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İŞLETME ANABİLİM DALI
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COST MANAGEMENT SYSTEM IN LEAN ENTERPRISES: LEAN ACCOUNTING

Doktora Tezi

AYŞE İREM KESKİN

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Danışman: DOÇ. DR. FİGEN ÖKER

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Marmara Üniversitesi
Sosyal Bilimler Enstitüsü Müdürlüğü

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İŞLETME Anabilim Dalı MUHASEBE FİNANSMAN(İNG) Bilim Dalı Doktora öğrencisi AYŞE İREM KESKİN nın COST MANAGEMENT SYSTEM IN LEAN ENTERPRISES:LEAN ACCOUNTING adlı tez çalışması ,Enstitümüz Yönetim Kurulunun 07.05.2010 tarih ve 2010-8/22 sayılı kararıyla oluşturulan jüri tarafından oybirliği/~~oyçokluğu~~ ile Doktora Tezi olarak kabul edilmiştir.

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ABSTRACT

COST MANAGEMENT SYSTEM IN LEAN ENTERPRISES: LEAN ACCOUNTING

The manufacturing companies are forced to produce high quality products more quickly and at a competitive cost, as a result of rising global competitive environment. In order to reach these goals, today's manufacturing organizations need to produce with modern manufacturing systems such as lean manufacturing. It is not possible to provide all the advantages of lean manufacturing without having management accounting Understanding the key elements of lean approach to manufacturing is also essential to the competitive success of Turkish manufacturing industry in global competition.

The purpose of this dissertation is to discover the effect of lean manufacturing practices in financial performance of a company. The research area of dissertation is a case study on a manufacturing enterprise. The main objective of this research is to develop a lean cost management system in a manufacturing enterprise and to examine the effects of lean improvements on this company. Therefore, first section of the research determines the current state and the second section of the research displays the future state of lean enterprise.

This study shows that the lean improvements lead the development in operational, capacity and financial performance of the value stream. The lean initiatives reduce the production time and therefore decrease the production costs. The lean accounting provides more adequate and relevant information to support managerial stuff for better business decisions. Improvement activities in the future state free up more employee and machine time, so provide an opportunity to enhance new products or to use labor more efficiently without increasing production costs.

GENEL BİLGİLER

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ÖZET

YALIN İŞLETMELERDE MALİYET YÖNETİM SİSTEMİ: YALIN MUHASEBE

Dünya çapında artan küresel rekabetin sonucunda, işletmeler yüksek kaliteli ürünleri daha çabuk ve rekabetçi maliyetlerle üretmek için çaba göstermektedirler. Bu hedeflere ulaşmak için, günümüz işletmeleri yalın imalat gibi modern üretim sistemlerine ihtiyaç duymaktadırlar. Ancak yalın imalatın tüm avantajlarını, yalın üretim sistemini destekleyen ve başarılı olmasını sağlayan yönetim muhasebesi sistemini de işletmede kurmadan sağlamak mümkün değildir. Yalın imalat yaklaşımının temel esaslarını anlamak, Türkiye'deki imalat sektörünün küresel rekabette başarılı olması açısından ayrıca önemlidir.

Bu çalışmanın amacı, yalın imalat uygulamalarının işletmenin finansal performansına olan etkisini belirlemektir. Tezin uygulaması bir imalat işletmesinde vaka çalışmasıdır. Uygulamanın ana hedefi, bir imalat işletmesinde yalın maliyet yönetim sisteminin kurulması ve yapılan yalın iyileştirmelerin firmaya etkilerinin ölçülmesidir. Bu yüzden, uygulamanın birinci bölümünde mevcut durum belirlenmiş ve ikinci bölümde yalın işletmenin gelecekteki durumu gözler önüne serilmiştir.

Ele alınan işletmedeki yalın iyileştirme çalışmaları, işletme değer akışının organizasyonel, kapasite ve finansal performansında gelişmeler sağlamıştır. Yalın uygulamalar üretim zamanını kısaltmış ve böylece üretim maliyetlerini azaltmıştır. Yalın muhasebe, yöneticilere daha iyi işletme kararlarını destekleyen uygun ve doğru bilgiyi sağlamaktadır. Bazı birimlerde işçilik ve makine saatinde ortaya çıkan atıl kapasite hesaplamaları işletmeye üretim maliyetlerini arttırmadan yeni ürün geliştirme veya işgücünü daha iyi kullanma imkânı vermiştir.

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ABBREVIATIONS

AR	Accounts Receivable
C/O	Changeover Time
C/T	Cycle Time
EBITDA	Earnings before Income Taxes, Depreciation and Amortization
ECI	Electronics Components Incorporated
FIFO	First-in-first-out
FTT	First Time Through
GAAP	Generally Accepted Accounting Principles
IMVP	International Motor Vehicle Program
JIT	Just-in-time
OEE	Operational Equipment Effectiveness
ROS	Return on Sales
SMED	Single-Minute Exchange of Die
SOP	Standard Operations Procedure
SOS	Standard Operations Sheet
SMT	Surface Mount Machine
SWIP	Standard Work-In-Process
TPM	Total Productive Maintenance
WIP	Work in Process
5 S	Sifting-Sorting-Sustain-Standardize-Sweeping

1. INTRODUCTION

The globalization of world has an important effect on companies as it realizes the strict competition among companies. The manufacturing companies are imperative to produce high quality products more quickly and at a competitive cost, as a result of rising global competitiveness worldwide. Therefore, this enables customers to purchase quality products at a competitive price on a timely basis.

In order to reach these goals, today's manufacturing organizations need to produce with modern manufacturing systems such as lean manufacturing. It is not possible to provide all the advantages of lean manufacturing without management accounting systems that encourage and succeed the lean production system.

Traditional management accounting system is not appropriate for lean production. Formerly, the share of overhead costs in the company is lower than today's environment. In lean accounting, overhead costs are traced according to product groups that use the resources in the entire value stream. This change in cost structures leads to new approaches in accounting systems. Therefore, lean accounting system is developed to support lean manufacturing.

The world's manufacturing environment went through the change from craft to mass production in the late nineteenth and early twentieth centuries.

The mass production was developed by Henry Ford who designed the new automobile production system. Individual automobiles were produced by master craftsmen with high quality and high price in the craft production. Henry Ford discovered this lack of effectiveness and introduced the assembly process.

The mass production transforms to a new manufacturing system named as lean production as the world enters twenty first century.

The origin of lean enterprise and production is Japan. The concept "lean" was developed by Toyota Production System after World War II, however, not called as "lean production" until 1990. This system was suitable to Japan's postwar environment.

The problems of post war environment were low employee quantity, small domestic market, scarce resources, low capital level and limited land. As a result of the new improvement efforts, Toyota Production System was discovered by Taiichi Ohno. The Toyota Motor Company could provide the profit by reducing costs, excess inventory and workforce through improvement activities to eliminate of transactions that create waste.

The global economy was in recession after Oil Crisis of 1970's. However, the Toyota Motor Company enabled higher earnings compared to other companies. Therefore, other companies were financially interested in Toyota Production System.

The term lean production system was identified first by John Krafcik in his master thesis. It was used widely by James Womack, Daniel T. Jones and Daniel Ross in their book "The Machine that Changed the World". Five key principles of lean production; value, value stream, flow, pull and perfection, were developed by James Womack and Daniel T. Jones in their book "Lean Thinking".

Lean manufacturing has become a critical global business strategy for many manufacturers around the world. Understanding the key elements of lean approach to manufacturing is also essential to the competitive success of Turkish manufacturing industry in global competition.

The purpose of this dissertation is to discover the effect of lean manufacturing practices in financial performance of a company. The case study tests this impact through investigating the characteristics of lean production that have an effect on the costs of the company. In order to reach to this purpose, the dissertation measures the following assumptions;

- Lean accounting provides low costs by removing waste from manufacturing and accounting processes.
- Lean production initiatives improve operational performance of the company.

- Lean production improvements develop capacity performance of the company.

In order to prove these assumptions, the dissertation is organized in four remaining chapters.

Two important revaluations in manufacturing sector occurred in the twentieth century. The first development was mass production and the second development was lean production. Chapter 2 reviews the historical background of lean enterprises.

Chapter 3 provides a theoretical framework for the dissertation and a review of the literature on lean manufacturing and accounting. This chapter consists of two main sections; manufacturing and management environment in lean enterprises and accounting and costing systems in lean enterprises. Principles of lean enterprises, basic terminology of lean enterprises and value stream management are defined in manufacturing and management environment in lean enterprises section of dissertation. Basic terminology of lean enterprises section highlights the terms; just-in- time, autonomation, continuous improvement, 5 S, mistake proofing and visual control. Value stream management section suggests the usefulness of value stream mapping, value stream capacity analysis and value stream performance measurements in identifying the value adding and non-value adding activities in lean enterprises. Accounting and costing systems in lean enterprises section of Chapter 3 contains lean financial accounting and lean cost management.

Chapter 4 describes the case study and presents the findings from this research. The research includes current and future state of value stream.

Chapter 5 presents conclusions, recommendations and offers directions for future research into the effects of lean management practices to financial performance. This dissertation represents that value stream costing provides operational, capacity and financial performance information to make better business decision in lean manufacturing companies.

2. HISTORICAL BACKGROUND OF LEAN ENTERPRISES

Before lean thinking concept, it is essential to understand the historical context of the shift from the agricultural system to the craft system; from craft to mass production; and from mass production to lean thinking.

The important industrial developments have not occurred immediately. Every step of the process has experienced an evolution over long periods, going through centuries in the case of craft production, almost a century of mass production and lately in the case of lean production. Table 1 shows the comparison of thinking associated with craft, mass production and lean production.[1]

Table 1

The Comparison of Craft, Mass and Lean Production

	Craft	Mass Production	Lean thinking
Focus	Task	Product	Customer
Operations	Single Items	Batch and queue	Synchronized flow and pull
Overall Aim	Mastery of Craft	Reduce cost and increase efficiency	Eliminate waste and add value
Quality	Integration (part of the craft	Inspection (a second stage after production)	Prevention
Business Strategy	Customization	Economies of scale and automation	Flexibility and adaptability
Improvement	Master-driven continuous improvement	Expert-driven periodic improvement	Workforce-driven continuous improvement

Source: Murman, Earll M. **Lean Enterprise Value : Insights from MIT's Lean Aerospace Initiative**. Great Britain, New York, NY, USA: Palgrave Macmillan, 2002, p.97.

In the twentieth century, two essential revaluations in manufacturing sector occurred. The first development was mass production, best described with Henry Ford's Model T, and the second development was lean production with Toyota. Both

[1] Murman, Earll M. **Lean Enterprise Value : Insights from MIT's Lean Aerospace Initiative**. Great Britain, New York, NY, USA: Palgrave Macmillan, 2002, p.96-98.

innovations maturity path took ten years, mass production between 1915 and 1925 and lean production between 1951 and 1961.[2]

In the craft production, individual cars were built by master craftsmen with an extensive range of skills and abilities but with inadequate efficiency and at high cost. Henry Ford discovered this lack of productivity and the assembly process was divided by him down into 30-second tasks, which were realized nearly a thousand times per day.[3]

Before Henry Ford developed mass production, the automobile industry had been conducted by craft producers who assembled their products with high quality and sold them with high prices.[4]

Henry Ford definitely designed the automobile production system. The Ford manufacturing system is the basis of mass-production. The system depends on work flow, which mostly defined the automation system. In mass production system, raw materials are machined and transported along line belts to be transformed into assembled parts. Each of assembled part is combined in final manufacturing process and becomes fully assembled automobiles coming out the line one by one. The final assembly line has a fixed speed.[5]

The origin of the mass-production system was standardization of components, production processes and an easy way to manufacture standard products. Concerning mass-production system, in regards to standardization, innovations are made in machine tools and measurement systems with a moving continuous assembling line.[6]

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[2] Cooper, Robin. **When Lean Enterprises Collide, Competing Through Confrontation.** Boston, Massachusetts: Harvard Business School Press, 1995, p.3-5.
[3] Worley, J.M. and T.L. Doolen. "The Role of Communication and Management Support in a Lean Manufacturing Implementation". **Management Decision.** Volume 44, Issue 2, 2006, p. 229.
[4] Cooper, Robin. **When Lean Enterprises Collide, Competing Through Confrontation.** Boston, Massachusetts: Harvard Business School Press, 1995, p.3-5.
[5] Ohno, Taiichi. **Toyota Production System : Beyond Large-Scale Production.** United States of America: Productivity, Inc.,1988, p.93.
[6] Hobbs, Dennis P.. **Lean Manufacturing Implementation : A Complete Execution Manual for Any Size Manufacturer**. United States of America: J. Ross Publishing, 2004, p.14

After the introduction of mass production, it was possible to produce a car at a low cost compared to the costs of the craft producers. As a result of cost reduction, middle class customers were introduced to the automobile sector. Because of cost advantage, more firms became effective mass producers to be competitive. For that reason, the competition in the industry shifted from rivalry among craft producers to rivalry among mass producers. With the occurrence of lean production, the competition shifted from among mass producers to among lean producers.[7]

Lean thinking concept is defined with two important approaches: eliminating waste and creating value. The general definition of lean thinking according to the synthesis of studies is "The dynamic, knowledge-driven, and customer focused process through which all people in a defined enterprise continuously eliminate waste with the goal of creating value."[8]

The lean philosophy approves permanent improvement related to eliminating all operational and organizational waste. Generally, lean applications deal with operational waste instead of organizational waste, but lean thinking can be implemented anywhere the waste occurs.[9]

In manufacturing sector, the lean thinking emphasizes following wastes:[10]

- Over production,
- Waiting between processes,
- Inappropriate transportation,
- Inadequate processing,

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[7] Cooper, Robin. **When Lean Enterprises Collide, Competing Through Confrontation.** Boston, Massachusetts: Harvard Business School Press, 1995, p.3-5.
[8] Murman,.p. 89-90.
[9] Northrup, C. Lynn. **Dynamics of Profit-Focused Accounting : Attaining Sustained Value and Bottom-Line Improvement**. United States of America: J. Ross Publishing, 2004, p.13.
[10] Bhasin, Sanjay and Peter Burcher. "Lean Viewed as a Philosophy". **Journal of Manufacturing Technology Management.** Volume 17, Issue 1, 2006, p. 58.

- Unnecessary actions, and
- Faults.

Lean manufacturing not only successfully changed the well known mass manufacturing practices in the automobile industry; but also positively affected the relationship between productivity and quality. Lean production is redevelopment of an extensive range of manufacturing and service operations beyond the high-volume iterative manufacturing processes. [11]

Table 2

Lean Thinking Development

Phases	1980-1990	1990-mid 1990	Mid 1990-2000	2000-Present
Literature Subject	Development of shop-floor practices	Best practice movement, benchmarking leading to emulation	Value stream thinking, lean enterprise, collaboration in the supply chain	Capability at system level
Focus	JIT techniques, cost	Cost, training and promotion, Total Quality Management, process reengineering	Cost, process-based to support flow	Value and cost, tactical to strategic, integrated to supply chain
Key Business Process	Manufacturing, shop-floor only	Manufacturing and materials management	Order fulfillment	Integrated processes, such order fulfillment and new product development
Industry Sector	Automotive – vehicle assembly	Automobile – vehicle and component assembly	Manufacturing in general – often focused on repetitive manufacturing	High and low volume manufacturing, extension into service sectors

Source: Hines, Peter, Matthias Holweg and Nick Rich. "Learning to Evolve: A Review of Contemporary Lean Thinking". **International Journal of Operations & Production Management.** Volume: 24, Issue 10, 2004, p. 996.

[11] Holweg, Matthias. ‘‘The Genealogy Of Lean Production’’. **Journal of Operations Management**. Volume 25, Issue 2, March 2007, p. 420.

Table 2 shows the summary of lean thinking development. Between 1980 and 1990, the awareness of lean thinking occurred in manufacturing sector. The practice of manufacturing was only tool-focused in shop-floor. A gradual extension of lean thinking which was realized after 1990, based upon Womack and Jones's basic lean principles. This development may be presented in summary as a focus on quality during the early literature, on cost and delivery in late 1990's and on customer value from 2000 to present.[12]

In spite of the managerial terminology, the term "lean" was observed in the literature between late 1980's and early 1990's, this new manufacturing thinking method developed many years ago. Figure 1 shows the timeline of lean concept related studies from 1970 to present. Dates above the timeline present the concepts on lean thinking studies such as lean, quality, just-in-time, six sigma and continuous improvement. [13]

In the past tree decades, lean production has been known as the Toyota Production System or Just-in-Time system.[14] Fundamental studies in the timeline are Ohno and Shingo's "Toyota Production System", Deming's "Out of Crisis", Monden's "Just-in-time", Imai's "Kaizen", Womack and Jones's "The Machine That Changed the World" and "Lean Thinking".

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[12] Hines, Peter, Matthias Holweg and Nick Rich. "Learning to Evolve: A Review of Contemporary Lean Thinking". **International Journal of Operations & Production Management.** Volume: 24, Issue 10, 2004, p.995.

[13] Murman, p. 101.

[14] Wu, Yen Chun. "Lean Manufacturing: A Perspective of Lean Suppliers". **International Journal of Operations & Production Management.** Volume 23, Issue 11, 2003, p.1349.

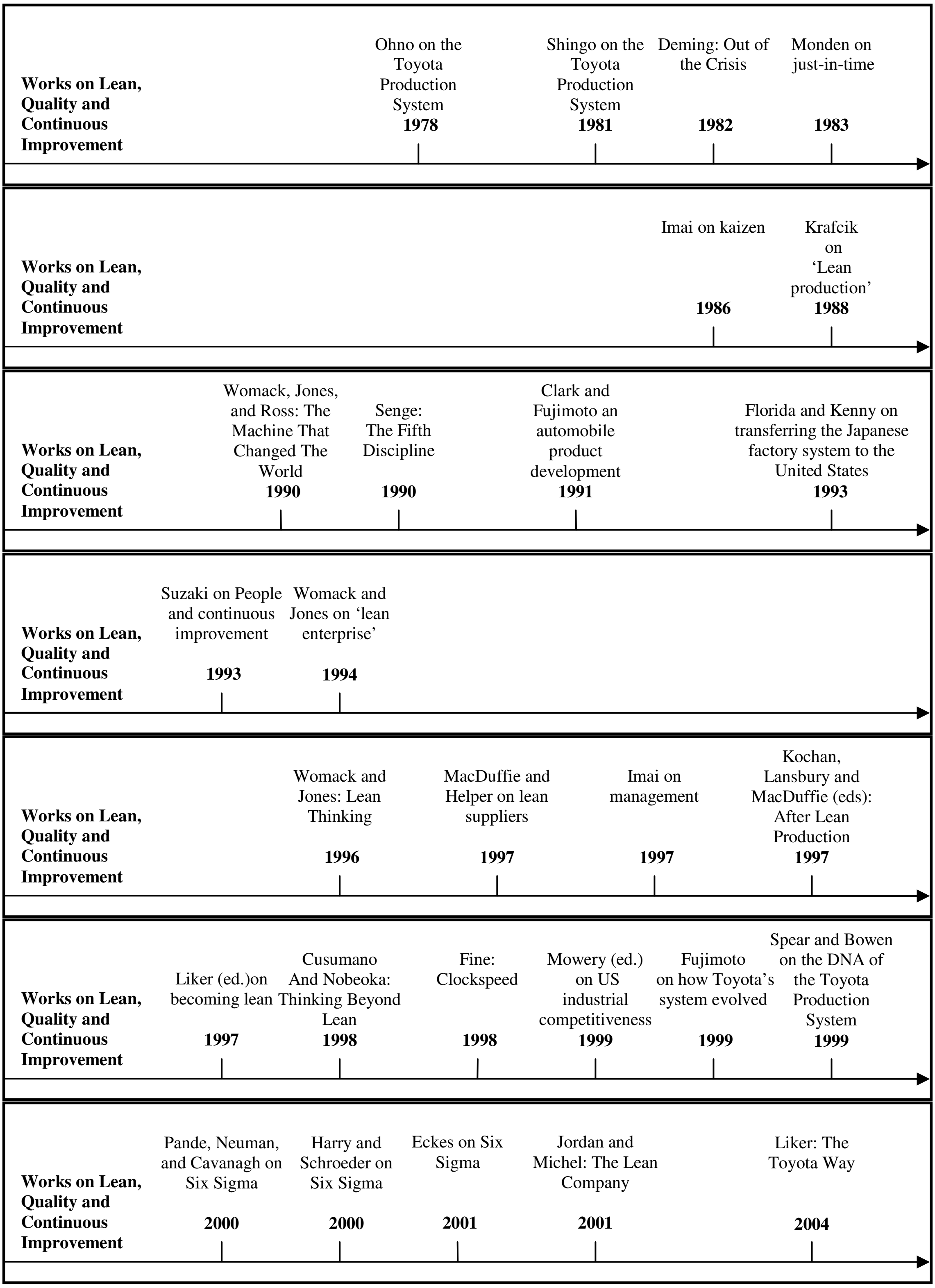

Figure 1: Timeline of the History of Lean Thinking from 1970 to Present

Source: Murman, p.100-106.

The basis of lean enterprises and production is Japan. The philosophy of lean thinking is achieving improvements in most effective ways with a special view on waste. The term waste is one of the most significant concepts in quality improvement activities and is developed by Toyota. This production philosophy was named as Toyota Production System.[15] The Toyota production system was discovered and executed by Toyota Motor Company. The basic aim of the system is to eliminate activities that create waste through improvement.[16]

Most of the Japanese manufacturing firms have succeeded in perfect international competitiveness in several industries such as auto, electronics, and machinery through the past twenty years. Because of strict competition in the world, increasing operation costs and growing operational obstacles, many production firms have tended to understand Japanese manufacturing methods.[17]

The beginning of lean thinking is based on the Japanese manufacturing, and particularly, on beneficial improvements at Toyota Motor Company. These improvements and developments do result from lack of resources and competition in the Japanese market for automobiles.[18]

After the Oil Crisis in the fall of 1973, the World's economy was in recession. Governments, businesses, and societies all over the world were affected. In 1974, Japan's economy had zero growth and many companies collapsed. Although profits were influenced at the Toyota Motor Company, higher earnings were provided from 1975 to 1977 compared to other companies. This difference between Toyota Motor Company and other companies made people becoming aware of Toyota Company.[19]

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[15] Dahlgaard, Jens J. and Su Mi Dahlgaard-Park. "Lean Production, Six Sigma Quality, TQM and Company Culture". **The TQM Magazine.** Volume 18, Issue 3, 2006, p. 264.
[16] Monden, Yasuhiro. **Toyota Production System : An Integrated Approach to Just-In-Time.** United States of America: The Institute of Industrial Engineers, 1993, p. 1.
[17] Wu, p.1349.
[18] Hines, p. 994.
[19] Ohno, p.1.

In the slow growth period, Toyota Motor Company could make a profit by diminishing costs and applying a production system that completely eliminates excess inventory and workforce.[20]

Toyota Production System was well suited to Japan's postwar environment and developed by Taiichi Ohno who was one of the Toyota executives. In 1978, Taiichi Ohno published a study on the Toyota Production System. In the postwar environment, the domestic market was both small and parted, the employee number was low, resources were scarce, land was quite limited, and little capital was available for new investments. For that reason, the mass production model would not work in the Japanese environment.[21]

Certain difficulties in the market required the production of low quantities of many varieties under circumstances of low customer demand. Toyota's problem was how to decrease costs while producing small quantity of many types of cars. The most important objective of the system was increasing production efficiency and eliminating waste. For elimination of waste, the Toyota production system had two supporting concepts: just-in-time and autonomation known as automation with a human touch.[22]

Toyota Production System avoided the standard thinking of Cost + Profit = Sales Price. According to the Toyota Production System formulation of profit is Sales Price – Costs. This approach helps the management to concentrate on costs. In this system, cost is defined as waste and the purpose of the system is the elimination of waste.[23]

The management concept "lean" was introduced by Toyota Production System in 1950s, but not named as lean manufacturing until 1990.[24]

Lean is a management system developed for meeting the needs of humans in business and providing better effects for related business stakeholders such as

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[20] Monden, p.1.
[21] Murman, p.101.
[22] Ohno, p.1,4.
[23] Hobbs, p.16.
[24] Andersson, Roy, Henrik Eriksson and Hakan Torstensson. "Similarities and Differences Between TQM, Six Sigma and Lean". **The TQM Magazine.** Volume:18 Issue:3 2006, p. 288.

associates, suppliers, customers, investors and communities. It is based in two key principles, continuous improvement and respect for people, as shown in Table 3. The continuous improvement principle defines the key elements used to develop productivity. The respect for people principle defines management behaviors and business acts that provides elimination of waste and creation of value for customers. Also, the lean management system has two key aims, eliminating waste and creating value for customers, as shown in Table 3.[25]

Table 3

Key Lean Principles and Objectives

	Explanation	
Lean Principles Ohno (1988) and Toyota (2001)	Continuous improvement	Day-to-day activities performed to improve business processes in response to changing market conditions. Called "kaizen" in Japanese, which literally means "change for the better" (multi-lateral sense), and is often interpreted as "continuous improvement." Utilizes specific processes and tools to achieve improvements.
	Respect for people	People (i.e. stakeholders such as associates, customer, suppliers, investors and the community) are valuable resources to which a business owes it existence. Disrespecting people creates waste.
Objectives Ohno (1988)	Eliminate waste	Eliminate activities and behaviors that add cost but do not add value as perceived by end-use customers. The original seven wastes are: overproduction, waiting, transportation, processing, inventories, movement and defects. The eighth waste is behaviors. Waste is called "muda" in Japanese. Important related concepts are the elimination of unevenness.
	Create value for end-use customers	Focus on the value-creating activities that end-use customer's desire.

Source: Emiliani, and Stec, p.372.

In 1981, Shigeo Shingo did a study on the Toyota Production System. Shigeo Shingo designed innovations to improve production processes. Although the other

25 Emiliani, M.L. and D.J. Stec. "Leaders Lost in Transformation". **Leadership & Organization Development Journal.** Volume 26, Issue 5, 2005, p. 371.

managers in manufacturing sector applied large batch sizes, limited order quantities, long setup times, faulty products, deficient workforce and poor inspection systems, Shingo developed a new production system for manufacturing processes and their operations. His fundamental works are just-in-time (JIT), single-minute exchange of die (SMED), and the poka-yoke system (mistake-proof system) in factory floor.[26]

In 1982, W. Edwards Deming published the book named “Out of the Crisis”. Dr. W. Edwards Deming suggested that by applying proper tools of management, companies can rise quality and furthermore, decline costs by lowering waste, rework, and unemployment while rising customer satisfaction. The fundamental element is to apply permanent improvement and think of manufacturing as a hole system. When people and companies pay attention initially on quality, quality tends to increase and costs decrease over time. Furthermore, when people and companies pay attention initially on costs, costs tend to increase and quality decreases over time.[27]

In 1983, Yasuhiro Monden published the book on Toyota Production System and Just-in-time. According to Yasuhiro Monden, the just-in-time manufacturing system is an internal system in use by corporations especially by Toyota Motor Company. The aim of just-in-time system is producing required items in required amount at the required time. With the support of computer integrated technology and new information system programs, just in time systems realize decreased cost, increased quality and improved lead time.[28]

Masaaki Imai made a study called “Kaizen: The Key to Japan’s Competitive Success” in 1986. He presented the term “Kaizen” to the manufacturing sector. Kaizen means improvement. Furthermore, Kaizen is defined as ongoing improvement including

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[26] Shingo, Shigeo. **The Shingo Production Management System : Improving Process Functions.** United States of America: Productivity Press, Inc., 1992, p. xv.
[27] Deming, W. Edwards. **Out of Crisis**. United States of America: Massachusetts Institute of Technology, 1986, p.1-3.
[28] Monden, p.xv.

everyone both the mangers and workers.[29] An extensive definition of Kaizen concept is provided in Chapter 3.

In 1988, John Krafcik was the first one to use the term lean production system. He was a graduate student at MIT's Sloan School of Management and a researcher in the International Motor Vehicle Program (IMVP). In his master's thesis, he emphasized that lean production uses less manufacturing resources.[30]

Lean production is "lean" because this production type uses less human effort, manufacturing space, investment in tools and engineering hours for developing a new product, compared with mass production. Also, fewer inventories are needed in factory, defects are lower and product variety increases.[31]

James P. Womack, Daniel T. Jones and Daniel Ross published "The Machine that Changed the World" in 1990. After Toyota Company developed a new system of manufacturing, lean production term was used widely in "The Machine that Changed the World". Lean Production was the next big development of manufacturing after mass production.[32]

James P. Womack and Daniel T. Jones published the book named "Lean Thinking" in 1996. Five basic principles of lean production are identified by James J. Womack and Daniel T. Jones in their book. These principles are value, value stream, flow, pull and perfection.[33] The principles of lean production are explained in detail Chapter 3.

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[29] Imai, Masaaki. **Kaizen, The Key to Japan's Competitive Success.** United States of America: McGraw-Hill, Inc.,1986, p. 3.
[30] Murman, p.90.
[31] Womack, James P., Daniel T. Jones and Daniel Roos. **The Machine That Changed the World.** United States of America: Harper Collins Publishers, 1990, p. 13.
[32] Liker, Jeffrey K. and David Meier. **Toyota Way Fieldbook : A Practical Guide for Implementing Toyota's 4Ps**. United States of America: McGraw-Hill Professional Publishing, 2005, p. 3.
[33] Womack, James P. and Daniel T. Jones**. Lean Thinking: Banish Waste and Create Wealth in Your Corporation.** USA: Free Press, 2003, p.10.

In Table 4, the summary of characteristics related to lean production is compared among the studies of lean production.[34] These studies are made by James P. Womack, Daniel T. Jones, Taiichi Ohno, Shigeo Shingo and Yasuhiro Monden. Besides, the basic characteristics listed in the table are explained particularly in Chapter 3. Some of the characteristics of lean production are continuous improvement, elimination of waste, just-in-time production, kanban system, setup time reduction, 5 S – housekeeping, visual control system, poka yoke – mistake proofing.

[34] Pettersen, Jostein. **"Defining Lean Production: Some Conceptual and Practical Issues".** The TQM Journal. Volume 21, Issue 2, 2009, p. 131.

Table 4

The Summary of Characteristics Related to Lean Production

	Womack & Jones	Ohno	Monden	Shingo
Kaizen/Continuous Improvement	X	X	X	X
Setup time reduction	X	X	X	X
Just in time production	X	X	X	X
Kanban Pull System	X	X	X	
Poka yoke		X	X	X
Production leveling	X	X	X	X
Standardized work		X	X	X
Visual control and management		X	X	X
5S / Housekeeping	X	X	X	
Andon	X	X	X	X
Small lot Production		X	X	X
Time/Work Studies	X	X	X	
Waste Elimination	X	X		X
Inventory Reduction	X	X	X	X
Supplier involvement	X		X	
Takted Production			X	X
TPM/Preventive maintenance		X		
Autonomation			X	X
Statistical quality control	X		X	
Teamwork	X	X		
Work force reduction		X	X	X
100 % inspection				X
Layout adjustments			X	X
Policy Deployment	X			
Improvement circles			X	
Root cause analysis	X	X		
Value stream mapping	X			
Education/Cross training			X	
Employee involvement	X			
Lead time reduction				
Process synchronization			X	X
Cellular manufacturing				
Goal	Make products with fewer defects to precise customer desires	Cost reduction	Eliminate waste and reduce costs	Cost reduction through waste elimination

Source: Pettersen, Jostein. **"Defining Lean Production: Some Conceptual and Practical Issues".** The TQM Journal. Volume 21, Issue 2, 2009, p. 131.

3. LITERATURE REVIEW

In this chapter, theoretical origin of lean philosophy is explained in detail. The concept has a deep content with two main aspects; management and manufacturing environment of lean enterprises and accounting and costing systems in lean enterprises.

3.1. Management and Manufacturing Environment in Lean Enterprises

Management and manufacturing environment in lean enterprises is a fundamental subject for the understanding of lean thinking. Three main concepts are explained, such as principles of lean enterprises, basic terminology of lean enterprises and value stream management.

3.1.1. Principles of Lean Enterprises

In this chapter, the five basic principles of Lean Accounting are defined as an overview. These principles support customer value through target costing, avoiding waste through value stream management, improving flow through capacity management, managing pull through activities with planning, and maintaining perfection through continuous process improvement.[35]

James J. Womack and Daniel T. Jones identify five basic principles of lean production in their book ‘‘Lean Thinking’’ as follows:[36]

- Value,
- Value stream,
- Flow,
- Pull,

[35] Berry, Patrick K. and John Hilary Cox. **Lean Accounting And Management : Improving Profitability By Streamlining Operations.** Lewisville, Tex.: American Institute of Certified Public Accountants, 2006, p.1-1.

[36] Womack, James P. and Daniel T. Jones**. Lean Thinking: Banish Waste and Create Wealth in Your Corporation.** USA: Free Press, 2003, p.10.

- Perfection.

Value is definitely determined for the product, value stream is established for every product, value is provided for continuous flow, pulled by customer from producer, so perfection is established. [37]

These principles provide a framework for the lean enterprise. Figure 2 describes the relationship of these principles.[38]

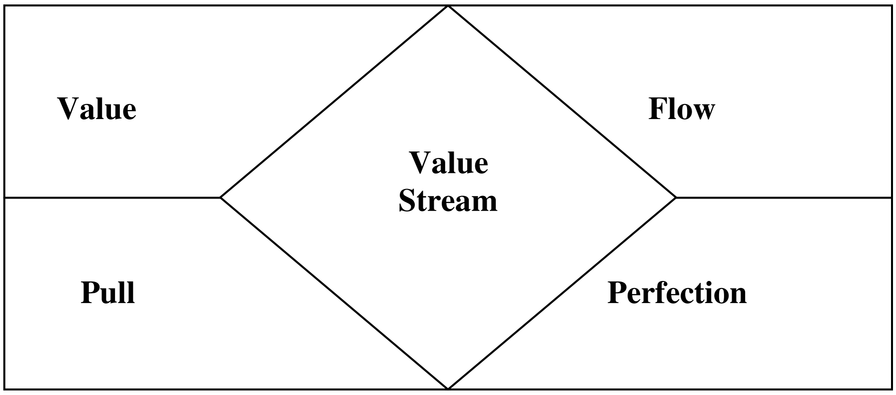

Figure 2: The Five Principles of Lean Thinking

Source: Maskell and Kennedy, p.4.

James J. Womack and Daniel T. Jones determine these five simple principles to guide lean organizations:[39]

- Provide value that actually meets customer needs.
- Determine the value stream for each product. Value stream is the series of actions (the process) required to bring a good or service from concept to design (the development process) and from an order to

[37] Womack, James P. and Daniel T. Jones**. Lean Thinking: Banish Waste and Create Wealth in Your Corporation.** USA: Free Press, 2003, p.10.
[38] Maskell, Brian H. and , Frances A. Kennedy. ''Lean Enterprise Fundamentals'', Institute of Management Accountants Publication, Management Accounting Quarterly, Statements on Management Accounting, https://www.imanet.org/secure/SMA%204KK%20FINAL-LeanEnterprise.pdf (10.05.2007), p.3.
[39] Womack, James P. and Daniel T. Jones. **Lean Solutions: How Companies and Customers Can Create Value and Wealth Together.** Great Britain: Simaon & Schuster UK, 2005, p.2.

delivery the product to customer (the fulfillment process). Research every step in these processes to find the steps that really create value for the customer and eliminate the steps that do not create customer value.

- Array the remaining production steps in a continuous flow. Eliminate waiting between steps and excess inventories in the production process.
- Encourage the customer pull value from the firm. Otherwise the push methods are used by organizations with long return times, which force the customers what the firm has already produced.
- Eventually, once value, the value stream, flow and pull are founded, begin from the beginning with an infinite search for perfection. That is perfect value procured with zero waste.

3.1.1.1. Value

An organization must begin its lean thinking process by identifying value that is the critical first step. The companies need to determine what value their customers place on the services or products they produce.

According to lean thinking, only the customer can determine value. Value exists when a specific good or service correspond the customer's requirements at a desired time and at a desired price. It is created by the producer due to customer needs. Value is generated by the producer. Because of many reasons, value is very difficult for producers to define. These problems could be related to organization, technology or competency. [40]

Most of the organizations define value as product's selling price, which is computed as cost plus profit margin, but that is not customer oriented calculation. In lean thinking process, the organization must stop defining value as the organization's

[40] Womack and Jones, **Lean Thinking: Banish Waste and Create Wealth in Your Corporation,** p.16.

cost plus a profit percentage and instead should use the marketplace price, or value, for a product or service's true value.[41]

Value designates how much money customers want to pay for the products and services. Prices required by customers can be provided at a greater profit when the organization understands what customers want to pay for products and services, and how waste (''muda'') and the non-value added costs can be eliminated from the value stream.[42]

Muda is a Japanese word for waste and specify any human activity which spends resources without creating value. These activities are mistakes which require rework, goods and services which do not provide customer satisfaction and demands, production steps which are not actually needed, movement of employees and transportation of goods without any aim, employees waiting between two processes and the burden of excess inventory.[43]

Muda is divided into two parts;

- Muda 1
- Muda 2

Muda 1 is waste that realizes no value but is inevitable with current situation. The payroll process could be an example of Muda 1. Muda 2 realizes no value and is avoidable. Shop-floor labor reporting could be an example of Muda 2.[44]

Two essential elements of the value principle are customer focus and leadership. Lean companies work cooperatively with their customers. Customer focus is defined as all of the feedback information systems are enforced by the organization

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[41] Langenwalter, Gary A.. **Shaping Up Your Accounting Function : Trimming The Fat And Going Lean.** Lewisville, Tex. : American Institute of Certified Public Accountants, 2006, p.1-2
[42] Berry and Cox, p.1-2.
[43] Womack and Jones, **Lean Thinking: Banish Waste and Create Wealth in Your Corporation**, p.15.
[44] Maskell, Brian H. and , Frances A. Kennedy. ''Accounting for the Lean Enterprise: Major Changes to the Accounting Paradigm'', Institute of Management Accountants Publication, Management Accounting Quarterly, Statements on Management Accounting, https://www.imanet.org/secure/SMA_LeanParadigm.pdf, (10.05.2007), p.33.

according to customer needs. The supportive act of lean production is production performance improvement according to customer needs.[45]

Leadership is the management's ability to transfer customer requirements into production processes and organizational policies. The relationship between leadership and value creation is essential for ensuring the company development, elimination of waste, improvement in cost, quality, lead time, and innovation.[46]

3.1.1.2. Value Stream

James J. Womack and Daniel T. Jones identify the first principle of lean thinking as customer value. Organizations give weight to wide amounts of value for the customer. The second principle of lean organizations is working by value stream.[47]

Value stream is the overall flow of a service or product's life-cycle. In the value stream management, the organizations must have clear intelligence of topics, where value is formed, which processes are non-value added and create waste, and which processes are non-value added but are needed for legal causes.[48]

A value stream is composed of all the activities needed to maintain customer value for a product or service. These activities consist of all the steps required from selling the product and taking a customer order through producing and shipping a product to gathering the cash. Value stream could create customer value by developing new products, from innovation to concept and from concept to completed design that is ready for production. The organizations carefully determine carefully their value streams and manage their operations to maximize the value provided for the customer and minimize the waste and non-value added costs in these steps.[49]

Production value streams do consist of a group of related products that have the same production parts. Traditional organizations deal with optimizing units rather than

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[45] Maskell and Kennedy, ''Lean Enterprise Fundamentals'', p.3.
[46] Maskell and Kennedy, ''Lean Enterprise Fundamentals'', p.5.
[47] Maskell, Brian H. and Bruce Baggaley**. Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise.** New York, NY : Productivity Press, 2004, p.95.
[48] Berry and Cox, p.1-2.
[49] Maskell and Kennedy, ''Lean Enterprise Fundamentals'', p.5.

the entire organization. Value stream management focuses on which operating unit belongs to which value stream. It makes reorganization in value stream teams, developing a culture for continuous improvement, mapping current and future states, and restructuring into work cells to ensure the rapid flow. For that reason, the organization applies mapping of each individual step involved in the processes of production and order taking for products. [50]

Especially, the primary objective in creating value stream map identifying every activity needed to design, order, and make a specific product is to classify these activities into three categories. Value stream analysis shows three types of activities in the value stream: [51]

- Many steps that clearly create value for customer,
- Other steps that create no value but are unavoidable with current technologies and production items. (Type One Muda)
- Other steps that create no value and are avoidable. (Type Two Muda)

The value stream is the set of all essential activities needed to bring a special good or service through the three important management assignments of any businesses. These assignments are problem solving, information management and physical transformation. The problem solving assignment means detailed production designing and manufacturing engineering. The information management assignment is about the process from order taking through detailed scheduling to delivery. The physical transformation assignment means the transactions from acquiring raw materials to a finished product.[52]

A standard value stream designs customer orders through a process as shown below in Figure 3. The value stream shows more than just the manufacturing processes.

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[50] Maskell and Kennedy, ‘‘Lean Enterprise Fundamentals’’, p.5.
[51] Womack and Jones, **Lean Thinking: Banish Waste and Create Wealth in Your Corporation,** p.37-38.
[52] Womack and Jones, **Lean Thinking: Banish Waste and Create Wealth in Your Corporation** p.19-20.

In Figure 3, manufacturing is one step in the entire process of serving the customer and creating value. There are many processes supporting the manufacturing steps. [53]

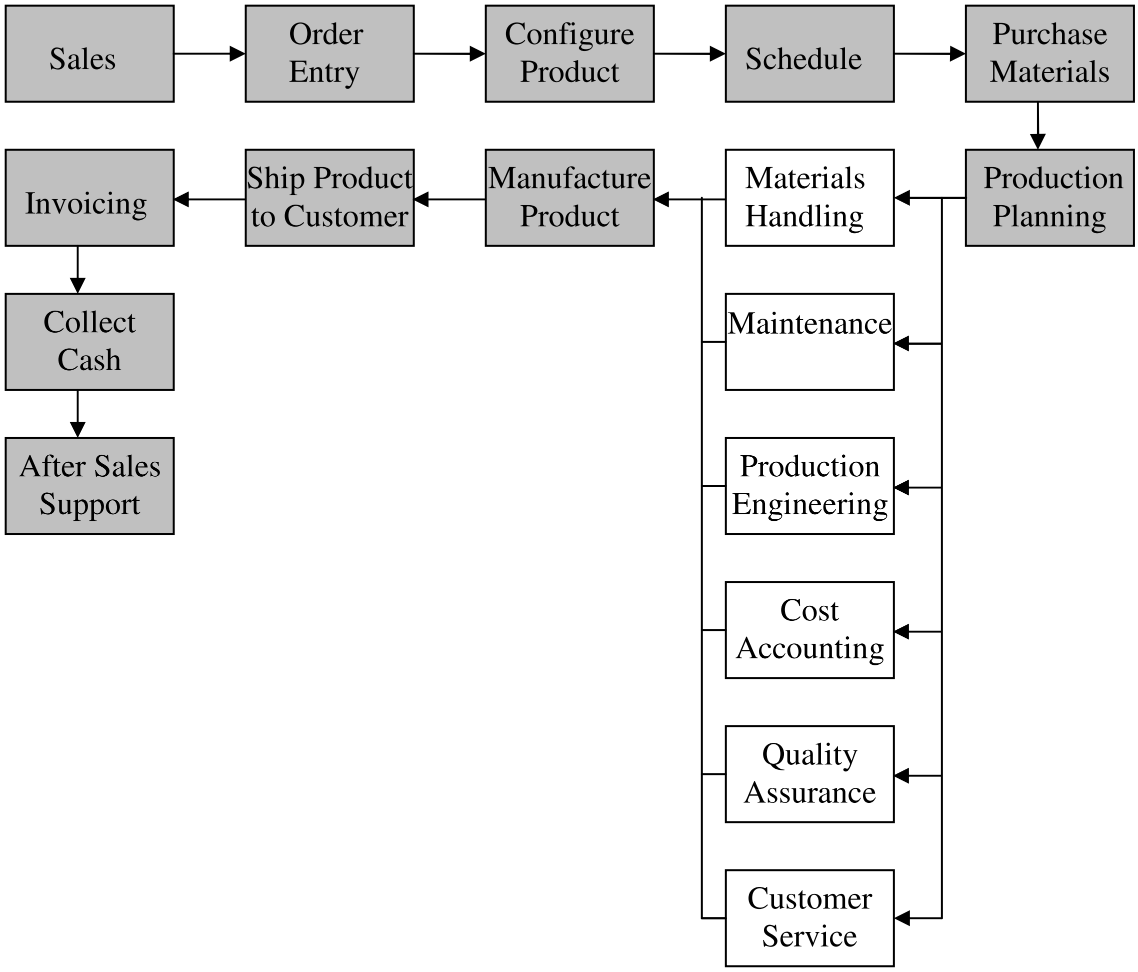

Figure 3: Typical Value Stream Structure

Source: Maskell and Baggaley, p.95.

When the organization begins to apply lean production, it primarily focuses on its internal ‘‘physical’’ value stream for materials, from receiving customer demand to shipping the products. It also focuses at its information value stream, from order- taking through planning the final delivery. For each value stream, the organization specifies

[53] Maskell and Baggaley, p.95-96.

every activity, and determines how much time and cost it adds to the process, and whether that activity creates value to the customer.[54]

Most of the value streams are order fulfillment value streams in lean manufacturing companies. They receive orders from customers and deliver product to fill these orders. Order fulfillment value streams ensure current products to current customers. Furthermore, there are other kinds of value streams. A value stream that introduces new products to new customers is a new product development value stream. This value stream has marketing processes, design engineering, production engineering and target costing. Furthermore, the same lean issues – value, flow, waste, teamwork, accountability and perfection are applied in this value stream. In Figure 4, different kinds of value streams are presented.[55]

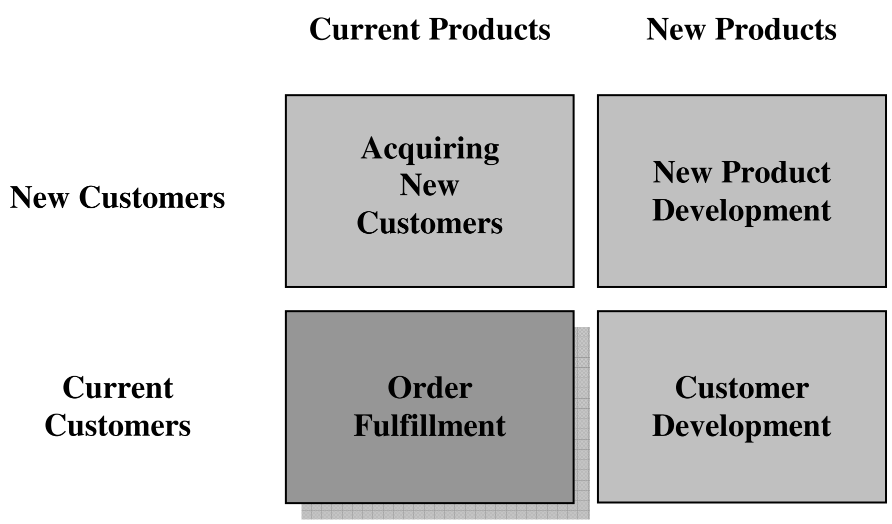

Figure 4: Categories of Value Streams

Source: Maskell and Baggaley, p.97.

[54] Langenwalter, p. 1-2,1-3.
[55] Maskell and Baggaley, p.96-97.

3.1.1.3. Flow

In value stream analysis, the first step is defining the value and identifying the entire value stream for a specific design, order and the product itself. The second step, that makes the first step applicable, is to eliminate the traditional applications of jobs and functions, and helps firm to develop a lean enterprise eliminating all barriers to the continuous flow of the specific product or product family. The third step is to rearrange work practices and tools to remove all kinds of waste. As a result of these steps, design, order, and production can proceed permanently.[56]

The concept of flow support by lean thinkers has its basis in the Toyota Production System. Any activity that disables the flow of products and services in the organization's value stream is defined as muda or waste. The organization must study the value stream and succeed perfect flow from raw materials to shipped products and services.[57]

In every organization, flow is an important key to removing waste. In case of the value chain stops moving forward due to any cause, waste will occur. Because waste is formed by anything that damages the flow of products or services through the value stream, value streams must be analyzed continuously. Non-damaged flow should be succeeded by systematically removing waste.

Initially, the company must determine value, entirely map out the value stream for a special product or service and remove clear wasteful and non-value added activities, so should find a system to make the remaining steps of flow permanent. The real difficulty is to provide a continuous flow. This difficulty is overcame if the company finds a way to quickly answer the emerging market situations.[58]

The production process is established to smooth the flow of the product through the value stream. Lean companies try to improve the flow of materials, information, and cash. Perfect flow requirements working with customers and suppliers,

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[56] Womack and Jones, **Lean Thinking: Banish Waste and Create Wealth in Your Corporation,** p.52.
[57] Maskell, Brian H. and Bruce Baggaley. "Lean Management Accounting". http://www.maskell.com/LeanArticle.htm#What%20is%20Lean%20Thinking (21 Haziran 2007), p.2.
[58] Berry and Cox, p.1-3.

single-piece flow production, setup time decrease, pull production system, and an aim of perfection.[59]

The value stream flow is composed of the following functional activities; [60]

- Usage of Marketing to define customer requirements,
- Sales to work with customer buying for realizing an order,
- Engineering to develop the product and process based upon demands of customers,
- Purchasing to maintain the materials needed to make the product for meeting engineering standards,
- Manufacturing to make the product based upon standards required from engineering,
- Logistics to buy raw materials from suppliers and store as well as delivering the product,
- To maintain the management and information flows and to operate the value stream, companies support services such as Human Resources, Accounting, and Information Systems.

3.1.1.4. Pull

In narrow terms, pull means not producing goods or services, unless the customer demands any good or service. However in practice, applying this rule is more complicated. The optimum system to discover the logic and difficulty of appliance behind pull term is to start with a real customer requirement for a real product and to

[59] Maskell and Kennedy, ‘‘Lean Enterprise Fundamentals’’, p.10.
[60] Maskell and Baggaley, **Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise,** p.273.

work backwards through all the processes needed to make the desired product for the customer.[61]

The production process is developed to improve the flow of the product through the value stream, started by the pull of customer demand.[62]

Formerly, manufacturers demanded a unique product of a specialized size and shape. The same type of product could be manufactured for a day, a week, or longer time before the other product came out. Because having materials to move smoothly is important, manufacturers held enough inventories between the steps of the processes to prevent any cutoff. But with raised world competition and different user requirements, a manufacturer's capability to answer quickly to the market became an essential item of success and survival. For that reason, pull production is a system of controlling a process and answering quickly to changes. In a pull system, each step of a process manufactures exactly what the further stage demands. Material is pulled through the process by each stage, manufacturing only what is required from the next stage. Pull production is the exactly the opposite of push production wherein every stage manufactures due to an arranged plan, then pushes material to the next stage, whether that next stage is ready for the production or not. The aim of pull production term in lean production is to remove non-value-adding works from the value stream.[63]

Pull approach specifies the idea that no service or product is manufactured until it is demanded by the customer. For the success of this principle of lean thinking, great flexibility and very short cycle times for development, production and shipping of products and services is needed. Pull is a system for providing each step in the value chain to know what is needed each day due to the demands of customers. On the other hand, pull approach is an essential system for providing the flow of products and services. Any item of production should not be pushed through production or service processes as in traditional system. Through on the leading of the real requirements of the customer, production materials should be pulled between processes. When pull

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[61] Womack and Jones, **Lean Thinking: Banish Waste and Create Wealth in Your Corporation,** p.67.
[62] Maskell and Baggaley, **Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise** p.297.
[63] Maskell and Kennedy, ''Lean Enterprise Fundamentals'', p.12.

approach is applied in a manufacturing company, resource and inventory stock levels should be flexible enough. This principle requires the customer to pull the product from the organization rather than for the organization to push often undesired products or services to the customer.[64]

The customer can pull value through the system, when non-value-added actions are eliminated and value creation steps are organized to flow. Traditional production systems are liable to push products through the system in the opinion that a customer will purchase them once it is produced. In a pull environment, production steps are not accomplished until required by the next step.[65]

3.1.1.5. Perfection

Perfection is described as total quality on maintaining perfect flow at the pull of the customer. Anything that cuts the flow to the customer causes deterioration of perfection.[66]

In lean companies, ways to eliminate muda by removing waste is an important concept. Perfection concept refers to the improvement efforts of complete elimination of muda.[67]

The maintenance of perfection is important for lean thinking. The goal of perfection is not to make local changes for improvement to eliminate a competitor in the marketplace. The objective is for everyone in the company to deal with making progressive improvement in their own production steps day in and day out. When any of these improvements will fundamentally change the production steps, the total effect of these changes is a valuable development in quality, cost, service, flow, and customer value. The managers know that perfection does not exist completely in a company; but that is the objective of any firm. The traditional companies use such tools like economic

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[64] Berry and Cox, p. 1-4.

[65] Ward, Yvonne and Andrew Graves. ‘‘ A New Cost Management & Accounting Approach For Lean Enterprises’’, 05.2004. University of Bath School of Management. http://www.bath.ac.uk/management /research/ papers.htm (10.05.2007), p.5.

[66] Maskell and Baggaley, **Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise** p.297.

[67] Womack and Jones, **Lean Thinking: Banish Waste and Create Wealth in Your Corporation,** p.90.

order quantities or inventory rationalization to achieve their goals. These tools are very different from lean companies.[68]

Every organization must discover the significance of maintaining perfection through the short and long terms. According to the concept of lean thinking, perfection has two elements. The first element is the classical total quality management which realizes improvement. The ongoing improvement is implemented by lean organizations to make continuous and important changes in their operations. This practice explains how these organizations maintain excellence in both the short and long runs. In the second element of the lean thinking concept of perfection, the organizations view benchmarking and the other "best practice" measurements with mistrust. With process analysis and lean accounting, the organization must adopt the principles of flow and pull to define and remove all waste within its value streams. In this principle, the firm is not comparing itself to other companies; it is comparing its current performance to its own former performance.[69]

Most organizations build an annual policy development matrix for maintaining the perfection in the company. Figure 5 shows an example of policy development matrix. The matrix summarizes the purpose and projects for that year as well as the targets for these projects. Thereby, the workers can observe the one year improvement plan in the whole organization.[70]

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[68] Maskell and Kennedy, ''Lean Enterprise Fundamentals'', p.13-14.
[69] Berry and Cox, p. 1-5.
[70] Womack and Jones, **Lean Thinking: Banish Waste and Create Wealth in Your Corporation,** p.96.

Identify value stream by product	Introduce continuous flow and pull	Dramatically improve quality	**Selected projects** / **Objectives** / **Improvement Targets** / **Target dollar results (current year)**	Perform six major improvement activities	From product teams within six months	From lean enterprises within one year	**Product line reorganization**	**Improvement function team**	**Product family A team**	**Product family B team**	**Product family C team**	**Product family D team**	**Product family E team**
*			Reorganize by product families		*		*						
	*		Create productivity and quality improvement function	*				*					
*	*	*	Create lean enterprises with suppliers			*			*	*	*	*	*
	*		Reduce inventory by $30 M	*									
		*	Reduce cost of quality $15 M	*									
	*		Reduce labor costs by $30 M	*									

(Improvement teams)

Figure 5: Lean Policy Deployment Matrix

Source: Womack and Jones, **Lean Thinking: Banish Waste and Create Wealth in Your Corporation,** p.96.

In lean organizations, the projects involve;[71]

- Restructuring producing process with framework of product groups and developing product team that takes on many of the jobs of the traditional functions,

- Creating a "lean function" to assemble the information and the ability environment to help the product teams in the conversion,

[71] Womack, James P. and Daniel T. Jones**. Yalın Düşünce**. Nesime Aras (çev.). İstanbul: Sistem Yayıncılık, 1998, p.126.

- Initiating a systematic set of improvement activities to convert large batches and rework into continuous flow.

The targets of these projects would determine numerical improvement aims and schedules for the projects.

The objectives of lean applications are zero waste, zero lost information, and zero fault. Information architecture and standard operations are important issues for achieving perfection.

3.1.1.5.1. Information Architecture

Lean processes depend on the design of a framework that encourages a team-based lean organization and provides information effectively. Architectural characteristics contain improvement focused performance measures, management accounting systems and the usage of visual control systems. Visual boards show equipment malfunctions, takt-time (effective working time per time period / customer requirement during the time period) success, personnel limitations, hourly production objectives, overtime needs and are apparent from every workplace, Information architectures are related to improvements in transportation, cost, delivery, product innovation, quality, and production process flexibility. Especially, information architectures of lean production aim to succeed the following expressions:[72]

- Associate daily operations to strategic goals,
- Implement visual management,
- Balance financial measures with non-financial ones,
- Support workers and managers through visual information and involvement,

[72] Maskell and Kennedy, ‘‘Lean Enterprise Fundamentals’’, p.14.

- Define and remove waste,
- Assess what is essential to customers,
- Rapidly organizational learning support and adopt change in customer demands,
- Convert company flexibility into special assessments.

3.1.1.5.2. Standard Operations

The potential of improvement is very restricted without standard operations. Standard operations are times determined for production of a unit of output, arrays of assignments, and the work schedules. The standard operations schedule, the standard completion time per unit and standard work in process (WIP) are the fundamental elements of standard operations. The accomplishment time per unit is the average time needed to fulfill an assignment, an operation or group of assignments. The standard operations procedure (SOP) is a group of activities combined in a special, predetermined sequence. When the minimum work in process inventory exists in an organization, the process activates efficiently. All data about the operations schedule, standard work in process and completion times per unit are reported on a standard operations sheet (SOS). Standard operations define important functions in lean production. They are substantial for communicating and teaching standard times and processes. Standard operations give workers, correct, actual information about cycle times and operations capacity. Standard operations and standardized work have the same importance for lean managerial processes. In lean organizations, visual work application and standard process flows are usually used by the employees. Improvement can not be achieved without visual standardized work, and additional improvement can not be realized without an obvious determination of the organizations current state.[73]

[73] Maskell and Kennedy, ‘‘Lean Enterprise Fundamentals’’, p.14-15.

3.1.2. Basic Terminology of Lean Enterprises

In this part of dissertation, basic terminology of lean enterprises is explained widely. Each concept of terminology serves to other concept and the concepts are interrelated. These topics are just-in-time production, kanban system, setup time reduction, autonomation, continuous improvement, elimination of waste, 5 S – housekeeping, mistake-proof system, and visual control system.

The lean production system's first aim is manufacturing products for definite goal – profit. To reach this aim, lean enterprises could reduce costs or improve productivity. In spite of cost – reduction is the system's most fundamental aim, it must first meet tree other related goals. They are: [74]

- Quantity control, which realizes the adoption to daily and monthly changes in customer requirement of quantity and diversity.
- Quality assurance, which enables that each process will produce only high quality goods to continuing processes.
- Respect for humanity, which must be developed while the system uses human resources to achieve its cost targets.

The diagram of improvement of costs, quantity, and quality in lean enterprises is drawn in Figure 6. Before explaining the terminology of lean production system in detail, a review of this system is shown in diagram. The results such as costs, quantity, quality and respect for humanity and the inputs of the production system in lean enterprises are depicted in Figure 6.

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[74] Monden, p. 3 – 4.

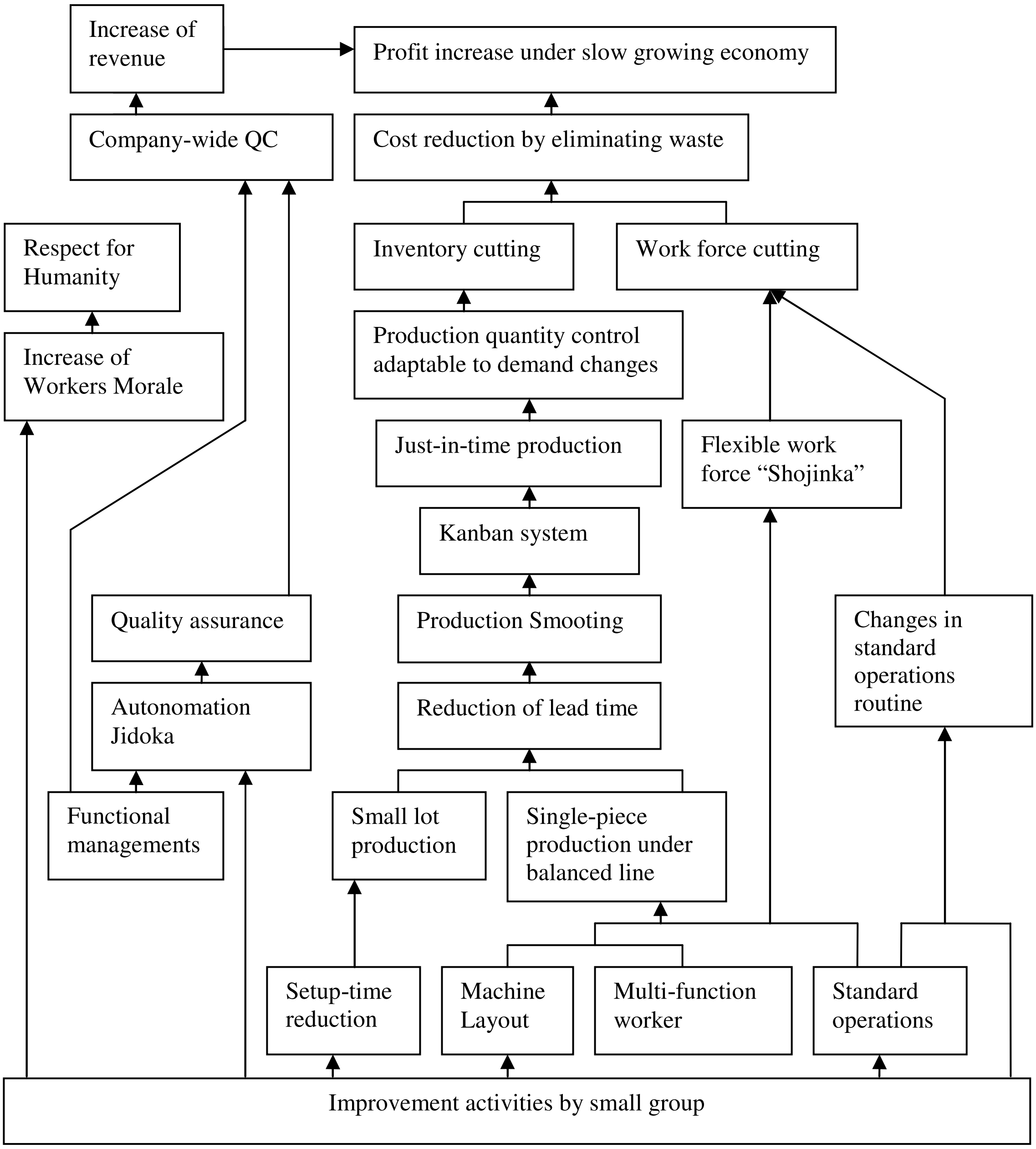

Figure 6: Improvement of Costs, Quantity, Quality and Humanity in Lean Enterprises

Source: Monden, p. 4.

3.1.2.1. Just-in-Time Production

The Japanese confirmed the inventory problem from a wider and more important perspective. They were not deal with maximizing the level of inventory, they wanted to eliminate inventory. For that reason they developed Just-in-time (JIT) production system.[75]

JIT was developed from work done in the area of lean manufacturing from the early 1950s through the 1980s. JIT programs were affected by continuous process improvements. From a wide view, JIT is a philosophy and from a very limited view, JIT is defined planning the right part, at the right place, at the right time. JIT is a philosophy that is exercisable in the transportation and distribution fields besides in the manufacturing areas.[76]

Companies evaluate their degree of commitment to lean production with JIT programs. Furthermore, some degree of flexibility is important to deal with uncertainties. This flexibility includes a various number of kanbans and set-up reduction. Kanban system plays a considerable role in materials flow.[77]

JIT is the important concept of Toyota Production System. JIT system is developed with subtitle concepts such as small lot production, set-up time reduction, the Kanban system.[78]

The purpose of Toyota Production System is the definite elimination of waste. Just-in-time is one of the supporting pillars of the system. JIT is defined as in manufacturing flow process, the right product parts required in assembly reach the assembly line at the time they are demanded and only in the quantity demanded. A

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[75] Johnson, H. Thomas and Robert S. Kaplan. **Relevance Lost : The Rise And Fall of Management Accounting.** United States of America: Harvard Business School Press, 1987, p.212.

[76] Viale, J. David and Christopher Carriganm. **Inventory Management: From Warehouse to Distribution Center**. USA: Course Technology Crisp., 1996, p.103.

[77] Domingo, Rosario, Roberto Alvarez, Marta Melodia Pena and Roque Calvo. "Materials Flow Improvement in A Lean Assembly Line: A Case Study". **Assembly Automation.** Volume 27, Issue 2, 2007, p. 141.

[78] Papadopoulou, T.C. and M. Ozbayrak. "Leanness: Experiences from the Journey to Date". **Journal of Manufacturing Technology Management.** Volume 16, Issue 7, 2005, p. 786.

manufacturing enterprise that succeeds this flow can reach zero inventory.[79] The aim of zero work-in-process inventory is no product part produced until next process of production is available to work on it.[80]

JIT is defined as a production system with main aim of continuously reducing and ultimately removing all waste. Work-in-process inventories and delays are two of important types of waste that JIT determines. JIT manufacturing techniques are subset of lean manufacturing. The tools and methods used to achieve the company improvement are;[81]

- Lot size declining,
- Cycle time lowering,
- Quick changeover systems,
- Cellular process layout,
- Reengineering production processes, and
- Bottleneck elimination.

Fundamental issues of a JIT system's reliability include the following measures of manufacturing cycle effectiveness: fault rates, cycle times, percent of time that shipments are arrived on time, order correctness, actual production as exactly the planned production and actual machine time available compared with planned machine time.[82]

JIT is "a philosophy of manufacturing based on planning elimination of all waste and continuous improvement of productivity. It encompasses the successful execution of all manufacturing activities required to produce a final product from design

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[79] Ohno, p. 4.
[80] Johnson and Kaplan, p.214.
[81] Kumar, Sameer and David Meade. **Financial Models and Tools for Managing Lean Manufacturing.** New York: Auerbach Publications, Taylor & Francis Group, 2007, p.18-19.
[82] Atkinson, Anthony A., Robert S. Kaplan, Ella Mae Matsumura and S. Mark Young. **Management Accounting**. Fifth Edition. New Jersey: Pearson Education Inc., 2007, p.232-233.

engineering to delivery and including all stages of conversion from raw material onward. The primary element of JIT is to have only the required inventory when needed; to improve quality to zero defects; to reduce lead times by reducing set-up times, queue lengths, and lot sizes; to incrementally revise the operations themselves; and to accomplish these things at minimum costs."[83]

The JIT philosophy has the advantages as follows:[84]

- Reduced lead time,
- Shortened time spent on non-process work,
- Decreased inventory,
- Improved balance between different processes,
- Problem solving.

In manufacturing companies, basic features for realizing JIT production system are as follows;[85]

- Production with a constant speed,
- Establishment of an information system for providing the requirements of production just in time,
- Making raw material and component purchases and finished good production with small batches,
- Programming production machines timely and economically,
- Providing high quality and timely raw material through long term agreements with small number of suppliers,

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[83] Papadopoulou and Ozbayrak, p.788.
[84] Imai, p. 90.
[85] Öker, Figen. **Faaliyet Tabanlı Maliyetleme, Üretim ve Hizmet İşletmelerinde Uygulamalar**. İstanbul: Literatür Yayıncılık, 2003, p.23–24.

- Understanding the importance of employee training in production,
- Providing default elimination during production through preventive maintenance planning,
- Developing a production environment provides improvement of production systems.

In a JIT manufacturing system, raw materials and supplies are obtained or produced just in time to be needed at each stage of the production processes. This application to inventory and production management provides important cost savings from decreased inventory levels.[86]

JIT principles provide cost reduction through;

- Improving housekeeping
- Reducing inventory
- Decreasing lead time,
- Improving material handling
- Simplifying processes and
- Developing organization wide involvement.

Improving housekeeping means, eliminating all items that are not really important to performing the production process. By reducing the level of inventory in the material distribution, the overall amount of inventory and the related costs can be declined. This inventory reduction decreases lead time. The decreasing lead time in all distribution channels provides faster shipments to customers. Improving material handling and adequate declining in unplanned downtime decrease lead times. Simplifying processes realizes a smooth flow from supplier to customer and elimination

[86] Hilton, Ronald W.. **Managerial Accounting.** Sixth Edition. New York: McGraw-Hill Publishing, 2005, p.22.

of wastes. Developing organization wide involvement means, all organizational groups in company must be involved for all types of changes. JIT is an organization wide term not just a manufacturing concept.[87]

The fundamental feature of JIT system is "pull" approach to controlling production processes. This approach is showed in Figure 7, which displays a simple diagram of production stages.[88]

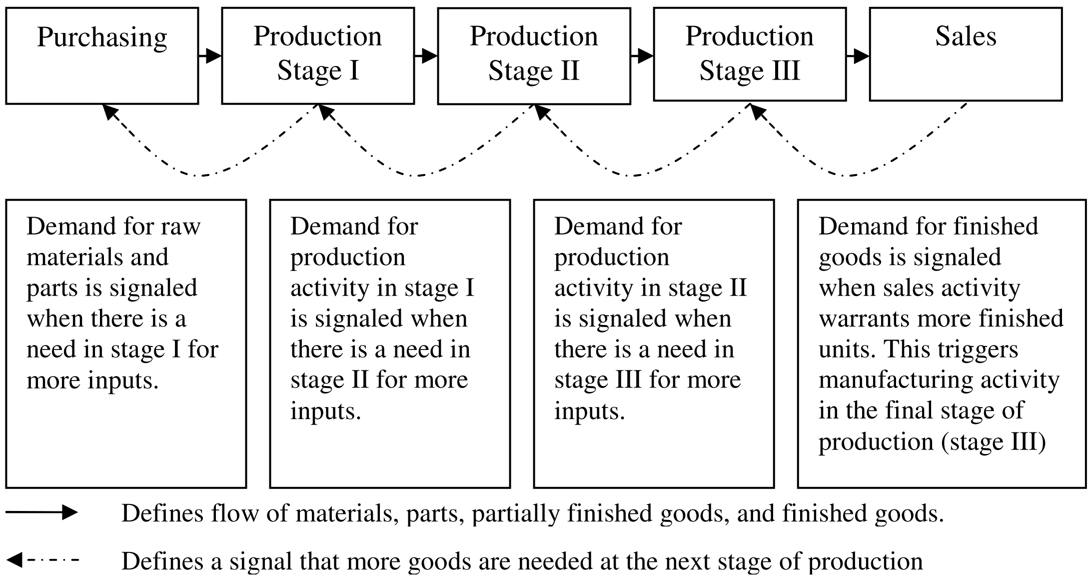

Figure 7: Just-in-time Production and Inventory Management System

Source: Hilton, Ronald W.. **Managerial Accounting.** Sixth Edition. New York: McGraw-Hill Publishing, 2005, p.23.

The goals of JIT manufacturing system are to realize customer demand in a timely way with quality products at the lowest total cost. JIT manufacturing system has the features there are explained below to provide these aims.[89]

- Production is made in manufacturing cells, a summary of all the distinct types of equipment used to make the same product. Materials move

[87] Viale and Carriganm, p. 103-104.
[88] Hilton, p.22.
[89] Horngren, Charles T., Srikant M. Datar and George Foster. **Cost Accounting: A Managerial Emphasis.** Twelfth Edition. New Jersey: Pearson Prentice Hall, 2006, p.704.

from one cell to another and different operations are realized in sequence, minimizing materials handling costs.

- Employees are trained to realizing multi skilled performance for various operations and tasks. These operations and tasks include basic repairs of equipment and routine maintenance of equipment.

- Faults of products are removed. JIT develops a quick problem solving mechanism for solving problems and removing the causes of faults. Low levels of stocks allow employees to focus problems and solve problems at earlier production processes.

- Set-up time and manufacturing lead time is reduced. Declining set-up time makes production in smaller batches and reduces inventory levels. Declining manufacturing lead time provides a firm to react faster to changes in customer demand.

- Many firms implementing JIT production also implementing JIT purchasing. JIT production firms demand timely shipments of high quality goods directly to the production floor.

3.1.2.1.1. Kanban System

The Japanese word "Kanban" which known as signboard, means demand scheduling. Taiichi Ohno developed kanbans to monitor production between processes and to use JIT at Toyota manufacturing factories in Japan in the 1940s and 1950s. In 1970s, the implementation of kanbans gained world wide acceptance during the global recession. By implementing kanbans, the work-in-process between processes is minimized and also the costs of holding inventories are reduced.[90]

The kanban's Japanese-to-English translation is "communication signal" or "card". The kanban system is the key element of demand-pull system. It eliminates the

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[90] Gross, John M. and Kenneth R. Mclnnis. **Kanban Made Simple: Demystifying and Applying Toyota's Legendary Manufacturing Process.** New York, United States of America: AMACOM, 2003, p.1-2.

requirement of paper in scheduling and production actions. With kanban demand-pull system, the material is pulled to the point required in production.[91]

Taiichi Ohno discovered the concept of controlling the number of instruction slips in order to decline stocks kept between production processes. These instruction slips are named "kanban". This approach was kanban system and had many advantages.[92] The advantages of kanban scheduling are shown detailed in Figure 8.[93]

1. **Reduces inventory**
2. **Improves flow**
3. **Prevents overproduction**
4. **Places control at the operations level (with the operator)**
5. **Creates visual scheduling and management of the process**
6. **Improves responsiveness to changes in demand**
7. **Minimizes risk of inventory obsolescence**
8. **Increases ability to manage the supply chain**

Figure 8: Advantages of Kanban Scheduling

Source: Gross, John M. and Kenneth R. Mclnnis. **Kanban Made Simple: Demystifying and Applying Toyota's Legendary Manufacturing Process.** New York, United States of America: AMACOM, 2003, p.4.

Through calculating the kanban quantities in current conditions, manufacturing companies see a decrease in inventory levels. The kanban which properly implemented improves the flow of the operation. Reducing inventory amount and the order created by designing the kanban material flow improve the flow results. Through determining the production container sizes and the maximum amount of containers to be produced, the kanban eliminates overproduction. With proper rules and scheduling guidance, the

[91] Gilliam, Dean and Steve Taylor Jones. **Quantum Leap: The Next Generation.** Boca Raton, United States of America: J. Ross Publishing, 2004, p.69
[92] Shingo, p.56.
[93] Gross and Mclnnis, p. 4.

kanban system guides the operators what to run, how much to run and what queue to run. The kanban removes the requirement of paper schedule with appropriate use of visual management tools. The kanban scheduling process determines the maximum and minimum inventory amounts. With this determination the operators of production decide to stop production when demand decreases. When the kanban system eliminates overproduction, inventory can not be obsolete.[94]

The rules of managing kanban system are summarized as follows;[95]

- Kanban demand signal is the determinant of beginning work.
- Jobs are not realized without customers demand.
- The kanban system arranges the amount of work-in-process allowed in the process.
- The manufacturing lead-time is controlled by the number of kanbans through sequence management.
- Known faults of production are eliminated.
- Implementing first-in-first-out (FIFO) material flow.

In Figure 9, the seven steps of implementing kanban system are listed.[96]

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[94] Gross and Mclnnis, p. 5-7.
[95] Feld, William F.. **Lean Manufacturing: Tools, Techniques, And How to Use Them.** United States of America: The St. Lucie Press, 2000, p.54.
[96] Gross and Mclnnis, p. 8.

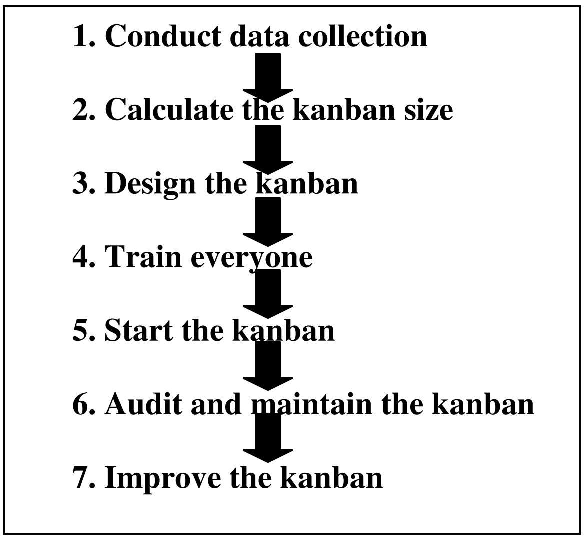

Figure 9: Seven Steps of Implementing Kanban System

Source: Gross and Mclnnis, p.8.

Gathering the data is important to determine the companies' production process. The purpose of data collecting is to make decisions based on facts instead of on desires. This data provide to the company the opportunity of calculating kanban quantities. The kanban system contains the designs of material controlling, visual signals, visual management items, implementation schedule, employee, and training requirements. All of the staff, work in the kanban system, must be trained before the implementation starts. After the kanban design and training are completed, the kanban system is realized. The next step of implementation is auditing and maintaining of the kanban system. The seventh step of the implementation is improvement of the kanban system. Through improvement of kanban system companies reduce inventory quantities.[97]

3.1.2.1.2. Setup-time Reduction

Passing from one operation to the next takes time and requires a shift of procedures known as setup-time.[98] Setup-time is the time needed to provide equipment, tools and materials ready to begin the production of a product.[99]

[97] Gross and Mclnnis, p. 9-12.
[98] Shingo, p. 147.

Setup-time reduction is determined an important feature of JIT. The JIT production system eliminates resource wasting elements by smoothing manufacturing operations. Setup-times have to be decreased to provide the full efficiency of streamlined operations. Declining setup time realizes flexible manufacturing cells and increases the company's competitive advantage. In Figure 10, direct effects of setup-time reduction of manufacturing companies are listed.[100]

1. **Declined lot sizes**
2. **Decreased work-in-process**
3. **Declined inventory**
4. **Decreased floor space occupancy**
5. **Decreased material handling**
6. **Decreased lead times**
7. **Improved efficiency and flexibility of manufacturing systems**
8. **Removed waste**
9. **Decreased production costs**
10. **Raised quality**
11. **Raised employee productivity**

Figure 10: Advantages of Setup-time Reduction

Source: Steudel Harold J. and Paul Desruelle. **Manufacturing in the Nineties: How to Become a Mean, Lean, World-Class Competitor.** United States of America: Van Nostrand Reinhold, 1992, p.164.

Setup-time reduction is the reduction of model changing time spent between the production of the last part of one lot and the production of the first good part of the next lot. The basic steps of setup-time reduction are;[101]

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[99] Horngren, Datar and Foster, p. 704.

[100] Steudel Harold J. and Paul Desruelle. **Manufacturing in The Nineties : How To Become A Mean, Lean, World-Class Competitor.** United States of America: Van Nostrand Reinhold, 1992, p.164.

[101] Marchwinski, Chet and John Shook. **Yalın Kavramlar Sözlüğü.** Ayşe Soydan & Regaip Baran (çev.).İstanbul: The Lean Enterprise Institute – Acar Basım, 2007,p.62.

- Measure total beginning time of new model production in current state.
- Identify internal (machine related activities) and external activities (activities before and after internal activities such as preparation, tool storage) through calculating time separately.
- Convert internal activities to external activities as much as possible.
- Reduce the time for remaining internal activities.
- Reduce the time for external activities.
- Standardize the new setup-time reduction method.

In Figure 11, strategies and techniques for setup-time reduction are listed.[102]

ORGANIZATION OF SETUP OPERATIONS

1. **Schedule and Plan the Setups**
2. **Use Checklists**
3. **Use Kits**
4. **Repair Tooling and Perform Function Checks**
5. **Use Preset Tooling**
6. **Review the Operation Sequence**
7. **Implement Parallel Operations**
8. **Dedicate Tools to Machines**
9. **Dedicate Fixtures to Workstations**
10. **Organize Fixture and Tool Storage**
11. **Organize the Workstations**
12. **Eliminate Waiting Periods**
13. **Preheat in External Time**

Figure 11: Strategies and Techniques for Setup-time Reduction

Source: Steudel and Desruelle, p. 195.

[102] Steudel and Desruelle, p. 195.

The first element of setup is to plan what time the machines should be setup and to schedule what processes should be succeed during that setup. Through using checklists, the verification of all tools and components and the listing of operation sequence are provided. Using kits is important for operators so they could find tools they need for a specific setup at a single location. Repair tooling and perform function checks are two important rules to apply when equipments and components are transferred between machines and storage. Because used tools and fixtures are needed in working place, tool or fixture shouldn't be carried to storage without being checked and should be repaired if required. Through preset tooling, adjustments of tooling can be made in external time. When operators review the operation sequence, operating sequences can be improved, became more efficient and repeated tasks can be eliminated. Through parallel operations implementation, operators perform parallel operations simultaneously. Because operators lose an important amount of time searching for tools or fixtures, tools and fixtures must be dedicated to machines or workstations. Tools and fixture storage must be arranged so generally used tools and fixtures are the most easily accessible. Workstations must be organized so every item has a specific place. For eliminating waste and increasing efficiency, every waiting period must be removed. Preheating period of machines could be made in external time if applicable. Consequently, setup-time reduction of production is realized in manufacturing companies.[103]

3.1.2.2. Autonomation

The second pillar of Toyota Production System is named autonomation – not to be confused with automation. Machines can't eliminate production problems "autonomously" with simple automation. It is also called as automation with a human touch. The idea of autonomation was invented by Toyoda Sakichi founder of Toyota Motor Company. He developed an auto-activated weaving machine.[104]

Autonomation, one of the basic characteristics of Toyota Production System is called "Jidohka" in Japan. Jidohka is a term developed for machines designed to cut

[103] Steudel and Desruelle, p. 195-198.
[104] Ohno, p. 6.

working when a production problem occurs. All machines in factory have automatic stop mechanisms. In autonomation, the machine and entire system stops, each time a faulty work piece is produced.[105]

Figure 12 shows how autonomation purposes are realized.[106]

[105] Imai, p. 90.
[106] Monden, p. 226.

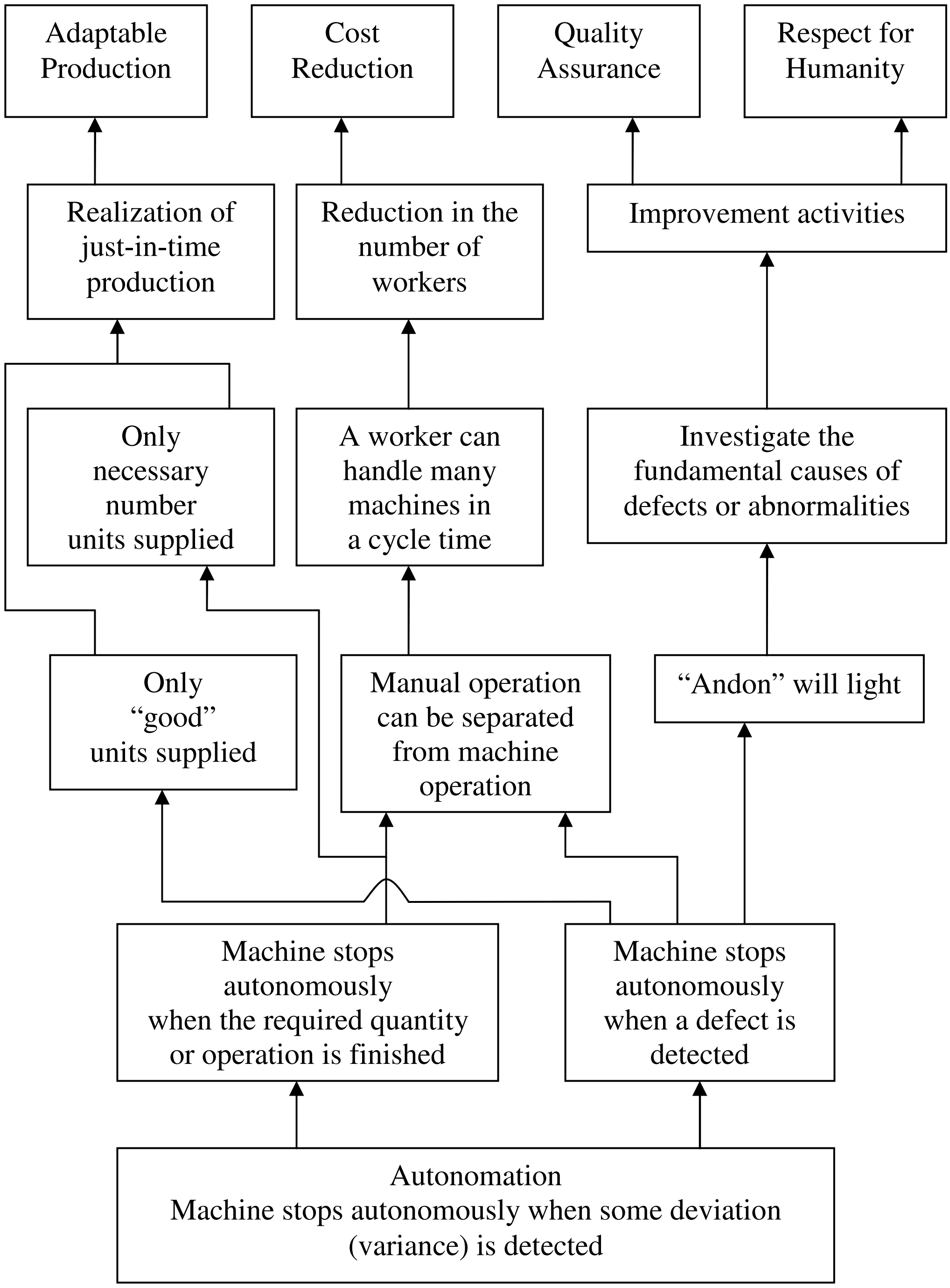

Figure 12: How Autonomation Attains Its Purposes

Source: Monden, p. 226.

Adaptable production, cost reduction and increased respect for humanity are vital elements and effects of autonomation. The equipment is developed to stop automatically when the needed quantity of product has been manufactured or when a fault occurs. Employee is not required for reviewing machine operations and that makes it possible to decline workforce and thus reduce the cost of production. Autonomation provides adaptability to changes in demand so eliminates excess inventory and makes possible JIT production. Autonomation encourages improvement activities and this increases respect for humanity.[107]

3.1.2.3. Continuous Improvement and Elimination of Waste

In the global competitive economy, manufacturers want to have the ability of continuous quality improvement while reducing costs. Continuous improvement is a philosophy that continually improvement in all processes through increase in quality, transportation, production or customer satisfaction and decrease in delivery time, cost or fault. In Japan, continuous improvement is called "Kaizen" and developed by Masaaki Imai.[108] The origin of kaizen is developed from the Japanese words kai, meaning "to take apart" and zen, meaning "to make good".[109]

The lean manufacturing aim is eliminating waste, so all operations in value stream create value are known perfection. Activities focused on the elimination of waste are realized through continuous improvement or kaizen events.[110] Kaizen events are often implemented only production areas within the organization. The organizations choose kaizen events for production and administrative functions provide benefits in terms of waste elimination. In Table 5, eight types of waste are defined and improvement opportunities of these wastes are listed.[111]

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[107] Monden, p. 225.
[108] Sim, Khim L. and John W. Rogers. "Implementing Lean Production Systems: Barriers to Change". **Management Research News**. Volume 32, Issue 1, 2009, p.37-39.
[109] Burton, Terence T. and Steven M. Boeder. **Lean Extended Enterprise: Moving Beyond the Four Walls to Value Stream Excellence**. United States of America: J. Ross Publishing, 2003, p.72.
[110] Arnheiter, Edward D. and John Maleyeff. "The Integration of Lean Management and Six Sigma". **The TQM Magazine.** Volume 17, Issue 1, 2005, p. 9.
[111] Burton, p.76.

Table 5
The Categories of Waste

Waste Categories	Description	Sample Opportunities for Improvement
Overproduction	Producing more than is demanded by the customer	Reduce lot size/batch size Reduce setup time Reduce start-up rejects Simplify the process Shorten search time Eliminate unnecessary data
Waiting	Waiting for the next process step to occur	Synchronize work Combine work Balance workloads Cross-train employees One-touch information access Implement visible cues
Transportation	The unnecessary movement of materials	Create work cells Create one-stop workstations Create paperless processes Fewer suppliers and closer Minimize number of moves Point of use storage
Processing	Excessive processing because of poor product or process design	Redesign the process to eliminate tasks Redesign the process to simplify Fail-safe the process Establish standard work
Inventory	Storing more than the bare minimum	Reduce batch size Reduce lead time Synchronize work flows Add capacity to handle peak loads Minimize checks and reviews
Motion	Excess or unnecessary motion for anything: people, machine, or materials	Every-move-counts philosophy Combine multiple steps into one Eliminate searching activities Organize layout through 5 S Create visible system
Defects	Creating scrap, rework, or paperwork errors	Quality standards Standard documentation Standard work Process capability Fail-safe processes
Information	The unnecessary movement of information	Decrease process waste Easy-to-understand information Decrease process waste Accuracy of data

Source: Burton, Terence T. and Steven M. Boeder. **Lean Extended Enterprise: Moving Beyond the Four Walls to Value Stream Excellence**. United States of America: J. Ross Publishing, 2003, p.98–99, 122.

3.1.2.4. 5 S – Housekeeping

5 S philosophy is definitely essential on the factory floor as a discovery for later improvements. 5 S was developed by Toyota to define the appropriate methods of housekeeping.[112] 5 S is a system used to remove lack of productivity in factories. 5 S involves the Japanese words Seiri, Seiton, Seiso, Seiketsu and Shitsuke, which collectively mean cleanup activities at the work place of factory. Seiri means clearly separating necessary items from unnecessary ones and eliminate the unnecessary one. Seiton is defined as tools arrangement and identification of things for ease of use. Seiso represents to always clean up and to provide continuous orderliness and cleanliness. Seiketsu provides constant maintenance of 3 Ss as defined above through standardization. Shitsuke means to have employees always complying with the rules for sustaining 4 Ss, which was defined above.[113] Figure 13 shows the interaction of 5 S in plant.[114]

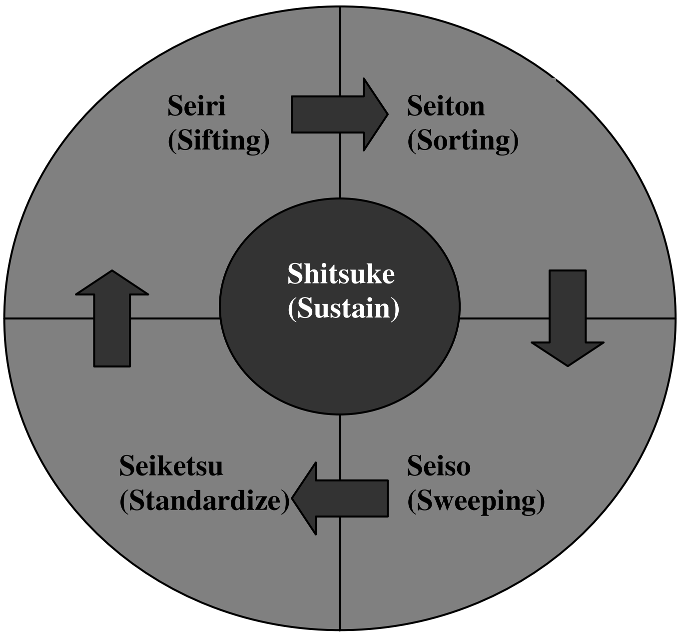

Figure 13: Five S

Source: Marchwinski and Shook, p. 6.

[112] Kocakülâh, Mehmet C., Jason F Brown and Joshua W. Thomson. "Lean Manufacturing Principles and Their Application". **Cost Management.** Volume 22, Issue 3, May / June 2008, p. 19.
[113] Monden, p.199-201.
[114] Marchwinski and Shook, p. 6.

Furthermore, 5 S embodies simple, strong, structured, synchronous, serviceable housekeeping for all practical purposes in plant. Practical purposes of workers in work place are listed below;[115]

- Regulate and determine all items in the cell (no loose tools)
- Label place for equipment, tools, and materials.
- Clean up plant daily (no grit or grime)
- Provide visually identified abnormalities
- Use housekeeping audit checklist.

Through implementation of 5 S, the manufacturing company can improve the levels of quality, lead time and cost reduction. These terms are the three main targets of production management. By applying 5 S, a factory can manufacture the products which customers want, in good quality, at a low cost, quickly and safely.[116]

3.1.2.5. Mistake-proof System

Employees will make errors in manufacturing sector because of human factor. When an error occurs faults take place in factory. If errors are caught before they cause faults, then a fault-free environment becomes possible. At this point, mistake-proof system's power occurs. Mistake-proof system was developed by Shingo after World War II. [117] Mistake proofing is called poka-yoke in Japan.[118]

In 1986, Shingo summarized poka-yoke approach as follows in his book "Zero Quality Control: Source Inspection and the Poka-Yoke System":[119]

- Using hundred percent inspections through poka-yoke devices that immediately shut down machines and call workers when errors occur.

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[115] Feld, p.86.
[116] Monden, p.199.
[117] Feld, p.84.
[118] Okur, Ayperi Serdaroğlu. **Yalın Üretim.** 2.Basım. İstanbul: Mart Matbaacılık, 2005, p.82.
[119] Shingo, p.107.

- Corrective actions of manufacturing are never overlooked because errors provide automatically correction in control cycle. This system makes it possible to success no faults.

- The systematic elements of poka-yoke devices are divided into two categories such as, control types and warning types.

Poka-yoke, or mistake-proofing system is developed with simple and inexpensive active devices designed to find errors and so eliminate defects. Through these devices, the operators do the job correctly in the process. These tools could be physical, mechanical or electrical such as electronic eye sensor, matched quantity, reference guide or restricted sequence.[120]

3.1.2.6. Visual Control System

In the previous parts of dissertation, autonomation is defined as stopping production line or machine whenever an error occurs. This identifies what is normal and what is abnormal in manufacturing process.[121]

In application of autonomation, various visual controls check the situation of production line and flow. Some of visual control elements are related with various types of quality control devices. Visual control systems are andon and call lights, standard operation sheets, kanban tickets, digital display panels and storage and stock plates. In Figure 14, framework of the visual control systems is drawn detailed. Furthermore, the relationship of all concepts, explained before, is shown in figure. Foolproof and andon serve elimination of abnormality on production line. Standard operations sheets provide maintenance of standard operations routine. Through kanban and digital display plate, production goals are realized. Store plate and stock plate assure correct transportation and inventory control. [122]

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[120] Feld, p.85.
[121] Ohno, p.129.
[122] Monden, p.232-235.

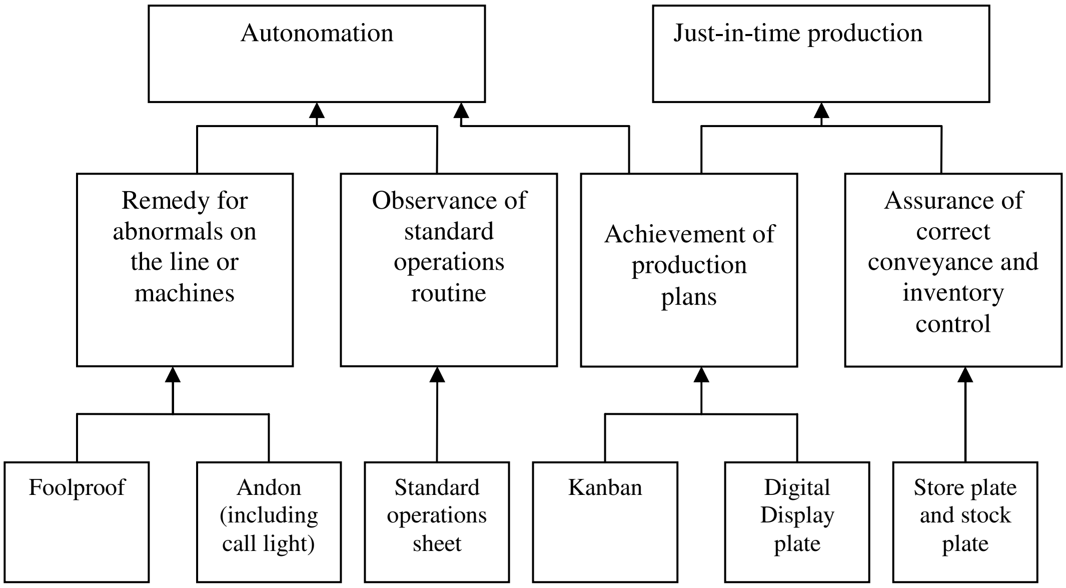

Figure 14: Framework of the Visual Control Systems

Source: Monden, p.235.

Visual control systems ensure visibility to manufacturing problems that are otherwise hidden or postponed. The significance of visual controls is how they provide improvement activities, performance level, problems and operational rules appearance.[123]

In Figure 15, andon system is shown detailed. Andon system consists of a call light, andon boards and stop switch used to control the warning lamps. Andon is a warning board that indicates when the production line is stopped by worker. The board usually has colored lamps with the meaning listed below;[124]

- Red: Machine error
- White: Production is completed; needed quantity of products has been manufactured
- Green: Production is stopped depending on lack of supplies

[123] Feld, p.88.
[124] Monden, p.232.

- Blue: Faulty product
- Yellow: Setup needed (includes equipment changes)

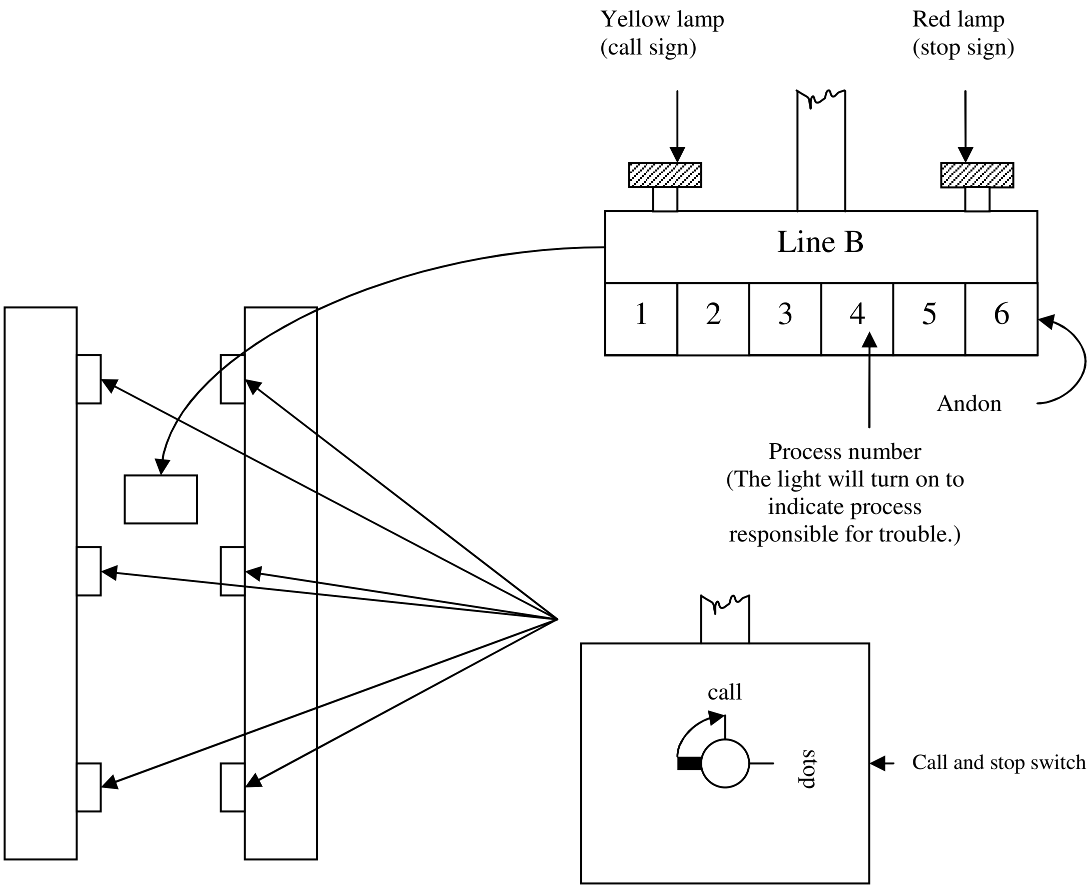

Figure 15: Call Light, Andon, and Stop Switch

Source: Monden, p.233.

In visual control system, standard operation sheets for each production process must be plain and comprehensible. The components of standard operation sheets are;[125]

- Cycle time, the duration of one unit production,
- Operations sequence, the sequence of operations in production,
- Standard inventory, the limit of goods is required to continue the process.

[125] Ohno, p.127-128.

In digital display panels, daily production aims and the amount of units produced are shown. Store plates indicate the storage location of produced units. Stock plate determines the standard quantity of stock for inventory control.[126]

3.1.3. Value Stream Management

In principles of lean enterprises part of the dissertation, value stream concept is explained widely. Value stream is briefly defined before as the arrangement of all specific operations needed for production of a specific good or service through three management jobs of any company; problem solving, information management, and physical transformation. [127]

The implementation of lean manufacturing becomes important for managing the value streams when it matures within the business. In Figure 16, the maturity path to lean value stream organization is shown.[128]

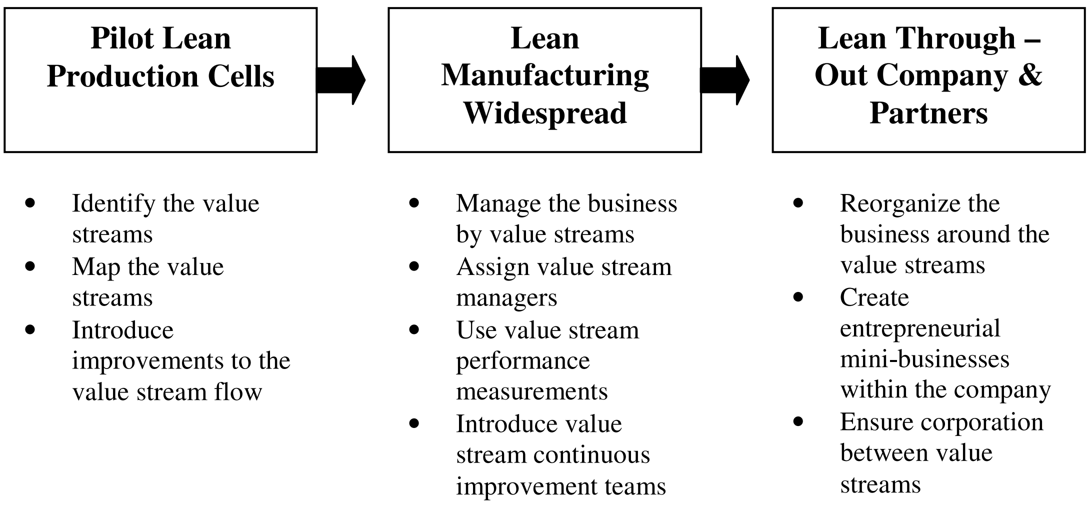

Figure 16: The Maturity Path to Lean Value Stream Organization

Source: Baggaley, Bruce and Brian Maskell. "Value Stream Management for Lean Companies, Part I". **Jounal of Cost Management.** Volume 17, Issue 2, March / April 2003, p. 25.

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[126] Monden, p.234-235.
[127] Womack and Jones, **Lean Thinking: Banish Waste and Create Wealth in Your Corporation,** p.19.
[128] Baggaley, Bruce and Brian Maskell. "Value Stream Management for Lean Companies, Part I". **Joural of Cost Management.** Volume 17, Issue 2, March / April 2003, p. 25.

The maturity path consists of three stages; pilot lean production calls, lean manufacturing widespread, lean through-out company and partners. In the first stage of maturity path, lean manufacturing is implemented and pilot lean cells are developed. In the second stage, lean manufacturing is widespread in the company and the production cells are linked into value streams. The third stage organizes the entire company and partners around value streams.[129]

In value stream management, the company is divided into value streams and manages and evaluates results by value streams instead of managing and evaluating results by traditional processes.[130] The value stream perspective simplifies the management of the business. Management of these value streams – value stream management – involves value stream mapping, capacity management and performance measurement.

3.1.3.1. Value Stream Mapping

One of the important principles of lean production philosophy is focusing on information and materials flow. Lean production management is a flow-based management.[131]

Value stream mapping is generally named "material and information flow mapping". Value stream maps are flow charts showing the process needed to make a product. They were first invented by Toyota Motor Corporation in late 1980's. Value stream maps determine the methods to ensure material and information to flow continuously, realize improvement of production efficiency and competitiveness and help value stream workers see waste in production processes.[132]

Value stream mapping is a drawing tool, helps the company to visualize and communicate the flow of material and information in production way of value stream. It

[129] Baggaley and Maskell. "Value Stream Management for Lean Companies, Part I". p. 26.
[130] Brosnahan, Jan P.. "Unleash the Power of Lean Accounting". **Journal of Accountancy**. Volume 206, Issue 1, July 2008, p. 61.
[131] Al-Sudairi, Abdulsalam A.. "Evaluating the Effect of Construction Process Characteristics to the Applicability of Lean Principles". **Construction Innovation: Information, Process, Management,** Volume 7, Issue 1, 2007, p. 100.
[132] Emiliani, M.L. and D.J. Stec. "Using Value-stream Maps to Improve Leadership". **Leadership & Organization Development Journal.** Volume 25, Issue 8, 2004, p. 622.

is reviewing a producer's production path from customer to supplier and detailed illustration of every process in production. In Figure 17, why value stream mapping is important tool for company is explained.[133]

- **It helps you visualize more than just the single process level i.e. assembly, welding etc. in production. You can see the flow.**
- **It helps you see more than waste. Mapping helps you see the sources of waste in value stream.**
- **It provides a common language for talking about manufacturing processes.**
- **It makes decisions about the flow apparent, so you can discuss them. Otherwise many details and decisions on your shop floor just happen by default.**
- **It ties together lean concepts and techniques.**
- **It forms the basis of an implementation plan.**
- **It shows the linkage between the information flow and the material flow.**

Figure 17: Why Value Stream Mapping is an Essential Tool

Source: Rother, Mike and John Shook. **Learning to See: Value Stream Mapping to Create Value and Eliminate Muda.** Cambridge: Lean Enterprise Institute,1998, p. 4.

The seven value stream mapping tools are developed according to seven wastes as listed following:[134]

- Overproduction,
- Waiting,
- Transportation,
- Inappropriate processing,
- Unnecessary inventory,

[133] Rother, Mike and John Shook. **Learning to See: Value Stream Mapping to Create Value and Eliminate Muda.** Cambridge: Lean Enterprise Institute,1998, p. 4.

[134] Hines, Peter, Nick Rich and Ann Esain. "Value Stream Mapping: A Distribution Industry Application". **Benchmarking: An International Journal.** Volume 6, Issue 1, 1999, p. 63.

- Unnecessary motions,
- Defects.

Value stream mapping tools are process activity mapping, supply chain response matrix, production variety funnel, quality filter mapping, demand amplification mapping, decision point analysis and physical structure mapping. Process activity mapping is known commonly process analysis. General aims of this tool are identification of the process flow and waste, process arrangement for efficient sequence, flow improvement and elimination of waste. Supply chain response matrix is an approach to determination of critical lead time constraints for a specific process through usage of a simple diagram.[135] Production variety funnel is a diagram helps the mapper about the firm and supply chain operations. Quality filter mapping identifies quality problems in the supply chain. Two types of problems exist in quality mapping; these are product defects and service defects.[136] Demand amplification mapping is a simple analytic tool that shows demand changes along the supply chain in different times.[137] In the supply chain, decision point analysis is the analysis that identifies the point at which production stops according to actual demand (pull) and starts according to forecasts (push). Physical structure analysis ensures the knowledge about supply chain. This knowledge is supportive in understanding industry type, operations and determination of improvement areas.[138] The relationship between wastes and value stream mapping tools is settled in Table 6.[139]

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[135] Hines, Peter and Nick Rich. "The Seven Value Stream Mapping Tools". **International Journal of Operations & Production Management.** Volume 17, Issue 1, 1997, p. 51-52.
[136] Hines, Peter, Richard Lamming, Daniel Jones, Paul Cousins and Nick Rich. **Value Stream Management: Strategy And Excellence in the Supply Chain.** Great Britain: Prentice Hall, 2000, p.22-23.
[137] Hines and Rich, p. 56.
[138] Hines, Lamming, Jones, Cousins and Rich, p.25-26.
[139] Hines and Rich, p. 50.

Table 6

The Seven Value Stream Mapping Tools

Wastes/ Structure	Process Activity Mapping	Supply Chain Response Matrix	Production Variety Funnel	**Mapping Tool** Quality Filter Mapping	Demand Amplification Mapping	Decision Point Analysis	Physical Structure (a)volume (b)value
Overproduction	L	M		L	M	M	
Waiting	H	H	L		M	M	
Transport	H						L
Inappropriate processing	H		M	L		L	
Unnecessary Inventory	M	H	M		H	M	L
Unnecessary Motion	H	L					
Defects	L			H			
Overall structure	L	L	M	L	H	M	H

Notes: H = High correlation and usefulness
M = Medium correlation and usefulness
L = Low correlation and usefulness

Source: Hines, Peter and Nick Rich. "The Seven Value Stream Mapping Tools". **International Journal of Operations & Production Management.** Volume 17, Issue 1, 1997, p. 50.

The origins of value stream mapping tools are listed in Table 7. Value stream tools 1 and 5 include engineering. Tools 2 and 6 are about action research and logistics. The origin of tool 3 is operations management and tools 4 and 7 are new developed tools.[140]

[140] Hines and Rich, p. 50.

Table 7

Origins of the Seven Value Stream Mapping Tools

Mapping Tool	**Origin of Mapping Tool**
1. Process Activity Mapping	Industrial Engineering
2. Supply Chain Response Matrix	Time Compression / Logistics
3. Production Variety Funnel	Operations Management
4. Quality Filter Mapping	New Tool
5. Demand Amplification Mapping	Systems Dynamics
6. Decision Point Analysis	Efficient Consumer Response/Logistics
7. Physical Structure Mapping	New Tool

Source: Hines, Peter, Richard Lamming, Daniel Jones, Paul Cousins and Nick Rich. **Value Stream Management: Strategy And Excellence in the Supply Chain.** Great Britain: Prentice Hall, 2000, p.18.

The aim of value stream mapping is to support the management in reviewing not only how the company organizes today, but also how it should organize in the future to affect cost and quality of the products and services.[141] Value stream mapping is composed of five stages, implemented by a special team for a special aim. These stages are listed below:[142]

- Choosing a product family;
- Current state mapping;
- Future state mapping;
- Determining a working plan; and
- Realizing the working plan.

[141] Keyte, Beau and Drew Locher. **The Complete Lean Enterprise: Value Stream Mapping For Administrative And Office Processes**. New York: Productivity Press, Sep 2004, p.6.

[142] Lasa, Ibon Serrano, Carlos Ochoa Laburu and Rodolfo de Castro Vila. "An Evaluation of the Value Stream Mapping Tool". **Business Process Management Journal.** Volume 14, Issue:1, 2008, p. 41.

In Figure 18, these stages are illustrated.[143]

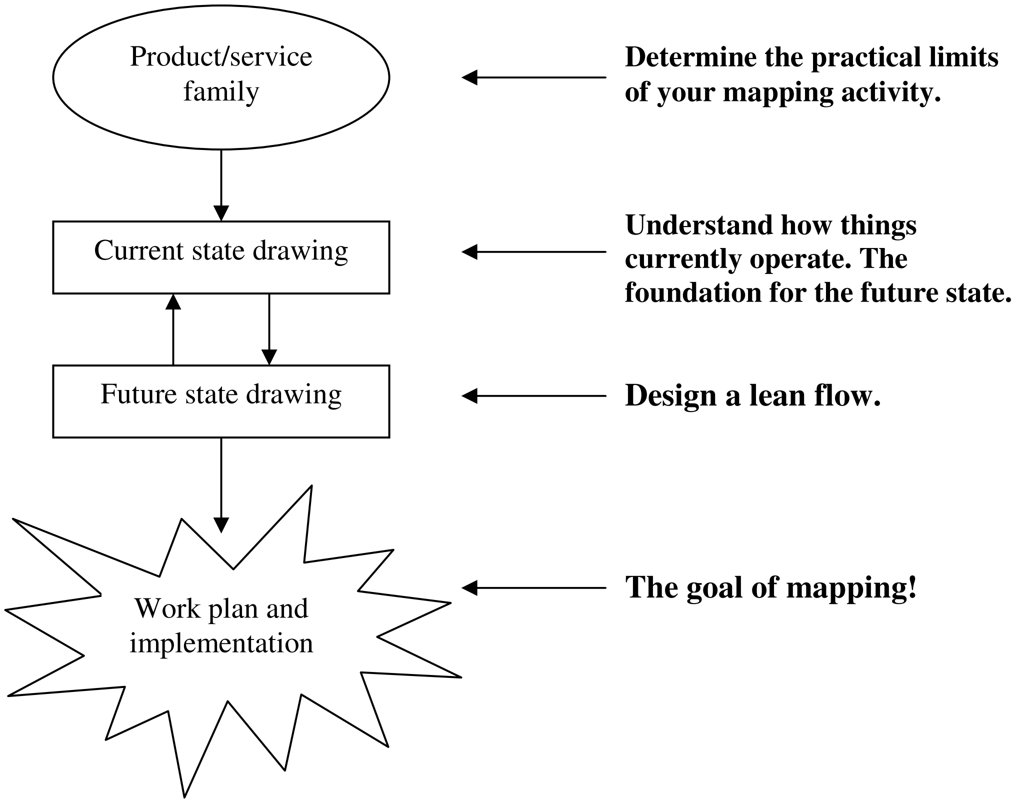

Figure 18: Steps for Mapping an Office Value Stream and Implementing an Improved Design

Source: Keyte, Beau and Drew Locher. **The Complete Lean Enterprise: Value Stream Mapping For Administrative And Office Processes**. New York: Productivity Press, Sep 2004, p.7.

3.1.3.1.1. Selecting a Product Family

In the beginning of value stream mapping, single product family or service family is selected according to consideration of customer desires. [144] In an appropriate value stream, all the steps of value creation for the customer exist for a family of product or service. These products or services are family because of similar production steps. Generally, these steps are associated to the production processes.[145]

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143 Keyte and Locher, p.7.
144 Langenwalter, p.2-5.
145 Maskell and Baggaley, **Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise,** p.105.

After the selection of value stream team, the team should make a matrix of products or services and production process steps to determine product or service families.[146] The value streams in many production plants are clear and simply determined by value steam team. If the value streams are not obvious, value stream team use production flow matrix for the definition of value stream. In Figure 19, example of a production flow matrix is drawn.[147]

	Production Steps													
Product Families	Order Entry	Scheduling	Stamping	Machining	Deburr	Heat Treat	Outside Processing	Inspection	Subassembly A	Subassembly B	Final assembly A	Final assembly B	Pack & Ship	Invoice
112	X	X	X				X	X				X	X	X
212	X	X		X			X	X		X		X	X	X
212a		X		X	X	X			X		X		X	
356	X	X	X				X	X				X	X	X
356e		X		X	X	X			X		X		X	
401	X	X	X				X	X				X	X	X
402	X			X			X	X		X		X	X	X
596	X			X			X	X		X		X	X	X

Figure 19: Example of a Production Flow Matrix

Source: Maskell and Baggaley, **Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise,** p.106.

Production flow matrix is a simple spreadsheet; include a matrix of the products and the steps of the production processes. Production steps are on the x-axis and steps of production processes are on the y-axis. For determination of which product families use which production processes, the production flow matrix is marked by the team. The product families have similar production processes are sorted and grouped in Figure 20. In value stream definition analysis, the products with similar production processes are grouped within same value stream. Furthermore, the production cycle

[146] Keyte and Locher, p.9.

[147] Maskell and Baggaley, **Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise,** p.105-106.

time, the physical size of products and size of the value stream are important determinants of value stream. Production cycle times and physical size of products in same value stream must be similar. In case of the value stream's output is less than 10 percent of plant's output or greater than 60 percent, value stream is not developed.[148]

		Production Steps													
		Order Entry	Scheduling	Stamping	Machining	Deburr	Heat Treat	Outside Processing	Inspection	Subassembly A	Subassembly B	Final assembly A	Final assembly B	Pack & Ship	Invoice
Product Families	112	X	X	X				X	X				X	X	X
	356	X	X	X				X	X				X	X	X
	401	X	X	X				X	X				X	X	X
	212a		X		X	X	X			X		X		X	
	356e		X		X	X	X			X		X		X	
	212	X	X		X			X	X		X		X	X	X
	402	X			X			X	X		X		X	X	X
	596	X			X			X	X		X		X	X	X

Figure 20: Example of a Value Stream Definition Analysis

Source: Maskell and Baggaley, **Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise,** p.107.

3.1.3.1.2. Value Stream Mapping Symbols

Value stream mapping symbols are required for the standardization of value stream maps. In Figure 21, value stream mapping symbols are drawn and defined. [149]

[148] Maskell and Baggaley, **Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise,** p.106-108.
[149] Langenwalter, p.2-15 – 2-16.

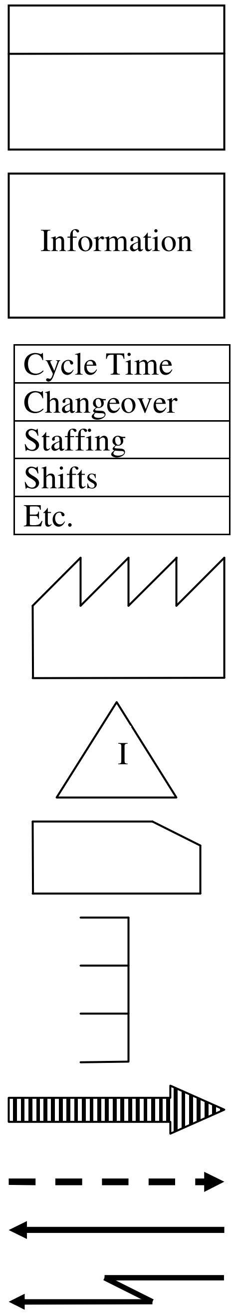
Operation Symbols	Notes
	Process or activity box; write process description in the box. Information box; write information name and description in the box. Data box. Outside sources Inventory Kanban or pull signal for a product or service Supermarket; in-process inventory storage between the production cells in plant. Push arrow Inventory Movement Manual Flow Information Electronic Flow Information

Figure 21: Value Stream Mapping Symbols

Source: Langenwalter, Gary A.. **Shaping Up Your Accounting Function : Trimming The Fat And Going Lean.** Lewisville, Tex.: American Institute of Certified Public Accountants, 2006, p.2-15, 2-16.

3.1.3.1.3. Designing the Current State Map

While the design of the current state map, the designers of the map focus on a product family flow, from receiving dock to shipping dock, invoice, or a service from beginning to finish.[150]

Data gathering of material flow is began at the shipping dock and worked upstream all the way to the starting point of production process through collection of data such as inventory levels before each processes, process cycle times (C/T), number of workers, changeover times (C/O), waiting times, preparation times, inspection times, and number of shifts.[151]

In Figure 22, current state value stream map of the Electronics Components, Incorporated (ECI) is drawn. ECI is an electronics company and the diagram shows the current state electronics components value stream. The company is realized two aims during current state mapping; collecting the data and associate the data to analytical framework for both worker and machine capacity.[152]

When current state value stream map is analyzed, the following processes have seen;

- SMT – Standard components are mounted to boards with the usage of surface mount machine (SMT).
- Hand Load – Specialized components are mounted by hand into boards.
- Test & Rework – Every board is tested and faults are reworked for correction.
- Assemble – The finished product is assembled.

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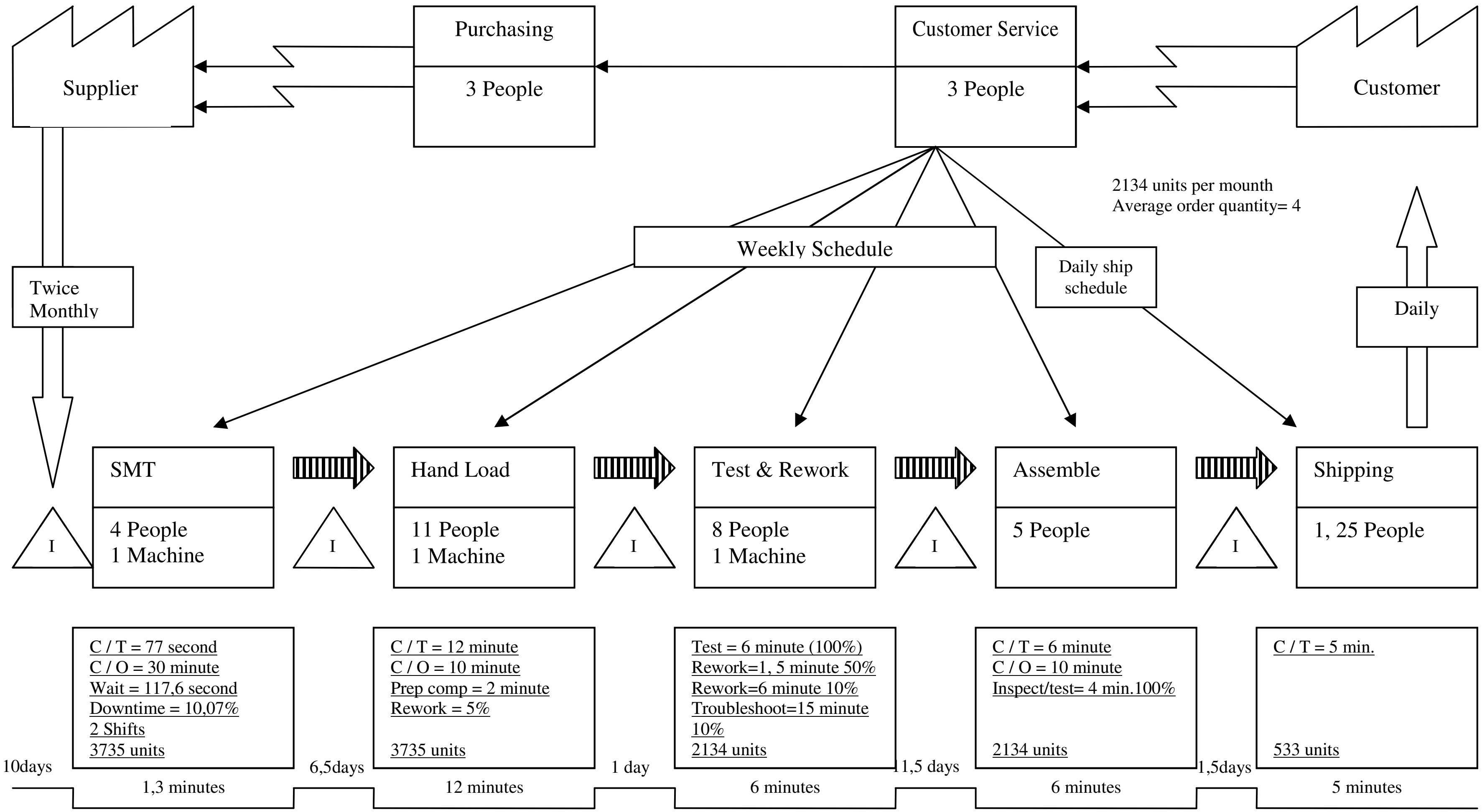
[150] Langenwalter, p.2-7.
[151] Abdulmalek, Fawaz A. and Jayant Rajgopal. "Analyzing The Benefits Of Lean Manufacturing And Value Stream Mapping Via Simulation: A Process Sector Case Study". **International Journal Production Economics**. Volume 107, 2007, p. 226.
[152] Maskell and Baggaley, **Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise,** p.324.



Production Lead Time = 20,5 days
Processing Time = 30,3 minutes

Figure 22: Example of Current State Value Stream Map for the Controllers

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.325.

Hand Load	
11 People 1 Machine	**Process Box**

C/T =12 minutes	
C/O = 10 minutes	
Preparation of Components = 2 minutes	**Data Box**
Rework = 5%	
3735 units	

Figure 23: Hand Load Process Box and Data Box

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.326.

- Shipping – The finished product is shipped. [153]

The small boxes in the framework show the processes and the number inside the box represents the number of employee at each process. Furthermore, each process has a data box below the process, which includes C/T, C/O, the number of shifts, waiting and inspection times. This data is collected from the workers in the shop floor. The processing and set-up times is gathered from the historical data of processes.[154] In Figure 23, "Hand Load" process in the map is reviewed. The process box shows that 11 people are working and there is one machine in the process. The data box of this process provides the information about the operation during the selected month.[155]

Hand load process has 12 minutes C/T, represents the time used for a circuit of a product to move through the process. C / O is 10 minutes in data box, meaning

[153] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.59, 62.
[154] Abdulmalek and Rajgopal, p.226.
[155] Maskell and Baggaley, **Practical Lean Accounting : A Proven System For Measuring and Managing The Lean Enterprise,** p.324.

changeover time from one type of component to another. This time represents consumed time by employees ready to make another component. Furthermore, preparation time to product 3735 units in the process is two minutes.[156]

At the bottom of the current state map in Figure 22, there is a timeline has two values; production lead time in days and the processing time. The production lead time is calculated by summing the lead time before each process. The processing time is the total processing time for each process in the value stream. [157] The production lead time of ECI is 20, 5 days and the processing time of ECI is 30, 3 minutes of the lead time.

According to lean assumptions, there are various things wrong within the processes; [158]

- There is a push system with excess inventory stocks.
- The process cycle times are unarranged.
- There is excess consumed time for inspection and rework.
- Shipping times are non-programmed and production is hurried.

3.1.3.1.4. Designing the Future State Map

While the current state value stream map defines the performance in the existing company, the future state value stream map is the chance for management to determine the company to realize specific business aims relating the cost, service and quality as demanded by the market. When designing a future state value stream map, the mapping team will choose one alternative among several alternatives. Furthermore, the team must choose the alternative for future state that directly realizes business aims and that the company can apply in a reasonable time interval.[159]

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[156] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.326.
[157] Abdulmalek and Rajgopal, p.226-227.
[158] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.62.
[159] Keyte and Locher, p.67.

The process of determining the future state map begins while improvement activities of the current state map.[160] In Figure 24, future state value stream map of ECI is shown.[161]

In future state value stream map of electronic components, an obvious change occurs in production lead time, so dock-to-dock days are reduced from 20, 5 to 4, 5 days. A kanban system is applied to pull customer demands through the value stream, rather than push system. In-process inventories are kept in stores called supermarkets between the production cells in value stream. The exact quantities of inventory required by the next step in production are stored in supermarkets. The following improvements are made in future state value stream;[162]

- The cycle time of Hand Load cell is declined from 12 minutes to 6 minutes. The reason of this reduction is redesigning of the cell thereby the flow of the cell is realized more smoothly.

- Through implementing self-inspection and continuous improvement of SMT and Hand Load cells, quality is improved. In Test & Rework cell, rework ratio is reduced to 3 percent from 50 percent.

- Agreements and certification is made with suppliers, thereby key suppliers deliver daily to the supermarkets between value stream cells. This delivery is response to kanban order from the cell.

- The operating time of SMT cell is reduced through the elimination of one shift.

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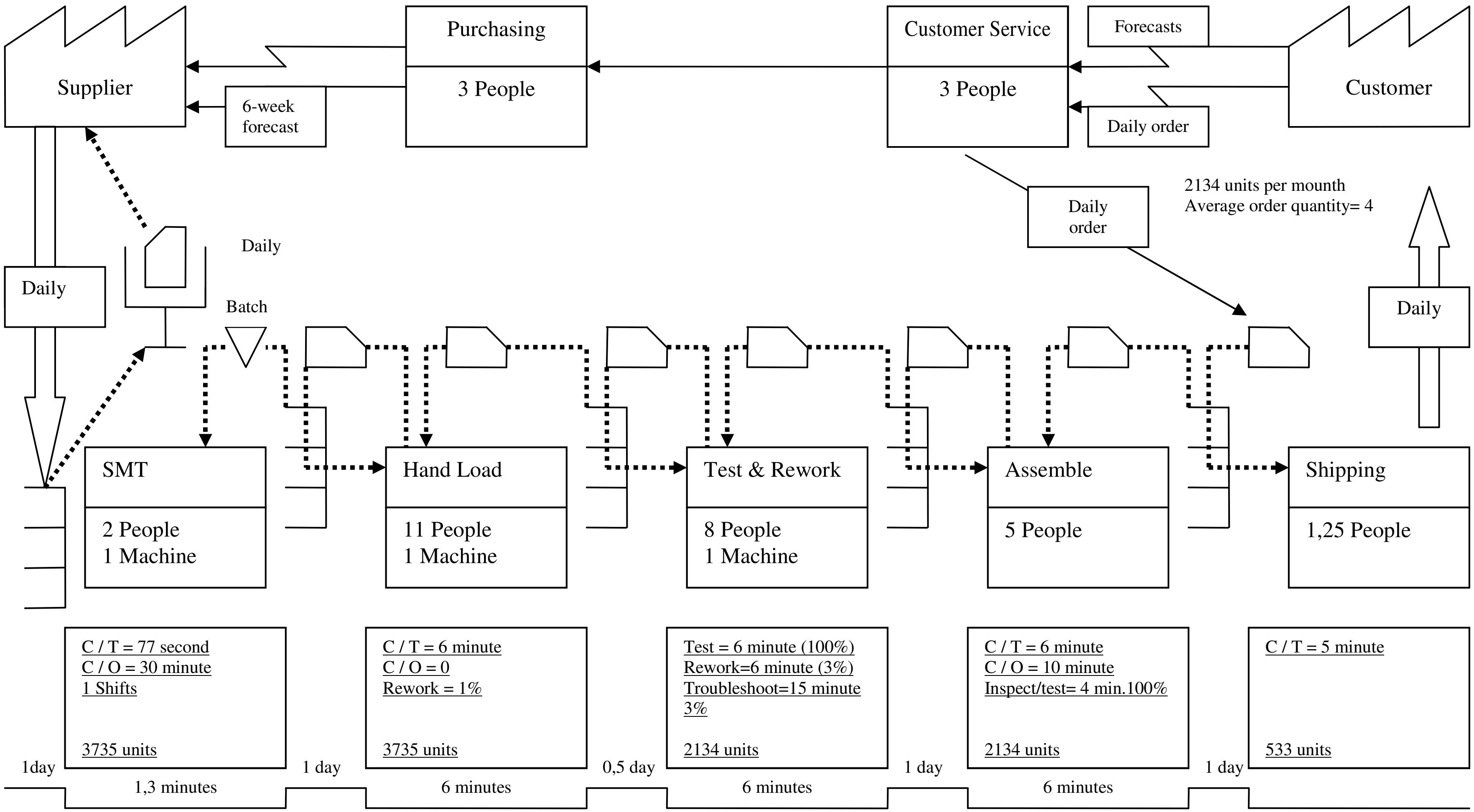
[160] Abdulmalek and Rajgopal, p.227.
[161] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 335.
[162] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.62.



Production Lead Time = 20, 5 days
Processing Time = 30, 3 minutes

Figure 24: Example of Future State Value Stream Map for the Controllers

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.335.

3.1.3.2. Value Stream Capacity Analysis

The company's second aim after collecting the data in value stream map is association of the data to analytical framework for both worker and machine capacity. The capacity analysis of value stream is illustrated both current state and future state.

Capacity is the adequacy to do production supported by resources. Two types of resources are used for this support;[163]

- Employee; the time available to do production during a period. The time can be hours and period can be a shift, a day, a week or a month.
- Machine; the time available to do production during a period. The time can be hours.

The capacity usage time of employee and machine is categorized as the following; [164]

- Productive,
- Non-productive,
- Available.

Productive capacity is the capacity consumed to actually produce a product or a service. Productive capacity is also the value creating or value added capacity to the company.[165] Non-productive capacity is all other uses of time from productive capacity. Non-productive capacity is also the non-value adding capacity, such as time spent on rework, planning, supply, repair, maintenance, management, administration, material movement and inspection.[166] Non-productive capacity is categorized into planned non-

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[163] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.67.
[164] Maskell, Brian H., Bruce Baggaley**,** Nick Katko and David Paino. **The Lean Business Management System, Lean Accounting: Principles & Practices Toolkit.** First Edition. New Jersey, United States of America: BMA Press, 2007, p. 33.
[165] Berry and Cox, p.4-16.
[166] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.68.

productive and unplanned non-productive capacity. Planned non-productive capacity is planned capacity such as preventive maintenance and planned machine shutdowns. Unplanned non-productive capacity is unplanned capacity such as machine breakdowns, unplanned maintenance, process faults, lack of production materials or other delays.[167] Available capacity is employee and machine time left over after productive and non-productive time has been consumed.[168]

3.1.3.2.1. Employee Capacity Analysis

In order to understand how employee capacity analysis is implemented the company tracks the activities and the employee time used to performing these activities in the value stream. Information of the activities is collected from data boxes on the value stream maps. The employee capacity is categorized according to usage of activities as productive, non-productive or available.[169]

The employee capacity analysis is made for current and future time due to value stream maps.

3.1.3.2.1.1. Current State Employee Capacity Analysis

In Figure 25, current state employee capacity analysis of ECI Company is drawn as a spread sheet for Hand Load process.[170] The first step for the preparation of capacity analysis is determination of activities. The second step is categorizing the activities as productive and non-productive. The third step is calculation of duration of these activities as hour. Then total productive and non-productive times in the process are calculated. After the calculation of total time available for use per month in the process, available time-total time not used per month of the process is determined.

The productive activity in this process is “Make for Demand”. The non-productive activities are “Get Ready”, “Rework”, “Move in Material”, “Move Material”

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[167] Berry and Cox, p.4-16.
[168] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.68.
[169] Maskell, Brian H. and Bruce Baggaley. “Lean Management Accounting”, p.8.
[170] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 331.

and "Administration". All these activities are listed in the activity column of spread sheet.

The first activity "Make for Demand" is calculated through multiplication of cycle time and units produced in the Hand Load process. The formulation of this activity is as follows;

Make for Demand = 3735 units * 12 minutes per item = 44.820 minutes

To convert minutes into hours, the value divided by 60 minutes per hour. The following formulation is;

Make for Demand = 44.820 minutes / 60 minutes = 747 hours

"Get ready" activity means all activities such as changeovers, preparation of components, set-ups of production. In Hand Load process, there are two get ready activities; total changeover time and total preparation of components time. The first "get ready" activity is calculated by multiplication of number of batches produced in this process and change over time. The second "get ready" activity is calculated through number of produced units in this process times preparation time of the components. The formulation of the first and the second "get ready" activities are as follows;

Get Ready = (100 Batches * 10 minutes) / 60 minutes = 16, 7 hours

Get Ready = (3735 units * 2 minutes) / 60 minutes = 124, 5 hours

"Rework / Remake" activity is related of the errors realized in this process. This activity is calculated by errors times the correction time of this errors. The formulation is as follows;

Rework / Remake = (227 errors * 6 minutes) / 60 minutes = 22, 7 hours

The other activities that are no existence in data box are performed by the process team. These activities are such as move the material in the process, move the work-in-process inventory out of the work center and administrative actions; meeting, training, improvement projects performing during the month.

"Move in Material" activity of this process is calculated through the multiplication of the number of material moves in the process and the duration of movement. The formulation is as follows;

Move in Material = 60 moves * 1 hour = 60 hours

"Move Material" activity is determined by the number of batches moved out the process times the duration of this movement. The formulation is as follows;

Move Material = (100 batches * 20 minutes) / 60 minutes = 33, 3 hours

"Administration activity" is the total time consumed for administrative activities by employees in this process. The formulation is as follows;

Administration = 11 employees * 53 hours = 583 hours

The total productive time is 747 hours and the total non-productive time is 840, 2 hours in the current state. The summary of time used current state is 1587, 2 hours in the selected month. Total time of employees available for use per month is 1650 hours. This time is calculated by one employee hours available for work during a month times number of employees in the process. One employee has 150 hours available for use and 11 employees work in the process. [171] Available time-total time not used per month is calculated as follows;

Available Time = Total Available Time-Total Used Time

Available Time = 1650 hours – 1587, 2 hours = 62, 8 hours.

[171] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.330.

	Value Stream: Electronics	Observer:		Date		Page
		Current State		Future State		
Process Steps	Activity	Non-productive	Productive	Non-productive	Productive	
Hand Load	Make for Demand (3735 units * 12 minutes)		747			
	Get Ready (100 batches * 10 minutes)	16,7				
11 persons	Get Ready-prep components (3735 units * 2 min.)	124,5				
1 shift	Rework/remake (227 errors * 6 minutes)	22,7				
hours	Move in material (60 moves * 1 hour)	60				
	Move material (100 batches * 20 minutes)	33,3				
	Administration (11 employees * 53 hours)	583				
	Total time by value creating category	840,2	747			
	Total time used current/future state	1587,2				
	Total time not used per month	62,8				
	Total time available for use per month	1650				
	Productive Percent	0,45				
	Non-Productive Percent	0,51				
	Available Percent	0,04				

C/T=12min.
C/O=10min.
Prep comp=2min.
Rework=5%
3735 units

Figure 25: Current State Employee Capacity Analysis

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.331.

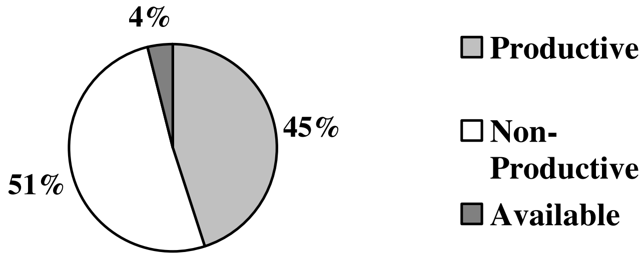

Figure 26: Current State Employee Capacity Usage

In Figure 26, the percentage of productive, non-productive and available employee capacity is shown. The percentages are calculated by the ratios of used as productive, non-productive and non-used times to total available time. The productive time of the process is 747 hours and total available time is 1650 hours, consequently the productive percentage is 45 %. The non-productive time is 840, 2 hours and total available time is 1650 hours, consequently the non-productive percentage is 51 %. The available time is 62, 8 hours and total available time is 1650 hours, consequently the available percentage is 4 %.

3.1.3.2.1.2. Future State Employee Capacity Analysis

In Figure 27, future state employee capacity analysis of ECI Company is shown as a spread sheet for Hand Load process. Important changes are made and performed by the lean improvement team.

Through redesigning of the cell, the smoothly cell flow is provided and for that reason "Make for Demand" activity of Hand Load process is declined from 747 hours to 373,5 hours. As determined in "Designing the Future State Map" part of the dissertation, C / T of Hand Load process is 6 minutes in the future state. The following calculation is made for "Make for Demand" activity;

Make for Demand = (3735 units * 6 minutes) / 60 minutes = 373, 5 hours

The C / O time of Hand Load process is eliminated in the future state. Thus, "Get Ready" employee activity is zero in the future state. The necessity for preparation of components is eliminated by the changes in prior process.[172] Also, "Get Ready-prep components" employee activity is zero in the future state.

The number of products reworked is declined from 227 errors to 45 errors. Thereby, "Rework/remake" employee activity is calculated as follows in the future state;

Rework / remake = (45 errors * 6 minutes) / 60 minutes = 4, 5 hours

Movement of materials is eliminated through the inventory stocks at the cells by using supermarkets.

Administrative activities are cut by half through lean improvements. The duration of "Administration" activity is 291, 5 hours in the future state.

The total productive time is 373, 5 hours and the total non-productive time is 296 hours in the future state. The summary of time used future state is 669, 5 hours in the selected month. Total time of employees available for use per month is 1650 hours. Available time-total time not used per month is calculated as follows;

Available Time = 1650 hours – 669, 5 hours = 980, 5 hours.

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[172] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.333.

Value Stream Study	Value Stream: Electronics	Observer:		Date		Page
		Current State		Future State		
Process Steps	Activity	Non-productive	Productive	Non-productive	Productive	
Hand Load	Make for Demand (3735 units * 6 minutes)		747		373, 5	Cut in half
	Get Ready (100 batches * 0 minutes)	16,7		0		Eliminated
11 persons	Get Ready-prep components (3735 units * 0 min.)	124,5		0		Eliminated
1 shift	Rework/remake (45 errors * 6 minutes)	22,7		4,5		Cut to 1%from 5%
hours	Move in material (60 moves * 0 hour)	60		0		Eliminated
	Move material (100 batches * 0 minutes)	33,3		0		Eliminated
	Administration (11 employees * 53 hours) / 2	583		291,5		Cut in half
	Total time by value creating category	840,2	747	296	373, 5	
	Total time used current/future state	1587,2		669,5		
	Total time not used per month	62,8		980, 5		
	Total time available for use per month	1650		1650		
	Productive Percent	0,45		0,23		
	Non-Productive Percent	0,51		0,18		
	Available Percent	0,04		0,59		

C/T=6min.
C/O= 0 min.
Prep comp=0 min.
Rework=1%
3735 units

Figure 27: Future State Employee Capacity Analysis

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.337.

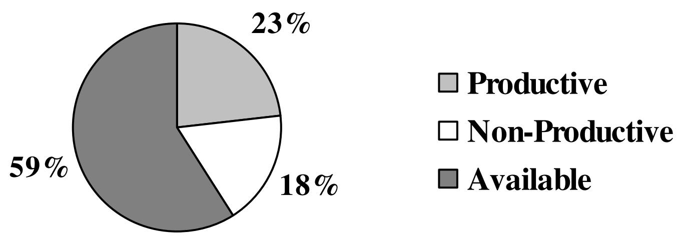

Figure 28: Future State Employee Capacity Usage

In Figure 28, the percentage of productive, non-productive and available employee capacity is shown in the future state. The percentages are calculated by the ratios of used as productive, non-productive and non-used times to total available time. The productive time of the process is 373, 5 hours and total available time is 1650 hours, consequently the productive percentage is 23 %. The non-productive time is 296 hours and total available time is 1650 hours, consequently the non-productive percentage is 18 %. The available time is 980, 5 hours and total available time is 1650 hours, consequently the available percentage is 59 %.

3.1.3.2.2. Machine Capacity Analysis

In Figure 29, current state and future state machine capacity analysis of ECI Company is drawn as a spread sheet for Hand Load process. The data of capacity analysis is same for current and future state, because no improvements are made for the machine in this process.

The productive activity in this process is “Make for Demand”. The non-productive activity is “Scheduled Maintenance”.

The first machine activity “make for demand” is calculated through multiplication of one products machine operation time and units produced in the Hand Load process. The formulation of this activity is as follows;

Make for Demand = (3735 units * 1, 5 minutes per item) / 60 minutes = 93, 37 hours

"Scheduled Maintenance" machine activity is calculated by maintenance procedures times the duration of the maintenance. The formulation is as follows;

Scheduled Maintenance = 4 procedures * 1 hour = 4 hours

The total productive time is 93, 37 hours and the total non-productive time is 4 hours. The summary of time used current state is 97, 37 hours in the selected month. The machine works 8 hours a day and 20 days during the month.[173] Total time of machine available for use per month is 160 hours. Available time-total time not used per month is calculated as follows;

Available Time = 160 hours – 97, 37 hours = 62, 63 hours

[173] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.330.

Value Stream Study	Value Stream: Electronics	Observer:		Date		Page
		Current State		Future State		
Process Steps	Activity	Non-productive	Productive	Non-productive	Productive	
Hand Load	Make for Demand (3735 units * 1,5 minutes)		93,37		93,37	
	Scheduled maintenance (4 procedures * 1 hour)	4		4		
1 machine						
1 shift						
hours						
	Total time by value creating category	4	93,37	4	93,37	
	Total time used current/future state	97,37		97,37		
	Total time not used per month	62,63		62,63		
	Total time available for use per month	160		160		
	Productive Percent	0,584		0,584		
	Non-Productive Percent	0,025		0,025		
	Available Percent	0,391		0,391		

Figure 29: Current / Future State Machine Capacity Analysis

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.332.

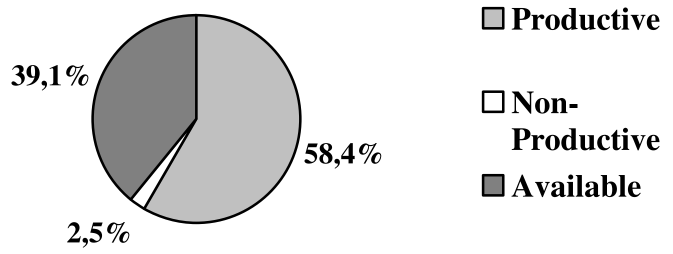

Figure 30: Current / Future State Machine Capacity Usage

In Figure 30, the percentage of productive, non-productive and available machine capacity is shown both current and future state. The percentages are calculated by the ratios of used as productive, non-productive and non-used times to total available time. The productive time of the process is 93, 37 hours and total available time is 160 hours, consequently the productive percentage is 58, 4 %. The non-productive time is 4 hours and total available time is 160 hours, consequently the non-productive percentage is 2, 5 %. The available time is 62, 63 hours and total available time is 160 hours, consequently the available percentage is 39, 1 %.

Two alternatives exist for the usage of available capacity. There are resources elimination and business development. In Table 8, the possible usages of the freed up resources of analyzed value stream is determined. [174]

[174] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.337.

Table 8

Alternative Uses of Freed-Up Capacity

Reduce expenses	**Increase Revenue without increasing expenses (using freed capacity)**
• Close down a plant	• Sell more product
• Avoid future planned capital investment	• Introduce new products
• Sell the machines and equipment	• Build new markets
• In-source outsourced items	• Sell excess capacity
• Layoff the employee	• Add more value to products
• Sell or lease plant space	• Use floor space without new building expense

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.337.

3.1.3.3. Value Stream Performance Measurements

Value stream performance measurements are subdivision of lean performance measures. For definition of value stream performance measurements, it's fundamental to understand overall lean performance system.

Managerial staff of lean company determines strategic objectives. Accounting specialists use performance measures to define these strategic objectives.[175] Performance measurements are related to continuous improvement processes. When the basic lean changes are realized, the company begins to apply continuous improvement activities and value stream workers are responsible for the success of these activities.[176] Performance measures evaluate the lean management improvements of the company. Lean management has the following improvements;[177]

- Lower cycle time,
- Lower lead time,
- Shorter work-in-Process,

[175] Kennedy, Frances, Lisa Owens-Jackson, Laurie Burney and Michael Schoon. "How Do Your Measurements Stack up to Lean?". **Strategic Finance.** Volume 88, Issue 11, May 2007, p. 33.

[176] Maskell, Brian H. and Cherry Hill. "Lean Accounting for Lean Manufacturers". **Manufacturing Engineering.** Volume 125, Issue 6, December 2000, http://www.sme.org/cgi-bin/find-articles.pl?&00de0046&ME&20001221&&SME&(08 September 2009), p.1.

[177] Bhasin, Sanjay. "Lean and Performance Measurement". **Journal of Manufacturing Technology Management.** Volume 19, Issue 5, 2008, p. 675.

- Quick response time,
- Decreased cost,
- More flexible production,
- Increased quality,
- Higher profit,
- Increased revenue,
- Increased throughput, and
- Faster customer service.

The linkage chart is a planned framework to measure the countable factors of the lean company.[178] Through using lean performance measurements linkage chart, measurements are linked to company strategy. Strategy cause to arise strategic measurements, strategic measurements cause to value stream measurements and value stream measurements are related to cell or process measurements.[179]

Strategic objectives are related to strategic measures. Strategic objectives are special company aims and have preset time for success. Through strategic objectives, value stream is guided for product and financial targets. Value stream goals are special aims to realize the value stream achievement factors in a planned time. Value stream measure evaluates the achievement of value stream targets. Cell goals are important aims for cell to success critical achievement factors. Cell measure evaluates the success of cell targets.[180]

In Figure 31, the linkage chart between strategic objectives and performance measures of lean company are shown. The strategic aim of profitable growth is related to the strategic target of sales growth. Sales growth causes three value stream aims;

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[178] Maskell, Baggaley**,** Katko and Paino, p.24.
[179] Maskell, Brian H. and Susan J. Lilly. **Life's Little Lean Accounting Instruction Book.** USA: BMA Inc., 2006, p.23.
[180] Maskell, Baggaley**,** Katko and Paino, p.25.

economical processes, producing to customer demand, and perfect quality at the source. These three value stream goals are related to value stream measures, such as on-time delivery, cost per unit, first-time through and units-per-person. These value stream measures are linked to five cell success factors. Cell success factors are related to cell aims and cell aims are linked to three cell measures.[181]

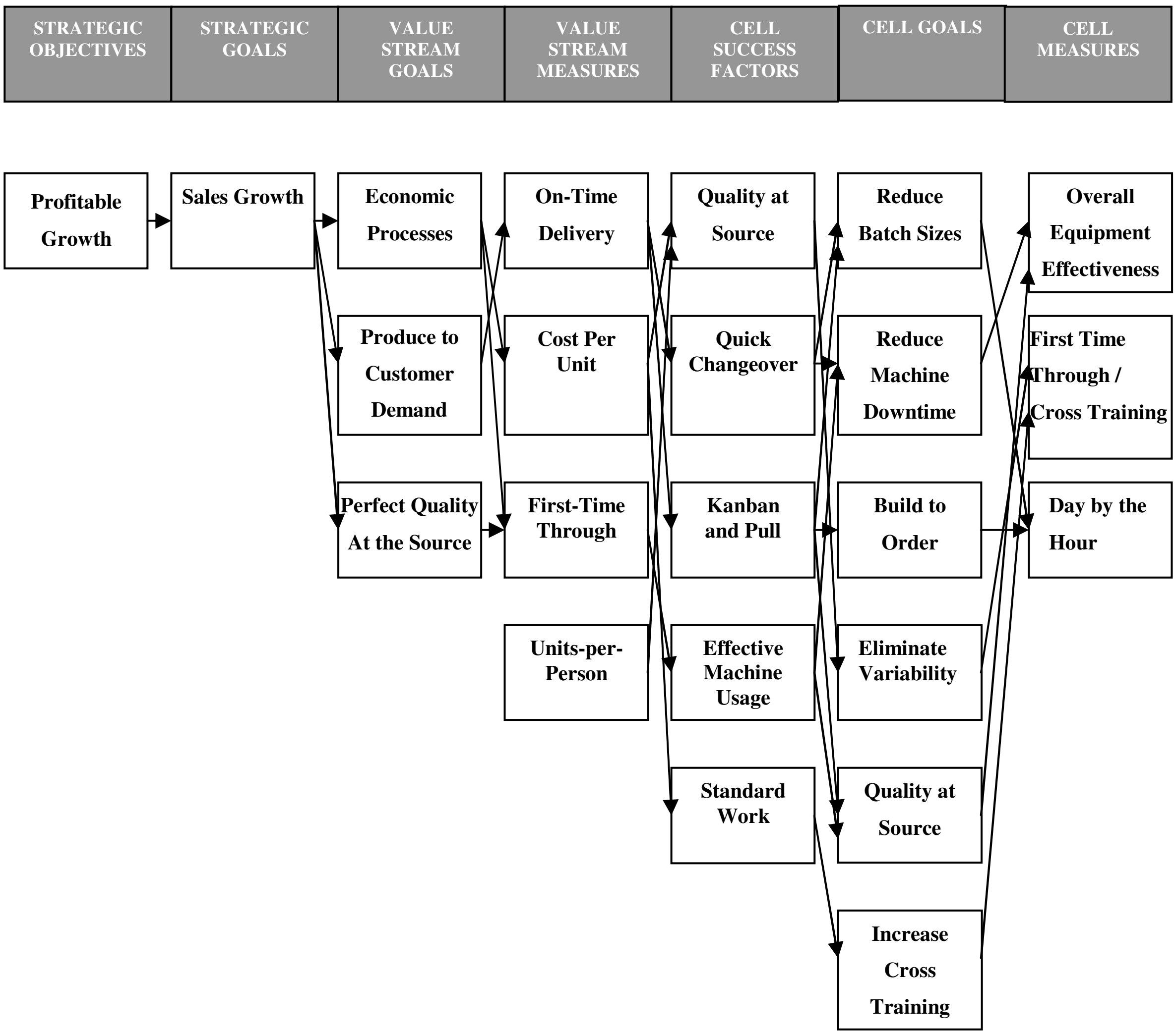

Figure 31: The Linkage between Strategic Objectives and Performance Measures

Source: Kennedy, Frances A. and Peter C. Brewer. "Lean Accounting: What's It All About?". **Strategic Finance.** Volume 87, Issue 5, November 2005, p. 29.

[181] Kennedy, Frances A. and Peter C. Brewer. "Lean Accounting: What's It All About?". **Strategic Finance.** Volume 87, Issue 5, November 2005, p. 30.

In Figure 32, strategic and value stream measurements for the order fulfillment value stream and the linkage between the goals and measurements are presented.[182]

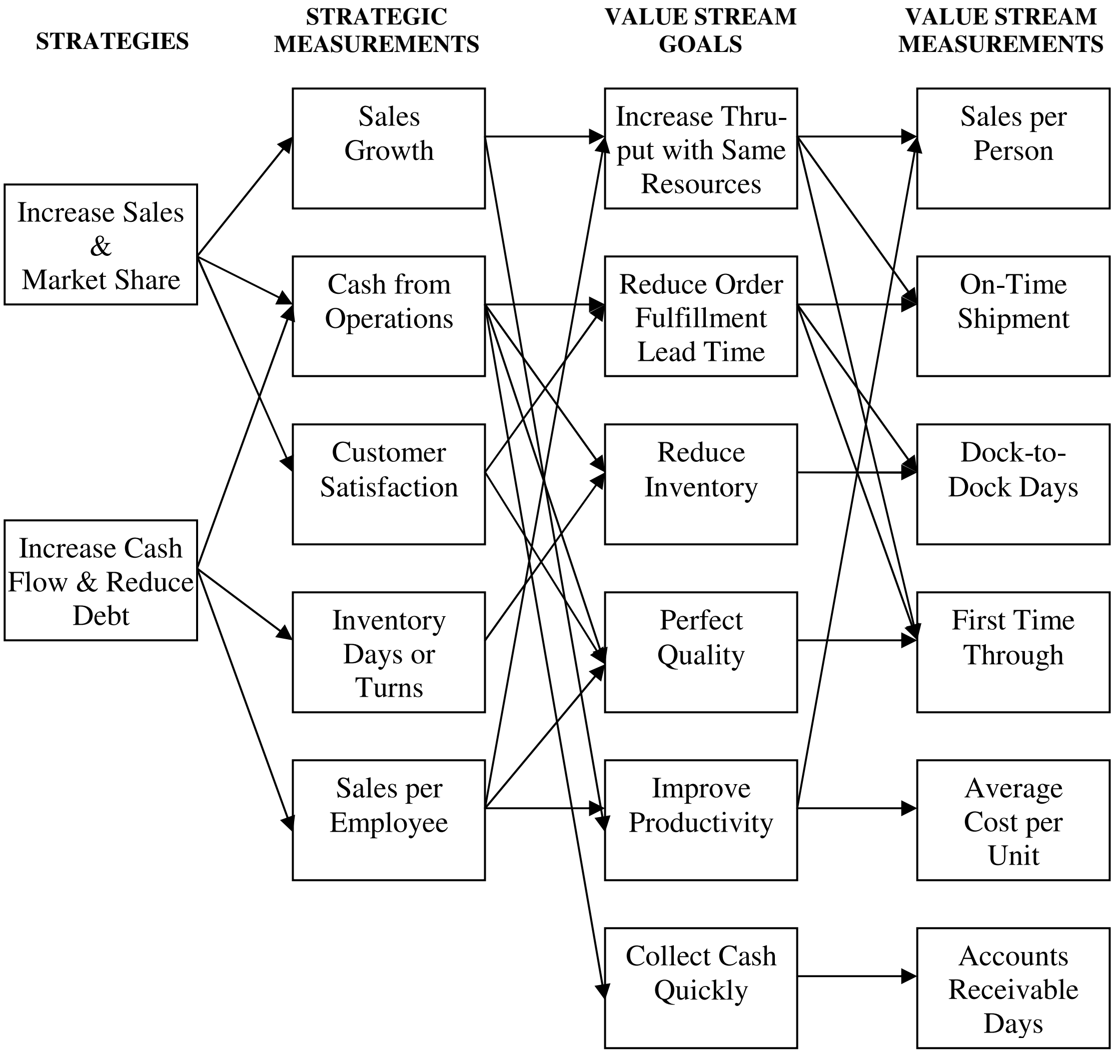

Figure 32: Strategic & Value Stream Measurements for the Order Fulfillment Value Stream

Source: Maskell, Brian H., Bruce Baggaley, Nick Katko and David Paino. **The Lean Business Management System, Lean Accounting: Principles & Practices Toolkit.** First Edition. New Jersey, United States of America: BMA Press, 2007, p. 30.

In Table 9, the set of performance measurements used by lean company is showed. Lean performance measurements are cell level, value stream level and

[182] Maskell, Baggaley, Katko and Paino, p.30.

company level measurements. There are important issues of visual management, value streams, production cells and are developed for continuous improvement. [183]

Table 9

Example of Performance Measurements Reflecting Lean Motivation and Focus on the Company's Strategy

STRATEGIC MEASURES	**VALUE STREAM MEASURES**	**CELL / PROCESS MEASURES**
Sales Growth	Sales per Person	Day-by-the-hour production
EBITDA	On-Time Delivery	WIP to SWIP
Inventory Days	Dock-to-Dock Time	First Time Through
On-time Delivery	First Time Through	Operational Equipment Effectiveness
Customer Satisfaction	Average Cost per Unit	
Sales per Employee	Accounts Receivable Days Outstanding	

Source: Maskell, Brian H.. "What is Lean Accounting". **Superfactory Newsletter.** May 2004, http://www.maskell.com/site/subpages/lean_accounting/ components/ What_is_Lean_Accounting.pdf (01 June 2008), p.7.

Strategic measures are sales growth, earnings before income taxes, depreciation and amortization (EBITDA), inventory days, on-time delivery, customer satisfaction and sales per employee. Sales growth can be calculated by matching a given quarter of year to the same quarter a year earlier. In a lean company, sales growth must be obtained by more quality products, satisfied customers and better lead time, not decreased prices. EBITDA is a cash flow measurement and presents the cash from operations before accounting adjustments and allowances. Inventory days measure the scale of inventory in the company. This measurement can be calculated by monetary value of all production inventories divided to average monetary value of shipments or day. On-time delivery will be explained comprehensive in the next part of dissertation. Customer satisfaction is fundamental for the sustainability of the company. Repeated

[183] Maskell, Brian H.. "What is Lean Accounting". **Superfactory Newsletter.** May 2004, http://www.maskell.com/site/subpages/lean_accounting/ components/ What_is_Lean_Accounting.pdf (01 June 2008), p.6.

sales and customer surveys are two measurement methods of customer satisfaction.[184] Sales per person will be defined in the next part.

Cell measures are day-by-the-hour production, work-in-process (WIP) to standard work-in-process (SWIP), first time through and operational equipment effectiveness. Day-by-the-hour production is the amount of units produced during a day planned in one hour time intervals compared to actual production within those one hour time intervals.[185] SWIP is calculated by the ratio processing time plus load or unload time to the process cycle time. WIP to SWIP ratio is computed by total inventory in a cell divided to SWIP for that cell.[186] First time through will be explained in value stream performance measurements part. Operational equipment effectiveness (OEE) is calculated by three types of data; machine availability, machine performance and product quality. Machine availability is calculated by the ratio of total machine time minus machine downtime to total machine time. Machine performance efficiency is computed by the ratio of actual machine run rate to ideal machine run rate. Quality of products is calculated the ratio of total amount of production minus amount of defect products to total amount of production. The formulation of OEE is as follows;[187]

OEE = Availability * Performance Efficiency * Quality

Value stream performance measurements are sales per person, on-time delivery, dock-to-dock time, first time through, average cost per unit and accounts receivable days outstanding.

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[184] Langenwalter, p.4-6 – 4-8.
[185] Kennedy, Frances A. and Peter C. Brewer. ‘‘The Lean Enterprise and Traditional Accounting - Is the Honeymoon Over?’’. **Journal of Corporate Accounting & Finance**. Volume 17, Issue 6, September-October 2006, p. 71.
[186] Langenwalter, p.4-12.
[187] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 38-39.

3.1.3.3.1. Sales per Person

Sales per person measurement is calculated by the ratio of total sales to the total number of employee in the value stream. [188]

Sales per person measurement calculates the value, is realized by the value stream. It presents the productivity of the value stream. If productivity of the value stream rises, the company can manufacture and sell more products with the same resources and thus, the value stream raises its value.[189]

As an example, when total sales of value stream is 100 units and the number of employees work in value stream is 10 person, sales per person for this value stream will be 10 units.

3.1.3.3.2. On-time Delivery

On time delivery measurement monitors each customer order and determines that it was delivered on time or if not, determines delay time of order.[190]

On-time delivery is the measurement of company performance through customer's eyes. There two types of measurement exist for measurement of on-time delivery; the number of products that are delivered at the customer's dock timely and the number of deliveries that arrive exactly complete and error-free. [191]

When value stream processes are effective, on-time delivery is high. On-time delivery is an important measure to evaluate the degree of control within value stream processes.[192]

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[188] Langenwalter, p.4-8.
[189] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.117.
[190] Kennedy and Brewer. ''The Lean Enterprise and Traditional Accounting - Is the Honeymoon Over?'', p. 71.
[191] Langenwalter, p.4-7.
[192] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 119.

3.1.3.3.3. Dock-to-dock Time

Dock-to-dock evaluates the flow of materials within the value stream. It is the duration it takes between buying a component and raw material from the buying dock, and selling a product from the shipping dock. It is the efficiency of company in turn of raw material into a finished good in the value stream. When dock-to-dock days decrease, the rate of material flow raises and the amount of inventory in the value stream declines.[193]

Dock-to-dock time is the total time of a material or component takes to move through the value stream. Furthermore, it is a determinant of cash tied up in stock. The calculation of dock-to-dock days is made as follows;[194]

Dock-to-dock days = Raw material Stock Days + Work-in-process Stock Days + Finished Goods Stock Days

Dock-to-dock time is similar to inventory days or inventory turns. The formulation of dock-to-dock hours is computed as follows;[195]

Dock-to-dock hours = Units in Production Inventory / (Units Shipped this Week / Production Hours in the Week)

Units in production inventory include raw material, work-in-process and finished goods inventory.

In companies with low products and components, the data of dock-to-dock time is gathered from counting the amount of items in inventory. Companies with complicated production collect the inventory data from kanbans. In Table 10, an example of dock to dock hours is illustrated.[196]

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[193] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 120.
[194] Maynard, Ross. "Lean Accounting". **Financial Management.** March 2008, p. 44.
[195] Langenwalter, p.4-9.
[196] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 121.

Table 10

An Example of Dock-to-dock Hours

Inventory	Shipments	Dock-to-Dock Hour
Raw Materials: 46 units	Units shipped this week: 1203 units	124 units/15, 04 = 8,24 hours
Work-in-Process:72 units	Hours this week: 80 hours	
Finished Goods: 6 units	Shipment per hour: 15, 04	
Total Inventory: 124 units		

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.121.

3.1.3.3.4. First Time Through

First time through (FTT) is the percentage of error-free production in value stream. Error-free product means products without rework, repair, retest, recalibration or fault. It evaluates process effectiveness.[197] First time through of a cell is calculated as follows;[198]

FTT = (Total Units Processed-Rejects or Reworks) / Total Units Processed

In Table 11, an example of first time through of a value stream is shown.[199] First time through of a value stream is computed as follows;[200]

$$\text{Total FTT} = FTT_1 * FTT_2 * FTT_3 * FTT_4 * FTT_5$$

$$\text{Total FTT} = 92\% * 75\% * 84\% * 96\% * 95\% = 53\%$$

Total first time through of value stream is calculated by all computed first time through of cells in value stream multiplication.

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[197] Langenwalter, p.4-9.

[198] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 33.

[199] Langenwalter, p.4-9.

[200] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 33.

Table 11

An Example of Value Stream First Time Through

Cut	Weld	Paint	Assemble	Ship	Total
92%	75%	84%	96%	95%	53%

Source: Langenwalter, p.4-9.

3.1.3.3.5. Average Cost per Unit

Average cost per unit is computed by division of total value stream costs to the amount of units shipped.[201] The total value stream cost consists of all costs in value stream, including;[202]

- Material Costs
- Employee Cost
- Machine Cost
- Supplies, Tooling Cost
- Other Costs

In Figure 33, the calculation of average cost per unit of value stream is presented. [203]

[201] Kennedy and Brewer. ''The Lean Enterprise and Traditional Accounting - Is the Honeymoon Over?'', p. 71.
[202] Langenwalter, p.4-10.
[203] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 125.

Materials cost	60.125
Employee cost	34.130
Machine cost	3.230
Outside processing	3.441
Other costs	6.713
Value stream cost	107.639
Units shipped	3.000
Average product cost	35, 88

Figure 33: An Example of Average Cost per Unit Calculation of Value Stream

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.125.

Average cost per unit determines the general direction of value stream. When inventory is increased in the value stream, the average cost per unit will raise. When value stream produce less good than sells, the average cost per unit will decrease. Furthermore, lean improvement implementations realize the average cost reduces.[204]

3.1.3.3.6. Accounts Receivable Days Outstanding

Lean companies are related to flow and partnerships. Accounts receivable (AR) days outstanding measurement is concerned with the flow of cash and the cash from customers.[205]

Accounts receivable is a fundamental issue of cash flow. Accounts receivable days outstanding measurement evaluates the speed of cash collected from customers. In many lean companies, cash flow is more important than profitability, because when material and information flow raises, cash flow increases. The calculation of accounts receivable days outstanding is as follows;[206]

AR Days Outstanding = AR balance / (Monthly Sales / Number of Days in the Month)

[204] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 126.
[205] Langenwalter, p.4-10.
[206] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 127.

AR Days Outstanding = AR balance / Average Daily Sales

3.1.3.4. Value Stream Box Score

The lean company could make good evaluations about business decisions through various value stream performance measurements. The box score shows a three-dimensional view of the value stream performance.[207]

Value stream box score is a tool of performance reporting, seeing financial benefits, understanding strategic change and decision making in lean companies. It's a picture of usage of resources as productive, non-productive and available. Box score is consist of three main items of value stream; operational measurements, capacity usage and financial results. In Figure 34, three dimensional view of value stream is presented.[208]

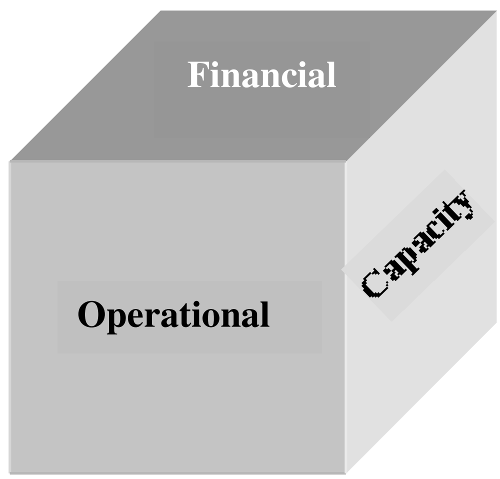

Figure 34: Dimensional View of the Value Stream

Source: Maskell and Lilly, p. 7.

The aim of box score is to submit the related value stream performance information clearly and on a single spread sheet.[209] It is a one-sheet summary for the

[207]Maskell, Brian H. and , Frances A. Kennedy. ''Why Do We Need Lean Accounting and How Does It Work?''. **Journal of Corporate Accounting & Finance**. Volume 18, Issue 3, March-April 2007, p. 67-68.
[208] Maskell and Lilly, p. 8-9.
[209] Stenzel, Joe (Ed.). **Lean Accounting: Best Practices For Sustainable Integration.** USA: John Wiley & Sons, 2007, p. 166.

value stream providing the data of operational performance, financial performance and usage of the capacity.[210] Table 12 presents an example of a box score.[211]

Table 12

An Example of a Box Score

		Current State	Future State
OPERATIONAL	**Units per Person**	**42, 05**	**51, 39**
	On-Time Shipment	**94 %**	**98 %**
	First Time Through	**42 %**	**50 %**
	Dock-to-Dock Days	**20, 5**	**16,5**
	Average Cost	**37**	**35**
CAPACITY	**Productive**	**11 %**	**25 %**
	Non-Productive	**55 %**	**23 %**
	Available Capacity	**34 %**	**52 %**
FINANCIAL	**Revenue**	**$ 1.280.400**	**$ 1.408.440**
	Material Costs	**$ 512.160**	**$ 535.207**
	Conversion Costs	**$ 231.884**	**$208.696**
	Value Stream Profit	**$ 536.356**	**$ 664.537**
	Value Stream Return on Sales	**41, 89 %**	**47, 18 %**

Source: Maskell, Brian H. and , Frances A. Kennedy. ''Why Do We Need Lean Accounting and How Does It Work?''. **Journal of Corporate Accounting & Finance**. Volume 18, Issue 3, March-April 2007, p. 68.

In Table 12, current state of value stream box score and the targeted future state box score are illustrated in general view. It provides to determine areas for lean improvement of value stream.[212]

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[210] Maskell, Brian H. and Bruce Baggaley. "Lean Accounting: What's it All About?". **Association for Manufacturing Excellence.** Volume 22, Issue 1, 2006, http://www.leanaccountingsummit.com/LeanAccountingDefined-Target.pdf(01 June 2008), p. 38.

[211] Maskell and Kennedy, ''Why Do We Need Lean Accounting and How Does It Work?'', p.68.

In lean companies, traditional variance reports change places with box scores. Comprehensive performance measures of box score show lean enterprises' operating, capacity and financial characteristics both current and future state. Therefore, the company can see the success level of strategic targets for growth.[213]

Operational results part of box score provides the information of lean implementation's effects on value stream performance measures.[214] Value streams are responsible for operational improvement through continuous improvement activities. These activities are administrated with performance measures in operational section of box score.[215]

Capacity usage part of box score illustrates the effect of lean implementation on utilization of capacity, categorized into three categories; productive capacity, non-productive capacity and available capacity.[216] Productive capacity is the range of total resources used for value-adding activities. It is calculated by multiplication of total cycle time and units shipped. Non-productive capacity is the value of total resources used for wasteful activities. Available capacity is calculated by total capacity less productive and non-productive capacity.[217]

Financial results part of box score shows the effect of lean implementations on income statement of value stream.[218] The calculation of financial part of box score is explained 3.2. section of the dissertation.

3.2. Accounting and Costing Systems in Lean Enterprises

In this part of dissertation, accounting and costing systems in lean enterprises – lean accounting are explained comprehensively. In lean enterprises, applied accounting and costing systems are different from traditional accounting. Traditional accounting is inappropriate for lean manufacturing firms.

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212 Maskell and Kennedy, ''Why Do We Need Lean Accounting and How Does It Work?'', p.68.
213 Heston, Tim. "A Lean-Accounting Primer". **Fabricating & Metalworking.** Volume 6, Issue 4, April 2007, p. 26.
214 Maskell, Baggaley**,** Katko and Paino, p. 33.
215 Stenzel, p. 166.
216 Maskell, Baggaley**,** Katko and Paino, p. 33.
217 Stenzel, p. 166.
218 Maskell, Baggaley**,** Katko and Paino, p. 33.

Lean enterprises provide the accuracy of production to customer requirements. Production amounts greater than customer demands cause costly inventory. The apparent conflict between traditional financial accounting, which supports high inventory, and lean, which encourages limited production according to demand, creates a dilemma.[219]

The accounting function is necessary for achievement of lean transformation. There are two approaches to lean accounting: implementing lean principles to eliminate waste out of the accounting function itself; and development of the accounting process to appropriately improve lean behaviors.[220]

Lean accounting deals with lowering cost by removing waste.[221] Unless removing waste from accounting process, accountants spent a lot of time on non-value added activities.[222] The way to discovering and removing non-value added costs is rationalization of operations. After identifying and removing examples of non-value added activities, the company communicates with customers to define which activities are value-added.[223]

The strategy for decreasing cost and increasing profit is continuously improvement of the system between all parts of business. Therefore, elimination of waste and increase of flow are realized and improvement of long term financial results is provided.[224]

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[219] Engle, Paul. "Keep your Books Lean". **Industrial Engineer.** October 1, 2005, p. 22.
[220] Deluzio, Mark C.. ''Accounting For Lean''. **Manufacturing Engineering**. Volume 137, Issue 6, December 2006, p. 83.
[221] Johnson, H. Thomas. "Management by Financial Targets Isn't Lean". **Manufacturing Engineering.**. Volume 139, Issue 6, December 2007, p. 78.
[222] Deluzio, Mark C., p. 83.
[223] Baker, M. William. "Eliminate Non-Value-Added Costs". **Industrial Management.** Volume 44, Issue3, May-June 2002, p. 27.
[224] Johnson, H. Thomas. "Manage a Living System, Not a Ledger". **Manufacturing Engineering.** Volume 137, Issue 6, December 2006, p. 76.

Lean accounting is concerned with organizing costs by value stream, changing inventory valuation methods, improvement of management financial reports and creating awareness of non-financial information.[225]

The purposes of lean accounting are explained in summary as follows;[226]

- Providing the information of performance measurement and cost to value stream manager for ensuring effective control and continuous improvement of value stream.
- Ensuring the information to top managers for reporting performance and costs.
- Gathering the data of costs for recordings to income statement and accounting entry.

Lean accounting is implemented by lean production companies and can be analyzed with two dimensions; lean financial accounting and lean cost management.

3.2.1. Lean Financial Accounting

Lean financial accounting and control processes are described as "a new method of managing a business that is built upon lean principles and lean methods".[227]

Lean financial accounting is series of methods designed for supporting lean production. Therefore, lean accounting must be lean and eliminate additional wasteful activities. In lean accounting, all transactions of accounting could be accepted as wasteful because these activities are non-value added activities for goods and services.[228]

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[225] Bremer, Michael, Brian McKibben and Thomas McCarty. **Six Sigma Financial Tracking and Reporting.** United States of America: McGraw-Hill Professional Publishing, 2006, p. 56.
[226] Gürdal, Kadir, Murat Koçsoy and Orhan Ünal. "Yönetim Muhasebesinde Yeni Bir Yaklaşım: Yalın Muhasebe". **Muhasebe Bilim Dünyası Dergisi.** Volume 7, Issue 4, December 2005, p. 32.
[227] Kennedy, Frances A. and Sally K. Widener. "A Control Framework: Insights from Evidence on Lean Accounting". **Management Accounting Research.** Volume 19, Issue 4, December 2008, p. 302.
[228] Gürdal, Kadir. **Maliyet Yönetiminde Güncel Yaklaşımlar.** Ankara: Siyasal Kitabevi, 2007, p. 60.

In Figure 35, transaction control change in lean enterprises is presented. Through standardization of work, limited number of suppliers, aware to perfection and flow and trained employees to solve problems, transaction control methods change in lean companies.[229]

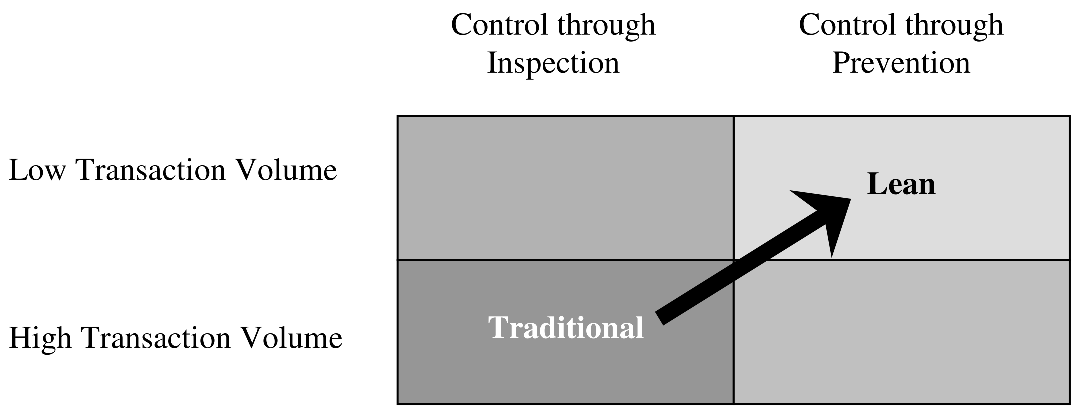

Figure 35: Transaction Control Change in the Lean Finance Function

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.88.

Figure 36 presents lean accountant behaviors. These behaviors are summarized as follows;[230]

- Lean accountants try to provide process ownership by value stream team members. They ensure this by giving timely and understandable information to non-accounting employees.

- Lean accountants can develop a lean structure in company by thinking sales growth first. In company, net income is raised by profitable sales growth.

- Lean accountants should focus more on long-term state of company during analytically measurement of corporate performance.

[229] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.88.

[230] Kennedy, Frances A. and Peter C. Brewer. ''Motivating Lean Behavior: The Role of Accounting**''. Journal Of Cost Management For The Manufacturing Industry.** Volume 20, Issue 6, 2006, p.24-26.

- Lean accountants can ensure internal relationship with non-accounting employees by becoming business partners.

- Lean accountants regard an enterprise view of lean by describing value streams from the customer's point of view.

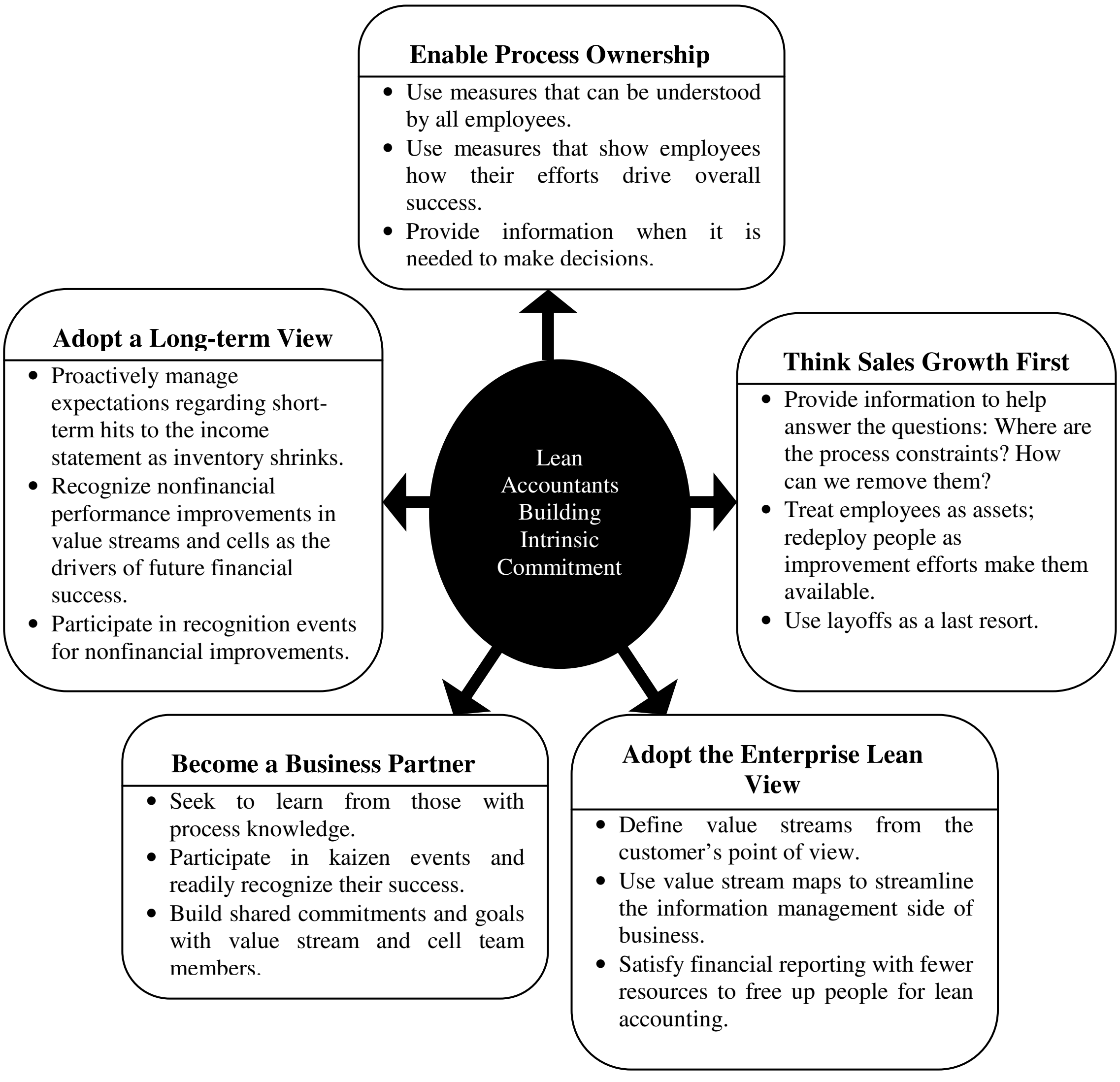

Figure 36: Lean Accountant Behaviors

Source: Kennedy, Frances A. and Peter C. Brewer. ''Motivating Lean Behavior: The Role of Accounting**''. Journal Of Cost Management For The Manufacturing Industry.** Volume 20, Issue 6, 2006, p. 25.

Waste must be removed to free up accounting personnel from general transaction audits and managerial works through certification of suppliers, kanban control and procurement improvements. Therefore, the accountants have more time to realize lean improvements. In lean companies, the real control is on the shop floor. In freed-up time, the accountants help the shop floor employees in applying these controls and provide the assurance of these controls operating as planned. Besides, the remove of wasteful bookkeeping activities ensures the freed-up time for accountants. The changing role of accounting personnel is drawn below in Figure 37.[231]

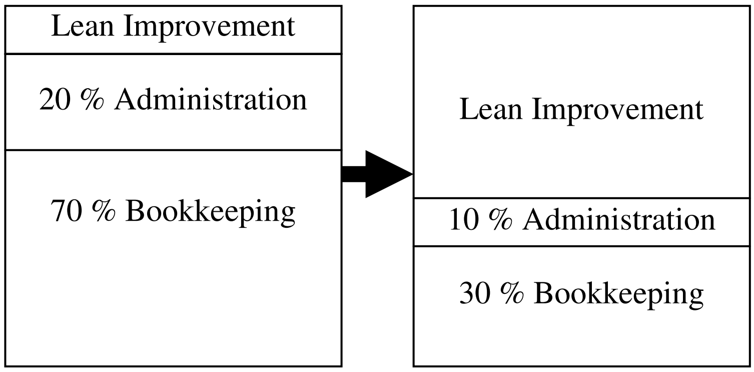

Figure 37: Changing the Role of Accounting Personnel

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.89.

Figure 38 shows the triangle of accounting and finance transformations for both traditional and lean accounting. First triangle represents traditional accounting levels. The largest area of the first triangle is general transactions means the greatest amount of total time is spent in transactions. These transactions are paying bills, collecting money, filing taxes and paying people. Second triangle illustrates lean accounting levels. The largest area of the second triangle is consulting. Consulting area represents consultants and business partners of lean enterprise.[232] The long term target of lean accounting is to reverse the triangle so accounting activities present the lean triangle on the right part of figure. Through spending most of the time in consulting

[231] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.88-89.

[232] Cunningham, Jean E. and Orest Fiume. Real Numbers: Management Accounting in a Lean Organization. Canada: Managing Times Pres, 2003, p. 23-24.

activities and least time on transactions, accounting can add important value to lean enterprise.[233]

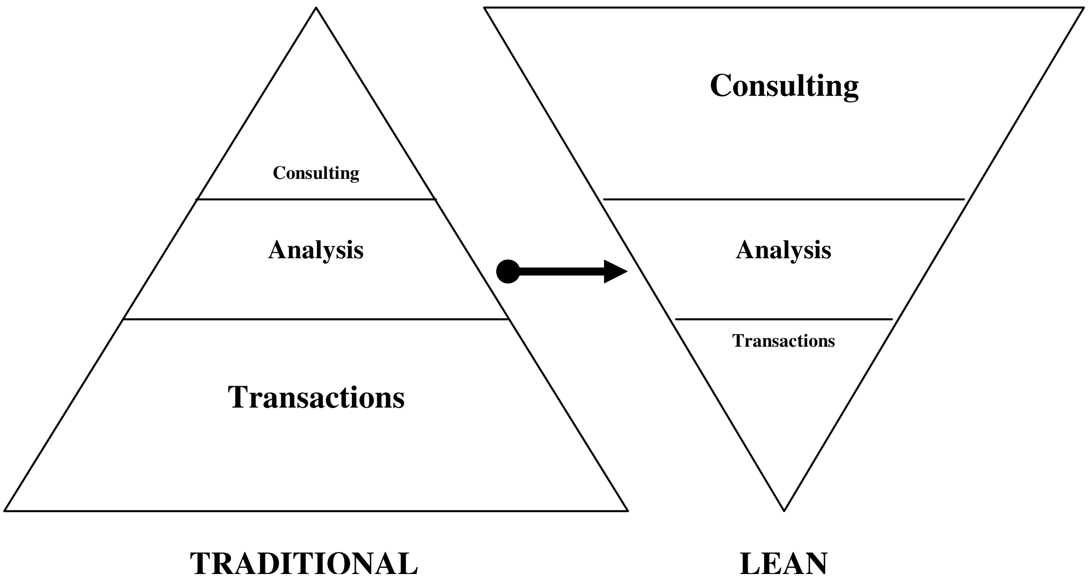

Figure 38: Accounting and Finance Transformation

Source: Cunningham, Jean E. and Orest Fiume. **Real Numbers: Management Accounting in a Lean Organization.** Canada: Managing Times Pres, 2003, p. 23.

The ways of waste elimination from financial accounting processes are defined in Figure 39. [234]

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[233] Stenzel, p. 227.
[234] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.90.

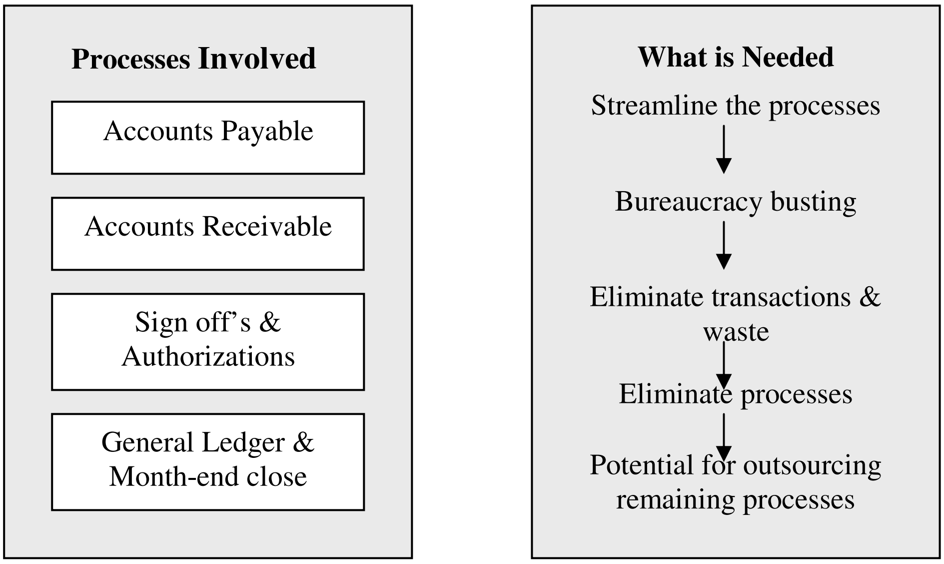

Figure 39: Eliminating Waste from the Financial Accounting Processes

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 90.

The process of closing the books every month is a time consuming process for accounting department. In Figure 40, lean general ledger and month-end close process features are determined. Lean company changes its chart of accounts from functional departments to value streams.[235]

[235] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.92-93, 219.

- Lengthy and late close every month
- Simplify and standardize the month-end process
- Reduce cost centers, simplify the chart of accounts, eliminate the accruals and adjustments
- Move to quarterly closes
- Expand sales & operations planning to provide relevant month-end information ahead of time
- Automate the month-end and quarterly close
- Outsource if necessary

Lean Thinking:
Move from lengthy & wasteful month-end closes to simplified & automated quarterly closes .

Figure 40: Lean General Ledger and Month-End Close Processes

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.94.

The concepts of lean financial accounting are accounts payable, accounts receivable, inventory valuation and financial reporting processes. Financial reporting process is discussed as value stream financial reporting in lean cost management part of the dissertation.

3.2.1.1. Accounts Payable

Suppliers are an important part of the supply chain and an essential resource to the company. The lean company seeks ways to remove all feasible paperwork from the accounts payable cycle when suppliers are part of the partnership and have a long term relationship of reliance. Furthermore, the devoted suppliers can raise long-term profitability significantly, through improved business methods. Lean focused companies seek and apply different approaches from traditional accounting controls. These approaches achieve the same targets without non-value added costs. Therefore, in a lean company, the initial aims of the accounts payable function are as follows;[236]

- Assure that suppliers are paid what the company takes on debt them,
- Increase the company's profits,

[236] Langenwalter, p.3-3,3-4.

- Assure fiscal integrity.

In accounts payable process, most spent time is the inspection of all invoices taking from suppliers and comparing them with purchase orders and receiving reports.[237] An accounts payable employee enters supplier invoices, recording them to the computer system then give the invoices to filing employee. At a future date, the invoices are pulled from the file and compared with the receiving report. This example of accounts payable process is waste of time for a lean company.[238]

The following steps are for the remove of the need for matching receipts, purchase orders and supplier invoices from the accounts payable process;[239]

- Decrease the amount of suppliers by removing various suppliers of the same commodity. The rest of suppliers are defined as key suppliers of that commodity. Thus, the amount of invoices received is decreased significantly.

- Make master purchase agreements with key suppliers. The master purchase agreement determines the appraisal of needed commodity during the next year, price information and which key supplier provides the delivery of commodity. This master agreement removes purchase orders for every delivery and declines the work in the purchasing department of the lean company.

- Make certification with suppliers about quality conformance, on time delivery and in the desired amounts.

The important target of lean is eliminating all activities that do not add value to customer and most accounting activities are non-value added to customers.[240]

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[237] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.90.
[238] Langenwalter, p.3-7.
[239] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.215-216.
[240] Langenwalter, p.3-9.

Through certification of suppliers, the elimination of invoice amounts is realized. After certification with suppliers, the company introduces blanket purchase orders that clarify conditions for supplying all of the item needs. The elimination of transactions could be realized with given purchase credit cards to employees. Some payments are made through these cards thereby one single transaction applied. The materials are paid automatically by electronic transfer of funds from backflush from the bill of materials into the suppliers' bank account. Consequently, the cash outflow process of the company is automated. Figure 41 determines the lean accounts payable processes.[241]

- Manual three-way match for all payments
- Introduce supplier certification
- Blanket purchase orders
- Voucher on receipt-eliminate invoices
- Introduce purchase credit cards
- Automatically voucher on receipt
- Voucher on backflush or
- Pay on monthly statements
- Automatically pay on backflush using EFT

Lean Thinking:
Very few transactions, payments under control, cooperative supplier relationship.

Figure 41: The Lean Accounts Payable Process

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.91.

3.2.1.2. Accounts Receivable

In lean companies, the purpose of accounts receivable function is increasing incoming cash flow.[242] Cash flow is increased in the value stream when customers are

[241] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.90-91.
[242] Langenwalter, p.3-14.

pay as soon as possible after shipping of the materials.[243] The following instructions are applied to achieve these requirements;[244]

- Send invoices immediately,
- Track late payments from customers,
- Decrease the items decline the amount of cash received from customers such as customer credits, chargeback and others.

In supply chain of lean enterprises, a major part of customers are used preapproved and blanked sales orders for accounts receivables and customer sales. Payments are realized electronically with pay-on receipt or pay-on-usage method.[245]

Lean companies shift from a transaction intensive and complex accounts receivable process to minimum transactions and built-in controls. To provide this shift, the following steps are made by lean companies;[246]

- Decrease the amount of received purchase orders through supporting blanket purchase orders from key suppliers.
- Apply instructions to become certified suppliers to key customers.
- Remove the invoicing process from accounts receivable process through invoicing automatically from the delivery, including the invoice with delivery documents.
- Support payment of the invoice based on receipt of materials; in case of key customers are lean companies.

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[243] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.218.
[244] Langenwalter, p.3-14.
[245] Cokins, Gary. "Achieving Leaner Accounting". **Cost Management.** Jul 2002, p. 2.
[246] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p.92.

- Support automated wire transfers into the lean companies bank accounts according to materials shipped, payment is made upon the customer' s product usage.

3.2.1.3. Inventory Valuation Methods

Traditional accounting method induces the company to over produce and purchase in quantities at the minimum cost. This approach motivates high level of investment in inventory.[247] Inventory valuation is different in lean companies. Because of the attention to producing only what is demanded by customer, inventories are much lower than in traditional manufacturing companies. Therefore, valuation of inventory is performed in a short time.[248] If sales stay in a constant level, lower production capacity is provided by the reducing of excess inventory.[249]

In a lean enterprise, inventory tracking transactions that track an item from receipt on the receiving dock to delivery from the delivery dock are not used. These transactions are waste according to lean thinking, because they cause cost to the company, but do not provide value to the customer. Various methods of approaches are applied for valuing inventory;[250]

- Finished Goods Inventory: Average actual cost of value stream product family could be used or finished goods are traced at direct material cost and a month-end adjustment is made.

- Work-in Process Inventory: WIP is valued based on the amount of kanbans according to value stream product family.

- Raw Materials Inventory: Raw materials are valued simply through days of inventory on hand, multiplied by the average daily value of inventory buying.

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[247] Northrup, Lynn C. "Bridging The Gaap To Lean Accounting". http://www.nwlean.net, (11 June 2007), p.1.
[248] Kroll, Karen M.. "The Lowdown on Lean Accounting". **Journal of Accountancy.** July 2004, p. 73.
[249] Drickhamer, David. "Lean Accounting: Novel Number Crunching". **Industry Week.** December 2004, p. 50.
[250] Langenwalter, p. 7-12.

Whether inventory is low and under observation, various techniques of inventory valuation are used in lean environment.[251] These common methods are days of stock, material cost plus days of conversion cost, quantity of finished goods, average cost, product cost and prior inventory plus purchases minus usage.

3.2.1.3.1. Days of Stock

In days of stock valuation method, the inventory value is calculated from the number of days, after inventory is computed and the days of inventory are determined.[252]

Generally, lean companies trace the inventory days for purchased materials, WIP and finished goods as a performance measurement of the value stream. Through this information, it is easy to compute inventory value. In Figure 42, an example of days of stock method is shown. The material cost for the month in the value stream is $100.000 and the working day in a month is 20 days. Thereby, the material cost per day is $5000 ($100.000 /20 days).[253] In cost management of lean enterprises, all value stream costs except material costs are classified as conversion costs.[254] The total conversion cost is $150.000 and $7500 ($150.000 / 20 days) per day. There are 8 inventory days for purchased materials, so the value of purchased material inventory is $40.000 ($5000 * 8 days). For WIP inventory, 3 days exist, so material cost is $15.000 ($5000 * 3 days) and conversion cost is $22.500 ($7.500 * 3 days). Total WIP inventory value is $37.500. The value of finished goods inventory is $150.000 [($5000 * 12 days) + ($7500 * 12 days). [255]

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[251] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 144.
[252] Langenwalter, p. 7-12.
[253] Maskell, Baggaley, Katko and Paino, p. 123.
[254] Hacırüstemoğlu, Rüstem and Münir Şakrak. **Maliyet Muhasebesine Güncel Yaklaşımlar.** İstanbul: Türkmen Kitabevi, 2002, p. 79-80.
[255] Maskell, Baggaley, Katko and Paino, p. 123.

	This Month	Per Day
Material Cost	$ 100.000	$ 5000
Conversion Costs	$ 150.000	$ 7500

	Purchased Materials	Work-in Process	Finished Goods
DAYS	8	3	12
Material Cost	$ 40.000	$15.000	$60.000
Conversion Cost	$0	$22.500	$90.000
Inventory Value	$40.000	$37.500	$150.000

Figure 42: Days of Stock Method for Calculating Inventory Value

Source: Maskell, Baggaley**,** Katko and Paino, p. 122.

3.2.1.3.2. Material Cost plus Days of Conversion Cost

In this inventory valuation method, the amount and material cost of the inventory is tracked by computer. Therefore, the material cost of inventory is known by company. But the conversion costs are computed according to days of stock method. As shown in the example above, the material cost is already known as $115.000 by tracking and conversion costs are calculated as $112.500 ($7500 * 15 days) through days of stock.[256]

3.2.1.3.3. Quantity of Finished Goods

In this method, the amount of units in finished goods is calculated as a percentage of total production in the month and inventory value is this percentage of total value stream costs.[257]

If lean company have large finished good inventory, quantity of finished goods method is used. When the assumption is that the company has 90 units of finished goods in stock and has 150 produced units. The finished goods inventory is computed

[256] Maskell, Baggaley**,** Katko and Paino, p. 123.
[257] Langenwalter, p. 7-13.

monthly value stream cost $250.000 ($100.000 + $150.000) multiplied by 0, 6 (90/150). According to example, the value of finished goods is $150.000.[258]

3.2.1.3.4. Average Costs

In average costs valuation method, the company take the inventory value of last month-end, the amount of unit and calculate the average cost of inventory. Then the average cost per unit is multiplied by units produced during the month.[259]

As an example, when last month-end finished goods inventory is $340.000 and 200 units are produced, the average cost of a unit is $1700 ($340.000 / 200 units). If current month-end inventory stock is 90 units, the value of finished goods is $153.000 (90 units * $1700). When the total number finished goods include previous month's products, the calculation is made according to both the average cost of the current and prior month.[260]

3.2.1.3.5. Product Cost

The product cost of each item is computed from the value stream average cost and a simple table. The table is related to product features and characteristics and the rate of product flow through the value stream.[261]

This valuation method is used when the company has high levels of stocks. The amount of finished good inventory is traced by the computer systems.[262]

3.2.1.3.6. Prior Inventory plus Purchases minus Usage

In this valuation method, material cost of inventory is calculated as follows:

(Prior Month's Material Cost + Current Month's Purchased Material Cost) – (Current Month's Scrapped Materials Cost + Current Month's Shipped Material Cost)

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[258] Maskell, Baggaley, Katko and Paino, p. 123.
[259] Langenwalter, p. 7-13.
[260] Maskell, Baggaley, Katko and Paino, p. 124.
[261] Langenwalter, p. 7-13.
[262] Maskell, Baggaley, Katko and Paino, p. 124.

The value of conversion cost is determined by days of stock method. Total inventory value is the sum of material cost and conversion cost.[263]

3.2.2. Lean Cost Management

Traditional accounting methodology was invented and applied long time ago for implementation in a competitive environment. Formerly, most firms' cost structures included 60 percent direct labor, 30 percent materials and 10 percent overhead. At the present day, labor costs are mostly fixed and overhead costs increase their shares in total cost, such as 50 percent or more. This change causes new approaches to accounting concepts.[264] The traditional cost accounting system is inappropriate to the progress in implementing lean. This tendency toward implementing lean management appeared at the same time new developments enhanced in cost accounting.[265]

Traditional costing is developed for traditional mass production to ensure the lowest unit cost of products. However, lean is applied for improvement of flow through the production steps. Thus, flowing greater amounts of production is realized with the same resources. Table 13 shows the differences between traditional costing world and lean world.[266]

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[263] Maskell, Baggaley, Katko and Paino, p. 124.
[264] Bremer, McKibben and , p. 54.
[265] Grasso, Lawrence P.. ''Barriers to Lean Accounting''. **Cost Management.** Volume 20, Issue 2, March - April 2006, p. 6.
[266] Baggaley, Bruce L.. "Solving The Standard Costing Problem". **Article of the Month on The Northwest Lean Website,** August 2003, http://www.maskellweb.com/subpages/lean_accounting/articles/standard_costing_problem.html (23.04.08), p.1-2.

Table 13

The Comparison of Traditional Costing World and Lean World

Traditional Costing World	Lean World
• Make more product • Build inventory • Utilize resources to the max • Optimize department efficiencies • Track direct labor • Allocate other costs	• Eliminate barriers to flow • Focus on value stream rather than departments • Continuous improvement and teamwork • Eliminate waste, inventory and overproduction

Source: Baggaley, Bruce L.. "Solving The Standard Costing Problem". **Article of the Month on The Northwest Lean Website,** August 2003, http://www.maskellweb.com/subpages/lean_accounting/articles/standard_costing_problem.html (23.04.08), p. 2.

Lean companies try for low total costs, but unit costs are not used as a measurement of operations. In traditional companies, average unit costs are pursued by assessing departments with standard cost variances. In Table 14, attributes of cost management are determined. These cost management approaches direct employees toward two dimensions. In traditional mode, pursuing average unit costs ensures employees to aware of output produced. Furthermore, in lean mode, chasing low total cost ensures employees attention to consumption of resources.[267]

Table 14

Attributes of Cost Management

Topic	Lean Mode	Traditional Mode
Cost Management	• Pursue Low Total Cost • Reduce Consumption to Reduce Total Cost	• Chase Average Unit Cost • Increase Output to Reduce Average Unit Cost

Source: Johnson, H. Thomas. "Work Lean to Control Costs". **Manufacturing Engineering**. Volume 135, Issue 6, December 2005, p. 82.

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[267] Johnson, H. Thomas. "Work Lean to Control Costs". **Manufacturing Engineering**. Volume 135, Issue 6, December 2005, p. 80-82.

The main concepts of lean cost management are value stream costing and value stream financial reporting.

3.2.2.1. Value Stream Costing

A new method of costing, value stream costing corresponds the requirements of the lean enterprise.[268] Lean accounting determines the value stream as a single cost collector. According to value stream cost accounting view, the total cost of all resources plus any product material and outside service costs are counted in value stream cost object.[269]

Lean companies create a value stream costing system, which includes product based costing. Consequently, all employees in the value stream can see obviously whether their works are causing more cost than value or the reverse to the company.[270]

Value stream costing is implemented effectively through the following assumptions;[271]

- Reporting is made through value stream and not through departments.
- The employee in the company must be charged to value streams.
- Low or no divided service departments and low monuments.
- Production processes are controlled and have low diversification.
- Inventory stock is controlled, low and constant.

Monuments are machines or departments shared with another value stream. The aim of lean enterprise is to decrease the monuments.[272] Value stream costing is

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[268] Baggaley, Bruce and Brian Maskell. "Value Stream Management for Lean Companies, Part II". **Journal of Cost Management.** Volume 17, Issue 3, May / June 2003, p. 25.
[269] Van Der Merwe, Anton and Jeffrey Thomson. ''The Lowdown On Lean Accounting''. **Strategic Finance.** Volume 88, Issue 8, February 2007, p. 29.
[270] Bergstrom, Robin Yale. "Lean Principles & Practices". **Production**. Volume 107, Issue 8, August 1995, p. 33.
[271] Baggaley and Maskell. "Value Stream Management for Lean Companies, Part II", p. 30.
[272] Stenzel, p. 161.

examined with two aspects; value stream cost information and value stream cost analysis.

3.2.2.1.1. Value Stream Cost Information

The value stream cost is generally computed monthly and includes all the costs of the value stream. According to value stream costing, there is no difference between direct costs and indirect costs. All the costs are accepted direct within the value stream. The costs outside the value stream are not counted in value stream costing.[273]

In value stream costing, costs are included in the value stream and related to real materials, real employee, real machines and real support services. Allocations of costs are removed or decreased.[274] In Figure 43, accurate product cost information is drawn for the value stream.[275] The costs are labor costs, material costs, machine costs, facilities costs, outside process costs and other direct costs. Because costs are charged directly to the value stream, there is low allocation in the value stream.[276]

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[273] Maskell, Brian H.. "Solving the Standard Cost Problem". **Cost Management.** Volume 20, Issue 1, January / February 2006, p. 28.
[274] Jusko, Jill. "Lean Manufacturing, Accounting for Lean Tastes". **Industry Week.** September 2007, p.37.
[275] Huntzinger, James R.. **Lean Cost Management: Accounting for Lean by Establishing Flow.** Ft. Lauderdale, FL : J. Ross Publishing, 2006, p. 254.
[276] Maskell, Baggaley**,** Katko and Paino, p. 36.

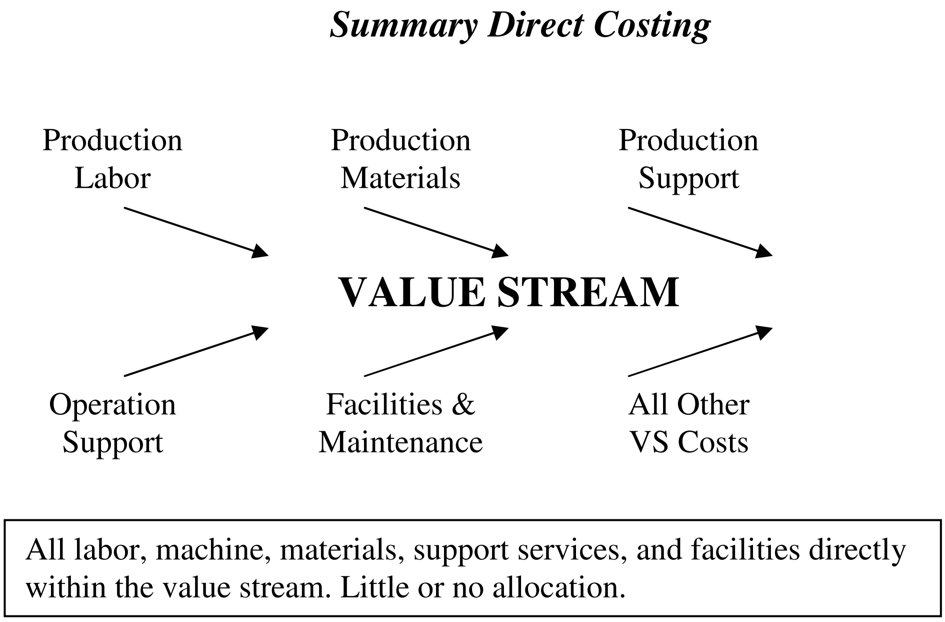

Figure 43: Direct Costing Via the Value Stream

Source: Huntzinger, James R.. **Lean Cost Management: Accounting for Lean by Establishing Flow.** Ft. Lauderdale, FL : J. Ross Publishing, 2006, p. 254.

Value stream costing is based on charging the costs where the capacity being used.[277] All labor costs, both traditionally direct and indirect costs are charged into value stream. The employees, make product, move materials, design the product, maintain the facility, schedule production, perform purchasing, make sales or do accounting, are included in labor cost of value stream.[278] Labor cost is computed from firm's payroll, related to actual employee who works in the value stream as determined in the value stream map.[279] In lean companies, most employees are attached to a single value stream and labor costs occurred outside of value stream, are not charged into value stream.[280] Furthermore, there are employees who work for more than one value stream. For instance, a payroll specialist may work into three value streams. In such a

[277] Kennedy, Frances A. and Jim Huntzinger. ''Lean Accounting: Measuring and Managing the Value Stream''. **Journal Of Cost Management For The Manufacturing Industry.** Volume 19, Issue 5, 2005, p. 34.
[278] Baggaley and Maskell. "Value Stream Management for Lean Companies, Part II", p. 25.
[279] Stenzel, p. 159.
[280] Maskell, Baggaley**,** Katko and Paino, p. 37.

case, the employees' salary is allocated to three value streams according to the time spent for payroll process of each value stream.[281]

The material costs are practically computed from actual purchased materials for the value stream. The total value stream material cost is the sum of purchased materials. Therefore, for accurate material cost, the company must have low raw materials, work-in process inventories. If the amount of inventory is low, material purchase reflect the real material costs.[282] This amount can be computed from cash payments made by accounts payable.[283]

Support costs like components and soft tooling are purchased for value stream. Support costs are generally directly charged to the value stream by using purchase credit cards attached to value stream.[284] Machine costs generally consist of the depreciation of the machines and other machine based costs such as maintenance, repairs and supplies.[285] Depreciation expense is computed from firm's fixed asset and depreciation system.[286]

For the determination of facilities costs, allocation is used within value stream costing. The allocation method is a square footage or square meters cost for the facility. This method encourages the value stream members to decrease the amount of space used by the value stream. Facilities costs consist of the rent cost of the facility, utilities and the maintenance costs for the facility.[287] The cost per square foot is computed through dividing the total facilities cost by the total square footage. The value stream facilities cost is calculated through multiplying the square footage of value stream by the cost per square. The square footage area consists of the production area, stockroom area and office space area used by value stream employees. [288]

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[281] Kennedy and Huntzinger, p. 33-34.
[282] Maskell, "Solving the Standard Cost Problem",p. 30.
[283] Stenzel, p. 160.
[284] Maskell, "Solving the Standard Cost Problem",p. 30.
[285] Maskell, Baggaley**,** Katko and Paino, p. 37.
[286] Stenzel, p. 160.
[287] Maskell, "Solving the Standard Cost Problem",p. 30.
[288] Baggaley and Maskell. "Value Stream Management for Lean Companies, Part II", p. 26.

The costs of all work done by outside contractors are outside process costs.[289] Outside process costs can be computed from cash expenses in accounts payable.[290]

Other direct costs are related to shop supplies, office supplies, spare parts, consumable tools, travel costs and other various costs.[291] Table 15 shows an example of value stream costs table for controller products value stream. In the table, the total value stream costs of the month are $ 702.026.

Table 15

Value Stream Costs of Controller Products Value Stream

	Material Cost	Outside Cost	Employee Cost	Machine Cost	Other Cost	Total Cost
Customer Service	-	-	12.108	-	-	12.108
Purchasing	-	-	16.145	-	-	16.145
SMT	358.512	-	17.080	16.956	20.000	412.548
Hand Load	25.608	-	23.485	2.016	-	51.109
Test and Rework	-	-	17.080	3.528	-	20.608
Assemble and Burn-in	128.040	-	10.675	-	-	138.715
Shipping	-	-	2.669	-	-	2.669
Quality Assurance	-	-	8.073	-	-	8.073
Manufacturing Engineering	-	-	8.073	-	-	8.073
Maintenance	-	-	8.073	-	-	8.073
Accounting	-	-	8.073	-	-	8.073
Information Systems	-	7.760	4.036	-	-	11.796
Design Engineering	-	-	4.036	-	-	4.036
	$512.160	$7.760	$139.606	$22.500	$20.000	$702.026

Source: Baggaley, Bruce and Brian Maskell. "Value Stream Management for Lean Companies, Part II". **Journal of Cost Management.** Volume 17, Issue 3, May / June 2003, p. 26.

[289] Maskell, Baggaley**,** Katko and Paino, p. 37.
[290] Stenzel, p. 160.
[291] Maskell, Baggaley**,** Katko and Paino, p. 38.

3.2.2.1.2. Value Stream Cost Analysis

Value stream cost analysis is an essential measurement method for lean accounting and determines how the resources are consumed within the value stream. In Figure 44, value stream cost analysis steps are shown.[292] Step one of the analysis is defining the value stream. The lean company determines value stream maps and the data of value stream, then, composes the box score of value stream for current and future state. Second step of the analysis is analyzing the capacity of value stream. The company creates an analytical framework for capacity analysis. The last part of the analysis is the determination of freed up capacity usage.

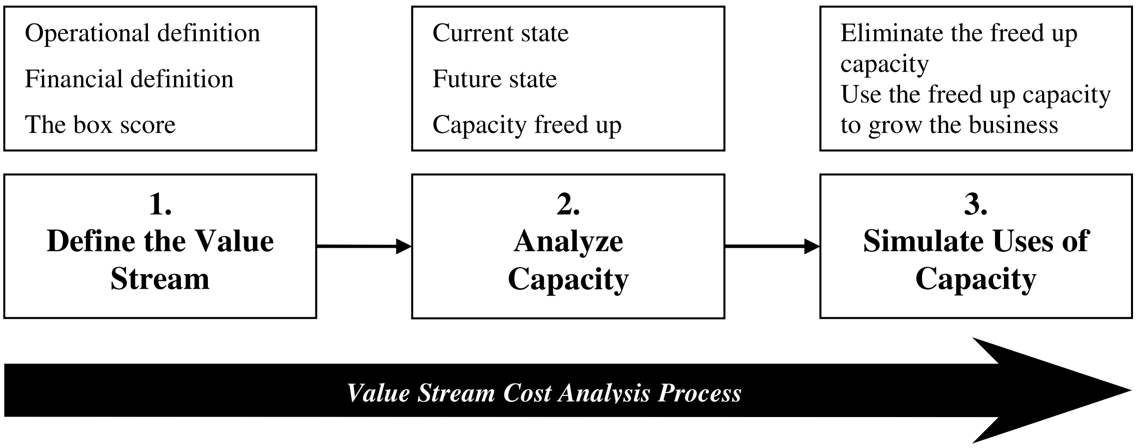

Figure 44: Value Stream Cost Analysis Steps

Source: Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 319.

3.2.2.2. Value Stream Financial Reporting

In lean enterprises, the role of the cost accountant is related with the value creating business activities. The finance staffs are essential members of the value stream

[292] Maskell and Baggaley, **Practical Lean Accounting: A Proven System For Measuring and Managing The Lean Enterprise,** p. 319.

teams. The accounting, control and performance measurement data is gathered to encourage the continuous improvement process.[293]

Value stream financial reports show the outcomes of operations for each of the value streams within the factory during the reporting period.[294]

Two essential tools are used for financial reporting to management in a lean enterprise. These are as follows;

- Plain-English Financial Statements,
- Cash-based Financial Reporting.

3.2.2.2.1. Plain-English Financial Statements

All resources used in value stream activities, from sales order to customer delivery, are accepted as costs, charged to the value stream statements.[295]

The lean company is managed according to value stream units, deal with identifying customer needs. Value stream management smoothes the accounting processes through using summarized direct costing. Every value stream has its own income statement and balance sheet.[296]

In Table 16, profit and loss statement of the controller products value stream is shown.[297] Revenues from controller products are $ 1.280.400. Total costs of this value stream are $ 702.026. Value stream profit is $ 578.374 ($ 1.280.400 - $ 702.026). Return on sales (ROS) of this value stream is 45, 2 % ($ 578.374 / $ 1.280.400).

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[293] Maskell, Brian H.. "Future of Management Accounting in the 21st Century". **Journal of Cost Management.** January / February 2001, http://www.maskell.com/lean_accounting/subpages/lean_accounting/future_of_management_accounting.html (09 May 2009), p. 3.
[294] Maskell, Baggaley**,** Katko and Paino, p. 51.
[295] Kennedy and Huntzinger, p. 33.
[296] Maskell,. "Future of Management Accounting in the 21st Century". p. 3.
[297] Baggaley and Maskell. "Value Stream Management for Lean Companies, Part II", p. 27.

Table 16

P&L for the Controller Products Value Stream

Revenue	$ 1.280.400
Material Costs	$ 512.160
Conversion Costs	$ 189.866
Value Stream Profit	$ 578.374
ROS	45,2 %
Inventory	$ 593.008

Source: Baggaley and Maskell. "Value Stream Management for Lean Companies, Part II", p. 27.

The report is not related to changes in inventory level when computing the value stream profit. The motivation for this is that the company wants to ensure the accurate attitude for the value stream employees. When the value stream decreases inventory by selling more than it produces, the company profit increases and average unit cost decreases. On the contrary, when inventory level rises, the company profit decreases and average unit cost increases.[298] For that reason, the value stream profit does not include changes in inventory level.

The value stream income statement provides the monetary information for decision making and gives profit through subtracting material and all other conversion costs from revenue. A value stream profit margin is computed through dividing value stream profit by revenues.[299] Table 17 shows the income statement of the controller products value stream.

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[298] Maskell, "Solving the Standard Cost Problem",p. 32.
[299] Van Der Merwe and Thomson, p. 29.

Table 17

Income Statement of the Controller Products Value Stream

Sales	$ 1.280.400
Additional Revenue	-
Material Costs	$ 512.160
Employee Costs	$ 139.606
Machine Costs	$ 22.500
Outside Process Costs	$ 7.760
Other Costs	$ 20.000
Value Stream Profit	$ 578.374
ROS	45,2 %

In Table 18, consolidated income statement of the lean enterprise is displayed.[300] Factory income statement consolidates outcomes for all value streams within the factory. The plain-English financial statement determines clearly where company profit was created during the reporting period.[301] The table shows the income statements for all the firm's value streams and again support costs such as administrative and overhead costs. Three value streams exist in the consolidated income statement. These are controller products value stream, the vertical positioners value stream and new product development value stream. The forth column displays the administrative and business supporting costs.[302] These support costs are outside the value streams. The total factory income statement is displayed in the right side column of the table. This column is the sum of all the other columns. Additional support costs are displayed below the total income statement. Then the inventory adjustments are shown in the statement. [303]

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[300] Baggaley and Maskell. "Value Stream Management for Lean Companies, Part II", p. 28.
[301] Maskell, Baggaley, Katko and Paino, p. 51-53.
[302] Baggaley and Maskell. "Value Stream Management for Lean Companies, Part II", p. 27.
[303] Maskell, "Solving the Standard Cost Problem",p. 32.

The total value stream profit is calculated as $ 1.007.637 [$ 3.329.040 – ($ 1.139.518 + $ 1.181.885)]. Division gross profit is computed $ 399.222 through subtracting support costs outside the value streams and inventory change from value stream profit. Return on sales of lean enterprise is 12 % ($ 399.222 / $ 3.329.040).

Table 18

Consolidated Income Statement of the Lean Enterprise

	Value Streams				
	Controller Products	**Vertical Positioners**	**New Product Development**	**Administration & Overhead**	**Division P&L**
Revenue	$1.280.400	$2.048.640	$0		$3.329.040
Material Costs	$512.160	$614.592	$12.766		$1.139.518
Conversion Costs	$189.866	$313.445	$678.574		$1.181.885
Value Stream Profit	$578.374	$1.120.603	($691.340)		$1.007.637
Value Stream ROS	45,20%	54,70%			
Employee Costs				$44.355	$44.355
Expenses				$27.943	$27.943
				Prior Period Inventory	**$1.788.549**
				Current Inventory	**$1.252.432**
				Inventory Change	**- $536.117**
				Division Gross Profit	**$399.222**
				Division ROS	**12%**

Source: Baggaley and Maskell. "Value Stream Management for Lean Companies, Part II", p. 28.

3.2.2.2.2. Cash-based Financial Reporting

Cash-basis accounting enables the preparation of financial statements on generally accepted accounting principles (GAAP) basis. Furthermore, it ensures a clear view of the financial impacts of inventory decreases succeed by lean improvements. Cash-based financial statements present the cash used during the period for operations. Table 19 displays the data on the cash-based financial statement and where it comes from. Because most data are gathered from basic accounting records, detailed transaction tracking through complex computerized system, is not required.[304]

Table 19

Data on the Cash-based Financial Statement

Cost Category	Basis	Source of Data
Materials	Voucher on receipt of materials	Purchase journal
Direct Labor	When paid	Payroll system
Support Labor	When paid	Payroll system
Outside Processing	Supplier PO/invoice	Purchases journal
Machines	Depreciation expense	General journal
Facilities	Square feet occupied	Standard journal entry
Other Costs	Voucher on receipt	Credit card payment

Source: Maskell, Baggaley**,** Katko and Paino, p. 55.

Table 20 shows an example calculation of GAAP net profit of value stream.[305] GAAP net profit is calculated as $ 99.723 through subtracting inventory change from value stream profit ($ 322.610 - $ 222.887).

Table 20

Calculation of GAAP Net Profit

Value Stream Profit		$ 322.610
Opening Inventory	$ 1.186.035	
Less: Closing Inventory	$ 963.148	
Inventory Change / Adjustment	($ 222.887)	($ 222.887)
GAAP Net Profit		$ 99.723

Source: Maskell, Baggaley**,** Katko and Paino, p. 56.

In Table 21, an example calculation of GAAP cost of goods sold is displayed.[306] GAAP cost of goods sold is computed as $ 1.948.963 through subtracting ending inventory from the sum of beginning inventory and value stream costs ($ 2.912.111 - $ 963.148). The difference between value stream costs and GAAP cost of goods sold gives the decrease in inventory balances from the beginning to the end of the period.

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304 Maskell, Baggaley**,** Katko and Paino, p. 54-55.
305 Maskell, Baggaley**,** Katko and Paino, p. 56.
306 Maskell, Baggaley**,** Katko and Paino, p. 56.

Table 21

Calculation of GAAP Cost of Goods Sold

Beginning Inventory		$ 1.186.035
Value Stream Costs		$ 1.726.076
	Subtotal	$ 2.912.111
Less: Ending Inventory		($ 963.148)
GAAP Cost of Goods Sold		$ 1.948.963

Source: Maskell, Baggaley**,** Katko and Paino, p. 56.

4. RESEARCH

The research area of dissertation is a case study on a manufacturing enterprise. The main objective of this research is to develop a lean cost management system in a manufacturing enterprise and to examine the effects of lean improvements on this company. Therefore, first section of the research determines the current state of lean enterprise and the second section of the research displays the future state of lean enterprise.

4.1. General Information and Organizational Structure of the Company

ABC Manufacturing Company is an incorporated company, which has manufactured plastic based products for sectors of construction, agriculture, automotive, medical and white-goods since 30 years in Turkey. Because the company identity is intended to be kept secret, the firm is named as ABC. The company has three main product groups; gasket, pipe and polyvinyl chloride (PVC) door and window systems. The company is one of the largest industrial plants of plastic production in Europe.

General process scheme of the company contains top management, purchasing, human resources, design, maintenance, production, quality, planning, shipping, accounting-finance and customer relations.

Top management is responsible for planning, coordination, procurement of resources, management control, audit of company performance and improvement projects. Purchasing department is accountable from purchasing orders, purchasing transactions, measurement of supplier performance and improvement of suppliers. Finance and accounting department ensures the transactions about the procurement of financial resources and the re-usage of resources. Human resources department determines training and proficiency requirements and is responsible for measurement and development of training and proficiency level. Design department executes demand, planning, development, verification and improvement of designs. Maintenance planning and improvement of maintenance performance are fulfilled in maintenance department. Production department develops production plans, controls production and improves production performance. Quality department is accountable from quality control, internal investigation, product control, measurement and quality improvement projects. Material requirements, production and inventory planning are performed in planning department. Planning of delivery and improvement activities of shipment are executed in shipping department. Customer relations department deals with receiving and correcting the complaints and gathering customer data. In Figure 45, organizational chart of ABC Manufacturing Company is displayed.

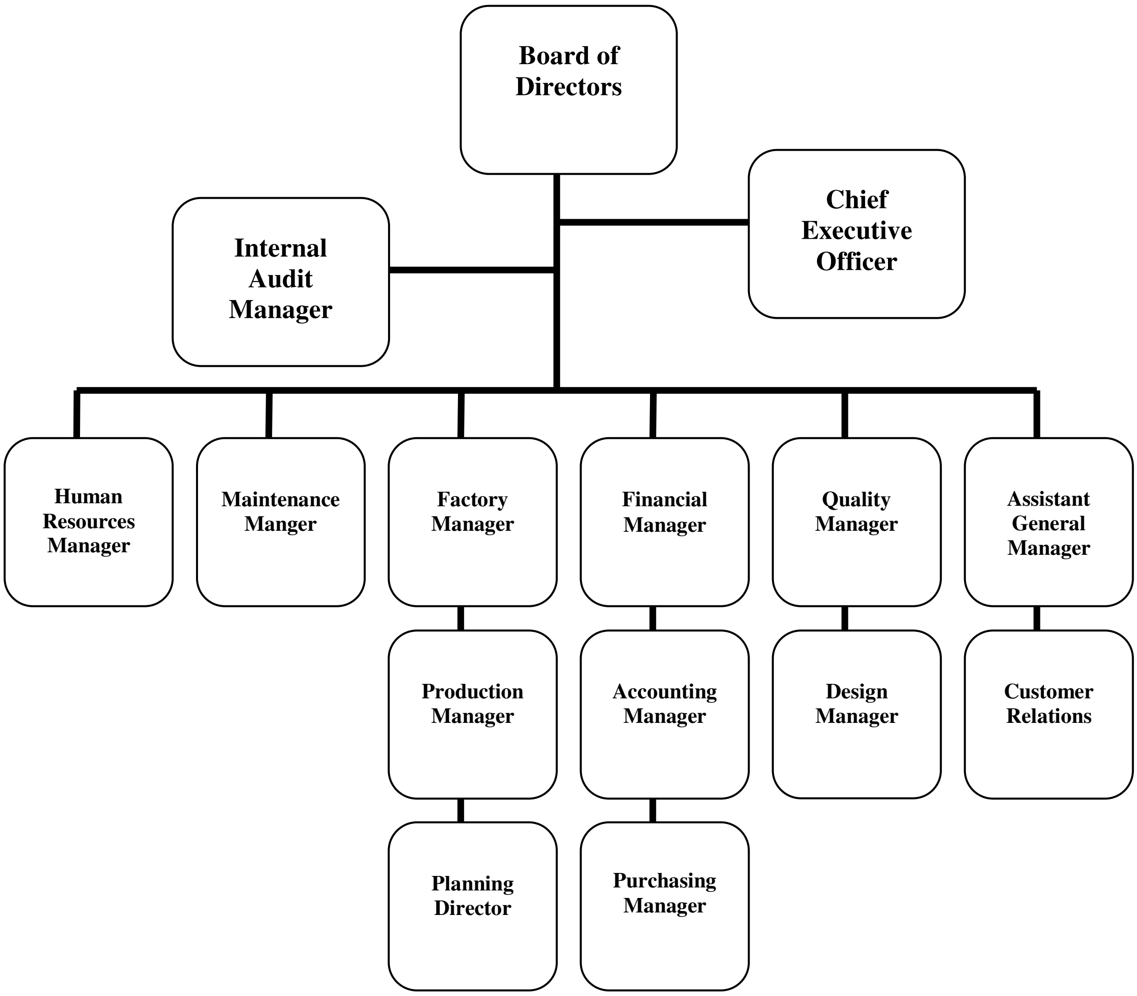

Figure 45: Organizational Chart of ABC Manufacturing Company

4.2. Limitations of the Study

ABC Manufacturing Company produces gasket, pipe and PVC door and window systems. However, gasket product family is chosen for research. The reason for choosing the gasket product family as research area is that the detailed cost and production information gathered from gasket production of company.

Taxation of product groups and selection of product family is explained in “The Determination of Value Stream” section of the research.

4.3. Research Methodology of the Study

The research is implemented according to observations and interviews with ABC Manufacturing Company. Some of gathered information is identified based on statistical data in company.

Information of value stream map is obtained from production department. Total time spent in production department is 56 hours. Cost information of the value stream is collected from accounting department and total time consumed in accounting department is 44 hours. In order to gather data about the value stream, the method of interview with quality, planning and human resources departments of company is used. Total times spent in these departments are in order 15 hours, 6 hours and 4 hours.

4.4. The Determination of the Value Stream

Production flow matrix is used in company for the purpose of value stream determination. Gasket product groups are labeled as six different groups. These are A 505, B 756, C 403, G 612, D 236 and E 745.

Production steps used for gasket manufacturing are purchase order entry, planning, mixing unit, extrusion, process control, welding, quality control, test, packing, shipping and invoicing.

Figure 46 represents production flow matrix of gasket product group. According to production flow matrix, G 612, E 745, D 236 product groups are followed in the same value stream and A 505, B 756, C 403 product groups are tracked in a different value stream. A 505, B 756, C 403 product groups are included in the same value stream due to similar production processes, however, it should be noted that product group “A 505” has a different production time. Therefore, product group “A

505” is viewed in a different value stream. Since detailed production and cost information is gathered from product group “A”, this value stream is chosen for the research.

Product Families	Production Steps: Order Entry	Planning	Mixing Unit	Extrusion	Process Control	Welding	Quality Control	Test	Packing and Shipping	Invoice
G 612	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**
C 403	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
E 745	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**
B 756	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
D 236	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**
A 505	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Figure 46: Production Flow Matrix

In Figure 47, value stream definition analysis is shown. Product groups that have similar production steps are categorized in the same value stream.

Product Families	Production Steps: Order Entry	Planning	Mixing Unit	Extrusion	Process Control	Welding	Quality Control	Test	Packing and Shipping	Invoice
G 612	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**
E 745	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**
D 236	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**
C 403	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
B 756	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
A 505	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Figure 47: Value Stream Definition Analysis

The plant relies on five main manufacturing processes in the value stream; mixing, extrusion, welding, control and test, shipping.

In mixing production part, raw material and supplementary materials are mixed to develop into dough of product according to product prescriptions. Raw material consists of natural rubber in various ratios and diversification. Supplementary materials used based on product prescriptions include; paraffinic oil, wax, paint and various stabilizers. These stabilizers are used for resistance and coloring. Procurement of raw materials is provided from domestic market.

In extrusion production part, plaques of product dough are extruded based on specialty of product.

In welding production part, gasket becomes circular through welding activity. Packing activity is done in this part of production.

In control and test production part, products are tested and controlled. Testing systems are; density test, melt flow index, size determination in warm test and homogeneity test. Material's density is determined by an analytical scale. Raw material's melting speed in unit time is determined by melt flow index test. It also provides data about how the material would act during process and between which temperatures that the material would be processed. Size determination in warm test determines how the gasket acted against warm and what amount would be the gasket’s size change in terms of percent ratio. Homogeneity test examines probable errors on microtome section that is taken from gasket surface.

According to observations, the production time used for selected value stream is detected as 12 % of total production time spent in factory.

4.5. Current State of the Value Stream

Initially, current state of the value stream is examined in this research. The analyzed topics in current state of value stream are; current state cell flow, current state value stream map, value stream capacity analysis, value stream costing analysis, value stream cost statement, value stream profit and loss statement, inventory valuation, net profit according to GAAP, cost of goods sold according to GAAP, bookkeeping entry of value stream costs and value stream box score.

4.5.1. Current State Cell Flow

In mixing process of production, raw material mixture is developed and vulcanized. Then, vulcanized dough of product is stored as plaques. Furthermore, 12 hours production of raw material mixing part correspond 24 hours production of extrusion process.

In extrusion part of production, rubber plaques are cut and placed on extrusion machine. Shaping, vulcanization and refrigeration are realized through extrusion machine.

After extrusion process of production, formed semi-finished goods are cut according to required length. Subsequently, solution is applied to the prepared products and they are welded at 165 centigrade.

In control and test process, density, melting, homogeneity tests and naked eye control, calibration controls are examined to 4 % of total outgoing products from welding process.

Finally, finished products are sent to shipping process and delivered to the customers.

In Figure 48, current state cell flow is shown according to factory layout of machines.

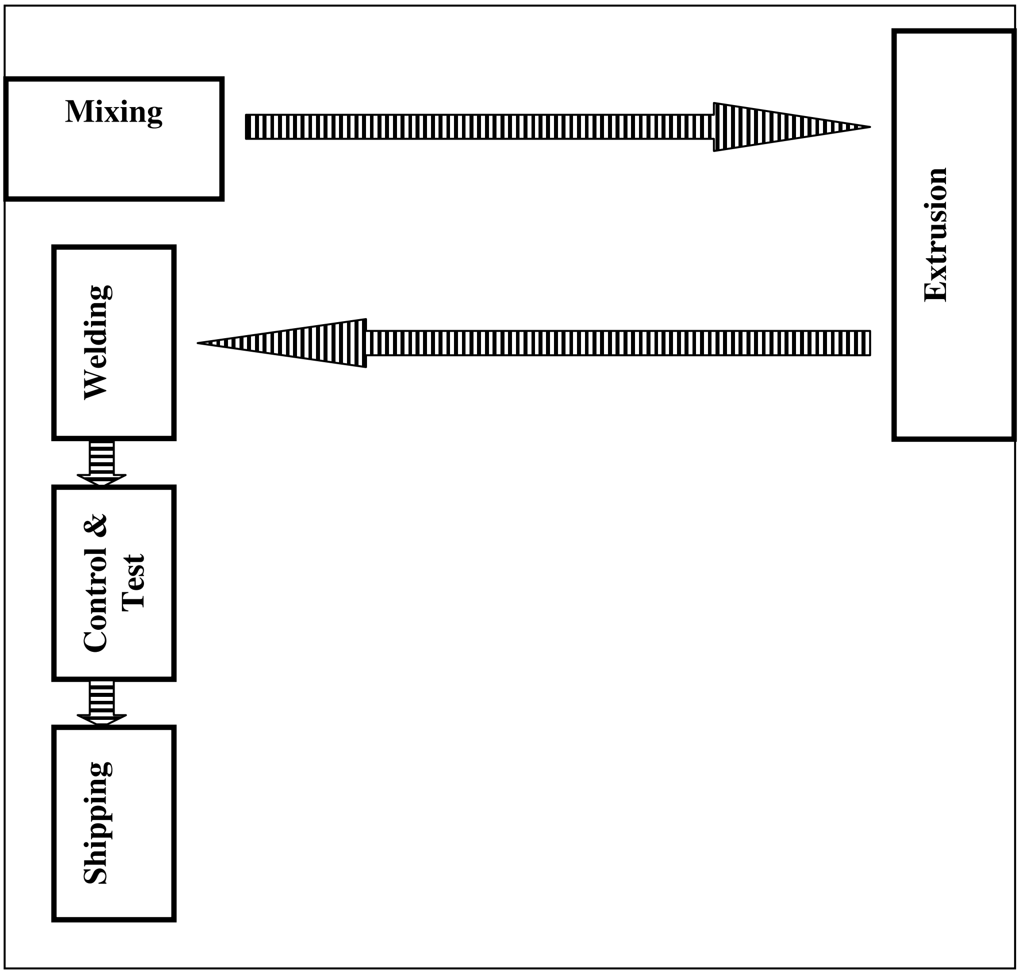

Figure 48: Current State Cell Flow

4.5.2. Current State Value Stream Map

This section of research is examined in two parts; data of value stream map and value stream map.

4.5.2.1. Data of Value Stream Map

Data of value stream map is collected from enterprise for a selected month and used for employee and machine capacity analysis. Value stream data is gathered through interviews and observation from production, human resources, planning, accounting and quality departments of company.

The value stream relies on ten main production processes; mixing, extrusion, welding, control and test, shipping, customer relations, planning, purchasing, design and accounting.

4.5.2.1.1. Employee and Machine Data of Mixing Process

Cycle time (C/T) is the time to realize an operation on one product at a process. In mixing work center, every mixture is 170 kilogram. One mixture is performed in 8, 5 minutes (8, 5 * 60 = 510 seconds). One product's average weight is 230 grams. Under these circumstances, C/T of this process is 0, 69 seconds [(230 * 510) / 170.000].

Get ready activity is preparing the machine to reach the necessary temperature level and it takes about 20 minutes.

Changeover time (C/O) is the time it takes to get ready to manufacture a different product at a process. C/O time of this work center is 15 seconds.

According to one month's observation, actual time spent by employees is determined as 5 hours on average at mixing machines.

Production is performed in one shift. The amount of products manufactured in mixing process is 129.886 units.

4.5.2.1.2. Employee and Machine Data of Extrusion Process

In extrusion process, 18 meters material is extruded in 60 seconds. Average product length at this process is 0, 67 meter and C/T is 2, 23 seconds [(0, 67 * 60)/18].

Get ready activity is preparing the machine to reach the necessary temperature level and it takes about 45 minutes in this process.

C/O time of this work center is 2 seconds.

In accordance with the feature of production, leakage ratio of this process is 2%.

Extrusion process has three production shifts. The amount of products manufactured in extrusion process is 129.886 units in selected month.

4.5.2.1.3. Employee and Machine Data of Welding Process

The welding process consists of cutting, application of solution, welding and trimming transactions. The welding mold has nine holes. In Table 22, the operation time of welding process is displayed.

Table 22

Operation Time of Welding Process

Operation	**Operation Time**
Cutting	5 seconds
Solution Application	5 seconds
Welding	130 seconds
Trimming	6 seconds
Total Time	146 seconds

Total operation time of welding process is 146 seconds in Table 22. Therefore, C/T is 16, 2 seconds (146 / 9) in this process.

C/O time is mold change over and takes 15 minutes.

Get ready activity is preparing the machine to reach the necessary temperature level in this process and is performed in 15 minutes.

Packing activity is performed by same employees in this part of production. One pack consists of 200 products and it is prepared in 9 minutes. Therefore, packing time of one product is 2, 7 seconds [(9 * 60) / 200].

Production is performed in two shifts. The amount of products manufactured in welding process is 124.690 units.

4.5.2.1.4. Employee and Machine Data of Control and Test Process

Control and test process is performed in two shifts. The amount of products tested and controlled in the process is 124.690 units.

Control and test transaction is done by sampling 4 % of total products. Therefore, controlled and tested products in a day of month are 168 units [(124.690 * %4) / 30]. Sample products are tested and controlled three times in a day and the duration of every test and control is 20 minutes. One product is tested and controlled in 21, 4 seconds [(60 * 60) / 168].

4.5.2.1.5. Employee Data of Shipping Process

When 120.856 units are shipped in a month, 4028 units are shipped on average in a day. In every day, the duration of shipping transactions for this value stream is 50 minutes. C/T is 0, 74 seconds [(50 * 60) / 4028].

4.5.2.1.6. Employee Data of Customer Service Process

Customer service share of the value stream is determined according to the amount of customer orders. Time spent for all orders are close to one another. The ratio of value stream's customer order is 10 % in all customer orders of the company. In Table 23, the calculation of this ratio is presented.

Table 23

Calculation of the Ratio of Value Stream's Customer Order

Product Groups	Number of Customers	Number of Monthly Order	Amount of Total Order	Ratio of Customer Order
PVC Profile	99	8	792	54 %
Pipe	86	4	344	24 %
Gasket	81	4	324	22 %
Total	266		1460	1
A Product Group	38	4	152	**10 %**

Three main products of the company are PVC profile, pipe and gasket. Calculations are generated based on these product's order amounts.

PVC profile product group has 99 customers and the number of monthly order is 8 units. Pipe product group has 86 customers and the number of monthly order is 4 units. Gasket product group has 81 customers and the number of monthly order is 4 units. Therefore, the amounts of total order of profile, pipe and gasket are 792 units (99 * 8), 344 units (86 * 4) and 324 units (81 * 4). After these calculations, company's total customer number is determined as 266 persons (99 + 86 + 81) and amount of total customer order is calculated as 1460 units (792 + 344 + 266). Value stream's customer number is 38 persons and the number of monthly order is 4 units. Accordingly, the amount of total order of profile is 152 units (38 * 4).

Customer order ratios of PVC profile, pipe and gasket product groups are computed as 54 % (792 / 1460), 24 % (344 / 1460) and 22 % (324 / 1460) respectively. Customer order ratio of value stream is calculated as 10 % (152 / 1460).

According to these calculations, the following equations are developed;

Amount of Total Order = Number of Customers * Number of Monthly Order

The Ratio of Customer Order = Amount of Value Stream Order / Amount of Total Order

4.5.2.1.7. Employee Data of Planning Process

Planning share of the value stream is identified based on the amount of monthly batch planning. Value stream's planning ratio is 12 %.

In order to meet customer demand, only one batch is produced from every product group daily. For this reason, monthly produced batch number is 30 units. The amount of output per batch of profile product group is 3327 kilograms. The amount of output per batch of pipe product group is 2846 kilograms. The amount of output per batch of gasket product group is 1793, 66 kilograms. Therefore, monthly amounts of total profile, pipe and gasket outputs are computed as 99.810 kg. (3327 * 30), 85.380

kg. (2846 * 30) and 53.810 kg. (1793, 66 * 30) respectively. When value stream is examined, the amount of output per batch is 956 kilograms and monthly amount of total output is 28.680 kg. (956 * 30).

Planning process ratio of value stream is shown in Table 24.

Table 24

Calculation of the Ratio of Value Stream's Planning Process

Product Groups	Number of Monthly Produced Batch	Output per Batch (kg.)	Monthly Total Output (kg.)	Planning Ratio
PVC Profile	30 Batch	3327 kg.	99.810 kg.	41,8 %
Pipe	30 Batch	2846 kg.	85.380 kg.	35,7 %
Gasket	30 Batch	1793, 66 kg.	53.810 kg.	22,5 %
Total			239.000 kg.	100 %
A Product Group	30 Batch	956 kg.	28.680 kg.	**12 %**

Total amount of monthly output is 239.000 kilograms (99.810 + 85.380 + 53.810). According to this total amount, planning process ratios are as follows; 41, 8 % (99.810 / 239.000) PVC profile, 35, 7 % (85.380 / 239.000) pipe, 22, 5 % (53.810 / 239.000) gasket. Planning process ratio of value stream is calculated as 12 % (28.680 / 239.000), which can be seen on Table 24.

4.5.2.1.8. Employee Data of Purchasing Process

Value stream's share for purchasing process is computed according to the number of purchasing orders for the month. Value stream's ratio of purchase orders is 8%, so in this case, the purchasing process ratio will be 8 % as well.

The number of supplier of PVC profile product group is 92 persons and the number of monthly purchasing order is 8 units. The number of supplier of pipe product group is 88 persons and the number of monthly purchasing order is 6 units. The number of supplier of gasket product group is 59 persons and the number of monthly purchasing order is 4 units. Therefore, the amounts of monthly total profile, pipe and gasket purchase orders will be 736 units (92 * 8), 528 units (88 * 6) and 236 units (59 * 4) respectively. The value stream's number of supplier is 30 persons and the number of monthly purchasing order is 4 units. Accordingly, the amount of monthly total purchase order will be 120 units (30 * 4).

Table 25 shows calculation of value stream's purchasing process ratio.

Table 25

Calculation of the Ratio of Value Stream's Purchasing Process

Product Groups	Number of Supplier	Number of Monthly Purchase Order	Amount of Total Purchase Order	Ratio of Purchase Order
PVC Profile	92	8	736	49 %
Pipe	88	6	528	35 %
Gasket	59	4	236	16 %
Total	239		1500	1
A Product Group	30	4	120	**8 %**

Total amount of monthly purchase order is computed as 1500 units (736 + 528 + 236). According to this total amount, purchasing process ratios are as follows; 49 % (736 / 1500) PVC profile, 35 % (528 /1500) pipe, 16 % (236 / 1500) gasket. Purchasing process ratio of value stream is 8 % (120 / 1500).

4.5.2.1.9. Employee Data of Design Process

Value stream's share for design process is calculated based on the number of annual projects. The completion time of projects is nearly same for main product groups. Design process ratio is 12 %, because this value stream's ratio of design projects is 12 % in total projects of company.

The annual project number of profile product group is 11 units, the annual project number of pipe product group is 8 units and the annual project number of gasket product group is 6 units. The number of value stream's annual project is 3 units.

Table 26 displays the calculation of value stream's design process ratio.

Table 26

Calculation of the Ratio of Value Stream's Design Process

Product Groups	**Number of Annual Project**	**Ratio of Project**
PVC Profile	11	44 %
Pipe	8	32 %
Gasket	6	24 %
Total	25	1
A Product Group	3	**12 %**

Yearly applicable total projects are 25 units (11 + 8 + 6). According to this total amount, design process ratios profile, pipe and gasket are as follows; 44 % (11 / 25), 32 % (8 / 25) and 24 % (6 /25). Purchasing process ratio of value stream is calculated as 12 % (3 / 25).

4.5.2.1.10. Employee Data of Accounting Process

The accounting process of the company consists of selling, purchasing and employee related activities, so the accounting process ratio is weighted average of these activities. The ratio of accounting process is found as 10 % through weighted average of activities.

In accounting process, inventory control and invoicing activities are performed in terms of selling activities. Purchasing activities can be listed as; tracking delinquent receivables, collection activities and mutual agreements with suppliers. Employee related activities of the company are payroll and checking. The equation of weighted ratio is; Time Used for Activity / Total Time Used.

The calculation of weighted ratio of accounting activities is shown in Table 27.

Table 27

Calculation of Weighted Ratio of Accounting Activities

Activities	Time Used (Hours)	Weighted Ratio
Selling	12,9	42 %
Purchasing	9,3	30 %
Employee Related	8,4	28 %
Total	30,6	100 %

In accounting process, time used for selling activities is 12, 9 hours, time used for purchasing activities is 9, 3 hours and time used for employee related activities is 8, 4 hours. Therefore, total time used for accounting activities is 30, 6 hours (12, 9 + 9, 3 + 8, 4). Weighted ratios of activities are as follows; 42 % (12, 9 / 30, 6) selling activity, 30 % (9,3 / 30,6) purchasing activity, 28 % (8,4 / 30,6) employee related activity.

Table 28 presents the calculation of weighted average ratio of accounting processes.

Table 28

Calculation of the Ratio of Value Stream's Accounting Process

Activities	Value Stream Ratio	Weighted Ratio	Weighted Average Ratio
Selling	%10	%42	4,2 %
Purchasing	%8	%30	3,4 %
Employee Related	%12	%28	2,4 %
Accounting Process Ratio of Value Stream			**10 %**

Value stream's selling, purchasing and employee related activity ratios are determined as 10 %, 8 % and 12 % in previous sections of research. When these ratios are multiplied by weighted ratio of accounting activities, weighted average ratios of activities are determined. Weighted average ratio of selling activity is 4, 2 % (10 % * 42%), weighted average ratio of purchasing activity is 3, 4% (8 % * 30 %) and weighted average ratio of employee related activities is 2, 4% (12 % * 28 %). Value stream's accounting process ratio is computed as 10 % (4, 2 % + 3, 4 % + 2, 4 %).

4.5.2.2. Value Stream Map

After all data of value stream map is computed, value stream map is presented in Figure 49.

The 24, 5 days production lead time of value stream is calculated through the sum of inventory days between processes (7, 5 + 8, 5 + 5 + 2 + 1, 5). Inventory days between current state processes are determined by observations in the value stream.

Processing time is the time used for completion of one product in value stream. Processing time is computed by the sum of all cycle times in value stream and it is 0, 6875 minutes (0, 0115 + 0, 0371 + 0, 27 + 0, 3566 +0, 0123). The equation form of processing time is as follows;

Processing Time = [(0,69 / 60) + (2,23 / 60) + (16,2 / 60) + (21,4 / 60) + (0,74 / 60)]

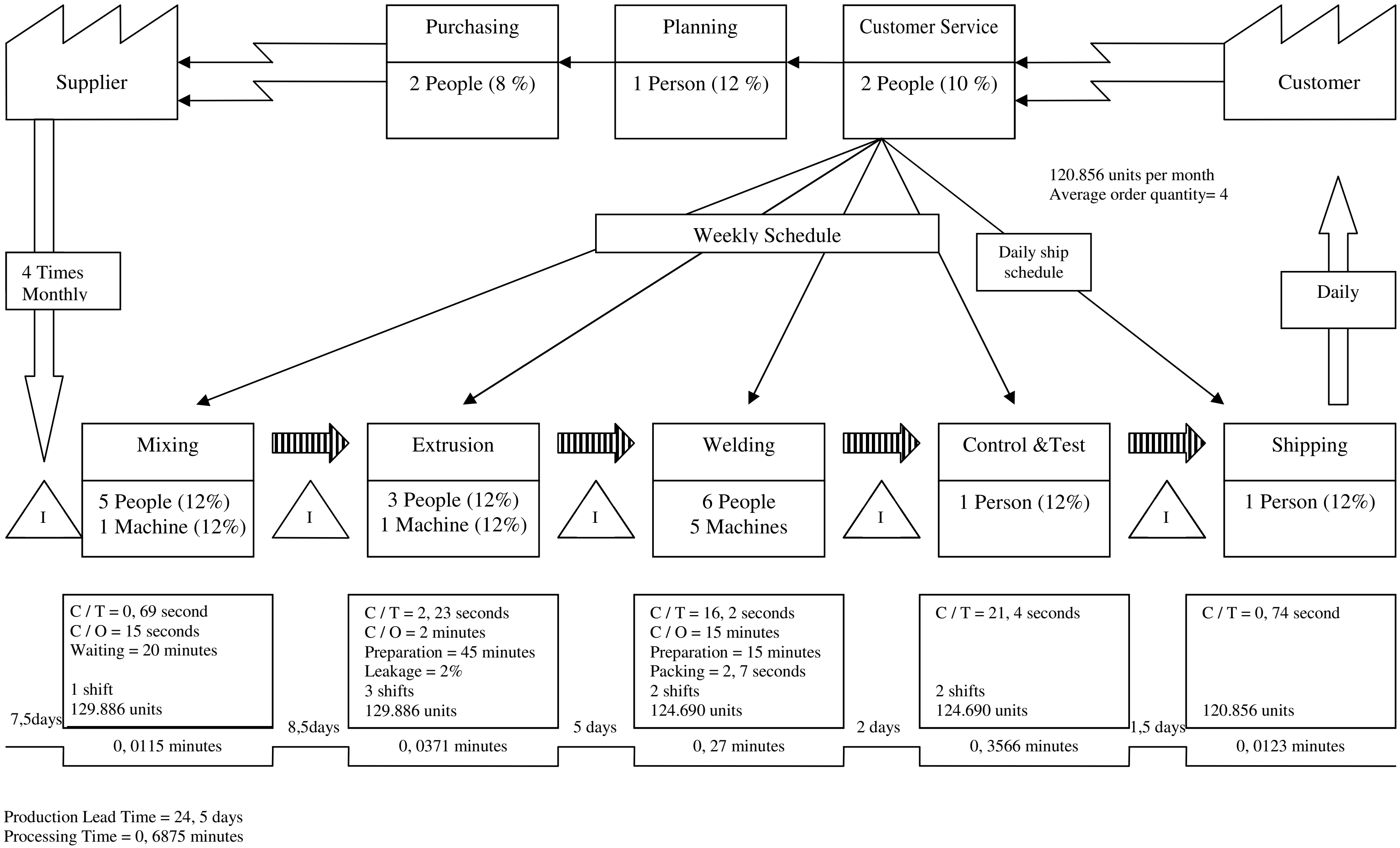

Figure 49: Current State Value Stream Map

4.5.3. Value Stream Capacity Analysis

In this section of research, employee and machine capacity analysis of value stream processes are illustrated according to the identified capacity data.

4.5.3.1. Employee Capacity Analysis of Mixing Process

In mixing process, employee related activities are “make for product demand”, “get ready”, “move in material”, “move out material” and “administration”. The value stream’s share of mixing process in entire production is 12 %.

Each employee spends daily 5 hours on making product demand in mixing process of value stream and 5 employees work in this process. Continuous production is performed in the company. The duration of “make demand” activity is 90 hours [(5 hours * 5 employees * 30 days) * 12%] in a month.

“Get ready” activity of the process is the preparation time of employees while passing from one product’s raw material mixture to another product’s mixture. Daily preparation time of the process is 15 seconds. Monthly produced batch number is 30 units. The duration of “get ready” activity of mixing process is 0, 13 hour [(15 seconds * 30 batch) / 3600].

Daily “move in material” activity duration for all production is 30 minutes. The time spent for “move in material” activity of mixing process is 1, 8 hours [(30 minutes / 60) * 30 days * 12%].

Daily “move out material” activity duration for all production is 15 minutes. The time spent for “move material” activity of mixing process is 0, 9 hour [(15 minutes / 60) * 30 days * 12%].

“Administration” activities include training and meeting activities. For entire production, the duration of administrative activities is 1 hour. The time spent for “administration” activities of mixing process is 0, 6 hour [(5 employee * 1 hour) * 12%].

Productive activity of mixing process is “make product demand” and the duration of this activity is 90 hours in selected month.

Non-productive activities of mixing process are; “get ready”, “move in material”, “move out material” and “administration”. Total non-productive time of the process is 3, 4 hours (0, 13 + 1, 8 + 0, 9 + 0, 6).

The total time used for current state consists of the sum of productive and non-productive time and it is 93, 4 hours (90 + 3, 4).

The total time available for use per month is 135 hours (7, 5 hours * 5 employee * 30 days * 12%).

In the current state, the total time not used is 41, 6 hours (135 – 93, 4).

Productive percent of capacity is 67% (90 / 135). Non-productive percent of capacity is 3% (3, 4 / 135) and available percent of capacity is 30% (41, 6 / 135).

In Figure 50, employee capacity analysis of mixing process is displayed.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:			Date	Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Mixing	Make for Demand [(5 hours * 5 employee * 30 days) * 12%]		90			
Employee	Get Ready-Preparation [(15 seconds * 30 batch) / 3600]	0,13				
5 Persons	Move in Material [(30 minutes / 60) * 30 days * 12%]	1,8				
1 Shift	Move Material [(15 minutes / 60) * 30 days * 12%]	0,9				
Hours	Administration [(5 employee * 1 hour) * 12%]	0,6				
Share in Total						
Production 12%						
	Total Time by Value Creating Category	3,4	90,0			
	Total Time Used Current State	93,4				
	Total Time Not Used Per Month	41,6				
	Total Time Available for Use Per Month	135				

Productive Percent	0,67	**Total Time Available for Use Per Month**
Non-productive Percent	0,03	**7,5 hours*5 employee*30 days*12%=135 hours**
Available Percent	0,30	
	1	

Figure 50: Employee Capacity Analysis of Mixing Process

4.5.3.2. Machine Capacity Analysis of Mixing Process

In mixing process, machine related activities are; "make for product demand", "planned maintenance" and "get ready-machine heating". The value stream's share of mixing process in entire production is 12 %.

In previous sections, cycle time of mixing process is identified 0, 69 seconds. Total products manufactured in this process are 129.886 units. The monthly duration of "make for product demand" activity is 24, 9 hours [(0, 69 seconds * 129.886 units) / 3600].

"Planned maintenance" activity is performed 3 times in a month and each maintenance time is 1 hour. Total time of "planned maintenance" activity for value stream is 0, 4 hour [(3 times * 1 hour) * 12%].

The duration of "get ready-machine heating" activity is daily 20 minutes for entire production. Total time of "get ready-machine heating" activity for the value stream is 1, 2 hours [[(20 minutes * 30 days) / 60] * 12%] in selected month.

Productive activity of mixing process is "make product demand" and the duration of this activity is 24, 9 hours in selected month.

Non-productive activities are "planned maintenance" and "get ready-machine heating". Total non-productive time of the process is 1, 6 hours (0, 4 + 1, 2).

The total time used for current state is 26, 5 hours (24, 9 + 1, 6).

The total time available for use per month is 27 hours (30 days * 7,5 hours * 12%).

In the current state, the total time not used is 0,5 hours (27 – 26,5).

Productive percent of machine capacity is 92% (24,9 / 27). Non-productive percent of capacity is 6% (1, 6 / 27) and available percent of capacity is 2% (0, 5 / 27).

In Figure 51, machine capacity analysis of mixing process is displayed.

Value Stream Study		Value Stream: Gasket Manufacturing - A 505 product group	Observer:			Date	Page
Process Steps	Activity		Current State		Future State		Change
			Non-Productive	Productive	Non-Productive	Productive	
Mixing	Make for Demand [(0,69 seconds * 129.886 units) / 3600]			24,9			
Machine	Planned Maintenance [(3 times * 1 hour) x 12%]		0,4				
1 Machine	Get Ready-Machine Heating [[(20 minutes * 30 days) / 60] x 12%]		1,2				
1 Shift							
Hours							
Share in Total							
Production 12%							
	Total Time by Value Creating Category		1,6	24,9			
	Total Time Used Current State		26,5				
	Total Time Not Used Per Month		0,5				
	Total Time Available for Use Per Month		27				

Productive Percent	0,92	**Total Time Available for Use Per Month**
Non-productive Percent	0,06	**30 days*7,5 hours*12%=27 hours**
Available Percent	0,02	
	1	

Figure 51: Machine Capacity Analysis of Mixing Process

4.5.3.3. Employee Capacity Analysis of Extrusion Process

In extrusion process, employee related activities are “make for product demand”, “get ready”, “move out material” and “administration”. The value stream’s share of extrusion process in entire production is 12 %.

Each employee spends daily 7 hours on making product demand in extrusion process of value stream and 3 employees work in this process. 3 shifts exist in the process. Continuous production is performed in the company. The duration of “make demand” activity is 226, 8 hours [(7 hours * 3 employees * 3 shifts * 30 days) * 12%] in a month.

“Get ready” activity of the process is the cutting activity. Cutting activity is realized 20 times in a day. The duration of every cutting activity is 2 minutes. Total time of “get ready activity” of extrusion process is 2, 4 hours [[(2 minutes * 20 times * 30 days) /60] * 12%] in selected month.

Daily “move out material” activity duration for all production is 15 minutes. The time spent for “move material” activity of extrusion process is 0, 9 hour [(15 minutes / 60) * 30 days * 12%].

“Administration” activities include training and meeting activities. For entire production, the duration of “administration” activity is 1 hour. The time spent for administration activity of extrusion process is 1, 1 hours [(3 employee * 3 shifts * 1 hour) x 12%].

Productive activity of extrusion process is “make product demand” and the duration of this activity is 226, 8 hours in selected month.

Non-productive activities of extrusion process are “get ready”, “move out material” and “administration”. Total non-productive time of the process is 4, 4 hours (2, 4 + 1, 1 + 0, 9).

The total time used for current state consists of sum of productive and non-productive time and it is 231, 2 hours (226, 8 + 4, 4).

The total time available for use per month is 259, 2 hours (8 hours * 3 shifts * 3 employees * 30 days * 12%).

In the current state, the total time not used is 28 hours (259, 2 – 231, 2).

Productive percent of capacity is 88% (226, 8 / 259, 2). Non-productive percent of capacity is 1% (4, 4 / 259, 2) and available percent of capacity is 11% (28 / 259, 2).

Employee capacity analysis of extrusion process is displayed in Figure 52.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Extrusion	Make for Demand [(7hours*3employees*3shifts*30days)*12%]		226,8			
Employee	Get Ready [[(2minutes*20times*30days)/60]*12%]	2,4				
3 Persons	Administration [(3 employee * 3 shifts * 1 hours) * 12%]	1,1				
3 shifts	Move Material [(15 minutes / 60) * 30 days * 12%]	0,9				
Hours						
Share in Total						
Production 12%						
	Total Time by Value Creating Category	4,4	226,8			
	Total Time Used Current State	231,2				
	Total Time Not Used Per Month	28,0				
	Total Time Available for Use Per Month	259,2				

Productive Percent	0,88	**Total Time Available for Use Per Month**
Non-productive Percent	0,01	**8hours*3shifts*30days*3emp.*12%=259,2hours**
Available Percent	0,11	
	1	

Figure 52: Employee Capacity Analysis of Extrusion Process

4.5.3.4. Machine Capacity Analysis of Extrusion Process

In extrusion process, machine related activities are "make for product demand", "planned maintenance" and "get ready-machine heating". The value stream's share of extrusion process in entire production is 12 %.

In previous sections, cycle time of extrusion process is determined 2, 23 seconds. Total products manufactured in this process are 129.886 units. The monthly duration of "make for product demand" activity is 80, 45 hours [(2, 23 seconds * 129.886 units) / 3600].

"Planned maintenance" activity is realized 3 times in a month and each maintenance time is 1 hour. Total time of "planned maintenance" activity for value stream is 0, 4 hour [(3 times * 1 hour) * 12%] in selected month.

The duration of "get ready-machine heating" activity is daily 45 minutes for entire production. Total time of "get ready-machine heating" activity for value stream is 2, 7 hours [[(45 minutes * 30 days) / 60] * 12%] in selected month.

Productive activity of extrusion process is "make product demand" and the duration of this activity is 80, 45 hours in selected month.

Non-productive activities are "planned maintenance" and "get ready-machine heating". Total non-productive time of the process is 3, 1 hours (0, 4 + 2, 7).

The total time used for current state is 83, 5 hours (80, 45 + 3, 1).

The total time available for use per month is 86, 4 hours (30 days * 8 hours * 3 shifts * 12%).

In the current state, the total time not used is 2, 9 hours (86, 4 – 83, 5).

Productive percent of machine capacity is 93% (80, 45 / 86, 4). Non-productive percent of capacity is 4% (3,1 / 86,4) and available percent of capacity is 3% (2,9/86,4).

Machine capacity analysis of extrusion process is displayed in Figure 53.

Value Stream Study		Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date	Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Extrusion	Make for Demand [(2,23 seconds * 129.886 units) / 3600]		80,45			
Machine	Get Ready-Machine Heating [[(45minutes * 30days)/60]x12%]	2,7				
1 Machine	Planned Maintenance [(3 times * 1 hour) x 12%]	0,4				
3 Shift						
Hours						
Share in Total						
Production 12 %						
	Total Time by Value Creating Category	3,1	80,45			
	Total Time Used Current State	83,5				
	Total Time Not Used Per Month	2,9				
	Total Time Available for Use Per Month	86,4				

Productive Percent	0,93	**Total Time Available for Use Per Month**
Non-productive Percent	0,04	**8 hours * 3 shifts * 30 days * 12%=86,4 hours**
Available Percent	0,03	
	1	

Figure 53: Machine Capacity Analysis of Extrusion Process

4.5.3.5. Employee Capacity Analysis of Welding Process

In welding process, employee related activities are “make for product demand”, “get ready”, “packing” and “administration” activities. The value stream’s share of welding process in entire production is 100 %.

Each employee spends daily 7 hours on making product demand in welding process of value stream and 6 employees work in this process. 2 shifts exist in the process. Continuous production is performed in the company. The duration of “make for demand” activity is 2520 hours (7 hours * 6 employees * 2 shifts * 30 days) in a month.

“Get ready” activity of the process is mold changing activity. Mold changing activity is realized 10 times in a month. The duration of every changing activity is 15 minutes. Total time of “get ready” activity of welding process is 2, 5 hours [(15 minutes * 10 times) /60] in selected month.

The duration of per products “packing” activity is 2, 7 seconds. In selected month, the amount of packed product is 124.690 units. The time spent for “packing” activity of welding process is 93, 5 hours [(2, 7 seconds * 124.600 units) / 3600].

“Administration” activities include training and meeting activities. For entire production, the duration of “administration” activities is 1 hour. The time spent for “administration” activities of welding process is 12 hours (6 employee * 1 hour * 2 shifts).

Productive activity of welding process is “make product demand” and the duration of this activity is 2520 hours in selected month.

Non-productive activities of welding process are “get ready”, “packing” and “administration”. Total non-productive time of the process is 108 hours (2, 5 + 93, 5 + 12).

The total time used for current state consists of sum of productive and non-productive time and it is 2628 hours (2520 + 108).

The total time available for use per month is 2700 hours (7, 5 hours * 2 shifts * 6 employees * 30 days).

In the current state, the total time not used is 72 hours (2700 – 2628).

Productive percent of capacity is 93% (2520 / 2700). Non-productive percent of capacity is 4% (108 / 2700) and available percent of capacity is 3% (72 / 2700).

In Figure 54, employee capacity analysis of welding process is displayed.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Welding	Make for Demand (7hours*6 employees*2shifts*30days)		2520			
Employee	Get Ready [(15 minutes * 10 times) /60]	2,5				
6 Persons	Packing [(2,7 seconds * 124.690 units)/3600]	93,5				
2 Shifts	Administration (6 employees * 2 shifts * 1 hour)	12				
Hours						
Share in Total						
Production 100%						
	Total Time by Value Creating Category	108	2520			
	Total Time Used Current State	2628				
	Total Time Not Used Per Month	72				
	Total Time Available for Use Per Month	2700				

Productive Percent	0,93	**Total Time Available for Use Per Month**
Non-productive Percent	0,04	**6employees*2shifts*7,5hours*30days=2700hours**
Available Percent	0,03	
	1	

Figure 54: Employee Capacity Analysis of Welding Process

4.5.3.6. Machine Capacity Analysis of Welding Process

In welding process, machine related activities are “make for product demand”, “planned maintenance” and “get ready-machine heating”. The value stream’s share of welding process in entire production is 100 %.

In previous sections, cycle time of welding process is determined 16, 2 seconds. Total products manufactured in this process are 124.690 units. The monthly duration of “make for product demand” activity is 561, 1 hours [(16, 2 seconds * 124.690 units) / 3600].

“Planned maintenance” activity is performed 3 times in a month and each maintenance time is 1 hour. Total time of “planned maintenance” activity for value stream is 15 hours (3 times * 1 hour * 5 machine) in selected month.

The duration of “get ready-machine heating” activity is daily 15 minutes. Total time of “get ready-machine heating” activity for value stream is 37, 5 hours [(15 minutes * 30 days * 5 machines) / 60] in selected month.

Productive activity of welding process is “make product demand” and the duration of this activity is 561, 1 hours in selected month.

Non-productive activities are “planned maintenance” and “get ready-machine heating”. Total non-productive time of the process is 52, 5 hours (15 + 37, 5).

The total time used for current state is 613, 6 hours (561, 1 + 52, 5).

The total time available for use per month is 2250 hours (5 machines * 30 days * 7, 5 hours * 2 shifts).

The total time not used is 1636, 4 hours (2250 – 613, 6).

Productive percent of machine capacity is 25% (561, 1 / 2250). Non-productive percent of capacity is 2% (52, 5 / 2250) and available percent of capacity is 73% (1634, 4 / 2250). In Figure 55, machine capacity analysis of welding process is displayed.

Value Stream Study		Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date	Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Welding	Make for Demand [(16,2 seconds * 124.690 units) / 3600]		561,1			
5 Machines	Get Ready-Machine Heating [(15 minutes * 30 days * 5 machines)/	37,5				
2 Shifts	Planned Maintenance (3 times x 1 hour * 5 machines)	15,0				
Hours						
Share in Total						
Production 100%						
	Total Time by Value Creating Category	52,5	561,1			
	Total Time Used Current State	613,6				
	Total Time Not Used Per Month	1636,4				
	Total Time Available for Use Per Month	2250				

Productive Percent	0,25	**Total Time Available for Use Per Month**
Non-productive Percent	0,02	**5machines*7,5hours*2shifts*30days=2250hours**
Available Percent	0,73	
	1	

Figure 55: Machine Capacity Analysis of Welding Process

4.5.3.7. Employee Capacity Analysis of Control and Test Process

In control and test process, employee related activities are “test and control” and “administration”. The value stream’s share of control and test process in entire production is 12 %.

In previous sections, cycle time of control and test process is identified 21, 4 seconds. Total products controlled and tested in this process are 5040 units (168 units * 30 days). The monthly duration of “test and control” activity is 29, 96 hours [(21, 4 seconds * 5040 units) / 3600].

“Administration” activities include training and meeting activities. For entire production, the duration of administrative activities is 1 hour. The time spent for “administration” activity of control and test process is 0, 24 hour [(1 employee * 1 hour * 2 shifts) * 12 %].

Productive activity does not exist in control and test process.

Non-productive activities are “test and control” and “administration”. Total non-productive time of the process is 30, 2 hours (29, 96 + 0, 24).

The total time used for current state is 30, 2 hours.

The total time available for use per month is 54 hours (1 employee * 30 days * 7, 5 hours * 2 shifts * 12 %).

The total time not used for current state is 23, 8 hours (54 – 30, 2).

Productive percent of employee capacity is 0 %. Non-productive percent of capacity is 56% (30, 2 / 54) and available percent of capacity is 44% (23, 8 / 54).

Employee capacity analysis of control and test process is displayed in Figure 56.

Value Stream Study		Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date	Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Control and Test	Test and Control [(21,4 seconds * 5040 units)/3600]	29,96				
1 Person	Administration [(1 employee * 2 shifts * 1 hour) * 12%]	0,24				
2 Shifts						
Hours						
Share in Total						
Production 12%						
	Total Time by Value Creating Category	30,20	0,00			
	Total Time Used Current State	30,20				
	Total Time Not Used Per Month	23,8				
	Total Time Available for Use Per Month	54				

Productive Percent	0	**Total Time Available for Use Per Month**
Non-productive Percent	0,56	**1 emp.*2 shifts*7,5hours*30 days*12%=54hours**
Available Percent	0,44	
	1	

Figure 56: Employee Capacity Analysis of Control and Test Process

4.5.3.8. Employee Capacity Analysis of Shipping Process

In shipping process, employee related activity is “shipping the product”. The value stream’s share of shipping process in entire production is 12 %.

The time used for daily shipping activity of the value stream is 50 minutes and shipping activity is realized every day in a month. The monthly duration of “shipping” activity is 25 hours [(30 times * 50 minutes) / 60].

Productive activity of shipping process is “shipping” and the duration of this activity is 25 hours in selected month.

The total time used for current state is 25 hours.

The total time available for use per month is 27 hours (30 days * 7, 5 hours * 12 %).

The total time not used for current state is 2 hours (27 – 25).

Productive percent of employee capacity is 93% (25 / 27). Non-productive percent of capacity is 0% and available percent of capacity is 7% (2 / 27).

In Figure 57, employee capacity analysis of shipping process is displayed.

Value Stream Study		Value Stream: Gasket Manufacturing - A 505 product group	Observer:				Date	Page
Process Steps	Activity		Current State		Future State		Change	
			Non-Productive	Productive	Non-Productive	Productive		
Shipping	Ship product [(30 shipment * 50 minutes) / 60]			25				
1 Person								
1 Shift								
Hours								
Share in Total								
Production 12%								
	Total Time by Value Creating Category			25,0				
	Total Time Used Current State		25,0					
	Total Time Not Used Per Month		2,0					
	Total Time Available for Use Per Month		27					

Productive Percent	0,93	**Total Time Available for Use Per Month**
Non-productive Percent	0	**30 days * 7,5 hours * 12%=27hours**
Available Percent	0,07	
	1	

Figure 57: Employee Capacity Analysis of Shipping Process

4.5.3.9. Employee Capacity Analysis of Customer Service Process

In customer service process, employee related activities are “take customer order”, “order entry to the system”, “take customer calls” and “pricing”. The value stream’s share of customer service process in entire production is 10 %.

“Take customer order” activity is performed every day. Total time used in a day for this activity is 20 minutes. The monthly duration of “take customer order” activity is 8, 6 hours [(26 days * 20 minutes) / 60].

“Order entry to the system” activity is realized every day. Total time used in a day for this activity is 5 minutes. The monthly duration of “order entry to the system” activity is 2, 2 hours [(26 days * 5 minutes) / 60].

“Take customer calls” activity is done every day. Total time used in a day for this activity is 50 minutes; because number of daily customer call is 10 calls and the average time spent for every call is 5 minutes. The monthly duration of “take customer calls” activity is 21, 6 hours [(26 days * 50 minutes) / 60].

“Pricing” is performed every day. Total time used in a day for this activity is 10 minutes. The monthly duration of “pricing” activity is 4, 3 hours [(26 days * 10 minutes) / 60].

Non-productive activities are “take customer order”, “order entry to the system”, “take customer calls” and “pricing”. Total non-productive time of the process is 36, 7 hours (8, 6 + 2, 2 + 21, 6 + 4, 3).

The total time used for current state is 36, 7 hours.

The total time available for use per month is 39 hours (26 days * 7, 5 hours * 2 employees * 10 %). The total time not used for current state is 2, 3 hours (39 – 36, 7).

Productive percent of employee capacity is 0 %. Non-productive percent of capacity is 94% (36, 7 / 39) and available percent of capacity is 6% (2, 3 / 39). In Figure 58, employee capacity analysis of customer service process is displayed.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date	Page
		Current State		Future State		
Process Steps	Activity	Non-Productive	Productive	Non-Productive	Productive	Change
Customer Service	Take Customer Order [(20 minutes * 26 days) / 60]	8,6				
2 Person	Order Entry [(5 minutes * 26 days)/60]	2,2				
1 Shift	Take Customer Calls [(26 days * 10 calls * 5 minutes)/60]	21,6				
Hours	Pricing [(10 minutes * 26 days)/60]	4,3				
Employee share 10%						
	Total Time by Value Creating Category	36,7				
	Total Time Used Current State	36,7				
	Total Time Not Used Per Month	2,3				
	Total Time Available for Use Per Month	39				

Productive Percent	0	**Total Time Available for Use Per Month**
Non-productive Percent	0,94	**26 days*7,5 hours*2 employees*10%=39 hours**
Available Percent	0,06	
	1	

Figure 58: Employee Capacity Analysis of Customer Service Process

4.5.3.10. Employee Capacity Analysis of Planning Process

In planning process, employee related activities are “material requirements planning”, “inventory planning” and “production planning”. The value stream’s share of planning process in entire production is 12 %.

“Material requirements planning” activity is realized every day. Total time used in a day for this activity is 15 minutes. The monthly duration of “material requirements planning” activity is 6, 5 hours [(26 days * 15 minutes) / 60].

“Inventory planning” activity is performed once a week. Total time used for every activity is 60 minutes. The monthly duration of “inventory planning” activity is 4 hours [(4 weeks * 60 minutes) / 60].

“Production planning” activity is performed once a week. Total time used for every activity is 180 minutes. The monthly duration of “production planning” activity is 12 hours [(4 weeks * 180 minutes) / 60].

Non-productive activities are “material requirements planning”, “inventory planning” and “production planning”. Total non-productive time of the process is 22, 5 hours (6, 5 + 4 + 12).

The total time used for current state is 22, 5 hours.

The total time available for use per month is 23, 4 hours (26 days * 7, 5 hours * 1 employee * 12 %).

The total time not used for current state is 0, 9 hours (23, 4 – 22, 5).

Productive percent of employee capacity is 0 %. Non-productive percent of capacity is 96% (22, 5 / 23, 4) and available percent of capacity is 4% (0, 9 / 23, 4).

Employee capacity analysis of planning process is displayed in Figure 59.

Value Stream Study		Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
Process Steps	Activity		Current State		Future State		Change
			Non-Productive	Productive	Non-Productive	Productive	
Planning	Material Requirements Planning [(15minutes*26days) / 60]		6,5				
1 Person	Inventory Planning [(60 minutes*4 weeks) / 60]		4				
1 Shift	Production Planning [(180 minutes*4 weeks) / 60]		12,0				
Hours							
Employee Share							
12%							
	Total Time by Value Creating Category		22,5				
	Total Time Used Current State		22,5				
	Total Time Not Used Per Month		0,9				
	Total Time Available for Use Per Month		23,4				

Productive Percent	0	**Total Time Available for Use Per Month**
Non-productive Percent	0,96	**26 days*7,5 hours*1employee*12%=23,4 hours**
Available Percent	0,04	
	1	

Figure 59: Employee Capacity Analysis of Planning Process

4.5.3.11. Employee Capacity Analysis of Purchasing Process

In purchasing process, employee related activities are “purchasing raw material”, “taking supplier offerings”, “placing supplier orders”, “preparing purchasing orders” and “incoming stock”. The value stream’s share of purchasing process in entire production is 8 %.

“Purchasing raw material” activity is realized once a week. Total time used for every activity is 30 minutes. The monthly duration of “purchasing raw material” activity is 2 hours [(4 weeks * 30 minutes) / 60].

In the value stream, 30 key suppliers exist. Every supplier spent 30 minutes for taking supplier offerings activity in a month. The monthly duration of “taking supplier offerings” activity is 15 hours [(30 suppliers * 30 minutes) / 60].

Placing supplier orders activity is performed 3 times a week. Total time used for every activity is 15 minutes. The monthly duration of “placing supplier orders” activity is 3 hours [(4 weeks * 3 times * 15 minutes) / 60].

“Preparing purchasing orders” activity is realized three times a week. Total time used for every activity is 15 minutes. The monthly duration of “preparing purchasing orders” activity is 3 hours [(4 weeks * 3 times * 15 minutes) / 60].

“Incoming stock” activity is performed every day. Total time used for every activity is 15 minutes. The monthly duration of “incoming stock” activity is 6, 5 hours [(26 days * 15 minutes) / 60].

Productive activities of purchasing process are “taking supplier offerings” and “placing supplier orders” and the duration of these activities is 18 hours (15 + 3) in selected month.

Non-productive activities of purchasing process are “purchasing raw material”, “preparing purchasing orders” and “incoming stock” activities. Total non-productive time of the process is 11, 5 hours (2 + 3 + 6, 5).

The total time used for current state is 29, 5 hours (18 + 11, 5).

The total time available for use per month is 31, 2 hours (26 days * 7, 5 hours * 2 employees * 8%).

The total time not used for current state is 1, 7 hours (31, 2 – 29, 5).

Productive percent of capacity is 58 % (18 / 31, 2). Non-productive percent of capacity is 37 % (11, 5 / 31, 2) and available percent of capacity is 5 % (1, 7 / 31, 2)

In Figure 60, employee capacity analysis of purchasing process is displayed.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:			Date	Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Purchasing	Purchasing raw material [(4 times x 30 minutes)/ 60]	2				
2 Persons	Taking supplier offerings [(30suppliers*30minutes)/ 60]		15			
1 Shift	Placing supplier orders [(12 times * 15 minutes) / 60]		3			
Hours	Preparing purchasing orders [(12 times * 15 minutes)/ 60]	3				
	Incoming stock [(26 days x 15 minutes)/ 60]	6,5				
Employee Share 8%						
	Total Time by Value Creating Category	11,5	18,0			
	Total Time Used Current State	29,5				
	Total Time Not Used Per Month	1,7				
	Total Time Available for Use Per Month	31,2				

Productive Percent	0,58	**Total Time Available for Use Per Month**
Non-productive Percent	0,37	**26 days*7,5 hours*2 employees*8%=31,2hours**
Available Percent	0,05	
	1	

Figure 60: Employee Capacity Analysis of Purchasing Process

4.5.3.12. Employee Capacity Analysis of Design Process

In design process, employee related activity is "research and development projects". The value stream's share of design process in entire production is 12 %.

In selected month, 3 research and development projects are realized. Total time used for every project is 5 hours. The monthly duration of "research and development projects" is 15 hours (3 projects * 5 hours).

Non-productive activity of design process is "research and development projects". Total non-productive time of the process is 15 hours.

The total time used for current state is 15 hours.

The total time available for use per month is 23, 4 hours (26 days * 7, 5 hours * 1 employee * 12 %).

The total time not used for current state is 8, 4 hours (23, 4 – 15).

Productive percent of capacity is 0 %. Non-productive percent of capacity is 64 % (15 / 23, 4) and available percent of capacity is 36 % (8, 4 / 23, 4).

Employee capacity analysis of design process is displayed in Figure 61.

Value Stream Study		Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
Process Steps	Activity		Current State		Future State		Change
			Non-Productive	Productive	Non-Productive	Productive	
Design	Research and development projects (3 project * 5 hours)		15				
1 Person							
1 Shift							
Hours							
Employee Share							
12%							
	Total Time by Value Creating Category		15				
	Total Time Used Current State		15				
	Total Time Not Used Per Month		8,4				
	Total Time Available for Use Per Month		23,4				

Productive Percent	0	**Total Time Available for Use Per Month**
Non-productive Percent	0,64	**26 days*7,5 hours*1 employee*12%=23,4hours**
Available Percent	0,36	
	1	

Figure 61: Employee Capacity Analysis of Design Process

4.5.3.13. Employee Capacity Analysis of Accounting Process

In accounting process, employee related activities are “inventory control”, “invoicing”, “payroll”, “tracking delinquent receivables-payments received”, monthly “reconcilement with suppliers” and “checking control”. The value stream’s share of accounting process in entire production is 10 %.

Inventory control activity is performed twice a day. Total time used for every activity is 5 minutes. The monthly duration of “inventory control” activity is 4, 3 hours [(2 times * 26 days * 5 minutes) / 60].

“Invoicing” activity is performed every day. The average number of invoice in a day is 10 units. Total time used for every activity is 2 minutes. The monthly duration of “invoicing” activity is 8, 6 hours [(10 invoices * 26 days * 2 minutes) / 60].

In the value stream, 37 employees work and total time used for every employee’s payroll activity is 8 minutes. The monthly duration of “payroll” activity is 4, 9 hours [(37 employees * 8 minutes) / 60].

Total time used in a month for making customer calls for receivables is 500 minutes; because number of monthly customer call is 50 calls and the average time spent for every call is 10 minutes. The monthly duration of “tracking delinquent receivables and payments received” is 8, 3 hours [(50 customers * 10 minutes) / 60].

Total time used in a month for “reconcilement with suppliers” is 1 hour [(30 suppliers * 2 minutes) / 60].

“Checking control” activity is the control of employee working hours from system. Checking control activity is realized every day. Total time used for every activity is 8 minutes. The monthly duration of this activity is 3, 5 hours [(26 days * 8 minutes) / 60].

Non-productive activities of accounting process are “inventory control”, “invoicing”, “payroll”, “tracking delinquent receivables-payments received”, monthly "reconcilement with suppliers" and "checking control". Total non-productive time of the process is 30, 6 hours (4, 3 + 8, 6 + 4, 9 + 8, 3 + 1 + 3, 5).

The total time used for current state is 30, 6 hours.

The total time available for use per month is 39 hours (26 days * 7, 5 hours * 2 employees * 10 %).

The total time not used for current state is 8, 4 hours (39 – 30, 6).

Productive percent of capacity is 0 %. Non-productive percent of capacity is 78 % (30, 6 / 39) and available percent of capacity is 22 % (8, 4 / 39).

In Figure 62, employee capacity analysis of accounting process is displayed.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
		Current State		Future State		
Process Steps	Activity	Non-Productive	Productive	Non-Productive	Productive	Change
Accounting	Inventory control [(2 times * 26 days * 5 minutes) / 60]	4,3				
2 Persons	Invoicing [(10 invoces * 26 days * 2 minutes) / 60]	8,6				
1 Shift	Payroll [(37 employees * 8 minutes) / 60]	4,9				
Hours	Tracking delinquent receivables and payments received [(50 customers*10 minutes) / 60]	8,3				
	Reconcilement with suppliers [(30 suppliers*2 minutes) / 60]	1,0				
Employee Share 10%	Checking control [(8 minutes * 26 days) / 60]	3,5				
	Total Time by Value Creating Category	30,6				
	Total Time Used Current State	30,6				
	Total Time Not Used Per Month	8,4				
	Total Time Available for Use Per Month	39				
	Productive Percent	0		**Total Time Available for Use Per Month**		
	Non-productive Percent	0,78		**26 days*7,5 hours*2 employees*10%=39 hours**		
	Available Percent	0,22				
		1				

Figure 62: Employee Capacity Analysis of Accounting Process

4.5.4. Value Stream Costing Analysis

In this section of research, value stream costs are calculated. Value stream costs are material costs, employee costs, machine costs, facilities costs and other costs. These costs are charged into processes where the capacity being used.

4.5.4.1. Material Costs

Material costs occur in mixing and welding processes in the value stream.

4.5.4.1.1. Material Costs of Mixing Process

In mixing process, material cost of one product is determined as 2, 3 TL. / kg. according to the average prices of raw materials and supplementary materials. The number of manufactured products is 129.886 units in this process. One product's average weight is 0, 23 kg.. Raw material cost of one product is 2, 2 TL. / kg. and supplementary material cost of one product is 0, 1 TL. / kg.. On the other hand, leakage occurs in extrusion process and it is about 2 %. The cost of leakage is charged into material costs of mixing process. Calculation of material costs of mixing process is as follows.

Total Manufactured Product Weight = Total Production * Unit Weight

Total Manufactured Product Weight = 129.886 * 0, 23 = 29.874 kg.

Leakage Cost = Amount of Leakage * Unit Cost

Leakage Cost = [(129.886 * %2) * 0, 23] * 2, 3 = 1.374 TL.

Leakage Cost per kg. = Leakage Cost / Total Production Weight

Leakage Cost per kg. = 1.374 / (129.886 * 0, 23) = 0,046 TL.

Unit Material Cost = 2, 3 + 0, 046 = 2,346 TL.

Unit Raw Material Cost = (2, 2 / 2, 3) * 2,346 = 2,244 TL.

Unit Supplementary Material Cost = (0, 1 / 2, 3) * 2,346 =0,102 TL.

Raw Material Cost = Amount of Total Production * Unit Raw Material Cost

Raw Material Cost = 29.874 * 2,244 = 67.037 TL.

Supplementary Material Cost = Amount of Total Production * Unit Supplementary Material Cost

Supplementary Material Cost = 29.874 * 0,102 = 3.047 TL.

Material Cost = Raw Material Cost + Supplementary Material Cost

Material Cost = 67.037 + 3.047 = 70,084 TL.

Total material cost is calculated as 70,084 TL. in mixing process.

4.5.4.1.2. Material Costs of Welding Process

In welding process, supplementary material is package. One package includes 200 products and weight of package is 0,020 kg.. Kilogram costs of one package is 1, 66 TL.. Cost of package consists of cost of plastic bags and labels. The number of manufactured products is 124.690 units in this process. The calculation of material costs is as follows.

Number of Package = Number of Products / Number of Products in One Package

Number of Package = 124.690 / 200 = 623 units

Total Package Weight = Number of Package * Weight of One Package

Total Package Weight = 623 * 0, 02 = 12 kg.

Total Package Cost = Total Package Weight * Package Unit Cost

Total Package Cost = 12 * 1, 66 = 21 TL.

The cost of total package is material cost of welding process.

Total material costs of value stream are presented in Table 29.

Table 29
Total Material Costs

	Units	Number of Package	Production (Kilogram)	Material Cost	Raw Material Cost	Supplementary Material Cost
Mixing	129.886	0	29.874	70.084	67.037	3.047
Extrusion	129.886	0	0	0	0	0
Welding	124.690	623	12	21	0	21
Total				**70.105**	**67.037**	**3.068**

Total material cost is the sum of material costs in mixing and welding processes. Material cost of value stream is 70.105 TL.. Raw material cost of value stream is 67.037 TL. and supplementary material cost is 3.068 TL.

4.5.4.2. Employee Costs

Employee costs of value stream are charged into each process. In value stream map, the number of employees and shifts are identified. Furthermore, the data of working time is gathered from capacity analysis of value stream and the information about cost per working hour is collected from payrolls.

The number of employees in the value stream is calculated through the following equation.

Total Number of Employees = Number of Shifts * Number of Employees per Shift

Working hours per employee is identified through the following equation.

Working hours per employee = Total Working Hours / Number of Employees

Working hours per employee is calculated in Table 30.

Table 30

Working Hours per Employee

	Number of Employees per Shift	Number of Shifts	Total Number of Employees	Total Working Hours	Working Hours per Employee
Mixing	5	1	5	135	27
Extrusion	3	3	9	259,2	28,8
Welding	6	2	12	2700	225
Control & Test	1	2	2	54	27
Shipping	1	1	1	27	27
Customer Service	2	1	2	39	19,5
Planning	1	1	1	23,4	23,4
Purchasing	2	1	2	31,2	15,6
Design	1	1	1	23,4	23,4
Accounting	2	1	2	39	19,5
Total			37		

In the value stream, total number of employees is 37 persons. Working hours per employee is calculated for every process of value stream. As an example, in welding process, total number of employees is 12 persons (6 employees * 2 shifts). Total working hours, computed in current state capacity analysis, are 2700 hours. So, working hours per employee are 225 hours (2700 hours / 12 employees).

Employee cost per worker is computed for every process of value stream. The following equations present calculation of employee cost per worker and total employee costs.

Employee Cost per Worker = Working Hours per Employee * Employee Cost per Hour

Total Employee Costs = Number of Employees * Employee Cost per Worker

Total employee costs are calculated in Table 31.

Table 31

Total Employee Costs

	Working Hours per Employee	Employee Cost per Hour	Employee Cost per Worker	Total Employee Costs
Mixing	27	6,27	169	846
Extrusion	28,8	7,06	203	1.830
Welding	225	7,06	1.589	19.062
Control & Test	27	7,06	191	381
Shipping	27	6,5	176	176
Customer Service	19,5	6,8	133	265
Planning	23,4	9,1	213	213
Purchasing	15,6	6,4	100	200
Design	23,4	13,6	318	318
Accounting	19,5	7,6	148	296
Total			3.239	**23.587**

For example, in welding process, employee cost per worker is 1.589 TL. (225 hours * 7, 06 TL.). The number of employees is 12 persons in welding process. So, total employee cost of welding process is 19.062 TL. (1.589 TL. * 12 employees).

Total employee cost of value stream is 23.588 TL..

4.5.4.3. Machine Costs

In value stream, machine costs occur in mixing, extrusion and welding processes. Machine costs consist of depreciation, electricity, gas, machine maintenance, repair and insurance expenses.

Total machine costs of mixing and extrusion processes are tracked collectively for all value streams of the company. Total machine costs of mixing and extrusion processes are 220.000 TL. in the company.

Total machine costs of welding process is 10.000 TL..

4.5.4.3.1. Machine Costs of Mixing and Extrusion Processes

The information about the number of machines is gathered from value stream map. The data about machine hours of mixing and extrusion processes is collected from current state value stream capacity analysis. Total machine hours of mixing and extrusion process are as follows;

Mixing Process : 1 shift * 7, 5 hours * 30 days = 225 hours

Extrusion Process : 3 shifts * 8 hours * 30 days = 720 hours

Total = 945 hours

The following equation expresses the calculation of machine costs per hour.

Machine Costs per Hour = Total Machine Cost / Total Machine Hours

Machine Costs per Hour = 220.000 / 945 = 233 TL.

Total cost per machine in mixing process is 6.291 TL. (233 TL. * 27 hours) and total cost per machine in extrusion process is 20.131 TL. (233 TL. * 86, 4 hours). One machine is used in mixing and extrusion processes, therefore, total machine cost of mixing process is 6.291 TL. (6.291 TL. * 1 machine) and total machine cost of extrusion process is 20.131 TL. (20.131 TL. * 1 machine).

4.5.4.3.2. Machine Costs of Welding Process

The information about machine hours of welding process is gathered from current state value stream capacity analysis. The data about number of machines is obtained from value stream map. 5 machines exist in welding process. Total time available for use in selected month is 2250 hours. Machine cost per hour is 4, 44 TL. (10.000 TL. / 2250 hours). Total available time per machine is 450 hours (2250 hours / 5 Machine). Cost per machine is 2.000 TL. (450 hours * 4, 44 TL.). Total machine costs of welding process is 10.000 TL..

In Table 32, total machine costs of the value stream are computed.

Table 32

Total Machine Costs

	Number of Shifts	Machine Hours	Number of Machines	Hours per Machine	Machine Costs per Hour	Total Cost per Machine	Total Machine Cost
Mixing	1	27	1	27	233	6.291	6.291
Extrusion	3	86,4	1	86,4	233	20.131	20.131
Welding	2	2250	**5**	450	4,444	2.000	10.000
Total							**36.422**

Total machine costs of value stream are 36.422 TL.

4.5.4.4. Facilities Costs

Total facilities costs consist of electricity, gas, security, cleaning, insurance, depreciation and maintenance repair expenses.

Facilities costs are charged into processes according to square meters of processes. The use of factory space is categorized as production area, warehouse space and office space. Mixing, extrusion and welding processes of value stream use production area. Shipping process uses warehouse space and control-test, customer service, planning, purchasing, design and accounting processes use office space of value stream.

Table 33 shows square meter areas used by value stream. Cost allocation ratio is calculated by the following equation.

Cost Allocation Ratio = Area Used by Process / Total Used Area

Table 34 presents total facilities costs of the company.

Table 33

Areas Used by Value Stream

	Production Area (m^2)	Warehouse Space (m^2)	Office Space (m^2)	Value Stream Usage Ratio	Production Area (m^2)	Warehouse Space (m^2)	Office Space (m^2)	Cost Allocation Ratio
Mixing	200			12%	24			0,00986
Extrusion	1.500			12%	180			0,07392
Welding	100			100%	100			0,04107
Control & Test	50			12%	6			0,00246
Shipping		500		12%		60		0,02464
Customer Service			20	10%			2	0,00082
Planning			10	12%			1	0,00049
Purchasing			20	8%			2	0,00066
Design			15	12%			2	0,00074
Accounting			20	10%			2	0,00082
Total	**1.850**	**500**	**85**		**310**	**60**	**9**	

Table 34

Total Facilities Costs of the Company

Facility Costs	
Electricity	34.810 TL.
Gas	11.873 TL.
Security & Cleaning	2.710 TL.
Insurance	1.150 TL.
Depreciation	660 TL.
Maintenance & Repair	480 TL.
Total	**51.647 TL.**

Total facility costs of the company are 51.647 TL.

Total facilities costs of value stream are calculated in Table 35.

Table 35

Total Facilities Costs

	Cost Allocation Ratio	Total Facilities Cost
Mixing	0,009856	509
Extrusion	0,073922	3.818
Welding	0,041068	2.121
Control & Test	0,002464	127
Shipping	0,024641	1.273
Customer Service	0,000821	42
Planning	0,000493	26
Purchasing	0,000657	34
Design	0,000739	38
Accounting	0,000821	42
Total		**8.030**

For example, facilities cost of mixing process is calculated as 509 TL. (51.647 TL. * 0, 009856). Total facilities costs of value stream is 8.030 TL..

4.5.4.5. Other Costs

Other costs of value stream are workers transportation service, meal, communication and office supplies expenses. Service-meal expenses and communication-office supplies expenses are allocated according to different methods.

Total other expenses of value stream are presented in Table 36.

Table 36

Total Other Costs of the Company

Other Costs	
Service and Meal	7.810 TL.
Communication	1.198 TL.
Office Supplies	497 TL.
Total	**9.505 TL.**

Service and meal expenses are allocated according to the number of employees. Total number of employees is 200 persons in the company. Therefore, service and meal expense per employee is 39, 05 TL. (7.810 TL. / 200 employees).

Table 37 shows the calculation of service and meal expenses of value stream.

Table 37

Service and Meal Expenses of Value Stream

	Number of Employees per Shift	**Number of Shifts**	**Total Number of Employees**	**Total Service and Meal Expenses**	**Value Stream Usage Ratio**	**Service and Meal Expenses of Value Stream**
Mixing	5	1	5	195,25	12%	23,43
Extrusion	3	3	9	351,45	12%	42,17
Welding	6	2	12	468,60	100%	468,60
Control & Test	1	2	2	78,10	12%	9,37
Shipping	1	1	1	39,05	12%	4,69
Customer Service	2	1	2	78,10	10%	7,81
Planning	1	1	1	39,05	12%	4,69
Purchasing	2	1	2	78,10	8%	6,25
Design	1	1	1	39,05	12%	4,69
Accounting	2	1	2	78,10	10%	7,81
Total			37	1.444,85		**579,5**

Service and meal expenses are computed for every process of the company. Service and meal costs of value stream are calculated through multiplication of these expenses by value stream usage ratios. For example, mixing process expense is 195, 25 (39, 05 TL. * 5 employees). Mixing process cost of value stream is 23, 43 TL. (195, 25 TL. * 12 %). Total service and meal expenses of value stream are 579, 5 TL..

Total expenses of communication and office supplies are 1.695 TL. (1.198 TL. + 497 TL.). Expenses of communication and office supplies are allocated according to 10% value stream ratio of purchasing, selling and employee transactions and number of employees. Communication and office supplies costs of value stream are 169, 5 TL. (1695 * 10 %). Cost per employee is 4, 58 TL. (169, 5 / 37)..

Communication and office supplies expenses of value stream are computed in Table 38.

Table 38

Communication and Office Supplies Expenses of Value Stream

	Number of Employees per Shift	Number of Shifts	Total Number of Employees	Communication and Office Supplies Expenses
Mixing	5	1	5	22,91
Extrusion	3	3	9	41,23
Welding	6	2	12	54,97
Control & Test	1	2	2	9,16
Shipping	1	1	1	4,58
Customer Service	2	1	2	9,16
Planning	1	1	1	4,58
Purchasing	2	1	2	9,16
Design	1	1	1	4,58
Accounting	2	1	2	9,16
Total			**37**	**169,50**

Communication and office supplies costs of value stream are calculated through multiplication of cost per employee by number of employees. For example, welding process expense is 54, 97 TL. (4, 58 TL. * 12 employees). Total service and meal expenses of value stream are 169, 5 TL..

Table 39 shows other costs of value stream.

Table 39

Total Other Costs

	Total Other Costs
Mixing	46
Extrusion	83
Welding	524
Control & Test	19
Shipping	9
Customer Service	17
Planning	9
Purchasing	16
Design	9
Accounting	17
Total	**749**

Total other costs of value stream are the sum of service-meal expenses and communication-office supplies expenses. Total other costs of value stream are 749 TL..

4.5.5. Value Stream Cost Statement

In "value stream costing analysis" section of research, all costs are calculated for every process of value stream. All value stream costs are material costs, employee costs, machine costs, facility costs and other costs. Table 40 presents value stream costs. Total value stream costs are calculated as 138.893 TL..

Table 40

Value Stream Costs

Process Steps	Material Costs	Employee Costs	Machine Costs	Facilities Costs	Other Costs	Total Cost
Mixing	70.084	846	6.291	509	46	77.776
Extrusion	0	1.830	20.131	3.818	83	25.862
Welding	21	19.062	10.000	2.121	524	31.728
Control & Test	0	381	0	127	19	527
Shipping	0	176	0	1.273	9	1.458
Customer Service	0	265	0	42	17	324
Planning	0	213	0	26	9	248
Purchasing	0	200	0	34	16	250
Design	0	318	0	38	9	365
Accounting	0	296	0	42	17	355
Total	**70.105**	**23.587**	**36.422**	**8.030**	**749**	**138.893**

Total material costs are 70.105 TL. (70.084 TL. + 21 TL.). All other costs except material costs are conversion costs of value stream. Conversion costs of value stream are computed as 68.788 TL. (23.587 TL. + 36.422 TL. + 8.030 TL. + 749 TL.). The following equation is developed for calculation of conversion costs.

Conversion Costs = Total Value Stream Costs – Material Costs

Conversion Costs = 138.893 – 70.105 = 68.788 TL.

Average material cost is calculated through dividing total material costs by the number of shipped product. Average material cost of value stream is 0, 58 TL. (70.105 TL./ 120.856 units). Average conversion cost is computed through dividing total conversion costs by the number of shipped product. Average conversion cost of value stream is 0, 57 TL. (68.788 TL./ 120.856 units).

Average unit cost is calculated through dividing total value stream costs by the number of shipped product. Average unit cost of value stream is 1, 15 TL. (138.893 TL. / 120.856 units).

Table 41 shows value stream cost statement.

Table 41

Value Stream Cost Statement

Value Stream Cost	**Total**
Material Costs	70.105 TL.
Outside Process Cost	0 TL.
Employee Costs	23.587 TL.
Machine Costs	36.422 TL.
Facilities Costs	8.030 TL.
Other Costs	749 TL.
Total Cost	138.893 TL.
Conversion Cost	68.788 TL.
Customer Order Quantity	120.856 units
Average Material Cost	0, 58 TL.
Average Conversion Cost	0, 57 TL.
Average Cost per Unit	1, 15 TL.

4.5.6. Value Stream Profit and Loss Statement

Unit sales price is determined as 1, 26 TL. and total sales in value stream are calculated as 152.279 TL. (120.856 units * 1,26 TL.).

Value stream profit is computed through subtracting value stream costs from value stream sales. Value stream profit is 13.386 TL. (152.279 TL. – 138.893 TL.). Return on sales (ROS) is computed through dividing value stream profit by total sales of value stream. ROS is 8, 79 % (13.386 TL. / 152.279 TL.) in the value stream.

Table 42 presents value stream profit and loss statement.

Table 42

Profit and Loss Statement of Value Stream

Sales	152.279 TL.
Material Costs	70.105 TL.
Employee Costs	23.587 TL.
Machine Costs	36.422 TL.
Outside Process Cost	0 TL.
Facilities Costs	8.030 TL.
Other Costs	749 TL.
Total Cost	138.893 TL.
Value Stream Profit	13.386 TL.
ROS	8,79 %

4.5.7. Inventory Valuation

The beginning inventory of value stream is previous months ending inventory. According to days of stock valuation method, beginning inventory is assumed as 99.000 TL..

Ending inventory of selected month is calculated by days of stock valuation method. In value stream map, the inventory days for purchased materials, WIP and finished goods are traced as a performance measurement of the value stream. The company tracks the number of days of inventory, hold in purchased materials, WIP and finished goods.

In Table 43, the calculation of value stream's ending inventory is shown.

Table 43

Ending Inventory of Value Stream

	Total Cost	Number of Working Day	Cost per Day
Material Cost	70.105	30	2.337
Conversion Cost	68.788	30	2.293
Total	138.893		

	Purchased Materials	WIP	Finished Goods
Inventory Days	7,5	15,5	1,5
Material Cost	17.526	36.222	3.505
Conversion Cost	0	35.540	3.439
Inventory Value	17.526	71.762	6.944
	Total Inventory Value		**96.232**

The total material cost for the selected month in the value stream is 70.105 TL. and the working day in a month is 30 days. Thereby, the material cost per day is 2.337 TL. (70.105 TL. / 30 days). The total conversion cost is 68.788 TL and 2.293 TL. (68.788 TL./ 30 days) per day.

Inventory days between processes are categorized as purchased materials stock days, WIP stock days and finished goods stock days. Stock days between suppliers and mixing process present inventory days for purchased materials. Stock days between mixing and control-test process involve inventory days for WIP. Stock days between control-test and shipping process are associated with inventory days for finished goods. There are 7, 5 inventory days for purchased materials, so the value of purchased material inventory is 17.526 TL. (7, 5 days * 2.337 TL.). The value of 15, 5 days (8, 5 days + 5 days + 2 days) of WIP comes to15, 5 days of material cost and 15, 5 days of conversion cost – assuming the WIP items are complete. So, material cost is 36.222 TL. (15, 5 days * 2.337 TL.) and conversion cost is 35.540 TL. (15, 5 days * 2.293 TL.). Total WIP inventory value is 71.762 TL. (36.222 TL. + 35.540 TL.). The value of finished goods inventory is 6.944 TL. [(1, 5 days * 2.337 TL.) + (1, 5 days * 2.293 TL.)]. Total ending inventory is 96.232 TL. (17.526 TL. + 71.762 TL. + 6.944 TL.).

Table 44 indicates daily inventory costs of value stream.

Table 44

Daily Inventory Costs

	Total Inventory Cost	Number of Working Days	Daily Inventory Cost
Raw Material Cost	67.037	30	2.234,57
Supplementary Materials Cost	3.047	30	101,57
	21	30	0,70
Total Material Cost	70.105	30	2.336,83
Conversion Cost	68.788	30	2.292,93
Total Value Stream Cost	**138.893**		

Material costs are categorized as raw material cost and supplementary materials cost. Daily raw material cost, supplementary materials cost and conversion cost are computed as 2.237, 57 TL., 102, 27 TL. (101, 57 +0, 70) and 2.292, 93 TL..

Table 45 shows WIP inventory cost and finished goods inventory cost of value stream processes.

Table 45

Inventory Costs of Value Stream Processes

	Material Cost	Conversion Cost	WIP Cost	Finished Goods Cost
Mixing	-	-	-	-
Extrusion	19.863	19.490	39.353	-
Welding	11.684	11.465	23.149	-
Control & Test	4.674	4.586	9.260	-
Shipping	3.505	3.439	-	6.944
Total	**39.726**	**38.980**	**71.762**	**6.944**

Costs of WIP inventory involve inventory cost between mixing and control-test processes. Total cost of WIP inventory is calculated as 71.762 TL. (39.353 TL. + 23.149 TL. + 9.260 TL.). For example, materials inventory cost of extrusion process is 19.863 TL. (8, 5 days * 2.337 TL.), conversion cost is computed as 19.490 TL. (8, 5 days * 2.293 TL.). The sum of material and conversion costs gives cost of WIP inventory in extrusion process. Inventory cost between control-test and shipping process presents finished goods inventory cost. Total cost of finished goods inventory is computed as 6.944 TL..

Table 46 displays costs of ending inventory in the value stream.

Table 46

Cost of Ending Inventory

	Stock Days	Cost of Raw Material Inventory	Cost of Supplementary Materials	Cost of WIP Inventory	Cost of Finished Goods Inventory	Cost of Ending Inventory
Mixing	7,5	16.760	762	-	-	17.522
Extrusion	8,5	-	-	39.353	-	39.353
Welding	5	-	4	23.149	-	23.153
Control&Test	2	-	-	9.260	-	9.260
Shipping	1,5	-	-	-	6.944	6.944
Total	**24,5**	**16.760**	**766**	**71.762**	**6.944**	**96.232**

Total cost of ending inventory is calculated as 96.232 TL. (17.522 TL. + 39.353 TL. + 23.153 TL. + 9.260 TL. + 6.944 TL.).

Figure 63 shows the chart for cost of ending inventory. Cost of raw material, supplementary materials, WIP and finished goods inventory are calculated as 16.760 TL., 766 TL., 71.762 TL. and 6.944 TL..

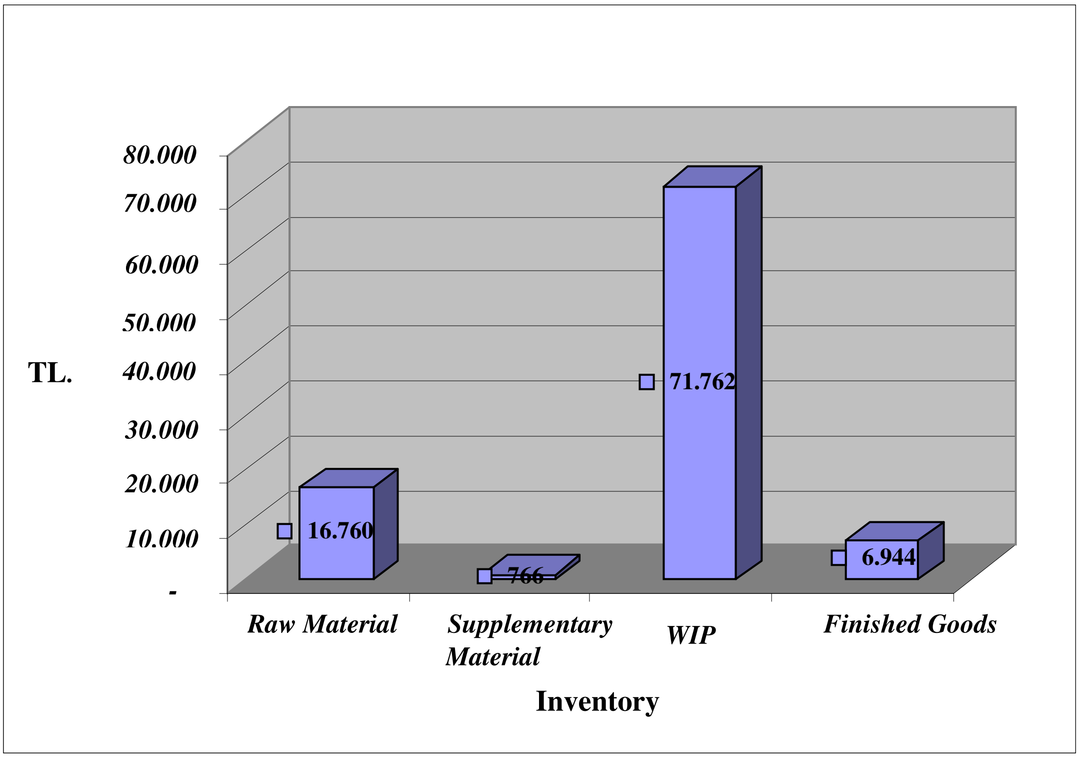

Figure 63: The Chart for Cost of Ending Inventory

4.5.8. Net Profit According to GAAP

Value stream profit is identified through cash-basis approach. However, it must be converted to reach net profit according to GAAP. Cash-basis value stream profit must be adjusted for the changes inventory balances to arrive at GAAP.

Table 47 shows the calculation of net profit according to GAAP.

Table 47

Net Profit According to GAAP

Value Stream Profit		13.386
Opening Inventory	99.000	
Less: Closing Inventory	96.232	
Inventory Change	(2.768)	(2.768)
GAAP Net Profit		**10.618**

GAAP net profit is calculated as 10.618 TL. through subtracting inventory change from value stream profit (13.386 TL. – 2.768 TL.).

4.5.9. Cost of Goods Sold According to GAAP

Value stream costs must be adjusted to reach cost of goods sold according to GAAP.

Table 48 displays the calculation of cost of goods sold according to GAAP.

Table 48

Cost of Goods Sold According to GAAP

Beginning Inventory	99.000
Value Stream Costs	138.893
Subtotal	237.893
Less: Ending Inventory	(96.232)
GAAP Cost of Goods Sold	**141.661**

In order to obtain GAAP cost of goods sold, ending inventory is subtracted from the sum of beginning inventory and value stream costs. GAAP cost of goods sold is computed as 141.661 TL. (237.893 TL. – 96.232 TL.).

4.5.10. Bookkeeping Entry of Value Stream Costs

Bookkeeping entries of value stream costs are developed according to the system known as dual entry bookkeeping.

Material cost, employee cost, overhead costs, sales and cost of goods sold of value stream are identified as 70.105 TL., 23.587 TL., 45.201 TL., 152.279 TL. and 141. 661 TL.. Also, value added tax rate is assumed as 18%.

The entries of journal are as follows:

1--/--

150 RAW MATERIALS	70.105	
191 DEDUCTABLE VAT	12.619	
320 SUPPLIERS		82.724

Purchasing materials

2--/--

710 DIRECT RAW MATERIAL COST	70.105	
150 RAW MATERIAL		70.105

Spending materials transfer to the production cost

3--/--

151 WORK IN PROCESS	70.105	
151.01.001.001 Mixing Process of Gasket Product Group "A" Value Stream 70.084		
151.01.003.001 Welding Process of Gasket Product Group "A" Value Stream 21		
711 DIRECT RAW MATERIAL APPLIED		70.105

Transferring the direct material cost to the work in process account

4--/--

720 DIRECT LABOR COST	23.587	
360 TAXES PAYABLE		4.245
361 SOCIAL SECURITY DUTIES PAYABLE		3.335
100 CASH		16.007

Paying the direct labor cost

---/--

5--/--

151 WORK IN PROCESS 23.587

151.01.001.002 Mixing Process of Gasket Product Group “A” Value Stream 846

151.01.002.002 Extrusion Process of Gasket Product Group “A” Value Stream 1.830

151.01.003.002 Welding Process of Gasket Product Group “A” Value Stream 19.062

151.01.004.002 Control&Test Process of Gasket Product Group “A” Value Stream 381

151.01.005.002 Shipping Process of Gasket Product Group “A” Value Stream 176

151.01.006.002 Customer Service Process of Gasket Product Group “A” Value Stream 265

151.01.007.002 Planning Process of Gasket Product Group “A” Value Stream 213

151.01.008.002 Purchasing Process of Gasket Product Group “A” Value Stream 200

151.01.009.002 Design Process of Gasket Product Group “A” Value Stream 318

151.01.010.002 Accounting Process of Gasket Product Group “A” Value Stream 296

721 DIRECT LABOR COST APPLIED 23.587

Transferring the direct labor cost to the work in process

6--/--

730 OVERHEAD COSTS 45.201

191 DEDUCTABLE VAT 4.068

100 CASH 49.269

Paying of the direct labor cost

---/--

7---/---

151 WORK IN PROCESS		45.201
151.01.001.003 Mixing Process of Gasket Product Group “A” Value Stream	6.846	
151.01.002.003 Extrusion Process of Gasket Product Group “A” Value Stream	24.032	
151.01.003.003 Welding Process of Gasket Product Group “A” Value Stream	12.645	
151.01.004.003 Control&Test Process of Gasket Product Group “A” Value Stream	146	
151.01.005.003 Shipping Process of Gasket Product Group “A” Value Stream	1.282	
151.01.006.003 Customer Service Process of Gasket Product Group “A” Value Stream	59	
151.01.007.003 Planning Process of Gasket Product Group “A” Value Stream	35	
151.01.008.003 Purchasing Process of Gasket Product Group “A” Value Stream	50	
151.01.009.003 Design Process of Gasket Product Group “A” Value Stream	47	
151.01.010.003 Accounting Process of Gasket Product Group “A” Value Stream	59	

731 OVERHEAD COSTS APPLIED		45.201

Transferring the overhead costs to the work in process account

8---/---

711 DIRECT RAW MATERIAL APPLIED	70.105	
721 DIRECT LABOR COST APPLIED	23.587	
731 OVERHEAD COSTS APPLIED	45.201	
710 DIRECT RAW MATERIAL COST		70.105
720 DIRECT LABOR COST		23.587
730 OVERHEAD COSTS		45.201

Closing the applied accounts

--/--

9--/--

152 FINISHED GOODS 138.893

152.01 Gasket Product Group “A” Value Stream

151 WORK IN PROCESS 138.893

151.01.001.001 Mixing Process of Gasket Product Group “A” Value Stream 70.084

151.01.003.001 Welding Process of Gasket Product Group “A” Value Stream 21

151.01.001.002 Mixing Process of Gasket Product Group “A” Value Stream 846

151.01.002.002 Extrusion Process of Gasket Product Group “A” Value Stream 1.830

151.01.003.002 Welding Process of Gasket Product Group “A” Value Stream 19.062

151.01.004.002 Control&Test Process of Gasket Product Group “A” Value Stream 381

151.01.005.002 Shipping Process of Gasket Product Group “A” Value Stream 176

151.01.006.002 Customer Service Process of Gasket Product Group “A” Value Stream 265

151.01.007.002 Planning Process of Gasket Product Group “A” Value Stream 213

151.01.008.002 Purchasing Process of Gasket Product Group “A” Value Stream 200

151.01.009.002 Design Process of Gasket Product Group “A” Value Stream 318

151.01.010.002 Accounting Process of Gasket Product Group “A” Value Stream 296

151.01.001.003 Mixing Process of Gasket Product Group “A” Value Stream 6.846

151.01.002.003 Extrusion Process of Gasket Product Group “A” Value Stream 24.032

151.01.003.003 Welding Process of Gasket Product Group “A” Value Stream 12.645

151.01.004.003 Control&Test Process of Gasket Product Group “A” Value Stream 146

151.01.005.003 Shipping Process of Gasket Product Group “A” Value Stream 1.282

151.01.006.003 Customer Service Process of Gasket Product Group “A” Value Stream 59

151.01.007.003 Planning Process of Gasket Product Group “A” Value Stream 35

151.01.008.003 Purchasing Process of Gasket Product Group “A” Value Stream 50

151.01.009.003 Design Process of Gasket Product Group “A” Value Stream 47

151.01.010.003 Accounting Process of Gasket Product Group “A” Value Stream 59

Transferring the finished goods to the stock account

--/--

10---/---

120 CUSTOMERS 179.689

600 DOMESTIC SALES 152.279

391 VAT RECEIVED 27.410

The entry of the sales

11---/---

620 COST OF GOODS SOLD 141.661

152 FINISHED GOODS 141.661

152.01 Gasket Product Group "A" Value Stream

Transferring the finished goods to cost of goods sold after selling

---/---

4.5.11. Value Stream Box Score

Value stream box score is monthly report of value stream performance. Also, it has three major sections; measuring operational performance, capacity usage and financial performance.

Table 49 displays value stream box score.

Table 49

Value Stream Box Score

Company	**ABC Manufacturing Company**	
Location	**Istanbul**	
Value Stream	**Gasket**	
Type	**Group A**	
OPERATIONAL	**Units per Person**	**8.143,94 units**
	On-Time Shipment	**100%**
	First Time Through	**98%**
	Dock-to-Dock Days	**24,5 days**
	Average Cost	**1,15 TL.**
CAPACITY	**Productive**	**78%**
	Non-Productive	**6%**
	Available Capacity	**16%**
FINANCIAL	**Revenue**	**152.279 TL.**
	Material Costs	**70.105 TL.**
	Conversion Costs	**68.788 TL.**
	Value Stream Profit	**13.386 TL.**
	Value Stream ROS	**8,79%**

4.5.11.1. Operational Data of Value Stream Box Score

Operational performance measurements in the value stream consist of units per person, on-time shipment, first time through, dock-to-dock days and average cost.

4.5.11.1.1. Units per Person

Units per person are calculated through dividing total sales by the total number of employee in the value stream. Table 50 shows the number of employees in the value stream.

Table 50

Number of Employees in the Value Stream

Process	Total Number of Employees	Ratio of Value Stream Usage	Number of Employees in the Value Stream
Mixing	5	12%	0,60
Extrusion	9	12%	1,08
Welding	12	100%	12,00
Control & Test	2	12%	0,24
Shipping	1	12%	0,12
Customer Service	2	10%	0,20
Planning	1	12%	0,12
Purchasing	2	8%	0,16
Design	1	12%	0,12
Accounting	2	10%	0,20
Total	**37**		**14,84**

The sales of selected month are 120.856 units. Therefore, the equation of unit per person in the value stream is as follows:

Units per Person = 120.856 units / 14, 84 persons = 8.143,94 units

4.5.11.1.2. On-Time Shipment

On-time shipment identifies the ratio of on time delivery to the customers in the value stream. Value stream processes are operated effective to meet customer requirements and on-time shipment is computed at 100 % level.

4.5.11.1.3. First Time Through

First time through (FTT) is the percentage of products without rework, repair, retest, recalibration or fault. Also, it evaluates process effectiveness.

The leakage of the extrusion process is at 2 % level in accordance with the feature of production. Therefore, the amount of leakage products is 2.597,72 units (129.886 * 2 %). In equation form, first time through of extrusion process is expressed as;

FTT of Extrusion Process = (129.886–2.597, 72) / 129.886 = 98 %

There is no leakage in other processes of value stream, so first time through is at 100 % level. The equation of FTT of value stream is as follows;

FTT = 100 % * 98 % * 100 % * 100 % = %98

4.5.11.1.4. Dock-to-Dock Days

Dock-to-dock days identify the flow of materials within the value stream. It is the time; it takes between buying a material from the supplier, and selling a product to customer.

Dock-to-dock days are the production lead time of the value stream. Accordingly, dock-to-dock days are 24, 5 days as displayed in the value stream map.

4.5.11.1.5. Average Cost

Average cost is computed through dividing total value stream costs by the amount of units delivered. In equation form, average cost of value stream is expressed as;

Average Cost = 138.893 TL. / 120.856 units= 1, 15 TL.

4.5.11.2. Capacity Data of Value Stream Box Score

In the capacity analysis of the value stream, the capacity of employees and machines is identified.

Table 51 shows the percentages of employee capacity analysis as productive, non-productive and available capacity. The data is gathered from capacity analysis of value stream.

Table 51

Employee Capacity Analysis

	Productive	Non-Productive	Available
Mixing	67%	3%	30%
Extrusion	88%	1%	11%
Welding	93%	4%	3%
Control & Test	0%	56%	44%
Shipping	93%	0%	7%
Customer Service	0%	94%	6%
Planning	0%	96%	4%
Purchasing	58%	37%	5%
Design	0%	64%	36%
Accounting	0%	78%	22%

Figure 64 displays the chart of the employees' capacity usage in the value stream.

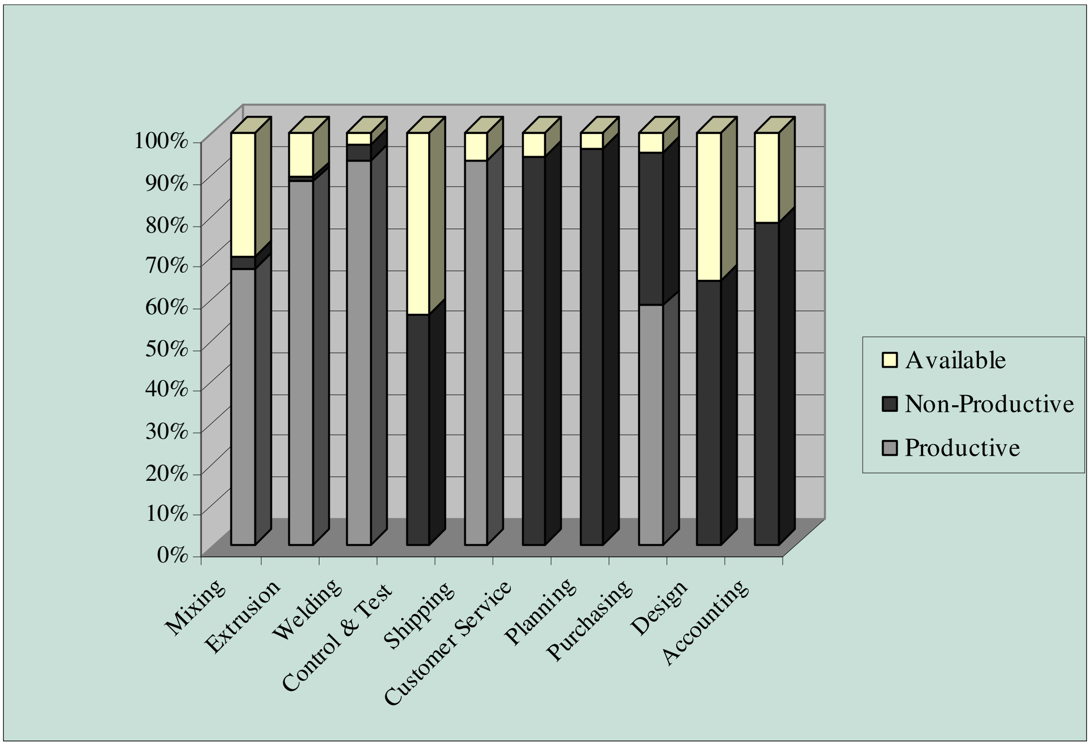

Figure 64: The Chart of the Employees' Capacity Usage

Table 52 shows the percentages of machine capacity analysis.

Table 52

Machine Capacity Analysis

	Productive	Non-Productive	Available
Mixing	92%	6%	2%
Extrusion	93%	4%	3%
Welding	25%	2%	73%
Control & Test	0%	0%	0%
Shipping	0%	0%	0%
Customer Service	0%	0%	0%
Planning	0%	0%	0%
Purchasing	0%	0%	0%
Design	0%	0%	0%
Accounting	0%	0%	0%

In Figure 65, the chart of the machines' capacity usage is drawn.

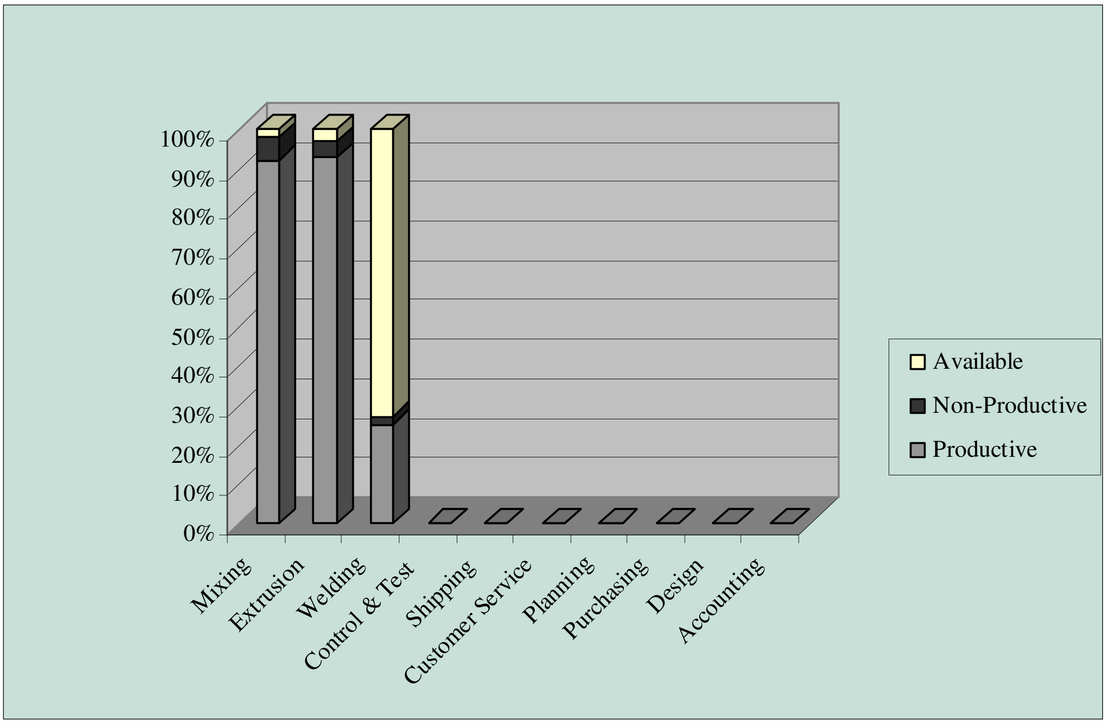

Figure 65: The Chart of the Machines' Capacity Usage

Table 53 indicates available capacity of value stream.

Table 53

Available Capacity of Value Stream

	Employee	Machine
Mixing	30%	2%
Extrusion	11%	3%
Welding	3%	73%
Control & Test	44%	0%
Shipping	7%	0%
Customer Service	6%	0%
Planning	4%	0%
Purchasing	5%	0%
Design	36%	0%
Accounting	22%	0%

In Figure 66, the chart of the available capacity is displayed.

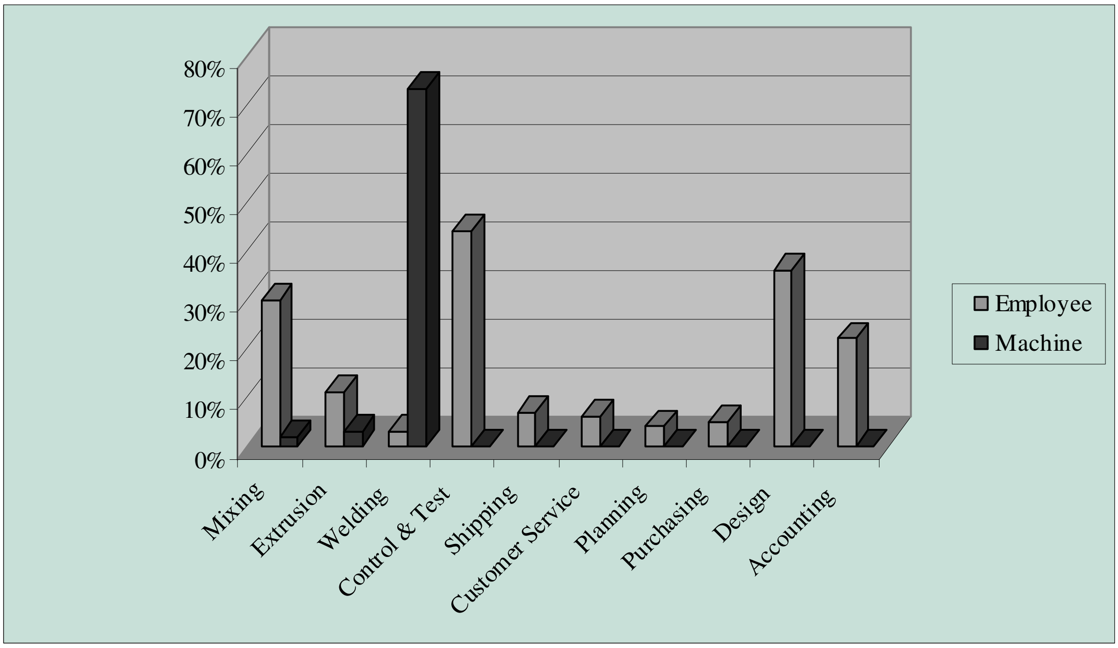

Figure 66: The Chart of the Available Capacity

In order to computing capacity data of value stream, capacity percentages are associated with the costs of value stream. In Table 54, employee capacity percentages and employee costs are shown.

Table 54

Employee Costs and Capacity Percentages

	Employee Cost	Productive	Non-Productive	Available
Mixing	846	67%	3%	30%
Extrusion	1.830	88%	1%	11%
Welding	19.062	93%	4%	3%
Control & Test	381	0%	56%	44%
Shipping	176	93%	0%	7%
Customer Service	265	0%	94%	6%
Planning	213	0%	96%	4%
Purchasing	200	58%	37%	5%
Design	318	0%	64%	36%
Accounting	296	0%	78%	22%
Total	**23.587**	**86%**	**8%**	**6%**

Employee capacity performance is used to assess employee costs of processes with respect to productive, non-productive and available.

Table 55 displays employee costs of processes, calculated according to capacity usage.

Table 55

Employee Costs According to Capacity Usage

	Employee Cost	Productive	Non-Productive	Available
Mixing	846	567	25	254
Extrusion	1.830	1.611	18	201
Welding	19.062	17.728	762	572
Control & Test	381	-	213	168
Shipping	176	164	-	12
Customer Service	265	-	249	16
Planning	213	-	204	9
Purchasing	200	116	74	10
Design	318	-	204	114
Accounting	296	-	231	65
Total	**23.587**	**20.186**	**1.980**	**1.421**

Total productive, non-productive and available employee costs are calculated as 20.186 TL., 1.980 TL. and 1.421 TL. For example, productive employee cost of mixing process is 567 TL. (846 TL. * 67 %), non-productive employee cost is 25 TL. (846 TL. * 3 %) and available employee costs is 254 TL. (846 TL. * 30%). In Table 55, these calculations are generated for all processes of value stream.

In Table 56, machine capacity percentages and employee costs are shown.

Table 56

Machine Costs and Capacity Percentages

	Machine Cost	Productive	Non-Productive	Available
Mixing	6.291	92%	6%	2%
Extrusion	20.131	93%	4%	3%
Welding	10.000	25%	2%	73%
Control & Test	0	0	0	0
Shipping	0	0	0	0
Customer Service	0	0	0	0
Planning	0	0	0	0
Purchasing	0	0	0	0
Design	0	0	0	0
Accounting	0	0	0	0
Total	**36.422**	**74%**	**4%**	**22%**

Table 57 displays machine costs of processes, calculated according to capacity usage.

Table 57

Machine Costs According to Capacity Usage

	Machine Cost	Productive	Non-Productive	Available
Mixing	6.291	5.788	377	126
Extrusion	20.131	18.722	805	604
Welding	10.000	2.500	200	7.300
Control & Test	0	0	0	0
Shipping	0	0	0	0
Customer Service	0	0	0	0
Planning	0	0	0	0
Purchasing	0	0	0	0
Design	0	0	0	0
Accounting	0	0	0	0
Total	**36.422**	**27.010**	**1.382**	**8.030**

Total productive, non-productive and available machine costs are computed as 27.010 TL., 1.382 TL. and 8.030 TL. For example, productive machine cost of mixing process is 5.788 TL. (6.291 TL. * 92%), non-productive employee cost is 377 TL. (6.291 TL. * 6%) and available employee costs is 126 TL. (6.291 TL. * 2%). In Table 57, these calculations are generated for all processes of value stream.

As a result of these computations, the capacity data of value stream box score is identified. Productive capacity data is determined through dividing the sum of productive employee and machine costs by total employee and machine costs. The sum of productive employee and machine costs is 47.196 TL. (20.186 TL. + 27.010 TL.) and total employee and machine costs is 60.009 TL.. Therefore, productive capacity ratio is calculated as 78 % (47.196 / 60.009).

The same method is used for computing non-productive and available capacity ratios. Non-productive and available capacity ratios of value stream box score is computed as 6 % (3.362 / 60.009) and 16 % (9.451 / 60.009).

Table 58 shows capacity dimension of value stream box score.

Table 58

Capacity Data of Value Stream Box Score

	Cost	Ratio
Productive	47.196	**78,0%**
Non-Productive	3.362	**6,0%**
Available	9.451	**16,0%**
Total	60.009	**100%**

4.5.11.3. Financial Data of Value Stream Box Score

Financial data of value stream box score consists of revenue, material cost, conversion cost, value stream profit and value stream ROS. The financial information is identified in “value stream costing analysis”, “value stream cost statement” and “value stream profit and loss statement” sections of research.

In Table 59, financial information of value stream box score is displayed.

Table 59

Financial Data of Value Stream Box Score

FINANCIAL	**Revenue**	**152.279 TL.**
	Material Cost	**70.105 TL.**
	Conversion Cost	**68.788 TL.**
	Value Stream Profit	**13.386 TL.**
	Value Stream ROS	**8,79%**

The revenue from sales, material costs, conversion costs, value stream profit and value stream ROS are calculated as 152.279 TL., 70.105 TL., 68.788 TL., 13.386 TL. and 8,79 %.

4.6. Future State of the Value Stream

Future state of the value stream is examined based on assumptions of improvement activities. Through improvement activities, significant changes are made and performed. The effects of these changes into value stream are traced and presented in this section of the research.

The analyzed topics in future state of value stream are; future state cell flow, future state value stream map, value stream capacity analysis, value stream costing analysis, value stream cost statement, value stream profit and loss statement, inventory valuation, net profit according to GAAP, cost of goods sold according to GAAP, bookkeeping entry of value stream costs and value stream box score.

4.6.1. Future State Cell Flow

The improvement activities in the future state cell are generated; rearrangement of machines in the cell and introduction to the kanban system. In-process inventories are kept in stores called supermarkets between the production cells in value stream. Consequently, the exact quantities of inventory needed by the next process in production are stored in supermarkets and continuous production is performed in the value stream.

Future state cell flow is presented according to factory layout of machines in Figure 67.

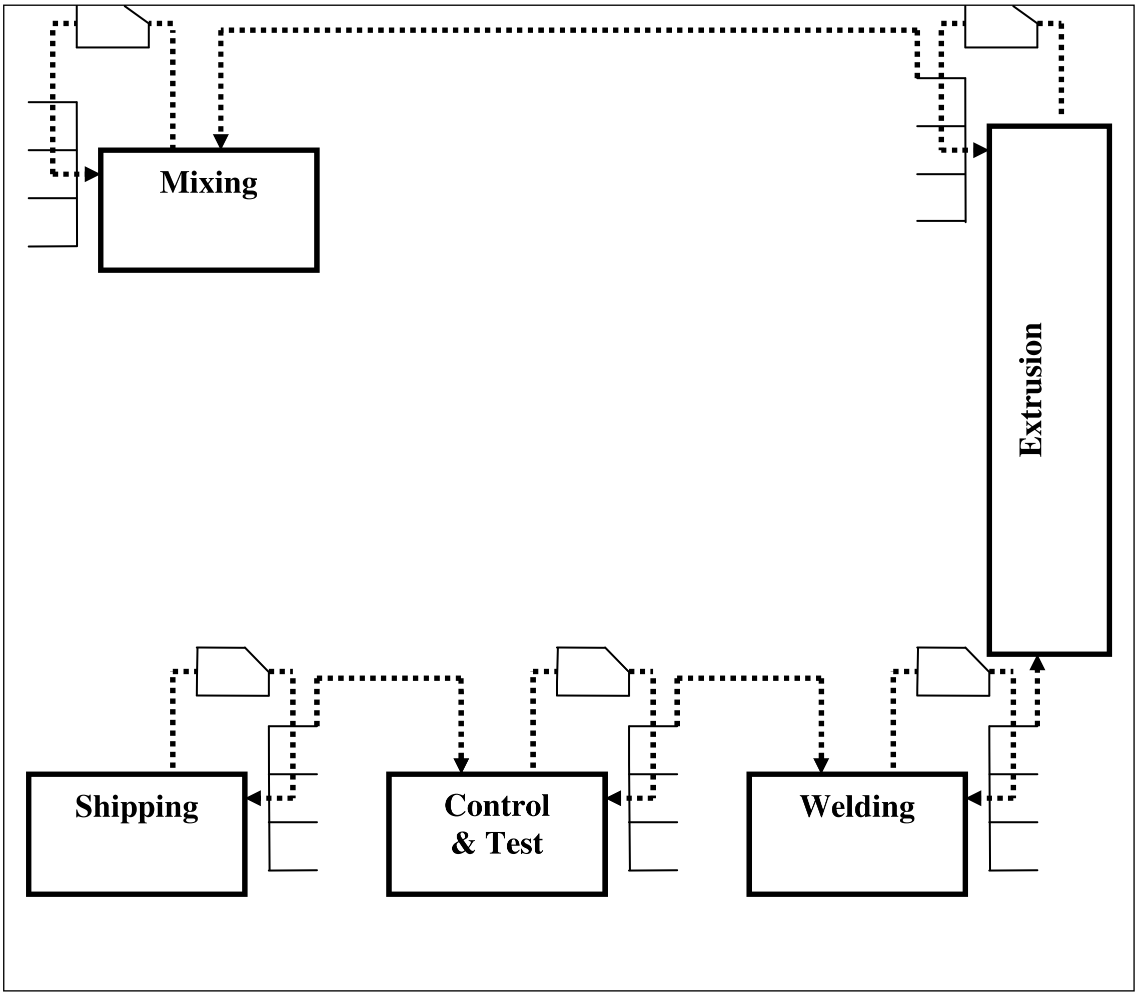

Figure 67: Future State Cell Flow

4.6.2. Future State Value Stream Map

Future state of value stream map is analyzed in two section; data of value stream and value stream map.

4.6.2.1. Data of Value Stream Map

Data of future state value stream map is based on assumptions of improvement activities about the future state of the company for a selected month and used for future state employee and machine capacity analysis. The correspondence of improvement activities is confirmed through interviews with production, human resources, planning, accounting and quality departments of company.

4.6.2.1.1. Employee and Machine Data of Mixing Process

C / O time of mixing process is reduced from 15 seconds to 10 seconds through rearrangement of cell.

Arrangements with suppliers are renegotiated and provided key suppliers deliver to the supermarket in front of mixing process according to kanban orders from the process. Therefore, moving material in or out of process is eliminated.

Administrative activities are declined from 1 hour to 30 minutes by generating the supermarket in front of mixing process.

As a result of improvement activities and trainings to maintenance personnel, each planned maintenance time is reduced from 1 hour to 45 minutes.

"Get ready" activity is preparation of machine and it is declined from 20 minutes to 10 minutes through rearrangement of cell.

4.6.2.1.2. Employee and Machine Data of Extrusion Process

The leakage of extrusion process is reduced from 2 % to 1, 5 % through quality improvement activities.

The suppliers of the process deliver supplementary materials to the supermarket in front of extrusion process. Accordingly, "move material" activity is removed from the process.

Administrative activities are decreased from 1 hour to 30 minutes by generating the supermarket in front of extrusion process.

"Get ready" activity is preparation of machine and it is declined to 20 minutes through rearrangement of cell.

As a result of improvement activities and trainings to maintenance personnel, each planned maintenance time is decreased to 45 minutes.

4.6.2.1.3. Employee and Machine Data of Welding Process

The welding process consists of cutting, application of solution, welding and trimming transactions.

New welding mode is developed by design department and produced by an outside mold manufacturing company. The outside cost of the investment to new mold is 9.000 TL.. The new welding mold has 12 holes. Therefore, C / T of welding process is reduced. The operation time of welding process is displayed in Table 60.

Table 60

Operation Time of Welding Process

Operation	Operation Time
Cutting	5 seconds
Solution Application	5 seconds
Welding	130 seconds
Trimming	6 seconds
Total Time	146 seconds

Total operation time of welding process is 146 seconds in Table 60. Therefore, C/T is 12, 16 seconds (146 / 12) in this process.

The daily time spent for making product demand by each employee is reduced from 7 hours to 5, 25 hours in welding process through mold change.

“Get ready” activity is preparation of machine and it is declined to 10 minutes through rearrangement of cell. The working areas of solution application and welding are generated closer to each other.

As a result of improvement activities and trainings to maintenance personnel, each planned maintenance time is decreased to 45 minutes.

Administrative activities are cut in half by generating the supermarket in front of welding process.

As a result of the increase in available capacity through improvement activities, the company decides to reduce production shift of process from two shifts to one shift. Consequently, the number of employees in the process is decreased from 12 to 6. The six employees freed up are deployed to other value streams.

4.6.2.1.4. Employee and Machine Data of Control and Test Process

Administrative activities are cut in half by generating the supermarket in front of control and test process.

The duration of control and test process could be reduced through executing computer based automatic measurement machines. Because of the cost of investment to this machine is 22.000 €, the company decides to avoid from this cost.

4.6.2.1.5. Employee Data of Shipping Process

C / T of shipping process is reduced through generating the supermarket in front of shipping process and implementing kanban system in the value stream.

When 120.856 units are shipped in a month, 4028 units are shipped on average in a day. The daily duration of shipping transactions for this value stream is decreased to 40 minutes. C/T is 0, 74 seconds [(40 * 60) / 4028] in future state of value stream.

4.6.2.1.6. Employee Data of Customer Service Process

"Take customer calls" activity is done every day and the average time spent for every call is 5 minutes. The number of daily customer call is reduced from 10 calls to 6 calls through improvement of customer service and quality. The monthly duration of "take customer calls" activity is decreased to 13 hours [(26 days * 30 minutes) / 60].

4.6.2.1.7. Employee Data of Planning Process

A kanban system is implemented to pull customer requirements through the value stream, rather than scheduling each work center and pushing. It is the key element of customer demand-pull system.

Arrangements with suppliers are renegotiated and provided key suppliers deliver daily to the supermarket in front of processes according to kanban orders from the process.

The kanban system replaces material requirements planning and daily planning time is reduced to 5 minutes from 15 minutes.

4.6.2.1.8. Employee Data of Purchasing Process

Value stream's share for purchasing process is computed according to the number of purchasing orders for the month.

In the future state, the number of suppliers of the company reduces through arrangements with certified suppliers.

The number of certified supplier of profile product group is 76 persons and the number of monthly purchasing order is 8 units. The number of supplier of pipe product group is 73 persons and the number of monthly purchasing order is 6 units. The number of supplier of gasket product group is 50 persons and the number of monthly purchasing order is 4 units. Therefore, the amounts of monthly total profile, pipe and gasket purchase orders will be 608 units (76 * 8), 438 units (73 * 6) and 200 units (50 * 4) respectively. The value stream's number of supplier is declined to 25 persons and the number of monthly purchasing order is 4 units. Accordingly, the amount of monthly total purchase order will be 100 units (25 * 4).

Table 61 shows calculation of value stream's purchasing process ratio.

Table 61

Calculation of the Ratio of Value Stream's Purchasing Process

Product Groups	Number of Supplier	Number of Monthly Purchase Order	Amount of Total Purchase Order	Ratio of Purchase Order
PVC Profile	76	8	608	%48,8
Pipe	73	6	438	%35,2
Gasket	50	4	200	%16
Total	199		1246	1
A Product Group	25	4	100	**% 8**

Total amount of monthly purchase order is computed as 1246 units (608 + 438 + 200). According to this total amount, purchasing process ratios are as follows; 48, 8 % (608 / 1246) PVC profile, 35, 2 % (438 / 1246) pipe, 16 % (200 / 1246) gasket. Value stream's ratio of purchase orders is 8%, so in this case, the purchasing process ratio will be 8 % (120 / 1500) as well.

Master purchase agreements and certification are made with key suppliers. The monthly duration of "taking supplier offerings" activity is decreased from 15 hours to 8 hours through these improvement activities. In the value stream, 25 certified suppliers exist. Every supplier spent 19, 2 minutes [(8 hours x 60 minutes) / 25 suppliers] for taking supplier offerings activity in a month.

Placing supplier orders activity is performed 3 times a week. Total time used for every activity is reduced from 15 minutes to 8 minutes.

Preparing purchasing orders activity is realized three times a week. Total time used for every activity is decreased to 5 minutes through using blanket purchase orders and automatically voucher on receipt.

4.6.2.1.9. Employee Data of Design Process

There is no difference between current and future state of design process.

4.6.2.1.10. Employee Data of Accounting Process

The accounting process of the company consists of selling, purchasing and employee related activities, so the accounting process ratio is weighted average of these activities. The ratio of accounting process is found as 10 % through weighted average of activities.

Total time used in a month for making customer calls for receivables is 200 minutes; because number of monthly customer call is reduced to 20 calls through improvement of customer service and quality and the average time spent for every call is 10 minutes.

The calculation of weighted ratio of accounting activities is shown in Table 62.

Table 62

Calculation of Weighted Ratio of Accounting Activities

Activities	Time Used (Hours)	Weighted Ratio
Selling	12,9	%51
Purchasing	4,16	%16
Employee Related	8,4	%33
Total	25,46	%100

In accounting process, time used for selling activities is 12, 9 hours, time used for purchasing activities is 4, 16 hours and time used for employee related activities is 8, 4 hours. Therefore, total time used for accounting activities is 25, 46 hours (12, 9 + 4, 16 + 8, 4).

Weighted ratios of activities are as follows; 51 % (12, 9 / 25, 46) selling activity, 16 % (4, 16 / 25, 46) purchasing activity, 33 % (8, 4 / 25, 46) employee related activity.

Table 63 presents the calculation of weighted average ratio of accounting processes.

Table 63

Calculation of the Ratio of Value Stream's Accounting Process

Activities	Value Stream Ratio	Weighted Ratio	Weighted Average Ratio
Selling	%10	%51	%5
Purchasing	%8	%16	%1
Employee Related	%12	%33	%4
Accounting Process Ratio of Value Stream			**10 %**

Value stream's selling, purchasing and employee related activity ratios are determined as 10 %, 8 % and 12 % in previous sections of research. When these ratios are multiplied by weighted ratio of accounting activities, weighted average ratios of activities are determined. Weighted average ratio of selling activity is 5% (10% * 51%), weighted average ratio of purchasing activity is 1% (8% * 16%) and weighted average ratio of employee related activities is 4% (12% * 33%). Value stream's accounting process ratio is computed as 10 % (5% + 1% + 4%).

4.6.2.2. Value Stream Map

After all data of value stream map is computed, future state value stream map is presented in Figure 68.

In the future state, the production lead time of value stream is calculated as 7 days (1 + 2, 5 + 1, 5 + 1 + 1) from the sum of inventory days between processes. Inventory days between future state processes are assumed by the interviews with company. The time used for procurement of raw material is reduced to 1 day, so inventory day before mixing process is 1 day. The time used for maturation of material mixture is 2, 5 days, so inventory days before extrusion processes are 2, 5 days.

Processing time is calculated as 0, 6176 minutes (0, 0115 + 0, 0371 + 0, 2026 + 0, 3566 + 0, 0098).

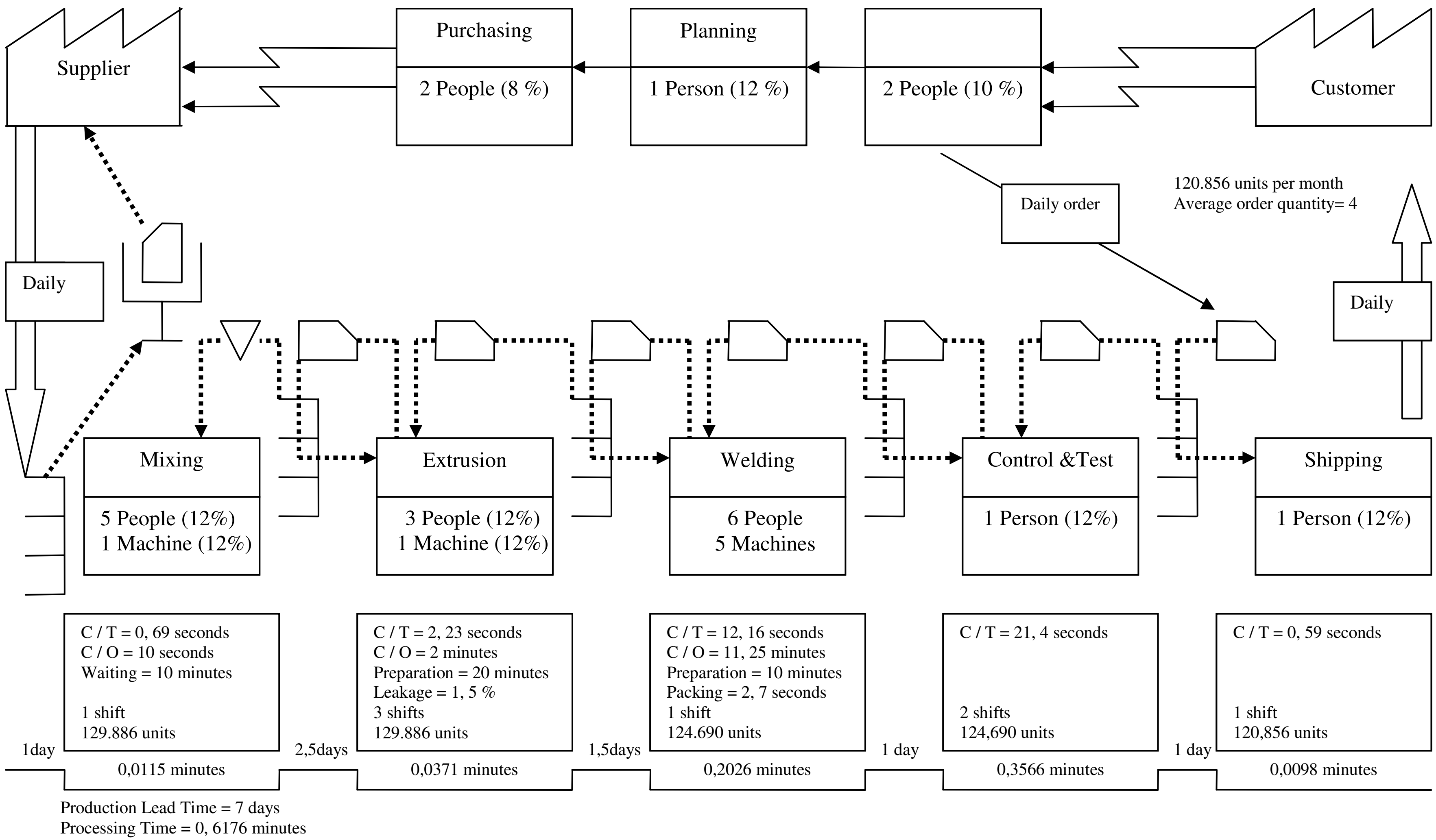

Figure 68: Future State Value Stream Map

4.6.3. Value Stream Capacity Analysis

In this section of research, employee and machine capacity analysis of future state value stream processes are illustrated according to the identified capacity data after improvement activities.

4.6.3.1. Employee Capacity Analysis of Mixing Process

C / O time of mixing process is reduced to 10 seconds through rearrangement of cell. The duration of "get ready" activity of mixing process is 0, 08 hour [(10 seconds * 30 batch) / 3600].

Daily "move in material" and "move out material" activities are eliminated from the process.

For entire production, the duration of administrative activities is 30 minutes. The time spent for "administration" activities of mixing process is 0, 3 hour [(5 employee * 30 minutes) * 12%].

Productive activity of mixing process is "make product demand" and the duration of this activity is 90 hours in selected month.

Non-productive activities of mixing process are; "get ready" and "administration". Total non-productive time of the process is 0, 4 hours (0, 08 + 0, 3).

The total time used for future state consists of the sum of productive and non-productive time and it is 90, 4 hours (90 + 0, 4).

The total time available for use per month is 135 hours (7, 5 hours * 5 employee * 30 days * 12%).

In the future state, the total time not used is 44, 6 hours (135 – 90, 4).

Productive percent of capacity is 66, 7 % (90 / 135). Non-productive percent of capacity is 0, 3 % (0, 4 / 135) and available percent of capacity is 33 % (44, 6 / 135).

Employee capacity analysis of mixing process is displayed in Figure 69.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:	Date	Page

Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Mixing	Make for Demand - [(5 hours * 5 employees * 30 days)*12%]		90		**90**	
Employee	Get Ready-Preparation [(10 seconds * 30 batch)/3600]	0,13		**0,08**		C / O time is reduced to 10 seconds
5 Persons	Move in Material [(0 minutes/60)*30*12%]	1,8		**0**		Eliminated
1 Shift	Move Material [(0 minutes/60)*30*12%]	0,9		**0**		Eliminated
Hours	Administration [[(5 employees * 30 minutes)/60]*12%]	0,6		**0,3**		Cut in half
Share in Total						
Production 12%						
	Total Time by Value Creating Category	3,4	90,0	**0,4**	**90,0**	
	Total Time Used Current State	93,4		**90,4**		
	Total Time Not Used Per Month	41,6		**44,6**		
	Total Time Available for Use Per Month	135		**135**		

	Current	**Future**
Productive Percent	0,67	**0,667**
Non-productive Percent	0,03	**0,003**
Available Percent	0,30	**0,33**
	1	**1**

Total Time Available for Use Per Month in Current State

7,5 hours*5 employee*30 days*12%=135 hours

Total Time Available for Use Per Month in Future State

7,5hours*5employee*30days*12%=135 hours

Figure 69: Employee Capacity Analysis of Mixing Process

4.6.3.2. Machine Capacity Analysis of Mixing Process

"Planned maintenance" activity is performed 3 times in a month and each maintenance time is 45 minutes. Total time of "planned maintenance" activity for value stream is 0, 27 hour [[(3 times * 45 minutes)/60] * 12%].

The duration of "get ready-machine heating" activity is daily 10 minutes for entire production. Total time of "get ready-machine heating" activity for the value stream is 0, 6 hour [[(10 minutes * 30 days) / 60] * 12%] in selected month.

Productive activity of mixing process is "make product demand" and the duration of this activity is 24, 9 hours in selected month.

Non-productive activities are "planned maintenance" and "get ready-machine heating". Total non-productive time of the process is 0, 87 hours (0, 27 + 0, 6).

The total time used for future state is 25, 8 hours (24, 9 + 0, 87).

The total time available for use per month is 27 hours (30 days * 7,5 hours * 12%).

In the future state, the total time not used is 1, 2 hours (27 – 25, 8).

Productive percent of machine capacity is 92% (24,9 / 27). Non-productive percent of capacity is 3% (0,87 / 27) and available percent of capacity is 5% (1,2 / 27).

In Figure 70, machine capacity analysis of mixing process is displayed.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:			Date	Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Mixing	Make for Demand [(0.69seconds*129.886units)/3600]		24,9		**24,9**	
Machine	Planned Maintenance [[(3 times*45 minutes)/60]*12%]	0,36		**0,27**		Reduced to 45 minutes
1 Machine	Get Ready-Machine Heating [[(10 minutes*30 days)/60]*12%]	1,20		**0,6**		Reduced to 10 minutes
1 Shift						
Hours						
Share in Total						
Production 12%						
	Total Time by Value Creating Category	1,6	24,9	**0,87**	**24,9**	
	Total Time Used Current State	26,5		**25,8**		
	Total Time Not Used Per Month	0,5		**1,2**		
	Total Time Available for Use Per Month	27		**27**		

	Current	**Future**	
Productive Percent	0,92	**0,92**	Total Time Available for Use Per Month in Current State
Non-productive Percent	0,06	**0,03**	30 days*7,5 hours*12%=27 hours
Available Percent	0,02	**0,05**	**Total Time Available for Use Per Month in Future State**
	1	**1**	**30 days*7,5 hours*12%=27 hours**

Figure 70: Machine Capacity Analysis of Mixing Process

4.6.3.3. Employee Capacity Analysis of Extrusion Process

Daily “move in material” and “move out material” activities are eliminated from the process.

“Administration” activities include training and meeting activities. For entire production, the duration of “administration” activity is 30 minutes. The time spent for administration activity of extrusion process is 0, 54 hours [(3 employee * 3 shifts * 30 minutes) * 12%].

Productive activity of extrusion process is “make product demand” and the duration of this activity is 226, 8 hours in selected month.

Non-productive activities of extrusion process are “get ready”, and “administration”. Total non-productive time of the process is 2, 9 hours (2, 4 + 0,54).

The total time used for future state consists of sum of productive and non-productive time and it is 229, 7 hours (226, 8 + 2, 9).

The total time available for use per month is 259, 2 hours (8 hours * 3 shifts * 3 employees * 30 days * 12%).

In the future state, the total time not used is 29,5 hours (259, 2 – 229, 7).

Productive percent of capacity is 88% (226, 8 / 259, 2). Non-productive percent of capacity is 1% (2,9 / 259,2) and available percent of capacity is 11% (29,5 / 259,2).

Employee capacity analysis of extrusion process is displayed in Figure 71.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Extrusion	Make for Demand [(7hours*3employees*3shifts*30days)*12%]		226,8		**226,8**	
Employee	Get Ready [[(2minutes*20times*30days)/60]*12%]	2,4		**2,4**		
3 Persons	Administration [[(3 employee * 3 shifts * 30 minutes)/60]*12%]	1,08		**0,54**		Cut in half
3 shifts	Move Material [(0 minutes / 60) * 30 days * 12%]	0,9		**0**		Eliminated
Hours						
Share in Total						
Production 12%						
	Total Time by Value Creating Category	4,4	226,8	**2,9**	**226,8**	
	Total Time Used Current State	231,2		**229,7**		
	Total Time Not Used Per Month	28,0		**29,5**		
	Total Time Available for Use Per Month	259,2		**259,2**		

	Current	**Future**	
Productive Percent	0,88	**0,88**	Total Time Available for Use Per Month in Current State
Non-productive Percent	0,01	**0,01**	8hours*3shifts*30days*3emp.*12%=259,2hours
Available Percent	0,11	**0,11**	**Total Time Available for Use Per Month in Future State**
	1	**1**	**8hours*3shifts*30days*3emp.*12%=259,2hours**

Figure 71: Employee Capacity Analysis of Extrusion Process

4.6.3.4. Machine Capacity Analysis of Extrusion Process

"Planned maintenance" activity is realized 3 times in a month and each maintenance time is 45 minutes. Total time of "planned maintenance" activity for value stream is 0, 27 hour [[(3 times * 45 minutes)/60] * 12%] in selected month.

The duration of "get ready-machine heating" activity is daily 20 minutes for entire production. Total time of "get ready-machine heating" activity for value stream is 1, 2 hours [[(20 minutes * 30 days) / 60] * 12%] in selected month.

Productive activity of extrusion process is "make product demand" and the duration of this activity is 80, 45 hours in selected month.

Non-productive activities are "planned maintenance" and "get ready-machine heating". Total non-productive time of the process is 1, 5 hours (0, 27 +1, 2).

The total time used for future state is 81, 9 hours (80, 45 + 1, 5).

The total time available for use per month is 86, 4 hours (30 days * 8 hours * 3 shifts * 12%).

In the future state, the total time not used is 4, 5 hours (86, 4 – 81, 9).

Productive percent of machine capacity is 93% (80, 45 / 86, 4). Non-productive percent of capacity is 2% (1,5 / 86,4) and available percent of capacity is 5% (4,5 / 86,4).

Machine capacity analysis of extrusion process is displayed in Figure 72.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Extrusion	Make for Demand [(2,23 seconds * 129.886 units) / 3600]		80,45		**80,45**	
Machine	Get Ready-Machine Heating [[(20 minutes*30days)/60]*12%]	2,7		**1,2**		Reduced to 20 minutes
1 Machine	Planned Maintenance [[(3 times*45 minutes)/60]*12%]	0,36		**0,27**		Reduced to 45 minutes
3 Shift						
Hours						
Share in Total						
Production 12 %						
	Total Time by Value Creating Category	3,1	80,5	**1,5**	**80,5**	
	Total Time Used Current State	83,5		**81,9**		
	Total Time Not Used Per Month	2,9		**4,5**		
	Total Time Available for Use Per Month	86,4		**86,4**		

	Current	**Future**
Productive Percent	0,93	**0,93**
Non-productive Percent	0,04	**0,02**
Available Percent	0,03	**0,05**
	1	**1**

Total Time Available for Use Per Month in Current State

8 hours * 3 shifts * 30 days * 12%=86,4 hours

Total Time Available for Use Per Month in Future State

8 hours * 3 shifts * 30 days * 12%=86,4 hours

Figure 72: Machine Capacity Analysis of Extrusion Process

4.6.3.5. Employee Capacity Analysis of Welding Process

The welding process is able to reduce its operating time from two shifts to one shift as a result of the improvement activities.

The total time used for "make for demand" activity is decreased as a result of changing the mold. The duration of "make for demand" activity is 945 hours (5, 25 hours * 6 employees * 1 shifts * 30 days) in a month.

The time spent for "administration" activities of welding process is 3 hours [(6 employee * 30 minutes * 1 shift) / 60].

Productive activity of welding process is "make product demand" and the duration of this activity is 945 hours in selected month.

Non-productive activities of welding process are "get ready", "packing" and "administration". Total non-productive time of the process is 99 hours (2, 5 + 93, 5 + 3).

The total time used for future state consists of sum of productive and non-productive time and it is 1044 hours (945 + 99).

The total time available for use per month is 1350 hours (7, 5 hours * 1 shifts * 6 employees * 30 days).

In the future state, the total time not used is 306 hours (1350 – 1044).

Productive percent of capacity is 70% (945 / 1350). Non-productive percent of capacity is 7% (99 / 1350) and available percent of capacity is 23% (306 / 1350).

Employee capacity analysis of welding process is displayed in Figure 73.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date	Page	
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Welding	Make for Demand (6 employees * 5,25 hours * 1 shift * 30 days)		2520		**945**	Reduced to 5,25 hours
Employee	Get Ready [(15 minutes*10 times)/60]	2,5		**2,5**		
6 Persons	Packing [(2,7seconds*124.690units)/3600]	93,5		**93,5**		
1 Shifts	Administration [(6 employees * 30 minutes)/60]	12		**3**		Cut in half
Hours						
Share in Total						
Production 100%						
	Total Time by Value Creating Category	108	2520	**99**	**945**	
	Total Time Used Current State	2628		**1044**		
	Total Time Not Used Per Month	72		**306**		
	Total Time Available for Use Per Month	2700		**1350**		

	Current	**Future**	
Productive Percent	0,93	**0,70**	Total Time Available for Use Per Month in Current State
Non-productive Percent	0,04	**0,07**	6employees*2shifts*7,5hours*30days=2700hours
Available Percent	0,03	**0,23**	Total Time Available for Use Per Month in Future State
	1	**1**	**6employees*1shift*7,5hours*30days=1350hours**

Figure 73: Employee Capacity Analysis of Welding Process

4.6.3.6. Machine Capacity Analysis of Welding Process

In “value stream data” section of research, cycle time of welding process is identified 12, 16 seconds. The monthly duration of “make for product demand” activity is 421, 18 hours [(12, 16 seconds * 124.690 units) / 3600].

“Planned maintenance” activity is performed 3 times in a month and each maintenance time is 45 minutes. Total time of “planned maintenance” activity for value stream is 11, 25 hours [(3 times * 45 minutes * 5 machine) /60] in selected month.

The daily duration of “get ready-machine heating” activity is reduced to 10 minutes. Total time of “get ready-machine heating” activity for value stream is 25 hours [(10 minutes * 30 days * 5 machines) / 60] in selected month.

Productive activity of welding process is “make product demand” and the duration of this activity is 421, 18 hours in selected month.

Non-productive activities are “planned maintenance” and “get ready-machine heating”. Total non-productive time of the process is 36, 3 hours (11, 25 + 25).

The total time used for future state is 457, 4 hours (421, 18 + 36, 3).

The total time available for use per month is 1125 hours (5 machines * 30 days * 7, 5 hours * 1 shifts).

The total time not used is 667, 6 hours (1125 – 457, 4).

Productive percent of machine capacity is 37% (421,18 / 1125). Non-productive percent of capacity is 3% (36,3 / 1125) and available percent of capacity is 60% (667,6 / 1125).

In Figure 74, machine capacity analysis of welding process is displayed.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Welding	Make for Demand [(12,16 seconds*124.690 units)/3600]		561,1		**421,18**	C/T reduced to 12,16 seconds
5 Machines	Get Ready-Machine Heating [(10minutes*30days*5machines)/60]	37,5		**25**		C/O time reduced to 10 minutes
1 Shifts	Planned Maintenance [(3 times*45 minutes*5 machines)/60]	15,0		**11,25**		Reduced to 45 minutes
Hours						
Share in Total						
Production 100%						
	Total Time by Value Creating Category	52,5	561,1	**36,3**	**421,2**	
	Total Time Used Current State	613,6		**457,4**		
	Total Time Not Used Per Month	1636,4		**667,6**		
	Total Time Available for Use Per Month	2250		**1125**		

	Current	**Future**	
Productive Percent	0,25	**0,37**	Total Time Available for Use Per Month in Current State
Non-productive Percent	0,02	**0,03**	5machines*7,5hours*2shifts*30days=2250hours
Available Percent	0,73	**0,60**	**Total Time Available for Use Per Month in Future State**
	1	**1**	**5machines*7,5hours*1shift*30days=1125hours**

Figure 74: Machine Capacity Analysis of Welding Process

4.6.3.7. Employee Capacity Analysis of Control and Test Process

For entire production, the duration of administrative activities is 30 minutes. The time spent for "administration" activity of control and test process is 0, 12 hour [[(1 employee * 30 minutes * 2 shifts) / 60] * 12 %].

Productive activity does not exist in control and test process.

Non-productive activities are "test and control" and "administration". Total non-productive time of the process is 30, 1 hours (29, 96 + 0, 12).

The total time used for future state is 30, 1 hours.

The total time available for use per month is 54 hours (1 employee * 30 days * 7, 5 hours * 2 shifts * 12 %).

The total time not used for future state is 23, 9 hours (54 – 30, 1).

Productive percent of employee capacity is 0 %. Non-productive percent of capacity is 56% (30, 1 / 54) and available percent of capacity is 44% (23, 9 / 54).

Employee capacity analysis of control and test process is displayed in Figure 75.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:			Date	Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Control and Test	Test and Control [(21,4 seconds * 5040 units)/3600]	29,96		**29,96**		
1 Person	Administration [[(1 employee*30 minutes*2shifts)*12%]/ 60]	0,24		**0,12**		Cut in half
2 Shifts						
Hours						
Share in Total						
Production 12%						
	Total Time by Value Creating Category	30,2	0,0	**30,1**	**0,0**	
	Total Time Used Current State	30,20		**30,1**		
	Total Time Not Used Per Month	23,8		**23,9**		
	Total Time Available for Use Per Month	54		**54**		

	Current	**Future**	
Productive Percent	0	**0**	Total Time Available for Use Per Month in Current State
Non-productive Percent	0,56	**0,56**	1 emp.*2 shifts*7,5hours*30 days*12%=54hours
Available Percent	0,44	**0,44**	**Total Time Available for Use Per Month in Future State**
	1	**1**	**1kişi x 2vardiya x 7,5saat x 30gün x 12%=54saat**

Figure 75: Employee Capacity Analysis of Control and Test Process

4.6.3.8. Employee Capacity Analysis of Shipping Process

The time used for daily shipping activity of the value stream is reduced to 40 minutes and shipping activity is realized every day in a month. The monthly duration of "shipping" activity is 20 hours [(30 times * 40 minutes) / 60].

Productive activity of shipping process is "shipping" and the duration of this activity is 20 hours in selected month.

The total time used for future state is 20 hours.

The total time available for use per month is 27 hours (30 days * 7, 5 hours * 12 %).

The total time not used for future state is 7 hours (27 – 20).

Productive percent of employee capacity is 74 % (20 / 27). Non-productive percent of capacity is 0 % and available percent of capacity is 26% (7 / 27).

Employee capacity analysis of shipping process is displayed in Figure 76.

Value Stream Study		Value Stream: Gasket Manufacturing - A 505 product group	Observer:			Date	Page
Process Steps	Activity	Current State		Future State		Change	
		Non-Productive	Productive	Non-Productive	Productive		
Shipping	Ship product [(30 times*40 minutes)/60]		25		**20**	Reduced to 10 minutes	
1 Person							
1 Shift							
Hours							
Share in Total							
Production 12%							
	Total Time by Value Creating Category		25		**20**		
	Total Time Used Current State	25		**20**			
	Total Time Not Used Per Month	2		**7**			
	Total Time Available for Use Per Month	27		**27**			

	Current	**Future**
Productive Percent	0,93	**0,74**
Non-productive Percent	0,00	**0**
Available Percent	0,07	**0,26**
	1	**1**

Total Time Available for Use Per Month in Current State

30 days * 7,5 hours * 12%=27hours

Total Time Available for Use Per Month in Future State

30 days * 7,5 hours * 12%=27hours

Figure 76: Employee Capacity Analysis of Shipping Process

4.6.3.9. Employee Capacity Analysis of Customer Service Process

"Take customer calls" activity is done every day. Total time used in a day for this activity is 30 minutes; because number of daily customer call is reduced to 6 calls and the average time spent for every call is 5 minutes. The monthly duration of "take customer calls" activity is 13 hours [(26 days * 30 minutes) / 60].

Non-productive activities are "take customer order", "order entry to the system", "take customer calls" and "pricing". Total non-productive time of the process is 28, 1 hours (8, 6 + 2, 2 + 13 + 4, 3).

The total time used for future state is 28, 1 hours.

The total time available for use per month is 39 hours (26 days * 7, 5 hours * 2 employees * 10 %).

The total time not used for future state is 10, 9 hours (39 – 28, 1).

Productive percent of employee capacity is 0 %. Non-productive percent of capacity is 72% (28,1 / 39) and available percent of capacity is 28% (10,9 / 39).

Employee capacity analysis of customer service process is displayed in Figure 77.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Customer Service	Take Customer Order [(20 minutes * 26 days) / 60]	8,6		**8,6**		
2 Person	Order Entry [(5 minutes * 26 days)/60]	2,16		**2,16**		
1 Shift	Take Customer Calls [(26days*6calls*5minutes)/60]	21,6		**13**		Reduced to 6 calls
Hours	Pricing [(10 minutes * 26 days)/60]	4,3		**4,3**		
Employee share						
10%						
	Total Time by Value Creating Category	36,7		**28,1**		
	Total Time Used Current State	36,7		**28,1**		
	Total Time Not Used Per Month	2,3		**10,9**		
	Total Time Available for Use Per Month	39		**39**		

	Current	**Future**	
Productive Percent	0	**0**	Total Time Available for Use Per Month in Current State
Non-productive Percent	0,94	**0,72**	26days*7,5hours*2emp.*10%=39hours
Available Percent	0,06	**0,28**	Total Time Available for Use Per Month in Future State
	1	**1**	**26days*7,5hours*2emp.*10%=39hours**

Figure 77: Employee Capacity Analysis of Customer Service Process

4.6.3.10. Employee Capacity Analysis of Planning Process

The company replaces material requirements planning by planning with kanban system. Total time used in a day for this activity is 5 minutes. The monthly duration of "planning with kanban system" activity is 2, 16 hours [(26 days * 5 minutes) / 60].

Non-productive activities are "planning with kanban system", "inventory planning" and "production planning". Total non-productive time of the process is 18, 2 hours (2, 16 + 4 + 12).

The total time used for future state is 18, 2 hours.

The total time available for use per month is 23, 4 hours (26 days * 7, 5 hours * 1 employee * 12 %).

The total time not used for future state is 5, 2 hours (23, 4 – 18, 2).

Productive percent of employee capacity is 0 %. Non-productive percent of capacity is 78% (18,2 / 23,4) and available percent of capacity is 22% (5,2 / 23,4).

Employee capacity analysis of planning process is displayed in Figure 78.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:			Date	Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Planning	Planning with kanban system [(26days * 5 minutes)/60]	6,5		**2,16**		Reduced to 5 minutes
1 Person	Inventory Planning [(60 minutes*4 weeks) / 60]	4		**4**		
1 Shift	Production Planning [(180 minutes*4 weeks) / 60]	12		**12**		
Hours						
Employee Share						
12%						
	Total Time by Value Creating Category	22,5		**18,2**		
	Total Time Used Current State	22,5		**18,2**		
	Total Time Not Used Per Month	0,9		**5,2**		
	Total Time Available for Use Per Month	23,4		**23,4**		

	Current	**Future**	
Productive Percent	0	**0**	Total Time Available for Use Per Month in Current State
Non-productive Percent	0,96	**0,78**	26days*7,5hours*employee*12%=23,4hours
Available Percent	0,04	**0,22**	**Total Time Available for Use Per Month in Future State**
	1	**1**	**26days*7,5hours*employee*12%=23,4hours**

Figure 78: Employee Capacity Analysis of Planning Process

4.6.3.11. Employee Capacity Analysis of Purchasing Process

In the value stream, 25 certified suppliers exist. Every supplier spent 19, 2 minutes for taking supplier offerings activity in a month. The monthly duration of "taking supplier offerings" activity is 8 hours [(25 suppliers * 19, 2 minutes) / 60].

"Placing supplier orders" activity is performed 3 times a week. Total time used for every activity is reduced to 8 minutes. The monthly duration of "placing supplier orders" activity is 1, 6 hours [(4 weeks * 3 times * 8 minutes) / 60].

"Preparing purchasing orders" activity is realized three times a week. Total time used for every activity is 5 minutes. The monthly duration of "preparing purchasing orders" activity is 1 hour [(4 weeks * 3 times * 5 minutes) / 60].

Productive activities of purchasing process are "taking supplier offerings" and "placing supplier orders" and the duration of these activities is 9, 6 hours (8 + 1, 6) in selected month.

Non-productive activities of purchasing process are "purchasing raw material", "preparing purchasing orders" and "incoming stock" activities. Total non-productive time of the process is 9, 5 hours (2 + 1 + 6, 5).

The total time used for future state is 19, 1 hours (9, 6 + 9, 5).

The total time available for use per month is 31, 2 hours (26 days * 7, 5 hours * 2 employees * 8%).

The total time not used for future state is 12, 1 hours (31, 2 – 19, 1).

Productive percent of capacity is 31% (9,6 / 31,2). Non-productive percent of capacity is 30% (9,5 / 31,2) and available percent of capacity is 39% (12,1 / 31,2).

In Figure 79, employee capacity analysis of purchasing process is displayed.

Value Stream Study	Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
Process Steps	Activity	Current State		Future State		Change
		Non-Productive	Productive	Non-Productive	Productive	
Purchasing	Purchasing raw material [(4 times x 30 minutes)/ 60]	2		**2**		
2 Persons	Taking supplier offerings [(25 suppliers*19,2minutes)/60]		15		**8**	Reduced to 19,2 minutes per employee
1 Shift	Placing supplier orders [(12times*8 minutes)/60]		3		**1,6**	Reduced to 8 minutes per transaction
Hours	Preparing purchasing orders [(12 times*5 minutes)/60]	3		**1**		Reduced to 5 minutes per transaction
	Incoming stock [(26 days*15 minutes)/60]	6,5		**6,5**		
Employee Share						
8%						
	Total Time by Value Creating Category	11,5	18,0	**9,5**	**9,6**	
	Total Time Used Current State	29,5		**19,1**		
	Total Time Not Used Per Month	1,7		**12,1**		
	Total Time Available for Use Per Month	31,2		**31,2**		

	Current	**Future**
Productive Percent	0,58	**0,31**
Non-productive Percent	0,37	**0,30**
Available Percent	0,05	**0,39**
	1	**1**

Total Time Available for Use Per Month in Current State

26days*7,5hours*2employees*8%=31,2hours

Total Time Available for Use Per Month in Future State

26days*7,5hours*2employees*8%=31,2hours

Figure 79: Employee Capacity Analysis of Purchasing Process

4.6.3.12. Employee Capacity Analysis of Design Process

Current state and future state capacity of design process have the same values.

Employee capacity analysis of design process is displayed in Figure 80.

Value Stream Study		Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date	Page

Process Steps	Activity	Current State Non-Productive	Current State Productive	Future State Non-Productive	Future State Productive	Change
Design	Research and development projects (3 project * 5 hours)	15		**15**		
1 Person						
1 Shift						
Hours						
Employee Share						
12%						
	Total Time by Value Creating Category	15,0		**15,0**		
	Total Time Used Current State	15,0		**15,0**		
	Total Time Not Used Per Month	8,40		**8,4**		
	Total Time Available for Use Per Month	23,4		**23,4**		

	Current	**Future**
Productive Percent	0	**0**
Non-productive Percent	0,64	**0,64**
Available Percent	0,36	**0,36**
	1	**1**

Total Time Available for Use Per Month in Current State

26 days*7,5 hours*1 employee*12%=23,4hours

Total Time Available for Use Per Month in Future State

26 days*7,5 hours*1 employee*12%=23,4hours

Figure 80: Employee Capacity Analysis of Design Process

4.6.3.13. Employee Capacity Analysis of Accounting Process

Total time used in a month for making customer calls for receivables is 200 minutes; because number of monthly customer call is reduced to 20 calls and the average time spent for every call is 10 minutes. The monthly duration of “tracking delinquent receivables and payments received” is 3, 33 hours [(20 customers * 10 minutes) / 60].

Total time used in a month for “reconcilement with suppliers” is 0, 83 hour [(25 suppliers * 2 minutes) / 60].

Non-productive activities of accounting process are “inventory control”, “invoicing”, “payroll”, “tracking delinquent receivables-payments received”, monthly “reconcilement with suppliers” and “checking control”. Total non-productive time of the process is 25, 5 hours (4, 3 + 8, 6 + 4, 9 + 3, 33 + 0,83 + 3, 5).

The total time used for future state is 25, 5 hours.

The total time available for use per month is 39 hours (26 days * 7, 5 hours * 2 employees * 10 %).

The total time not used for future state is 13, 5 hours (39 – 25, 5).

Productive percent of capacity is 0 %. Non-productive percent of capacity is 65% (25,5 / 39) and available percent of capacity is 35% (13,5 / 39).

In Figure 81, employee capacity analysis of accounting process is displayed.

Value Stream Study		Value Stream: Gasket Manufacturing - A 505 product group	Observer:		Date		Page
Process Steps	Activity	Current State Non-Productive	Current State Productive	Future State Non-Productive	Future State Productive	Change	
Accounting	Inventory control [(2 times * 26 days * 5 minutes) / 60]	4,3		**4,3**			
2 Persons	Invoicing [(10 invoces * 26 days * 2 minutes) / 60]	8,6		**8,6**			
1 Shift	Payroll [(37 employees * 8 minutes) / 60]	4,93		**4,93**			
Hours	Tracking delinquent receivables and payments received [(20customers*10minutes)/60]	8,3		**3,33**		Calls reduced to 20	
	Reconcilement with suppliers [(25 suppliers*2 minutes)/60]	1,0		**0,83**		The number of certified supplier is 25	
Employee Share	Checking control [(8 minutes * 26 days) / 60]	3,5		**3,5**			
10%							
	Total Time by Value Creating Category	30,6		**25,5**			
	Total Time Used Current State	30,6		**25,5**			
	Total Time Not Used Per Month	8,4		**13,5**			
	Total Time Available for Use Per Month	39		**39**			

	Current	**Future**
Productive Percent	0	**0**
Non-productive Percent	0,78	**0,65**
Available Percent	0,22	**0,35**
	1	**1**

Total Time Available for Use Per Month in Current State

26 days*7,5 hours*2 employees*10%=39 hours

Total Time Available for Use Per Month in Future State

26 days*7,5 hours*2 employees*10%=39 hours

Figure 81: Employee Capacity Analysis of Accounting Process

4.6.4. Value Stream Costing Analysis

In this section of research, value stream costs of future state are calculated. Value stream costs are material costs, employee costs, machine costs, facilities costs and other costs.

In order to see the effects of improvement activities to value stream costs, the value changes of all costs per unit is ignored in the future state of value stream.

4.6.4.1. Material Costs

Material costs occur in mixing and welding processes in the value stream.

4.6.4.1.1. Material Costs of Mixing Process

In mixing process, material cost of one product is determined as 2, 3 TL. / kg. according to the average prices of raw materials and supplementary materials. The number of manufactured products is 129.886 units in this process. One product's average weight is 0, 23 kg.. Raw material cost of one product is 2, 2 TL. / kg. and supplementary material cost of one product is 0, 1 TL. / kg.. On the other hand, leakage occurs in extrusion process and it is reduced to 1, 5 %. The cost of leakage is charged into material costs of mixing process. Calculation of material costs of mixing process is as follows.

Total Manufactured Product Weight = Total Production * Unit Weight

Total Manufactured Product Weight = 129.886 * 0, 23 = 29.874 kg.

Leakage Cost = Amount of Leakage * Unit Cost

Leakage Cost = [(129.886 * % 1, 5) * 0, 23] * 2, 3 = 1.031 TL.

Leakage Cost per kg. = Leakage Cost / Total Production Weight

Leakage Cost per kg. = 1.031 / (129.886 * 0, 23) = 0, 0345 TL.

Unit Material Cost = 2, 3 + 0, 0345 = 2,334 TL.

Unit Raw Material Cost = (2, 2 / 2, 3) * 2,334 = 2,233 TL.

Unit Supplementary Material Cost = (0, 1 / 2, 3) * 2,334 =0,101 TL.

Raw Material Cost = Amount of Total Production * Unit Raw Material Cost

Raw Material Cost = 29.874 * 2,233 = 66.709 TL.

Supplementary Material Cost = Amount of Total Production * Unit Supplementary Material Cost

Supplementary Material Cost = 29.874 * 0,101 = 3.032 TL.

Material Cost = Raw Material Cost + Supplementary Material Cost

Material Cost = 66.709 + 3.032 = 69,741 TL.

Total material cost is calculated as 69,741 TL. in mixing process.

4.6.4.1.2. Material Costs of Welding Process

In welding process, supplementary material is package. One package includes 200 products and weight of package is 0,020 kg.. Kilogram costs of one package is 1, 66 TL.. Cost of package consists of cost of plastic bags and labels. The number of manufactured products is 124.690 units in this process. The calculation of material costs is as follows.

Number of Package = Number of Products / Number of Products in One Package

Number of Package = 124.690 / 200 = 623 units

Total Package Weight = Number of Package * Weight of One Package

Total Package Weight = 623 * 0, 02 = 12 kg.

Total Package Cost = Total Package Weight * Package Unit Cost

Total Package Cost = 12 * 1, 66 = 21 TL.

The cost of total package is material cost of welding process.

Total material costs of value stream are presented in Table 64.

Table 64

Total Material Costs

	Units	Number of Package	Production (Kilogram)	Material Cost	Raw Material Cost	Supplementary Material Cost
Mixing	129.886	0	29.874	69.741	66.709	3.032
Extrusion	129.886	0	0	0	0	0
Welding	124.690	623	12	21	0	21
Total				**69.762**	**66.709**	**3.053**

Total material cost is the sum of material costs in mixing and welding processes. Material cost of value stream is 69.762 TL.. Raw material cost of value stream is 66.709 TL. and supplementary material cost is 3.053 TL.

4.6.4.2. Outside Costs

New welding mode is developed by design department and produced by an outside mold manufacturing company. As a result of this investment, outside process cost occurs in the future state of value stream. The cost of the investment to new mold is 9.000 TL..

Outside process cost of future state value stream is the amount of depreciation of mold in the selected month. Table 65 shows the calculation of annual depreciation expense. The company performs straight-line depreciation method and the useful life of mold is 5 years.

Table 65

Calculation of Annual Depreciation Expense

	Book Value at Beginning of Year	Depreciation Rate	Depreciation Expence	Book Value at End of Year
1	9000	20%	1800	7200
2	7200	20%	1800	5400
3	5400	20%	1800	3600
4	3600	20%	1800	1800
5	1800	20%	1800	0

The annual depreciation rate of mold is 20 % and annual depreciation expense is 1.800 TL. (9.000 * 20 %). Accordingly, monthly depreciation expense is calculated as 150 TL. (1.800 / 12).

4.6.4.3. Employee Costs

In the future state, employee costs of value stream are charged into each process. In future state value stream map, the number of employees and shifts are identified.

The number of employees in the value stream is calculated through the following equation.

Total Number of Employees = Number of Shifts * Number of Employees per Shift

Working hours per employee is identified through the following equation.

Working hours per employee = Total Working Hours / Number of Employees

Working hours per employee is calculated in Table 66. As a result of reduction in welding process operating time, the total number of employees is decreased from 37 to 31 in the future state of value stream.

Table 66

Working Hours per Employee

	Number of Employees per Shift	Number of Shifts	Total Number of Employees	Total Working Hours	Working Hours per Employee
Mixing	5	1	5	135	27
Extrusion	3	3	9	259,2	28,8
Welding	6	1	6	1350	225
Control & Test	1	2	2	54	27
Shipping	1	1	1	27	27
Customer Service	2	1	2	39	19,5
Planning	1	1	1	23,4	23,4
Purchasing	2	1	2	31,2	15,6
Design	1	1	1	23,4	23,4
Accounting	2	1	2	39	19,5
Total			31		

Working hours per employee is calculated for every process of value stream. For example, in welding process, total number of employees is 6 persons (6 employees * 1 shifts). Total working hours, computed in future state capacity analysis, are 1350 hours. So, working hours per employee are 225 hours (1350 hours / 6 employees).

Employee cost per worker is computed for every process of value stream. The following equations present calculation of employee cost per worker and total employee costs.

Employee Cost per Worker = Working Hours per Employee * Employee Cost per Hour

Total Employee Costs = Number of Employees * Employee Cost per Worker

Total employee costs are calculated in Table 67.

Table 67

Total Employee Costs

	Working Hours per Employee	Employee Cost per Hour	Employee Cost per Worker	Total Employee Costs
Mixing	27	6,27	169	846
Extrusion	28,8	7,06	203	1.830
Welding	225	7,06	1.589	9.531
Control & Test	27	7,06	191	381
Shipping	27	6,5	176	176
Customer Service	19,5	6,8	133	265
Planning	23,4	9,1	213	213
Purchasing	15,6	6,4	100	200
Design	23,4	13,6	318	318
Accounting	19,5	7,6	148	296
Total			3.239	**14.056**

For example, in welding process, employee cost per worker is 1.589 TL. (225 hours * 7, 06 TL.). The number of employees is 6 persons in welding process. So, total employee cost of welding process is 9.531 TL. (1.589 TL. * 6 employees).

Total employee cost of value stream is 14.056 TL. in the future state.

4.6.4.4. Machine Costs

In value stream, machine costs occur in mixing, extrusion and welding processes.

Total machine costs of mixing and extrusion processes are tracked collectively for all value streams of the company. Total machine costs of mixing and extrusion processes are 220.000 TL. in the company. Total machine costs of welding process is 10.000 TL..

However, operating time of welding process is reduced from two shifts to one shift; machine costs remain same in the future state.

4.6.4.4.1. Machine Costs of Mixing and Extrusion Processes

Total machine hours of mixing and extrusion process are as follows;

Mixing Process : 1 shift * 7, 5 hours * 30 days = 225 hours

Extrusion Process : 3 shifts * 8 hours * 30 days = 720 hours

Total = 945 hours

The following equation expresses the calculation of machine costs per hour.

Machine Costs per Hour = Total Machine Cost / Total Machine Hours

Machine Costs per Hour = 220.000 / 945 = 233 TL.

Total cost per machine in mixing process is 6.291 TL. (233 TL. * 27 hours) and total cost per machine in extrusion process is 20.131 TL. (233 TL. * 86, 4 hours). One machine is used in mixing and extrusion processes, therefore, total machine cost of mixing process is 6.291 TL. (6.291 TL. * 1 machine) and total machine cost of extrusion process is 20.131 TL. (20.131 TL. * 1 machine).

4.6.4.4.2. Machine Costs of Welding Process

The information about machine hours of welding process is gathered from future state value stream capacity analysis. The data about number of machines is obtained from value stream map. 5 machines exist in welding process. Total time available for use in selected month is 1125 hours. Machine cost per hour is 8, 88 TL. (10.000 TL. / 1125 hours). Total available time per machine is 225 hours (1125 hours / 5 Machine). Cost per machine is 2.000 TL. (225 hours * 8, 88 TL.). Total machine costs of welding process is 10.000 TL..

In Table 68, total machine costs of the value stream are computed.

Table 68

Total Machine Costs

	Number of Shifts	Machine Hours	Number of Machines	Hours per Machine	Machine Costs per Hour	Total Cost per Machine	Total Machine Cost
Mixing	1	27	1	27	233	6.291	6.291
Extrusion	3	86,4	1	86,4	233	20.131	20.131
Welding	1	1125	5	225	8,888	2.000	10.000
Total							**36.422**

Total machine costs of value stream are 36.422 TL.

4.6.4.5. Facilities Costs

Total facilities costs consist of electricity, gas, security, cleaning, insurance, depreciation and maintenance repair expenses.

Facilities costs are charged into processes according to square meters of processes. The use of factory space is categorized as production area, warehouse space and office space. Mixing, extrusion and welding processes of value stream use production area. Shipping process uses warehouse space and control-test, customer service, planning, purchasing, design and accounting processes use office space of value stream.

Table 69 shows square meter areas used by value stream. Cost allocation ratio is calculated by the following equation.

Cost Allocation Ratio = Area Used by Process / Total Used Area

Table 69

Areas Used by Value Stream

	Production Area (m^2)	Warehouse Space (m^2)	Office Space (m^2)	Value Stream Usage Ratio	Production Area (m^2)	Warehouse Space (m^2)	Office Space (m^2)	Cost Allocation Ratio
Mixing	200			12%	24			0,00986
Extrusion	1.500			12%	180			0,07392
Welding	100			100%	100			0,04107
Control & Test	50			12%	6			0,00246
Shipping		500		12%		60		0,02464
Customer Service			20	10%			2	0,00082
Planning			10	12%			1	0,00049
Purchasing			20	8%			2	0,00066
Design			15	12%			2	0,00074
Accounting			20	10%			2	0,00082
Total	**1.850**	**500**	**85**		**310**	**60**	**9**	

Table 70 presents total facilities costs of the company.

Table 70

Total Facilities Costs of the Company

Facility Costs	
Electricity	34.810 TL.
Gas	11.873 TL.
Security & Cleaning	2.710 TL.
Insurance	1.150 TL.
Depreciation	660 TL.
Maintenance & Repair	480 TL.
Total	**51.647 TL.**

Total facility costs of the company are 51.647 TL.

Total facilities costs of value stream are calculated in Table 71.

Table 71

Total Facilities Costs

	Cost Allocation Ratio	Total Facilities Cost
Mixing	0,009856	509
Extrusion	0,073922	3.818
Welding	0,041068	2.121
Control & Test	0,002464	127
Shipping	0,024641	1.273
Customer Service	0,000821	42
Planning	0,000493	26
Purchasing	0,000657	34
Design	0,000739	38
Accounting	0,000821	42
Total		**8.030**

Total facilities costs of value stream is calculated as 8.030 TL..

4.6.4.6. Other Costs

Other costs of value stream are workers transportation service, meal, communication and office supplies expenses. Service-meal expenses and communication-office supplies expenses are allocated according to different methods.

Total other expenses of value stream are presented in Table 72.

Table 72

Total Other Costs of the Company

Other Costs	
Service and Meal	7.810 TL.
Communication	1.198 TL.
Office Supplies	497 TL.
Total	**9.505 TL.**

Service and meal expenses are allocated according to the number of employees. Total number of employees is 200 persons in the company. Therefore, service and meal expense per employee is 39, 05 TL. (7.810 TL. / 200 employees).

Table 73 shows the calculation of service and meal expenses of value stream.

Table 73

Service and Meal Expenses of Value Stream

	Number of Employees per Shift	**Number of Shifts**	**Total Number of Employees**	**Total Service and Meal Expenses**	**Value Stream Usage Ratio**	**Service and Meal Expenses of Value Stream**
Mixing	5	1	5	195,25	12%	23,43
Extrusion	3	3	9	351,45	12%	42,17
Welding	6	1	6	234,30	100%	234,30
Control & Test	1	2	2	78,10	12%	9,37
Shipping	1	1	1	39,05	12%	4,69
Customer Service	2	1	2	78,10	10%	7,81
Planning	1	1	1	39,05	12%	4,69
Purchasing	2	1	2	78,10	8%	6,25
Design	1	1	1	39,05	12%	4,69
Accounting	2	1	2	78,10	10%	7,81
Total			31	1.210,55		**345,2**

Service and meal expenses are computed for every process of the company. Service and meal costs of value stream are calculated through multiplication of these expenses by value stream usage ratios. For example, welding process expense is 234, 30 TL. (39, 05 TL. * 6 employees). Mixing process cost of value stream is 234, 30 TL. (234, 30 * 100 %). Total service and meal expenses of value stream are 345, 2 TL..

Total expenses of communication and office supplies are 1.695 TL. (1.198 TL. + 497 TL.). Expenses of communication and office supplies are allocated according to 10% value stream ratio of purchasing, selling and employee transactions and number of employees. Communication and office supplies costs of value stream are 169, 5 TL. (1695 * 10 %). Cost per employee is 5, 46 TL. (169,5 / 31).

Communication and office supplies expenses of value stream are computed in Table 74.

Table 74

Communication and Office Supplies Expenses of Value Stream

	Number of Employees per Shift	Number of Shifts	Total Number of Employees	Communication and Office Supplies Expenses
Mixing	5	1	5	27,34
Extrusion	3	3	9	49,21
Welding	6	1	6	32,81
Control & Test	1	2	2	10,94
Shipping	1	1	1	5,47
Customer Service	2	1	2	10,94
Planning	1	1	1	5,47
Purchasing	2	1	2	10,94
Design	1	1	1	5,47
Accounting	2	1	2	10,94
Total			31	**169,50**

Communication and office supplies costs of value stream are calculated through multiplication of cost per employee by number of employees. For example, welding process expense is 32, 81 TL. (5, 46 TL. * 6 employees). Total service and meal expenses of value stream are 169, 5 TL..

Table 75 shows other costs of value stream.

Table 75

Total Other Costs

	Total Other Costs
Mixing	51
Extrusion	91
Welding	267
Control & Test	20
Shipping	10
Customer Service	19
Planning	10
Purchasing	17
Design	10
Accounting	19
Total	**514**

Total other costs of value stream are the sum of service-meal expenses and communication-office supplies expenses. Total other costs of value stream are calculated as 514 TL..

4.6.5. Value Stream Cost Statement

In "value stream costing analysis" section of research, all costs are calculated for every process of value stream. All future state value stream costs are material costs, outside costs, employee costs, machine costs, facility costs and other costs. Table 76 presents value stream costs. Total value stream costs are calculated as 128.934 TL..

Table 76

Value Stream Costs

Process Steps	Material Costs	Outside Costs	Employee Costs	Machine Costs	Facilities Costs	Other Costs	Total Cost
Mixing	69.741	0	846	6.291	509	51	77.438
Extrusion	0	0	1.830	20.131	3.818	91	25.870
Welding	21	0	9.531	10.000	2.121	267	21.940
Control & Test	0	0	381	0	127	20	528
Shipping	0	0	176	0	1.273	10	1.459
Customer Service	0	0	265	0	42	19	326
Planning	0	0	213	0	26	10	249
Purchasing	0	0	200	0	34	17	251
Design	0	150	318	0	38	10	516
Accounting	0	0	296	0	42	19	357
Total	**69.762**	**150**	**14.056**	**36.422**	**8.030**	**514**	**128.934**

Total material costs are 69.762 TL. (69.741 TL. + 21 TL.). All other costs except material costs are conversion costs of value stream. Conversion costs of value stream are computed as 59.172 TL. (150 TL. + 14.056 TL. + 36.422 TL. + 8.030 TL. + 514 TL.). The following equation is developed for calculation of conversion costs.

Conversion Costs = Total Value Stream Costs – Material Costs

Conversion Costs = 128.934 TL. – 69.762 TL = 59.172 TL.

Average material cost is calculated through dividing total material costs by the number of shipped product. Average material cost of value stream is 0,577 TL. (69.762 TL./ 120.856 units). Average conversion cost is computed through dividing total conversion costs by the number of shipped product. Average conversion cost of value stream is 0,489 TL. (59.172 TL./ 120.856 units).

Average unit cost is calculated through dividing total value stream costs by the number of shipped product. Average unit cost of value stream is 1,066 TL. (128.934 TL. / 120.856 units).

Table 77 shows value stream cost statement.

Table 77

Value Stream Cost Statement

Value Stream Cost	**Total**
Material Costs	69.762 TL.
Outside Process Cost	150 TL.
Employee Costs	14.056 TL.
Machine Costs	36.422 TL.
Facilities Costs	8.030 TL.
Other Costs	514 TL.
Total Cost	128.934 TL.
Conversion Cost	59.172 TL.
Customer Order Quantity	120.856 units
Average Material Cost	0,577 TL.
Average Conversion Cost	0,489 TL.
Average Cost per Unit	1,066 TL.

4.6.6. Value Stream Profit and Loss Statement

In order to measure the effect of improvement activities to the company, unit sales price assumed as the same value in current state. Total sales in value stream are calculated as 152.279 TL. (120.856 units * 1,26 TL.).

Value stream profit is computed through subtracting value stream costs from value stream sales. Value stream profit is 23.345 TL. (152.279 TL. – 128.934 TL.).

Return on sales (ROS) is computed through dividing value stream profit by total sales of value stream. ROS is 15, 33 % (23.345 TL. / 152.279 TL.) in the future state value stream.

Table 78 presents value stream profit and loss statement.

Table 78

Profit and Loss Statement of Value Stream

Sales	152.279 TL.
Material Costs	69.762 TL.
Employee Costs	14.056 TL.
Machine Costs	36.422 TL.
Outside Process Cost	150 TL.
Facilities Costs	8.030 TL.
Other Costs	514 TL.
Total Cost	128.934 TL.
Value Stream Profit	23.345 TL.
ROS	15,33 %

4.6.7. Inventory Valuation

In order to measure the effect of improvement activities to value stream inventory valuation, the beginning inventory is calculated according to reduction of inventory days in the future state value stream.

The beginning inventory value is assumed based on current state material and conversion costs per day. Days of stock valuation method is used and production lead time of future state value stream is 7 days.

The calculation of the beginning inventory is presented in Table 79.

Table 79

Beginning Inventory of Value Stream

	Total Cost	Number of Working Day	Cost per Day
Material Cost	70.105	30	2.337,00
Conversion Cost	68.788	30	2.293,00
Total	138.893		

	Purchased Materials	WIP	Finished Goods
Inventory Days	1	5	1
Material Cost	2.337	11.684	2.337
Conversion Cost	-	11.465	2.293
Inventory Value	2.337	23.149	4.630
	Total Inventory Value		**30.116**

The total material cost for the selected month in the current state value stream is 70.105 TL. and the working day in a month is 30 days. Thereby, the material cost per day is 2.337 TL. (70.105 TL. / 30 days). The total conversion cost is 68.788 TL and 2.293 TL. (68.788 TL./ 30 days) per day.

There is one inventory day for purchased materials, so the value of purchased material inventory is 2.337 TL. (1 days * 2.337 TL.). The value of 5 days (2, 5 days + 1, 5 days + 1 day) of WIP comes to 5 days of material cost and 5 days of conversion cost – assuming the WIP items are complete. So, material cost is 11.684 TL. (5 days * 2.337 TL.) and conversion cost is 11.465 TL. (5 days * 2.293 TL.). Total WIP inventory value is 23.149 TL. (11.684 TL. + 11.465 TL.). The value of finished goods inventory is 4.630 TL. [(1 day * 2.337 TL.) + (1 day * 2.293 TL.)]. Total beginning inventory of value stream is 30.116 TL. (2.337 TL. + 23.149 TL. + 4.630 TL.).

Ending inventory of selected month is calculated by days of stock valuation method. The calculation of value stream's ending inventory is shown in Table 80.

Table 80

Ending Inventory of Value Stream

	Total Cost	Number of Working Day	Cost per Day
Material Cost	69.762	30	2.325
Conversion Cost	59.172	30	1.972
Total	128.934		

	Purchased Materials	WIP	Finished Goods
Inventory Days	1	5	1
Material Cost	2.325	11.627	2.325
Conversion Cost	-	9.862	1.972
Inventory Value	2.325	21.489	4.297
	Total Inventory Value		**28.111**

The total material cost for the selected month in the future state value stream is 69.762 TL. and the working day in a month is 30 days. Thereby, the material cost per day is 2.325 TL. (69.762 TL. / 30 days). The total conversion cost is 59.172 TL and 1.972 TL. (59.172 TL./ 30 days) per day.

There is one inventory day for purchased materials, so the value of purchased material inventory is 2.325 TL. (1 day * 2.325 TL.). The value of 5 days of WIP comes to 5 days of material cost and 5 days of conversion cost – assuming the WIP items are complete. So, material cost is 11.627 TL. (5 days * 2.325 TL.) and conversion cost is 9.862 TL. (5 days * 1.972 TL.). Total WIP inventory value is 21.489 TL. (11.627 TL. + 9.862 TL.). The value of finished goods inventory is 4.297 TL. [(1 days * 2.325 TL.) + (1 days * 1.972 TL.)]. Total ending inventory is 28.111 TL. (2.325 TL. + 21.489 TL. + 4.297 TL.).

Table 81 indicates daily inventory costs of value stream.

Table 81

Daily Inventory Costs

	Total Inventory Cost	Number of Working Days	Daily Inventory Cost
Raw Material Cost	66.709	30	2.223,63
Supplementary Materials Cost	3.032	30	101,07
	21	30	0,70
Total Material Cost	69.762	30	2.325,40
Conversion Cost	59.172	30	1.972,40
Total Value Stream Cost	**128.934**		

Material costs are categorized as raw material cost and supplementary materials cost. Daily raw material cost, supplementary materials cost and conversion cost are computed as 2.223, 63 TL., 101, 77 TL. (101, 07 +0, 70) and 1.972,40 TL..

Table 82 shows WIP inventory cost and finished goods inventory cost of value stream processes.

Table 82

Inventory Costs of Value Stream Processes

	Material Cost	Conversion Cost	WIP Cost	Finished Goods Cost
Mixing	-	-	-	-
Extrusion	5.814	4.931	10.745	-
Welding	3.488	2.959	6.447	-
Control & Test	2.325	1.972	4.297	-
Shipping	2.325	1.972	-	4.297
Total	**13.952**	**11.834**	**21.489**	**4.297**

Costs of WIP inventory involve inventory cost between mixing and control-test processes. Total cost of WIP inventory is calculated as 21.489 TL. (10.745 TL. + 6.447 TL. + 4.297 TL.). For example, materials inventory cost of extrusion process is 5.814 TL. (2,5 days * 2.325 TL.), conversion cost is computed as 4.931 TL. (2,5 days * 1.972 TL.). The sum of material and conversion costs gives cost of WIP inventory in extrusion process as 10.745 TL. (5.814 TL. + 4.931 TL.). Inventory cost between control-test and shipping process presents finished goods inventory cost. Total cost of finished goods inventory is computed as 4.297 TL..

Table 83 displays costs of ending inventory in the value stream.

Table 83

Cost of Ending Inventory

	Stock Days	Cost of Raw Material Inventory	Cost of Supplementary Materials	Cost of WIP Inventory	Cost of Finished Goods Inventory	Cost of Ending Inventory
Mixing	1	2.223	101	-	-	2.324
Extrusion	2,5	-	-	10.745	-	10.745
Welding	1,5	-	1	6.447	-	6.448
Control&Test	1	-	-	4.297	-	4.297
Shipping	1	-	-	-	4.297	4.297
Total	**7**	**2.223**	**102**	**21.489**	**4.297**	**28.111**

Total cost of ending inventory is calculated as 28.111 TL. (2.324 TL. + 10.745 TL. + 6.448 TL. + 4.297 TL. + 4.297 TL.).

Figure 82 shows the chart for cost of ending inventory. Cost of raw material, supplementary materials, WIP and finished goods inventory are calculated as 2.223 TL., 102 TL., 21.489 TL. and 4.297 TL..

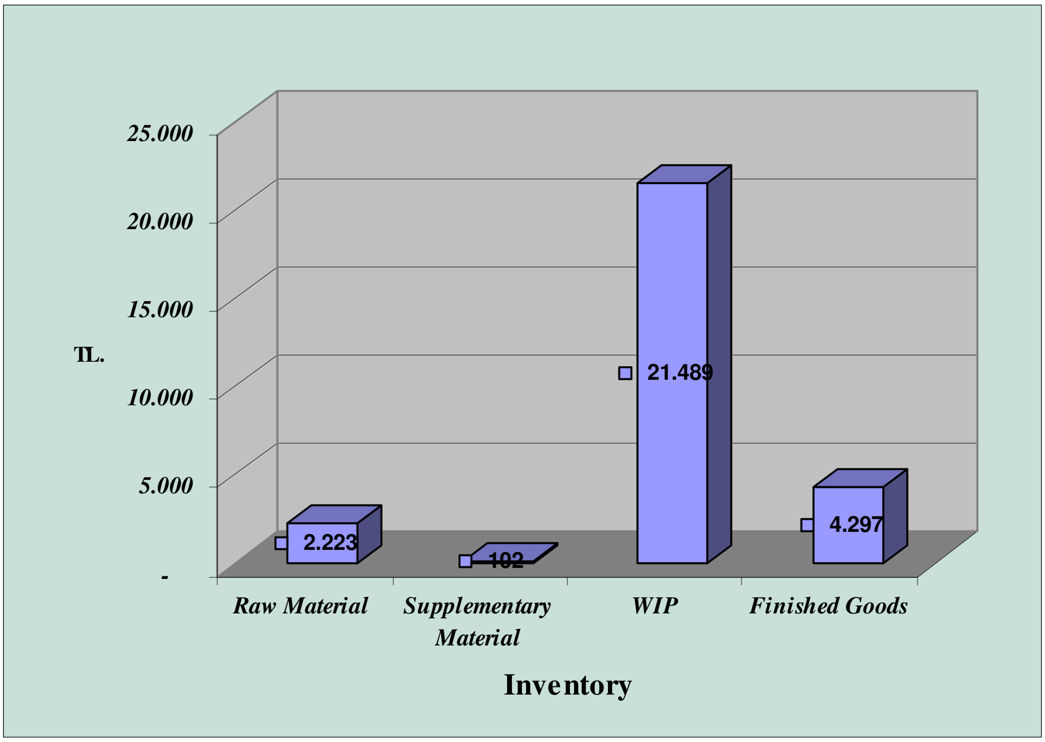

Figure 82: The Chart for Cost of Ending Inventory

4.6.8. Net Profit According to GAAP

Value stream profit is identified through cash-basis approach. However, it must be converted to reach net profit according to GAAP. Cash-basis value stream profit must be adjusted for the changes inventory balances to arrive at GAAP.

Table 84 shows the calculation of net profit according to GAAP.

Table 84

Net Profit According to GAAP

Value Stream Profit		23.345
Opening Inventory	30.116	
Less: Closing Inventory	28.111	
Inventory Change	(2.005)	(2.005)
GAAP Net Profit		**21.340**

GAAP net profit is calculated as 21.340 TL. through subtracting inventory change from value stream profit (23.345 TL. – 2.005 TL.).

4.6.9. Cost of Goods Sold According to GAAP

Value stream costs must be adjusted to reach cost of goods sold according to GAAP.

Table 85 displays the calculation of cost of goods sold according to GAAP.

Table 85

Cost of Goods Sold According to GAAP

Beginning Inventory	30.116
Value Stream Costs	128.934
Subtotal	159.050
Less: Ending Inventory	(28.111)
GAAP Cost of Goods Sold	**130.939**

In order to obtain GAAP cost of goods sold, ending inventory is subtracted from the sum of beginning inventory and value stream costs. GAAP cost of goods sold is computed as 130.939 TL. (159.050 TL. – 28.111 TL.).

4.6.10. Bookkeeping Entry of Value Stream Costs

Bookkeeping entries of value stream costs are developed according to the system known as dual entry bookkeeping.

Material cost, employee cost, overhead costs, sales and cost of goods sold of value stream are identified as 69.762 TL., 14.056 TL., 45.116 TL., 152.279 TL. and 130.939 TL.. Also, value added tax rate is assumed as 18%.

The entries of journal are as follows:

1--/--			
150 RAW MATERIALS		69.762	
191 DEDUCTABLE VAT		12.557	
320 SUPPLIERS			82.319
Purchasing materials			
2--/--			
710 DIRECT RAW MATERIAL COST		69.762	
150 RAW MATERIAL			69.762
Spending materials transfer to the production cost			
3--/--			
151 WORK IN PROCESS		69.762	
151.01.001.001 Mixing Process of Gasket Product Group “A” Value Stream	69.741		
151.01.003.001 Welding Process of Gasket Product Group “A” Value Stream	21		
711 DIRECT RAW MATERIAL APPLIED			69.762
Transferring the direct material cost to the work in process account			
4--/--			
720 DIRECT LABOR COST		14.056	
360 TAXES PAYABLE			2.530
361 SOCIAL SECURITY DUTIES PAYABLE			1.986
100 CASH			9.540
Paying the direct labor cost			
---/--			

5---/---

151 WORK IN PROCESS		14.056
151.01.001.002 Mixing Process of Gasket Product Group “A” Value Stream	846	
151.01.002.002 Extrusion Process of Gasket Product Group “A” Value Stream	1.830	
151.01.003.002 Welding Process of Gasket Product Group “A” Value Stream	9.531	
151.01.004.002 Control&Test Process of Gasket Product Group “A” Value Stream	381	
151.01.005.002 Shipping Process of Gasket Product Group “A” Value Stream	176	
151.01.006.002 Customer Service Process of Gasket Product Group “A” Value Stream	265	
151.01.007.002 Planning Process of Gasket Product Group “A” Value Stream	213	
151.01.008.002 Purchasing Process of Gasket Product Group “A” Value Stream	200	
151.01.009.002 Design Process of Gasket Product Group “A” Value Stream	318	
151.01.010.002 Accounting Process of Gasket Product Group “A” Value Stream	296	
721 DIRECT LABOR COST APPLIED		14.056

Transferring the direct labor cost to the work in process

6---/---

730 OVERHEAD COSTS	45.116	
191 DEDUCTABLE VAT	4.060	
100 CASH		49.176

Paying of the direct labor cost

--/---

7--/--

151 WORK IN PROCESS 45.116

151.01.001.003 Mixing Process of Gasket Product Group “A” Value Stream 6.851

151.01.002.003 Extrusion Process of Gasket Product Group “A” Value Stream 24.040

151.01.003.003 Welding Process of Gasket Product Group “A” Value Stream 12.388

151.01.004.003 Control&Test Process of Gasket Product Group “A” Value Stream 147

151.01.005.003 Shipping Process of Gasket Product Group “A” Value Stream 1.283

151.01.006.003 Customer Service Process of Gasket Product Group “A” Value Stream 61

151.01.007.003 Planning Process of Gasket Product Group “A” Value Stream 36

151.01.008.003 Purchasing Process of Gasket Product Group “A” Value Stream 51

151.01.009.003 Design Process of Gasket Product Group “A” Value Stream 198

151.01.010.003 Accounting Process of Gasket Product Group “A” Value Stream 59

731 OVERHEAD COSTS APPLIED 45.116

Transferring the overhead costs to the work in process account

8--/--

711 DIRECT RAW MATERIAL APPLIED 69.762

721 DIRECT LABOR COST APPLIED 14.056

731 OVERHEAD COSTS APPLIED 45.116

710 DIRECT RAW MATERIAL COST 69.762

720 DIRECT LABOR COST 14.056

730 OVERHEAD COSTS 45.116

Closing the applied accounts

---/--

9---/---

152 FINISHED GOODS	128.934
152.01 Gasket Product Group “A” Value Stream	
151 WORK IN PROCESS	128.934
151.01.001.001 Mixing Process of Gasket Product Group “A” Value Stream	69.741
151.01.003.001 Welding Process of Gasket Product Group “A” Value Stream	21
151.01.001.002 Mixing Process of Gasket Product Group “A” Value Stream	846
151.01.002.002 Extrusion Process of Gasket Product Group “A” Value Stream	1.830
151.01.003.002 Welding Process of Gasket Product Group “A” Value Stream	9.531
151.01.004.002 Control&Test Process of Gasket Product Group “A” Value Stream	381
151.01.005.002 Shipping Process of Gasket Product Group “A” Value Stream	176
151.01.006.002 Customer Service Process of Gasket Product Group “A” Value Stream	265
151.01.007.002 Planning Process of Gasket Product Group “A” Value Stream	213
151.01.008.002 Purchasing Process of Gasket Product Group “A” Value Stream	200
151.01.009.002 Design Process of Gasket Product Group “A” Value Stream	318
151.01.010.002 Accounting Process of Gasket Product Group “A” Value Stream	296
151.01.001.003 Mixing Process of Gasket Product Group “A” Value Stream	6.851
151.01.002.003 Extrusion Process of Gasket Product Group “A” Value Stream	24.040
151.01.003.003 Welding Process of Gasket Product Group “A” Value Stream	12.388
151.01.004.003 Control&Test Process of Gasket Product Group “A” Value Stream	147
151.01.005.003 Shipping Process of Gasket Product Group “A” Value Stream	1.283
151.01.006.003 Customer Service Process of Gasket Product Group “A” Value Stream	61
151.01.007.003 Planning Process of Gasket Product Group “A” Value Stream	36
151.01.008.003 Purchasing Process of Gasket Product Group “A” Value Stream	51
151.01.009.003 Design Process of Gasket Product Group “A” Value Stream	198
151.01.010.003 Accounting Process of Gasket Product Group “A” Value Stream	61

Transferring the finished goods to the stock account

---/---

10--/--

120 CUSTOMERS 179.689

600 DOMESTIC SALES 152.279

391 VAT RECEIVED 27.410

The entry of the sales

11--/--

620 COST OF GOODS SOLD 130.939

152 FINISHED GOODS 130.939

152.01 Gasket Product Group "A" Value Stream

Transferring the finished goods to cost of goods sold after selling

--/--

4.6.11. Value Stream Box Score

Value stream box score is monthly report of value stream performance. Also, it has three major sections; measuring operational performance, capacity usage and financial performance.

Table 86 displays the future state value stream box score.

Table 86

Value Stream Box Score

Company	**ABC Manufacturing Company**	
Location	**Istanbul**	
Value Stream	**Gasket**	
Type	**Group A**	
OPERATIONAL	**Units per Person**	**13.671,49 units**
	On-Time Shipment	**100%**
	First Time Through	**99%**
	Dock-to-Dock Days	**7 days**
	Average Cost	**1,006 TL.**
CAPACITY	**Productive**	**74%**
	Non-Productive	**5%**
	Available Capacity	**21%**
FINANCIAL	**Revenue**	**152.279 TL.**
	Material Costs	**69.762 TL.**
	Conversion Costs	**59.172 TL.**
	Value Stream Profit	**23.345 TL.**
	Value Stream ROS	**15,33%**

4.6.11.1. Operational Data of Value Stream Box Score

Operational performance measurements in the value stream consist of units per person, on-time shipment, first time through, dock-to-dock days and average cost.

4.6.11.1.1. Units per Person

Units per person are calculated through dividing total sales by the total number of employee in the value stream. Table 87 shows the number of employees in the value stream.

Table 87

Number of Employees in the Value Stream

Process	Total Number of Employees	Ratio of Value Stream Usage	Number of Employees in the Value Stream
Mixing	5	12%	0,60
Extrusion	9	12%	1,08
Welding	6	100%	6,00
Control & Test	2	12%	0,24
Shipping	1	12%	0,12
Customer Service	2	10%	0,20
Planning	1	12%	0,12
Purchasing	2	8%	0,16
Design	1	12%	0,12
Accounting	2	10%	0,20
Total	**31**		**8,84**

The sales of selected month are 120.856 units. Therefore, the equation of unit per person in the value stream is as follows:

Units per Person = 120.856 units / 8, 84 persons = 13.671,49 units

4.6.11.1.2. On-Time Shipment

Value stream processes are operated effective to meet customer requirements and on-time shipment is computed at 100 % level.

4.6.11.1.3. First Time Through

The leakage of the extrusion process is at 1, 5 % level in accordance with the feature of production. Therefore, the amount of leakage products is 1.948, 29 units (129.886 * 1, 5 %). In equation form, first time through of extrusion process is expressed as;

FTT of Extrusion Process = (129.886 – 1.948, 29) / 129.886 = % 98, 5

There is no leakage in other processes of value stream, so first time through is at 100 % level. The equation of FTT of value stream is as follows;

FTT = 100 % * 98, 5 % * 100 % * 100 % = %98, 5

4.6.11.1.4. Dock-to-Dock Days

Dock-to-dock days are the production lead time of the future state value stream. Accordingly, dock-to-dock days are 7 days as displayed in the value stream map.

4.6.11.1.5. Average Cost

Average cost is computed through dividing total value stream costs by the amount of units delivered. In equation form, average cost of value stream is expressed as;

Average Cost = 128.934 TL. / 120.856 units = 1,066 TL.

4.6.11.2. Capacity Data of Value Stream Box Score

In the capacity analysis of the value stream, the capacity of employees and machines is identified.

Table 88 shows the percentages of employee capacity analysis as productive, non-productive and available capacity. The data is gathered from future state capacity analysis of value stream.

Figure 83 displays the chart of the employees' capacity usage in the value stream.

Table 88

Employee Capacity Analysis

	Productive	Non-Productive	Available
Mixing	66,7%	0,3%	33%
Extrusion	88%	1%	11%
Welding	70%	7%	23%
Control & Test	0%	56%	44%
Shipping	74%	0%	26%
Customer Service	0%	72%	28%
Planning	0%	78%	22%
Purchasing	31%	30%	39%
Design	0%	64%	36%
Accounting	0%	65%	35%

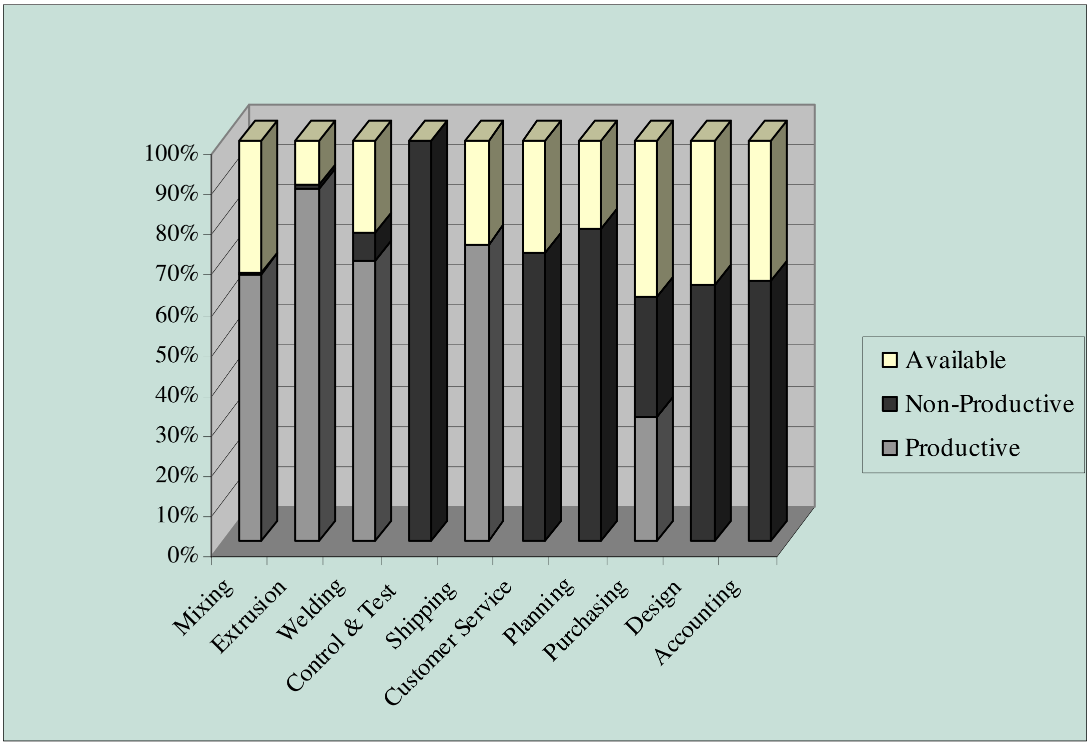

Figure 83: The Chart of the Employees' Capacity Usage

Table 89 shows the percentages of machine capacity analysis. In Figure 84, the chart of the machines' capacity usage is drawn.

Table 89

Machine Capacity Analysis

	Productive	Non-Productive	Available
Mixing	92%	3%	5%
Extrusion	93%	2%	5%
Welding	37%	3%	60%
Control & Test	0%	0%	0%
Shipping	0%	0%	0%
Customer Service	0%	0%	0%
Planning	0%	0%	0%
Purchasing	0%	0%	0%
Design	0%	0%	0%
Accounting	0%	0%	0%

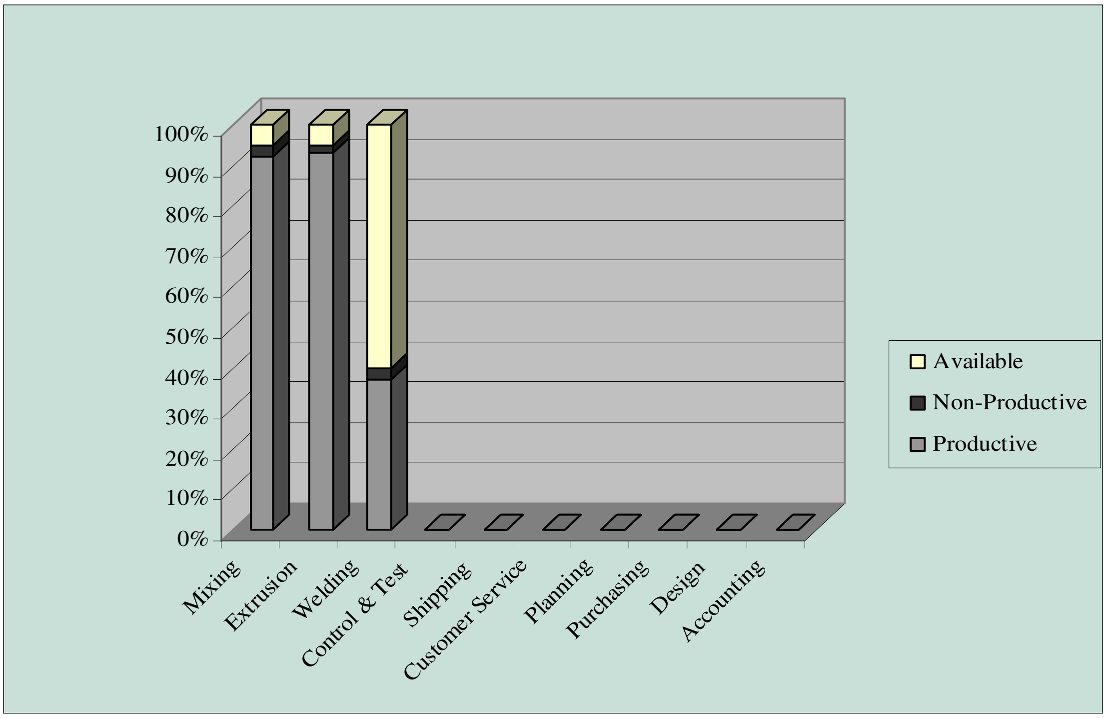

Figure 84: The Chart of the Machines' Capacity Usage

Table 90 indicates available capacity of value stream. In Figure 85, the chart of the available capacity is displayed.

Table 90

Available Capacity of Value Stream

	Employee	Machine
Mixing	33%	5%
Extrusion	11%	5%
Welding	23%	60%
Control & Test	44%	0%
Shipping	26%	0%
Customer Service	28%	0%
Planning	22%	0%
Purchasing	39%	0%
Design	36%	0%
Accounting	35%	0%

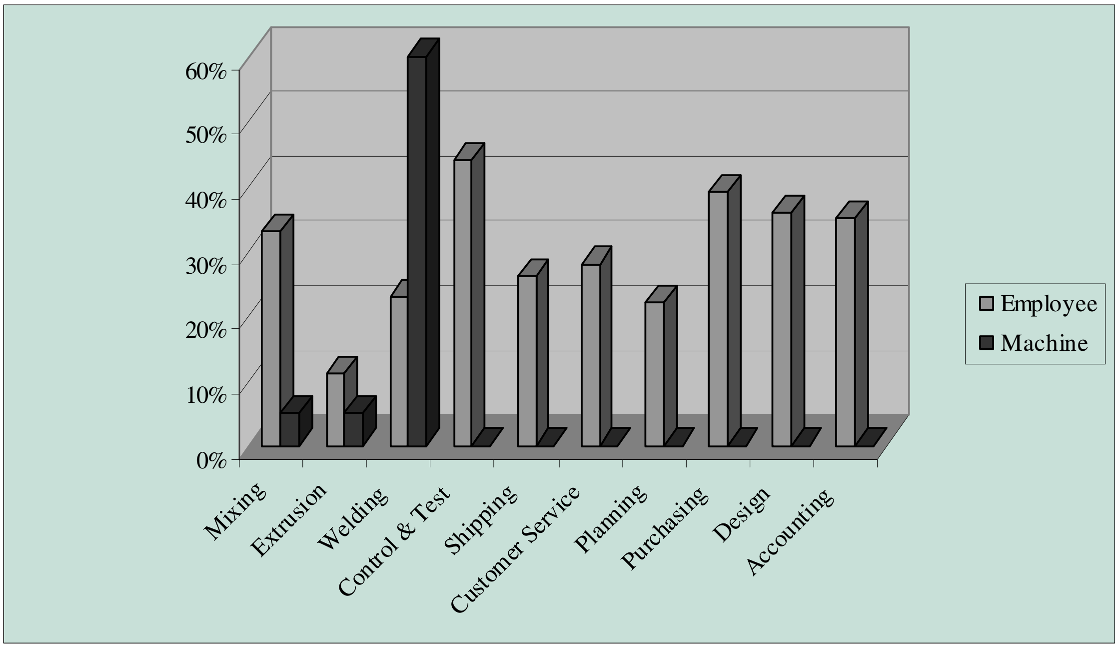

Figure 85: The Chart of the Available Capacity

In order to computing capacity data of value stream, capacity percentages are associated with the costs of value stream. In Table 91, employee capacity percentages and employee costs are shown.

Table 91

Employee Costs and Capacity Percentages

	Employee Cost	Productive	Non-Productive	Available
Mixing	846	66,70%	0,30%	33%
Extrusion	1.830	88%	1%	11%
Welding	9.531	70%	7%	23,00%
Control & Test	381	0%	56%	44%
Shipping	176	74%	0%	26%
Customer Service	265	0%	72%	28%
Planning	213	0%	78%	22%
Purchasing	200	31%	30%	39%
Design	318	0%	64%	36%
Accounting	296	0%	65%	35%
Total	**14.056**	**64%**	**12%**	**24%**

Employee capacity performance is used to assess employee costs of processes with respect to productive, non-productive and available.

Table 92 displays employee costs of processes, calculated according to capacity usage. Total productive, non-productive and available employee costs are calculated as 9.039 TL., 1.714 TL. and 3.303 TL. For example, productive employee cost of mixing process is 564 TL. (846 TL. * 66, 7 %), non-productive employee cost is 3 TL. (846 TL. * 0, 3 %) and available employee costs is 279 TL. (846 TL. * 33%). In Table 55, these calculations are generated for all processes of value stream.

Table 92

Employee Costs According to Capacity Usage

	Employee Cost	Productive	Non-Productive	Available
Mixing	846	564	3	279
Extrusion	1.830	1.611	18	201
Welding	9.531	6.672	667	2.192
Control & Test	381	0	213	168
Shipping	176	130	-	46
Customer Service	265	0	191	74
Planning	213	0	166	47
Purchasing	200	62	60	78
Design	318	0	204	114
Accounting	296	0	192	104
Total	**14.056**	**9.039**	**1.714**	**3.303**

In Table 93, machine capacity percentages and employee costs are shown.

Table 93

Machine Costs and Capacity Percentages

	Machine Cost	Productive	Non-Productive	Available
Mixing	6.291	92%	3%	5%
Extrusion	20.131	93%	2%	5%
Welding	10.000	37%	3%	60%
Control & Test	0	0	0	0
Shipping	0	0	0	0
Customer Service	0	0	0	0
Planning	0	0	0	0
Purchasing	0	0	0	0
Design	0	0	0	0
Accounting	0	0	0	0
Total	**36.422**	**78%**	**2%**	**20%**

Table 94 displays machine costs of processes, calculated according to capacity usage.

Table 94

Machine Costs According to Capacity Usage

	Machine Cost	Productive	Non-Productive	Available
Mixing	6.291	5.788	189	314
Extrusion	20.131	18.722	402	1.007
Welding	10.000	3.700	300	6.000
Control & Test	0	0	0	0
Shipping	0	0	0	0
Customer Service	0	0	0	0
Planning	0	0	0	0
Purchasing	0	0	0	0
Design	0	0	0	0
Accounting	0	0	0	0
Total	**36.422**	**28.210**	**891**	**7.321**

Total productive, non-productive and available machine costs are computed as 28.210 TL., 891 TL. and 7.321 TL. For example, productive machine cost of mixing process is 5.788 TL. (6.291 TL. * 92%), non-productive employee cost is 189 TL. (6.291 TL. * 3%) and available employee costs is 314 TL. (6.291 TL. * 5 %). In Table 94, these calculations are generated for all processes of value stream.

As a result of these computations, the capacity data of value stream box score is identified. Productive capacity data is determined through dividing the sum of productive employee and machine costs by total employee and machine costs. The sum of productive employee and machine costs is 37.249 TL. (9.039 TL. + 28.210 TL.) and total employee and machine costs is 50.478 TL.. Therefore, productive capacity ratio is calculated as 74% (37.249 / 50.478).

The same method is used for computing non-productive and available capacity ratios. Non-productive and available capacity ratios of value stream box score is computed as 5% (2.605 / 50.478) and 21% (10.624 / 50.478).

Table 95 shows capacity dimension of value stream box score.

Table 95

Capacity Data of Value Stream Box Score

	Cost	Ratio
Productive	37.249	**74%**
Non-Productive	2.605	**5%**
Available	10.624	**21%**
Total	50.478	**100%**

4.6.11.3. Financial Data of Value Stream Box Score

Financial data of value stream box score consists of revenue, material cost, conversion cost, value stream profit and value stream ROS. The financial information is identified in “value stream costing analysis”, “value stream cost statement” and “value stream profit and loss statement” sections of research.

In Table 96, financial information of value stream box score is displayed.

Table 96

Financial Data of Value Stream Box Score

FINANCIAL	**Revenue**	**152.279 TL.**
	Material Cost	**69.762 TL.**
	Conversion Cost	**59.172 TL.**
	Value Stream Profit	**23.345 TL.**
	Value Stream ROS	**15,33%**

The revenue from sales, material costs, conversion costs, value stream profit and value stream ROS are calculated as 152.279 TL., 69.762 TL., 59.172 TL., 23.345 TL. and 15, 33%.

4.7. Research Results

The ABC Manufacturing Company is a traditional manufacturing company which has manufactured plastic based products and tracks the costs in a traditional way. Initially, the lean environment is generated in the company. Then, the value stream is identified through the usage of value stream production flow matrix.

This study analyses the current and future state of value stream. The time interval for research is one month in the current and future state of value stream. In current and future state of selected value stream, the following lean initiative is performed; the determination of cell flow of the value stream. Therefore, the processes of value stream are classified as; mixing, extrusion, welding, control-test, shipping, customer service, planning, purchasing, design and accounting. The value stream map is designed and includes the information of capacity, the number of employee and machines in the process and inventory days between processes. The value stream employee and machine capacity is analyzed for every process of value stream and productive, non-productive and available capacities are defined. Value stream costing analysis is generated for every process of value stream and the profit of value stream is computed. Inventory valuation of value stream is performed according to days of stock valuation method. The calculation of net profit and cost of goods sold according to GAAP and bookkeeping entry of value stream costs are displayed. Finally, the data of value stream box score is calculated as the measure of operational, capacity and financial performance.

The implementation of lean initiatives causes constructive developments in value stream costs, capacity usage and profitability. The following changes and improvements activities are assumed in the future state of the value stream;

- C / O time of some processes is reduced through rearrangement of cell.
- The leakage of extrusion process is reduced from 2 % to 1, 5 % through quality improvement activities.

- Administrative activities are declined by generating the supermarket in front of processes.

- Maintenance time is reduced as a result of improvement activities and trainings to maintenance personnel.

- Arrangements with suppliers are renegotiated and the key suppliers made the deliveries directly to the supermarket, in front of mixing process according to kanban orders from the process. Therefore, the activity of moving material in or out of process is eliminated.

- The preparation times of machines are declined through the rearrangements in the cell.

- New welding mode is developed by design department inside the company and the production is outsourced to an outside mold manufacturing company. The new welding mold has 12 holes. Therefore, C / T of welding process is reduced. As a result of the increase in available capacity through this improvement activity, the company decides to reduce production shift of process from two shifts to one shift. Consequently, the number of employees in the process is decreased from 12 to 6.

- C / T of shipping process is reduced through generating the supermarket in front of shipping process and implementing kanban system in the value stream.

- The number of daily customer call is reduced from 10 calls to 6 calls through improvement of customer service and quality.

- The kanban system is replaced with material requirements planning system and daily planning time is reduced.

- Master purchase agreements and certifications are made with key suppliers. Therefore, the number of suppliers of the company is reduced through arrangements with certified suppliers.

The comparison of employee and machine available capacity is presented in Table 97 for current and future state of value stream. The available capacity of value stream is increased through lean initiatives in future state value stream. As a result of reducing shift from two to one in welding process by improvement activities, future state machine available capacity is decreased. However, excess capacity in welding process is still high.

Table 97

Comparison of Employee and Machine Available Capacity For Current and Future State of Value Stream

	Current State Employee	Future State Employee	Current State Machine	Future State Machine
Mixing	30%	33%	2%	5%
Extrusion	11%	11%	3%	5%
Welding	3%	23,0%	73%	60%
Control & Test	44%	44%	0%	0%
Shipping	7%	26%	0%	0%
Customer Service	6%	28%	0%	0%
Planning	4%	22%	0%	0%
Purchasing	5%	39%	0%	0%
Design	36%	36%	0%	0%
Accounting	21%	35%	0%	0%

The Comparison of Value Stream Box Score is displayed in Table 98. Improvements in operational, capacity and financial performance are identified from current state to future state in the value stream.

Table 98

Comparison of Value Stream Box Score

Company	**ABC Manufacturing Company**		
Location	**Istanbul**		
Value Stream	**Gasket**		
Type	**Group A**	**Current State**	**Future State**
OPERATIONAL	**Units per Person**	**8.143, 94 units**	**13.671, 49 units**
	On-Time Shipment	**100%**	**100%**
	First Time Through	**98%**	**99%**
	Dock-to-Dock Days	**24, 5 days**	**7 days**
	Average Cost	**1, 15 TL.**	**1, 066 TL.**
CAPACITY	**Productive**	**78%**	**74%**
	Non-Productive	**6%**	**5%**
	Available Capacity	**16%**	**21%**
FINANCIAL	**Revenue**	**152.279 TL.**	**152.279 TL.**
	Material Costs	**70.105 TL.**	**69.762 TL.**
	Conversion Costs	**68.788 TL.**	**59.172 TL.**
	Value Stream Profit	**13.386 TL.**	**23.345 TL.**
	Value Stream ROS	**8,79%**	**15,33%**

The operational performance measurements are units per person, on-time shipment, first time through, dock-to-dock days and average cost. Units per person are increased from 8.143,94 units to 13.671,49 units. The reason of increase in units per person is the reduction of the number of employees. On-time shipment remains at the same level for future state of the value stream. As a result of decreasing the leakage ratio, first time through is increased from 98 % to 99 %. The usage of kanban system, supermarkets in front of processes and agreements with certified suppliers provide the reduction in dock-to-dock days from 24, 5 days to 7 days. Average cost per unit is declined to 1,066 TL. based on overall reduction in value stream costs from current to future state.

The capacity performance measurements are productive, non-productive and available capacity. As a result of shift reduction in welding process, productive capacity is decreased from 78 % to 74 %. Various improvement activities are generated in the future value stream and non-productive capacity is reduced to 5 % in the future state. Therefore, the available capacity increased to 21 % according to reductions in productive and non-productive capacity of value stream.

The financial performance measurements are revenue, material costs, conversion costs, value stream profit and return on sales. In order to measure the impact of lean improvements to the company, value stream revenue assumed at the same level in the future state. When current and future state of value stream are compared with each other, material costs and conversion costs are declined and profit of value stream rises due to lean initiatives. Therefore, the return on sales in the future state increases from 8, 79 % to 15, 33 %.

5. CONCLUSION

The manufacturing industry went through an essential change in production methods over the past years. Organizations made changes in their production processes in order to decrease cost, improve quality, increase innovation and make more timely deliveries. Lean manufacturing is one of the major developments in manufacturing sector. The benefits of lean manufacturing have been discussed by many practitioners such as Taiichi Ohno, James Womack, Daniel T. Jones and Daniel Ross. Lean manufacturing principles are closely interrelated with financial performance.

The overall purpose for this dissertation is to explore the effects of relationship between lean manufacturing principles and managerial accounting methods and the perceived impact it has on organizational, capacity and financial performance in terms of quality, cost, profit, customer service and lead time, in manufacturing sector. The case study tests this effect.

Basic lean improvements are identified in the dissertation such as; just-in time production, autonomation, continuous improvement, 5 S, mistake proof system and visual control system. In order to generate these improvements in the lean company, some of the following supportive activities are made;

- Rearrangements in the cell,
- Establishment of the supermarkets in front of the value stream processes,
- Training the shop floor personnel,
- Arrangements with key suppliers to make deliveries to the supermarkets,
- Improving customer service and quality,
- Making master purchase agreements and certification with key suppliers.

The direct link between lean practice implementation and financial performance is demonstrated in this study.

The improvement activities reduce the production time and therefore decrease production costs. Through the lean initiatives, the company is able to identify wastes that occurred in the company. Once determined, waste can be removed from value stream through continual improvement activities including the development of the production processes. The company deals with eliminating waste in inventory and transaction time which causes lower total cycle time and this will assure the opportunity of quick customer service, more flexibility and additional excess capacity to invest new products in the lean manufacturing company. The decreased cycle time provides lower lead time in the company. Consequently, lean principle determines waste in terms of lead time, deals with low inventory levels and hundred percent on-time customer deliveries. Also, the cycle time plays an essential role as a measure of lean financial performance and reduction in cycle time generates more revenue which will identified in the financial statements of value stream.

The product cost is used to present the performance measure of accounting system in lean manufacturing company. The major percentage of product costs is overhead costs in today's manufacturing environment. The allocation of overhead costs is decreased in value stream of the product family. This overhead allocation has to be related with lean production principles. Since all costs are charged directly to the value stream, there is low allocation in the value stream. Any continuous improvement activity causes to change the value stream cost and eventually it affects the product cost.

The lean management accounting alternative presents properly data about all the manufacturing processes and activities. Therefore, this supports the decisions that provide better operational, capacity and financial performance in the short term as well as in the long term. The purpose of lean management accounting is to provide more adequate and relevant information to support managerial staff for better business decisions.

These lean initiatives lead the improvement in operational, capacity and financial performance of the value stream. The costs of value stream decrease and the productivity of the value stream increases in the future state of value stream. The value stream costing uses the non-financial measures too as one of the performance measures to display the consequences of lean improvements. In addition, traditional costing includes only financial measures to make any business decision and in many situations this causes bad business decisions.

Improvement activities in the future state free up more employee and time in the value stream and provide opportunity to enhance products without increasing production or product price. The further recommendations could be made to the lean company after these improvements without increasing expenses;

- Manufacture new products,
- Make new investments,
- Sell excess capacity,
- Layoff excess employee capacity or deploy them to other value streams.

This study could be expanded for all value streams of the company. Further research is needed to investigate the reasons for companies adopting lean production practices. This study raises other potential researches.

Finally, this dissertation also expands the opportunity for researchers to examine additional industries. The goal of such research can be to determine if lean has a similar impact on the financial performance of service companies as the impact it has on manufacturing firms.

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