestic Appliances Production Industry and Trade Incorporated Company (IHEVA) was successful. After getting efficient result from this application, the company started to utilize the lean production methods in other department too.

In addition to saving up from space, the factory decreases its daily production, inventory and finished product stocks. Thanks to these developments, there emerged new idle spaces in the factory. These spaces are ready to be used for new investments.

Lean production is not just a production method, but philosophy of lean thinking and lean management. Although the company that we have made our application is a small factory, the lean production methods, lean thinking and lean management will bring big gains if applied properly.

Lean production takes customer demands as its priority. For this reasons companies are now working focused on the customers. This is because; the customer pays for the efforts put on the product to create a value. Because if that, it is necessary to remove the parts that the customer does not want to pay from the production stream. To achieve this, lean production techniques are used.

There is no limit for improvement on the lean production system. The appliers of lean production should be sensitive to the ideas of workers and should take their advices into consideration.

The method of the value stream mapping helps us to easily recognize the extravagancies. To achieve a continuous development in the system and to gain efficient results, the participation of the operators to the system is necessary. This is because, they are the ones who do this working the best.

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APPENDIX A: Time Survey Forms

Time survey form before Kaizen

ZAMAN ETÜD FORMU						
Yapılan İş: Çalışan:		Gözlemci :			Tarih :	
Adım No:	İş Adımı	Ölçüm 1	Ölçüm 2	Ölçüm 3	İş Zamanı	Açıklamalar
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
	1 Çevrim için gereken zaman					Tekrarlanan En Küçük Çevrim ←
Çalışılan İst. :		WIP(Üretimdeki Parça Miktarı :		Takt Zamanı :	Çevrim Zamanı :	Çalışan Sayısı :

1 ZAMAN ETÜD FORMU (KAIZEN ÖNCESİ)						
Yapılan İş: Harne kontrol ve Sıvı Takip						
Çalışan: Hidayet Başyazıl Gözlemci: Erkan Adıgüzel Tarih: 22.2.2011.						
Adım No:	İş Adımı	Ölçüm 1	Ölçüm 2	Ölçüm 3	İş Zamanı	Açıklamalar
1	Harnein kutudan alınması	00:14	00:22	01:42	2	Harnein alınması uygun değil.
2	Harnein kontrolü	00:15	00:29	01:43	1	
3	Emniyet pistonu, emniyet kartası ve yayın kontrolü	00:20	00:33	01:47	4	
4	Yayın yuvaya yerleştirilmesi	00:21	00:34	01:48	1	
5	Emniyet Sıvısının Harneye elle tutulması	00:23	00:36	01:50	2	
6	Tabanca ile silinmesi	00:24	00:39	01:52	1	
7	Harnein kanda konması	00:25	00:39	1:53	1	
8		13 sn	15 sn	13 sn		
9				Σ = 12:51		
10						
11						
12						
13						
14						
15						
16						
1 Çevrim için gereken zaman						Tekrarlanan En Küçük Çevrim

Çalışılan İst. :	WIP(Üretimdeki Parça Miktarı :	Takt Zamanı :	Çevrim Zamanı :	Çalışan Sayısı :
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F152 3011

06.04.2009

ZAMAN ETÜD FORMU (KAIZEN SONRASI)

Yapılan İş:

Gözlemci :

Tarih : 08.03.2011

Çalışan: Hidayet boşayıl

Adım No:	İş Adımı	Ölçüm 1	Ölçüm 2	Ölçüm 3	İş Zamanı	Açıklamalar
1	Hazne olumuk kontrol	00.18 3	00.38 3	00.58 3		
2	Emniyet pistonunun Sımbındırılması	00.26 5	00.46 5	01.04 01.03		
3	Piston grubunun hazne yeletoılması	00.29 3	00.48 2	01.11 7		
4	Emniyet Somununun Conta toılması	00.33 4	00.53 5	01.19 8		
5	Emniyet Somununun hazneye toılması ve sımbılması	00.35 2	00.56 3	01.24 5		
6	Haznenin banta konulması	00.37 2	00.38 2	01.25 1		
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
	1 Çevrim için gereken zaman	19	20	27		Tekrarlanan En Küçük Çevrim

Çalışılan İst. :

WIP(Üretimdeki Parça
Miktarı :

Takt Zamanı :

Çevrim Zamanı :

Çalışan Sayısı :

F152 3012

06.04.2009

ZAMAN ETÜD FORMU (KAIZEN SONRASI)

Yapılan İş: Hazneye Rezistans Takılması Gözlemci: Osman Kesim

Tarih: 25/03/2014

Adım No:	İş Adımı	Ölçüm 1	Ölçüm 2	Ölçüm 3	İş Zamanı	Açıklamalar
1	Haznenin alınması	0,23 0,25	0,53 0,54	1,25 1,26	1	
2	Emriyet Sıboş Gurubunun takılması	0,33 8	1,03 9	1,34 8	8	
3	Haznenin apanata konması ve Çantanın takılması	0,36 3	1,06 3	1,38 4	3	
4	Flanş - Termotast - Rezistansın hazneye konması	0,45 9	1,15 9	1,43 5	9	
5	İflansı vidalanması	0,52 7	1,24 9	1,51 8	8	
6	Haznenin banta konması	0,53 1	1,25 1	1,52 1	1	
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
	1 Çevrim için gereken zaman				30	Tekrarlanan En Küçük Çevrim

Çalışılan İst. :

WIP(Üretimdeki Parça Miktarı :

Takt Zamanı :

Çevrim Zamanı :

Çalışan Sayısı :

APPENDIX B: Takt Time, Operation Cycle Times And Line Balancing Studies

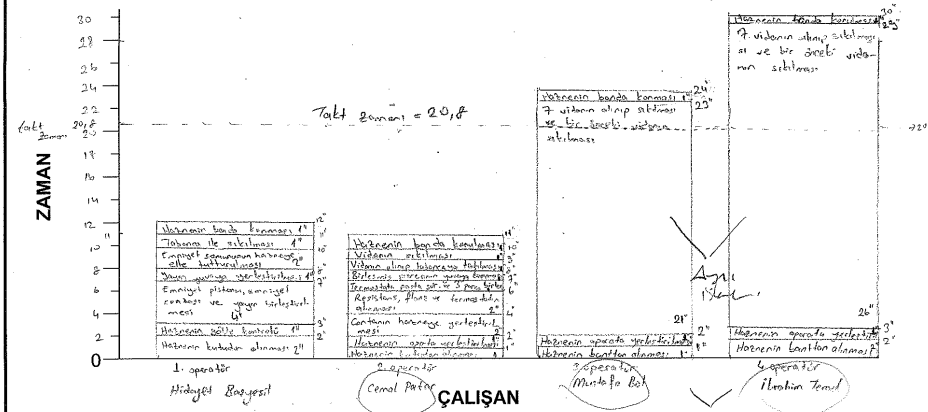
TAKT ZAMANI				
Günlük Çalışma Zamanı : _____ Çay Molası (-) : _____ Net Çalışma Zamanı : _____ Müşteri Talebi / Gün : _____ Net Çalışma Zamanı TAKT ZAMANI = _____ Müşteri Talebi dak. = ... dak. Adet				
Çalışılan İst. :	WIP(Üretimdeki Parça Miktarı) :	Takt Zamanı :	Çevrim Zamanı :	Çalışan Sayısı :

F152 3004 06.01.2005/01

TAKT ZAMANI / ÇEVİRİM ZAMANI				
$\frac{\text{Toplam Çevrim Zamanı}}{\text{Takt Zamanı}} = \text{.....Çalışan}$ ZAMAN ÇALIŞAN				
Çalışılan İst. :	WIP(Üretimdeki Parça Miktarı) :	Takt Zamanı :	Çevrim Zamanı :	Çalışan Sayısı :

F152 3005 06.01.2005/01

TAKT ZAMANI / ÇEVİRİM ZAMANI (KAIZEN ÖNCESİ)

$$\frac{\text{Toplam Çevrim Zamanı}}{\text{Takt Zamanı}} = \dots\dots\dots \text{Çalışan}$$


Çalışılan İst. :

WIP(Üretimdeki Parça Miktarı) :

Takt Zamanı :

Çevrim Zamani :

Çalışan Sayısı :

F152 3005

06.04.2009

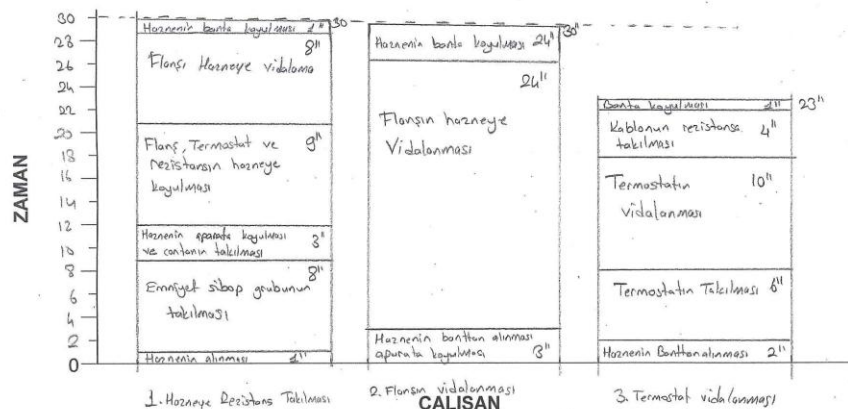
log A

06.04.2009
Erkan Adigül
Himmetiye Ders

23.02.201.

TAKT ZAMANI / ÇEVİRİM ZAMANI (KAIZEN SONRASI)

Takt = 306 s

$$\frac{\text{Toplam Çevrim Zamanı}}{\text{Takt Zamanı}} = \dots\dots\dots \text{Çalışan}$$


Çalışılan
F152 3006

WIP(Üretimdeki Parça Miktar ı):

Takt Zamanı :

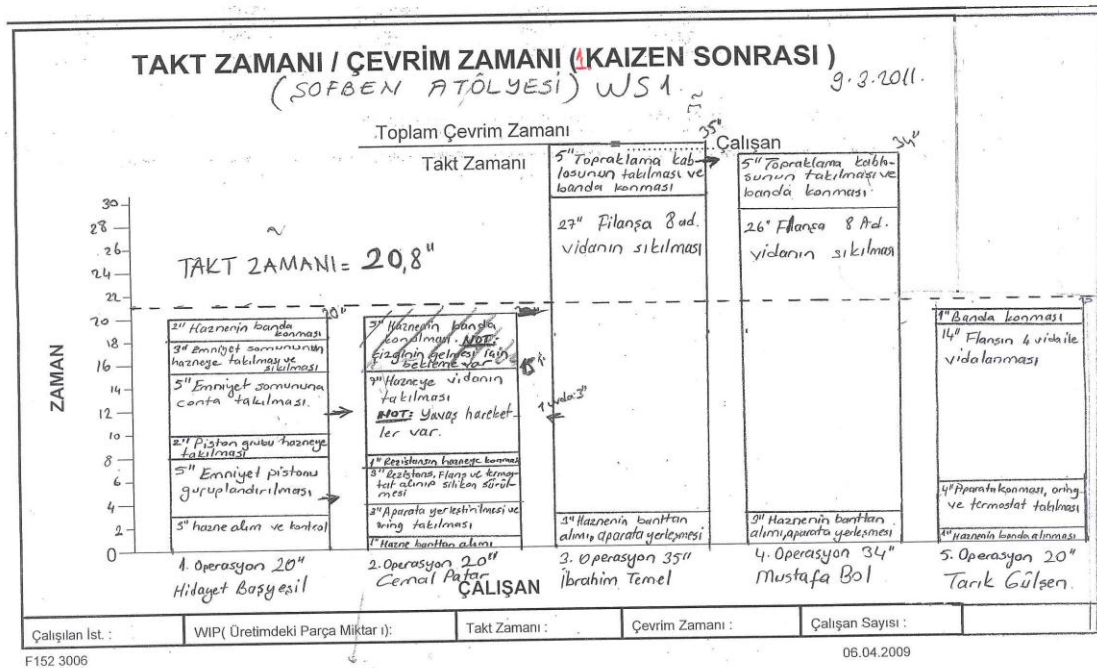
Çevrim Zamanı :

Çalışan Sayısı :

06.04.2009

Faruk Doğru

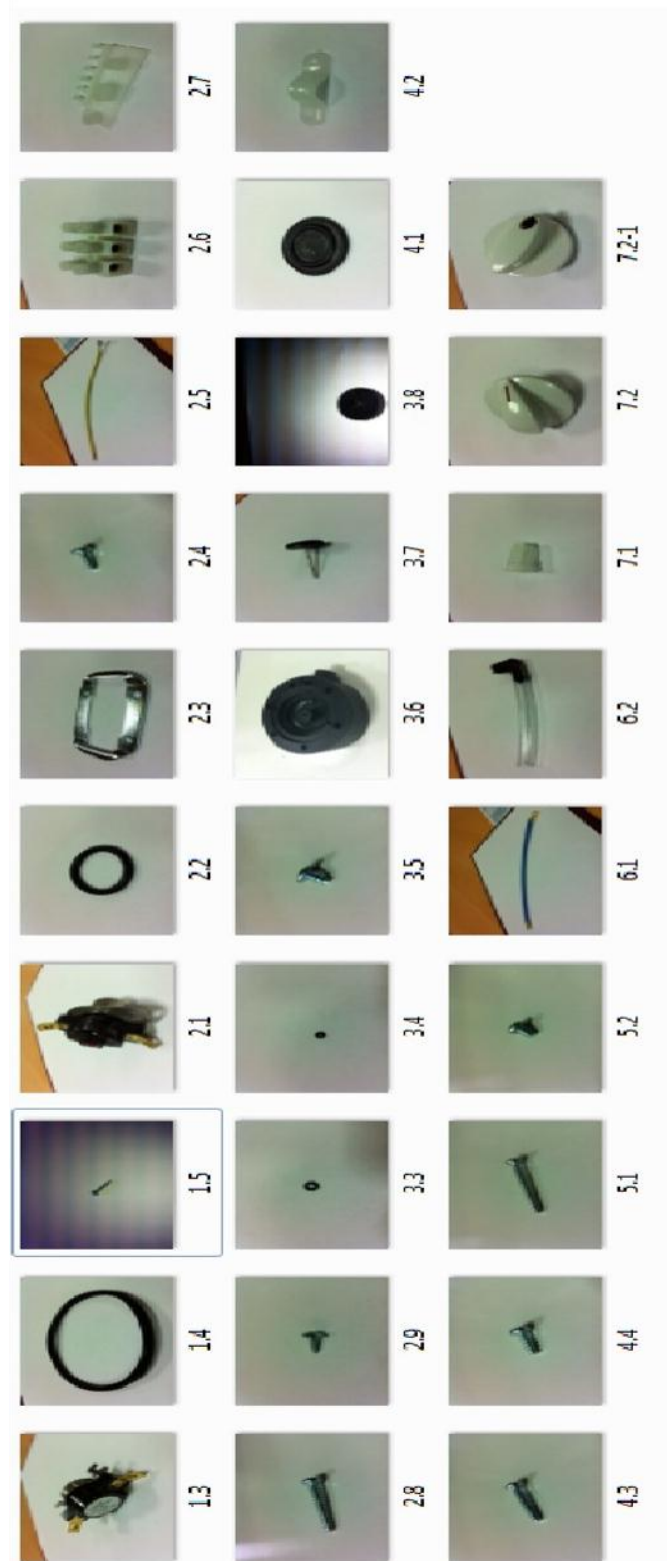
25.03.2014



APPENDIX C: Assembly Operation Phases

Stok Kodu	Stok İsmi	Kullanım Miktarı	Operatör Adı	Operasyon	Operatör İşlem S
120003Z01	MONTAJ GRUBU (VANA VE REDİKSİYONSUZ)	1,0000	Mehdi Demir	14	C
121006Z	DUS HORTUMU 3 MT	1,0000	Mustafa Güner	13	E
120007Z	EMNİYET PISTON GRUBU	1,0000	Mustafa Bol	1	B
124000Z	HAZNE ORINGI (75.5X5)	1,0000	Mustafa Bol	1	D
124013Z	BORU PVC SEFFAF	0,1200	Halil Polat	10	C
126017Z	TERMOSTAT 30 AMPER 60T21 105A3	1,0000	Mustafa Bol	1	E
128002Z01	IC POSET (40X45) (DELİKLİ VE YAZILI)	1,0000	Mustafa Güner	13	C
128003Z	DIS POSET (30+8+8+70)	1,0000	Mustafa İzzetoğlu	15	A
184004Z	EMNİYET SUBAB DİRSEĞİ	1,0000	Halil Polat	10	D
348055Z	BARKOD	4,0000	Mustafa Güner	13	B
601031Z	VIDA 3,5*24 YSB PLS KUT	1,0000	Turan Kula	4	F
601040Z	VIDA 3.5X9.5 YSB PLS.DIS KUT	4,0000	Mustafa Dal	3	D
601043Z	VIDA 3.5X13 YSB PLS. DIS KUT	1,0000	Seyit Arvas	12	D
601060Z	VIDA 3.5X13 RYSB PLS.DIS.SIVRI UC	2,0000	Turan Kula	4	B
601060Z	VIDA 3.5X13 RYSB PLS.DIS.SIVRI UC	1,0000	Turan Kula	4	D
601079Z	VIDA 3,5X17 ALTI KOSE BASLI	2,0000	Mustafa Bol	1	H
601079Z	VIDA 3,5X17 ALTI KOSE BASLI	6,0000	İbrahim Temel	2	A
603038Z	VIDA M4X6 YSB TİRTİLLİ	3,0000	Yusuf Arvas	8	A
603052Z	VIDA 3,5*19 YSB PLS KUT	4,0000	Şahin Gürler	6	B
603053Z	VIDA 3.5X28 YSB PLS KUT	2,0000	Tayyar Arvas	7	B
603054Z	VIDA 3.9 x6 RYSB ÇINKO KUT	1,0000	Mahir geylani	5	F
604000Z	EMNİYET SOMUNU	1,0000	Mustafa Bol	1	C
605004Z	RONDELA TİRTİLLİ M4(6798/04)	4,0000			
606053Z	MİL ORINGI 1.78X1.78	1,0000	Mahir geylani	5	C
606054Z	DIYAFRAM ORINGI 2.9X1.78	2,0000	Mahir geylani	5	B
606061Z	TERMOSTAT ORINGI 20 x 3	1,0000	Mustafa Dal	3	B
609005Z	ETİKET DIKKAT (YENİ TİP) KUTU	1,0000	Mehdi Demir	14	D
609009Z	HOLOGRAM ETİKET (19mm)	1,0000	Seyit Arvas	12	E
609020Z	VIDA 4.2X12 YSB PLS.KUT ZN	2,0000	Şahin Gürler	6	D
609020Z	VIDA 4.2X12 YSB PLS.KUT ZN	2,0000	Halil Polat	10	B
811007Z	DIYAFRAM GOVDE	1,0000	Mahir geylani	5	A
811011Z	DIYAFRAM ORING TIPASI	1,0000	Mahir geylani	5	E
811012Z	DIYAFRAM TIPASI	1,0000	Mahir geylani	5	D
811018Z	SINYAL VE KADEME LAMBASI TESPİT PARÇASI	1,0000	Turan Kula	4	C
812003Z	TERMOSTAT BAĞLANTI FLANSI (KUCUK)	1,0000	Mustafa Dal	3	C
814004Z	DIYAFRAM CONTASI (40 SHORE)	1,0000	Şahin Gürler	6	A
816006Z	TERMOSTAT 60T85 RESETLİ	1,0000	Mustafa Dal	3	A
831007Z	SU GİRİS SUZGEÇİ (B. SOFBENİ İÇİN)	1,0000	Seyit Arvas	12	C
831008Z	ON KUTU (MICROCONTROL)	1,0000	Seyit Arvas	12	A
831009Z	ARKA KAPAK (MICROCONTROL)	1,0000	Turan Kula	4	A
832001Z	TERMOSTAT FLANSI TERMINALSIZ	1,0000	Mustafa Bol	1	G
836017Z	REZİSTANS ELEKTRO NANO FINİSH 7KW 220V TERMINALLİ	1,0000	Mustafa Bol	1	F
840001Z	MICROSWİC GRUBU	1,0000	Tayyar Arvas	7	A
840003Z	BAGLANTI GRUBU	1,0000	Mehdi Demir	14	B
841004Z01	HAZNE ÇIKIŞ KUMANDALI (İNCE OLAN)	1,0000	Mustafa Bol	1	A
841005Z	KABLO KROSESİ(MICRO CONTROL)	1,0000	Şahin Gürler	6	C
841007Z	ANAHTAR DÜĞMESİ KADEME İSARETLİ 105MC	1,0000	Seyit Arvas	12	B
846001Z	KABLO GURUBU VDL MICRO CONTROL SOFBEN	1,0000	Mustafa Dal	3	E
846001Z	KABLO GURUBU VDL MICRO CONTROL SOFBEN	1,0000	Tayyar Arvas	7	C
846001Z	KABLO GURUBU VDL MICRO CONTROL SOFBEN	1,0000	Erkan Özfidan	9	A
846001Z	KABLO GURUBU VDL MICRO CONTROL SOFBEN	1,0000	Halil Polat	10	A
846002Z	KLEMENS 3 NOLU 3 LU	1,0000	Turan Kula	4	E
848000Z	KUTU AURA MICRO CONTROL SOFBEN	1,0000	Mustafa Güner	13	A
848003Z02	KUL.KLAVUZU AURA SOFBEN (MICROCONTROL)	1,0000	Mustafa Güner	13	D
848006Z	KOLİ AURA MICRO CONTROL SOFBEN	0,1700	Mustafa İzzetoğlu	15	B
848007Z	SEPERATOR	1,0000	Mehdi Demir	14	A
	ELEKTRİK VE SU TESTİ		Suray Gönülaçık	11	A

Kanban materials and box numbers of water heater parts



AURA MICROCONTROL BANYO ŞOFBEN (1300084) MONTAJI OPERASYON SAFHALARI

Hesaplamalar Günlük 1.000 Adede Göre Yapılmıştır.

Stok Kodu	Stok İsmi	Kullanım Miktarı	Sevkiyat Tipi	Sevkiyadaki Adet	TAKT (dakika)	Yeterlilik Süresi (dakika)	Günlük Tur Sayısı	Mevcut Stok	Gereken Kutu Miktarı	Sipariş Aralığı	Operatör Adı	Operasyon	İşlem Sırası	İşlem Açıklama
841004Z01	HAZNE	1,00	SET1	210	0,5	105	4,76	4.919	23,42		Mustafa Bol	1	1.1	Hazne Alınır
120007Z	EMNİYET PİSTON GRUBU	1,00	A300	2.000	0,5	1.000	0,50	11.992	6,00		Mustafa Bol	1	1.2	Haznedeki Yuvasına Monte Edilir.
604000Z	EMNİYET SOMUNU	1,00	A300	350	0,5	175	2,86	26.789	76,54		Mustafa Bol	1	1.3	Hazneye Takılır
124000Z	HAZNE ORINGI (75.5X5)	1,00	A300	300	0,5	150	3,33	18.109	60,36		Mustafa Bol	1	1.4	Hazneye Yerleştirilir
126017Z	TERMOSTAT 30 AMPER	1,00	A300	200	0,5	100	5,00	15.132	75,66		Mustafa Bol	1	1.5	Termostat Flanşına Takılır
836017Z	REZİSTANS	1,00	SET2	100	0,5	50	10,00	10.549	105,49		Mustafa Bol	1	1.6	Flanşa Takılır
832001Z	TERMOSTAT FLANŞI	1,00	SET2	100	0,5	50	10,00	7.973	79,73		Mustafa Bol	1	1.7	Hazneye Yerleştirilir
601079Z	VIDA 3,5X17 ALTI KOŞE BASLI	2,00	A300	10.000	0,5	2.500	0,20	257.691	25,77		Mustafa Bol	1	1.8	Flanş Hazneye Vidalanır
601079Z	VIDA 3,5X17 ALTI KOŞE BASLI	6,00	A300	10.000	0,50	833	0,60		0,00		İbrahim Temel	2	2.1	Bu Operasyonda 6 Adet Vida Takılır. 1. Operasyonda Takılan Vidalar Sıkılır.
816006Z	TERMOSTAT 60T85 RESETLİ	1,00	A300	125	0,50	63	8,00	15.626	125,01		Mustafa Dal	3	3.1	Alınır
606081Z	TERMOSTAT ORINGI 20 x 3	1,00	A300	2.500	0,50	1.250	0,40	50.874	20,35		Mustafa Dal	3	3.2	Oring Termostat Yuvasına Takılır ve Hazneye Yerleştirilir.
812003Z	TERMOSTAT BAĞLANTI FLANŞI	1,00	A300	500	0,50	250	2,00	13.717	27,43		Mustafa Dal	3	3.3	Termostat Bağlantı Flanşı Termostat Üzerine Monte Edilir.
601040Z	VIDA 3.5X9.5 YSB PLS.DİS KUT	4,00	A300	10.000	0,50	1.250	0,40	84.775	8,48		Mustafa Dal	3	3.4	Flanş Vidalanır.
846001Z	KABLO GURUBU	1,00	A300	800	0,50	400	1,25	10.728	13,41		Mustafa Dal	3	3.5	Topraklama Kablosu Rezistans Terminaline Takılır.
831009Z	ARKA KAPAK (MICROCONTROL)	1,00	SET3	80	0,50	40	12,50	3.495	43,69		Turan Kula	4	4.1	Alınır.
601060Z	VIDA 3.5X13 RYSB PLS.DİS.SİVRİ UC	2,00	A300	10.000	0,50	2.500	0,20	187.281	18,73		Turan Kula	4	4.2	Hazne Arka Kapağa Yerleştirilir ve Vidalanır.
811018Z	LAMBA TUTACAĞI (KAİDE)	1,00	A300	300	0,50	150	3,33	21.647	72,16		Turan Kula	4	4.3	Haznedeki Yeriye Yerleştirilir.
601060Z	VIDA 3.5X13 RYSB PLS.DİS.SİVRİ UC	1,00	A300	10.000	0,50	5.000	0,10		0,00		Turan Kula	4	4.4	Lamba Tutacağın (Kaide) Hazneye Vidalanır.
846002Z	KLEMENS 3 NOLU 3 LU	1,00	A300	2.000	0,50	1.000	0,50	39.712	19,86		Turan Kula	4	4.5	Arka Kapaktaki Yeriye Yerleştirilir.
601031Z	VIDA 3,5*24 YSB PLS KUT	1,00	A300	10.000	0,50	5.000	0,10	54.090	5,41		Turan Kula	4	4.6	Klemens Arka Kapağa Vidalanır.
811007Z	DIYAFRAM GÖVDE	1,00	A300	100	0,50	50	10,00	20.719	207,19		Mahir Geylani	5	5.1	Alınır
606054Z	DIYAFRAM ORINGI 2.9X1.78	2,00	A300	40.000	0,50	10.000	0,05	103.150	2,58		Mahir Geylani	5	5.2	Diyafram Gövdedeki Yeriye Takılır
606053Z	MİL ORINGI 1.78X1.78	1,00	A300	20.000	0,50	10.000	0,05	50.355	2,52		Mahir Geylani	5	5.3	Diyafram Gövdedeki Yeriye Takılır
811012Z	DIYAFRAM TİPASİ	1,00	A300	1.000	0,50	500	1,00	18.025	18,03		Mahir Geylani	5	5.4	Diyafram Gövdedeki Yeriye Takılır
811011Z	DIYAFRAM ORING TİPASİ	1,00	A300	4.000	0,50	2.000	0,25	22.075	5,52		Mahir Geylani	5	5.5	Diyafram Gövdedeki Yeriye Takılır
603054Z	VIDA 3.9 x6 RYSB ÇİNKO KUT	1,00	A300	10.000	0,50	5.000	0,10	40.860	4,09		Mahir Geylani	5	5.6	Diyafram Gövdesine Oringle Beraber Takılır
814004Z	DIYAFRAM CONTASI	1,00	A300	1.000	0,50	500	1,00	17.454	17,45		Şahin Gürler	6	6.1	Hazne ile Diyafram Gövde Arasına Takılır
603052Z	VIDA 3,5*19 YSB PLS KUT	4,00	A300	1.000	0,50	125	4,00	80.540	80,54		Şahin Gürler	6	6.2	Diyafram Gövdesi Hazneye Vidalanır
841005Z	KABLO KELEPÇESİ	1,00	A300	2.000	0,50	1.000	0,50	27.880	13,94		Şahin Gürler	6	6.3	Arka Kapağa Yerleştirilir
609020Z	VIDA 4.2X12 YSB	2,00	A300	10.000	0,50	2.500	0,20	104.090	10,41		Şahin Gürler	6	6.4	Kablo Kelepçesi Arka Kapağa Vidalanır
840001Z	MICROSWİC GRUBU	1,00	SET4	200	0,50	100	5,00	8.751	43,76		Tayyar Arvas	7	7.1	Alınır
603053Z	VIDA 3.5X28 YSB PLS KUT	2,00	A300	10.000	0,50	2.500	0,20	47.030	4,70		Tayyar Arvas	7	7.2	Mikroswitch Diyafram Gövdeye Vidalanır
846001Z	KABLO GURUBU	1,00	SET4	200	0,50	100	5,00	10.728	53,64		Tayyar Arvas	7	7.3	Led Göz Lambalan Kaideye Takılır. 1 Adet Kablo Soketi Microswitch Takılır
603038Z	VIDA M4X8 YSB TİRTİLLİ	3,00	A300	10.000	0,50	1.667	0,30	140.865	14,09		Yusuf Arvas	8	8.1	3 Adet Kademe Terminaleri Vidalanır. 3 Adet Kademe Soketleri Microswitch Takılır
846001Z	KABLO GURUBU	1,00	A300	800	0,50	400	1,25	10.728	13,41		Erkan Özfidan	9	9.1	Reset ve Limit Termostatların Kabloları Takılır. Ayrıca 4 Adet Vida Vidalanır.
846001Z	KABLO GURUBU				0,50	-		-			Halil Polat	10	10.1	Elektrik Bağlantıları (FTN) Klemense Takılır.
609020Z	VIDA 4.2X12 YSB	2,00	A300	10.000	0,50	2.500	0,20		0,00		Halil Polat	10	10.2	Kademe Anahtarı Arka Kapağa Vidalanır.
124013Z	BORU PVC SEFFAF (T.HORTUMU)	1,00	A300	200	0,50	100	5,00	5.122	25,61		Halil Polat	10	10.3	Hazne Üzerindeki Emniyet Somununa Takılır.
	ELEKTRİK VE SU TESTİ				0,50	-		-			Suray Gönülaçık	11	11.1	İlgili Testler Yapılır
831008Z	ON KUTU (MICROCONTROL)	1,00	PALET	300	0,50	150	3,33	2.165	7,22		Seyit Arvas	12	12.1	Arka Kapağa Monte Edilir
841007Z	ANAHTAR DUGMESİ	1,00	A300	250	0,50	125	4,00	2.990	11,96		Seyit Arvas	12	12.2	On Kutuya Takılır
831007Z	SU GRİS SUZGEÇİ	1,00	A300	2.000	0,50	1.000	0,50	53.429	26,71		Seyit Arvas	12	12.3	Haznenin Su Giriş Yeriye Takılır
601043Z	VIDA 3.5X13 YSB PLS. DİS KUT	1,00	A300	10.000	0,50	5.000	0,10	88.881	8,89		Seyit Arvas	12	12.4	On Kutu Arka Kapağa Vidalanır
609009Z	HOLOGRAM ETİKET (19mm)	1,00	A300	24.500	0,50	12.250	0,04	166.430	6,79		Seyit Arvas	12	12.5	Arka Kapağa Yapıştırılır
848000Z	KUTU	1,00	SET5		0,50	0	-	7.667	-		Mustafa Güner	13	13.1	Ambalaj Kutusu Hazırlanır
348055Z	BARKOD	4,00	A300	5.000	0,50	625	0,80	550.057	110,01		Mustafa Güner	13	13.2	Kullanma Kılavuzu, Mamul ve 2 Adet Kutuya Yapıştırılır.
128002Z01	İÇ POSET	1,00	SET5		0,50	0	-	57.009	-		Mustafa Güner	13	13.3	Poşetin İçine Mamul Konulur.
848003Z02	KUL KLAVUZU	1,00	A300		0,50	0	-	8.319	-		Mustafa Güner	13	13.4	İç Poşete Konulur
121006Z	DÜS HORTUMU 3 MT	1,00	SET5		0,50	0	-	13.760	-		Mustafa Güner	13	13.5	Kutunun İçine Atılır.
848007Z	SEPERATOR	1,00	SET6		0,50	0	-	9.531	-		Mehdi Demir	14	14.1	Mamul ve Montaj Grubunu Ayırmak İçin Kutuya Konulur.
840003Z	BAGLANTI GRUBU	1,00	SET6		0,50	0	-	2.682	-		Mehdi Demir	14	14.2	Kutuya Konulur
120003Z01	MONTAJ GRUBU	1,00	SET6		0,50	0	-	11.402	-		Mehdi Demir	14	14.3	Kutuya Konulur
609005Z	ETİKET DİKKAT (YENİ TİP) KUTU	1,00			0,50	0	-	19.260	-		Mehdi Demir	14	14.4	Kutu Kapatıldıktan Sonra Dikkat Etiketini Kutuya Yapıştırılır.
128003Z	DİS POSET (30*8+8*70)	1,00			0,50	0	-	23.975	-		Mustafa İzzetoğlu	15	15.1	Kolinin İçine 6 Adet Poşet Koyulur.
848006Z	KOLİ	0,17			0,50	0	-	2.536	-		Mustafa İzzetoğlu	15	15.2	Kutulanmış Mamuller Terazide Tartılarak, Barkodları Koliye Yapıştırılır.
605004Z	RONDELA TİRTİLLİ M4(6798/04)	4,00					-	121.268,00	-		Hüseyin Kızıkoğlu	Yan İş		Limit ve reset Termostatların Vidalarına Rondela Takılır.
124013Z	BORU PVC SEFFAF (T.HORTUMU)	0,12					-	5.122,00	-		Fehim Arvas	Yan İş		Tahliye Hortumu 12 Cm Uzunluğunda Kesilir.
184004Z	EMNİYET SUBAB DİRSEĞİ	1,00					-	22.075,00	-		Fehim Arvas	Yan İş		Tahliye Hortumuna Takılır
121029Z	EMNİYET PİSTONU	1,00					-	11.992,00	-		Fehim Arvas	Yan İş		
605056Z	EMNİYET PİSTON CONTASI	1,00					-	15.175,00	-		Fehim Arvas	Yan İş		120007Z EMNİYET PİSTON GRUBU Olarak Gruplanıp B.Ş Bantına Verilir.
607071Z	EMNİYET SİBOP YAYI	1,00					-	21.315,00	-		Fehim Arvas	Yan İş		