**ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY**

# LEAN MANUFACTURING PHILOSOPHY AND THE VISION OF THE TURKISH SHIPYARDS

**M.Sc. THESIS**

**Can ARIKAN**

**Department of Naval Architecture and Marine Engineering**

**Naval Architecture and Marine Engineering Programme**

**JULY 2013**

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**Thesis Advisor: Prof. Dr. Mustafa INSEL**

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**İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ**

# YALIN ÜRETİM FİLOZOFİSİ VE TÜRK TERSANELERİNİN VİZYONU

**YÜKSEK LİSANS TEZİ**

**Can ARIKAN**
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**Gemi İnşaatı ve Gemi Makinaları Mühendisliği Ana Bilim Dalı**

**Gemi İnşaatı ve Gemi Makinaları Mühendisliği Programı**

**Tez Danışmanı: Prof. Dr. Mustafa İNSEL**

**TEMMUZ 2013**

**Can ARIKAN**, a **Mr.Sc.** student of ITU **Graduate School of Science Engineering and Technology** student ID **508091011**, successfully defended the **thesis** entitled "**LEAN MANUFACTURING PHILOSOPHY AND THE VISION OF THE TURKISH SHIPYARDS**", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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**Jury Members : Assistant Prof. Nermin TEKOGUL** .....
Piri Reis University

**Date of Submission : 03 May 2013**
**Date of Defense : 06 June 2013**

***To my mother and father,***

## FOREWORD

Firstly, I would like to thank to my supervisor Prof. Dr. Mustafa Insel for his guidance throughout this project and for his understanding and for his patience.

I would like to thank to my family that they have always supported me throughout my life without any expectations.

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MAY 2013

Can ARIKAN
(Junior Engineer)

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## SUMMARY

Nowadays, conventional trade has been collapsed due to the diversity of goods and products and due to the huge number of firms that cause redoubtable competition between these firms. As a result of it new methods have been risen to lower the production costs.

At this point, lean manufacturing is one of the crucial methods to help the firms to compete to the rivals. In this study, lean philosophy and lean manufacturing techniques and the vision of Turkish Shipyards to lean manufacturing have been subjected.

The literature review part consists of historical background of lean philosophy and lean manufacturing. The selected studies about lean are also presented in this study. These methods are; 5S system and continuous improvement, visual controls, cellular manufacturing, total productive maintenance, just-in-time, standardization of work, single-minute exchange of die, value stream mapping, production smoothing, kaizen blitz.

In this study also 6 sigma has been introduced. The reason of informing 6 sigma is in conclusion part there is a prediction section that combines lean and 6 sigma. 6 sigma targets to minimize the failure in manufacturing and lean targets the defects in manufacturing. So it is obvious that these two philosophy support each other.

This study focused on lean manufacturing principles, lean manufacturing tools and techniques. The part that makes this study individual is Turkish Shipyards. Information and data have been given about Turkish Shipyards and their role world shipyard marketing. Three Turkish Shipyards, which are Girgin Kale Shipyard, Kocatepe Shipyard and Besiktas Shipyard, have been visited and photos have been taken from these shipyards. Furthermore, a shortly interview has been made in each shipyards. According to these data and images, the existence of lean manufacturing in Turkish Shipyards has been interrogated.

The crucial and making the study more worthy is implementation part. Beside these three shipyards, another shipyard has been investigated deeply and recommendations (one of the method for implementing lean philosophy into companies) while applying 5S have been presented. Furthermore, while appliyng 5S into the shipyard the importance of determination and discipline of authorities have been advised. Of course, this has been done just in theory for some plausible reasons which are explained in relevant chapter 8.

In conclusion it has been emphasized that the best way to challenge with competitiveness between the companies will be LEAN SIX SIGMA for every type of business in the future. Turkey has great potential in shipyard industry. To transform this potential energy to kinetic, it is obvious that Turkish Shipyards should

understand the lean philosophy and should implement it to their shipyards by the help of the methods that is mentioned at chapter 3 lean manufacturing techniques and tools. I predict that the shipyards, which have accomplished the implementation of lean and start to use lean six sigma, will survive in Turkey.

**YALIN ÜRETİM FİLOZOFİSİ VE TÜRK TERSANELERİNİN VİZYONU**

## ÖZET

Günümüzde mal ve ürün çeşitliliğinin artması bununla birlikte aynı ürünü üreticiye arz edecek firma sayısının artmasından dolayı eski moda yapılan ticaret artık neredeyse uygulanamaz hale gelmiştir. Bu sebeplerden dolayı firmalar birbirleriyle rekabet edebilmek için, üretim maliyelerini azaltmak adına birçok iyileştirici yöntemler bulmak zorunda kalmışlardır.

Bu noktada yalın üretim felsefesi ve uygulamaları, birbirleriyle rekabet eden firmalar arasında üstünlük sağlama konusunda önemli bir rol oynamaya başlamıştır.

Üretim maliyetlerini azaltmak ve daha rekabetçi olabilmek için bu çalışmada yalın filozofisini, yalın üretim tekniklerini ve Türk Tersaneleri'nin yalın üretim ile ilgili mevcut vizyonları incelenmiştir.

Yalın üretimin başlıca çıkış sebebi, Japonlar tarafından Amerikalıların toplu üretim stratejisi ile rekabet edebilmek içindir. Bununla birlikte Türk tersanelerinin son yıllardaki üretim eğilimlerinden ve durumlarına değinilmiş ve alınan siparişlerin dolayısıylada üretilen gemi sayısında ciddi bir düşüş yaşandığından bahsedilmiştir. Yapılan araştırmalar sonucunda yalın üretim ve Türk tersaneleri ile ilgili yeterli sayıda bir çalışmanın olmadığı ve bu konuda bir çalışma yapılması sonucuna varılmıştır. Bu çalışmanın başlıca olarak 5 adet amacı vardır. İlki, yalın üretimi ve yalın üretim tekniklerini anlaşılır şekilde tanımlamaktır. İkinci olarak, yalın üretim ile beraber uygulandığı zaman çok daha etkili olabilecek 6 sigma teorisini tanımlamaktır. Çalışmanın bir diğer amacı, Türk Tersaneleri'nin yalın üretim ile ilgili bilgi birikim ve vizyonlarını ortaya koymaktır. Çalışmanın dördüncü amacı farklı tersanelerden alınan datalar sonucunda geleceğe yönelik Türk Tersaneleri ile ilgili varsayımda bulunmaktır. Çalışmanın son amacı ise; yalın üretim uygulama tekniklerinden birisi olan 5S yöntemini teorik olarak bir tersaneye nasıl adapte edilebileceğine dair önerilerde bulunmaktır.

1900'lerin başında Amerikalıların toplu üretim stratejisi uygulamasına rağmen aslında yalın üretim o adla olmasa da bu yöntemi ilk uygulayan Henry Ford'dur. Daha sonra Japonlar, başta Toyota (otomotiv sektöründe faaliyet göstermektedir) olmak üzere yalın üretimi teori haline getirmiş ve endüstri kollarında uygulamaya başlamışlardır. Bu teorinin ortaya çıkmasındaki amaç, Japonların Amerikalıların toplu üretim stratejisine karşı maliyetleri düşürülerek onlarla rekabet edebilecek hale gelip pazarda paylarını almaktı. Daha sonra bu teori dünya çapında yayılmış ve rakipleri arasında üstünlük sağlamak amacıyla üretim maliyetlerini düşürmek isteyen birçok firma tarafında kullanılmaya başlanmıştır.

Yalın üretim aslında adından da anlaşılabileceği gibi bir ürünü aynı kalitede hatta daha kaliteli üretirken eski yöntemlere göre daha az adam ile daha az sürede üretme felsefesine sahip bir iyileştirme yöntemidir. Bunu yaparken 5 adet ana ilke uygular. Birincisi, değerin (ürünün) tanımlanmasıdır. Yani ürünü müşterinin gözünde bakarak inceler, değerlendirir ve analizlerini bu bakış açısıyla yapar. İkinci olarak, değer

akışının iyi tanımlanmasıdır. Değer akışı ham maddenin nihai ürüne dönüşme sürecindeki bir üreticiden diğer üreticiye ve son kullanıcıya kadar olan tüm aşamaları içerir ve inanılmaz boyutlarda israf barındırır. Üçüncüsü, üretimin sürekli olarak devam edebilmesidir ki bunu yalın üretim kısaca sürekli akış olarak tanımlar. Sürekli akış sağlanırken kayıpların da minimize edilmesi yalı üretim felsefisinin ana amacıdır. Ancak akışın sağlanması yeterli değildir. İstenmeyen ürünleri hızla akıtmak sonuçta sadece israf olacaktır. Müşteriye istemediği ürünlerin itilmesi yerine müşteri istediğinde ürünü çekmesini sağlamak pek çok israf kaynağını ortadan kaldıracaktır. Sürekli akış uygulandığında ürün geliştirme, sipariş alma, fiziksel üretim işleri çok kısa sürede tamamlanabilir hale gelecektir. Bu müşterinin gerçekten istediği şeyleri, tam istediği zamanda tasarlayabilme, planlayabilme ve üretebilme imkanını verdiğinden satış tahmini yapmak, karmaşık planlama yazılımları kullanmak, stokta kalan ürünleri itmek için kampanyalar düzenlemek zorunluluklarını ortadan kaldırarak sadece istenen şeylerin daha iyi üretilmesine odaklanabilmeyi de sağlayacaktır. Dördüncüsü, çekme ilkesidir. Yalın Düşünce'nin çekme ilkesi değerin müşteri tarafından kaynağından çekilmesini öngörür. Çekme, sonraki aşamalarda yer alan müşteri istemeden önceki aşamalarda hiçbir şekilde ürün ya da hizmet üretilmemesi anlamına gelir. Çekme ilkesi, nihai müşterinin belli bir ürün için yaptığı taleple başlar, ürün müşteriye ulaşana kadar geçen tüm aşamaları geriye doğru izleyip her aşamanın bir öncekinden talep etmesiyle üretimi başlatmak şeklinde uygulanır. Son ilkesi mükemmeliktir. Böylece, yalın yaklaşımı uygulandığında işgücü verimliliği, işin tamamlanma zamanı, stoklar, müşteriye ulaşan hatalı ürünler ile hurda oranları, ürünü pazara sunma süresi gibi parametrelerin hepsinde birden radikal iyileşmeler görülecek, çok küçük ilave maliyetlerle ürün çeşitliliği artırılabilecek ve bunlar yeni teknoloji yatırımlarına gerek kalmadan, hatta mevcut bazı ekipmanlar satılarak negatif sermaye yatırımı ile ve birkaç yıllık bir süre içinde başarılabilecektir.

Bu ilkeleri firmalara entegre edip uygulayabilmek için geliştirilmiş olan bazı yöntemler vardır. Bunlar; doğru zamanda üretim (just-in-time production), kanban sistemleri, değer akışının analizi, işlerin standartlaştırılması, bir dakikada kalıp değiştirme, 5S,Poka-Yoke ya da başka bir ifadeyle otonomasyon, toplam üretken bakım, kalite çemberleri ve daha birçok yöntem mevcuttur. Hemen hemen her türlü endüstri branşına entegre edilebilmesinin kolaylığı açısından yapılan bu tez çalışmasında uygulama bölümünde 5S yöntemi tercih edilmiştir.

5S yöntemi adını Japonca'da Seiri (sınıflandırma), Seiton (düzenleme), Seiso (temizlik), Seiketsu (standartlaştırma) ve Shitsuke (disiplin) kelimelerinin baş harfi olan "S" harfinden almıştır. Aslında bu saydıklarımız yöntemin aşamalarıdır. Birinci adım sınıflandırmada gereksiz olan malzemeler çalışma ortamından uzaklaştırılır. Fazla, zamanı geçmiş ve ne olduğu belirsiz eşyalara bir işaret koyarak sınıflandırılır ve toplanır. İkinci adım düzenlemede ise her şeyin bir yeri olmalıdır. Nesnelere kolay ulaşabilmeli ve operatörün fiziksel olarak zorlanmayacağı şekilde olmalıdır. Üçüncü adım temizliğin bazı aşamaları vardır; temiz olması gereken yer için bazı aşamalar vardır. Bunlar: temizlik seviyesinin tespiti, görevlendirme, metodlara karar verme, araçların temini, takip ve kontrol listeleri hazırlamak. Hedef ise bütün çalışma alanlarını temiz aydınlık tutarak çalışanların moralini yükseltmek. Standartlaştırma aşamasında ise ulaşılan sistemin sürekli hale gelmesi sağlanır. Beşinci ve son olarak disiplin aşamasında ise çalışmaların sonucu her fırsatta anlatılır ve örneklerle desteklenir kontrol listeleri ile korunur.

6 Sigma teorisi yalın üretim gibi ortaya çıkan ve üretim maliyetlerini sıfır hatalı üretimi hedefleyerek indirmeye çalışan, bir iyileştirme yöntemidir. Aslında sigma zaten hata olasılığı ya da doğrudan şaşma anlamına gelir ve 6 sigmada 1 milyon üründe sadece 3 adet üründe hata demektir ki zaten bu felsefenin amacı ve hedefi budur. Yalın üretim değeri yani müşteriye sunulan nihai ürünü, 6 sigmada değerin sıfır hata ile üretilmesini hedefler. Dolayısıyla bu iki teori birbirini tamamlayıcı felsefelerdir. Daha sonra sonuç bölümde yapılacak olan geleceğe yönelik öngörü-tahminde bulunulacağı için yapılan bu çalışmanın beşinci bölümünde detaylı olarak yer verilmiştir.

Türk Tersaneleri 2000'lerin başından itibaren 2008'lerin ortasına kadar yükselişe geçmiş ve Cumhuriyet tarihindeki en yüksek gemi üretim tonajlarına çıkmıştır. Maalesef gerek dünya genelindeki ekonomik kriz gerekse yanlış stratejiler sebebiyle 2008 yılının son çeyreğinden itibaren gemi siparişleri düşüşe geçmiş ve 2013 yılına gelindiğinde ise birkaç tersane haricinde yeni proje alan tersane sayısı iki elin parmaklarını geçmeyecek durumu gelmiştir. Bu durumun sebeplerinden bir tanesi ise Asya kıtasında bulunan tersanelerin Türkiye'den daha ucuza gemi imal etmesi ve dolayısıyla da dünyadaki gemi siparişi tercihinin bu bölgeye kaymasıdır.

Yalın üretim felsefesinin Türk Tersanelerindeki durumu incelendiğinde ise büyük tersanelerin üst düzey yöneticilerin bu felsefeden haberdar olduğu fakat şirket geneline yayılamadığı için herhangi bir uygulamanın yapılmadığı ya da yapılsa da tam entegrasyonun sağlanamadığı için yalın üretimin faydalarından fazla yararlanılamadığı incelenmiştir. Ufak çaptaki tersanelerde ise durumun daha kötü olduğu, tersane sahiplerinin bile böyle bir felsefeden haberdar olmadığı incelenmiştir.

Uygulama bölümünde, yukarıda da bahsedilen yalın üretim yöntemlerinden 5S metodu kullanılmıştır. Uygulama yeri için Ada Tersanesi'ne gidilmiş ve bu tersanenin boru atölyesine 5S yönteminin uygulanmasına karar verirmiştir. Yalnız bu uygulama pratik olarak değil teorik olarak yapılmıştır. Böyle bir yöntemin (pratik değil teorik olarak uygulama yapılması) seçilmiş olmasının başlıca sebepleri vardır. Bunlardan ilki, yalın üretim uygulamasının firmalarda bir devrim niteliğinde olmasıdır ve maalesef insanların yeniliğe karşı oldukça direnç göstermesinden dolayı, belirli bir zamana (minimum 1sene) gerek olduğudur. İkinci sebep olarak, insanların yeniliklere karşı dirençli olmasından dolayı bu uygulamaları yönetecek kişinin tersanede tam zamanlı ve yaptırım gücü yüksek bir pozisyonda çalışır olması gerekliliğidir. Bu bölümde tersane organizasyonunun 5S yöntemine nasıl entegre edilebileceğine dair önerilerde bulunuldu. Daha sonra 5S yöntemlerine derinlemesine inilip her bir adım için teker teker önerilerde bulunulmuştur. Ayrıca çalışanların yapılan bu yeniliklere karşı göstereceği dirence karşı kararlı ve tutumları olmaları ve gereken yaptırımları almaları gerektiği önerisinde bulunulmuştur.

Müşteri taleplerindeki çeşitlilikten dolayı, ürün çeşitliliğinde de sürekli artışın yaşandığı günümüz dünya ekonomisinde, artık eski tarz yöntemleri kullanarak üretim yapan firmaların rakipleri ile rekabet edebilme yetileri oldukça azalmaktadır. Firmaların, birbirleriyle rekabet edebilmeleri içim olabildiğince maliyetleri azaltmaları gerekmektedir. Bunu da yapabilmeleri için gereksiz harcamalar minimize edilmelidir. Son birkaç yıl öncesine kadar işlerin çok iyi olduğu Türk Tersaneleri son yıllarda sipariş sorunu yaşamakta ve kriz dönemine geçilmiştir. Araştırmalar göstermektedir ki, bu problemleri yaşayan Türk Tersaneleri, maliyetleri düşürüp verimliliği oldukça arttıran yalın üretim yöntemini ve hatta onu destekleyen 6 sigma

yöntemini kullanmazlar ise yakın gelecekte yurt dışındaki rakipleri ile rekabet edemez hale geleceklerdir.

# 1. INTRODUCTION

## 1.1 General Introduction

Shipping plays a crucial role in the global economy and especially in trading for 5000 years (Stopford, 2009). For this reason, it is obvious that ship construction and its services will be always important.

Conventional trade has been changed after the diversity of goods and products due to the change in customer demand. Customers have started to look for specialized products that suits with their fancy with the best quality at the lowest price. That forces the companies and firms to look for alternative ways to reduce the production costs as they cannot increase the selling prices. In this situation lean manufacturing and 6 Sigma are the best methods to compete with the rivals.

The Japanese has given birth to lean manufacturing as to compete with Ford`s mass production methodology. Lean manufacturing is a methodology that aims to reduce the production costs by eliminating waste. It can be said that 6 sigma is first applied by Motorola. 6 Sigma is a methodology that aims to reduce production costs by eliminating defects (variations). For Turkish Shipyards, using lean and 6 sigma will be the only way to survive in ship construction marketing.

Turkey is one of the countries that operating shipyards and its services (construction, repair and scrapping). In 2002, Turkey was the 23th in ship construction in the world. In 2206 Turkey became the 8th in the world with the ship delivery of 1.8 million DWT. Furthermore, Turkey became the 1st in mega yacht construction in the beginning of 2008. However, since after the second half of 2008, the business tends to be very slow in Turkish Shipyards. (World Shipyard Monitor) Due to the economic crisis and the lower cost of production in other countries cause this result in Turkey.

There are plenty of studies about the philosophy and the implementation of lean manufacturing and six sigma. For shipyards, the National Shipbuilding Research Program (NSRP) is the main objective for the studies in marine science. However,

there is a few source or study about lean and six sigma about shipyards in Turkey and for Turkish Shipyards. Therefore, there are no enough satisfying studies about the lean & six sigma in Turkish Shipyards.

### 1.2 Aim of Study

There are mainly four goals in this study. One of them is to determine and identify the lean manufacturing and its tools and techniques. The second aim of the study is to define the 6 sigma. Tools and techniques of 6 sigma are identified briefly. The reason of defining 6 sigma is to find an answer for firms that have confused and have been in dilemma in deciding which one to use; lean manufacturing or 6 sigma. The third objective is to identify and observe the vision of Turkish Shipyards in lean manufacturing. The fourth goal of this study is to conclude the data that is taken from the Turkish shipyards and make a prediction about the future of the Turkish Shipyards. Lastly, implementation of 5S (a method of lean manufacturing) into a shipyard in theory.

### 1.3 Structure of Study

This study based on 8 chapters. The first chapter is the introduction part to give a brief information about the study. The other chapters are summarized below:

- Chapter 2 involves the literature review which is about the lean manufacturing and lean philosophy.
- Chapter 3 involves the presents the detailed explanations of lean manufacturing.
- Chapter 4 gives information about the lean manufacturing tools and techniques.
- Chapter 5 defines Six Sigma and its methodology. In this chapter the answer for firms , that are in dilemma to use lean or Six Sigma, is found.
- Chapter 6 gives data about the Turkish Shipyards and their role in the world.
- Chapter 7 covers the observation of the existence of lean in three visited Turkish shipyards.
- Chapter 8 is implementation of 5S into Ada Shipyard part.

Chapter 9 is the conclusion part

## 2. LITERATURE REVIEW

### 2.1 Historical Background of Lean

There are some instances in history back to 1450`s in Venice but the first man who truly applied lean philosophy was Henry Ford in 1913. His manufacturing understanding based on interchangeable with standard work and moving conveyance as he named it as flow production. He had special-purpose machines and go/no-go gauges to fabricate and assembles the components going into the vehicle in a few minutes' and deliver perfectly fitting components directly to line-side. This was an innovation in American industry. He did not have any problems at flow, but his system could only supply identical cars. Model T was not just only limited with the same colour it was also limited with same body style. After a while in 1926, the market demanded on variety so the production way of Ford lost his popularity. Other companies supplied the need of variety but it needed much longer throughput times. Over time they tried to supply the demand by putting larger machines which reduced the costs per process steps but provided more throughput times and inventories. Furthermore time legs between all process steps and the complex part routings required more and more sophisticated information management systems that required computerized Materials Requirements Planning (MRP) systems. Afterwards this system was called as mass production.

Kiichiro Toyoda, Taiichi Ohno and others at Toyota tried to seek for other ways to compete with the US auto giants of Ford, General Motors and Chrysler in the 1930`s mainly after World War II. They believed that it might be more possible by providing continuity in both process flow and in product offerings. They revised the Ford`s original thinking and invented the Toyota Production System (TPS).

This system in essence shifted the focus of the manufacturing engineer from individual machines and their utilization, to the flow of the product through the total process. Toyota concluded that by right-sizing machines for the actual volume needed, introducing self-monitoring machines to ensure quality, lining the machines

up in process sequence, pioneering quick setups so each machine could make small volumes of many part numbers, and having each process step notify the previous step of its current needs for materials, it would be possible to obtain low cost, high variety, high quality, and very rapid throughput times to respond to changing customer desires. Also, information management could be made much simpler and more accurate.

Lean manufacturing did not actually get its name until 1990`s when J*ames Womack, Daniel T.Jones, Daniel Roos* wrote a book called *"The Machine That Changed the World".*They combined production methods from the United States, Europe, and Japan. They first characterize the lean philosophy and lean manufacturing. They stated as:

"Lean production is `lean` because it uses less of everything compared with mass production: half the human effort in the factory, half the manufacturing space, half the investments in tools, half the engineering hours to develop a new product in half the time." They took the attention of manufacturers, implementers and researchers all over the world. The very term of "lean production" has become widely used as a reference for specific templates and practice of production and also for the Toyota Production System.

Since their book was published, the subject of lean has been studied by many production engineers and specialists and continues to be a popular trend for production companies who are trying to save money by making their particular production methods more efficient. There is a timeline of lean manufacturingat the appendix part.

## 2.2 Toyota Production System (TPS)

It is a well-known and acknowledged fact that TPS is the basic and the first truly applied organization for the lean manufacturing. So it would be suitable to mention the definitions about the production for Toyota. Here are some definitions that I would like to cite:

"TPS is an organization has a value flow without interruptions." (Ohno, 1988)

"TPS bases on the elimination of waste. Just-in-time and automations are the promoters of this system." (Ohno, 1988)

“The main idea in TPS is to reduce the storages, produce products in the basis of just-in-time technique, and reduce costs.” (Monden, 1983)

“TPS covers the standardization of works, making value without interruptions, having a direct connection between the suppliers and customers and having a continuous improvement.” (Spear and Bowen, 1999)

### 2.3 Studies About Lean Manufacturing

There are lots of applications that have been done so far. I picked some application that is crucial. These are:

McLachlin (1997): He has studies in participating of workers, just-in-time, quality management fields.

Hopp and Spearman (2004): They have studies in pull systems, elimination of waste, reducing parameters, continuous improvement. According to Hopp and Spearman tracing lean manufacturing and reducing storages firms should manage the parameters in storages, process time and demand. These parameters are recognized by Hopp and Spearman as:

- Precautions should be taken for the changes in suppliers. Firm should provide that suppliers are producing materials in the right in the right quantity.
- Changeover times should be reduced.
- Organization should react to the fluctuations on demands.

Li, Subba Rao and Ragu-Nathan (2005): They studied on pull systems, installation time and low production quantity.

Shah and Ward (2003): They have studies in just-in-time, total preventive maintenance, human resources management and total quality management. They developed measurementsabout these fields and they made them measurable. In 2007 they had a literature research about measures in lean manufacturing. They put the relationship between the measurements into tablesand by empirical formulas they designate 48 lean manufacturing measurements.

De Treville and Antonakis (2006): They studied on just-in-time, total quality management, total preventive maintenance, Kaizen, human resource management.

Perez and Sanchez (2000): They had a questionnaire research that covers the 28 automobile suppliers in Spain. They examined the relationship between the lean manufacturing and suppliers. They found out that there is a positive trend between the delivery just-in-time and the percentages of workers that have been trained well.

Sohal and Egglestone (1994), Kasul and Motwani (1997), Bhasin and Burcher (2006) and, Abdulmalek and Rajgopal (2007) had studies about lean manufacturing tools and techniques and stated that tools and techniques are very important in lean manufacturing. They also highlighted that using tools and techniques will help the organization to transform their manufacturing system into lean manufacturing.

Worley and Doolen (2006): They studied in management in lean manufacturing. They stated that managemant support is one of the crucial point in applying lean manufacturing. Rewards and recognition will thrust the motivation and participation and also it will increase the continuous improvement.

Little and McKinna (2005): They searched how culture will effect the development of lean manufacturing in an organization. They found that enterprising will be nore succesfull if the culture encourages employees to work and participate and co-oparate with each other.

## 2.4 Implementations in Different Types of Industry

It is obvious that automotive industry has an effective role in the development of the lean manufacturing. However, that does not mean that lean manufacturing is only developed by implementations in lean manufacturing. In *1997Rinehart* indicated that lean manufacturing will be the basic production technique all over the world in all branches of industry.

USA Air forces has researched the feasibility of lean manufacturing by the program named as Lean Aerospace Initiatives. This program started in 1993 with 47 participating institutions. Eventually Earll Murman published a book called Lean Enterprise Value: Insights from MIT`s Lean Aerospace Initiativesin 2003 (Stoewer, 2003).

There is another study made by Crute, Ward, Brown and Graves for space and aviation industry. The study covers about the feasibility and difficulties of lean manufacturing in implementing it into aviation.

We can see the studies in USA and in UK at the end of 1990`s to adapt lean manufacturing to other branches of industry. Lockheed Martin Company declared the year 1999 as the year of lean and adopted the lean techniques to the fighter aircrafts of F-16 & F-22 and to the military cargo plane of C130J. In UK BAE systems struggle to adapt lean manufacturing to fighter aircraft production facilities. The firm believes that lean manufacturing will be more efficient to control Eurofighter (a program for the production of fighter aircrafts) program`s costs (Crute,et al., 2003).

There are also other examples in adapting lean manufacturing like in computer industry. In 2004 Brunn and Mefford defined how the use internet effects lean manufacturing. They gave definitions about the firms and the ways that they are using the internet in implementing lean manufacturing. They also mentioned about the obstacles in internet in lean enterprising. They showed Dell Computer Corporation, Cisco Systems and ODAM (Ostergaard Danish Automative Materials) as reference in their research.

### 2.5 Implementations in Shipyards

There have been studies by NAVSEA (Naval Sea systems Command) in USA in shipyard industry since 2000 with the Lean Shipbuilding Initiatives (LSI) program. Since 2000 seminars, forums, lectures, articles and magazines are being organized and sponsored by Naval Shipbuilding Research Program (NSRP). In this context, Brogger, Northrop Grumman, Pearl Harbour, Portsmouth navy yards` applications were presented in the forums. One of the studies is the line ball valve model which is applied in the navy yard of Portsmouth. More information is going to be given in the next chapters.

On October 19$^{th}$ 2003, Alok K. Verma submitted a report to NSRP-ASE Program. In his report he stated that Lean training has the components of MEP exercises, Six Sigma programs, NIST-MEP 5s training. He also stated that stimulation activities are essential to implement lean to shipyards.

Tom Demas, NAVSEA NSRP Program Manager and Rick Self, NSRP Executive Director prepared a report in the name of NSRP ASE Brief to JINII on November 8 in 2001. They presented what is lean manufacturing, what are the goals, which US shipyards implementing lean and the plans for future.

On September 2006 (14/12/2006) the National Shipbuilding Research Program (NSRP) and the Naval Sea System Command's "NAVSEA Lean" kept going on ınteresting in Lean and organised a forum called Shipbuilding and Ship Repair Forum in Jacksonville, Florida. The participants argued the growth of the lean philosophy under the umbrella of NSRP and they examined the feedback from the implementations of lean (Url-1).

# 3. LEAN MANUFACTURING

## 3.1 Definition of Lean Manufacturing

Lean manufacturing or with another name lean production is first characterized by James P.Womack, Daniel T.Jones, Daniel Roos in the book The machine that changed the world (1990). They stated as:

"Lean production is `lean` because it uses less of everything compared with mass production: half the human effort in the factory, half the manufacturing space, half the investments in tools, half the engineering hours to develop a new product in half the time."

Lean manufacturing is a set of philosophies, concepts, and methods to improve production processes. It is a logical approach to identify, expose, and eliminate wastes. It improves profits and reduces production time. One goal of lean manufacturing is to produce a high quality product at the lowest possible cost in less time, rather than producing a product and then inspecting it for quality.

Briefly, lean manufacturing is a systematic approach to the identification and elimination all forms of waste from the value stream.

## 3.2 Principles of Lean Manufacturing

Lean production focuses on the product itself and what needs to be completed, rather than the hardware and software of existing resources. It defines `value' from the standpoint of customers (internal or external) in terms of specific products or product families (interim or final products). Lean production tries to eliminate all wastes (including labour, material, facility, time) which do not create value, in all the production steps from raw materials to final products. Then it reorganizes all the essential, value-creating production activities into the most efficient processes and makes the processes flow with minimized interruptions and variations. In brief, lean production requires continuous and uniform flow of value-creating processes.

The principles of lean manufacturing is simply summarised by *Womack and Jones* in their book of Lean Thinking in 1996 in 5 main topics. These are:

- Precisely specify value by specific product (Value).
- Identify value stream for each product (Value Stream).
- Make value flow without interruptions (Flow).
- Let the customer pull value from the producer (Pull).
- Pursue perfection (Perfection).

### 3.2.1 Specify value by specific product

Value is what the customers want. There are three types of valuein production activities. First one is the value-added activities whichare the activities that transform the materials into the exact product that the customer requires. The second one is the non value-added activities which are activities that aren't required for transforming the materials into the product that the customer wants. The third one is the necessary non value-added activities which are activities thatdon't add value from the perspective of the customer but are necessary to produce the product unless the existing supply or production process is radically changed. *The Lean Enterprise Research Centre* (LERC, 2004) at Cardiff Business School highlighted that for most production operations:

- 5% of activities add value;
- 35% are necessary non-value activities;
- 60% add no value at all (necessary non value-added activities).

According to this research it is obvious that %95 of production activities is non-value adding. This provides a necessity to understand and specify value perfectly to satisfy the customers. Without understanding clearly and perfectly what customers really want a company cannot move forwards.

Even for the same product value can vary for individuals. That provides value propositions. The table below explains value propositions within the process industries (T. Melton; 2005).

**Table 3.1 :** Example of value propositions within the process industries.

| Customer Type | Value Proportions | Manufacturer Type |
|---|---|---|
| A. Major pharmaceutical manufacturer of drug products | Robust process and product development at fast track speed ensuring regulatory Compliance | Toll manufacturer of Pharmaceutical intermediates |
| B. Other manufacturer in a low cost base industry | Correct specification, low cost and delivered on time in the volumes specified | Bulk chemicals manufacturer |
| C. The patient (via the companies who distribute the drugs) | High quality, safe drugs that 'work' at an appropriate price | Bulk chemicals manufacturer |

According to this table it can be said that the development of process in toll manufacturer is a added value for customer A but that would be waste for customer B.

In the book of *Lean Thinking* by *James P. Womack and Daniel T. Jones* (1996) in page 16,value is defined as:

"The critical starting point for Lean Thinking is value. Value can only be defined by the ultimate customer. And it`s only meaningful when expressed in terms of a specific product (a good or a service, and often both at once) which meets the customer`s needs at a specific price at a specific time".

### 3.2.2 Identify value stream for each product

A value stream can be defined as all the value-added and non value-added activities that are needed to provide specific product, service, or combination of products and services, to a customer, including those in the overall supply chain as well as those in internal operations (William G. Sullivan et al., 2002). When value stream is done correctly and in the right order then the product turns into a product that customer values. A lean manufacturing should follow and manage the whole activities that bring the value in any situation or time. Production activities can be entirely or partly unnecessary even they can be wasteful. The ones in those activities which do not support value-added activities should be eliminated or should be reduced as possible as they can be. The most efficient way to identify the value-added and non value-added activities is the Value Stream Mapping (VSM). As it can be understood from its name that VSM is a set of methods that display the flow of materials and

information in the production processes visually. VSM is going to be mentioned in more detail in the next chapter of lean manufacturing tools and techniques.

In the book of *Lean Thinking* by *James P. Womack and Daniel T. Jones* (1996) in page 19, value stream is defined as:

"The value stream is the set of all the specific actions required to bring a specific product (whether a good, a service, or, increasingly, a combination of the two) through the… problem-solving task from the concept through detailed design and engineering to production launch, the information management task running from order-taking through detailed scheduling to delivery, and the physical transformation task proceeding from raw materials to a finished product into the hands of the customer"

### 3.2.3 Make value flow without interruptions

In an industry which is working in lean principles work should be continuous and uninterrupted from each process to another process. This is contrasted with the "batching" of work where, for instance a week's expenses claims are collected for a manager to authorise in one go. Where it is suitable, flow significantly speeds the processing and every effort should be made to eliminate obstacles and bottlenecks that prevent flow.

In the book of *Lean Thinking* by *James P. Womack and Daniel T. Jones* (1996) in page 21,value flow is defined as:

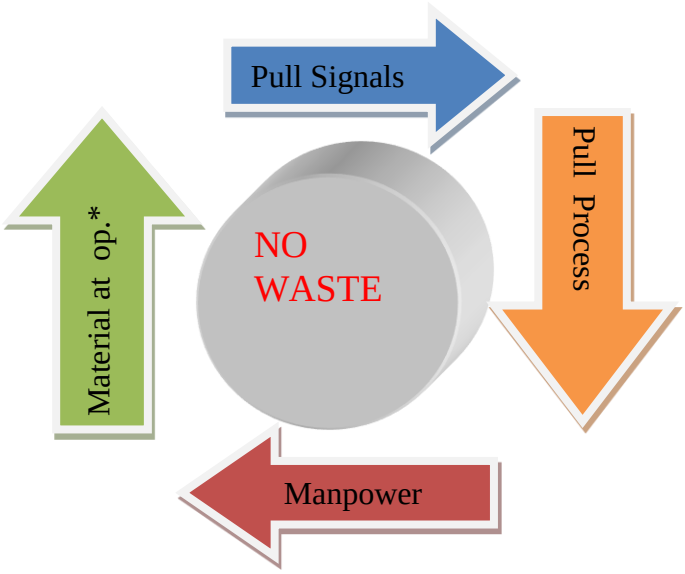
"Once value has been precisely specified; the value stream for a specific product family fully mapped by the Lean enterprise, and obviously wasteful steps eliminated, it`s time for the next step in Lean Thinking… make the remaining, value-creating steps flow".

### 3.2.4 Let the customer pull value from the producer

The system should meet the customers` demand. In other words customers pull the work through the system. On the contrary, in a non-lean organization the system pushes the work at the convenient time so organization produces outputs that are unnecessary. Most services meet customers` demand and so pull the work through the system. The concept is that each process is manufacturing each component in line with another department to build a final part to the exact expectation of delivery from

the customer. Because your production process are designed to produce only what is deliverable your business becomes leaner, as result of not holding excessive stock levels of raw, part-finished, and finished materials.

One of main identifier of pull systems comes in the form of having Kanban methods in your production cycle. In essence a Kanban can be described as a visual aid which is used to show that either you have either finished a process, require work/more materials. The aim of having a visual aid is that the person who either feeds work off you or gives you work, becomes apparent of your needs quickly. Kanban is a concept that lends itself to high turnaround industries, but it can be applied to other environments. We shall be discussing Kanban in more detail in other areas of this web-site. Unfortunately pull systems do not lend themselves to all business types, because of product types, lead times and any stock holding arrangements with customers. However by having pull systems in some of your production processes, you will be able to reduce your lead times, and perhaps associated costs.




op*: Operator

**Figure 3.1 :** Pull system how it prevents wastes.

In the book of *Lean Thinking* by *James P. Womack and Daniel T. Jones* (1996) in page 67, pull is defined as:

"Pull is the simplest terms means that no one upstream should produce a good or service until the customer downstream asks for it."

### 3.2.5 Pursue perfection

Once you start applying the four steps above; there starts an endless cycles within these principles or processes. The more you identify the value the more you identify your value stream. The more you identify your value stream the more you let the customer pull value. That provides a challenge between or the steps and that makes your organization more perfect. Briefly, once you begin you cannot stop lean organization.

In a perfect process, every step is valuable-adding, capable (produces a good result every time), available (produces the desired output, not just the desired quality, every time), adequate (does not cause delay), flexible, and linked by continuous flow. If one of these factors fails some waste is produced.

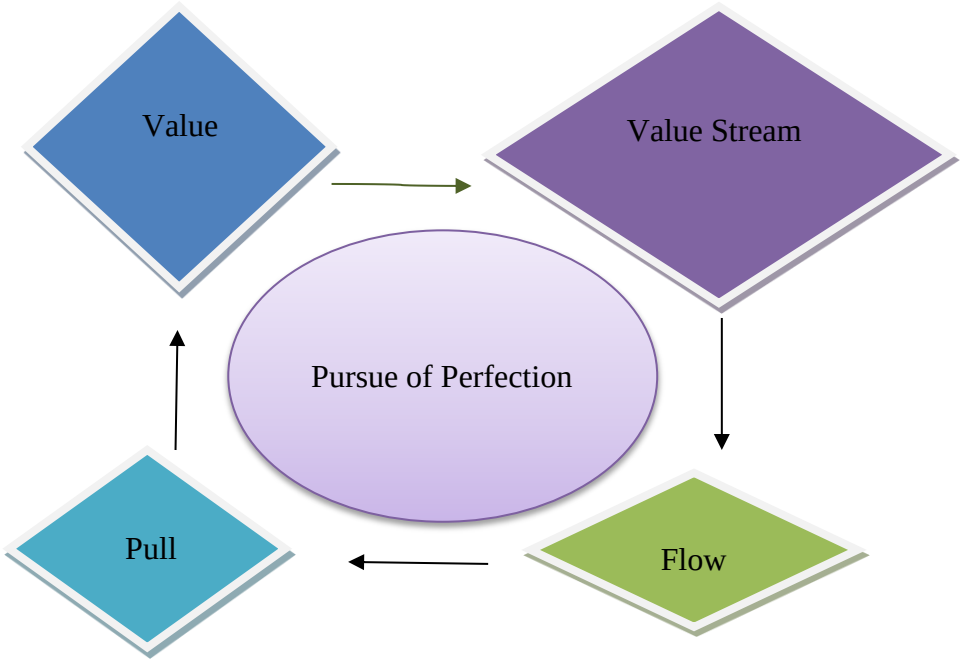



**Figure 3.2 :** Pursue of perfection is an endless process.

In the book of *Lean Thinking* by *James P. Womack and Daniel T. Jones* (1996) in page 25, perfection is defined as:

"As organizations begin to accurately specify value, identify the entire value stream, make the value-creating steps for specific products flow continuously, and let customers pull value from the enterprise, something very odd begins to happen…suddenly perfection... doesn`t seem like a crazy idea".

### 3.3 The Objectives of Lean Manufacturing

The main aim of lean manufacturing is continuously to reduce and if it is possible eliminate all the wastes as Japanese call it as Muda. The main benefits of this are lower production costs, increased output and shorter production lead times. We can sum up wastes in 7 groups. These are:

Defects and wastage: Reduce defects and unnecessary physical wastage, including excess use of raw material inputs, preventable defects, costs associated with reprocessing defective items, and unnecessary product characteristics which are not required by customers.

- Cycle times: Reduce manufacturing lead times and production cycle times by reducing waiting times between processing stages, as well as process preparation times and product/model conversion times.

- Inventory levels: Minimize inventory levels at all stages of production, particularly works-in-progress between production stages. Lower inventories also mean lower working capital requirements.

- Labor productivity: Improve labor productivity, both by reducing the idle time of workers and ensuring that when workers are working, they are using their effort as productively as possible (including not doing unnecessary tasks or unnecessary motions).

- Utilization of equipment and space: Use equipment and manufacturing space more efficiently by eliminating bottlenecks and maximizing the rate of production though existing equipment, while minimizing machine downtime.

- Flexibility: Have the ability to produce a more flexible range of products with minimum changeover costs and changeover time.

- Output: Insofar as reduced cycle times, increased labor productivity and elimination of bottlenecks and machine downtime can be achieved, companies can generally significantly increased output from their existing facilities.

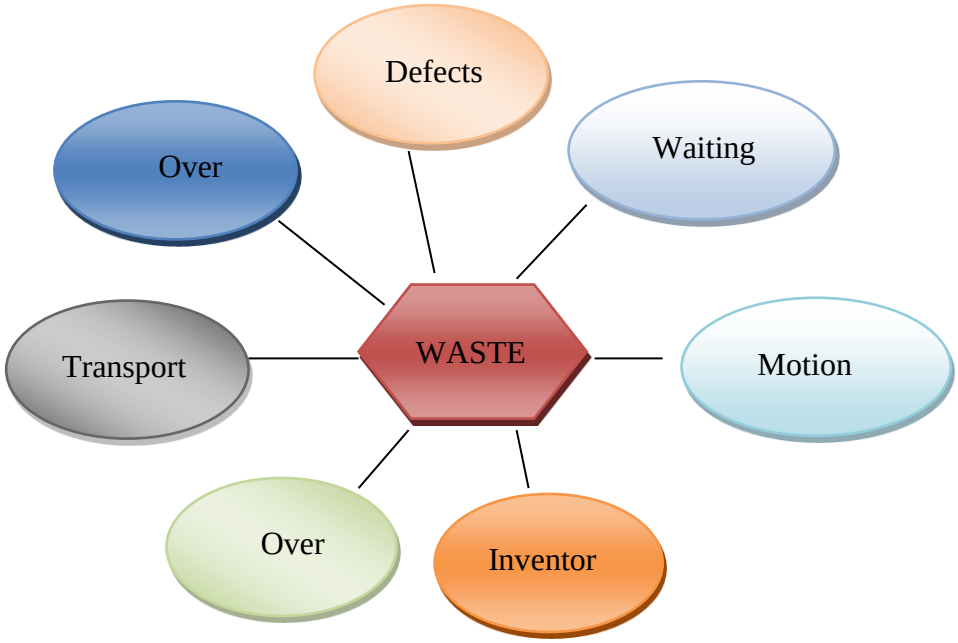



**Figure 3.3 :** Kinds of waste.

# 4. LEAN MANUFACTURING TECHNIQUES AND TOOLS

## 4.1 5S System and Continuous Improvement

Continuous improvement is one the fundamental in lean thinking. Its target is to keep and improve the perfection steadily. One of the most effective tools of continuous is 5S.

5S is a methodology that uses a list of 5 phases which named by Japanese as *Seiri, Seiton, Seiso, Seiketsu* and *Shitsuke*. These 5 phases are:

Sort (*Seiri*): This phase eliminates all the tools, parts and instructions that are not necessary. It gets rid of all the unnecessary or stores them and it only keeps the essential things for the production in an easily accessible way. While getting rid of the unnecessary tools there some questions that help you. These are:

- Is there any unnecessary stuff in your workplace?
- Is there any unnecessary cable or pipe that is leaven on the workplace?
- Is there any outfit or tools on the ground?
- Are all materials classified, stored and tagged?
- Are all materials, tools, outfits classified and stored in their right place?

Setting in order or Straightening (*Seiton*): It takes everything that is required to do the job(what`s left after the "sort" step) and provides a place for it. We could summarize its role as a place for everything and everything is in its right place.

Shine or sweeping or cleanliness (*Seiso*): Seiso means providing a clean work area. Every employee is responsible for its working place to be clean. Maintaining cleanliness in working areas increases productivity and also it should be part of daily work.

Standardizing (Seiketsu): Once you implement the three phases you have to be sure that they stay in the same quality. That brings standardization. To do this appropriate

standard operating procedures (SOPs), inspection checklists, etc. should be written and followed (Feld, 2000).

Sustain (*Shitsuke*): There is a natural tendency for even the best 5S programs to lapse without consistent follow-up that ensures the SOPs, checklists, etc. is being followed. Also management should be constantly seeking ways of improving on the program including ideas the workers might have for this.

The 5S are the primary phases of this system. There are also some other phases that we can mention about. These are safety, security and satisfaction. These phases can be put to the system as if it is needed to be added which is differs from each organization to another.


**Figure 4.1 :** The relationship between phases of 5S system.

In consequence, 5S means good housekeeping and better workplace organization.

### 4.2 Visual Controls

Using visual controls is one most of the most important lean technique even it might be expensive to implement but expenses can be omitted as its feedbacks are brilliant. For example design. For example determining lanes for forklifts can simplify forklift movements and also increase the safety (Austenfeld,2005). As it is mentioned in his article, there are lots ways that can be used as visual controls. These are;

- To show where tools should be kept when not being used (part of 5S).
- To show the status of a particular production operation using andonlights8).
- To color-code tools or parts.

- To color-code pipes according to what they are carrying (water, steam, some chemical, etc.).
- To show the results of defect reduction efforts with large, easy-to-read charts.
- To show where a stock replenishment box should be located.
- To warn employees of some danger such as high-voltage or steam discharge.
- To display job aids or SOPs at the point of use.
- To show production goals and extent of achievement.
- To provide motivational messages (e.g., “well done!”) or announce upcoming employee events (e.g., “all-hands meeting this Thursday”).

### 4.3 Cellular Manufacturing

Cellular manufacturing is one of the major techniques for becoming lean. Its working principle is to increase the mix of products and minimize the waste as possible as it can be. It is like a cell that uses equipment and workstations which provide smooth flow of materials and components in a process. To achieve this well trained and qualified workers and operators are required. There are some advantages that are occurred by using cells. One of them is the one piece flow concept. That derives that each product moves through the production process one by one without interruptions with the demand of customer. The second advantage is as cellular manufacturing extends the product mix. That provides an organization to supply the customers` high variety of demand easily and fast. Briefly, it provides flexibility for customers` needs. This flexibility makes required time shorten for transition between products that stimulates production in smaller portions. There are also other advantages or benefits that cellular manufacturing provides. These are :

- Inventory reduction
- Reduced transport and material handling
- Better space utilization
- Lead time reduction
- Identification of causes of defects and machine problems

- Improved productivity
- Improved teamwork and communication
- Improved flexibility and visibility

### 4.4 Total Productive Maintenance (TPM)

Breakdown of machine is a natural incident in an organization. It is very serious issue that a break or halt in a workshop may stop the entire production line. Besides the fact of breakdown of machine, machines also have to work perfectly. There are three reasons to keep the machine`s performance at maximum. One of them is; machine working out of adjustment or not well-maintained may produce defects. The second one is machine with small problems may occur failures. The last one is well-maintained equipment lasts longer (Austenfeld, 2005). In this manner, total productive maintenance is one of the most effective tools to prevent unexpected (sudden) breakdowns. It is a system that ensures to keep the machines and equipment in the best possible condition.

There are three main components of total productive maintenance as to do its duty correct. These are preventive maintenance, corrective maintenance and maintenance prevention. Preventive maintenance designates the check-ups and detects the breakdowns. Corrective maintenance decides to fix or buy a new machine or equipment. Maintenance prevention decides the best machine to buy. The machine that is going to be bought should be easy to fix when it breaks and it should be easy to maintain.

### 4.5 Just-In-Time (JIT)

The main goal of lean manufacturing is to reduce the waste and if it is possible eliminate all the sources of production waste (**Muda)** in the right place in the right time. In this situation it would be suitable to say that the principle of just-in-time is closely associated with lean thinking and lean production. Just-in-time is a tool that makes the internal process of an organization to tolerate or adapt to sudden changes in the market. It makes it happen by producing products in the right time in the right quantities (Monden,1998). There are some benefits of using JIT. These are:

- It reduces inventory costs.
- Quality problems can be detected earlier.
- The waste of storage space reduces because of the reduction in inventory.
- Hidden problems can be detected as mass production is prevented.

Just-in-time tool can be divided into three parts: JIT production, JIT distribution, JIT purchasing.

### 4.5.1 Just-in-time production

JIT uses pull system as we mentioned about it before. That`s why we could easily say that JIT is the backbone of lean manufacturing (Monden, 1998, Levy, 1997). By using the pull system all the process is coordinated by Kanban system.

Kanban is an information system that is used to control the number of parts to be produced in every process (Monden, 1998). Kanban is a Japanese word. It means signboard or billboard in English. As it can be understood from its meaning all the process is coordinated with these moving cards. These cards or withdrawals specify all the material`s details.

It was created by Taiichi Ohno who is inspired from the supermarkets when he had been in USA. The system is actually very simple. The next process should pull from the previous succeeded process which is defined by Kanban. The fact of being pulled starts at assembly part of the process. It starts from here and continuous from a workshop to another workshop or it happens between the industry and supplier industry. Monden has specify some rules to make the system work properly (Monden, 1983). These are:

Rule 1: Next production process should pull materials from the previous process in the right time and in the right quantities. All materials should be tagged.

Rule 2: Preceding process should produce materials depending on the succeeding process` needs.

Rule 3: Failure should never be pulled.

Rule 4: Number of Kanbans should be minimized.

Rule 5: Kanban system should be maintained as to tolerate the fluctuations in demands.

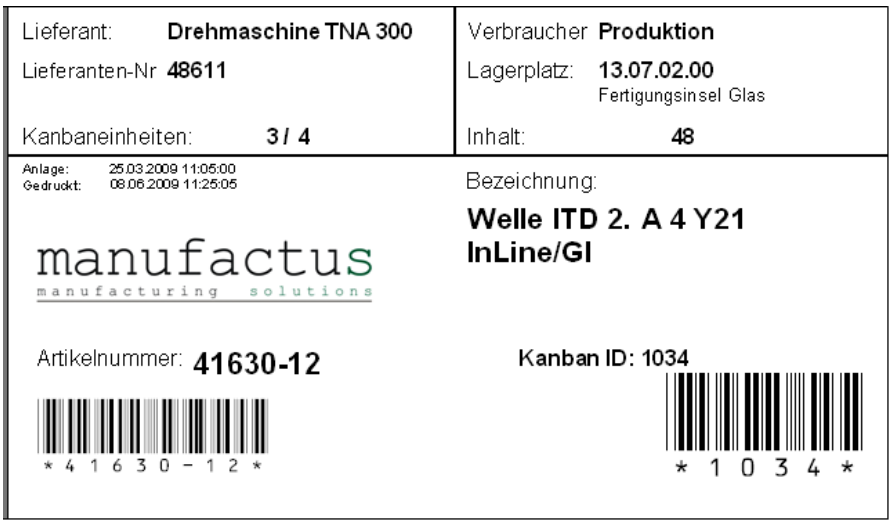



**Figure 4.2 :** Example of a Kanban card

### 4.5.2 Just-in-time distribution

Alliance between buyers and suppliers play a big role in the effectiveness of JIT. Having a third party logistics (3PL) distributor ease company`s responsibilities. By having this, they can focus on their production and competition between the other companies. 3PL can provide JIT distribution by having on time delivery to customers or distributors. (JITD) requires the change of frequent and also it needs an effective transportation management system as the transportation of inbound and outbound material can have a great effect on production when there is not any branch of inventory (Spencer et. al, 1994).

### 4.5.3 Just-in-time purchasing

Just-in-time purchasing has been defined by Ansari and Mondarress (1986) as the purchase of goods such that their delivery immediately precedes their demand or they are required for use. Supplier selection, production lot sizing and production development are very important as it can be said as critical. The relationships between customer and supplier are very crucial as well. Just-in-time purchasing (JITP) needs a small number of qualified suppliers as it guides the inspection function of quality. That provides a perfect way to reduce the defects and waste.

### 4.6 Standardization of Work

One of the basic principle of lean manufacturing is the elimination of waste. Standardization of work is a guarantee of being be sure that all the waste are eliminated and all the processes are being carried out on the most effective way. That simplify the inspection of workers as in a standardized organization it is not matter who is doing the job since the product will always be in the same quality. The most efficient tool for standardization of work is takt time.

#### 4.6.1 Takt time

Takt time originally comes from German word Taktzeit. It means cycle times. On each cycle (process), work has to be completed before (less than) the takt time as the final product could be finished within the divided time. Takt time is calculated as (Feld, 2000):

$$Takt\ Time(TT) = \frac{Available\ work\ time\ per\ day}{Customer\ demand\ per\ day}$$

### 4.7 Single-Minute Exchange of Die (SMED)

Mass production based on changeover times. So far, length of the changeover times is supposed to be a constant data that cannot be reduced and nobody has strived to change it. It's a natural result that high rates of changeover times occurs massive lots. Also it has been supposed that mass production will bring less changeover times and that will result in high efficiency at the machines. On the other hand, mass production or high numbers of lot bring the need of storage. That is totally contrary the aim of lean manufacturing. So as to minimize and eliminate storage, changeover times should be reduced. The aim of minimizing changeover times is not to reduce manpower or have more number of lots. The aim is to achieve more changes with the time that is reduced from changeover times and with that changes organization can reduce the size of the lots.

SMED is created first by Shigeo Shingo to exchange dies of production. Even the name of the tool seems like that it exchanges the dies so it is suitable for the processes deal with machines, actually it can implemented to other production processes that are operated without machines.

The setupsof SMED are divided into two parts. These are:

1. Internal Setups: These are the setups that only can be applied while the machine is in off position. For example, putting the die onto the machine or putting it off.

2. External Setups: These are the setups that there is no need to switch the machine off in order to be applied.

External setups and internal setups are generally mixed. To avoid this there are some methods like timing setup stages, making video etc.

To reduce the changeover times there are 4 main concepts (Monden, 1983) :

Concept 1: Separation of external and internal setups.

Concept 2: Transforming the internal setups into the external setups as much possible as it can.

Concept 3: Elimination of setups.

Concept 4: Eliminate the changeover totally. This can be made it happen by producing standardized products and producing the two different standardized materials in the same time.

There are 6 methods to make these four concepts achievable. These are:

Method 1: Standardizing the external setups.

Method 2: Standardization of the machine`s essential equipments.

Method 3: Usage of the faster connection elements.

Method 4: Usage of parallel operations.

Method 5: Usage of additional elements.

Method 6: Usage of mechanical changeover systems.

In consequence the organization that uses the tool of SMED will benefits from the elimination of storage and changeover times. Also the work efficiency increases.

### 4.8 Poka-Yoke (Error-Proofing)

Poka-yoke is a Japanese term that means mistake-proofing (Url-2). It is a lean technique that prevents errors (human faults like careless, misunderstanding, lack of

concentration, besides lack of standardization, sabotage etc.). Poke-yoka purposes to prevent this kind of errors.

Three types of poka-yokemethods are recognized by Shigeo Shingo to detect and prevent errors in a production. These are:

1. Contact method: It identifies the product defects bytesting the product`s shape; size, colour other physical characteristics.

2. Fixed-value (constant number) method: It alerts the operator if a certain number of movements are not made.

3. Motion-step (Sequence) method: It determines whether the prescribed steps of the process have been followed.

### 4.9 Value Stream Mapping (VSM)

As it is mentioned in the topic of 2.2.2 value stream mapping is a technique that is used to analyze the flow of materials and information required to bring a product or serviceto a customer. In other words the objective of value streaming is to identify the value-added activities and non-value added activities.

There are 5 steps in implementing the value stream mapping. These are:

A. Identify the target product, product family, or service.

B. Draw while on the shop floor a current state value stream map, which shows the current steps, delays, and information flows required to deliver the target product or service. This may be a production flow (raw materials to consumer) or a design flow (concept to launch). There are 'standard' symbols for representing supply chain entities.

C. Assess the current state value stream map in terms of creating flow by eliminating waste.

D. Draw a future state value stream map.

E. Work toward the future state condition

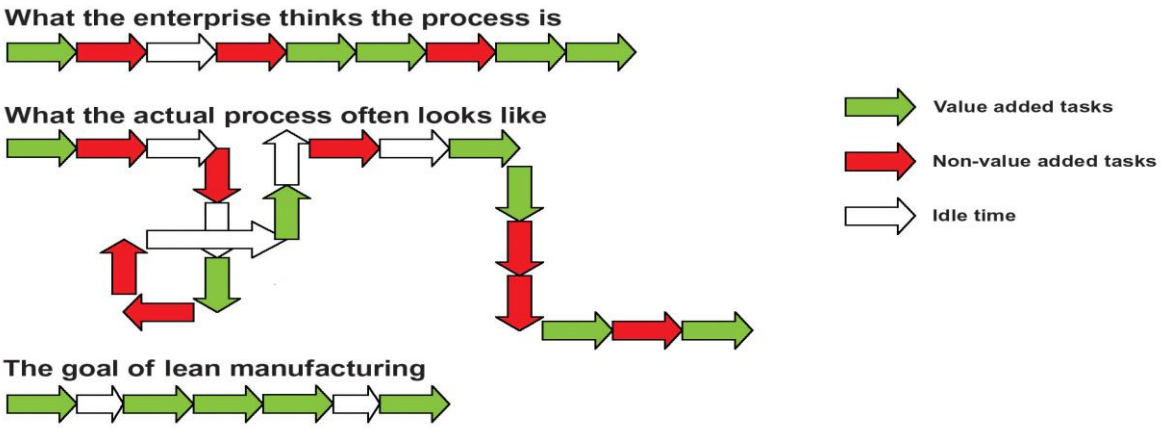



**Figure 4.3:** A demonstration of value stream mapping (deMin, 2007).

### 4.10 Production Smoothing (Production Levelling)

The term comes originally from the Japanese the term heijunka. Heijunka is a concept that decrease production cost by keeping the production as constant as possible from day to day. It is adapted from Toyota production system (TPS).

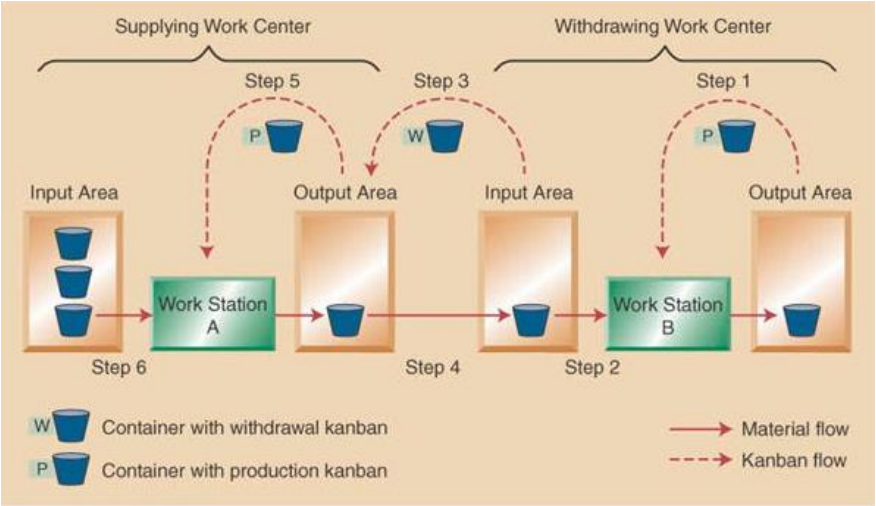



**Figure 4.4:** The smoothing of production (deMin, 2007).

### 4.11 Kaizen Blitz

Kaizen is a philosophy or practices which focus on a rapid or continuous improvement. It is usually a rapid improvement that last daily or at latest a week. It eliminates the hard work (Muri) and teaches employees to use their experiments efficiently on their work. It also teaches the people how to increase productivity. It is a concept that emphasizes the participation of workers in improvement. It covers all

the working levels in an organization from top to down. There are some important points in Kaizen blitz. These are:

- The event should have an “action bias”; that is, no analyzing things to death but some quick data gathering, brainstorming and deciding on solutions, and implementing the solutions. We are not trying to do everything at once—looking for substantial improvement but not perfection.
- Upper management should be involved in deciding what to work on to ensure the project has that level of support.
- The process picked should be something fairly important to lend credibility to the project.
- Some clear objectives should be set such as reducing cycle time or inventory.
- The event should be looked upon as not only making a rapid improvement but the basis for further continuous improvement. That is, this intensive event should begin to engender a cultural change in those involved.
- The success of the first *kaizen* blitz should be well publicized to get everyone in the company thinking “lean.” Additional events should be scheduled.

The typical 5 day in Kaizen is:

1st day:

- Introduction by sponsor
- Introductory Blitz and process training
- Review and refinement of Blitz Project Definition
- 2nd day:
- Process map and walk-through
- Identification of current problems
- Initial data collection
- 3rd day:
- Continue data collection
- Analyse data

- Develop initial views on workable solutions
- 4th day:
- Refine and prioritise solutions for implementation
- Begin implementation of solutions
- 5th day:
- Prepare summary of analysis and solutions
- Prepare plan for continuation of implementation and communications
- Present outcomes and recommendations to Sponsor and other stakeholders

## 5. SIX SIGMA

My dissertation is about Lean. However, nowadays everybody is comparing Lean and Six Sigma as both of them are the dominant ways to develop your production system and product your products more efficiently to compete with the other companies. The point actually is that you should use and integrate Lean and Six Sigma together. This is the reason that I want to mention Six Sigma.

First of all, I would like to give information about the history of six sigma. The development of six sigma can be divided into three periods. First one happened between the years of 1987 and 1994 by the company called Motorola to reduce the defects in production. The second period is between the years of 1994 and 2000 by Honeywell, GE (General Electrics) and DuPont to reduce the production costs. The third period, which providing customer' satisfaction, is still developing. The companies, which are Samsung and Posco, are the major examples of the third period in six sigma.

Shortly, we can say that six sigma is begun with Motorola to compete with the Japanese companies in the beginning of 1980's. In order to accomplish that Motorola made a whole difference in their production system and began to use six sigma under the leadership of Robert W. Galvin (Chairman Emeritus of Motorola, Inc.). In 1989 by the help of six sigma, Motorola won the Malcolm Baldrige National Quality Award. After that award they shared their system (Six Sigma) with the others so other companies have started to be inspired from them and the age of six sigma has begun (Quinn, 2002).

### 5.1 How is Six Sigma Defined by the Companies

I would like to highlight some definitions of Six Sigma across the various companies. Here are some of them:

<u>Motorola: Interview with Robert W. Galvin - Six Sigma:</u>

"Million opportunities, or a Six Sigma level. Our people coined the term and it stuck. It was shorthand for people to understand that if you can control the variation, you can achieve remarkable results."

General Electric: What is Six Sigma?-The Road Map to Customer Impact:

"First, what it is not. It is not a secret society, a slogan, or a cliché. Six Sigma is a highly disciplined process that helps us focus on developing and delivering near-perfect products and services. Why 'Sigma'? The word is a statistical term that measures how far a given process deviates from perfection. The central idea behind Six Sigma is that if you can measure how many 'defects' you have in a process, you can systematically figure out how to eliminate them and get as close to 'zero defects' as possible. Six Sigma has changed the DNA at GE—it is now the way we work—in everything we do and in every product we design."

TRW: What is Six Sigma?:

"Six Sigma is a structured and disciplined, data-driven process for improving business. TRW is committed to the implementation of Six Sigma focusing on how we can dramatically improve our competitiveness by increasing customer focus, enhancing employee involvement, instilling positive change into our culture and ultimately creating bottom and top line growth. At the highest level, Six Sigma is all about satisfying customer needs profitably. It is a highly disciplined methodology that helps develop and effectively deliver near-perfect products and services. It will help TRW in all of our operations, engineering, manufacturing and staff areas."

Honeywell: Six Sigma Plus:

"Six Sigma is one of the most potent strategies ever developed to accelerate improvements in processes, products, and services, and to radically reduce manufacturing and/or administrative costs and improve quality. It achieves this by relentlessly focusing on eliminating waste and reducing defects and variations.

"Leading-edge companies are applying this bottom-line enhancing strategy to every function in their organizations—from design and engineering to manufacturing to sales and marketing to supply management— for dramatic savings.

"Now, Honeywell has developed a new generation of Six Sigma . . . Six Sigma *Plus* is Morris Township, NJ–headquartered Honeywell's principal engine for driving

growth and productivity across all its businesses, including aerospace, performance polymers, chemicals, automation and control, transportation, and power systems, among others. In addition to manufacturing, Honeywell applies Six Sigma *Plus* to all of its administrative functions."

Was Six Part of the Natural Progression of Quality, or Was It a Totally New Event and a New Thrust?:

Bob Galvin: "I think it was both. You could lean either way in terms of the natural intelligence that finally emerged. Was it a great discovery or just remarkably good mathematics and common sense? You can interpret it either way."

Mikel Harry:"I think Six Sigma is now squarely focused on quality of business, where TQM is concerned with the business of quality. That is, when you adopt TQM, you become involved in the business of doing quality, and when you adopt Six Sigma, you're concerned about the quality of business. In a nutshell, TQM is a defect-focused quality improvement initiative, whereas Six Sigma is an economics-based strategic business management system. Didn't start off that way, but it has evolved that way. So I see Six Sigma as a vector change. As I look across the history of quality from the era of craftsmanship, it's fairly continuous; each step is a logical continuance of the preceding step, built off the same fundamental core beliefs and principles, whereas Six Sigma represents a radical departure from that continuum. It's actually a reassessment of quality from a whole new perspective and frame of reference. It's a reinvention of the history, if you will, but it's a birth of a new history, and that's the way to say it. It's been the evolution of a business management revolution."

### 5.2 What is Six Sigma?

The word Sigma originally comes from the Greek alphabet (σ). Nowadays it is being used as a symbol that measures the standard deviation of a process (process variation) which deviates from the overall. Standard deviation is a measurement of dispersion, expansion, deflection and differentiation in a process, organization or service. The number of the standard deviation will increase when there will be more differentiation between the values in a certain process. When the differentiation decreases, standard deviation will decrease as well.

Six Sigma is a methodology that uses a set of statistical tools to understand the fluctuation of a process, management can begin to predict the expected outcome of that process. It is a methodology that also focuses on customer satisfaction. It basically searches the customer's demand and supplyit immediately. It accomplishes that goal by improving the outcome of the entire process by reducing the variation of multiple elements.

Six Sigma methodology uses defects per unit (DPU) as a measurement tool. That is a very good tool to measure the quality of a process or a product. Defects establish a connection between the cost and time. The value of sigma (σ) identifies how often defects occur. The high number of sigma means the less possibility of defection. Defect is anything that causes the customer's dissatisfaction. When sigma increases, the costs and cycle times decrease. That results in the increase of customer's satisfaction.

The ideal situation or the goal for a company is to attain the zero process variation. So basically, 6 Sigma focuses on reducing the process variation. So the question is what is the meaning of 6?

For a process or for a management the value sigma is determined as 690000 defective parts in a million. As we mentioned before the ideal goal of six sigma is to attain zero defects. Nowadays in a company which is operated with six sigma, the efficiency is % 99.9997. In other words, defective parts per million (DPM) is 3.4.

**Table 5.1 :** Levels of sigma.

| The Level of Sigma | The number of defective parts per million |
|---|---|
| 6 σ | 3.4 |
| 5 σ | 233 |
| 4 σ | 6210 |
| 3 σ | 66807 |
| 2 σ | 308537 |
| 1 σ | 690000 |

**Table 5.2 :** Levels of sigma in terms of percentage.

| The Level of Sigma | Sigma Efficiency in Terms of Percentage |
|---|---|
| 6 σ | 99.999966 |
| 5 σ | 99.9767 |
| 4 σ | 99.379 |
| 3 σ | 93.32 |
| 2 σ | 69.1463 |
| 1 σ | 31 |

In this table above you can the percentages for each sigma values. The more sigma values will increase the organization's efficiency in production.

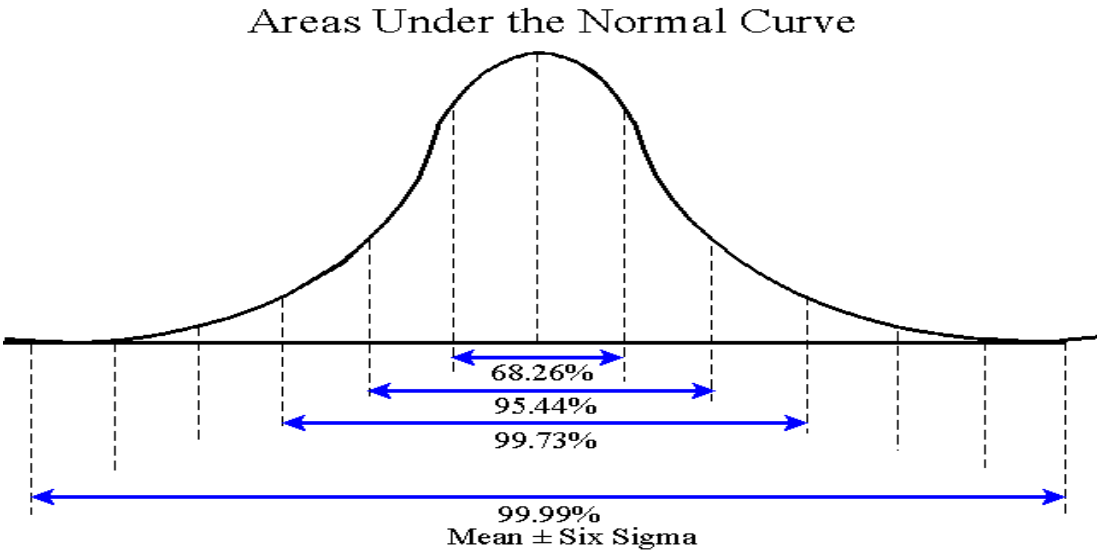



**Figure 5.1 :** Sigma levels demonstrated in graph (Url-3).

### 5.3 Six Sigma Methodology

Basically, Six Sigma has two key methods. These are DMAIC and DMADV. DMAIC improves an existing process. DMADV creates a new product or a process design. DMADV is also named as DFSS( Design For Six Sigma).

### 5.3.1 Dmaic

DMAIC has five significant steps. These are:

**D**efine: In this step, the goals and contents of the project or process are defined. Information about the process and customer are collected. The selected project should be suitable to provide high quality and reduce defects (or waste). The tools that are using in this step are:

- Feasibility plan
- Stakeholders analysis
- Suppliers
- Inputs
- Outputs
- Customers
- Processes
- CTQs ( characteristics that are Critical To Quality)
- Affinity Diagram

**M**easure: In this step, data is collected about the current situation. The main problems and the reasons of the current situation are examined. Collecting the proper data is the key process of this stage to find a solution to the problem. The tools for this step are;

- Plan for data collection
- Form for data collection
- Control cards
- Frequency distributions
- Predicting (Estimating) R&R (repeatability and reproducibility)
- Pareto cards
- Process Sigma
- Sampling

- Prioritization matrix

**A**nalyse: In this step, the data that is collected from the measure stage is verified. Cause and effect relationships are detected and determined. The other process is to ensure that all the factors are considered in this stage. The tools that are using are;

- Affinity diagram
- Brainstorming
- Cause-effect diagram
- Data Collection
- Data plan collection
- Design of experiments
- Flow diagrams
- Pareto cards
- Regression analysis
- Sampling
- Distribution diagram
- Frequency distribution

**I**mprove: In this step, solutions to the problem are developed and changes are made to the process. Results can be seen in this step so the company can decide or judge if the changes and solutions are beneficial. In addition to this, if the changes are not satisfied, the company can decide another set of changes (Dave Nave, 2002). The tools for this step are;

- Brainstorming
- Consensus
- Creativity techniques
- Data collection
- Design of experiments
- Flow diagrams

- Tools for planning
- Stakeholder analysis
- Hypothesis tests

**C**ontrol: In this step, examining applied change plan and results and ensure that any deviations are corrected are the key processes. Furthermore, another goal is to improve the results. The tools that are being used for this step are;

- Control cards
- Data collection
- Flow diagrams
- Frequency distribution
- Pareto cards
- Process quality control cards
- Standardization

### 5.3.2 Dmadv

DMADV is also known as DFSS. It has five primary steps:

**D**efine: In this step, the design goals are defined. While defining those goals customer demands and the initiative strategy should be considered in details.

**M**easure: In this step characteristics that are critical to quality, product capabilities, risks and production process capability in briefly feasibility of the project is defined.

**A**nalyse: In this step analyses are made to develop the production or to design an alternative way to the existing production. The aim of this step is to figure out the best design for applying the six sigma to the organization.

**D**esign: Details are designed and after that the design are optimised. In this step stimulations may be used if it is required.

**V**erify: In this step pilot runs are setup and then production process are implemented and I is given to the process authorities.

### 5.4 The Benefits of Six Sigma

Six Sigma can be implemented to any kind of an organization. There are lots of benefits of applying six sigma to an organization. Briefly these are;

- It reduces the number of defects.
- It reduces the product cost in the rate of %10-25.
- It reduces the production cost in the rate of % 10-40.
- The quality of production and product are increased.
- Customer expectations are defined in a better way.
- It increases the performance of the delivery and quality.
- It enhances the design process performance.
- All the wastes in every processes are minimized.
- It simplifies the production stages.
- It increases the market share.

#### 5.4.1 Examples of organizations that has benefitted by appliying six sigma

In a competitive world you should always open to the innovations and you should always renew yourself and your organization. In this aspect I would like to give some examples of organization that applied six sigma and what benefits did they gain. Here are some organizations that applied six sigma:

- POSCO is a steelmaker company thas troubled in 2000 and it resulted in privatization. After privatizaiton, they started to apply six sigma and all things started to change. They reduced the products and production costs and they became an innovative steel producer. Now, they are the world's third largest company in steelmaking (George Byme et al., 2007).

Ku-taek Lee, Chairman and CEO, POSCO gave a comment as:

*"With increasing globalization, every steel company must innovate to prosper and compete in this new environment. POSCO was in a difficult situation – you might almost say a crisis – a few years ago as we faced this new global competitive threat.*

*As a management team, we felt that Six Sigma was a good vehicle to change all employees' way of thinking, current working styles and mind-sets."*

- After losing the fact of being monopoly ScottishPower in 2001, they were losing their customers. They were searching new ways to gain their customers back. They decided to implement six sigma. After using six sigma in four years they have increased their market share by 60 percent (George Byme et al., 2007).

After this success, Willie MacDiarmid who is the director of Energy Retail, ScottishPower gave a speech abou lsix sigma in one his interview. He said that:

"*I believe the methodology is robust and transferable – it enhances the customer experience, develops my staff and improves the bottom line. If I left ScottishPower tomorrow and joined another company, [this approach] would be one of the first things that I would adopt."*

- In January 2001 Caterpillar troubled by the static growth. They decided to make a change by using six sigma and by 2005 their growth percentage was is in the rate of 80 percent (Byme et al., 2007).

Dave Burritt, who is the Vice President, Chief Financialn Officer of Caterpillar, commented about their success as:

*"It is always about control. 6 Sigma forces you to have the processes and the people accountable to make sure the results are enduring."*

*"You can use 6 Sigma for anything; we used it for Sarbanes-Oxley compliance. When people talk about SOX, they don't know how much it costs them – but we do… because we tracked it."*

### 5.5 The Comparison of Lean and Six Sigma Methodology

In theory, lean focuses on elimination of non- value added activities, waste (Muda) and six sigma focuses on reducing variation in processes in other words it reduces defects.

The phases of lean is identfying value, identifying value stream, flow, pull and perfection. On the other hand, the phases of six sigma is defining a problem, measuring, analysing, improving and control.

Lean focuses on flow, six sigma focuses on problem. Lean assumes that reducing waste will solve the problems in a business and it will improve the business. Six sigma assumes that statistical data and measures are the first essential things to find out and solve a problem. Business will improve itself if variation in all processses can be reduced.

On the other hand, there are some points that are common like less inventory, improving quality.

### 5.6 Conclusion

I mentioned in the beginning of this chapter, why I explained so much about six sigma. So as a proof from the writings above, we can say that lean eliminates non-added value activities and waste from the process. Basically, the most important thing is value for lean. It starts its process with defining the value. While value is important for lean, six sigma improves quality of added-value activities by reducing the variation of the process. Lots of companies are in dilemma because lean manufacturing and six sigma are the most efficient and popular ways to improve an organization make it more profitable and make it enable to compete with other organizations. So they can't decide which one they should choose. In this situation there is a solution to eliminate this dilemma. The solution is called LEAN SIX SIGMA. Lean Six Sigma is a methodology that uses the combination of lean and six sigma philosophies to achieve the optimization of a business. There is a figure below that is modified from the Motorola Six Sigma Research Institute by Lean Sigma Institute. There is also another figure that combines the Lean and Six Sigma (DMAIC which is a method of six sigma that we defined above in topic 4.3.1).

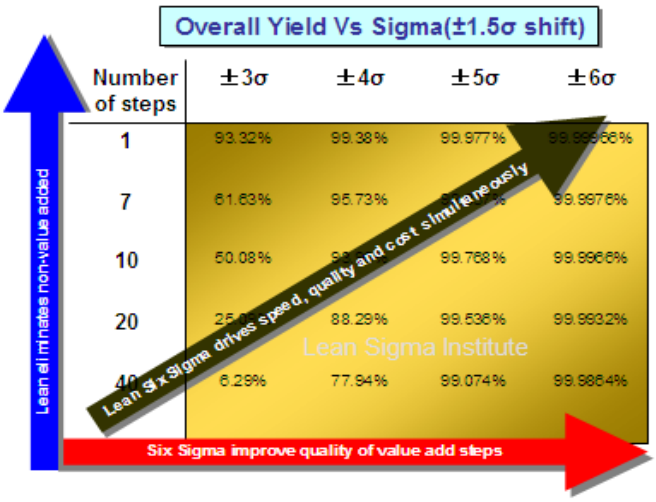



**Figure 5.2 :** Lean Six Sigma (Url-4).

As you can see from the figure above there is a positive effect of using lean and six sigma together. As they both improves the processes mutually, optimization is provided very quickly with more quality and less cost.

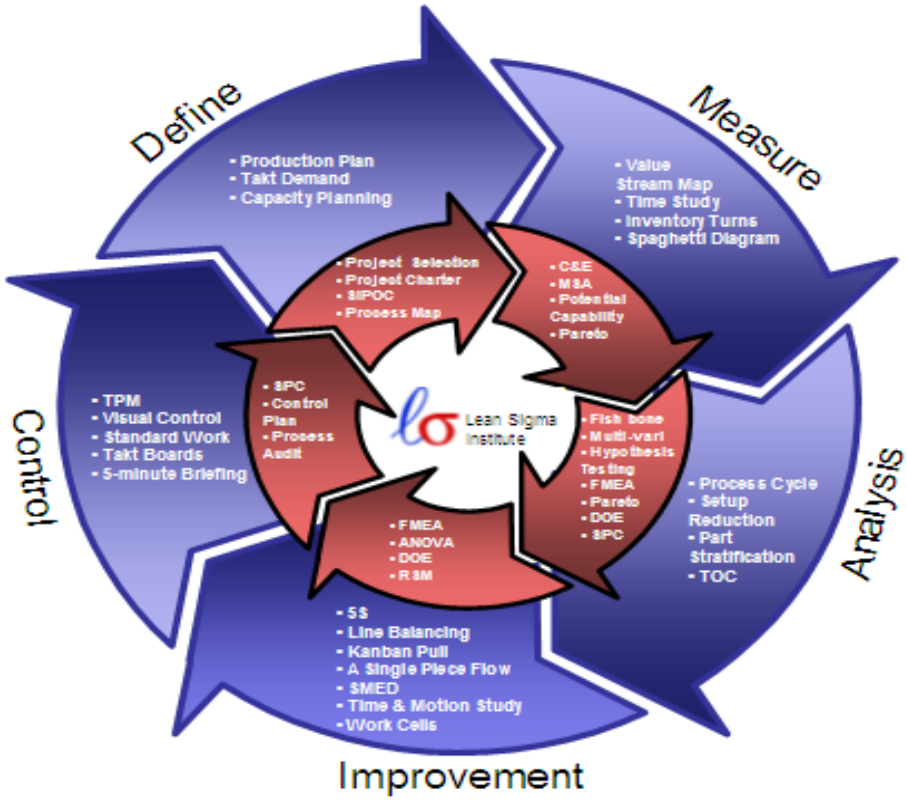



**Figure 5.3 :** Lean and Six Sigma DMAIC Integration (Url-4).

In the figure above, lean manufacturing uses its own tools and principles while six sigma uses its own as well at the same time for the same business. They both work

for the same goal; optimization of the business, make it work more efficiently with less waste and with more quality.

In consequence, using lean and six sigma will improve your system's efficiency faster and you will benefit more, especially for the organization which they are in the branch of industry producing something with machines.

# 6. TURKISH SHIPYARDS AND THEIR ROLE IN THE WORLD

Seafaring in Anatolia (the name of a region inside of the Turkish border) stands up till 1000's.So naval life and ship construction is not very new for Turkey. In this chapter I will not give historical information of Turkey about marine life. I am going to give information but very simple and short about the shipyards in Turkey and their situation in the world shipyards.

## 6.1 Turkish Shipyards

In 2002 the number of the shipyards in Turkey was 32. In 2007 it raised to 62. When we come to 2011 there are now 140 shipyards but due to economical problems 70 of them are in operation. In 2013 it is planned to have 140 shipyards in operation. The major shipyard area with 29 shipyards is Tuzla Shipyards Region in İstanbul (Tuzla Tersaneler Bölgesi). [Gisbir, April 3 2008] Altınova - Yalova is the second major region for the shipyards. The other regions are Gallipoli (Gelibolu), Gölcük and Black Sea Region (Trabzon, Ereğli-Zonguldak are the major cities where have shipyards). Some images from these shipyard regions are shown below.

The capabilities of Turkish Shipyards are;

- 14.6 million DWT repair
- 1.8 million DWT ship construction
- Constructing a ship at maximum 80.000 DWT
- 450000 tonnes steel processing.


**Figure 6.1 :** Image from Tuzla Shipyards Region from the satellite (Url-5).


**Figure 6.2 :** Image of Altınova-Yalova Shipyard Region (Url-5).


**Figure 6.3 :** Image from Eregli-Zonguldak Shipyard Region (Url-5).


**Figure 6.4 :** Image from Gallipoli (Gelibolu) Shipyard (Url-5).

**Table 6.1 :** The number of Turkish Shipyards in operation.

| Year | Number of Shipyards(In Operation) |
|---|---|
| 2006 | 61 |
| 2007 | 77 |
| 2008 | 92 |
| 2009 | 83 |
| 2010 | 74 |
| 2011 | 70 |

In Turkey you can find the three types of physical processes which are construction, repair and scrapping. Most of the scrapping operations happen in Aliağa (İzmir).

There are 19 yards which are doing recycling there (Url-6). Here is an image from Aliağa:

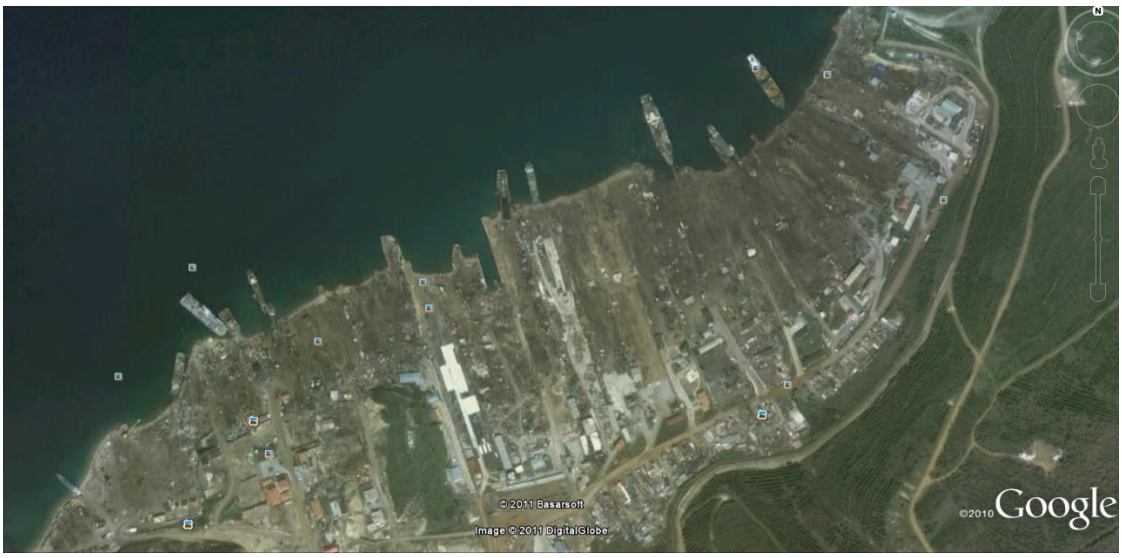


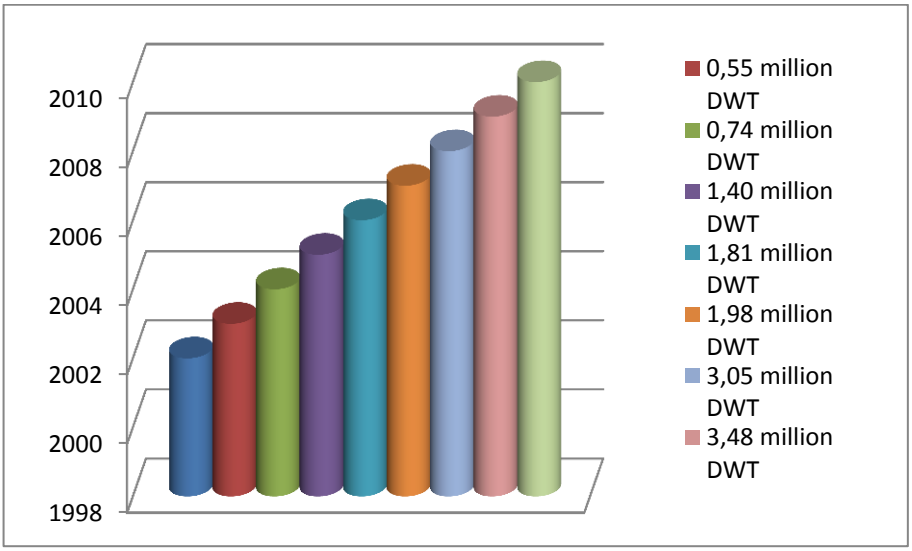

**Figure 6.5 :** Image of Aliaga Scrapping (Recycling) Yard (Url-5).

## 6.2 The Situation of Turkish Shipyards in the World

In recent years if we omit the effects of global economical problems we could say that Turkish shipyards have developed and improved themselves very positively. In 2002 Turkish shipyards were the 23rd in the world. In 2006 with the delivery of 1.8 million DWT ship and yacht, Turkish shipyards became the 8th. Just one year later they nearly doubled themselves and became the 6th in the world. In small chemical tankers they were the 1st. Furthermore, in mega yacht construction they became the 1st in the world in 2008 (Url-7)

In shipyard marketing Japan-South Korea and China had the 96 percentage of the market share (Nowadays, it is still almost the same percentage for these three countries). After these countries in 2008, Turkish shipyards and Vietnam competed for becoming first at the rest of the market share (%4). Furthermore, shipyards grew %89 while Turkish shipyards grew %360 between the years of 2004 and 2008. With this rate of grow, Turkish shipyards shad the %0.83 of the market share of delivered ships in DWT and they had %2.92 of the world market share in pieces of ships in 2008 (Auditing Board of Turkish Republic-Research and Inspection Report, 26/11/2008).

**Table 6.2 :** The change of Turkish Shipyard capacities due to the years. (Auditing Board of Turkish Repuclic-Research and Inspection Report, 2008).




In Turkish shipyards, %86 of the ships are made for the Turkish shipping companies and the rest of them are made for the foreign shipping companies. Table 6.3 shows the types of the ships in numbers that are ordered by the foreign shipping companies in 2008.

According to the table above, it can be said that most of the foreign shipping companies preferred to order chemical tankers. One of the reason for this situation was the regulations that IMO designated. According to these regulations till the end of 2008 all the chemical tankers should be double sided.

Even Turkish shipping companies dominate the rate of the order of ships in Turkey, Turkish shipping companies order to foreign shipyards (outside of the Turkey) is twice times bigger than the entire Turkish shipyards in DWT.

It can be seen from the Table 6.5 and from the data that 84 ships are ordered to Turkish shipyards while Turkish shipping companies ordered 196 ships to the shipyards outside of the Turkey in 2008 which I believe that this is not good evidence even it is a truth that Turkish shipyards are improving and growing.

**Table 6.3 :** The distribution of ship types in numbers that are ordered by foreign shipping companies.

| Type of the Ship | Number |
|---|---|
| Cargo | 1 |
| River Type Tanker | 1 |
| Ro-Ro | 1 |
| Research Vessel | 1 |
| Fishing Vessel | 3 |
| Dry Cargo | 4 |
| Container | 7 |
| Non-Commercial Vessels | 8 |
| Trailer | 9 |
| Open Sea Platforms | 12 |
| Chemical Tankers | 32 |
| Others | 5 |

**Table 6.4 :** The amount of ships, the companies ordered to foreign shipyards (2008) .

| Country | DWT |
|---|---|
| Korea | 6,341,594 |
| China | 5,079,380 |
| Philippines | 1,680,000 |
| Russia | 105,249 |
| Japan | 982,600 |
| Germany | 159,936 |
| Bulgaria | 111,000 |
| Indonesia | 50,300 |

**Table 6.5 :** The number of ships, the companies ordered to foreign shipyards (2008).

| Country | Number |
|---|---|
| Korea | 77 |
| China | 68 |
| Philippines | 13 |
| Russia | 12 |
| Japan | 12 |
| Germany | 10 |
| Bulgaria | 2 |
| Indonesia | 1 |

### 6.3 Conclusion

Turkish shipyards have been improving and developing since 2000 due to IMO regulations about chemical tankers, cheap labour costs, its geographical situation and etc. However, China, South Korea and Japan are the masters in ship construction as they together have %96 of the market share. In 2010, according to the ministry of transport, ship construction industry deployed 45,000 employees and it provided 90000 employee for the supplier indusrty so in total 135,000 employees worked for ship construction industry directly or indirectly (Mühendis ve Makina Dergisi, March 2008). It is obvious that ship construction is one of the best branch of industry for the countries ,that have not completed their economical and industrial development, to set up their economy as ship construction is an industry that works with over than 500 different branches of industry.

If we look at the table 6 and table 7, it can be easily figured out that Turkish Shipping companies order huge numbers of their ships to the foreign shipyards (outside of the Turkey). So it can be said that for ship construction Turkey has own potential as well. In order to improve and develop ship construction in Turkey, first of all these Turkish shipping companies should be attracted to construct or repair their ships in hometown.

As a consequence, Turkey has a great potential to be one of the best ship constructor in the world. In order to do this, Turkey has to find ways to compete with the other

master ship constructor countries. The best and the most feasible way would be competitive is to implement lean manufacturing into Turkish shipyards.

# 7. LEAN MANUFACTURING IN TURKISH SHIPYARDS

The best way to observe the lean manufacturing in Turkish shipyards would be obviously to go and survey in the place (in Turkey). So 3 shipyards have been visited in Turkey to observe the existence of lean manufacturing. To say the truth I would like to go more shipyards as more shipyards will make my comments and report more realistic. However, some of the shipyards are constructing navy ships that they hide processes from public and from the rest of it, most of the shipyards do not let students in as students do not have working insurance.

The name of the shipyards, that I have been, are Girgin Kale Tersanesi (Girgin Kale Shipyard), Kocatepe Tersanesi (Kocatepe Shipyard) and Beşiktaş Tersanesi (Beşiktaş Shipyard).

## 7.1 Kocatepe Shipyard (Kocatepe Tersanesi)

Basically Kocatepe Shipyard, which does construction and repair in the same place, is in Tuzla in Istanbul. They also have another shipyard in the name of Kocatepe Denizcilik ve Gemi İnşa. Tic. Ltd. Şti.. I have surveyed their second shipyard where is located in Altınova-Yalova. This shipyard is built around 40,000 $m^2$ area. The length of the shipyard is 300 meters and it has 130 meters berth. There is a close fabrication area in the dimension of 50 m. length and 55 m. Width and in this working area there are three overhead cranes with capabilities of 60+20 tonnes, 20+10 tonnes, and 10 tonnes and there is also a 8,5*40 m. of CNC cutting workshop. Furthermore, there is a hydraulic press with a capacity of 600 tonnes and width of 8 meters to ease the construction. There are also two mobile cranes (90 tonnes and 40 tonnes of lifting capacity) and two forklifts (7 tonnes and 10 tonnes of capacities). There is also a box and eccentric press for Holland profiles.

Nowadays there are three project which are two 4400 DWT bulk carriers and a 3000 DWT container ship that are in construction (Url-8).

### 7.2 Girgin Kale Shipyard (Girgin Kale Tersanesi)

Girgin Kale Shipyard is located in Altınova-Yalova. They have the capability to construct a 15,000 DWT of ship. They also have place to give maintenance and repair service. Right now there are three ships in small sizes in construction. It has a slipway (gantry) in the dimension of 144 m. length and 22 m. width (Url-9)

### 7.3 Besiktas Shipyard (Beşiktaş Tersanesi)

Beşiktaş Shipyard, which belongs to Besiktas Group, started its ship construction work in 2002. Between the years of 2002 and 2009 they have delivered 21 projects which is mostly ordered by customers from Europe. It has been located in 120,000 $m^2$ (35,000 m2 of it is closed area) of total area in Altınova-Yalova. It has 1200 meters of total berth with draft range of 8 meters to 16 meters (Url-10).

There are two docks which one of them is graving dock and the other one is floating dock. Graving dock has 92,000 DWT of capacity with 235 meters of length. Width is 40 meters with maximum draft of 6.5 meters. The graving dock is equipped with two gantry cranes with the capacity of 35 tonnes, a 40 tonnes Jib crane and a 10 tonnes tower crane. Floating dock facilities are; 92,000 DWT of capacity with 230 meters of length and 37 meters of width. Maximum draft of the floating dock is 7.5 meters. It has a 20 tonnes jib crane and a 15 tonnes crane (Url-10). There is a 2100 $m^2$ of storage facility which is managed by an online stock program that makes the yard to ease the logistic services for ship and repair.

### 7.4 Observations Depended To the Three Selected Turkish Shipyards

I believe that the best way to demonstrate the existence of lean is showing photos. So in this section there will be images that are taken individually from the shipyards that have been and below or above these images, there are going to be comments when it is necessary.

#### 7.4.1 Observing kocatepe shipyard

Kocatepe Shipyard has been observed by the help of Erbil Aksöz, who is working for Kaptan Paşa Shipping (Kaptan Pasa Denizcilik) which has a ship to be constructed in

Kocatepe Shipyard, is the project manager for Kaptan Paşa Shipping. Here are the images from this shipyard:

**Figure 7.1 :** An image from Kocatepe Shipyard.

One of the key methods of lean manufacturing is the kanban systems. Kanban cards ease to name the materials and it helps to control the number of parts that are produced. In this image above (figure 7.1) it can easily be obtained that there is not any naming. Furthermore, it just stands in the middle of the working area (just next to the ship that is being constructed). That can cause problems like confusion about where it is going to be fitted or it may be damaged as it is just standing on the working area without any protection. It also occupies a place in the working are that limits labouring.

**Figure 7.2 :** An image from Kocatepe Shipyard.

The figure above is another of proof of the lack of lean manufacturing. There is not any information about the materials again and they are just standing on the working area.

**Figure 7.3 :** An image from Kocatepe Shipyard.

As it can be seen from the figure 7.3, all pipes and materials stand without any arrangement. They seem like they do not have function in the production process even they have or not. I believe that this is a great example of lack of lean. This image also confronts to 5S. One of the phases of 5S is cleanliness or sweeping or shine (Seiso). In this image it can be said that the employees do not keep the working area clean.

**Figure 7.4 :** An image from Kocatepe Shipyard.

The image above (Figure 7.4) is a good example of lean. There is not any unnecessary staging, materials or tools. On the other hand in figure 21 below that has been taken from the other side of the ship, there are lots unnecessary cables for welding, grinding or tempering that limits the working area.

**Figure 7.5 :** An image from Kocatepe Shipyard.

There is another image below (figure 7.6) that confronts to 5S again. One of the phases of 5S is setting in order or straightening (Seiton) that provides a place for everything in the right place in the right time. As it can be seen from the figure, these materials are far away from working area and there is not any information about the materials where and when they are going to be used for production. So I think that this is a good example of lack of lean. In this figure there are also some pieces of materials (sheet iron) that look like the remaining parts of the sheet iron after cutting that are not necessary. The most important and the first goal and principle of lean manufacturing are the elimination of the waste in a production process. It is obvious that figure 7.6 is a proof of lack of lean.

**Figure 7.6 :** An image from Kocatepe Shipyard.

### 7.4.2 Observing girgin kale shipyard

Girgin Kale Shipyard has been observed by the help of Ramazan Girgin who is the owner of this shipyard. Here are the images from Girgin Kale Shipyard:

**Figure 7.7 :** An image from Girgin Kale Shipyard.

In figure 23 above, it can be seen from the image that there is not any information about the materials (confronts to Kanban System). Furthermore, this situation runs also against one of the phase of 5S which is set in order (Seiton). There is no arrangement in laying materials.

**Figure 7.8 :** An image from Girgin Kale Shipyard.

This is a good example of demonstrating lack of elimination of waste. However, these wastes are just next to the working area, not outside of the shipyard. As it is known well that eliminating waste is the key point of lean manufacturing. These wastes prevent employees to work efficiently.

**Figure 7.9 :** An image from Girgin Kale Shipyard.

In this image (figure 7.8), there are three employees that are working. Actually one of them is working and the other ones are looking at him. This is totally waste in lean philosophy. Lean manufacturing principles believe that workers should be focused on a work that they are qualified and there should not be any worker that is needless or non-working in the processes. In this situation two employees out of three are waste. So this is a good example of lack of elimination of waste.

In the figure 7.9, there is an image from stockpiling. Kanban systems are the most key method of stockpiling (but not like mass production) in lean manufacturing. There should be shelves that divide different types of materials from each other and Kanban cards defining materials' functions and usages. However, as it can be seen from the image that different type of materials are stocked in the same places without any definition.

**Figure 7.10 :** An Image from Girgin Kale Shipyard.

### 7.4.3 Observing besiktas shipyard

Beşiktaş Shipyard has been observed by the help Doğan Gökçe (production engineer in design department) and Bahadır Acartürk (planning engineer). Here are the images:


**Figure 7.11 :** An image from Besiktas Shipyard.

This is a very good example of lean philosophy (Figure 27). Kanban systems have been applied very well. All different types of materials are stored in different shelves with their definitions stuck on them.

**Figure 7.12 :** An image from Besiktas Shipyard.

As it can be seen from the image above (figure7.12) all materials are set in order or it is a suitable example of cellular manufacturing that ease the flow of work.


**Figure 7.13 :** An image from Besiktas Shipyard.

### 7.5 Interviews

Commenting up to photos would not be enough to search for the existence of lean manufacturing in Turkish shipyards. I did not go on questionnaire as questionnaire always takes too long to collect as they are generally done by sending e-mails and most of the time feedback is too hard. So, interviews have been made in these 3 shipyards to observe lean in Turkish Shipyard more efficiently. 10 questions have been prepared that cover the fundamental principles of lean as much as it can. Questions are limited at amount of ten to keep the interviewee's concentration at maximum.

#### 7.5.1 Interview at kocatepe shipyard

The interview has been made with Erbil Aksöz , who is working for Kaptan Paşa Shipping (Kaptan Paşa Denizcilik) which has a ship to be constructed in Kocatepe Shipyard, is the project manager for Kaptan Paşa Shipping. Here are the questions and the answers:

1. Have you ever heard about lean manufacturing?

No, I have not.

2. Are the suppliers successful at delivering materials?

Yes, they are good at delivering goods.

3. Are the suppliers' materials qualified or have you detected any defects so far?

The materials are qualified. Sometimes we detect defects.

4. What is your frequency of using domestic materials?

I can see that the %30-40 of our materials are domestic sourced.

5. Are domestic goods qualified?

It is enough.

6. What do you think about innovative developments?

There is not any effort from the shipyard. If customer demands then we supply it.

7. How often do you train your employees?

There are training sessions monthly.

8. Is there any pursuing, motivating and awarding?

There is pursuing and motivating but there is no awarding.

9. Do you provide technical support at solving problems (know how knowledge)?

Technical support is provided by our engineers. If they are not sufficient, we cooperate with the classification society.

10. How is your stockpiling and how long does a material wait to be manufactured?

We have a storage area. The regular materials wait a month at most. Some special materials which are ordered from outside of Turkey may wait up to 2 months.

### 7.5.2 Interview at girgin kale shipyard

The interview has been made with Ramazan Girgin who is the owner of the Girgin Kale Shipyard. Here are the questions and the answers:

1. Have you ever heard about lean manufacturing?

No, I have not heard lean manufacturing before. What is that?

2. Are the suppliers successful at delivering materials?

We do not have any problems with the suppliers.

3. Are the suppliers' materials qualified or have you detected any defects so far?

European materials are the best but they cost three times more than the domestic materials. Turkish materials are good well qualified though.

4. What is your frequency of using domestic materials?

The %60 of our materials are domestic sourced.

5. Are domestic goods qualified?

It is enough.

6. What do you think about innovative developments?

We do not pursue innovative developments oftenly.

7. How often do you train your employees?

We train our employees 5-6 times in a year.

8. Is there any pursuing, motivating and awarding?

There is pursuing and motivating but there is no awarding.

9. Do you provide technical support at solving problems (know how knowledge)?

Technical support is provided the engineers.

10. How is your stockpiling and how long does a material wait to be manufactured?

The materials are stored in the specialized storage. Generally, the materials wait up to 30-40 days.

### 7.5.3 Interview at besiktas shipyard

The interview has been made with Bahadır Acartürk who is the planning engineer at Beşiktaş Shipyard. Here are the questions and the answers:

1. Have you ever heard about lean manufacturing?

No, I have not heard lean manufacturing before. What is that?

2. Are the suppliers successful at delivering materials?

Yes, they are quite successful at delivering goods.

3. Are the suppliers' materials qualified or have you detected any defects so far?

The materials that have been ordered from outside of Turkey are best qualified. However, Turkish materials are better than Chinese materials. European materials are the best. Briefly, the quality of material depends to its cost.

4. What is your frequency of using domestic materials?

I can say that the %30-40 of our materials are domestic sourced.

5. Are domestic goods qualified?

It is enough.

6. What do you think about innovative developments?

There is not any effort from the shipyard. If customer demands then we supply it.

7. How often do you train your employees?

There are training sessions monthly.

8. Is there any pursuing, motivating and awarding?

There is pursuing and motivating but there is no awarding.

9. Do you provide technical support at solving problems (know how knowledge)?

Technical support is provided by our engineers. If they are not sufficient, we cooperate with the classification society.

10. How is your stockpiling and how long does a material wait to be manufactured?

We have a storage area. The regular materials wait a month at most. Some special materials which are ordered from outside of Turkey may wait up to 2 months.

## 8. IMPLEMENTING 5S TO ADA SHIPYARD

After all, an implementation will definitely strength the topic and I believe some questions will be answered clearly. To achieve this, I would like to do an implementation to a shipyard called Ada Shipyard and my implementation will be 5S. It is going to be done so as the best way in implementation is first to try to implement a way of lean manufacturing in an department/workshop and make people to see the benefits of it and then to promote companywide. Ada Shipyard locates in Tuzla Shipyard Region. Unfortunately, this implementation is going to be theoretical since, I am not working in that shipyard (means there is no promotion to take charge) and even you have the power, it is too difficult to change people's behaviour. So it is impossible to implement 5S while you are not a part of the organization. As a solution to that issue, I will make a work on 5S and implement it to Ada Shipyard theoretically. To prevent misunderstanding, all work is for the pipe workshop not for all departments.

Even the steps may vary according to different industrial branches, a standard set of introduction stages could still be applied. The steps, which are shown below, also lead us in implementing 5S into Ada Shipyard.

Step 1: Establish a 5S Promotion Organization

An organization should be promoted for 5S implementation and this organization must be supported by company's managers to apply implementations companywide.

Step 2: Establish a 5S Promotion Plan

5S implementation is an endless activity. To provide continuity, the best way is to schedule implementation yearly.

Step 3: Create 5S Crusade Materials

Company mangers should take charge in determining materials for the implementation.

Step 4: In-house Education

Every employee should be educated and taught the importance of 5S and its benefits.

Step 5: 5S Implementation

This step covers the implementation of five Ss in the company which are red-tagging and the signboard strategy for visual orderliness.

Step 6: 5S Evaluation and Follow-up

In order to deformation in 5S, 5S evaluations should be done to check, maintain and improve 5S conditions. Also step 4 and step 5 should be repeated to pursuit perfection.

First of all, to see the general view of the workplace, in which 5S is going to be implemented, there are some images of the workplace are shown below:

**Figure 8.1 :** A view from piping workshop of Ada shipyard.


**Figure 8.2 :** A view from piping workshop of Ada shipyard.

**Figure 8.3 :** A view from piping workshop of Ada shipyard.

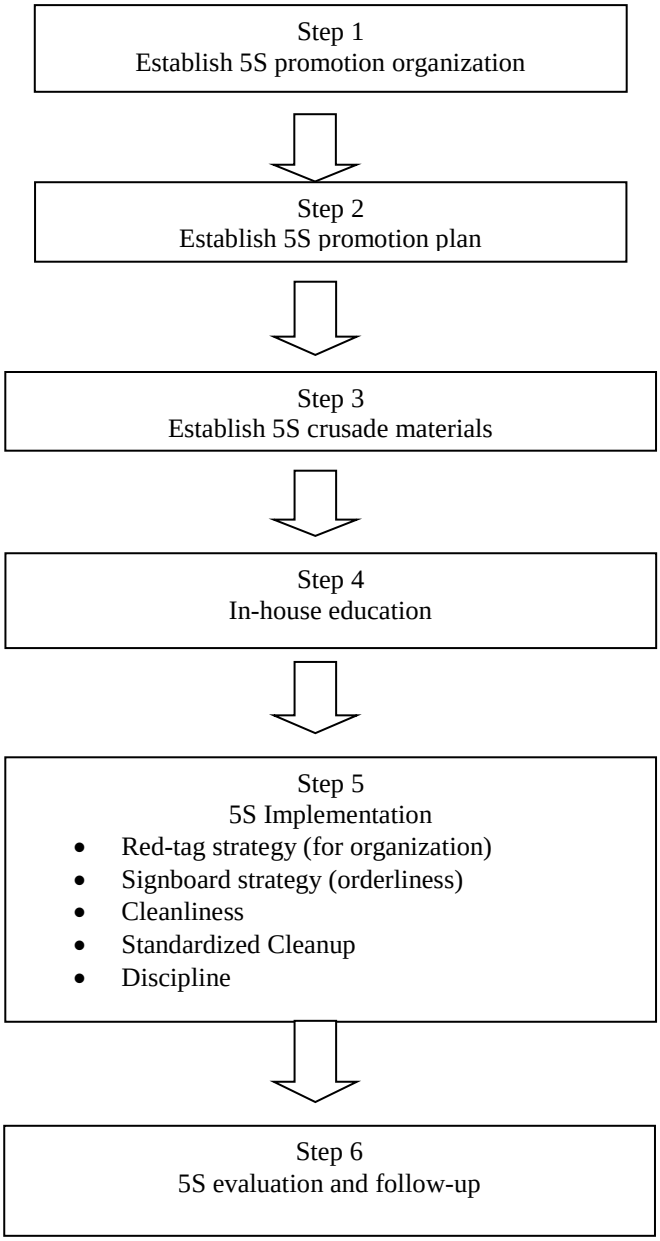



**Figure 8.4 :** 5S introduction steps.

## 8.1 Establishing the 5S Promotion Organization

In order to implement 5S to company, an organization should be established. Organization should determine its methods in implementation and make the plans and this organization should be announced by the top managers as to provide authorization in giving order. A promotion organization should simply be as below:

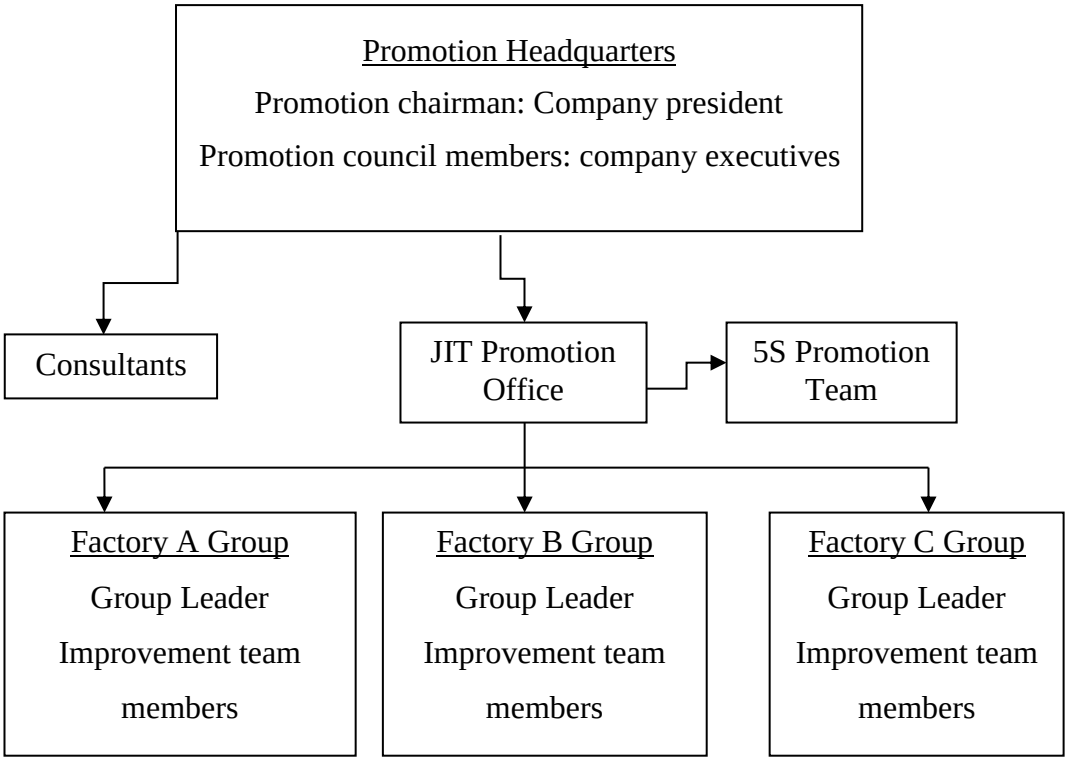



**Figure 8.5 :** 5S promotion organization

- Promotion Headquarters

5S implementation is entirely a reform in a company so this action must be led by top managers. So Mr. Adil Erkoç and Mr. Murat Erzaim must lead the reform in Ada Shipyard.

- JIT Promotion Office

JIT promotion office leads the promotional and instructional activities. The staff should be capable to understand how information and goods flow in the company and also has the ability to apply basic industrial engineering techniques.

- 5S Promotion Team

5S promotion team is simply a subcommittee of JIT promotion team. They do the activities on site such as 5S educations, discipline training, 5S standardization, leading 5S techniques and providing 5S tools.

In Ada Shipyard, there is not enough staff and engineers to establish an organization as shown above. Due to that reason simpler organization, which provides minimized number of people, should be established in Ada shipyard as it is shown below.

**5S Leader** goes to the factory manager or CEO,who is Mr. Murat Erzaim, should lead the 5S reform. **5S Patrol** member is the piping workshop manager who answers directly to factory manager. He (as I have seen him) also makes weekly or biweekly inspection tours to check up on 5S conditions and suggests solutions when deterioration on conditions have been begun.**5S Council** are the brain of the organization. The members are the most specialized at implementing 5S. **5S Action Team** consists of workshop leaders (foreman) and ordinary employees that are really doing the job- study the 5S theory and putting it in practice-.**5S Engineering Team** supports the 5S action while technical issues are occurred.

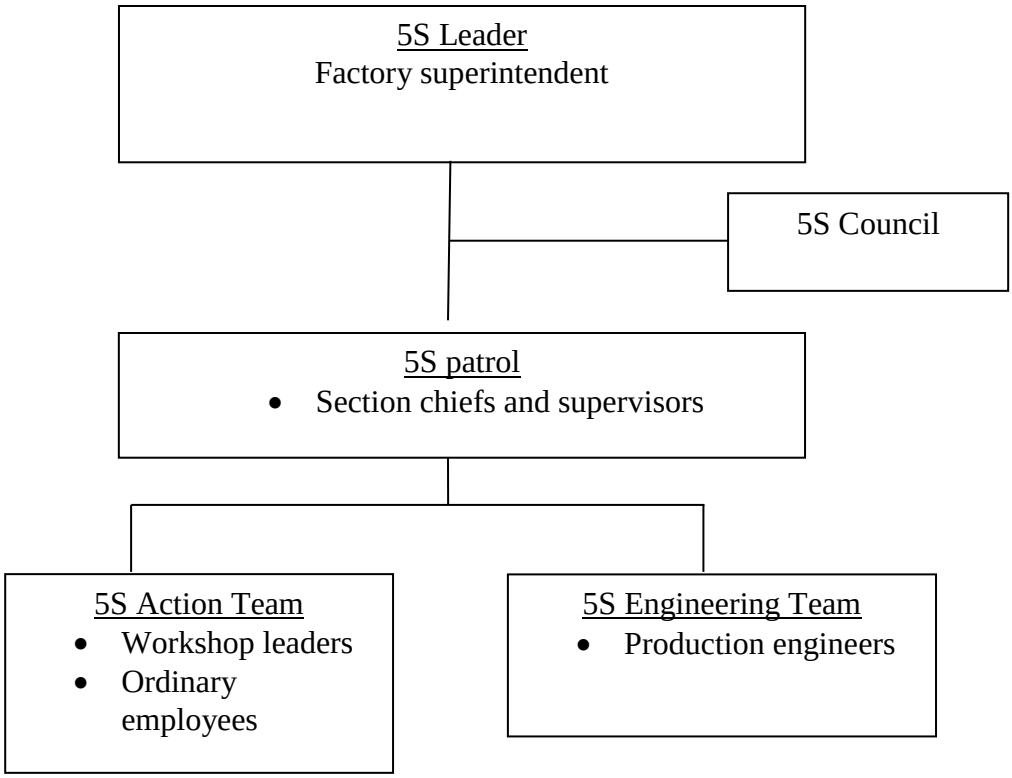



**Figure 8.6 :** Compact 5S promotion organization for Ada Shipyard (Hirano, 1990).

### 8.2 Establishing 5S Promotion Plan

Some people think that 5S implementation is a steady reform. They think once you implement it, it is enough. That is totally a misunderstanding. Every employee should know that 5S is a never-ending progress. As new products are brought then new machines or equipments, new layouts and new staff assignments will be required that means 5S will automatically change.

In order to achieve in 5S, company should designate its plan in implementing and the plans should cover only periods of one or two years. The suitable promotion plan for Ada Shipyard is shown as below:

**Table 8.1 :** S promotion plan for Ada Shipyard.

| Month/Year / Promotion Topic | Education and Training | | | Basic Practice | | | | | | Spin-off Development | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 |
| 1. 5S Booster Months | 5S campaign materials | | Red tagging month | | Sign board month | | Equipment cleanliness month | | | Workplace cleanliness booster month | | | |
| 2. 5S Staff Operations | 5S studies<br>Draft 5S schedule | Make campaign posters<br>Write 5S manual | | 5S standardization | | | 5S photo exhibit | | | 5S photo exhibit | | 5S schedule for the second year | |
| 3. 5S Report Meetings | Red tag reports at the end of month 9. Signboard reports at the end of month 10. Year review on 5S activities at the end of the year. | | | | | | | | | | | | |
| 4. 5S Factory Inspections | Tour by 5S Leader at least three times in a year. Tour by 5S patrol every month. | | | | | | | | | | | | |
| 5. Education and Training | Education for offices | | Education for red-tagging applications and signboard strategies | | Education for employee on orderliness | | Education for employee on cleanliness and cleanup | | | Education on 5S case studies | | Education for offices to improve 5S | |
| 6. Factory Study Tours | Tour for manager and 5S Leader | | | Tour four 5S patrol | | | Tour for 5S Action Team | | | | Tour for 5S Action Team | | |
| 7. Major Cleanup Performances | First major cleanup | | | | Second major cleanup | | | | | Third major cleanup | | | |
| 8. 5S Brochures | A brochure should be distributed at least every two months. | | | | | | | | | | | | |
| 9.Model 5S workplace | It is not suitable as implementation is applied on a department. So implementation place is actually a model workplace in this case. | | | | | | | | | | | | |

### 8.3 Establishing 5S Campaign Materials

After completing the first two steps, the next step is to start 5S activities. There are lots of materials that you can announce the reform to the employees. However, if Turkish ordinary workers' attitudes to innovation is considered the best way is that Mr. Erzaim better Adil Erkoç should collect the workers and executive management and announce it. Ada Shipyard is not a big company and if the total number of employees working in piping workshop, which is 20, is considered, it is not an issue to have face to face meetings.

The best format is to have monthly meetings and 5S Leader should show his enthusiasm. At the meetings, leader should describe the company's current conditions and goals and the plan to achieve the 5S implementation.

After face to face meetings if it is believed that employees are also believed the struggle, better way is to press instructions and brochures monthly.

### 8.4 In-house Education

Announcements or meetings by president or top managers to ordinary employee probably will not be sufficient to make them understand the importance of 5S for the future of the company. For that reason employees should be educated perceptibly.

There are some tips that 5S council may follow while giving lectures. First one is to make the education continuous as neither 5S nor Lean Philosophy is a steady action. Secondly, they should never expect the excellence. They should sometimes admit that they have implement 5S's. Thirdly, they should make the employees understand that they are the ones to apply 5S. Another point is that they should encourage employees to think and try to give suggestions for the implementation as they know the practice better than 5S council. The last but not the least, they should motivate employees and encourage them to improve their skills.

### 8.5 Implementation

First of all, starting with company managers everybody should really understand that 5S is a continuous development and it has always to be improved. So it should be

become aware of that once you have started 5S, there is no way to stop it. If it stops, then you have to start from the beginning.

### 8.5.1 Organization and orderliness

First S is **Organization**, however I do not recommend to apply organization alone. The implementation will definitely be more successful if organization and orderliness are applied together. Thus, first tip is to apply **Organization/Orderliness Strategy**. Most of the companies do not realize that detail and apply these two S's separately.

The first step is to get rid of everything that is unnecessary. To do this, Ada Shipyard should categorize necessary and unnecessary things according to the figure 37.

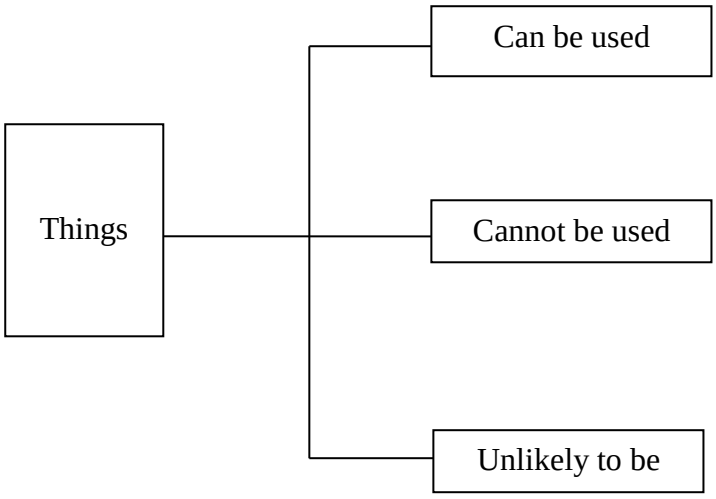



**Figure 8.7 :** Categorizing necessary and unnecessary things (Hirano, 1990).

Materials, which are not used, even it expensive or not, they are wastes for the company. They must be thrown away or they must be sold immediately. For materials that are unlikely to use (they are not being used now but may be used later), they should not be kept in working area. They may be kept in a storage area.

While doing this organization **red-tag strategy** is the most efficient method to eliminate unnecessary things. There are some steps that has to be followed to do red-tag in the right way. First, company should identify red-tag targets. These targets are inventory, equipment and space. We must be especially careful about inventories wasting clutter and inventories having no specified locations. Secondly we must define criteria for red-tag by determining what is needed and what is not. Then make the red-tags but the size of the red-tag paper must be as big as or bigger than standard

piece of paper as to attract attention. After that, put red-tags on materials without any doubt. Finally, make lists to throw the materials away.

| | | |
|---|---|---|
| **RED TAG** | **AREA** | **TAG#:** |
| **CATEGORY (circle one)** | | |
| **Supplies** | **Raw Materials** | |
| **Office Materials** | **Finished Goods** | |
| **Furniture** | **Tools** | |
| **Books/Magazines/Files** | **Equipment** | **Other:** |
| **Date Tagged:** | | **Tagged by:** |
| **Item:** | | **Quantity:** |
| **Reason:** | | |
| **Action to take(circle one):** | | |
| **Discard** | **Sell** | |
| **Store in Area** | **Transfer** | |
| **Long term Storage** | **Other:** | |
| **Additional Comments:** | | |

**Figure 8.8 :** A suitable red-tag format for Ada Shipyard.

While putting these red-tags, the activation should be fully supported by top manager. Figure 39 illustrates red-tag in Ada Shipyard. In this figure the bucket and things inside of it is not used by anyone and will never be used. It is fully waste.

There are some examples below from Ada Shipyard that 5S patrol can categorize them unnecessary. In Figure 40, the materials are not used in piping workshop. These materials are for shipbuilding at the stage of hull construction. So for the shipyard those materials are necessary, but for piping workshop they are unnecessary. So they must be thrown away from the piping workshop working place and put to another suitable place. The sheet metals are not going to be used in Figure 41 at any stage of shipbuilding and they stay at piping workshop. Thus, they must be thrown away.

**Figure 8.9 :** Red-tag in Ada Shipyard.

**Figure 8.10 :** An image from Ada Shipyard's piping workshop.

**Figure 8.11 :** An image from Ada Shipyard's piping workshop.

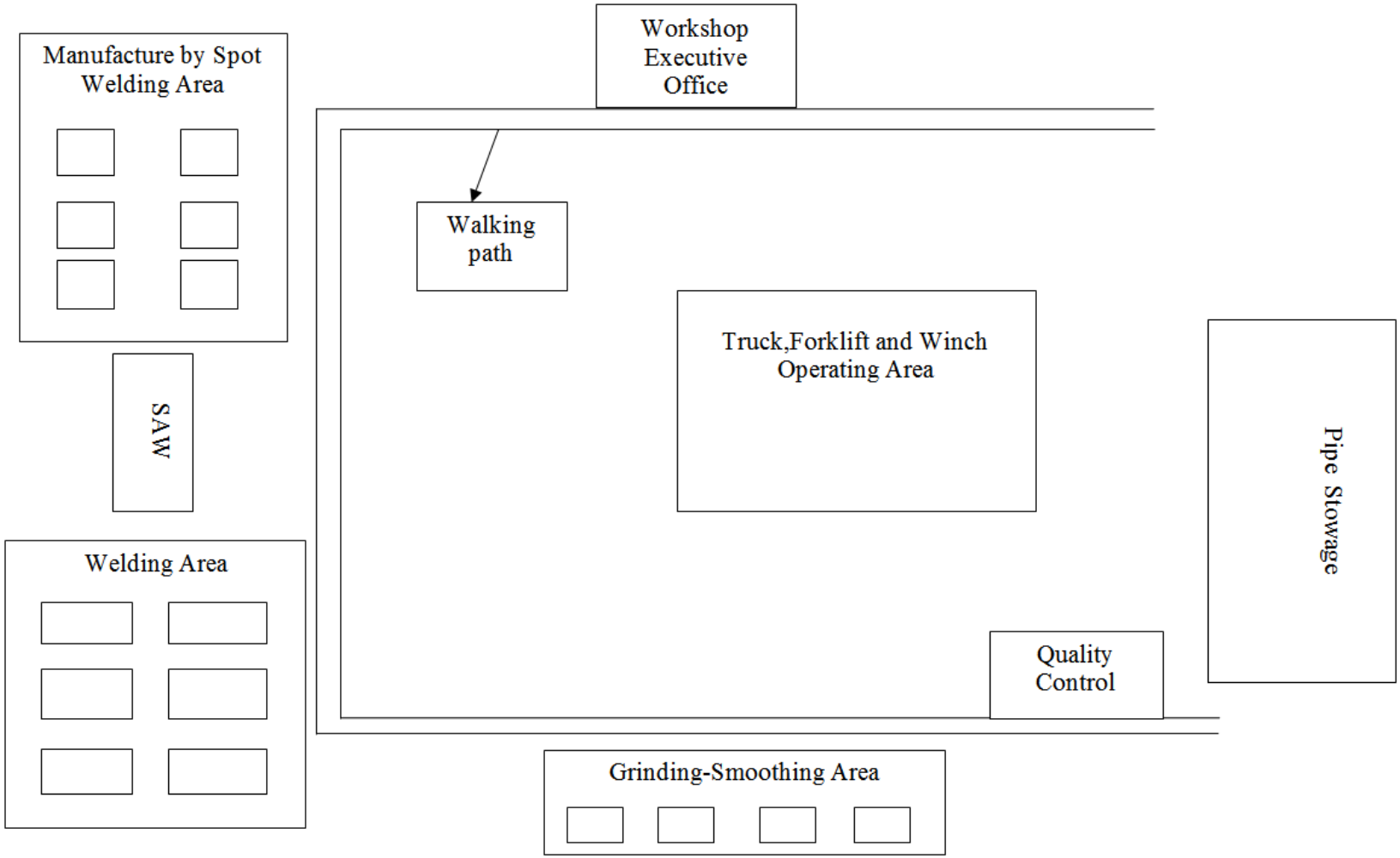



**Figure 8.12 :** Recommended layout for Ada Shipyard.

Another crucial point is to organize the working places and working paths at the workshop. For this issue, I do recommend a layout that is shown above on Figure 42.

The difference between current situation in Ada shipyard and the layout above is that there is no walking path. So employees walk everywhere which increases the risk of accidents. The other one is there is not a particular area for operating trucks, forklift and winch. They are operated at where the operators find gaps. Furthermore, other working areas seems to be organized but working tables are not organized properly. They must be close each other (close enough without providing danger to each other) as to gain space and to maintain orderliness.

After removal of wastes, needed items should be put in order to increase efficiency in production. The best method to achieve this is **signboard strategy.**

Signboard strategy is simply a method to arrange and indicate items in the most efficient way. There is a simple procedure to do signboard in the right way. First, Ada shipyard should decide where to place items. They must choose closer places to help employees to work efficiently. After that, shelving and cabinets should be organized in their specified places. Put the signboards which indicate the item where they belong to. Also signboard shall cover item names and the number of the shelf or cabinet where items will be kept. Then maximum and minimum amounts should be covered by signboard. Finally, Ada Shipyard should prevent deterioration of orderliness and keep this strategy as a habit. The signboard strategy procedure is shown in Figure 43.

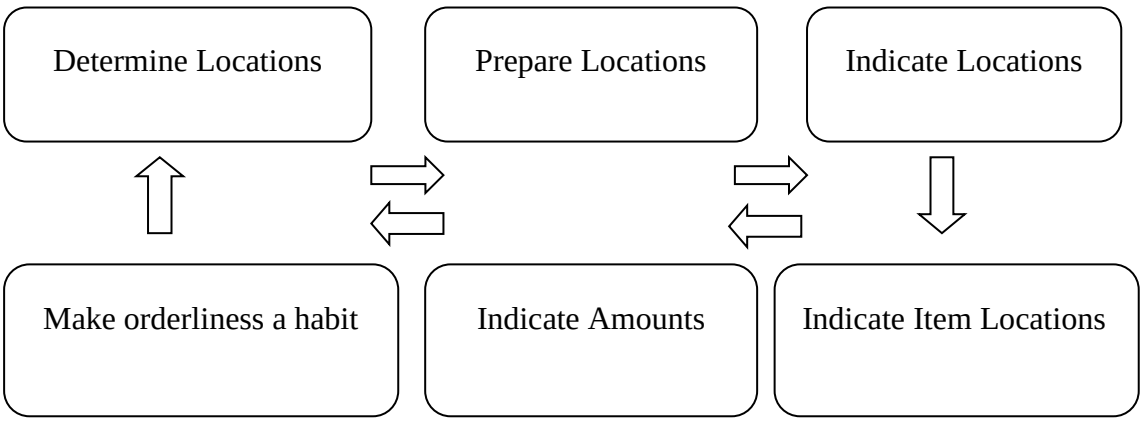



**Figure 8.13 :** Signboard strategy stage.

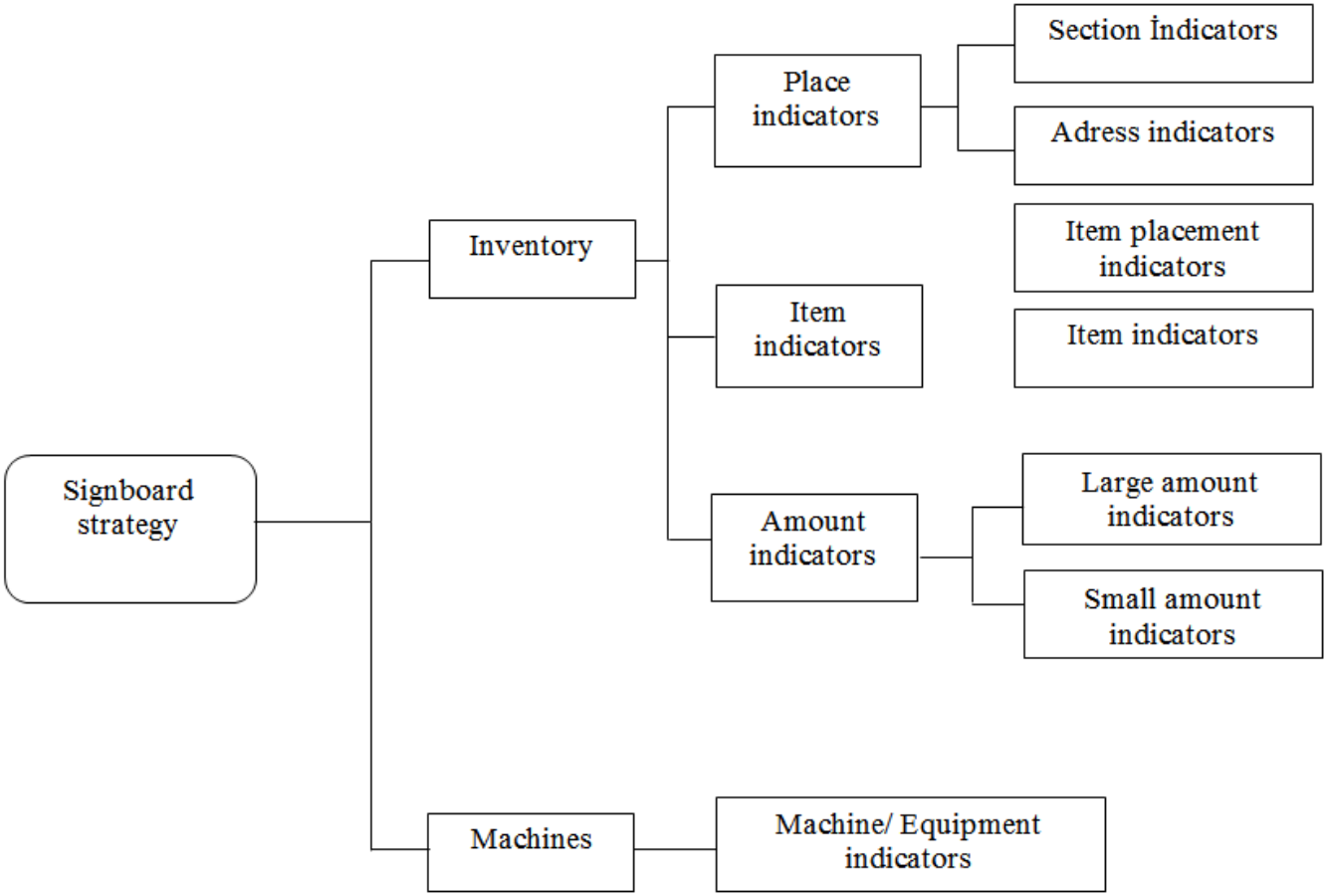



**Figure 8.14 :** Overview of visual orderliness using the signboard strategy (Hirano, 1990) .

Ada Shipyard should notice some tips when applying signboard strategies. These are:

- Use perpendicular display. It helps people to see signboards from distance.
- Divide items into sections.
- Use vertical and horizontal address signboards.
- Put maximum and minimum inventory amount limits on the shelves. This will help you to make schedule in ordering or producing the relevant item.(Just-in-time production)
- Every tool(welding machine ,keys, hammers, bolts, nuts etc.) should have a specified place.
- Make reports after each signboard application.

**Figure 8.15 :** An image from Ada Shipyard.

Figure 45 shows how wrong the staff storing items. There is no signboard on boxes so people should open the boxes to understand which item it is inside every time. That is huge amount of waste of time!

In figure 46, there are no signs for wrenches, so it can be seen that some wrenches are not placed and nobody can know which wrenches are missing. Also the boxes

underneath the table are just put disorderly. Even necessity of the boxes is not known. First, Ada Shipyard should do red-tagging for the boxes and then apply signboard to the tables and items on it.

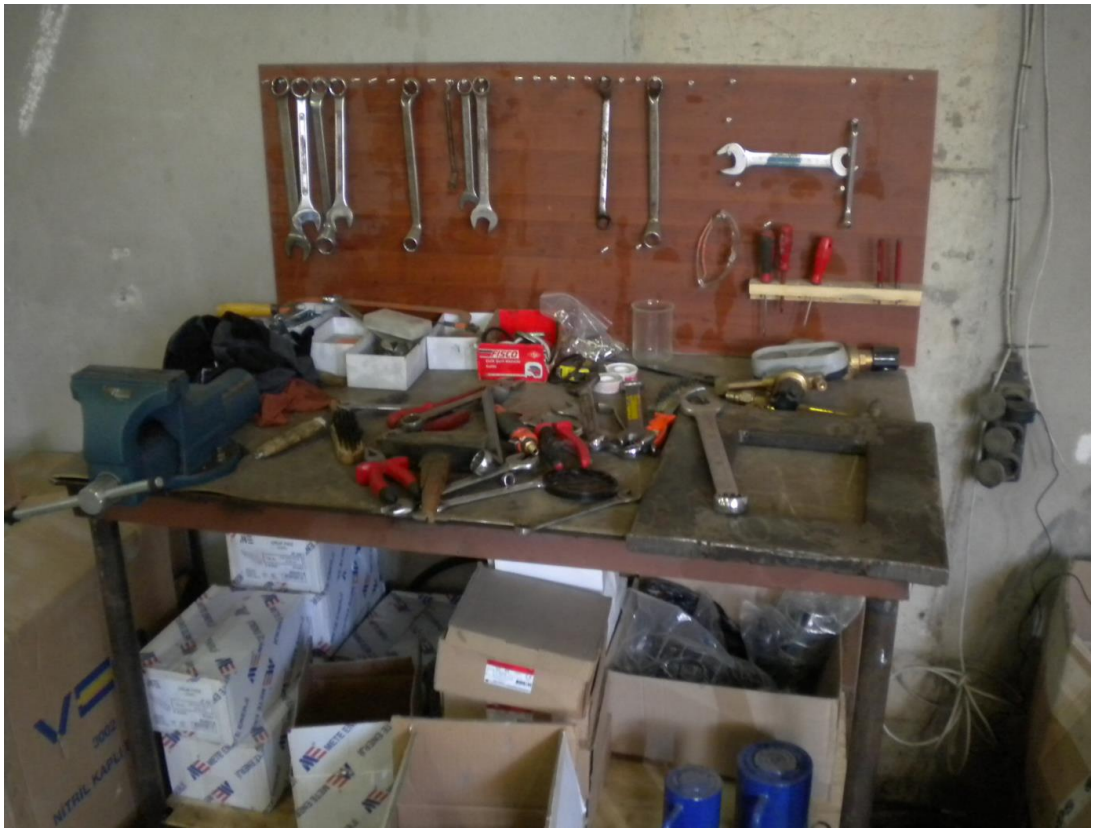


**Figure 8.16 :** An image from Ada Shipyard.

### 8.5.2 Cleanliness

Cleanliness is the key for the maintenance. Company do not realize when they do cleaning every day, actually they do maintenance for the tools. Another point is that it is easier to detect failures while everywhere is clean. As a result, cleanliness itself is a method of efficiency.

There are some steps that Ada Shipyard can apply for cleanliness. Steps have been shown in Figure 47.

- Cleanliness targets basically consist of three categories which are warehouse items, equipment, space. Raw materials, purchased parts, all kind of products are included in warehouse items. Machines and all tools are referred for equipment. Floors, working places, lights, windows, doors, gates, fences are referred for space.

- Ada Shipyard should divide piping workshop into specific areas and give responsibility for cleanliness from top manager to ordinary employee as cleanliness is a fact that everybody should be involved in. Then Ada should prepare checklist to inspect cleanliness.

- Ada Shipyard should determine cleanliness methods. Materials and storage for them for cleanliness should be determined. Ada shipyard should announce that every employee should clean his/her working place for 5 minutes at the end of the day.

- Materials that are decided at step 3 should be provided.

- Cleanliness should be implemented. Checklist must be provided. Reports must be provided monthly.

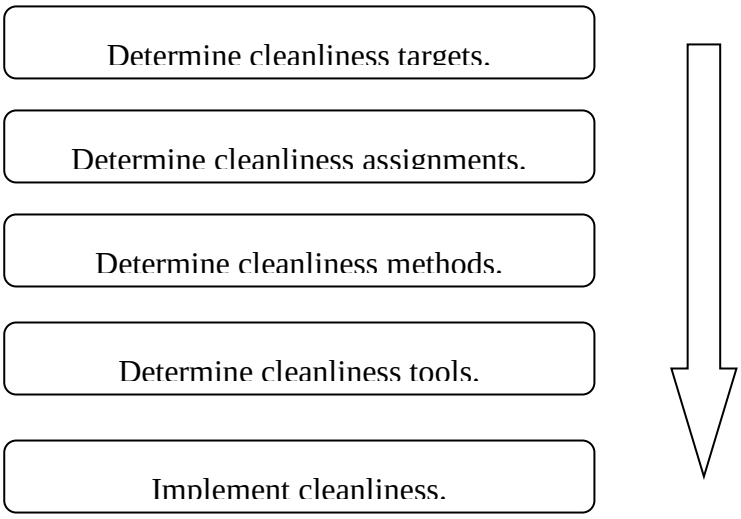



**Figure 8.17 :** Cleanliness steps (Hirano, 1990).

| No. | Checklists | Checked |
|---|---|---|
| 1 | Have you removed dirt, dust and oil from working table? | |
| 2 | Have you removed dirt, dust and oil under | |
| 3 | Have you removed dust and dirt from the welding machine? | |
| 4 | Have you cleaned your welding gun? | |
| 5 | Have you cleaned wrenches you have used? | |

**Figure 8.18 :** An example of equipment checklists that Ada Shipyard can apply for piping workshop.

**Inspection** is another crucial point to achieve cleanliness. It has almost the same steps with cleanliness that Ada Shipyard must apply. Cleanliness inspection steps are outlined in Figure 49.

- Determining targets are basically the same regarding cleanliness.
- The people applying cleanliness inspection should be the same that operate the machine or using tools.
- Inspection checklists and items should be determined.
- Implement cleanliness inspection by using your senses to detect abnormalities. For instance, use your nose to detect burning smells or listen carefully to detect change of sounds while machine is working. Another one is that looking for any leakage or deformation.
- Final step is implementing maintenance. **Cleanliness maintenance** can be divided to two parts. One is Instant Maintenance that operator can take action immediately. The second one is Requested Maintenance which action can not be taken immediately and operator request help from the maintenance department.

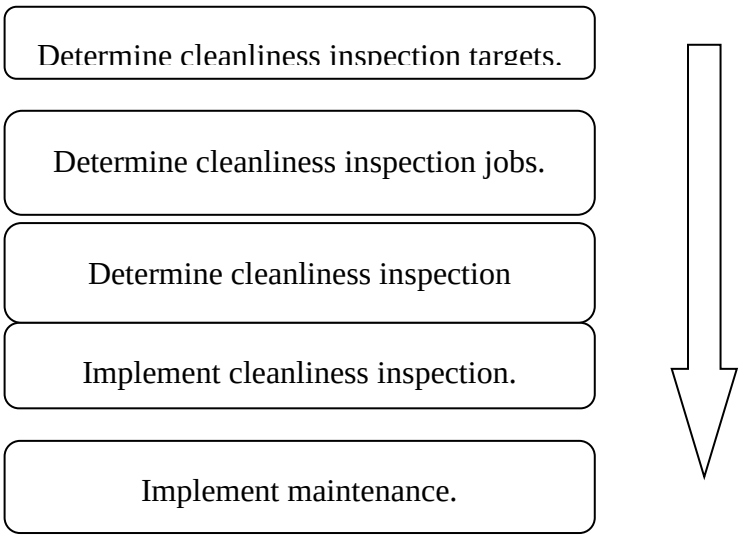



**Figure 8.19 :** Cleanliness inspection steps (Hirano, 1990).

Ada Shipyard should provide similar check points as shown in the figure below:

**Table 8.2 :** Recommended checkpoint for Ada Shipyard.

| Mechanism | No. | Point | Main Action | | | |
|---|---|---|---|---|---|---|
| | | | Clean | Lubricate | Replace | Restore |
| Welding Machine | 1 | Are there any damages in switches, lambs and control panel? | | | | |
| | 2 | Are there any leakages in water recirculation of the machine? | | | | |
| | 3 | Is there any strange voice while operating machine? | | | | |
| | 4 | Is the machine dirty? | | | | |
| | 5 | Is there any foreign matter near the machine? | | | | |

Figure above can be extended and divided as electrical system, air compression system, hydraulic tools etc. Extension may be applied after the first six months.

All implementation should be clerical so preparing checklist for cleanliness is a good way do to follow applications.

For Maintenance also maintenance cards should be put on the relevant machines.

### 8.5.3 Standardized cleanup

Standardized activity is not activity that reforms company. It is an activity of maintaining and providing continuity of organization, orderliness and cleanliness. It can only exist as long as 3S conditions are maintained. It can be said that the basic purpose of standardized cleanup is to prevent deterioration of first 3S and provide these 3S's a daily habit companywide. There are some points that Ada Shipyard can apply to achieve in standardized cleanup.

- First one, to prevent dirt and to solve problems, Ada Shipyard should use **five why's method.** They should keep asking questions until they find the main reason of the failure. After finding the reason, they should ask "how" in order to find a solution. So the first tip is to apply **5W1H** method to prevent failures and dirt. A simple example can be applied like that:

Failure: One of the pump is leaking water.

Question #1: Why does the pump leak water?

Answer #1: Because there is leakage at o-ring.

Question #2: Why does O-ring leak?

Answer #2: Because O-ring has been damaged.

Question #3: Why has O-ring been damaged?

Answer #3: Because O-ring does not resist to little impacts.

Question #4: Why does O-ring not resist to little impacts?

Answer #4: Because current O-ring is an old-fashioned product.

Question #5: Why is that O-ring still used?

Answer #5: Because it is cheap.

The conclusion from the example is that the main reason is wrong strategy of purchasing department.

It is very important to make organization, orderliness and cleanliness a daily habit. To achieve this, Ada shipyard should apply three steps.

- So far everybody has learned the tasks and duties they are responsible. Yet, it is essential to give clear information to people for their workplaces. The efficient way is to prepare 5S job cycle chart to assign 3S responsibilities. In Figure 51, the numbers indicate cycle periods. "1" is for continuously, "2" is for daily, "3" is for weekly actions ad "4" is for monthly actions and "5" is for occasionally. Figure 51 is a good guide while preparing charts like that.

- Secondly, Ada Shipyard should achieve to integrate 3S tasks into regular work tasks.

- Ada Shipyard should check on 3S maintenance level. To accomplish this task, company should prepare five-point standardized checklists. In Figure 52, there is a suitable checklist to maintain 3S level. By doing this, company can view the progress at implementing 5S and correct or take precautions.

**Table 8.3 :** Recommended job cycle chart for Ada Shipyard.

| Piping Workshop<br>5S Job Cycle Chart | | Prepared by:<br>Date: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | 5S Activities | Organize | Orderlines | Cleanlines | Cleanup | Discipline | 1 | 2 | 3 | 4 | 5 |
| 1 | Red-tag strategy | x | | | | | x | | | | |
| 2 | Place indicators | x | | | | | | | x | | |
| 3 | Item indicators | | x | | | | | | x | | |
| 4 | Amount indicators | | x | | | | | | x | | |
| 5 | Clean work areas | | | x | | | | | x | | |
| 6 | Clean walking paths. | | | x | | | | | x | | |
| 7 | Clean worktables. | | | x | | | | | x | | |

**Table 8.4 :** Recommended checklist for 3S maintenance level.

| Piping Workshop<br>3S Checklist | | | Entered by:<br>Date: | | | |
|---|---|---|---|---|---|---|
| No. | Process | Organization Level | Orderliness Level | Cleanliness Level | Total | Previous |
| 1 | Work at manufacture by spot welding line | 2/5 | 3/5 | 3/5 | 8 | 6 |
| 2 | Work saw line | 2/5 | 2/5 | 2/5 | 6 | 5 |
| 3 | Welding line | 4/5 | 3/5 | 2/5 | 9 | 7 |
| 4 | Grinding line | 3/5 | 2/5 | 3/5 | 8 | 6 |
| 5 | Quality control line | 3/5 | 2/5 | 3/5 | 8 | 7 |
| 6 | Average in total lines | 2,8/5 | 2,4/5 | 2,6/5 | 39 | 31 |

### 8.5.4 Discipline

Company should understand that once you leave implementation, everything is going to revert to the previous situation. To avoid this, discipline must be provided.

Management should understand how to criticize things to improve and view failures. There are some tips that managers can follow in criticizing. These are:

- Company management should never forget that if 5S implementation deteriorating, they should not blame employees! When manager criticizes employees, they should criticize workplace not individuals.
- Supervisor should identify problems and take action immediately. Otherwise, it will never be done or it will be too late.
- 5S leader should never criticize ordinary employees by himself (Murat Erzaim). Employees should be criticized by piping workplace leader.

To improve discipline, there are five measures that company may follow. First one is visual 5S's. It is a measure that company should determine to resolve and to identify problems. All the methods that have been used so far are actually visualization. Secondly, criticism should be made for correcting actions and improving skills. Thirdly, lectures should be made to build discipline by telling how to do things in the right way. Another measure is; company manager should motivate every member of the piping workshop to participate in 5S implementation. Lastly, 5S tools should be provided like 5S badges, brochures or newspaper.

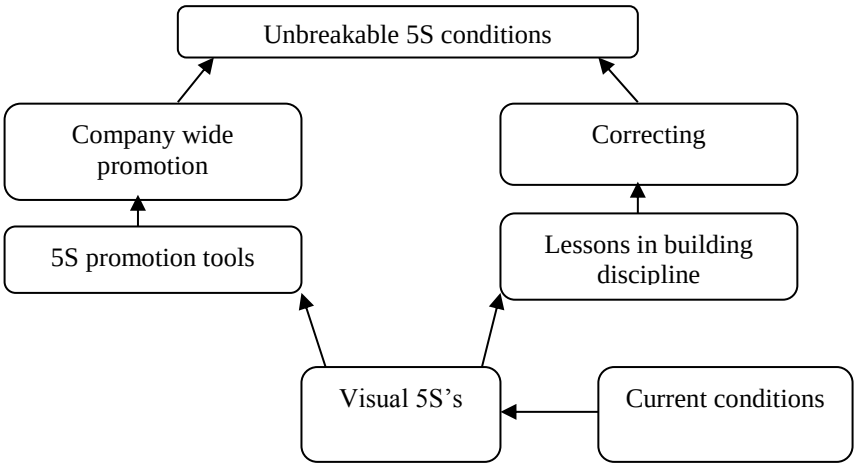



**Figure 8.20 :** Five measures for building discipline (Hirano, 1990).

# 9. CONCLUSION

In the past, conventional trading and marketing depended to product more and more. The cost of production was not very important as the customer demands were up to companies. So you could make more profit by increasing the offer price. The calculation of a firm's profit was like:

$$Conventional\ Profit = Offer\ Price - Purchase\ Price$$

Then things have started to change. Customers have become more and more selective as they have started to look for diversity. Furthermore, they have wanted specialized products that it fits their fancies entirely with the highest quality at the lowest price.

By the globalization of the world and China's entrance to the global arena that reduces the price of the products as in China labour costs are much more cheaper than the other countries, traditional trading and marketing have been starting to change. After the adaptation to the globalization, the diversity of the products and the goods and the quality of them has increased. However, that diversity of goods and products has brought active marketing. Then active marketing has brought the idea of gaining more profit so the numbers of competitive firms have increased enormously. After the huge numbers of the competitive organizations, selling the goods and products has become very tough. As a result of that, organizations have tried to find ways to reduce the manufacturing cost of the products to gain more profit to lead the market. As a result of these events standardization in key processes and international certification standards become essential. First, quality management which covers ISO 9000 series has arised. Then total quality management has become important.

Lean philosophy and lean manufacturing cover the methods which are before its existence. Actually it is not coverage, it is more like catalyzer that makes the goal of the previous methods happen or become faster and better with the methods that have been indicated in the previous chapter.

There are lots examples about lean applications in different branches of business mainly in automotive industry. But my observations are focused on Turkish shipyards.

For Turkish Shipyards, from the visited organizations, it can be said that there are two types of shipyard organization. The first one is the shipyard that is managed by the boss and the second one is the shipyard that is managed by a group or managed like institute. The difference between them is; the second one is more organized, more cleaned and it seems more like working in lean philosophy. The second one is more like an industrial place. At the first type, boss is responsible from everything in the shipyard. Boss rules the shipyard. But at the second type, there are different authorities for different departments. Unfortunately, even the second type of the shipyard does not actually apply lean manufacturing. It seems like they have lean at first but they do not have it. (It can be obtained from the first question's answer in chapter 6.5.3) They have total quality management applications, ERP (Enterprise Resource Planning) applications or MRP (Material Requirement Planning) applications as they are organized shipyards. However, in every industrial branch these applications are essential as the computers or employees now.

In shipyard marketing Japan, China and South Korea are the major shipyard areas. The main reason for that labour costs are cheaper than the other countries and the other and the main reason that they are working with lean manufacturing. Even most of the Turkish shipping companies prefer to make their ship construct at those countries.

Turkey has great potential in shipyard industry. To transform this potential energy to kinetic, it is obvious that Turkish Shipyards should understand the lean philosophy and should implement it to their shipyards by the help of the methods that is mentioned at chapter 3 lean manufacturing techniques and tools. If and only the usage of lean manufacturing in Turkish Shipyard will make the costs reduce and make the shipyards compete with the other countries.

<u>Prediction:</u>

In Turkey lean philosophy is recognized in 1995. 6 Sigma is first successfully applied in 2007-2008 by Ford in Turkey. Even in automotive sector in Turkey, 6 Sigma is a new developing issue. The best way to challenge with competitiveness

between the companies will be LEAN SIX SIGMA for every type of business in the future. I predict that the shipyards, which have accomplished the implementation of lean and start to use lean six sigma, will survive in Turkey.

## REFERENCES


**Abdullah, F.** (2003). Lean Manufacturing Tools And Techniques In The Process Industry With a Focus On Steel.

**Byrne, G., Lubowe, D. and Blitz, A.** (2007). Driving Operational Innovation Using Lean Six Sigma.

**deMin, J. E.** (2007). The Journey to Lean Manufacturing, British Telecommunications Plc.

**Davis, John W.** (2009). A Road Map to Quick and Lasting Success Lean Manufacturing.

**Fafandjel, N., Zamrin, A. and Hadjina, M**. (2008). Shipyard production cost structure optimisation model related to product type.

**George, Michael L.** (2003). Lean Six Sigma For Service.

**Gijo, E. V., Scaria, J. and Antony, J.** (2011). Application of Six Sigma Methodology to Reduce Defects of a Grinding Process.

**Hines, P. (2009).** The Principles Of The Lean Business System.

**Hirano, H.** (1995). 5 Pillars of the Visual Workplace.

**Hatipoğlu, H. N0** (2006). Gemi İnşa Pazarında Küresel Rekabet (Global Competition in Shipyard Marketing).

**Ismail, G.** (2006). Renewing Current Production Process By Lean Manufacturing Approach and An Implementation.

**International Journal of Six Sigma And Competitive Advantage** (2004), Issue Volume1, Number1, 44-64.

**Koenig, P., Narita, H. & Baba, K.** (2001). Strategies and outcomes in the two sectors of the Japanese shipbuilding industry. Journal of Ship Production, Vol. 17, No. 3.

**Koskela L. (**2001). Moving-On-Beyond Lean Thinking.

**Lamb, T. And Liker, J. K.** (2002). What is Lean Ship Construction and Repair, Journal of Ship Production, vol. 18 No.3, 121-142.

**Lamb T.** (2006). Design For Production.

**Maritech Ase The National Shipbuilding Research Program** (2000). Lean Manufacturing Principles Guide Version 0.5, June 26.

**McCarron, B.** (2006). Introduction to Lean Thinking.

**Melton, T.** (2005). The Benefits Of Lean Manufacturing-What Lean Thinking Has To Offer The Process Industries., 662-663,June.

**Menisy, A. and El-Gammal, M. M.** (2010). Review and Study of Quality Management Tools in Shipbuilding Industry.

**Mühendis ve Makina Dergisi, (**March 2008**).**

**Nair, A., Malhotra, Manoj K. and Ahire, Sanjay L.** (2011).Journal of Operational Management 29 , Toward A Theory of Managing Context in Six Sigma Process-improvement projects:An Action Research Investigation,529-548.

**National Steel & Shipbuilding Co., Maritech ASE-Project 99-21.** (2000). Whole Ship Design & Guidelines, Develop and Implement 'World Class' U.S. Material Standards and Parametric Design Rules to Support Commercial and Naval Auxiliary Ship Construction, July 10.

**Nave, D.** (2002). How To Compare Six Sigma, Lean And The Theory of Constraints, Quality Progress,73-78.

**Negrin, I., Parmet, Y. And Schechtman, E.** (2011) Developing a Model-based Sampling Plan.

**Odabaşı, A. Y., & Alkaner, S., & Ölçer, A. İ**. (2000). Gemi Üretimi Yöntemleri Ders Notları (Lecture Notes of Ship Production Methods). İstanbul Teknik Üniversitesi, Gemi İnşaatı ve Deniz Bilimleri Fakültesi.

**Odabaşı, A.Y.,& Helvacıoğlu, H. İ.** (2008-2009). Lecture Notes of Shipyard Organization, year 2008-2009.

**Quinn, Daniel L.** (2002). What is Six Sigma.

**Padhy, R. K. and Sahu, S.** (2011), A Real Option Based Six Sigma Project Evaluation And Selection Model, 27 January**.**

**Rina Corrosion Conference Paper,** (1999). Painting and Ship Production-Interference or Integration.

**Robert B. Austenfeld, Jr.** (2005).A Study of the Use of Lean Manufacturing Techniques By Japanese Small and Medium Enterprises, May 10.

**Sanidas, E.** (2001). The Successful Imitation of the Japanese Lean Production System by American Firms: Impact on American Economic Growth.

**Shah, R., & Ward, P. T.** (2003). Lean manufacturing: context, practice bundles, and performance. Journal of Operations Management 21 (2), pages 129–149,2003.

**Slavonski B.** (2005).Lean in Shipbuilding, 3rd International scientific-professional Conference, November 19-18.

**Storch, R. L. and Lim, S.** (1999). Production Planning & Control, Improving how to achieve lean manufacturing in shipbuilding, VOL. 10, NO. 2, 127-137.

**T.C Cumhurbaskanlığı Devlet Denetleme Kurulu Araştırma ve İnceleme Raporu.** (2007).(Auditing Board of Turkish Republic-Research and Inspection Report),Tersanecilik Sektörü ile İş Sağlığı ve Güvenliği Açısından Tuzla Tersaneler Bölgesinin İncelenmesi ve Değerlendirilmesi Hakkında, 26 Novermber.

**The National Shipbuilding Research Program-** (1995). Ship Production Symposium, Technology Development: A European Experience, January 1995.

**The National Shipbuilding Research Program** (1999). Reduction and Elimination of Welded Temporary Attachments, March .

**The National Shipbuilding Research Program** (1999). Design for Production Manual 2nd Edition, July.

**The National Shipbuilding Research Program** (2004). Implementation of R&D Project Results, September.

**Womack, J. P., & Jones, D. T., & Roos, D.** (1990).The Machine That Changed the World, Harper Perennial, New York.

**Verma, A. K.** (2003). The National Shipbuilding Research Program-Ase Program, Simulation Tools and Training Programs in LeanManufacturing-Current Status-Final Report, October 19.

**Verma, A. K., et al.** (2004) Enhancing Instruction in Lean Manufacturing through Development of Simulation Activities in Shipbuilding Operations.

**William G. Sullivan, Thomas N. McDonald, Eileen M. Van A.** (2002). Equipment replacement decisions and lean manufacturing, Robotics and Computer Integrated Manufacturin, 255–265.

**Womack, J.P. and Jones, D.T**. (1996). Lean Thinking: Banish Waste and Create Wealth in Your Corporation, 1-11.

**Wong, Y. C.,Wong, K. Y., and Ali, A**. (2009).A study on Lean Manufacturing Implementation in the Malaysian Electrical and Electronics Industry.

**Yıldız, A.** (2008), Türkiye'de Tersanelerin Tarihi ve Gemi İnşa Sanayinin Gelişimi,Mühendis ve Makina Dergisi.

**Url1** <http://www.docstoc.com/docs/44113905/shipyards-Showcase-Shipbuilding-Affordability-Through-Lean-SixiSigma>, date retrieved 07.03.2011.

**Url-2** <http://www.en.wikipedia.org/wiki/Poka-yoke>, date retrieved 18.03 2011.

**Url-3** <www.maaw.info/SixSigmaSummary-htm>, date retrieved 27.06. 2011.

**Url-4** <http://www.sixsigmainstitute.com/leansigma/index-leansigma.shtml>, date retrieved 21.05.2011.

**Url-5** <http://www.google.com/earth/index/html> ,date retrieved 18.03.2011.

**Url-6** <http://www.tersanedergisi.info/?pid=20352>, 25.06.2011.

**Url-7** <www.denizcilik.gov.tr>, date retrieved 5.05 2011.

**Url-8** <www.kocatepegemi.com/yalova.aspx>, date retrieved 5.05 2011.

**Url-9** <www.girginkale.com>, date retrieved 5.05 2011.

**Url-10** <www.besiktasshipyard.com>, date retrieved 5.05 2011.

# APPENDICES

## APPENDIX A:Timeline of Lean

## APPENDIX A

1574: King Henry III of France watches the Venice Arsenal build complete galley ships in less than an hour using continuous flow processes.

1760: French general Jean-Baptiste de Gribeauval had grasped the significance of standardized designs and interchangeable parts to facilitate battlefield repairs.

1799: Whitney perfects the concept of interchangeable parts when he took a contract from the U.S. Army for the manufacture of 10,000 muskets at the low price of $13.40 each.

1807: Marc Brunel in England devised equipment for making simple wooden items like rope blocks for the Royal Navy using 22 kinds of machines that produced identical items in process sequence one at a time.

1822: Thomas Blanchard at the Springfield Armory in the U.S. had devised a set of 14 machines and laid them out in a cellular arrangement that made it possible to make more complex shapes like gunstocks for rifles. A block of wood was placed in the first machine, the lever was thrown, and the water-powered machine automatically removed some of the wood using a profile tracer on a reference piece. What this meant was really quite remarkable: The 14 machines could make a completed item with no human labor for processing and in single piece flow as the items were moved ahead from machine to machine one at a time.

1850: All of the American armories were making standardized metal parts for standardized weapons, but only with enormous amounts of handwork to get each part to its correct specification. This was because the machine tools of that era could not work on hardened metal.

1890: Sakichi Toyoda invents a wooden handloom.

1902: Jidoka concept established by Sakichi Toyoda.

1905: Frank and Lillian Gilbreth investigate the notion of motion economy in the workplace. Studying the motions in work such as brick laying they develop a system of 18 basic elements that can depict basic motion.

1906: Italian economist Vilfredo Pareto creates a mathematical formula to describe the unequal distribution of wealth in Italy. He notices that 80% of the wealth is in the hands of 20% of the population.

1908: Ford introduces the Model T.

1910: Ford moves into Highland Park - the "Birthplace of Lean Manufacturing".

1910 - 1912: Ford brought many strands of thinking together with advances in cutting tools, a leap in gauging technology, innovative machining practices, and newly-developed hardened metals. Continuous flow of parts through machining and fabrication of parts which consistently fit perfectly in assembly was possible. This was the heart of Ford's manufacturing breakthrough.

1911: Sakichi Toyoda visits U.S. and sees Model T for the first time.

1912: The Ford production system based on the principles of "accuracy, flow and precision" extends to assembly.

1914: Ford creates the first moving assembly line, reducing chassis assembly time from over 12 hours to less than 3 hours.

1924: Sakichi creates the auto loom.

1924: Walter Shewhart launches the modern study of process control through the invention of the control chart.

1926: Henry Ford publishes Today and Tomorrow.

1928: Ford's River Rouge plant completed, becoming the largest assembly plant in the world with over 100,000 employees.

1929: Sakichi Toyoda sells foreign rights to loom and Kiichiro Toyoda visits Ford and European companies to learn the automotive business.

1933: Automobile department established in Toyoda Auto Loom.

1937: J.M. Juran conceptualizes the overall Pareto Principle and emphasizes the importance of sorting out the vital few from the trivial many. He attributes his

insight to the Italian economist Vilfredo Pareto. Later the term is called the 80/20 rule.

1937: Toyota Motor Corporation established. Kiichiro Toyoda President .

1937: The German aircraft industry had pioneered takt time as a way to synchronize aircraft final assembly in which airplane fuselages were moved ahead in unison throughout final assembly at a precise measure takt of time. (Mitsubishi had a technical relationship with the German companies and transferred this method back to Japan where Toyota, located nearby in Aichi Prefecture, heard about it and adopted it.)

1938: Just-in-time concept established at Koromo / Honsha plant by Kiichiro Toyoda. JIT wa later severely disrupted by World War II.

1939: Walter Shewhart publishes Statistical Methods from the Viewpoint of Quality Control. This book introduces his notion of the Shewhart improvement cycle Plan-Do-Study-Act. In the 1950's his colleague W Edwards Demming alters the term slightly to become the Plan-Do-Check-Act cycle.

1940: Consolidated Aircraft builds one B-24 bomber per day. Ford's Charles Sorensen visits to see if Ford's methods can improve on that number.

1940: Deming develops statistical sampling methods for the 1940 census, and then teaches statistical process control techniques to workers engaged in wartime production.

1943: Ford completes construction of the Willow Run bomber plant, which reaches a peak of one B-24 bomber per hour.

1943: Taiichi Ohno transfers from Toyoda Auto Loom to Toyota Motor Corporation.

1943: Edsel Ford dies.

1946: Ford adopts GM management style and abandons lean manufacturing.

1947 - 1949: Ohno promoted to machine shop manager. Area designated model shop.

- Rearrangement of machines from process flow to product flow.
- End of one man one machine. Start of multi process handling.
- Detail study of individual process and cycle times.

- Time study and motion analysis.
- Elimination of "waste" concept.
- Reduction in work in process inventory.
- In-process inspection by workers.
- Line stop authority to workers.
- Major component sections (Denso, Aishin etc.) of Toyota divested.

1950: Toyota financial crisis and labor dispute. Ends with 2146 people losing work. Kiichiro Toyoda steps down as President

1950: Deming invited to Japan to assist with the Japanese 1951 census. He then gives the first of a dozen lectures on statistical quality control, emphasizing to Japanese management that improving quality can reduce expenses and improve productivity.

1951 - 1955: Further refinements to the basic TPS system by Ohno

- Aspects of visual control / 4S.
- Start of TWI management training programs (JI, JR, JM).
- Creative suggestion system.
- Reduction of batch sizes and change over time.
- Purchase of rapid change over equipment from Danley corp.
- Kanban implementation.
- Production leveling mixed assembly.

1951: J.M. Juran publishes his seminal work The Quality Control Handbook.

1956: Shigeo Shingo begins regular visits to teach "P-Course".

1957: Basic Andon system initiated with lights.

1960: Deming receives the Japanese "Second Order of the Sacred Treasures" award, with the accompanying citation stating that the people of Japan attribute the rebirth of their industry to his work.

1961: Start of Toyota corporate wide TQC program.

1962: Toyota - Pull system and kanban complete internally company wide.

- Average die change time 15 minutes. Single minute changeovers exist.
- 50% defect reduction from QC efforts.
- Initial application of kanban with main suppliers.

1965: Toyota wins Deming Prize for Quality.

1969: Start of Toyota operations management consulting division.

1973: Toyota - Regular supplier improvement workshops begin with top 10 suppliers.

1973: Oil Shock plunges Japan economy into crisis. Only Toyota makes a profit .

1975: First English TPS handbook drafted by Sugimori, Cho, Ohno, et al.

1977: Nick Edwards presents a paper at the APICS conference describing the fallacies of MRP.

1978: Taiichi Ohno retires and becomes honorary chairman of Toyoda Auto Loom.

1979: First U.S. study missions to Japan to see the Toyota Production System.

1979: Norman Bodek forms Productivity Inc.

1979: Several APICS members who had seen Toyota production facilities and understood the problems with MRP began to meet regularly.

1980: *Kanban: The Coming Revolution* is published. It is the first book describing TPS as "JIT".

1980: Under the auspices of the Detroit APICS chapter, several future founders of the Association for Manufacturing Excellence organized the first known North American conference on the Toyota Production System at Ford World Headquarters, with 500 people attending. Featured speaker was Fujio Cho, who became president of Toyota.

1983: First broader description of TPS by an American author - *Zero Inventories* by Robert "Doc" Hall is published.

1984: Norman Bodek forms Productivity Press.

1984: Toyota / GM joint venture NUMMI established in U.S.

1984: Several of AME's founders barnstormed for the APICS Zero Inventory Crusade, collectively making hundreds of presentations on what is now called lean manufacturing. APICS calls for the resignation of the steering committee for violating APICS special interest group rules. The committee decides to go out on its own.

1985: The Association for Manufacturing Excellence is officially formed from cast off APICS members.

1985 - 1989: Shingo's books on *SMED*, *Poka-Yoke*, and *Study of Toyota Production System from Industrial Engineering Viewpoint* are published in the U.S.

1988: Taiichi Ohno's *Toyota Production System - Beyond Large Scale Production* is published in English.

1988: First wholly owned U.S. facility Toyota Motor Manufacturing in Georgetown, Kentucky.

1988: Kaizen Institute leads the first U.S. kaizen event at Jake Brake in Connecticut.

1988: Shingijutsu hired by Danaher Corpopration to assist in implementing TPS a Jacobs Chuck and Jacobs Vehicle Systems.

1988: Shingo Prize for Manufacturing Excellence created by Norman Bodek and Professor Vern Buehler of Utah State University.

1988: Kaizen Institute of Americal holds kaizen seminars at Hartford Graduate Center (Hartford, Conn.), with TPS sessions taught by principals from Shingijutsu Co., Ltd.

1990: *The Machine That Changed the World* by Womack and Jones.

1991: *Relevance Lost* by Tom Johnson and Robert Kaplan exposes weaknesses in manufacturing accounting systems, eventually leading to the Lean Accounting movement.

1991 - 1995: The business process re-engineering movement tried, but mostly failed, to transfer the concepts of standardized work and continuous flow to office and service processes that now constitute the great bulk of human activities.

1996: *Lean Thinking* by Womack and Jones.

2001: Totota publishes "The Toyota Way 2001" document, which makes explicit the "respect for people" principle.

2003: Shingo Prize-winning Better Thinking, Better Results published, case study and analysis of The Wiremold Company's enterprise-wide Lean transformation.

2004: Shingo Prize-winning *Kaikaku* published by Norman Bodek, chronicling the history and personal philosophies of the key people that helped develop TPS. [http://www.superfactory.com/content/timeline.html]

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