KADİR HAS UNIVERSITY
GRADUATE SCHOOL OF SCIENCE AND ENGINEERING

# MINIMIZING THE DEFECT RATE USING SIX SIGMA DMAIC METHOD; A CASE STUDY IN SUPSAN A.Ş.

MASTER THESIS

N. YAĞMUR ASLAN

Mayıs, 2016

N.YAĞMUR ASLAN | Master Thesis | 2016

# MINIMIZING THE DEFECT RATE USING SIX SIGMA DMAIC METHOD; A CASE STUDY IN SUPSAN A.Ş.

N.YAĞMUR ASLAN

Endüstri Mühendisliği Ana Bilim Dalı Programı'nda Yüksek Lisans derecesi
için gerekli kısmi şartların yerine getirilmesi amacıyla
Fen Bilimleri Enstitüsü'ne
teslim edilmiştir.

KADİR HAS ÜNİVERSİTESİ
Mayıs, 2016

KADİR HAS UNIVERSITY

GRADUATE SCHOOL OF SCIENCE AND ENGINEERING

MINIMIZING THE DEFECT RATE USING SIX SIGMA DMAIC METHOD; A CASE STUDY IN SUPSAN A.Ş.

N.YAĞMUR ASLAN

APPROVED BY:

| | | |
|---|---|---|
| Prof. Dr. Zeki AYAĞ | Advisor | Kadir Has University |
| Prof. Dr. Cengiz KAHRAMAN | | İTÜ |
| Asst. Prof. Dr. Emre ÇELEBİ | | Kadir Has University |

APPROVAL DATE: 10/6/2016

"Ben, N.Yağmur ASLAN, bu Yüksek Lisans Tezinde sunulan çalışmanın şahsıma ait olduğunu ve başka çalışmalardan yaptığım alıntıların kaynaklarını kurallara uygun biçimde tez içerisinde belirttiğimi onaylıyorum."

N.YAĞMUR ASLAN

# TABLE OF CONTENTS

# ÖZET

6 SIGMA DMAIC METHODU KULLANARAK HATA YÜZDESİ AZALTIMI; SUPSAN'DA ÖRNEKOLAY ÇALIŞMASI

N.YAĞMUR ASLAN
Endüstri Mühendisliği Ana Bilim Dalı, Yüksek Lisans
Danışman: Prof. Dr. Zeki AYAĞ
Mayıs, 2016

Günümüz üretim sanayileri hızlı değişen ekonomik koşulların büyük etkisi altındadır. Bu doğrultuda üretim sanayileri küreselleşme ile birlikte küresel rekabet ile karşı karşıya kalmaktadır. Bu sektörlerin önemli sorunları, azalan kar marjı, müşterilerinin yüksek kaliteli ürün istemesi ve ürün çeşitliliğidir. Bu yüzden birçok kuruluş özellikle üretim sektöründekiler, kalitenin önemini anlamıştır. Firmalar çeşitli stratejiler uygulamayı ve yenilikler ile üretim süreçlerini geliştirmeyi denemiştir. Bu alanda en güçlü felsefe 6 Sigmadır. 6 Sigmanın amacı; maliyeti, israfı azaltmak ve yüksek kalitede ürün üretebilmek için verimliliği arttırmaktır. Böylece, bu çalışma üretilen supaplarda kaliteyi geliştirmek, üretim israfını azaltmak ve üretim sürecindeki verimi arttırmak için 6 Sigma metodolojisi uygulanmıştır. DMAIC, Jidoka, Value Stream Transformation, Kaizen gibi yaklaşımlar arasında karşılaştırma analizi yapılmıştır. Sonuç olarak DMAIC bu proje için seçilmiştir. DMAIC yaklaşımı karlılığı arttırmaya yardım eden ve operasyonların verimliliğini arttırarak müşteri taleplerini karşılamaya yardım eden bir iş stratejisidir. Bu araştırmada, SUPSAN isimli üretim firmasında kalite ve verimlilik iyileştirilmesi tartışılmıştır. Ve bu çalışma SUPSAN da kalite performansını yükseltmek, Stellit kaplama sürecindeki hataların temel nedenlerini DMAIC araçları ile bulmakla ilgilidir. Pareto çizelgesi, FMEA, SIPOC, C&E Diyagramı gibi birçok araç temel hataları bulmak için ve durumu analiz etmek için kullanılmıştır. Geliştirme evresinde süreç kapabilite analizi ve uygulama planı yapılmıştır. Ayrıca geliştirme süreçleri uygulanmıştır. Sonrasında kontrol çizelgeleri

ve istatistiksel süreç control analizi ile sonuçlar izlenmiş, belgelenmiş ve kontrol edilmiştir. SUPSAN'da 6 Sigma DMAIC metodolojisi uygulaması sonucunda fire oranı 4.34% den 2% ye azaltılmıştır.

# ABSTRACT

MINIMIZING THE DEFECT RATE USING SIX SIGMA DMAIC METHOD; A CASE STUDY IN SUPSAN A.Ş.

N.YAĞMUR ASLAN

Master of Science in Industrial Engineering

Advisor: Prof. Dr. Zeki AYAĞ

Mayıs, 2016

Today manufacturing industries are highly impacted by the fast changing economic conditions. In this scenario, manufacturing industries become face to face with global competition due to globalization. The major problems of these industries are declining profit margin, customer demand for high quality product and product variety. Therefore so many organizations, especially in manufacturing sector, understand the importance of quality. Companies try to implement various strategies and innovations for enhancing their producing process. A very powerful philosophy in this area is Six Sigma. The aim of Six Sigma is to reduce cost, waste and increase productivity to produce high-quality products. So this study is applied to improve the quality of the manufactured valves, reduce the manufacturing waste and increase the yield of the manufacturing process by applying the Six Sigma methodology. Also comparison analysis is made between approaches as DMAIC, Jidoka, Value Stream Tranformation, Kaizen. In result of the analysis DMAIC is chosen for this project. DMAIC approach is a business strategy help to improve business profitability and efficiency of operations to meet customer needs and expectations.

In this search discusses the quality and productivity improvement in an manufacturing enterprise which is called SUPSAN. And this search deals with an application of Six Sigma DMAIC methodology in SUPSAN to improve quality performance, to identify root causes of failure in Stellite Coating Process which is found with help of DMAIC

tools. Several tools are used to identify root causes and situation analysed with help of Pareto Charts, FMEA, SIPOC, C&E Diagram. In improve phase Process Capability Analysis and Implementation Plan are made. Also improvement solutions are applied. Then with the help of tools as Control Charts, SPC Analysis results tracked, documented and controlled.In SUPSAN, the appliation of Six Sigma DMAIC methodology resulted in a reduction in the defect rate from 4.34% to 2%.

# ACKNOWLEDGEMENTS

Foremost, I would like to express my sincere gratitude to my advisor Prof. Dr. Zeki AYAĞ for the continuous support of this study and research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis.

Second, I would like to thank Prof. Dr. Cengiz KAHRAMAN for encouragements, valuable time, advice, comments and all the helping hand provided towards the successful completion of this thesis.

I especially thank my parents and all of my friends who have gave their support and encouragement, otherwise, I could not have completed this much volume of study.

# Table List

# Figure List

# ABBREVIATIONS

C&E Diagrams: Cause and Effect Diagrams

SPC Analysis: Statistical Process Control

PCA: Process Capability Analysis

ANOVA: Analysis of Variance

DMAIC: Define-Measure-Analyse- Improve-Control

FMEA: Failure Modes and Effects Analysis

SIPOC: Supplier-Input-Process-Output-Customer

VOC: Voice of Customer

VOB: Voice of Business

CCR: Critical Customer Requirement

CBR: Critical Business Requirement

BRM: Business Risk Management

AHP: Analytic Hierarchy Process

VST: Value Stream Transformation

DOE: Design Of Experiment

# 1. INTRODUCTION

In today’s world, business is more competitive. All industries and organisations have to themselves survive and be profitable in industry. SUPSAN, engine parts manufacturing company, studied in this thesis for helping company to maintain the quality of its products, to help meet with company’s customers needs. Therefore, SUPSAN will effectively compete in the market. SUPSAN aims to improve quality for creating competitive strategic advantage. This thesis investigates quality issues for finding best method to implement in SUPSAN and provides a solution to reduce defects. In order to accomplish this, most effective and suitable quality methodologies are chosen. So Six Sigma DMAIC is followed in this search to reduce defects in company. Today, Six Sigma has a great interest for manufacturers in the world. It is because this principle affects companies of all sizes. Companies apply Six Sigma technologies and see dramatic improvements in quality, production, customer service, and profitability.

DMAIC approach is used to reduce the number of defects in the stellite line, improve customer satisfaction and profitability. In industry, nonconforming products cause unsatisfied customers. This is why company needs to pay attention to detail of the product through a stellite line in valve production. Whether the process is producing defective parts or scrap, company will certainly have higher operating costs due to the need to reproduce or rework product. This thesis provides systematic approach by using the Six Sigma methodology to assess the application of Six Sigma and its techniques. Aim of this thesis is to show how to apply Six Sigma methodology in a manufacturing problem. Besides, company should to adopt a process improvement method, so Six Sigma is one of the best tools to improve quality of products by reducing defect in manufacturing. In this thesis, SUPSAN company valve manufacturing part is aimed to find out strategy for developed solutions to reduce product defect by using DMAIC approach from Six Sigma method.

From February 2015 to the middle of August, 53.755 pieces of defects threw from within the 1.237.468 valves which is produced in Stellite line and percentage of defect materialized as %4.34. In this process, defect cost is 102.134$. This situation block the sending intended products to stated lines and causes problems as additional labor, traceability. VOB, make a demand the enhancement of situation that create extra cost due to high ratio of defect in related line. Percentage of defect of Stellite Line in last 6.5 months amounted %4.34 at 2015, daily 9.000 pieces and yearly 2.565.000 pieces of valve production envisioned. Unless making an enhanement in process, production will have same defect ratio and 2.565.000 pieces of valves 111.321 pieces of it will be defect. Cost of defect will be 211.510$. With this project, defect ratio withdraw to the target valve level %2 defect goal will cause reduce %53 of wastes becauseof this helps to gain 91.386$ return. Also project will support the SUPSAN in achieving their general defect goals.

# 2.SIX SIGMA

In 1980 Six Sigma is developed by Motorola in companies. Today, it is the most popular management methodology. The objective of Six Sigma is improving the quality of process by identifying and removing the defects.

The goal is to increase level of performance which reflects the customer needs. Achieving a Six Sigma level means that less than 3.4 ppm. Hence, Six Sigma is seen as a problem solving approach with help of tools to improve process.

Six Sigma is a disciplined, statistical method that aimed to increase profitability by reducing defects. The foundation logic and approach is “DMAIC” which has phases as; Define, Measure, Analyze, Improve and Control. Six  Sigma has a variety of tools available to reduce defects and improve quality.

The improvement tools used in Six Sigma processes to measure, gather data to track progress. Six Sigma provides high quality, low cost, customer-defined value, a never-ending stream of efforts for eliminating waste and nonvalue-added activities, relentless improvement. After Motorola such companies used this methodology too as ABB, Allied Signal, General Electric (GE), DuPont, Nokia and Toyota.

Six Sigma systems improve customer satisfaction, quality, speed of process and expand knowledge of product and processes. Six Sigma philosophy states that defects can be eliminated by reducing variations as improved customer needs, reduced operating costs and increased profitability.

In addition, it is a problem identification technique. 6 Sigma has tools to define process and make statistical analysis. It improves quality and minimizes defects.
6 Sigma is a business strategy for reducing process variability, minimizing defects. Key factors of 6 Sigma projects are; management involvement, commitment, progress tracking and monitoring, training and teamwork and Project selection and its link to business. Cost of poor quality, tool expenses, labour expenses, production

time, index cost, volume, production time, control time, material and internal scraps reduced with help of Six Sigma and so annual benefits increased.

In conclusion, Motorola developed and implemented Six Sigma to achieve perfection in manufacturing and to sustain competitive advantage. Six Sigma uses statistical methodologies as Business Process Engineering, Kaizen, Dmaic, Value Stream Mapping, jidoka and techniques to solve problems of production process. Six Sigma is an zero defect approach. First of all, Six Sigma aims to identify avoiding defects, besides it helps to decrease operating cost and increase customer satisfaction by reducing defect, linking to business strategy. Six Sigma focus on customer needs, waste prevention, cost saving and cycle time reduction and it eliminates costs.

## 2.1 Six Sigma Application Reasons

1-To focus on continuous improvement and innovation for meeting customer expectations so 6 Sigma can ensure this.

2- It is possible with 6 Sigma to apply approaches which adoptable most quickly to technologic changes in product and production systems.

3- 6 Sigma ensures success to adobt to changing global conditions with help of continuous innovations.

4- Allow to achieve the goal to provide products that meet customer needs and expectation for anyone working in the business and services.

5- Six Sigma is able to providee to accelerate, production and sharing of new ideas.

6- Six sigma can make strategic changes easily which better understands and evaluate company processes and entire operating systems.

6 Sigma program basically can be useful to companies seeking solutions to issues in 3 different levels, as follows;

-A need of transformation which creates fundamental change in the style of the organization's work.

-Strategic improvements which targeted basic strategic or operational weaknesses or opportunities.

-Ensure help to subjects as problem solving or resolve issues as high cost, repetitive tasks and delays.

## 2.2 Six Sigma History

Quality management developed with conceptual foundations but it continued to grow as a strategic process improvement. It begins with Motorola in the 1980s, many companies as GE, Honeywell, Sony etc. adopted Six Sigma. 6 Sigma uses quantitative and critical quality metrics for continuous improvement and to measure defects.

Motorola developed Six Sigma in 1985 with aim of 3.4 defects in million. In 1994 Six Sigma produces better results and improve processes.

In 1995 General Electric began to implement Six Sigma. Lots of studies are made about Six Sigma as it is a data-driven approach to analyze causes of problems and solves them by ensuring performance. 6 Sigma is a business process that improve and monitor business activities by minimizing waste and increasing customer satisfaction.

The first generation of Six Sigma between1987 and 1994 had focused reducing of defects and Motorola saw success of it.

The second generation of Six Sigma between 1994 and 2000 had concentrated on cost reduction. Therefore companies as General Electric, Du Pont and Honeywell adopted it to their organizations.

The third generation of Six Sigma created value to customers and the enterprises. By this way, its application can be founded within the companies as Posco and Samsung. This processes give importance to delivery times, customer waiting time and inventory service levels.

Six Sigma application of in service sector and manufacturing sector grew. Besides, in the manufacturing sectors automatic data collection started to be used especially in assembly lines and to measure impact of the quality became more easier. As a result of this innovation, large organisations introduced Six Sigma in their manufacturing facilities.

### 2.2.1 Six Sigma In Automobile Industries

“Dr. Rajeshkumar U. Sambhe (2012) this case study focused on mid-sized auto ancillary unit. The Six Sigma approach reduced defects level and implementation caused a financal hit on the bottom-line of the enterprise” [1].

“J Antony, M Kumar, and M K Tiwari (2005) this study was Six Sigma based methodology to eliminate an engine-overheating problem in an automative company. The aim was to reduce process variation and high defect rate. The process capability increased from 0.49 to 1.28 and the financial impact saved over $US110.000 per annum” [2].

“Rajeshkumar U.Sambhe and Dr. Rajendra S. Dalu (2011) used Six Sigma to implement in medium scale Indian automotive enterprises. The survey is used. Study found that 25.64% of medium scale automobile sector has implemented Six Sigma.
S.Suresh, A.L.Moe and A.B.Abu (2015) applied DMAIC methodology reduce defects in manufacturing of automobile piston ring. The rejection percentage reduced to 13.2% from the existing 38.1%” [3].

“S.N.Teli, Dr.V.S.Majali, Dr.U.M.Bhushi, Sanjay Patil (2012), 6 Sigma tools reduce the cost of quality for automobile industry. DMAIC approach discussed with its advantages. Research is presented about Reduction in Exhaust Pipes&Silencer Failures. In addition, use of Six Sigma concept helps to keep quality controlled to avoid unnecessary downsizing of one’s overall profits” [4].

## 2.3.Comparison Analysis of Methods

There are many other valuable methods that should be used in defect reduction projects. Many methods depend on the size and industry of the company. These methods as follow;

Six Sigma, DMAIC; this method has data based conclusions. DMAIC process includes defining project, identifying root causes and finalizing the improvements. It ensures long lasting solutions, flexibility in timing and quality training. Also this approach is so beneficial for corporate organizations. Especially in big companies, it identifies the problems easily and it is used to adress this problem with great efficiency. Dmaic method is reliable and extremely result oriented as well and has huge pool of satisfied clients. This method helps workers to carry out the job to solve potential problems. Thus, they become more aware of the process. 6 Sigma also has customer focus, employee involvement, continuous improvement. In addition, Six Sigma increases cash flow, improves knowledge on tools and tehniques, reduces variability in process performance, product capability and reliability. It ensures new customer opportunities and improves market position.

### 2.3.1 Kaizen

Kaizen is a methodology that identifies the opportunities for continuous improvement in a short period of time. Also Kaizen is a team-based improvement. It selects and organizes team members and informs them about steps and possible outcome. Besides Kaizen has sense of urgency, immediate resource availability and it gives immediate results.

Kaizen; is a Japanese workplace philosophy that focuses on making continuous improvements. It means continuous improvement that involves everyone in the organization and it is also customer-driven strategy. This scientific approach uses statistical quality control and adoptive to organazitional values and beliefs which focus on zero defects. So Kaizen emphasises on problem awareness and identifying problems.

Kaizen has advantages; it encourages the development self managing groups, consolidates team-working. It also helps leads understanding to change and helps to recognise employee efforts. On the other hand Kaizen has disadvantages as, permanent change of management system. Hard to return to previous management systems, difficult to apply to other cultural contexts and it increases the burden or lower level management. Also they have to work after hours to compute administative tools in the implementation of the method. It concentrates attention process and activities are centired. It is an approach for active problem solving. Kaizen gives employees a sense of purpose, it eliminates the need for inspection and helps to breakdown departmental barriers. It focuses on improvement is returned to the needs for the customer.

Kaizen; while there are advantages of using Kaizen and there are some limitations that worth to be aware of before deciding to implement to company. Kaizen is necessary for companies to undergo a complete reset of their tactics and approach on the other hand it can be difficult and cause problems to the business if they are not ready to do so. It is necessary for companies to be open to change so employees speak up easily. Kaizen can not have success for a while, hence the long term goals must clearly be understood by those involved. Some companies should bring a change in their style of functioning and mind set but sometimes this is difficult and initial problems created can be very bad for business overall. Also the initial excitement around using a new management style dies down all too soon. As a result; companies are not able to get the results they are expecting.

Kaizen is a rapid choice it emphasizes creativity before capital. In this approach, a cross functional team improve the process or problem within specific area. Team meets full time for 3 to 5 days and study rapidly phases as training, discovery, analysis, assessment, brainstorming, implementation. Specialized on training that is about setup reduction methodology and defect prevention. And team takes a guided tour to understand basic process flow, products produced, machines used. Team gathers datas from current situation, demand, defect history, downtime history etc. In last, team implements prioritized ideas. Kaizen; it is process centered and able to identify what is going wrong and reduces defects and reduces waste of resources.

### 2.3.2 Jidoka

This method is human integrated automation and it aims to find machine detects and stop immediately preventing producing bad product. The principle of this method is to stop and respond to every abnormality and it can be applied to all processes. It detects the abnormality, stops, fixs or corrects the immediate condition, investigate the root cause and install a counter measure are steps of Jidoka. An organization need Jidoka because JIT can't run smoothlity and effectively without Jidoka. Jidoka, adds human judgment, minimizes poor quality, gives the employee responsibility. Also it prevents equipment breakdown and ensures high quality products, improves productivity.

### 2.3.3 Business Process Engineering

BPR is invented in the early 1990s. It focuses on the analysis and design of workflows in the company. BPR aims to help to rethink how company do its work in order to improve customer service, decrease operational costs, and become world-class competitors. Re-engineering focuses on business objectives, encourages full-scale recreation of processes. It increases effectiveness, all processes are monitored under the control of the management. It reduces cost, improves efficiency and ensures quick delivery of products to the buyers. BPR also help to growth of business. On the other hand it has disadvantages as, its implementation is very difficult. Employees are very resistant to this kind of change therefore, it is important to have support from the top management. Also it can not be appropriate for all processes for all organisations. The core-business processes designed to satisfy customer needs.

### 2.3.4 Value Stream Transformation

A Value Stream Transformation begins with a realisation of there is a need for change and it continues with a detailed Value Stream Analysis and the implementation of a planned future state. Advantages of VST; reduction of the time for the process from beginning to completion, increases productivity, increases process reliability by removing errors and inconsistent quality. It gives a clearer picture of processes involved in a work flow. It helps to identify waste and its sources and where change is required. VSM brings standardisation to process also it helps identify potential problems and help to make organizations more efficient by improving their processes.

Key stages; to make trainings to understand strategy, tools and techniques in the organisation, coaching value stream managers, development of metrics to create value, eliminate waste and enhance customer service and company performance. On the other hand disadvantages of VST are; It does not include any significant monetary measure for value. It has responsibility of the stakeholder to determine which activity can be termed. VST fails to handle multiple products that do not have identical maps, transportation and quening delays.

In this search, all methods examined and Six Sigma DMAIC method selected to use in this company to help defect reduction in Stelllite Line. In recent years, implementation of Six Sigma became a source of competitive advantage within the businesses. Because its properties are more useful for process in this company.So we applied it to the line that causes defects.

## 2.4 WHY SIX SIGMA, DMAIC IS CHOSEN?

Six Sigma become a key of knowledge-based businesses and it guides companies to achieve specific goals and objectives.

After making a comparison analysis between each methods, Six Sigma, DMAIC method is choosed to implement target production line. Six Sigma found as the most suitable approach for the line conditions. It is different from other quality efforts because it targets higher standards of quality and lower defects, related to the customer needs. In any organization it is important to create a culture that allows employees to feel connected to their work environment, Six Sigma method ensure this. The culture that follows Six Sigma differs from that of any traditional business mentality in many ways as pulling on the key concept of continuous improvement while achieving financial goals. Six Sigma creates a culture of continuous improvement and it is a combination of changing the way of work by changing processes. Six Sigma enables workers to not only attain new tools for solving problems, but also it creates new approaches to problem solving all together by examining a process in a very methodical fashion. Six Sigma culture allows to collect input from all different facets of the organization, including bottom-up suggestions from project leaders and team members. Besides the team members should have with different skill sets to allow for the best possible brainstorming sessions and innovative solutions. Six Sigma allows employees to work by interacting with the managers where the improvement work needs to happen. The main advantage of DMAIC is to help project management. Unlike other quantitative techniques of Six Sigma, DMAIC is easy to follow for all members of the project team. In the Six Sigma implementation, DMAIC method helps to integrate human aspects as culture change, helps to make training, it focuses on customer.

Six Sigma projects use the DMAIC process to improve quality by reducing defects and makes by decisions analyzing related to amount of data. For example, a Six Sigma/DMAIC Project would be the best approach if your goal is defect reduction or reduction of cost in the organization as in this thesis.

Benefits of Six Sigma; improves quality, ensures lower cost, maximizes invested capital, helps to company have market share in the competitive global markets. Hence global competitiveness is almost impossible without Six Sigma. Every company would benefit by adopting Six Sigma concepts and philosophy. In addition, profitability improves to all workforces in every department of the corporation.

Also it helps to reduce operational costs. Six Sigma has benefits from implementing 6 Sigma interms of cost savings, enhancement of productivity and improvement of process. Behind the 6 Sigma philosophy, there is a fundamental plan to monitor process continuously and aim to eliminate wastes from manufacturing process.

DMAIC is the best way for improving work process to eliminate the defect rates in the final product. Six Sigma, DMAIC projects increase performance of the company, make enhancement in customer satisfaction. It improves quality by analyzing data. As a business improvement DMAIC strategy, improves profitability by reducing defects and efficiency to meet customer-focused program, helps to identify improvement opportunities, defines and solves problems and establishes measures to sustain the improvement.

In conclusion, Six Sigma provides tools to improve services and increases quality. It is known as important way for improving competitive advantages to reach quality excellence. Six Sigma should be choosen to implement this Project because it has lots of advantages besides other methods. The elimination of waste costs means more profit. In addition, Six Sigma generates long-term success because it involves a cultural change.

# 3. DMAIC

In the late 1980s, DMAIC was introduced by Motorola. Since then, DMAIC has become the essential component for Six Sigma that aim to improve processes. DMAIC is a well-known methodology for problem-solving. DMAIC reduces defects, reduces cost and time. Also, DMAIC identifies requirements and tools for a project team to utilize. The DMAIC methodology is fundamental to 6 Sigma process improvement projects.

DMAIC has five phases; define, measure, analyse, improve and control. The simplified definitions of each phase are;
Define phase; help to select right project and identify scope,aim.
Measure phase; gather datas and parameters.
Analyse phase; identifies potential causes and processes.
Improve phase; changes the current process is enhanced and performance of the process is increased.
Control phase; monitor and track new process.

The detailed version of process steps are;

Define phase; define the purpose, scope, objectives, define resources of the project. It includes project charter and describes Voice of Customer (VOC), defines Voice of Business (VOB), understands the current process. It identifies problem statement/opportunity and goal statement. Develops high-level process map, gather business requirements, develops communication plan and finalizes project charter. Also this phase identifies business financial drivers and determines critical-to-quality processes, defines project issues. This phase include selecting project, identifying process parameter input, establishing process flowchart, setting boundaries of process, selecting fully trained project team members, establishing execution plan. After determining what needs to be accomplished, resources and milestones put in place in order for the completion of these steps. These steps are located within the goals and objectives, milestones and the roles and responsibilities sections of the team charter. After illustration of team charter, the process should be mapped out. Once completed, the process map provides a great visual for the duration of the project and also helps to more specifically identify the customer's needs and requirements in relation to the specific process being improved. A clear statement of the project will be written, a basic timeline will be created, and a business case will be developed. In conclusion, this step starts with problem identification. The goal of the project and resources should have to be defined. This phase helps to understand the needs of the customers, defines the goal statement.

Measure phase; helps to identify, summarize and gather datas from what source and develops a plan to gather it. This usually involves utilization of graphical tools. The tools of this stage are flow charts, SPC tools, pareto analysis and run charts. This phase measures the problem, determines if the process in control and if measurement system is accurate. Measure phase determines current process performance. Measurement objectives; developing and defining key process measures and clarifying aim, identifying processes that have the huge impact on the project, collecting and analyzing data, measuring performance. The main purpose of the measure stage is the focus on improvement effort by gathering the proper information or data that is being produced in the process. Usually flowcharts and histograms are used in the process and the graphs, charts help to identify problems within the process. Pareto charts may also help team to display the relative importance of specific problems. Process Sigma can be calculated to describe the capacity of the current process. The failure modes with higher RPN should be solved first. Measure phase focuses on ensures the data needed is available and accurate.
In conclusion measure phase; determines how the process currently performs, looks for cause of problem, creates a plan to collect the data.

Analyze phase**;** validates the root causes of problems and determines if the process capable of producing the customer requirements. The Analyze phase steps are; establishing process capability, defining performance goals and identifying the sources of variation. The aim of this stage is to determine and validate the root causation of our original problem. The next step is to organize these potential causes using tools such as fishbone diagrams. A simple way of analyzing the data and creating a good visual for root cause is frequency distribution checklist. Fishbone diagrams can be used to take the raw data and analyze root causes. Run charts is another key element in the analyze stage that monitors the performance of processes to detect trends, shifts, or cycles. This information allows teams to focus attention on changes in the process, enables the most beneficial solutions to be created for the next stage. Knowledge that is gained in the analyse phase is used to develop solutions and improvements in the improve phase.

The improvement phase; DOE can help to optimize the process for reaching financial goals. The performance can be improved and financial goal is reached by implementing brainstorm solutions and prioritize them related to customer needs and make a selection between them, then and test to see if the solution resolves the problem. During this step, ideas and solutions are put to work. There must be checks for results to find best solution. Improve phase help to develop ımprovements for main causes, develops evaluation criteria. Also it measures results, develops detailed future process map of improvement and updates project plan. Certain charts may be used to compare before and after results of the implementation. Some of those charts include histograms, Pareto, and the many different control charts. Run charts provide a glimpse of whether or not a solution has a real or lasting effect on the process.
In conclusion improve phase; brainstorms solutions that might fix the problem, selects the practical solutions, develops maps of processes based on different solutions, selects the best solutions, implements the solutions, measures improvement.

Control phase; at the final phase the stability and reliability of the process is controlled and the final capability is determined. It requires revision and a control plan to monitor ongoing performance. This phase; demonstrates how the improvements can be sustained, manages risks, documents new measurement process, defines control plan, documents recommendation or improvement summary and highlight changes. The final step of the DMAIC methodology monitors ongoing measures and actions to sustain improvement. Control phase assess proposed solutions and make controls to ensure the desired results and prevent future defects and problems. Critical inputs set under control and process outputs monitored.

Outputs of the contol phase; analysis of data before and after, well monitored system, completed documentation of process results.

In conclusion control phase; ensures continuous improvement in the process, monitors process and applies new knowledge to other processes in organization.

## 3.1 Tools Of Phases

Define Tools; Project charter, VOC tools, process map.

Measure Tools; Measurement system analysis, exploratory data analysis, descriptive statistics, pareto analysis, data collection plan, check/data sheet, histograms, process capability.

Analyze Tools; cause and effect diagrams, tree diagram, brainstorming, SPC, process maps, DOE, FMEA. Several tools are used to determine root causes of the defects as the affinity diagram, brainstorming, data collection, flow diagrams, pareto charts, tree diagrams or statistical process control, process maps and simulation. These tools calculate the amount of variation and helps to determine which inputs are the most important for the overall performance.

Improve Tools; project planning and management tools, brainstorming, data-collection forms, flow diagrams, frequency plots, FMEA, planning tools, Pareto charts, prioritization matrix, process capability, stakeholder analysis. Also simulation analysis, DOE, tolerance analysis can be used. FMEA and pilot plan can develop the solution of problems in the process too.

Control Tools; SPC, FMEA, ISO900, change budgets, cost estimating models, reporting system and benefits tracking. Some of the tools used in the control phase include control charts, data-collection forms, flow diagrams, quality-control process charts, sampling, statistical process control, reporting systems, process control plan, pareto chart and process capability.

## 3.2 Dmaic Roles

### 3.2.1 Executive Sponsor

The executive sponsor communicates, leads and directs the company's overall objectives toward successful and profitable Six Sigma implementation. The sponsor supports the team and the program in every step. Thus, the executive sponsor needs to be involved in project selection. Also ensures the projects required resources.

### 3.2.2 Champion

The champion is part of executive members of the company. Champion should have managerial and technical skills to reinforce, to make plan, to allocate resources, and provide  the necessary tools. Champions make improvement plan and charter of the projects, identifies teams required to facilitate 6Sigma deployment, determines goals, directs projects, identifies and removes barriers, monitors and reports Six Sigma progress, validates project results. Champions train green belts and black belts. Champions; who are committed to six sigma success and they are informal leaders of six sigma in their day-to-day work. Champion; fix the scope of projects, confirm changes and give directions about scope and aim of project, find sources for project, represent top quality council, work with process owners to finish project without obstacles.

### 3.2.3 Master Black Belt

Master Black Belts are technical leader who support data analyzes and trains green belts and black belts. They also help the champion on project selection. Master Black Belt has technical knowledge in Six Sigma and managerial skills. MMB has knowledge about statistical analysis. This professional has highest level of technical profiency in applying. They work with process owners to reduce defects, track progress and improve quality. Master black belts collaborates with champions, helps to define project, supports Black Belts at project works, joins project investigations to give technical consulting. Master black belt; they have highest level of technical and organizational proficiency. They have additional skills to success six sigma program as deep understanding of mathematical theory of statistical methods. MBB must processes excellent communication and teaching skills. Master Black Belts; communicate with Project sponsor and top quality council, make program for project, eliminates inability to cooperate, predict potensials and control results, collect data and analyze them about team workers.

### 3.2.4 Black Belt

The BB should have leadership and communication skills. They coach Green Belts in accomplishing their projects. Black Belt has technical problem-solving skills help achieving strategic objectives and improve bottom-line performance. Also they explain the basic tools. Training of the black belt completes in a six months period of time. In addition Black belts determine project boundaries, directs the team to verify the projects, reports progress to leaders, help champions if it is necessary, determine active tools in implementation. Black belt; they are actively involved in the process of organizational change and development. Their proficient involves use of advanced statistical analysis software pachages too. Black Belts; clarify the Project logic with sponsor, create and update the Project report and improvement plan, choose Project team, search and define sources, help the use of 6 sigma tools and management techniques, help to ensure improvement of Project programs and control it, work with process owners and department manager and help to make easy finding new solutions for in progress applications.

### 3.2.5 Green Belt

They involve with 6Sigma projects before obtaining the certification. Statistical tools are available in Minitab software for training. Green Belts are trained in the use of Six Sigma methodology and tools. The number of projects per year is around two to three, because green belts work only part time on their projects. Green belts; provide a supporting role on improvement projects. They are able to forming and facilitating six sigma teams and manage projects. Green Belts; help to restoration of process and carry the improvement activities out personally, know basic analysis and measurements besides make analysis easily with the help of software, take 2 weeks training, green belts involve part time to projects.

### 3.2.6 Process Owners

They are responsible for the processes related to objective of project. It is important help to ensure sustained gains.

### 3.2.7 Project Sponsor

Sponsor is ultimately responsible of project success, assures adequate resources of project. Sponsors are owner of processes and they coordinate six sigma improvement activities.

### 3.2.8 Yellow Belts

All of the employees work for Project, take introducing education of Six sigma, join in suitable projects and contribute to continuous improvement.

### 3.2.9 Top Quality Council

Within 6Sigma, determine roles and create infrastructure of it, choose projects and find sources, evaluate progress in projects, give idea and support, support 6 Sigma projects as “sponsor”, determine the company’s net profit from 6 sigma efforts, find weaknesses and strong parts of work and evaluate progress, share best application examples of projects with employees and if it is necessary with supplier and customer, eliminate barriers which is reported by team.

### 3.2.10 Management Representative

Prepare 6 sigma education plans and track it, if it is necessary, take help from educational institutiens and consulting firms, answer demands of institutients which need help about 6 Sigma, help to quality champion in selecting project and occuring teams, confirm teams which is designated for projects, evaluate needs of teams and supply them, support in every subject to quality champion, track all restoration projects and report them to champions.

### 3.2.11Financial Representative

Determine how will project cost and return calculated, supervises the benefits of the Project, financial representative should be independent from project team.

## 3.3 Tools Of Dmaic

Methods, Tools & Techniques are important to the success of any Six Sigma, DMAIC. Every stage of a Six Sigma project requires these tools & techniques. Six Sigma and its tools have created an impact in the operations of many companies. Six Sigma tools can be utilized to promote improvements in quality both as a systematic and strategic manner. Six Sigma is a customer focused, well defined methodology for process improvement. Companies included tools of Six Sigma approach ensure more effective process and to eliminate defects. These toolsets include statistical and analytical tools. Six Sigma tools are included in DMAIC improvement project roadmap. It is important to ensure total commitment and leadership from the top management to have success with use of tools and techniques.

Application of tools and techniques;

Checklists, Control plans support Checking.
Check sheets, Bar charts, Histograms, Graphs help to collect data.
Pareto Analysis, Quality Costs set priorities and help to planning.

Affinity Diagrams, Brainstorming structures ideas.
Statistical Process Control helps to measure capability.
Flow Chart, C&E Diagram help to analyse problem and process.
Scatter Diagram help to identify relationships.
DOE identifies Control Parameters.
Mistake Proofing, FMEA, Matrix Data Analysis monitor and maintain control.

Definitions of main tools;

### 3.3.1 The Affinity Diagram

Help to generate a high volume of ideas or issues. It creatively brainstorms and organizes a large number of ideas. Affinity Diagram brainstorms ideas to find solutions and problems also it summarizes them to understand the basic of the problem. It also states the question, records and reviews ideas. Ideas which generated from a brainstorming session is analyzed, prioritized before they can be implemented with help of this diagram. Affinity diagramming is an effective technique for a large number of ideas.

### 3.3.2 SIPOC

SIPOC means Supplier, Inputs, Processes, Outputs, and Customer. It identifies these elements of process improvement project. SIPOC is a high level map of a process to view how a company satisfies their customer requirements in the supply chain. SIPOC addresses any of the problems, as long leadtime, poor quality, high cost etc.

### 3.3.3 Process Mapping

It is a process flowchart that helps to see detailed version of the process. Process Mapping is a method that used during the define step of a Six Sigma project to illustrate how a product is processed. A process map is a type of flowchart that uses symbols connected with arrows to represent visually how the parts of a process interact. Process Mapping helps to represent a process that contains a series of linked tasks activities which produce an output. It clarifies current situation and simulates targeted solution. It shows adds resources, costs, volumes and durations to build up cost models and identifies how the performance of this process can be measured.

### 3.3.4 Pareto Charts

It constructs and prioritizes the defect factors. So it will determine which issue has the huge impact in the process. Pareto Chart; ranks orders the bars from highest to lowest in order to prioritise problems of any nature. It shows importance of a particular categories which might be types of defects, expenditure categories, and reasons for a situation, categories of complaints. Working on the category with the highest occurence has the potential to give you the most benefit. This tool helps to allow us to devote our energies to the areas that will have the biggest impact.

### 3.3.5 Experimental Design (DOE)

It identifies key process input variables and its optimum settings that effect process mean. DOE establishes critical and noncritical variable selection and identifies process performance. Design of Experiments method identifies experimentation. DOE focuses on planning experiments to reduce the effects of random, uncontrollable the most effective method for identifying key input factors, establishing a mathematical relationship between inputs and outcomes, determining optimal input levels and setting process tolerances. The goal of DOE is to determine the most important process factors and find its optimal settings. It also helps to identify less important process for final product that may be set to a more economical level than previously thought. In not clear situations that causes problem or there are so many process parameters to consider nearly impossible to find the right combination to provide optimum performance, DOE tool is used.

### 3.3.6 Failure Mode Effects Analysis (FMEA)

It is an analytical approach for preventing defects by prioritizing problems. FMEA is a systemized group of activities aimed to recognize the failure of a product/process. It also identifies actions that eliminate the probability of the potential failure. FMEA is a proactive quality planning process. And the calculation of reducing risks by identifying the ways in which a product, process, or service can fail. FMEA approach facilitates the relative weighting of a potential failures before the action is committed at a conceptual or an early stage of operation. It prioritizes risks and documents recommended actions. Potential type of failure of product is assessed relative to 3 criteria on scale of 1 to 10. The 3 scales of potential failure are multiplied together to produce a combined rating which is risk priority number to provide the focus process efforts.

### 3.3.7 Process Control Plan

It establishes a process control system and it monitors the process response. Then it maintains the control of process inputs under SPC guidelines.

### 3.3.8 Project Charter

It help to link process to strategic business requirements, identifies customer characteristics, includes team charter and problem statement, shows scope and goals. In addition identifies and calculates financial benefits. A Project Charter is the starting point and it takes place in the Define stage of DMAIC. Project Charter is a guide for the team members to be focuse on the project.

### 3.3.9 Brainstorming

It is a group activity that people interacts with each other collaboratively to solve a problem have almost always had a better outcome than the average of the outcomes of each person working on the same problem individually. It establishes the aim of the meeting, does not criticize or compliment ideas as they are represented, records every each of ideas presented. In addition, brainstorming is an improvement tool to generate ideas on any topic by encouraging free thinking. All ideas are recorded without discussion until a complete list is constructed. BB or MBB act as an observer to guide the process and this technique actively manages team member participation.

### 3.3.10 Cause and Effect Matrix

It is used to identify and prioritize inputs that impact a set of output requirements based on their importance to the customer. It creates a process map prior to attempting to create a C&E matrix so that no factors are missed on the matrix. It arranges identified outputs the outputs on the process map in columns and assignes each one a rank, either relative to each other, or on a rating scale where 10 indicates an important output variable and 1 indicates a minor one. Cause and effect matrix captures VOC and also helps to find out less important steps so team can focus on critical input variables. It lists customer-related outputs and rank them interms of importance, therefore these outputs are key-process outputs of project. C&E lists process inputs that is taken from process map and brainstorming session and rates steps by using scale of 0,1,3,9 where 0 means no correlation and 9 is strong correlation. And finally it multiplies the process correlation times the customer weighting and adds the scores across the row to get a total score for each process input.

### 3.3.11 Cause And Effect Diagram

This tool is specialied idea organizing which helps to identify potential causes. 6 M’s (method, manpower, machine, material, measurement, mother nature-environment) organized in categories that looks like fish skeleton to collect data and resolve the issues. C&E is a graphical representation of potential causes. The aim of the diagram is to identify main causes of the problem. This diagram is using to study a problem or improvement opportunity to identfy root causes.

### 3.3.12 Statistical Process Control

This tool help to monitor a production process to help the process meets with quality standards. Some main tools can be involved in SPC as Process Control Charts, which establishes process control limits, and then are used over time ensure that the process stays “in control”. The seven basic tools as includes SPC tools as; Pareto Chart, C&E Diagram, Check Sheet, Scatter Diagram, Flow Charts, Control Charts. SPC helps process stability and guides on reduction of defects. SPC lies in applying it to the key process input variables identified with the DMAIC process, uncovering key inputs which is achieved in process control was the path to dramatic process improvement in the first place. Main comparents of SPC are creating a control chart, removing special causes of variation, instituting procedures for immediate detection and correlating of future problems.

### 3.3.13 Gage R&R Studies

It is used to evaluate a measurement system. These studies measure the amount of variability introduced into the measurement and compares it to the total variability observed in the process being measured. It is useful to identify an inconsistent tool or operator differences in measuring techniques and helps to establish the quality of the data which is collected and used to make decisions.

### 3.3.14 Flow Diagram

It represents and helps to understand of all steps in the process. It identifies flow of events. Flow Process Diagram shows the hierarchical structure of operations and the sequence of activities, non-value added activities.

### 3.3.15 Run Chart

It allows team to observe data over a period of time. Run chart detects trends, variations or cycles and allows team to compare performances of a process before and after the implementation of the solution. Run Chart tracks one or more variables over time. It is used to track variation and trends in the occurence of a defect over time. Data is collected will be produced over time such as key process measures taken each shift, number of defects produced per hour or per day, total lead time each day and so on. Run chart displays and analyzes data in the order is collected.

### 3.3.16 Scatter Diagram

It identifies the relationship between variables and factors. Scatter diagram is an initial step of Regression Analysis. Scatter diagram is useful for problem solving and to detect if there are more than two variables between causes and effects.

### 3.3.17 Control Charts

A control chart help to determine is process stable. Three control limits are drawn: the central line, the lower control limit and the upper control limit. The points above the UCL or below the LCL indicate a special cause. If no signals occur, the process is assumed to be under control, only common causes of variation are present. In addition, control chart helps to determine whether the variation seen in the data points is a normal part of the process or if something different is happening.

### 3.3.18 Process Capability Analysis

It helps to understand how well process variation fits within the range of customer specifications process or product should have stability before assessing capability. Therefore, capability analysis will be conducted after control charts confirm which the process is stable.

### 3.3.19 Measurement System Analysis

It is a  measurement system that uses Gage R&R studies to quantify the measurement repeatability and reproducibility.

### 3.3.20 Multi-vari Study

It samples and operates the process identify statistical and graphical analysis identifies the important controlled and uncontrolled variables.

### 3.3.21 Value Stream Mapping

It identifies the flow of materials. The aim is to analyze the current process to determine which steps actually add value to the customer or identify which steps cause waste of time and money. This approach looks at the production flow from customer demand. VSM follows the production path from customer to supplier and draw a visual representation of every process in the material and information flow. In general, it helps to visualize process level and helps to see sources of wastes. It forms the implementation plan and shows the linkage between information flow and material flow. It improves process by identifying added value and eliminating waste also it is a process map that help to follow value creation process and describe what the firm will do to effect numbers. It is sequence of steps required to satify a need categories are, demand, delivery, development, support. It identifies waste to eliminated within the current state and design and implement future state map. VSM visualizes the work processes and helps to highlight problem as well as areas for improvement.

### 3.3.22 Analysis Of Variance (ANOVA)

It helps to find difference in averages among shifts, investigates and try to answer. It standardizes shifts, finds different ways to set up machines, determines which output will have greatest effect and which areas should we explore. ANOVA compares the response variable means to assess the importance of factors. ANOVA requires data from approximately normally distributed populations with equal variances between factor levels.

### 3.3.23 Tree Diagrams

It breaks down ideas in greater detail. The goal is to divide problems into its smaller component help tree diagram to make the idea easier to understand, and make the problem easier to solve. It also shows the goal or objective the means of accomplishing the goal.

### 3.3.24 Critical To Quality Tree

It describes the output characteristics of a process. A CTQ tree helps data collection stage of an improvement project. After establishing who the customers are by project team, team should determine the customer needs and requirements.

## 3.4 Dmaic Literature Review

Motorola was the first organization that has used DMAIC as a quality performance measurement and improvement program. Also General Electric, Sony, Allied Signal used quality tools to gain knowledge. Especially, General Electric spent 500 million dollars and gained 2 billion dollars on DMAIC works in 1995.

“In 2012 Ganguly, has analyzed the reduction of cycle time for reducing inventory” [5].
“In 2013 Dambhare, has analyzed the main problem to what leads wastage of man hours and labor cost” [6].

Various researchers worked on DMAIC approach and is described in below;
“Snee (2000) defined the concept of DMAIC for reducing product and process variation. Statistics of rejection collected and critical causes identified for corrective actions. Then, suggestions implemented, rejections collected and compared with the previous rejection. So considerable improvements found. The results achieved were demonstrated by using Pareto diagrams. Accordingly rejections were reduced to 5.9%” [7].

“Horel (2001) explained DMAIC approach. It is applied in manufacturing operations and it started to expand to other functional areas such as marketing, engineering, purchasing and servicing. Whirlpool increased their quality by 10% by adopting DMAIC technique” [8].

“Anthony and Banuelas (2002) explained a case study on bulb manufacturing company for reducing the shell cracking during the manufacturing of bulbs and achieved improvements in defects by using DMAIC method” [9].

“Tony (2002) claimed that DMAIC approach is a global trend seter in developing quality management strategy. The success is related to its data based approach, which eliminates personal bias” [10].

“Zbaracki (2002) defined DMAIC as approach that help eliminating defects and quality control problems. If business activities in DMAIC approach properly implemented, it will improve customer satisfaction, quality and create a continuous improvement” [11].

“Breyfogle (2004) defined the DMAIC is effective in terms of delivering cost saving and it increases customer satisfaction. Also, DMAIC technique helps to reduce cycle time” [12].

“Joseph (2004) stated DMAIC method as it helps to achieve zero defect quality by using quality tools. In the 1980s, between different problem-solving methods was Juran’s five-step method that provide a standaridized way to achieve DMAIC results. Then, DMAIC became a standardized process today” [13].

“Bendall and Marra (2005) said that DMAIC approach is need to be applied to reduce quality problems in the industry and to eliminate customer complaints. Also, DMAIC brings improvement in organization by reducing defects in processes” [14].

“Kumar et al. (2006) dealt with the reduction of casting defects in an automative engine. The improvement achieved as a result of listening the problem of customer with the aim of evaluating and understanding their concerns. And, the defect rate is reduced from 19.4% to 2.9%” [15].

“Sanders and Hilolo (2007) explained that DMAIC method is a quality improvement process that help to solve customer problems. It focuses on employees for establishing a common language across the entire company. Also DMAIC creates well defined performance goals. After the detailed study case study analysed that the quantum of rejections in the castings can be reduced after applying the DMAIC technique” [16].

“Kim Yong et al. (2010) analyzed telecom company in Korea to identify and remove defective components and steps in work. DMAIC identified information utilization and the improvement plans” [17].

“Al-Refaie et al. (2013) used DMAIC for improving the performance of compression process with two quality responses; tablet’s weight and hardness. Results found as the process capability values for hardness and weight are 1.5 and are 0.587. The multivariate capability index, calculated 0.938. And the process capability, process improvement values found equals to 3.31 and 0.848” [18].

“Roy et al.(2013); Six-Sigma is applied in Bangladesh, Manufacturing Industry shows the technical pathway of implementing this method in industries for improving the productivity and quality. Sigma Level of current state is calculated and total factors are taken under calculation. All the process of production are observed. Six-Sigma tools are implemented as the total improvement of production system and developing the process. A Fan Manufacturing Company analyzed and implemented DMAIC. As a result, remarkable improvements achieved by using DMAIC method” [19].

## 3.5 Literature Review Of Defect Reduction With Six Sigma Dmaic Method

“Improvement in production rate by reducing the defects of injection moulding (Vikas Tayal, Jitender Kumar) 2012”, in this article Dmaic method has applied. This approach helps to accelerate improvements in the injection moulding process by reducing defects. In define phase, this article about reduction of injection due to moulding defects in a moulding industry. Process map is created. In analyse phase, cause&effect diagram and sand control test is made. Also plastic control tests are made as ESCA, AES and gren compression strength. In improve phase, the root factors for blush defects were excessive injection fill speed. Therefore to perform these tests was necessary to improve the blush defects. On the other hand, some improvements are done to reduce the rough surface defects too. The result of present work showed that the rejection has reduced from 7.44% to 2.75%.

“A case study of defects reduction in a Rubber Gloves Manufacturing Process by applying Six Sigma Principles and Dmaic problem solving methodology(Ploytip Jirasukprasert, Jose Arturo Garza-Reyes, Horacio Soriano-Meier, Luis Rocha-Lona) 2012”, this case study ensures application of 6Sigma and Dmaic method to reduce product defects in a rubber gloves manufacturing organisation. “The analysis indicated that the oven’s temperature and conveyor’s speed influenced the amount of defective gloves produced” [20]. DOE and ANOVA techniques are combined. Thai gloves aimed to improve quality to create competitive strategic advantage and this case study investigates quality issues of this company and it provides solutions to reduce defects. In define phase, VOC identified the customer needs and it also ensured project problem. Also project charter used as tool to document targets and summarized project’s scope. In measurement phase, collection plan is adopted to gather data. DPMO and Sigma Level calculated. As a next step, Pareto Analysis is made to determine most critical problem. In analyse phase, manufacturing process illustrated by flowchart. Also in order to illustrate causes of problems, cause and effect diagram constructed. In addition, root causes brainstormed in cause&effect diagram. Improve phase aimed to identify solutions to reduce and tackle them after determining root causes. DOE techniques suggested to enhance process yields, decrease variability and lowering overall expenses. In order to anayse the experiments result, two way analysis of variance (ANOVA) is used too. Control phase sustained gains from process which improved. As a result, SixSigma solved quality problems, saved cost, increase product quality and enhanced customer satisfaction. “A reduction of about %50 in the leaking gloves defect was achieved which helped the organisation studied to reduce its defects per million opportunities (DPMO) from 195,095 to 83,750 and thus improve its Sigma Level from 2.4 to 2.9” [21].

“Reduction of welding defects using Six Sigma Techniques (Shashank Soni, Ravindra Mohan, Lokesh Bajpai, S.K. Katare) 2013, the root causes identified in a welding process and Six Sigma technique to eliminate the problem” [22]. In define phase, the aim is to define purpose of project and process background. SIPOC, VOC and Quality functions are used as tools. Pareto chart is made to show saw welding process, Project team charter and SIPOC diagram illustrated. VOC revealed based on customer data and CTQ prepared related to VOC and project objective. In measure phase, detailed process mapping and data collection chart is made. Current level of process performance assessed. In analyse phase, result of cause&effect diagram is described. Pareto analysis and why-why analysis is made to identify root causes. In improve phase, brainstorming is made to show results after solution of defect in controlled condition Final Action for Validation Method Table and The Machine Process of Structure is illustrated. “In control phase, a control plan was developed to ensure customer requirements, and to check how external/internal welding process on quality production level” [23]. As a result, possibility of defect reduced, cost of poor quality reduced and labors expenses reduced, production time and index cost/volume reduced. “Operational 6Sigma methodology was selected to solve the variation problem in a welding process” [24].

“Reduction of Defects in Latex Dipping Production: A Case Study in a Malaysian Company for Process Improvement (M.C.Ng, Hasnida Ab-Samat, Shahrul Kamaruddin) 2013”, this study is about implementation of process improvement in a latex company in Malaysia. “Dmaic phases applied in latex dipping production line. Latex production line in Malaysia was carried out with an objective of finding out a strategy for developing focused solutions to reduce product defects using Dmaic approach from 6Sigma method" [25]. First of all, framework of Dmaic steps introduced to reduce defects in dipping process. Dmaic is grounded in PDCA cycle to apply process improvement effort. In addition, surveys are made to determine the problem  according to customer requirements. In measure phase, measure is targeted to the total reject quality. Rejects are classified into types and list of defiency produced. In analyse phase, improvement plan made to analyse process and identify the root causes Latex-dipping process is studied and analyzed and defect types identified. Fishbone method is used to find causes and main suspect causes identified. After determining different defects also share same root causes with help of fishbone diagram. Pareto chart is used to identify causes of the highest defect rates. In ımprove phase, company tried to maximize benefits of efforts. Ideas collected to solve the problems and redundant ideas eliminated. "After that, some selection criteria to asist in making the most appropriate solution decision are identified" [26]. Differently, matrix tool is used to select the best applicable solution. The proposed ideas scored and final decision is made. Also Two Criteria Matrix were set up. "Additional resolution is needed to distinguish among opposing improvement methods, a finer scale is used and listed" [27]. After some alternatives eliminated, the team illustrated concept storing table differently. So more detailed analysis conducted and quantitive evaluations of removing concepts accomplished. Concept screaning tables are illustrated too and the improvement method that scores the highest rank is implemented. After the improvement process, defect rate measured. The results obtained, defect rates reduced and sigma level increased from 2 to 4. "According to the decline in defect rates, the capacity met with customer requirements and achieved to good quality products which delivery on time" [28]. High inventory reduced to minimal.

"Applying Lean Six Sigma for Waste Reduction in a Manufacturing Environment (Mohamed K. Hassan) 2013, this study applied in a welding wire manufacturing plant for improving the quality of the manufactured welding wires, reduce the manufacturing process, by applying the LSS methodology and waste management" [29]. The case study compares performance of before and after implementation. AHP is used in this case to determine causes of waste and to understand influence of waste causes. Aıan this case DMAIC process of LSS tried to make quality and productivity improvements in a welding wire company. This study aim to enrich Six Sigma methodology with use of engineering tools as AHP method to understand causes that leads the defect generation in the welding wire manufacturing process. Also SIPOC Diagram fort he welding wire manufacturing process is occured. In addition to these diagrams, investigation of the company process, collecting preliminary data and writing problem definition is made too. In measure phase, process mapping, data calculation and downtime measurements are made differently. In analyse phase, Fishbone Diagram, Pareto Chart and AHP applied to prioritize the different causes of waste. After determining causes of defects in improve phase, improvement actions accomplished and in control phase a control plan designed. “In conclusion, 5 phases of LSS methodology DMAIC process were implemented in the welding wire manufacturing company” [30]. Cause and effect study is used to determine main cause. “The aim of the company’s management was to reduce the waste ratio to be below 4% which could not be achieved without following a systematic methodology like LeanSixSigma” [31].

“Reduction in defects rate using DMAIC approach-A Case Study(Jitender Kumar, Mukesh Verma, K.S. Dhillon)2014”, this study identify the problems occuring during manufacturing. “DMAIC tool applied to better analysis of different processes in thread manufacturing. This textile firm has large departments where the thread produced from the waste clothes, after passing through different processes” [32]. So DMAIC methodology implemented in winding departments where the final package of thread is to be made. “Final package of thread is the end product and it is directly sent to the customers, any defect may lead to the customer’s complaints” [33]. “With the help of DMAIC approach the defects has been reduced from 13012 to 513 and sigma level of the industry has been increased from 3.8 to 5.03. This work deals with the reduction of rejection in the textile industry” [34]. The product of this industry is thread from the waste cloth pieces and having high rate of rejection due to defects in various operations. Data collected to find rate of rejection and sigma level of all departments to measure and find the must critical one. In analyse phase, failures recorded in manufacturing plant. VOC table and cause and effects diagram illustrated. In improve phase, prevention action is taken and critical parameter found to be changed. Changed settings of parameters used and its effect table occured and also chart between defect % and sigma level table illustrated. In control phase, new process conditions documented process is checked by control charts. Data of defects percentage and range showed that the process is under control. With the implementation of DMAIC approach the root causes of winding defects are identified. “The defects have been reduced from 13012 units per month to 513 units per month. The sigma level of the industry has been increased from 3.81 to 5.03”[35].

“Combining Lean Concepts&Tools with the DMAIC Framework to Improve Processes and Reduce Waste (Mazen Arafeh) 2015”, Six Sigma, DMAIC methodology applied to improve productivity in company of safety and fire resistance metal doors, windows and frames. Improvements implemented to reduce production cycle time from 216 min to 161 min. Also percentage of defective doors decreased from 100% to only %15. In define phase, clarify scope and define goals. Identify improvement opportunities with help of VOC, VOP, VOB and VOE. Manager and workers discussed the problems and made brainstorming sessions. In measure phase, data collected and performance measured according to customer requirements. Plant layout selected and plant observed. Informations are gathered from brainstorming sessions and stage of gathering data. Value-added flowchart and Pareto chart are created. In analyse phase, root causes analyzed, accounting for the errors or defects quantified. This phase focus on investing root causes of problems and brainstorming sessions to examine causes besides flowchart, cause and effect diagrams identified causes of each problem. In improve phase, another brainstorming session identified potential improvement opportunities. The control phase, monitoring system is implemented to reduce future errors and results documented.

“Analysis of a Six Sigma Project for the waste reduction of cold drawn steel pipes in a steel pipe manufacturing company (Zeynep Gergin, Elif Naz Acar, Dilara Terzi)”, this case study aims to analyse process steps of cold drawn steel pipes and a Six Sigma Project which is using the DMAIC methodology in a steel pipe manufacturing factory. In define phase, project’s goal and scope is identified. In measure phase, detailed data collected to find less capable process and analysed via frequency distributions. Rate of defect number and total production amount is determined with help of a graph. Defect type distribution is showed too. Defects and their occuring reasons detected and in improvement phase, improvements proposed to prevent defects. Monthly production distribution table and Pareto Analysis of defect types are made. Before-after analysis is illustrated to understand the effect of improvement. In control phase, improvement data collected and analysed to evaluate the effectiveness. After Project process defect rates calculated and firm reached the 2,24% targeted defect rate.

“Lean Six Sigma and an Application (Doç.Dr.Onur Özveri, Arş.Gör.Engin Çakır)”, this study is about an application of Six Sigma which implemented in a wheel manufacturing company. Pulley section problems determined with the help of VOC analysis. In define phase, VOC and CTQ’s determined and also AHP method is used to rank customer needs. AHP determined the most important customer need and Tree Diagram determined what should company to do. SIPOC diagram is illustrated to show the progress. Besides data collection plan is made and Pareto Analysis determined the root cause of defect. Flowchart of process is created. In measure phase, measurement system analyse method is used with eye control. Sigma levels had calculated for 10 months. Process capability analysis made and process cycle productivity calculated. Also differently, Takt Time calculated. In analyse phase, detailed process analysis is made by Microsoft Visio 2010 and Fishbone diagram is illustrated to find out causes of main defect. In improve phase, SMED and SS method used. After improvement, new sigma levels calculated in control phase DPMO values decreased as defect rates. Besides Time-Series Graphic and Before-After Analysis are made. After this implementation, number of defects in the Pulley production process is decreased, also the waste which is occured in production process eliminated.

“Reduction of paint line defects in shock absorber through Six Sigma DMAIC phases (K.Srinivasan, S.Muthu, N.K.Prasad, G.Satheesh), this case study focused on reduction of two imperative responses in spray painting process producing shock obserbers, namely peel off and blisters using the 6 Sigma Dmaic method that highly impacts quality at customer end” [36]. In define phase, Pareto chart, VOB and Project Charter created to define critical stage which is spray painting process. In measure phase, brainstorming session and process capability analysis is made by using the statistical software package Minitab 16. This showed current process look and signal level was 3.31. In analyse phase, root causes which has impact on responses are identified. The cause&effect diagram is illustrated to identify factors and its causes. The average rating causes calculated and total weight obtained. In improve phase, condition of optimization of process of is analyzed by ANOVA. In control phase, results obtained from runs and sigma level is embarked from 3.31 to 4.5. “The continuous pursue on eliminating variation in the processing stage was attained by framing a control plan to control the variation within acceptable levels in the pretreatment process” [37].

“Applying Six Sigma Methodology Based on DMAIC Tools to Reduce Production Defects in Textile Manufacturing (Mohammed T.Hayajneh), DMAIC model help to identify and eliminate sources of defects in a process, improve performance with help of control plans and promote one process improvement language for all members of an organization to employ” [38]. “The application of the 6 Sigma methodology resulted in a reduction in the overall quality level from 7.7% to 2%” [19]. Century Standard Textile achieved an averaged overall quality level (OQL) of 4.7% for cargo pant production line, which is obtained through its customer audits, while the customer calls to have this percentage as 2% [39]. In define phase, VOC is found to determine resource availability and business benefits. Also cause and effect diagram determine critical CTQ issues. The prioritization matrix is made to set items into an order of importance. “Reducing the OQL for pants production line to 2%” is found more important. In measure phase, C&E Diagram is used to understand current process and define causes so management members weightened all causes. Flowchart/Process mapping tool used to identify problems. Also Pareto analysis used to identify problems and results are displayed by it. Samples are taken and defects breakdown found during 6 months. In analyse phase, team identified root causes and critical factors to achieve target for improvements. In improve phase, organization made testing and standardizing these solutions. The control phase, study aimed to create standard measures to continue performance. Also, OQL and SPC charts helped to track processes by plotting data over time between USL, LSL limits with a center line. “Upper specification limit is set to be 2% as a request from the customer, accordingly OQL will be controlled. As a result, after applying Six Sigma methodology, averaged OQL of 4.7% reduced to 1.7%” [40].

“Manufacturing waste reduction using Six Sigma methodology (Ricardo Banuelas, Jiju Antony, Martin Brace)” , DMAIC methodology used for reducing waste in a film-coating process in this project. Scope of the project and developing project charters made in define phase. The main aim of this article is cost reduction through waste elimination and reducing manufacturing cost. Pareto analysis used to assign different defects. Team illustrated cause and effect matrix that lists potential projects and opportunities. During the define phase, the scope is defined by team, Dmaic roadmap listed, customer characteristics and financial benefits identified. In measure phase, map process is identified with help of SIPOC and SOP diagram, baseline process capability and measurement system capasity established. Cause&effect analysis and data collection plan is made. The current process performance at sigma level is 1.2 or 88.5% yield in the long term. Box plot table is made for operating time to show failures of operation cycle time. R&R analysis is also made to assess how much variation is associated with the measurement system. Fishbone diagram is illustrated and in analyze phase data collected from measure phase. In additon, main effect plot table illustrated. Hypothesis test, Gage R&R and data collection plan is made. In improve phase, the probability of re-winder defect based on the actual variation of gap is determined. Process capability is estimated. “As a result the sigma level short team was 3.52, whereas the sigma level long term was 1.47 sigma. Thus, the sigmma shift which describes how well the process being measured is controlled over time is estimated to be 2.0499” [41]. Transfer function estimated by the linear regression using DOE. Besides, vector diagram is made and alternative improvement is identified. The improvement using transfer functions are validated. The sustained solution implemented to improve even further to 2.64 sigma long term. Control charts are created (I and MR chart for rewinder by step) Team also developed a monitoring plan. Effective use of 6Sigma reduced defects in continuous film line. Savings increased, run time increased, quality improved, inspection reduced.

# 4. A CASE STUDY IN SUPSAN A.Ş.

## 4.1 BORUSAN HOLDING

Turkey’s leading industrial and service company Borusan Holding was founded in 1944. Borusan which is located among the pioneers of corporate management in Turkey, still has and operates in main five business areas as steel, distributionship, logistics, energy and telecommunications. Celebrating its 70th anniversary in 2014, the Borusan Group continues to consistently grow in the steel, distributorship, logistics and energy industries in various markets of the world, particularly in Turkey. The main strategy of Borusan Group is based on continuing to create added value for Turkey's economy while fostering a mindset that focuses on global markets and creates innovative products and services.

In 1984 Six Sigma method is used firstly in Motorola. Borusan has used this method since 2002. 6 Sigma showed that every reduction in defect rates has a huge effect on customer satisfaction. If sigma level increases, defect rate decreases. 6 Sigma that is applied by big companies of the world to reduce defect rates in business and production processes. Six Sigma is business methodology that target productivity, profitability and customer satisfaction. Borusan Group has used this methodology since 2002. With the help of Borusan's strategic management model Six Sigma methodology model, company increased their financial growth, profitability and made real cultural change. Six Sigma studies are implemented by fulltime employess who specialized in this methodology. These are; Black Belts that examine projects and give trainings, Green Belts that take part in project part timely and employees who can work in every level. In the end of 2006, 715 project is made that 2043 Borusan employee had joined. These projects provided value as near as 66 million USD. 6 Sigma Success Factors; work process designs, customer and market integration, stretegy integration, fulltime 6 sigma leaders, roles and responsibilities, measurable results. Primary responsibility of Borusan Holding is to move properly as its vision and mission. Company has 5 corporate value; determination to success, individual initiative, customer oriented, honesty and contribute to community.

### 4.1.1 BORUSAN And Six Sigma

Productivity and customer satisfaction are the critical success factors of Borusan Group. In years company has embraced this factors with help of implementation tools, new business strategies and Six Sigma methodology. Since the other half of 2002 Borusan Company has used Six Sigma method's DMAIC approach to get close strategic goals and critic success factors.

Six Sigma is a strategic method and a corporate approach to approach perfection in performance. Borusan Group applied Six Sigma as a part of its corporate structure in 2002 to create an innovative, and efficient business culture. Six Sigma in Borusan has a vision of 'continuous improvement' and 'customer satisfaction' in quality policy. Borusan improved their operations in order to meet the critical demands of our customers by listening to customers to reach high quality and service.

Company put effort into creating opportunities for all our employees to take charge in the Six Sigma projects and encourage them to participate. By applying Six Sigma, defect rate costs are reduced, efficiency is increased, customer satisfaction is enhanced.

Borusan's condition of continuous improvement means standardized operation processes, eliminating waste, not getting involved in business that adds no value, focusing on reducing the time, removing the principle reasons of the problems, making on site observations and investigations, improving multi-dimensional skills of employees, improving skills for fast problem solving.

In addition, Borusan Group has a strong corporate business culture and it is committed to develop an innovative, distinctive and economical solution intended for customers to understand their needs. Borusan offers innovative products, services and business models that will shape the markets of its presence thanks to its to take fast and flexible actions with no fear of risks.

Borusan Group maintains international partnerships with powerful corporations from all around the world. Borusan has successful partnerships with the world's leading steel manufacturer ArcelorMittal, EnBW AG, the world's largest industrial corporation Salzgitter Mannesmann and the automotive giant BMW AG.

The mission of Borusan Holding is a building corporate identity and culture, ensuring efficient utilization of resources, constructing effective communication channels.

To accomplish this mission, Borusan Holding is positioned as a “Strategic Holding” that calls for a balanced concentration on the investor role and the enabler role that exist within Borusan Holding: The investor role refers to active portfolio management to maximize value to the shareholder and the enabler role is responsible for supporting the success of the Group’s companies. Borusan Group determined 3 strategic priorities as long term strategy to focuse on reaching the strategic destination and includes a stream of linked objectives. These strategies are profitable growth, strategic market positioning and business excellence.

## 4.2 SUPSAN A.Ş.

Supsan is a Borusan Holding company started production on 3rd of September 1970 under the license of Eaton SRL. Supsan is the biggest valve manufacturer in Turkey with 10 million production capacity. Stellited product capacity is 4 million pieces, double pieced product capacity is 5 million pieces. Valve properties are; head diameter is between 19 mm-66 mm arasında, total length is between 73 mm-274. Supsan is the leader in Turkey in its own business. Anadolu Isuzu, Ford Otosan, Iveco, Oyak Renault, TofaşFIAT, Tümosan, Türk Traktör, Uzel, Başak Traktör, Pancar Motor, Yavuz Mühendislik, Otokar, Temsa, Daf-TIRSAN, Karsan are supplied with Supsan valves. FIAT, Peugeot, Renault, Ford, Ferrari, Nissan, Volkswagen, Mercedes Benz, Dacia, JCB, DAF, Volvo, Iveco, VM Motori, Isotta Fraschini, Bentley, John Deere, Chrysler, GM, Detroit Diesel are foreign customers. Supsan began to sell camshaft, valve lifter, gasket set and engine bearing with its own brand, starting from 2009.

Strategic Positioning; the leader in the domestic aftermarket, the largest manufacturer of engine valves, guides and valve cotters in Turkey.

It increases growth in sales thanks to improving relations with Eaton, the leading manufacturer in the global market. As a result of agreements with Eaton increased as 21% of export volume. It launches guide in the aftermarket segment. By scoring 82 points on the customer loyalty index, Supsan managed to remain above European and global industry sector averages. Following in the footsteps of the Voice of Customer scheme, different Six Sigma projects were completed in the past years. By listening to the VOC through its dealership channels, company attains a deeper understanding of the market. Business processes are continuously being evaluated by listening to the feedback of 1,500 different retailers, services and reconditioners.

Production of valves are under license from the leading global manufacturer.

Products and Services; 7 million valves yearly, 3 million stellited parts, 4 million bi-metallic parts.

SUPSAN ENGINE PARTS; Engine valve, Valve cotter, Engine guide, Seat insert, Camshaft, Valve lifter, Gasket set, Engine bearing.

Six Sigma studies are done by Black Belt who are specialized in this methodology.

### 4.2.1 What is Valve?

Mechanical or electromechanical device by which the flow of a gas, liquid or loose dry material can be started, stopped, diverted, and regulated. An engine valve is an important part of engine running. It is in the head which is just over the block and pistons. There are exhaust and intake valves. The camshaft triggers the valves to go up at certain point for allowing air and fuel in for intake and allowing waste to get out through exhaust. They return down with a spring and seal up the combustion chamber give you the compression needed for the engine to run and the fuel to ignite and drive the pistons. They allow the engine to run efficiently at all speeds.

### 4.2.2 Quality Policies of SUPSAN

- To carry out all requirements of quality management system.

- To respect a law.

- To provide high quality product or service just in time.

- Continuous innovation and improvement to increase productivity.

- To be reliable and preferred by customers.

- To be customer and employee oriented.

- Adding value and increasing proficiency of employees with continuous training.

- To encourage entrepreneurship.

- To ensure that suppliers fit with quality conditions.

### 4.2.3 Valve Production in Supsan

Supsan uses the high-technology in valve production. Finishing lines are equipped with fully automatic work stations. Customer orders are met as fast as possible. Supsan, uses 100% original OEM specified raw materials in its products, which are purchased from international Eaton approved suppliers. The head of the valve is upsetted by induction heating and applying pressure from the bottom until it takes the shape of an onion. And after it forged to get the conventional head shape of engine valve. Inlet valves and the stem of exhaust valves are hardened in special furnaces to get the metallurgical needs. After that they are tempered in tempering furnaces to be eligible to work in motor conditions.

The head of exhaust valves are kept in solution furnaces to fullfill the metallurgical needs. After that they are applied to aging process in tempering furnaces. The head and stem parts of the exhaust valves are welded with friction welding technology. The highly durable material, stellite is welded to the seat area of exhaust valves by the new plasma technology to get the outmost resistance to the hot and corrosive exhaust gases. Tip ends of valves are hardened by new induction technology to have the maximum endurance.

Valves are processed to their final dimentions by mechanical operations in high-tech finishing lines. Chromium is plated to the stem of finished valve in fully automatic plating pools. By plating, valve gets the maximum durability and smoothness for its life in valve guides. Valves are 100% checked for dimensional faults and cracks before packaging. Valves packed with original Supsan packages.

Completed valves are kept in warehouse under optimum conditions. Metallurgical characteristic of valves are controlled during after the production in Supsan metallurgical labatory with high tech equipment. In Supsan all processes are followed on a computer infrastructure.

### 4.2.4 What is Stellite?

Today stellite is using for coating parts that can be exposed to erosion in high temperature as stellite coating on valves. Stellite comes from family of alloys that exhibit excellent resistance to corrosion. Main constituents of Stellite alloys are Co, Cr, W, Mo, C. It shows excellent resistance to high temperature. Variety of manufacturing methods, including various casting and surfacing proceses, stellite cooating prevents cracking. Stellite alloy is designed for wear resistance. It is invented by Elwood Haynes 1900s and trademarked name of the Kennametal Stellite Company. The alloy is hard and maintains a perfect cutting edge even at high temperature, resists hardening. Stellite alloy is formulated to maximize combinations of wear resistance, corrosion resistance and ability to withstand extreme temperatures.

## 4.3 Research Questions

This research will adress the following questions;

Why DMAIC methos is used in this project instead of other methods?
SUPSAN generally uses Kaizen method in their defect reduction projects but in this thesis application I suggested to use DMAIC method because it was more suitable for what we aim to do in this Project.

Why defect reduction is made in this project?
Defects were causing extra cost and unit piece cost was increasing. In Stellite line which Project is made defect rates are out of target level so company needed an improvement.

What are the other methods that can be used in other processes and organizations?
DMAIC, Kaizen, BPR, JİDOKA and Value Stream Transformation methodologies are using by companies.

Wht is defect problem impotant for companies?
Defects cause ineffectiveness in final quality control lines that want to ensure zero failure in production.

What can be done if there are nonconforming products?
Methods as Poke Yoke, SPC, Inspection can be used to eliminate defects.

Relationship Between Six Sigma and Defect Rate?
6 sigma means 3,4 (ppm) defects in one million product. SUPSAN uses this rate in their customer restitution. Target defect rate for OEM customers is 3ppm for restitution. On the other hand SUPSAN aims to have %3,5 defect rates in manufacturing because Six Sigma can cause increasing in cost. Therefore, this rate is suitable fort he company. And the company aims %3 level of defect rates for new started project

## 4.4 Implementation In SUPSAN A.Ş.

### REDUCTION OF DEFECTS IN STELLITE LINE

4.4.1 Define Phase: It defines the aim, objective and resources of the project. This phase describes VOC and VOB and understands the current process. It identifies problem statement and goal statement.

DEFINE AGENDA

- Project Report
- Project Calender
- Communication Plan
- Lean 6 Sigma Risk Analysis rvz0
- Potential Root Causes

| Project | SUP-HU-02-Reduction of Defects in Stellite Line | Date | 19.08.2015 |
|---|---|---|---|
| | | Revision | 0 |

| Job Status | Opportunity Announcement |
|---|---|
| From February 2015 to the middle of August, 53.755 pieces of defects threw from within the 1.237.468 valves which is produced in Stellite line and percentage of defect materialized as %4,34. In this process, defect cost is 102.134$. This situation block the sending intended products to stated lines and causes problems as additional labor, traceability. VOB, make a demand the enhancement of situation that create extra cost due to high ratio of defect in related line. This project support the CFSs that is in strategic plan as FO-Shareholders Value Maximization, F2-OEM To Become Profitable, F8-Effective Cost Management, I6-Ensuring Continuity of Quality. | Percentage of defect of stellite line in last 6,5 months amounted %4,34. At 2015, Daily 9.000 pieces and yearly 2.565.000 pieces of valve production envisioned. Unless making an enhancement in process, production will have same defect ratio and 2.565.000 pieces of valve's 111.321 pieces of it will be defect. Cost of defect will be 211.510$. With this project, defect ratio withdraw to the target valve level %2,00 which is the aim of the line. Reaching the %2 defect goal will cause reduce %53 of wastes because of this it helps to gain VS 91,386$ return. Also project will support the Supsan in achieving their general defect goals. |

**Target Notification**

| | |
|---|---|
| Number of Defect | 53.755 |
| Absolute Pieces Undergoing the Process | 1.237.468 |
| Defect % | 4,34% |
| Target Defect Reduction | 53% |
| Planned Daily Production | 9.000 |
| Planned Yearly Production | 2.565.000 |
| Target Defect % | 2% |
| Defect Cost($) | 1,90 |
| Target Defect Return($) | 114.232 |
| Total Return-VSK ($) | 91.386 |

**Content**

All defects at Stellite Line.

**Project Plan**

| | Start | Finish |
|---|---|---|
| Define | 20.08.2015 | 05.09.2015 |
| Measure | 06.09.2015 | 04.10.2015 |
| Analyze | 05.10.2015 | 24.10.2015 |
| Improve | 25.10.2015 | 26.11.2015 |
| Control | 27.11.2015 | 15.12.2015 |

**Project Team**

| | | | |
|---|---|---|---|
| Sponsor | Ziya Ergin | Finance Officer | İzzet Kafalı |
| Process Owner | Oktay Köken | Black Belt | Hakan Üstündağ |
| Master Black Belt | Veysi S.Ünser | Green Belt | Abdullah Öksüz |
| Green Belt | Emin Eker | Green Belt | Aykut Yılmaz |
| Green Belt | M.Yanıkömer | Green Belt | Alpay Gülmez |
| Green Belt | Nurzat Güven | Green Belt | A.Osman Üstün |
| Green Belt | Erdal Kurt | Green Belt | Taner Kahraman |
| Tranee Engineer | Yağmur Aslan | | |

Table 12.1: PROJECT REPORT-rvz00

In Project Report Job Status and Opportunity Announcement is determined. Target Notification and Content stated. Also Project Plan and Preject Team defined.

Determined days for phases are as follow;

| | August | September | October | November | December |
|---|---|---|---|---|---|
| Define | 20.08.2015 | 05.09.2015 | | | |
| Measure | | 06.09.2015 | 04.10.2015 | | |
| Analyze | | | 05.10.2015-24.10.2015 | | |
| Improve | | | 25.10.2015 | 26.11.2015 | |
| Control | | | | 27.11.2015 | 15.12.2015 |

Table 12.2: Project Calender

COMMUNICATION PLAN

| STELLITE LINE DEFECTS | | | | |
|---|---|---|---|---|
| Target Group | Activity | In Charge Of | Date | Status |
| Stellite Line Team Leaders & Operators | Explanation of defect tracking and improvement systems extented of project. | H.Üstündağ | W14-W15 | OK |

Table 12.3: Communication Plan

**Lean 6 Sigma Risk Action Plan**

**Project Name : SUP-HU-02-Reduction of defects in Stellite Line**

| Key Risk Category | Risk Comments | Actions | Owner of Actions | Informed | Target Date for Completion | Status |
|---|---|---|---|---|---|---|
| Strategic | | | | | | |
| | | | | | | |
| Financial | Investment cost is higher than predicted value. | Cost/Benefit Analysis will be made with Process Owner. | Process Owner | GM | | |
| | | | | | | |
| | | | | | | |
| Operational | Not reaching to targeted improvement value in related defect codes. | Taken actions will be tracked. | Lean 6 Sigma team | Sponsor | | |
| | The emergence of new defect types. | Specified actions at FMEA will be reviewed. | Process Owner | Sponsor | | |
| | | | | | | |
| | | | | | | |
| External | | | | | | |
| | | | | | | |
| | | | | | | |
| Industrial | Reduction of Eaton demands. | Investigation of alternative markets. | Production Planning | Sponsor | | |
| | | | | | | |
| | | | | | | |

Table 12.4 : 6 Sigma Risk Action Plan-rvz00

POTENTIAL ROOT CAUSES

**EXTRUSION**

- Producing valves that has different thickness of bottom neck from extrusion.
- Producing valves that has vertical mattery from extrusion.
- Mold Crash
- Overhead Secretion

**SLOTS**

- No standard taking of extrusion mattery.
- Standard thickness of slots
- No eccentric “Kam” special to the valve
- Plunge of mattery pen to forehead as much as bottom neck thickness.

**PTA’S**

- Can’t set the angle of tray to angle of “sede.
- Not using sprung “punta” in all PTA’s.
- Not making periodic cleaning and maintenance of PTA tabla engine and generators.
- PTA cooling water temperatures.
- When the temperature increase, Not all PTAs have PTAs self-stopping systems and the temperature of stopping stall is high.(40C)
- Mechanical gaps at the loading and unloading systems.
- Not standard calculation of source parameters.
- Can’t send sample to crack at the moment of  welding. (especially in small parties.)
- Cooling Water Flows
- Change in speed of 227 tabla engine.

4.4.2 Measure Phase: Helps to identify which data is available in which source. It develops a plan to gather data and summarizes it. This phase measures the problem, determines if the process in control. It collects data from existing process and determines process performance.

MEASURE AGENDA

- SIPOC
- Process Map, Flow Chart &Value-Added Analysis
- VOB & CBR
- Current Situation
- Lean 6 Sigma Risk Action Plan
- Stakeholde Management Plan
- Measurement Plan
- Decision Proposal

SIPOC

**Start** :The Rough Grinding Operation **Finish**: Stellite Tension Removal Operation

| S | I | P | O | C |
|---|---|---|---|---|
| RECTIFICATION LINE | HUMAN | HARD STONING STELLITE SLOT ON STELLITE WELDING TENSION REMOVAL | STELLIT E COVERED VALVE | MECHANIC LINES |
| WORKSHOP | VALVE | | DEFECT | JUNKMAN |
| WAREHOUSE | STELLİTE POWDER | | STELLITE WASTE POWDER | PURCHASING & PLANNING |
| | KAM | | USED EDGE | |
| | HARD MINE EDGE | | USED STONE | |
| | CUTTING STONE | | STELLITE SAWDUST | |
| | GREASE | | LABOR COST | |
| | MACHINE | | OPERATING MATERIALS EXPENSES | |
| | METHOD | | | |

Table 12.5 : SIPOC Diagram

SIPOC; (Supplier, Inputs, Processes, Outputs and Customer) identify elements of project and its requirements.
It is a high level map of a process to view how a company meets with customer needs in the supply chain.

Process Map is illustrated of the Stellite Coating.

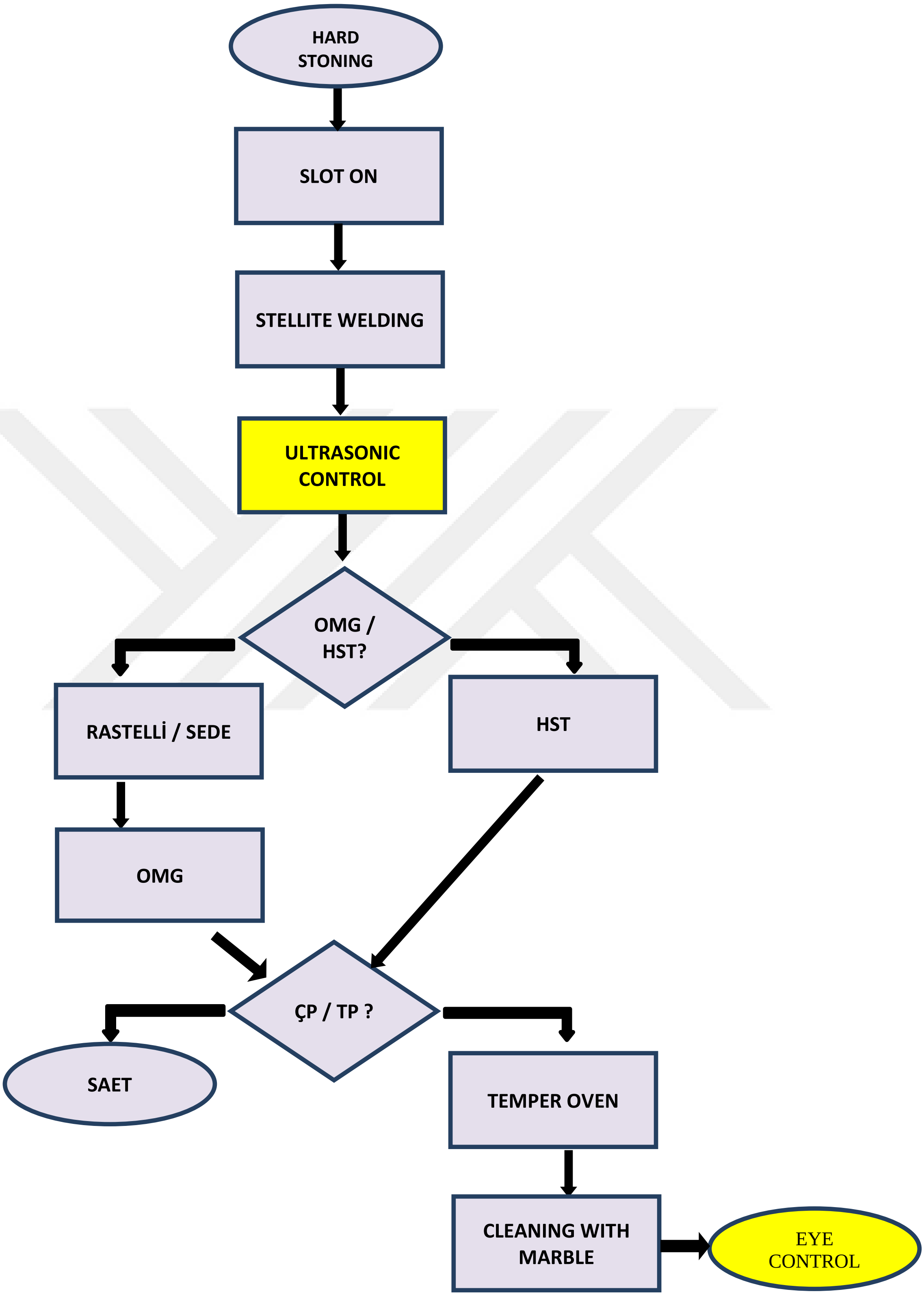



Figure 12.1: Process Map

VOC & VOB Determination
Transformation to CCR & CBR

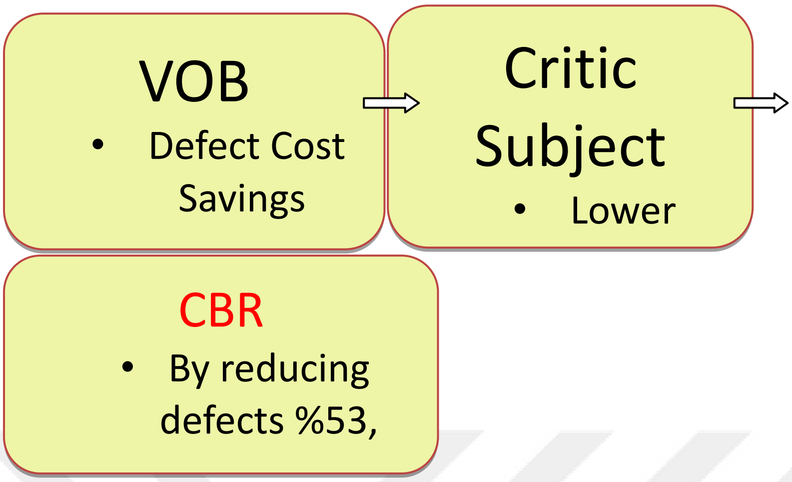



Figure 12.2: VOC&VOB Determination

| **Lean 6 Sigma Risk Action Plan** | | | | | | |
|---|---|---|---|---|---|---|
| Project Name: SUP-HU-02-Reduction of defectsin Stellite Line | | | | | | |
| Key Risk Category | Risk Comments | Actions | Owner of Actions | Informed | Target Date for Completion | Status |
| Strategic | | | | | | |
| | | | | | | |
| Financial | | | | | | |
| | | | | | | |
| | | | | | | |
| Operational | Can not carried out trial of giving sideward burr hammering. | Monitoring mold design and it's use of in related work order. | Blackbelt | Sponsor | 04.10.2015 | OK |
| | As a result of decreasing in production amount, target data collecting work cannot be made. | Working coordinated with Planning and Line manager. | Black Belt | Sponsor | 04.10.2015 | OK |
| | Can not carried out the measurement samples till FKK. | Work orders containing dash 1 will be opened after discussed with planning. | Black Belt | Sponsor | 20.10.2015 | OK |
| | | | | | | |
| External | | | | | | |
| | | | | | | |
| | | | | | | |
| Industrial | | | | | | |
| | | | | | | |
| | | | | | | |

Table 12.6: 6 Sigma Risk Action Plan rvz01

| Stakeholder | Responsible | Action Plan | Frequency | Feedback Mechanism |
|---|---|---|---|---|
| S1 | H.Üstündag - Black Belt | Keep contact regularly | Once / month | 1 to 1 meeting |
| S2 | H.Üstündag - Black Belt | Keep contact regularly | Twice / month | Verbal folllowing |
| S3 | H.Üstündag - Black Belt | Data interchange about the project ang progress | Twice / month | Verbal folllowing |
| S4 | H.Üstündag - Black Belt | Continue personal contact.Talk about the benefits | Once / week | Informal Personal Contact |

Table 12.7: Stakeholder Managmenement Plan

**2015 February – August**

Defect Amount : 53.755

Defect Rate : %4,34

Target: %2

Defect Cost: 102.000 $

After examining current situation defect rates on yearly basis is calculated and illustrated.

Defect Rates on Yearly Basis
2011-2015 February-August

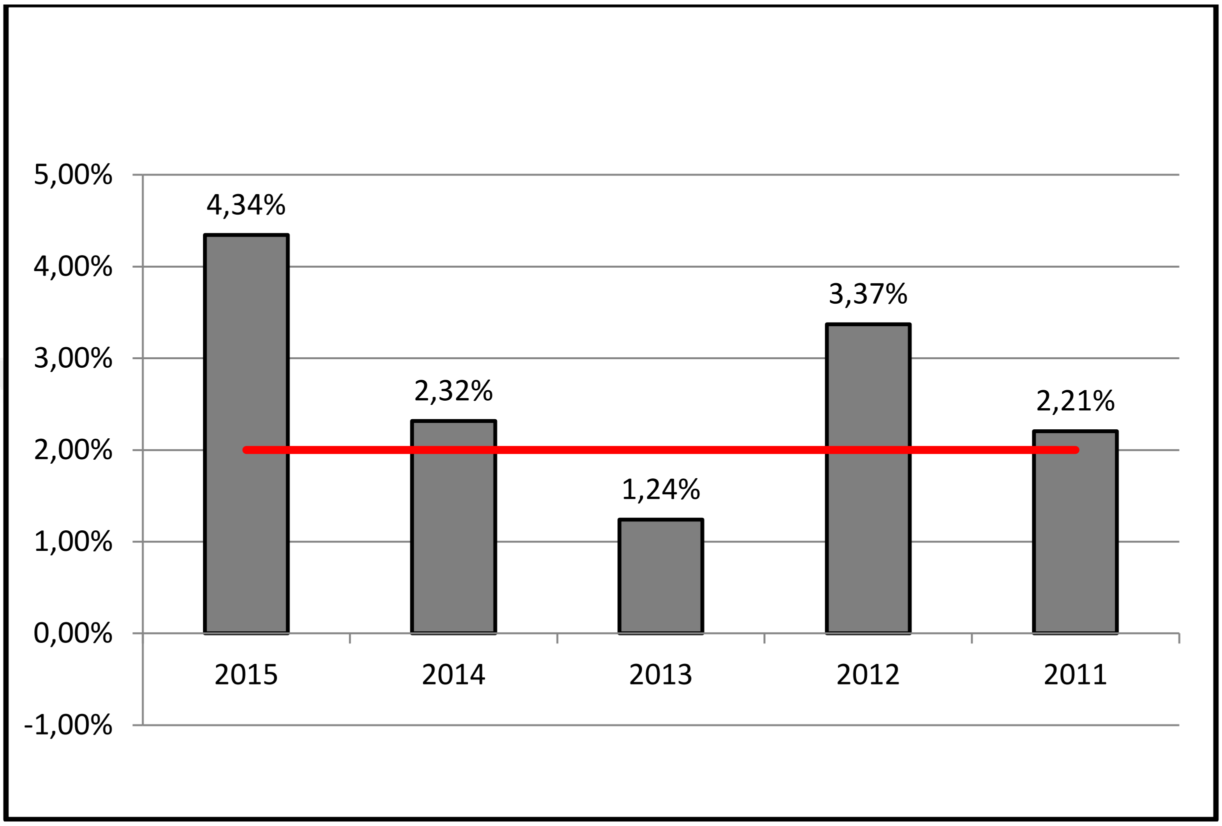



Figure 12.3: Defect Rates on Daily Basis

Defect Rates on Daily Basis are determined by collecting data between 2011 and 2015.
So, this datas that gathered are showed in graphic. The highest defect rate is seen in 2015. The defect rate is 4,34%. Therefore, in this study, we decided to minimize the defect rate.

Pareto Charts are used to prioritize the problem solving orders which has the most impact in the process. It shows importance of categories which might be types of defects, expenditure categories and reasons for a situation, categories of complaints. Working on the category with the highest occurrence has the potential to give you the most benefit.

Main failures are gathered and analyzed with help of Pareto Chart so the defect reason with high impact is found. That was Stellite Coating failure. So this defect is tried to eliminate in process with help of Six Sigma DMAIC methodology.

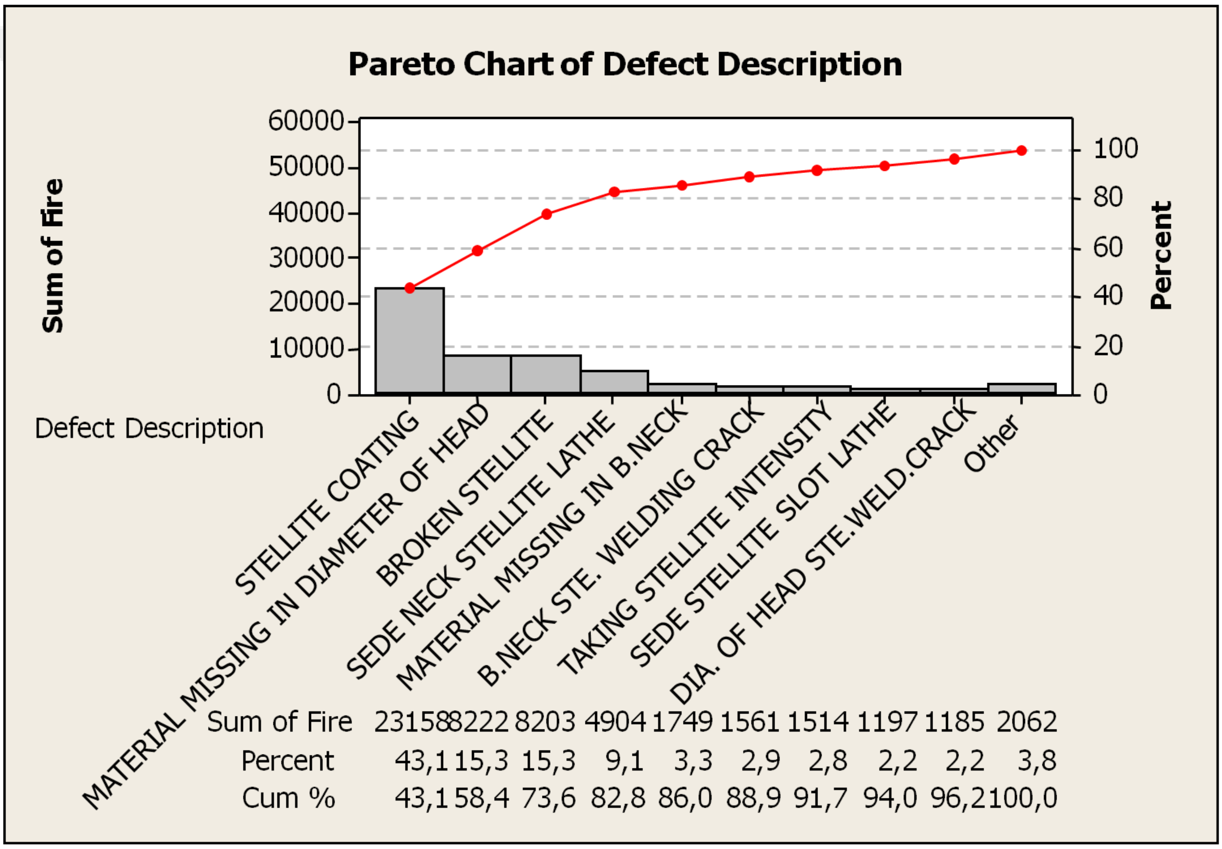



Figure 12.4: Defect Rates

First four defect types are determined and showed in graphics.

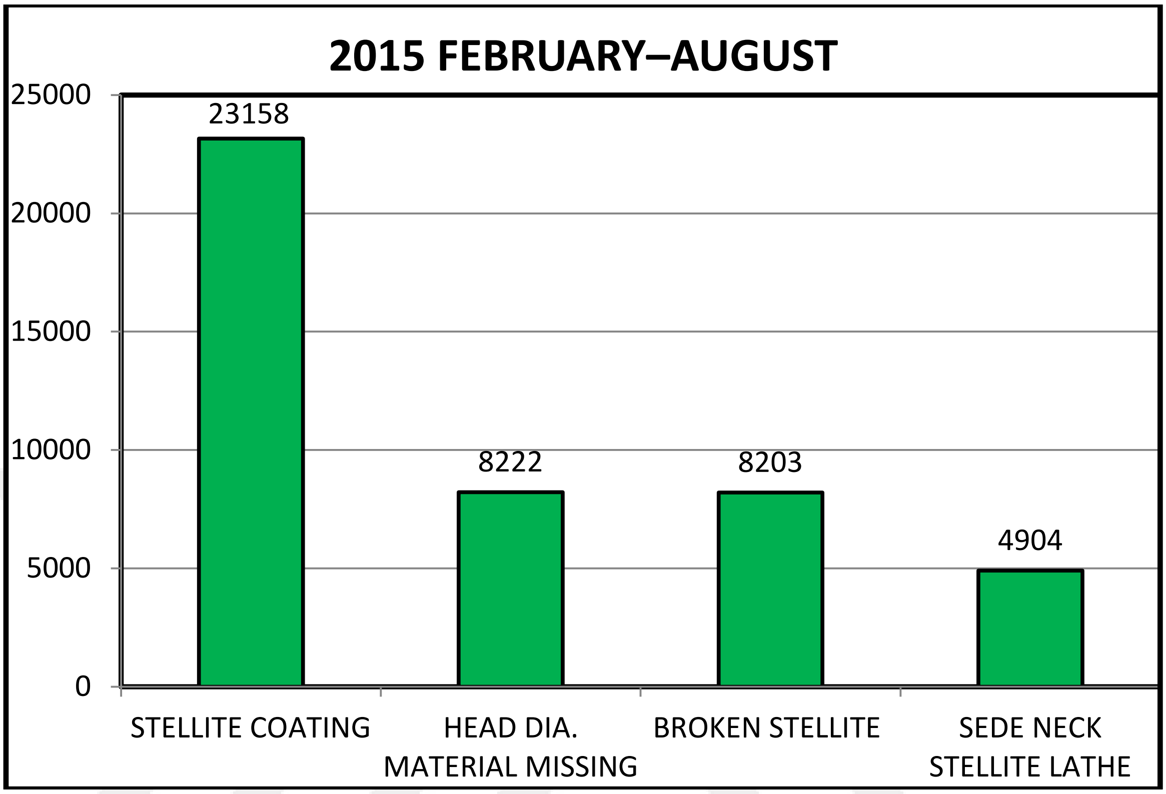



Figure 12.5 : First Four Defect Types

Distribution of Defect Types on Valves is found depends on failure causes as; Stellite Coating, Broken Stellite, Sede Neck Stellite Lathe, Head Dia. Material Missing.

After finding the failure that has huge effect, that was Stellite Coating in Valve Production. Pareto Chart is made between variety of valves to find, which kind of valve has the most failure?

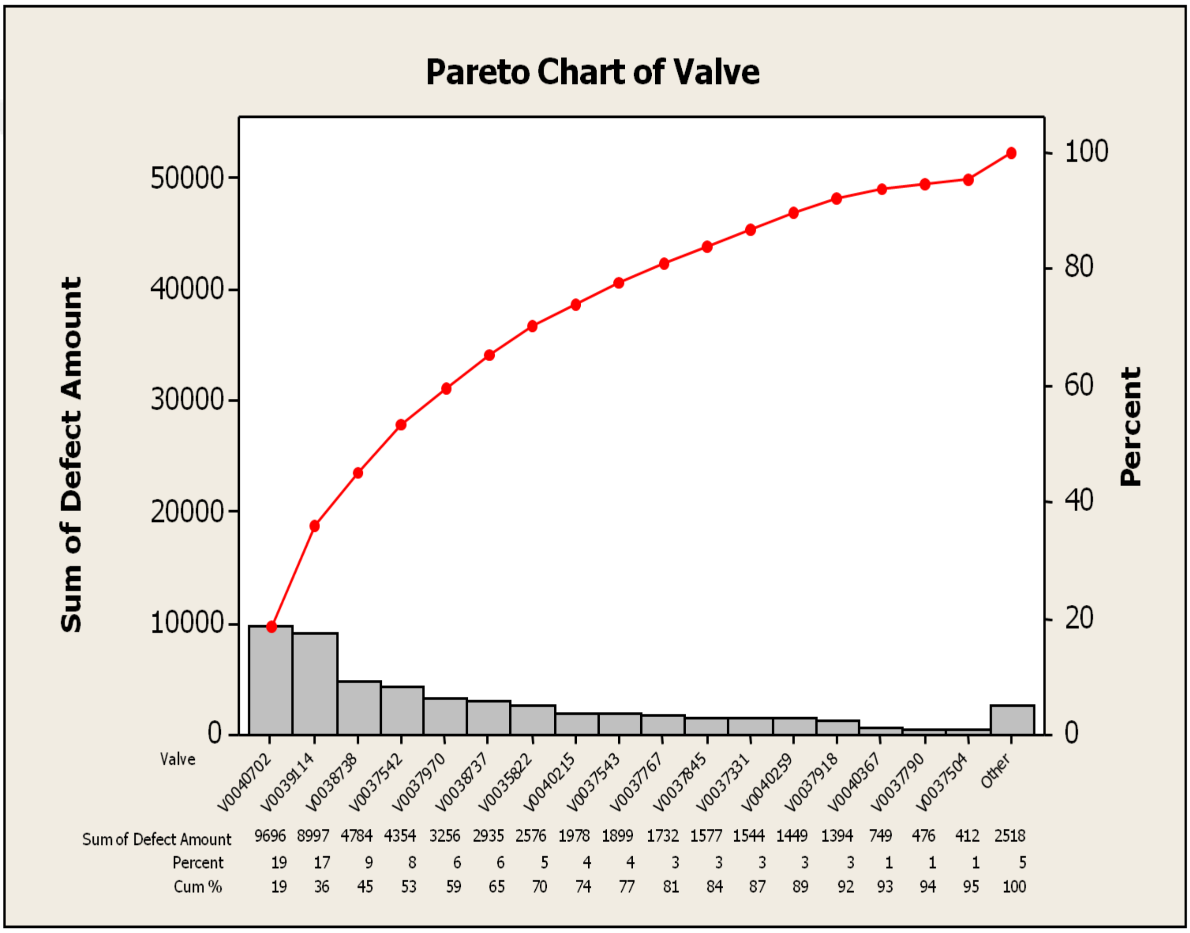



Figure 12.6: Defected Valves

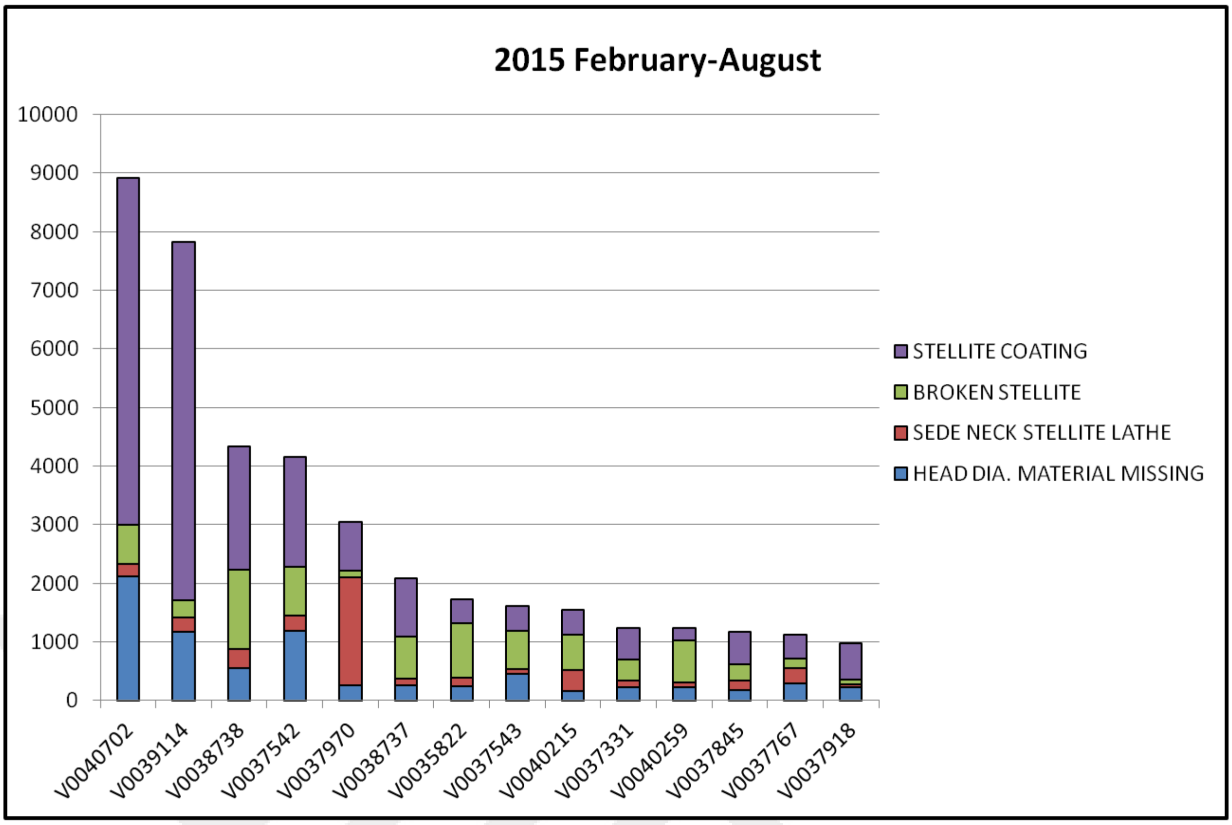



Figure 12.7: Distribution Of Defect Types

Between Valve Types, Distribution Of Defect Types Diagram is made. This graphic also shows the root causes distribution on types too. Root causes are Stellite Coating, Broken Stellite, Sede Neck Stellite Lathe and Head Diameter Material Missing.
As a result of the graph, it is seen the valve that has highest defect rate.

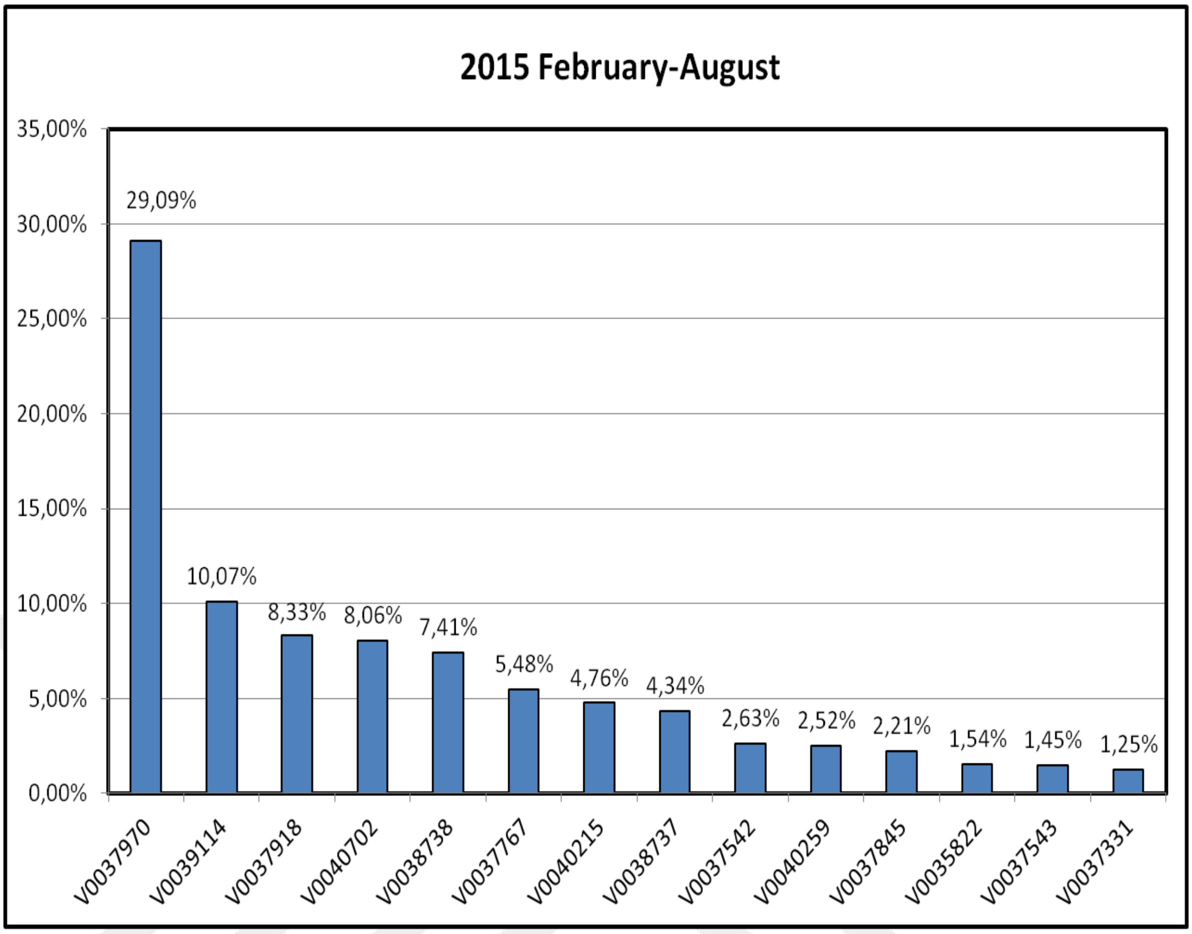



Figure 12.8: Defect Rates According to Work Order Amount

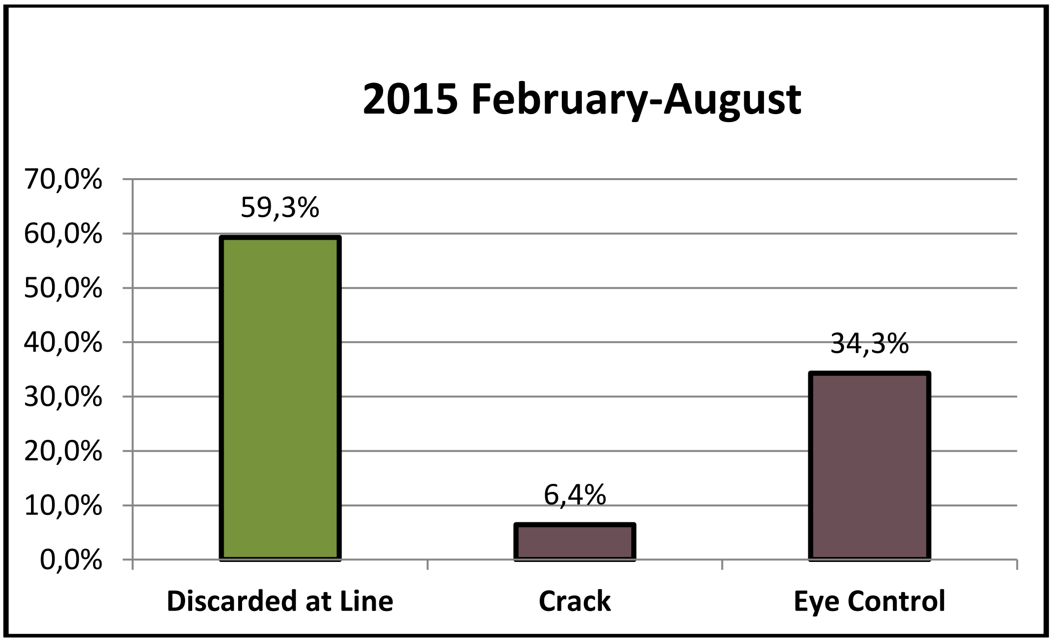



Figure 12.9: Discarded at Line – Discarded at FKK Defect Rates

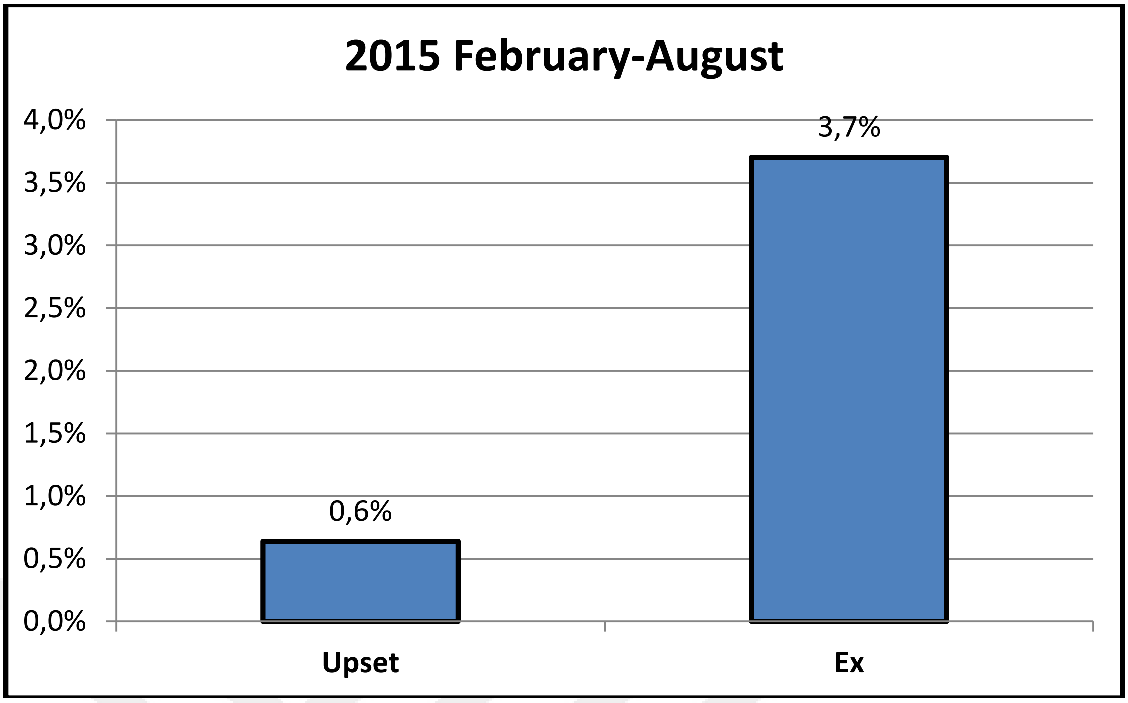



Figure 12.10: Defect Comparison of Extrusion – Upset

Measurement Plan

| No | Title is to be Measured | Description of Measurement | Source Of Data | Sample Size | Who will measure? | Time Range | How will be measured ? |
|---|---|---|---|---|---|---|---|
| 1 | Defect Rate | The ratio of number of defects at stellite line to net number of defects which undergoing the process. | MFG-Pro(39.24) | All valves passing through to stellite line. | H.Üstündağ | End of February-August (2015) | It will be taken from QAD and converted to excel file.Pareto diagram will be made. |
| 2 | Burr Dimesion | Comparision of defect rates between designed as sidewards burred valves which hammered with mold and vertically burred valves. | MFG-Pro(39.24) and field measurement | 38738 valve which will be hammering with 5 pieces of mold. | H.Üstündağ-A.Yılmaz | August-September 2015 | 1-Hammer sidewards burr in 38738 .<br>2-Pass it through the slot stall.<br>3-Pass it through from new PTA'.<br>4i-Compare the defects inside the line .<br>**5-Execute separatelly tii FKK.** |
| 3 | Kam | At 38737 valves, the ratio of defect number of valves which slot-opened with special kam to net number of defects which undergoing the process. | MFG-Pro(39.24) | First half of the 25.000 pieced party passed with old kam and the other part of it passed with new kam through stellite. | H.Üstündağ- | August-September 2015 | 38737 valve (İ.E:20121613)<br>Compare defect rates of first half of the party and the other of it. |
| 4 | Forehead pass | Comparison of defect rates will be made between work orders which forehead pass is increased and previous work orders. | MFG-Pro(39.24) | First work order which forehead pass is decreased. (hammered with new mold) | H.Üstündağ | August-September 2015 | New work order with forehead pass defect rate will be taken from QAD' and compared with old work orders. |
| 5 | Deburring Method | Ratio between defect amount of valves which comes from extrusion after overhead deburrring at HSF,TTS OR CNC to defect amount which net undergoing the process related to work order. | MFG-Pro(39.24) and field measurement | All work orders | H.Üstündağ-A.Yılmaz | September 2015 | 1-37542 Pass through all work orders from TTS. b<br>2-Compare defects that inside of the line with old work orders. |
| 6 | PTA Electrod | The effect of electrod that need to change to defect. | Field Measurement | 100 pieces | H.Üstündağ-A.Yılmaz<br>A.Osman | September 2015 | 1-Changing Elektrodu with new one when its time to change.<br>2-Weld 50 pieces more with current electrod, make ultrasonic control.<br>3-Weld one more party too that has 50 pieces and made ultrasonic control.<br>4-Compare separation rates at ultrasound. |

Table 12.8: Measurement Plan

Measurement Plan – continue

| No | Title is to be Measured | Description of Measurement | Source of Data | Sample Size | Who will Measure ? | Time Range | How will be Measured ? |
|---|---|---|---|---|---|---|---|
| 7 | **Process (PTA & Slot )** | Examination of PTA defect rates of products which deburred properly and overhead, bottomneck secretion within tolerance. | Field Measurement | *100 pieces normally deburred *100 pieces burred *100 pieces deeply deburred | H.Üstündağ-A.Yılmaz N.Güven | August-September 2015 | 1-Find products which bottomneck and overhead comes normal infront of slot. 2-Group by 100 each pieces according to burrs. 3-Let in some PTA after same slot. 4- Send crack to control. 5-Compare defects inside of the line. |
| 8 | **Overhead Secretion** | Examination of effect of overhead secretion to stellite combustion defects. | Field Measurement | * 100 pieces with secretion * 100 pieces with no secretion | H.Üstündağ-A.Yılmaz N.Güven | August-September 2015 | 1-Separate 2 categories the 100 pieced products which wait infront of the slot from whichever work order.(overhead secretion is out of tolerance, bottomneck secretion is normal) 2-Make eye control after slot. 3-Let in deburred properly ones to PTA. 4-Send crack to control. 5-Look at the line defect rate. |
| 9 | **Bottomneck Secretion** | Examination of defect rates in PTA process and slot opening of valves which bottomneck thickness is not grouped. | Field Measurement | *50 pieces thin *50 pieces thick *50 pieces thin-thick mix | H.Üstündağ-A.Yılmaz-N.Güven | August-September 2015 | 1-Select product in 3 group which wait infront of the slot whichever overhead secretion is out of tolerance, bottomneck secretion is normal. 2-Let in some PTA after same slot. 3- Send crack to control. 4-Compare defects inside of the line. |
| 10 | **PTA Plate** | Examination of effect of erosioned and dirty plates to stellite combustion. | Field Measurement | 50 pieces | H.Üstündağ-A.Yılmaz-A.Osman Üstün | August-September 2015 | Weld 50 pieces of valve with deformed plate and record combustion rates. |
| 11 | **PTA Stall** | Defect comparision will be made between work orders which passing through from new PTA and other PTAs. | MFG-Pro(39.24) | All work orders | A.Yılmaz | August-September 2015 | Defect report will be taken from QAD and will be compared of valve 37681. |

Table 12.9: Measurement Plan-continue

DECISION PROPOSAL

- Approval of financial return foresight.
- Approval of “Define-measure” phases.
- Approval of Project Announcement (Rev.00).

4.4.3 Analysis Phase: Root causes of problems is validated in the analyse stage. The aim of this stage is to determine root causation of problem. This phase helps to monitor the performance of processes to detect trends and shifts.

ANALYSIS AGENDA

- Critical Indicators
- C&E Matrix
- Result of Analysis
- Main Root Causes
- Decision Proposal

Critic Indicators are defined.

| No | Factors | Levels |
|---|---|---|
| 1 | Defect Rates | Historical Data (QAD) |
| 2 | Burr Dimension | 1-Vertically Burr<br>2-Sidewards Burr |
| 3 | Kam | 1-Special to valve<br>2-General |
| 4 | Forehead pass | 1-Increased<br>2-In being |
| 5 | Deburring Method | 1-HSF / TTS<br>2-Slot |
| 6 | PTA Elektrod | 1-Changed in time<br>2-Not changed in time |
| 7 | Process | 1-PTA<br>2-Slot |
| 8 | Overhead Secretion | 1-Secretion<br>2-No Secretion |
| 9 | Bottomneck Secretion | 1-Grouped<br>2-No Grouped |
| 10 | PTA Plate | 1-Dirty<br>2-Clean |

Table 12.10: Critic Indicators

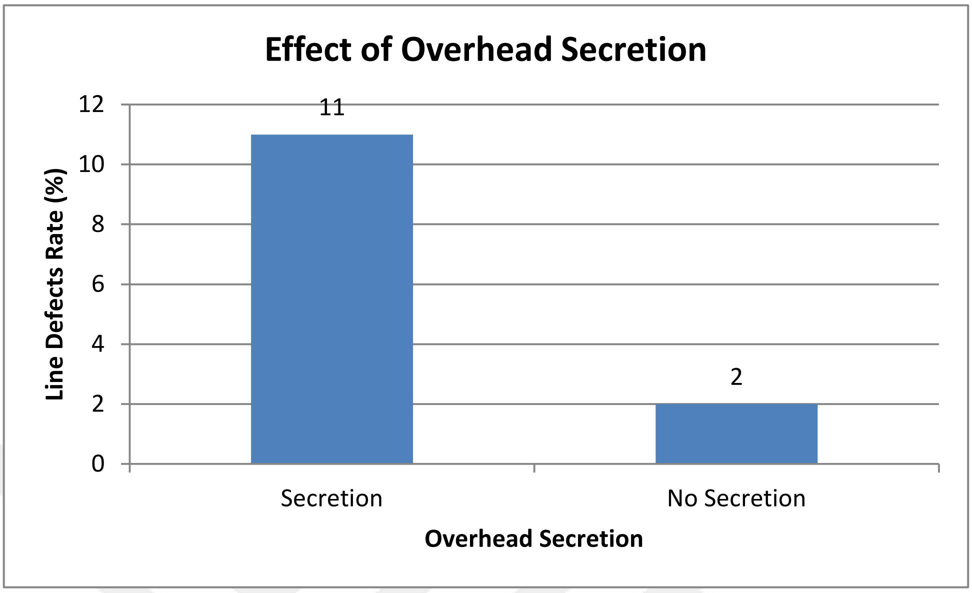
Input – Output Indicators is determined and C&E Diagram is illustrated.

| MEASURABLE PROCESS INDICATORS | | | OUTPUT INDICATORS | | | | EFFECT OF INPUT & PROSES IND. ON OUTPUT IND. |
|---|---|---|---|---|---|---|---|
| | | | Combustion Defects | Crack Defects | Dimensional Defects | Visual Defects | |
| | | | 9 | 9 | 9 | 9 | |
| INPUT & PROCESS INDICATORS | Process Step | Process input or variable | Rating of Correlation of Input to Output (0, 1, 3, 9) | | | | |
| | Stellite Line Op. | Burr Dimension | 9 | 9 | 9 | 9 | 324 |
| | | Kam | 9 | 3 | 3 | 3 | 162 |
| | | Forehead pass | 9 | 3 | 3 | 1 | 144 |
| | | Deburring Method | 9 | 9 | 3 | 9 | 270 |
| | | Overhead Secretion | 9 | 3 | 3 | 9 | 216 |
| | | Bottomneck Secretion | 9 | 3 | 3 | 9 | 216 |
| | | PTA Plate / Elektrod | 9 | 3 | 9 | 9 | 270 |

Table 12.11: C&E Diagram

C&E Diagram is specialized idea organizing which helps to identify potential causes.It represents potential causes graphically. The Cause and Effect diagram helps to explore causes and area of problem. Stellite Line is chosen to improve but we need to determine which input is more important. So after deciding input, outputs are determined too. Then we rated the steps with help of this diagram bu using scale of 0,1,3,9. 0 means no correlation. 9 means is strong correlation. It multiplies the process correlation times the customer weighting and adds the scores across the row to get a total score for each process input.

Overhead Secretion Analysis of Valve 38737 is analyzed.




Figures 12.11: Effect of Overhead Secretion

Capabilities Analysis After Rectification is examined.

Figure 12.12: Valve 39344

Overhead Process Capability of Rectification of valve 39344 is illustrated with help of Minitab.

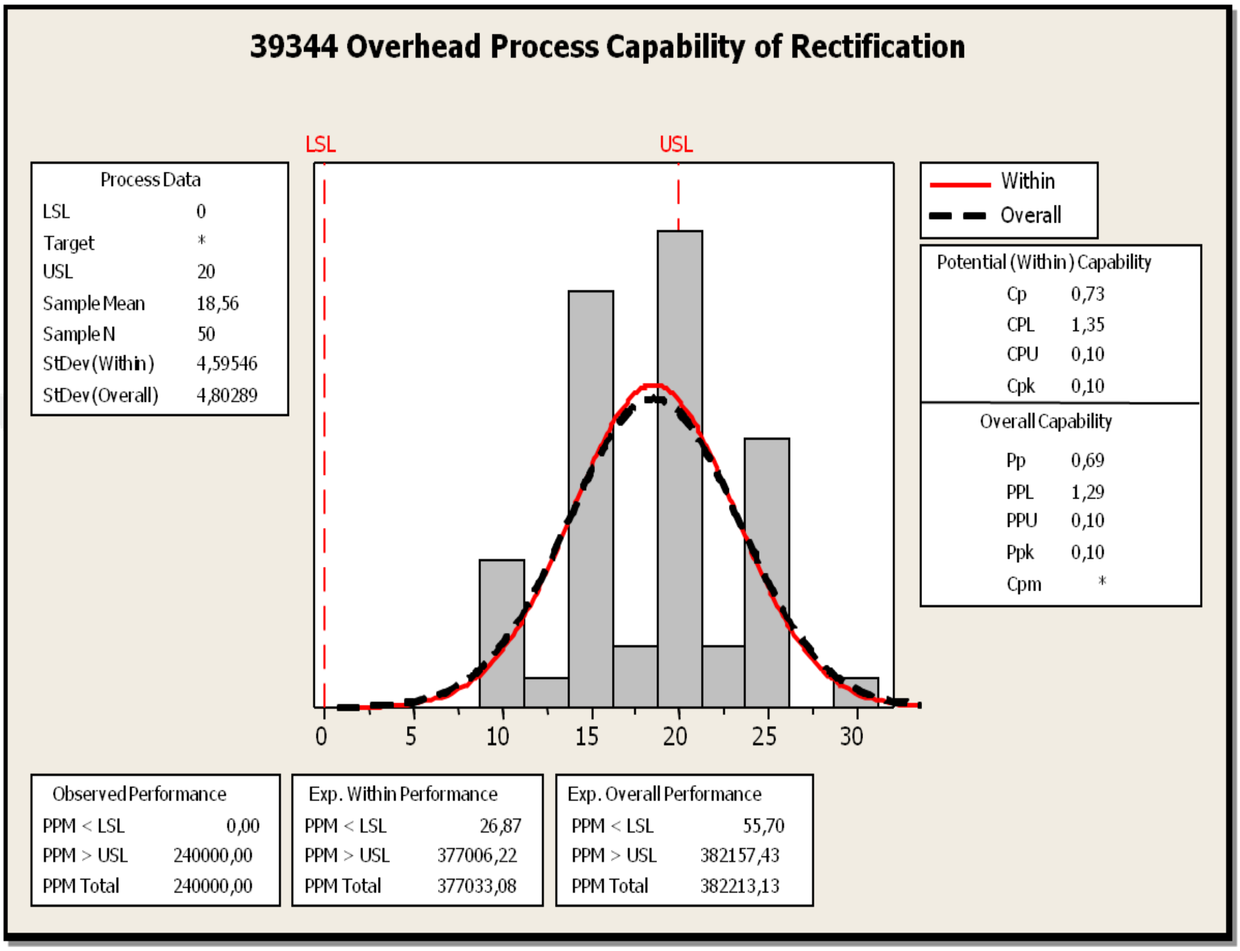


Figure 12.13: Overhead Process Capability of Rectification of valve 39344


Figure 12.14: Valve 37359

Overhead Process Capability of Rectification of Valve 37359 is illustrated with help of Minitab.

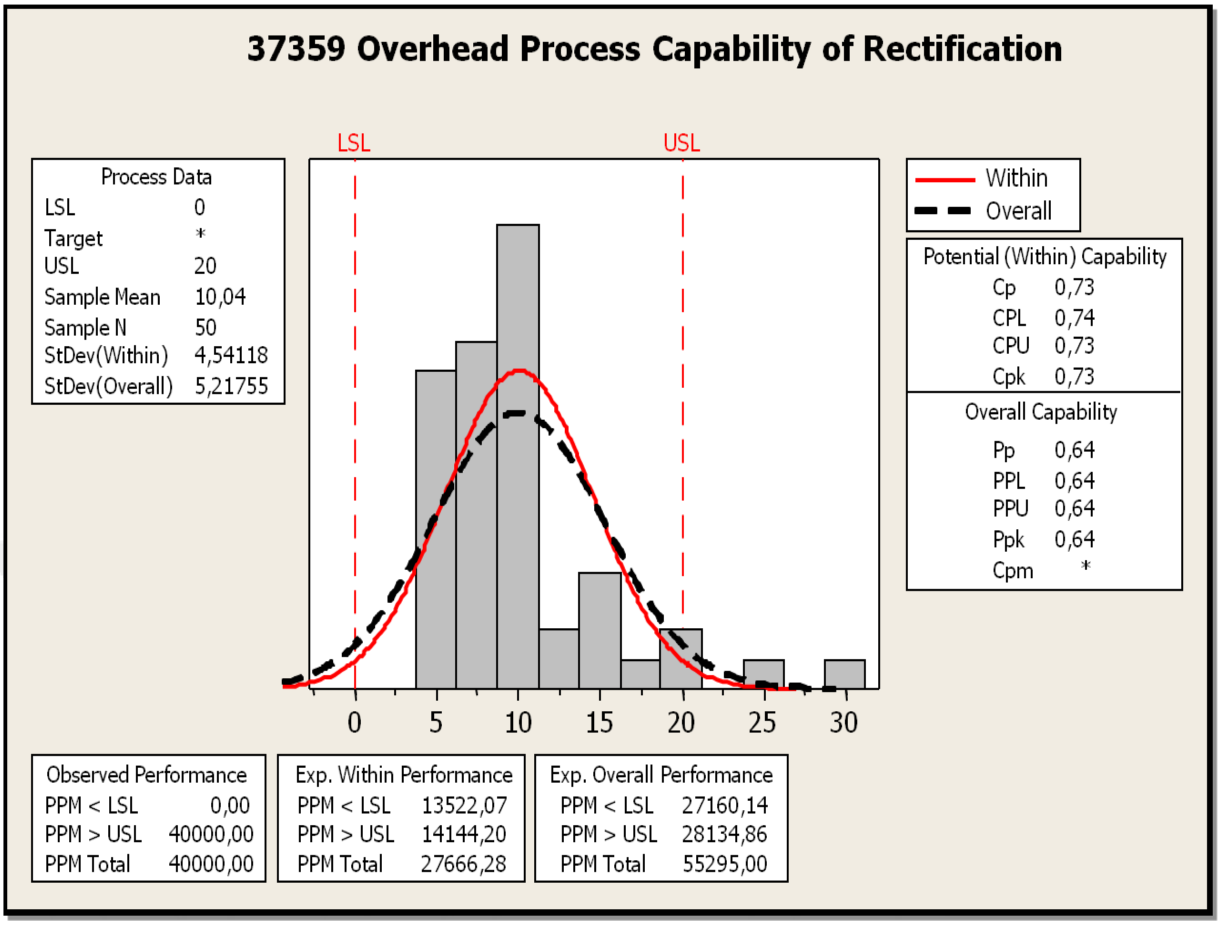



Figure 12.15: Overhead Process Capability of Rectification of Valve 37359

Bottomneck Thickness Analysis of Valve 38737

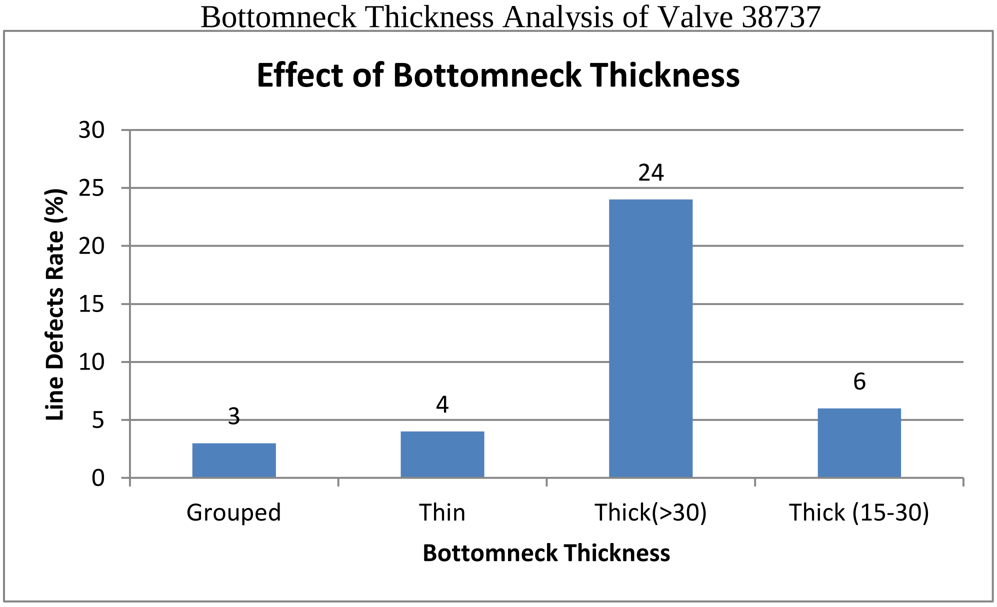



Figure 12.16: Effect of Bottomneck Thickness of Valve 38737

Samples of Burr Work

LEFTED BURR

DEEP-TAKEN BURR

Figure 12.17: Sample of Lefted Burr

Figure 12.18: Sample of Deep-Taken Burr

Burr Length Analysis of Valve 38737

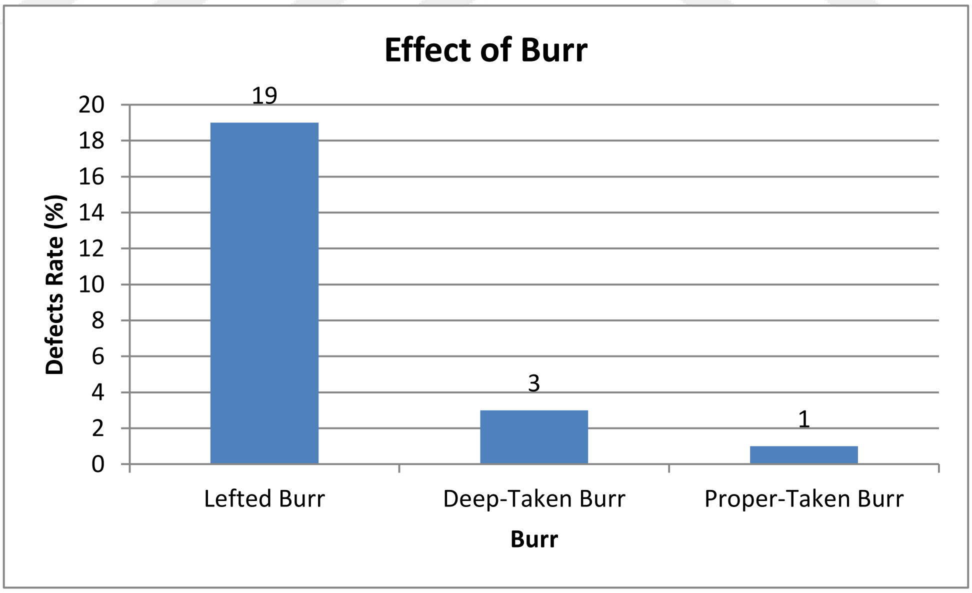



Figure 12.19: Effect of Burr of Valve 38737

Burr Length Analysis of Valve 39876

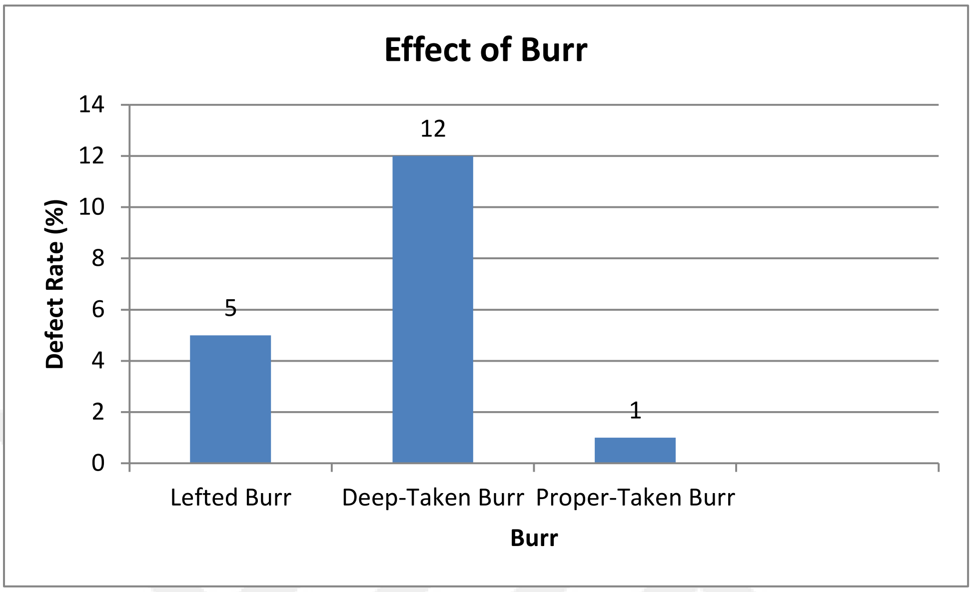



Figure 12.20: Effect of Burr of Valve 39876

38737 PTA-Slot Processes Analysis

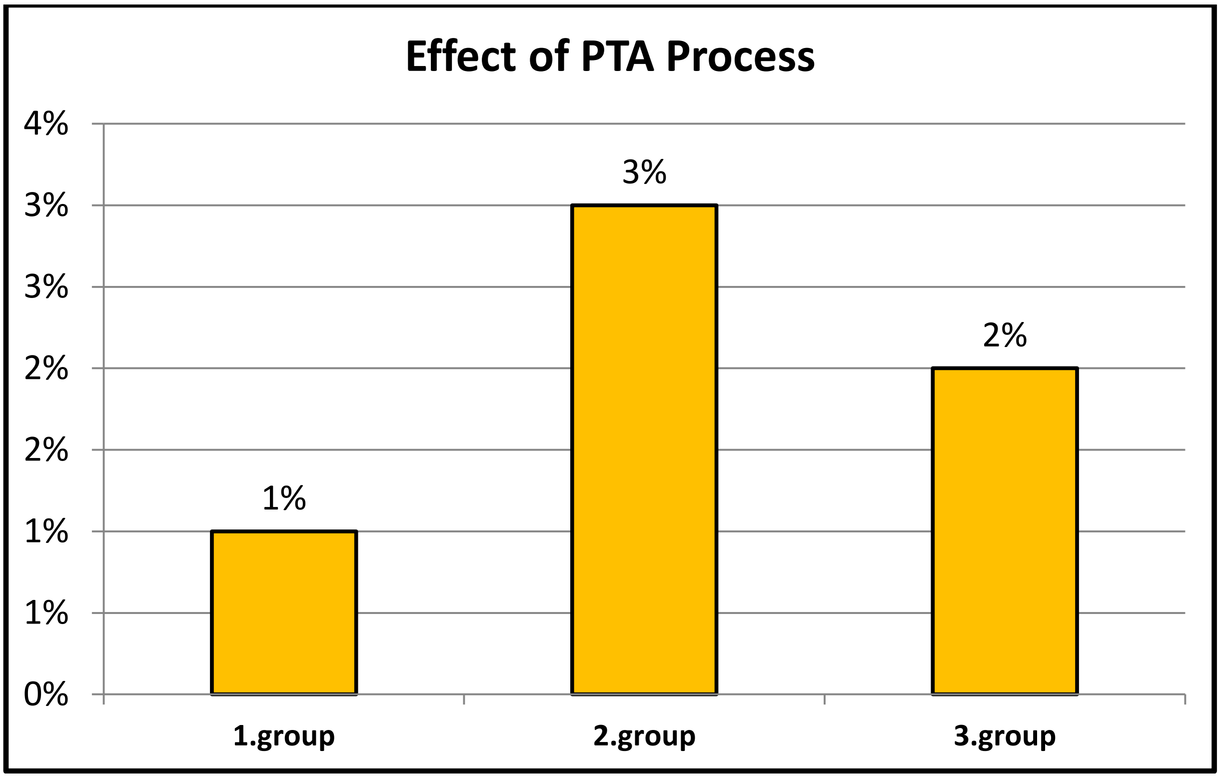



Figure 12.21: Effect of PTA Process of PTA 38737

PTA Plate Analysis of Valve 38737

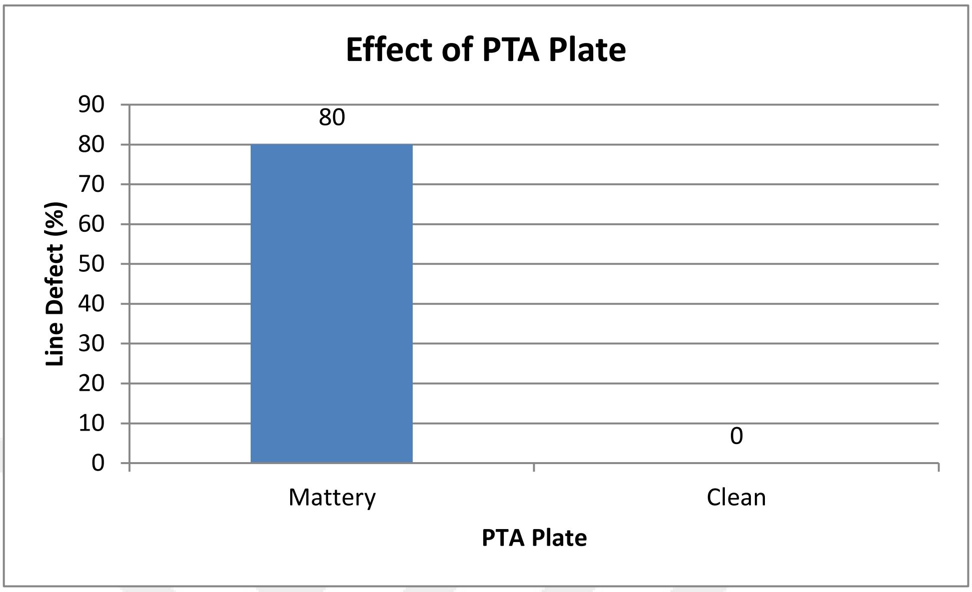



Figure 12.22: Effect of PTA Plate of Valve 38737

Welded Valves with Surface Broken Plate

Figure 12.23: Welded Valves with Surface Broken Plat

Comparison of  PTA Stalls

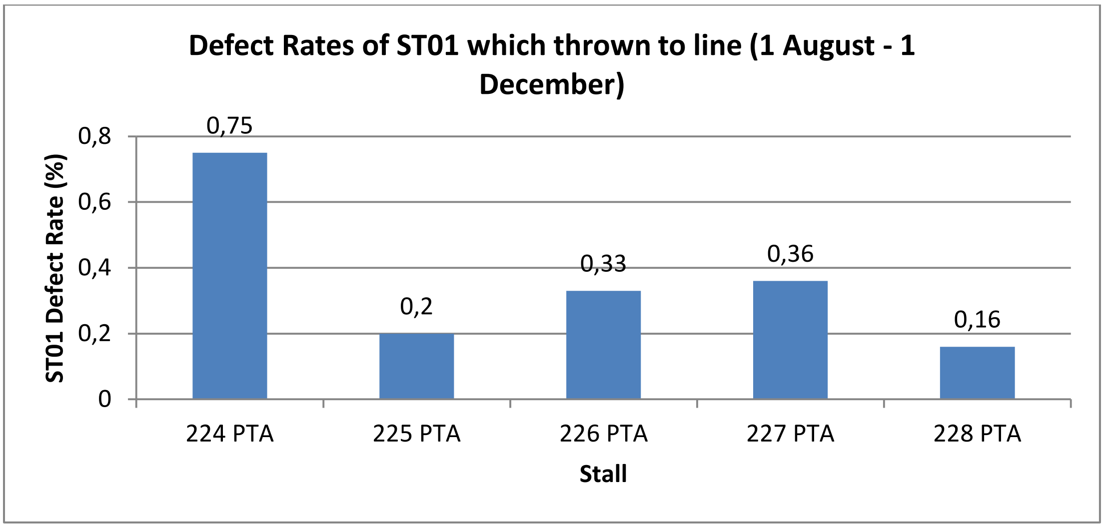



Figure 12.24: Defect Rates between PTA Stalls

38738 Analysis of Burr Direction ( Report 39.26 )

Hat....: S
Stok...: V - V99999
İşEmri.: 20130136 - 20130136

| Supap No | İş Emri | Lot | Red Ndni | Tanım | Fire Adedi |
|---|---|---|---|---|---|
| V0038738-05 | 20130136 | 130136-1 | ST02 | SEDE STELLİT YUVA TORNA | 2 |
| V0038738-05 | 20130136 | 130136-1 | ST01 | STELLİT KAPLAMA | 23 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 22 |
| V0038738-05 | 20130136 | 130136 | ST02 | SEDE STELLİT YUVA TORNA | 4 |
| V0038738-05 | 20130136 | 130136 | ST07 | SEDE BOYUN STELLİT TORNA | 3 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 5 |
| V0038738-05 | 20130136 | 130136 | ST02 | SEDE STELLİT YUVA TORNA | 1 |
| V0038738-05 | 20130136 | 130136-1 | ST01 | STELLİT KAPLAMA | 18 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 3 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 13 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 14 |
| V0038738-05 | 20130136 | 130136 | ST02 | SEDE STELLİT YUVA TORNA | 3 |
| V0038738-05 | 20130136 | 130136 | S01 | YUVA TORNALAMA | 40 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 40 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 6 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 13 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 15 |
| V0038738-05 | 20130136 | 130136-1 | ST07 | SEDE BOYUN STELLİT TORNA | 2 |
| V0038738-05 | 20130136 | 130136-1 | ST01 | STELLİT KAPLAMA | 3 |
| V0038738-05 | 20130136 | 130136-1 | ST01 | STELLİT KAPLAMA | 1 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 21 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 4 |
| V0038738-05 | 20130136 | 130136 | ST11 | STELLİT GERİLİM ALMA | 11 |
| V0038738-05 | 20130136 | 130136 | ST11 | STELLİT GERİLİM ALMA | 4 |
| V0038738-05 | 20130136 | 130136-1 | ST01 | STELLİT KAPLAMA | 6 |
| V0038738-05 | 20130136 | 130136 | st01 | STELLİT KAPLAMA | 2 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 4 |
| V0038738-05 | 20130136 | 130136 | FS02 | STELLİT BOZUK | 10 |
| V0038738-05 | 20130136 | 130136 | FS01 | KAFA ÇAPINDA MLZ EKSİK | 10 |
| V0038738-05 | 20130136 | 130136 | ST01 | STELLİT KAPLAMA | 6 |
| V0038738-05 | 20130136 | 130136 | ST07 | SEDE BOYUN STELLİT TORNA | 6 |
| V0038738-05 | 20130136 | 130136 | FS05 | BOYUNALTI MALZEME EKSİK | 10 |
| V0038738-05 | 20130136 | 130136 | FS02 | STELLİT BOZUK | 450 |
| V0038738-05 | 20130136 | 130136-1 | FS01 | KAFA ÇAPINDA MLZ EKSİK | 10 |
| V0038738-05 | 20130136 | 130136-1 | FS02 | STELLİT BOZUK | 400 |
| V0038738-05 | 20130136 | 130136 | FS01 | KAFA ÇAPINDA MLZ EKSİK | 7 |
| V0038738-05 | 20130136 | 130136 | FS02 | STELLİT BOZUK | 90 |

Table 12.12: 38738 Analysis of Burr Direction

38738 Analysis of Burr Direction

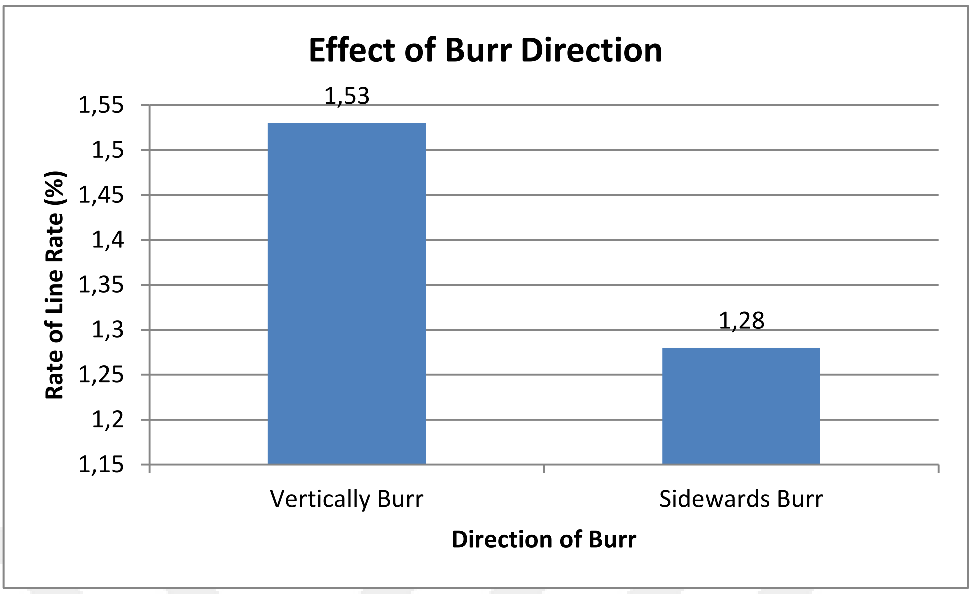



Figure 12.25: Effect of Burr Direction of Valve 38738

ROOT CAUSES

1) Burr of Overhead

**Source**

- Extrusion Presses Forging conditions and necessity of mold design.

**Caused Problems**

- Slot can't taken as standard at turning stalls.( If burr stays PTA plate does't fit and because cooling problem, stellite combustion defect occurs. If burr taken deep, thickness decreases and causes stellite combustion defect too.)
- In rectification operation, it obstructs taking  secretion of overhead secretion in valves which has less smoothness on overhead cause of their design.

2) Overhead Secretion

**Source**

- Extrusion Presses
- Not taken secretion because of valve design.
- Not taken secretion because of overhead burr.

**Caused Problems**

- At PTA plate, valve’s turning back with secretion causes stellite combustion defects.

3) Bottomneck thickness

**Source**

- Extrusion Presses

**Caused Problems**

- Burr pen in valves which comes bottomneck come thick break into to forehead as much as bottomneck thickness. Decreasing of thickness causes stellite combustions.
- Burr pen in valves which its bottomneck comes thin doesn’t touch to burr, burr stays as it is.

4) PTA

**Source**

- Expertise (PTA plates, electrode change periods, torch distance, adjustment...)
- Periodic cleaning and maintenance (tabla-punta centering, tabla engine, generators, cooling water temperature )
- System of loading-unloading(springy punta, mechanical spaces...)
- Control (Providing sample  to crack at welding process...)

**Caused Problems**

- Stellite coating,
- Damaged stellite
- Missing material at head diameter
- Head diameter causes stellite welding crack defects.

Problem Statement-Conclusion

1- At first, 3 critic factors as secretion of overhead, difference of bottomneck thickness and overhead burr causes increasing in stellite sourced defect rates to %4-5.
2-Even if proper valves on account of 3 foregoing factors comes infront of the PTA welding, between %1-2 defect occurs inside of the PTA.

Conclusion

- To go for %2,5 level which is line defect goal, first of all extrusion presses sourced external root causes should be cleared away.
- At a later stage to go down less of the %2,5 defect rate, PTA sourced internal root causes should be cleared away.

DECISION PROPOSAL

- Approval of financial return foresight.
- Approval of “Define-measure-Analyze” phases.
- Approval of Project Announcement (Rev.00).

4.4.4 Improve Phase;  ideas and solutions are put to work in this step. Improve phase helps to develop potential improvements for main causes, measures results and it evaluates improvements to meet targets.

IMPROVE AGENDA

- Proven Root Causes
- Solution  Evaluation Matrix
- Solutions / Actions
- Implementation Plan
- FMEA
- Risk Analysis

PROVEN ROOT CAUSES

EXTERNAL

- Overhead Burr
- Overhead Secretion
- Bottomneck Thickness

INTERNAL

- PTA (plate, electrod, loading systems...)
- Operator

SOLUTION EVALUATION MATRIX

| Root Causes | Solutions | Application Time | Cost | Benefit | Ease of Application | Total | Ranking |
|---|---|---|---|---|---|---|---|
| | | 2 | 2 | 3 | 2 | | |
| Overhead Burr, Bottomneck Thickness Difference, Overhead Secretion | Hammering stellited valves with giving sideward burr of extrusion. | 8 | 2 | 10 | 6 | 62 | 3 |
| | Using contacted prop in thickness separation process. | 6 | 4 | 6 | 6 | 50 | 5 |
| | To revise current MPs. | 4 | 2 | 6 | 4 | 38 | 7 |
| | Overhead deburring at TTS OR HSF. | 8 | 2 | 6 | 4 | 46 | 6 |
| | Taking new CNCs instead of MPs. | 4 | 2 | 10 | 4 | 50 | 5 |
| | Giving TTS operation after 1. Rough Stoning for 39114, 38738, 38737 valves intended for A-B-C lines. | 10 | 4 | 6 | 2 | 50 | 5 |
| | Giving TTS operation after 1.Rough Stoning for 37970, 37767, 37918 valves intended for D1-D2 lines. | 10 | 4 | 6 | 2 | 50 | 5 |
| PTA | Using springy punta in all PTAs. | 8 | 6 | 6 | 10 | 66 | 2 |
| | Taking mechanical spaces. | 8 | 8 | 6 | 4 | 58 | 4 |
| | PLC control because the change of periodic bottom plate. | 10 | 10 | 6 | 8 | 74 | 1 |

Table12.13: Solution Evaluation Matrix

With help of solution evaluation matrix , founded solutions are documented and ranked related to their properties as application time, cost, benefit, ease of application. Solutions are depended on root causes as overhead burr, bottomneck thickness difference, overhead secretion and PTA.

TAKEN ACTIONS

- Root Cause : Overhead Burr
- Solutions

1 ) Hammering at sideward burr at extrusion press.

2 ) Overhead deburring at TTS.

(Giving TTS operation after 1. Rough Stoning for 39114, 38738, 38737 valves intended for A-B-C lines, Giving TTS operation after 1.Rough Stoning for 37970, 37767, 37918 valves intended for D1-D2 lines. )

TAKEN ACTIONS

Root Causes : Bottomneck Thickness

Solution : Hammering at sideward burr at extrusion press.

- New mold design (First of all in 39114, 38738, 38737, 37542, 37543, 37767, 37970, 37918 valves)
- Tonnage monitor

TAKEN ACTIONS

Root Causes: At PTAs, tray changing frequency is not standard because of it is dependent to operator.

Solutions : PTA Tray Changing Frequency Automatization.

224, 226, 227 and 228 numbered PTA welding stall PLC programs changed in such a way that will give warning in every 1000 pieces when tabla changes.

Root Causes: At PTAs tray-punta centration is not standart.

Solutions:

1) Taking PTA loading slots.
2) For all PTAs springy punta supply / use.

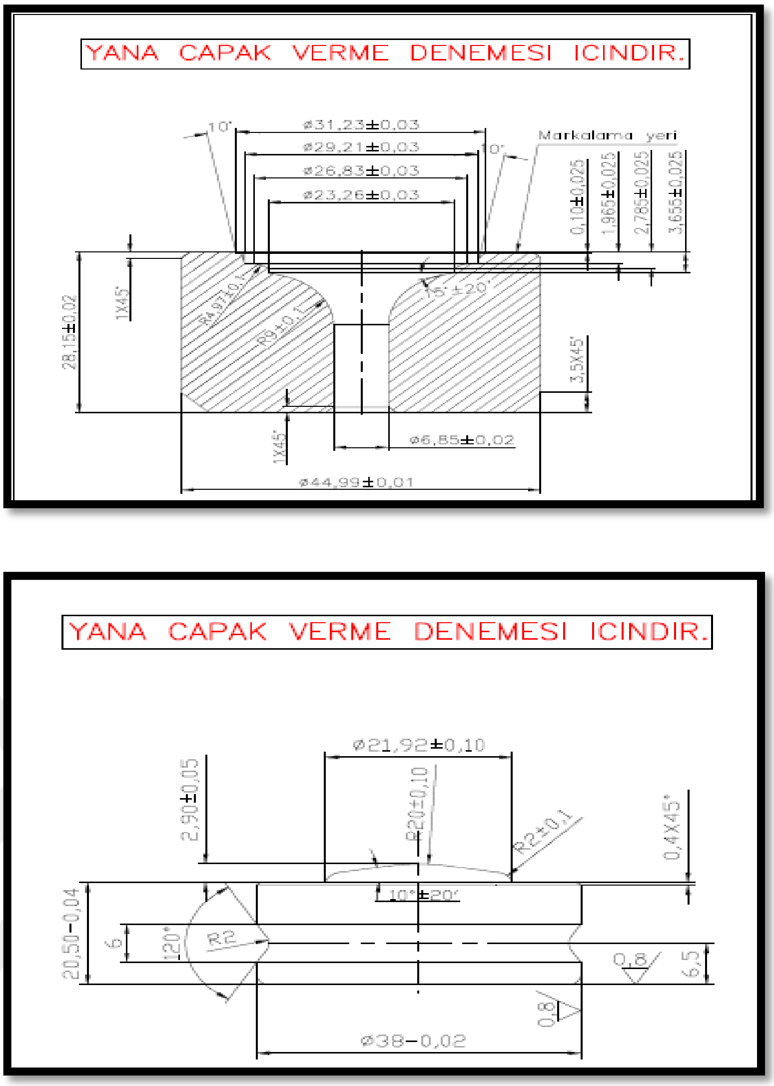



Figure 12.26: Technical Drawing of Valve

After finding and ranking solutions , tonnage monitor is determined to implement for improvement to the process.

TONNAGE MONITOR

**What it is?**

Tonnage monitor allows to display of tonnage which on the mold and press. (Tonnage changes when strok distance change in strok adjustable presses.)

**How it works?**

System occurs in 2 units:

1)Load Cell: It is a converter unit without measuring the weight. Also it is assembled to the press body, monitor works integrated. It comprehends physical strength in body of press and sends it in form of electric signal.

2) Monitor : This unit ensures to show weight in electronic screen. There is 2 types of alarm in monitor unit.

Capacity alarm: Alarm is set according to nominal tonnage capacity of press, when it exceed, it gives warning.

Process alarm: Alarm is set according to target tonnage values of press.

TONNAGE MONITOR

**What does it do?**

1) It helps to find min force amount which is necessary to forming at first adjustment. By this means,

- Life of press extends, mainteenance costs reduced. (Fatique resistance increases.)
- The lifetime of the mold extends.
- The quality of valve increases.
- Labor safety risks reduces.

TONNAGE MONITOR

**What does it do?**

2) It helps to stop, slowdown the movement physically if electrical connection is made between monitor alarms and PLC of press.

**<u>Critical Issue?</u>**

After taking signal from PLC (in short times as msec) press’s clutch and break systems should have capability to stop press physically.

**What does it do ?**

3) It helps to notice abnormal situations.

  - Temperature changes,
  - Different upper mold lengths,
  - Design changings trials

## IMPLEMENTATION PLAN

| Solt. No | Subject | In Charge Of | Planned Finish Date | Actual Finish Date | Solution Go-Live |
|---|---|---|---|---|---|
| 1 | Giving TTS operation after 1. Rough Stoning for 39114, 38738, 38737 valves intended for A-B-C lines. | A.Öksüz | w12 | w12 | 04.01.2016 |
| 2 | Giving TTS operation after 1.Rough Stoning for 37970, 37767, 37918 valves intended for D1-D2 lines. | A.Öksüz | w12 | w12 | |
| 3 | Within giving sideward burr works , mold design for **39114, 38738, 38737**, 37542, 37543, 37767, 37970, 37918 valves | A.Öksüz | w13 | w13 | |
| 4 | **39114, 38738, 38737**, 37542, 37543, 37767, 37970, 37918 2 valve's bottom and top molds manufacture at workshop | M.Yanıkömer | w14-w15 | w15 | |
| 5 | Within giving sideward burr, searching/meet with domestic and foreign firms for tonnage monitor. | H.Üstündağ | w12-13 | w13 | |
| 6 | Installation of tonnage monitor system | H.Üstündağ / O.Köken / A.Gülmez | w18 | | |
| 7 | Springy Punta supply for all PTAs . | H.Üstündağ / C.Işık | w18 | | |
| 8 | Taking slots in PTA loading-unloading system. | M.Yanıkömer | Maintenance of every PTA starting from 13th week. | Continue from 13th week | |
| 9 | To set time frequency for PTA tablas. (1000 pieces) | A.Gülmez | w-13 | w13 | |

Table 12.14: Implementation Plan

## FAILURE MODE AND EFFECTS ANALYSIS

| Reduction of Stellite Line Defects | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Process | Type of Error | Reason | Result | Control Method | | The degree of result | | | | In Charge Of |
| | | | | | Inhibitor | Detector | Frequency | Intensity | Caught | rpn | |
| 1 | Stellite Line Processes | High defect rate from target value. | New references begin to be produced. | The continuation of defect cost, the decline in the project return. | Making sideward mattery mold designs in extrusion presses for valves which newly added to product portfolio and hammering them in this way. | Reporting monthly process Control Report / Daily Quality Meetings | 2 | 4 | 2 | 16 | Line Manager, Production Engineer. |
| 2 | Stellite Line Processes | High defect rate from target value. | The emergence of new defect types. | The continuation of defect cost, the decline in the project return. | 8D is initialized by line manager. Process FMEAs reviewed. | Reporting monthly process Control Report / Daily Quality Meetings | 3 | 4 | 2 | 24 | Stellite Line team Leaders |
| 3 | Stellite Line Processes | At current situation Pareto, not ensuring the target decline in defect types. | Not implementing taken actions or staying them inadequate. | The continuation of defect cost, the decline in the project return. | Team Leaders should ensure the implementation of actions, and should report the situations that needs new actions to product engineer. | Reporting monthly process Control Report / Daily Quality Meetings | 3 | 4 | 2 | 24 | Stellite Line team Leaders |

Table 12.15: Failure Mode and Effects Analysis

| Lean 6 Sigma Risk Action Plan | | | | | | |
|---|---|---|---|---|---|---|
| Project Name: SUP-HU-02 Reduction of defects in Stellite Line | | | | | | |
| Key Risk Category | Risk Comments | Actions | Owner of Actions | Informed | Target Date for Completion | Status |
| Strategic | | | | | | |
| | | | | | | |
| Financial | | | | | | |
| | | | | | | |
| | | | | | | |
| Operational | Not reaching to target improvement values in related defect codes. | Tracking taken actions. | Lean 6 Sigma team | Sponsor | Throughout the year of 2015 | Continue |
| | Occurance of new type of defects. | Review stated actions at FMEA. | Process Owner | Sponsor | Throughout the year of 2015 | Continue |
| | Starting to produce new references at extrusion. (especially in nimonic valves) | Application of giving sideward burr design at new references too. | Black Belt | Sponsor | Throughout the year of 2015 | Continue |
| | Decreasing in mold lifetimes at giving sideward burr design. | Averages lifetimes will be tracking and using LITD in upper molds will be expanded. | Black Belt | Sponsor | Throughout the year of 2015 | Continue |
| | Job security is more critic at giving sideward burr. | Tonnage monitor, Eaton Polonya projects. | BB, Process owner | Sponsor | w19 | |
| External | | | | | | |
| | | | | | | |
| | | | | | | |
| Industrial | | | | | | |
| | | | | | | |

Table 12.16: Six Sigma Risk Action Plan-rvz02

4.4.5 Control Phase: Final capability is determined and reliability of the process is assured. It requires revision and a control plan to monitor ongoing performance. The aim of the control phase is to assess proposed solutions and develop controls.

CONTROL AGENDA

- Regime entry pieces after stopping
- New process capability analysis
- Process Capability Analysis
- Process Control System (I-MR Charts)
- Benefit/Return Tracking Table
- Benefit Calculation/Return Account
- Project Report rvz01

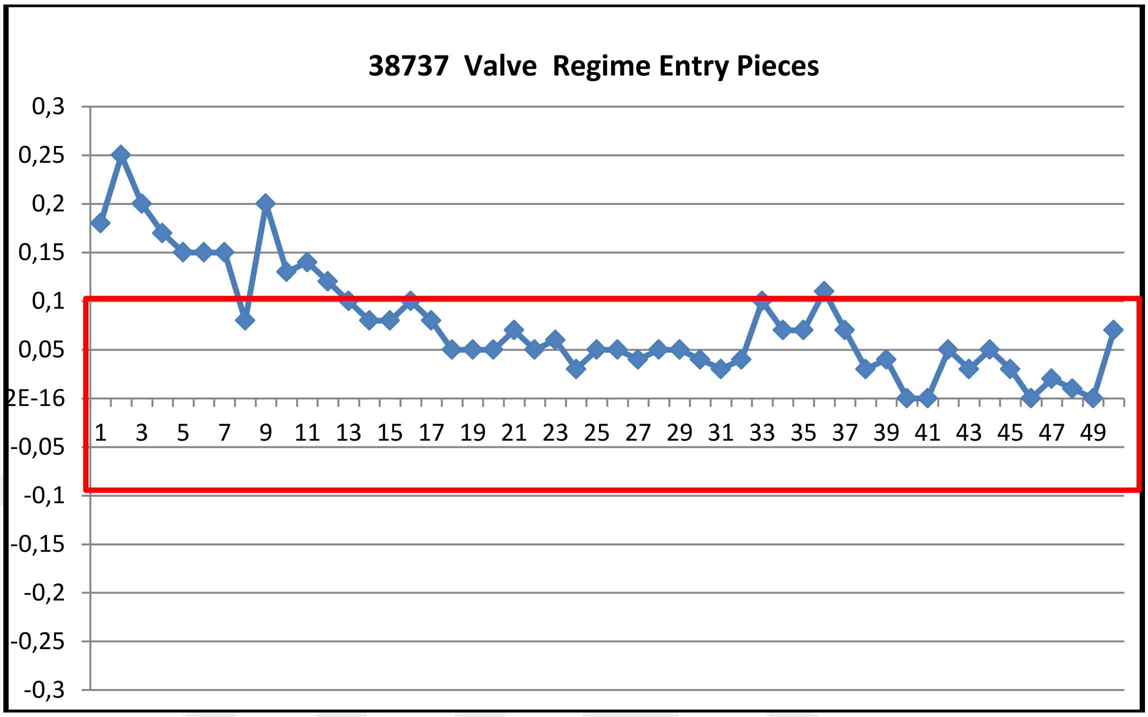



Figure 12.27: Sideward Burr Hammering of Valve 38737 Regime Entry Pieces

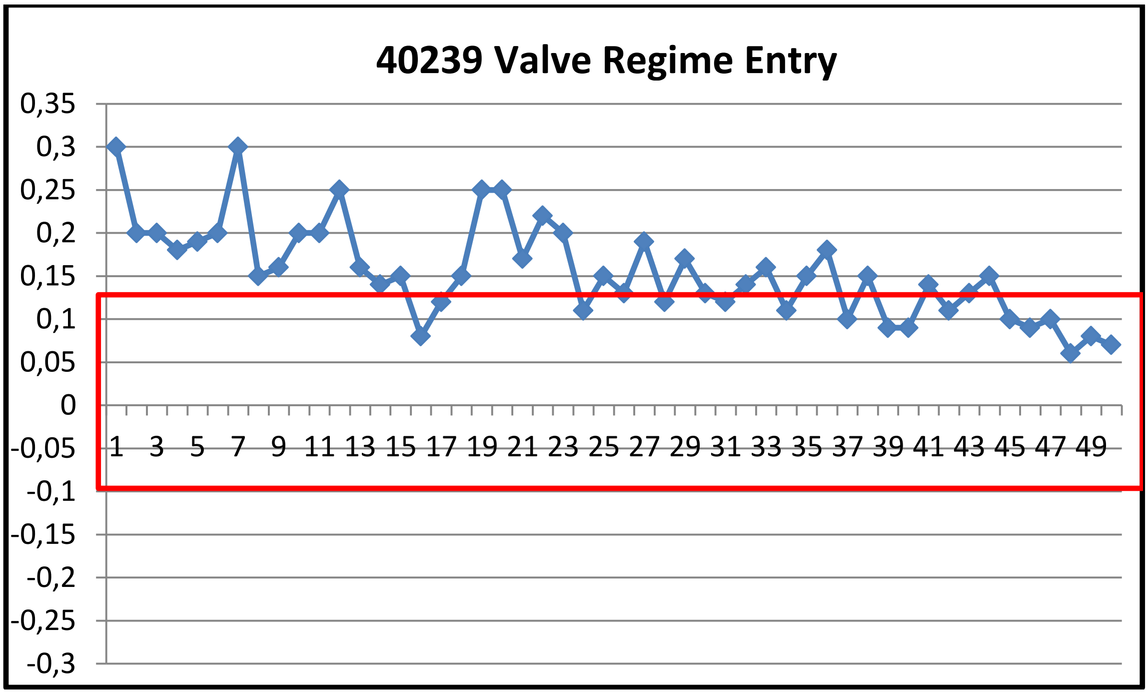



Figure 12.28: Vertically Burr Hammering of Valve 40239 Regime Entry Pieces

BOTTOMNECK THICKNESS CAPABILITY

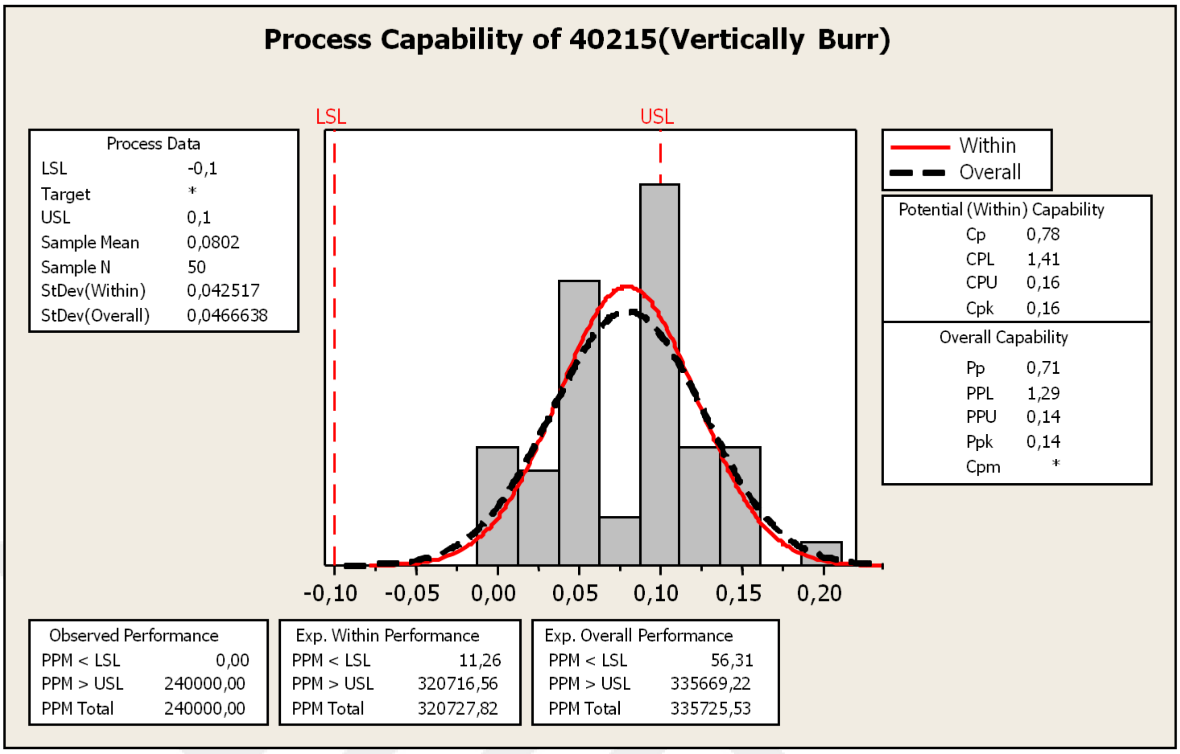



Figure 12.29: Process Bottomneck Thickness Capability of Valve 40215

BOTTOMNECK THICKNESS CAPABILITY

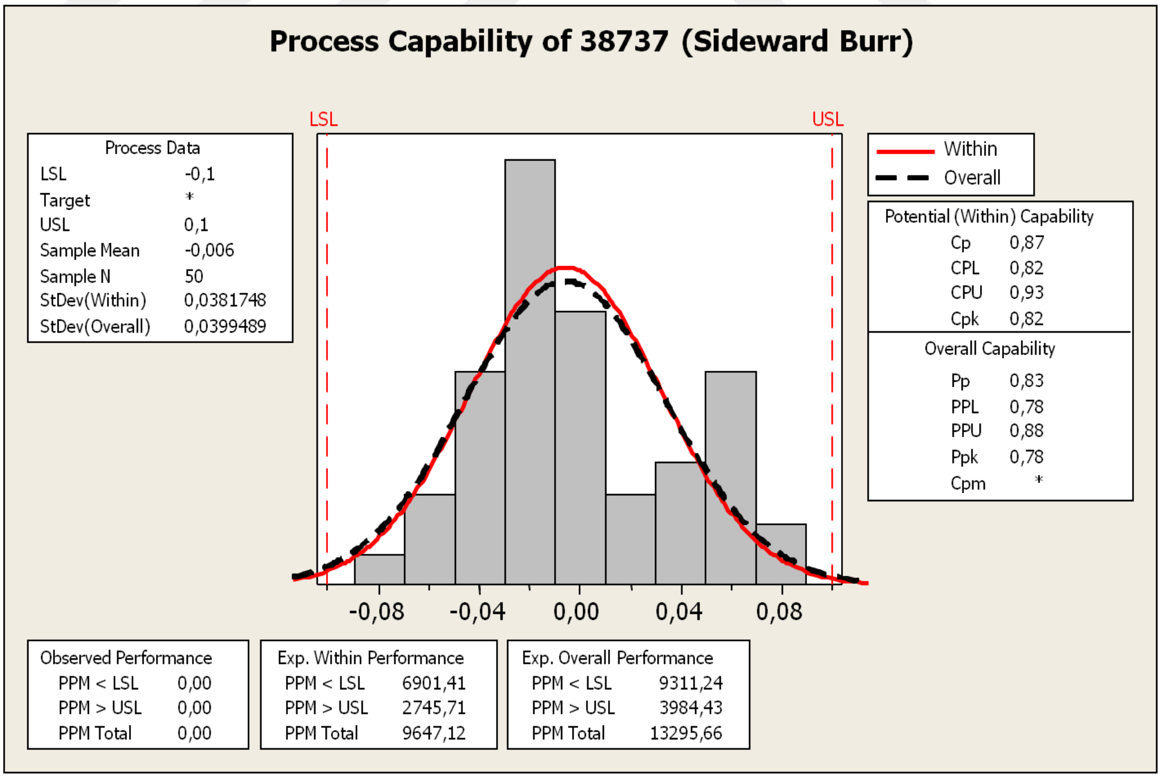



Figure 12.30: Process Bottomneck Thickness Capability of Valve 40215

Before this project, valves were hammering vertically. Bottomneck thickness capacity was not proper. Time of entering the regime was longer. Cpk:0,16

After this project, valves started to be hammering sidewardly. Bottomneck thickness of valves are made better. Time of entering regime became more shorter. Cpk:0,82

After Process Capability Analysis, gained results showed the improvement in the process.

1-Valves enters to regime more early without operation intervention.

2-Bottomneck thickness capability values are more high

BOTTOMNECK THICKNESS CONTROL GRAPHIC

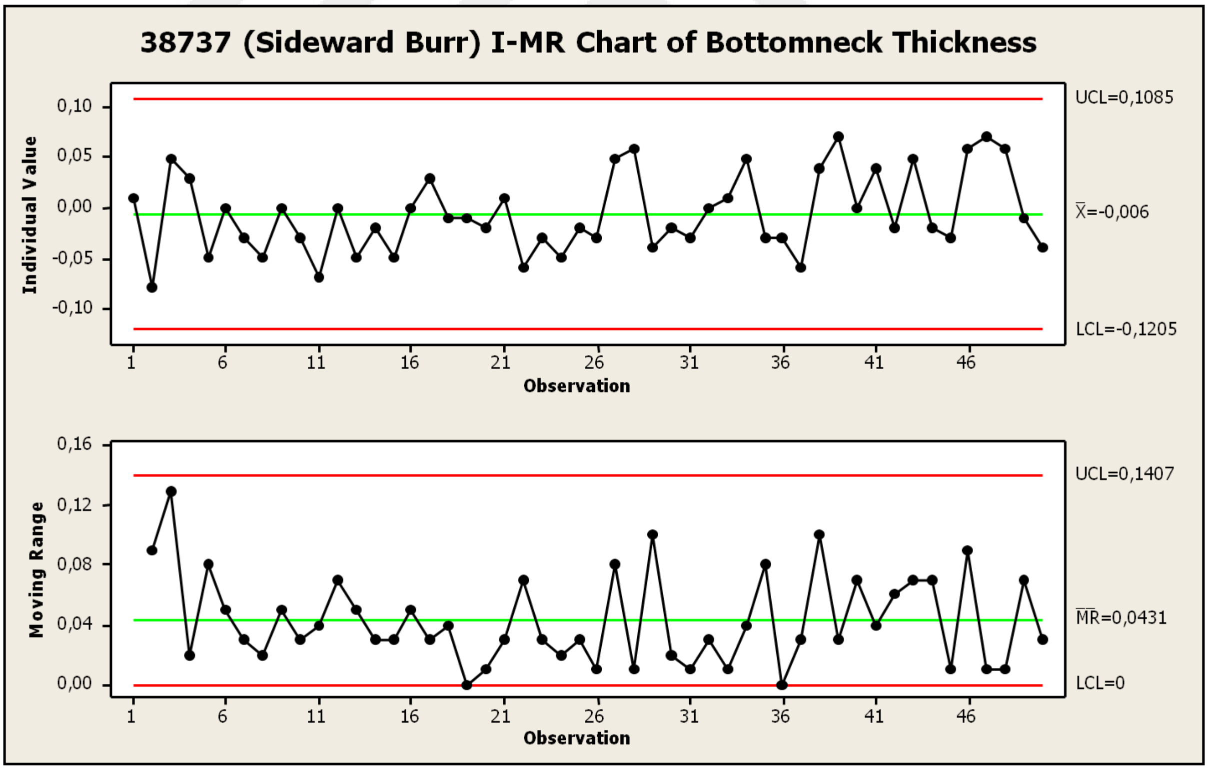



Figure 12.31: Bottomneck Thickness Control Graphic of Valve 38737

Control Charts helped to track and control the improved process. So levels are in control. And datas documented.

PROCESS CONTROL SYSTEM

| STELLITE DEFECTS | | | | | |
|---|---|---|---|---|---|
| Process Indicators | Control Limits (max) | Frequency | In Charge Of | Action Plan | Report No |
| Stellite Line Defect Rate | 2,04% | Monthly | Quality Manager | Informing Production Manager Offices | Report Ek-54 or QAD 39.24 |

Table 12.17: Process Control System of Stellite Defects

BENEFIT/RETURN TRACKING TABLE

| AFTER PROJECT PARAMETERS VALUES IN 6 SIGMA PROJECTS | | | | | | |
|---|---|---|---|---|---|---|
| Project Title | Project Code | Project Sponsor | Process Owner | Black Belt | Handover Date | Solution Go-Live Date |
| Reduction of defects in Stellite Line | SUP-HU-02 | Ziya Ergin | Oktay Köken | Hakan Üstündağ | 15.12.2015 | 04.01.2016 |

| Parameters | Baseline | Max | Jan 16 | Feb 16 | Mrc16 | April 16 | May16 | Jun 16 | July16 | Aug 16 | Sep 16 | Oct 16 | Nov 16 | Dec 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Absolute Defect Perc. | 4,34% | 2,04% | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| Ab. Processed Pieces [QAD 39.24] | | | | | | | | | | | | | | |
| Total Defect Amount [QAD 39.24] | | | | | | | | | | | | | | |
| Baseline Defect Amount | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Recovered Defect Amount | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Avrg.Unit Cost of Defect ($) | | | 1,90 | 1,90 | 1,90 | 1,90 | 1,90 | 1,90 | 1,90 | 1,90 | 1,90 | 1,90 | 1,90 | 2,90 |
| VÖ Return ($) | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total VS Return($) | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 12.18: Benefit/Return Tracking

# 5. BENEFIT CALCULATION/RETURN ACCOUNT

Defect Return :

Current Situation Defect Pieces: 53.755 (2015 February-August)

Net Pieces Undergoing the Process: 1.237.468 (2015 February-August)

Current Situation Defect Rate: 53755 / 1237468 = %4,34

Defect Cost: 1,90 $

Target Defect Reducing : %53

Target Defect: %2

2015 Planned Production Amount: 2.565.000

Target Defect Return: 2565000 x (0,0434 -0,02) x 1,9= 114.232 $

Expenditures :

Tonnage monitor: 13.000 $

Springy puntas : 1477 $

**EBT ($) : 114.232 – (14.477/10) = 112.785**

**EAT ($) : 112.785 * 0,8 = 90.228**

As a result, defect rate is enhanced from 4.34% to 2%.

| Project | SUP-HU-02-Reduction of Defects in Stellite Line | Date | 12.12.2015 |
|---|---|---|---|
| | | Revision | 1 |

**Job Status**

From February 2015 to the middle of August, 53.755 pieces of defects threw from within the 1.237.468 valves which is produced in Stellite line and percentage of defect materialized as %4,34. In this process, defect cost is 102.134$. This situation block the sending intended products to stated lines and causes problems as additional labor, traceability.
VOB, make a demand the enhancement of situation that create extra cost due to high ratio of defect in related line. This project support the CFSs that is in strategic plan as FO-Shareholders Value Maximization, F2-OEM To Become Profitable, F8-Effective Cost Management, I6-Ensuring Continuity of Quality.

**Opportunity Announcement**

Percentage of defect of stellite line in last 6,5 months amounted %4,34. At 2015, Daily 9.000 pieces and yearly 2.565.000 pieces of valve production envisioned. Unless making an enhancement in process, production will have same defect ratio and 2.565.000 pieces of valve's 111.321 pieces of it will be defect. Cost of defect will be 211.510$.
With this project, defect ratio withdraw to the target valve level %2,00 which is the aim of the line. Reaching the %2 defect goal will cause reduce %53 of wastes because of this it helps to gain VS 91,386$ return. Also project will support the Supsan in achieving their general defect goals.

**Target Notification**

| | |
|---|---|
| Number of Defect | 53.755 |
| Absolute Pieces Undergoing the Process | 1.237.468 |
| Defect % | 4,34% |
| Target Defect Reduction | 53% |
| Planned Daily Production | 9.000 |
| Planned Yearly Production | 2.565.000 |
| Target Defect % | 2% |
| Defect Cost ($) | 1,90 |
| Target Defect Return ($) | 114.232 |
| Tonnage Monitor($) | 13.000 |
| Springy Puntas ($) | 1.477 |
| **Total Return - VSK ($)** | 90.204 |

**Content**

All defects at Stellite Line.

**Project Plan**

| | Start | Finish |
|---|---|---|
| **Define** | 20.08.2015 | 05.09.2015 |
| **Measure** | 06.09.2015 | 04.10.2015 |
| **Analysis** | 05.10.2015 | 24.10.2015 |
| **Improve** | 25.10.2015 | 26.11.2015 |
| **Control** | 27.11.2015 | 15.12.2015 |

**Project Team**

| | | | |
|---|---|---|---|
| **Sponsor** | Ziya Ergin | **Finance Officer** | İzzet Kafalı |
| **Process Owner** | Oktay Köken | **Black Belt** | Hakan Üstündağ |
| **Master Black Belt** | Veysi S.Ünser | **Green Belt** | Abdullah Öksüz |
| **Green Belt** | Emin Eker | **Green Belt** | Aykut Yılmaz |
| **Green Belt** | M.Yanıkömer | **Green Belt** | Alpay Gülmez |
| **Green Belt** | Nurzat Güven | **Green Belt** | A.Osman Üstün |
| **Tranee Engineer** | Yağmur Aslan | **Green Belt** | Taner Kahraman |
| **Green Belt** | Erdal Kurt | | |

Table 12.19: PROJECT REPORT-rvz01

EAT : 90.240 $

DECISION PROPOSAL

- Approval of financial return foresight.
- Approval of "Improve-Control" phases.
- Approval of Project Announcement (Rev.01).

# 6. CONCLUSION

The Six Sigma is a financial improvement strategy for industries. It is a quality improving process for reducing the defects. It minimizes the variation and improves capability in the process. The aim of Six Sigma is to increase the profit margin and improve financial conditions by minimizing the defects rate of product. Also it increases the customer satisfaction, and improving the company's value.

This thesis presented a successful case study of defect reduction in Supsan. In this thesis Six Sigma is chosen to be used for reducing defects in SUPSAN. Therefore, in the beginning of the project Six Sigma methodology is explained and literature review is made. And all approaches is examined to help Six Sigma methodology and after comparison analysis between approaches. DMAIC approach is found more suitable for this project. Then DMAIC approach is explained and literature review of DMAIC is made. In implementation part, first of all project report is made. And current situation is defined. Project Calender is created. Then potential root causes are found of the defects. These were based on extrusions, slots and PTAs. In measure phase, SIPOC diagram is made and Process Map is illustrated. VOB and VOC is stated. Then stakeholder management plan is made. Current situation was, defect amount was 53.755 and defect rate was %4,34 so defect cost was 102.000$. Defect rates on yearly basis is found by graphics. And Pareto Chart is made with considerly all defect types. So Stellite coating is found that has huge impact on defect rates. And an another Pareto Chart is made to find most defective value between value types. Distribution of defects types on values is found. And measurement phase is made. In Analysis phase, Critic Indicators are identified. C&E Matrix is made. Process capability analysis for selected valves are made and their effects are analyzed. So main root causes are found. In improve phase, proven root causes are determined and solutions is illustrated with the help of solution evaluation matrix. Solutions were; hammering stellited valves with giving sideward burr of extrusion, using contacted prop in thickness separation process, to revise current MPS, overhead deburring at TTS or HSF, taking new CNCs instead of MPS, giving TTS operation after 1.Rough Stoning for 39114, 38738, 38737 valves intended for A, B, C lines, giving TTS operation after1.Rough Stoning for 37970, 37767, 37918 valves intended for D1-D2 lines, using springy punta in all PTAs, taking mechanical spaces, PLC control because the change of periodic bottom plate. And actions for implementation is decided. Problems were as follow;

- Slot can't taken as standard at turning stalls. ( If burr stays PTA plate does't fit and because cooling problem, stellite combustion defect occurs. If burr taken deep, thickness decreases and causes stellite combustion defect too.)
- In rectification operation, it obstructs taking secretion of overhead secretion in valves which has less smoothness on overhead cause of their design.
- At PTA plate, valve's turning back with secretion causes stellite combustion defects.
- Burr pen in valves which comes bottomneck come thick break into to forehead as much as bottomneck thickness. Decreasing of thickness causes stellite combustions.
- Burr pen in valves which its bottomneck comes thin doesn't touch to burr, burr stays as it is.
- Stellite coating,
- Damaged stellite
- Missing material at head diameter
- Head diameter causes stellite welding crack defects.

So in conclusion of problem statement; At first, 3 critic factors as secretion of overhead, difference of bottomneck thickness and overhead burr causes increasing in stellite sourced defect rates to %4-5. Even if proper valves on account of 3 foregoing factors comes infront of the PTA welding, between %1-2 defect occurs inside of the PTA.

Referred solutions are; To go for %2,5 level which is line defect goal, first of all extrusion presses sourced external root causes should be cleared away. At a later stage to go down less of the %2,5 defect rate, PTA sourced internal root causes should be cleared away. Solutions for Overhead Burr are, hammering at sideward burr at extrusion pres, overhead deburring at TTS. Solution for Bottomneck

Thickness are, hammering at sideward burr at extrusion pres, new mold design, tonnage monitor. As a result of Bottomneck Thickness Capability Analysis; Valves enters to regime more early without operation intervention, Bottomneck thickness capability values are more high. Besides at PTAs, tray changing frequency is not standard because of it is dependent to operator so PTA Tray Changing Frequency Automatization is suggested. At PTAs tray-punta centration is not standart hence, taking PTA loading slots and for all PTAs springy yaylı punta supply and use is suggested.

In conclusion of benefit calculation;

Current Situation Defect Pieces was 53.755 (2015 February-August) and Net Pieces Undergoing the Process was 1.237.468 (2015 February-August). So Current Situation Defect Rate is53755 / 1237468 = %4,34. Defect Cost is1,90 $ and Target Defect Reducing is %53. Target Defect is %2. Also 2015 Planned Production Amount is 2.565.000. So Target Defect Return is 2565000 x (0,0434 -0,02) x 1,9= 114.232 $ Expenditures are Tonnage monitor costs 13.000 $ andSpringy puntas costs 1477 $. So EBT ($) will be 114.232 – (14.477/10) = 112.785$ and EAT ($) will be 112.785 * 0,8 = 90.228 $

In continuation of study implementation plan is made. Implementations were as follow; giving TTS operation after 1.Rough Stoning for 39114, 38738, 38737 valves intended for A, B, C lines, giving TTS operation after 1.Rough Stoning for 37970, 37767, 37918 valves intended for D1-D2 lines, within giving sideward burr works, mold design for 39114, 38738, 38737, 37542, 37543, 37767, 37970, 37918 valves, (39114, 38738, 38737, 37542, 37543, 37767, 37970, 379182 ) valve’s bottom and top molds manufacture of workshop, within giving sideward burr, searching/meet with domestic and foreign firms for tonnage monitor, installation of tonnage monitor system, springy punta supply for all PTAs, taking slots in PTA loading-unloading system, to set time frequency for PTA tablas(1000 pieces).

Then Communication plan and FMEA are illustrated. Also Risk Action Plan is made too. In control phase, Valve Regime Entry Pieces after stopping is tracked and analyzed. Process Capability Analysis is made of the recruitted process. So valves enter to regime more early without operation intervention and bottomneck thickness capability valves are more high. Control charts are created of valves with help of Minitab and results found under control. Process control system table and benefit/return tracking table are illutrated. In the benefit calculation; before improvement situation defect pieces were 53.755 and net pieces undergoing the process were 1.237.468. So situation defect rate was %4,34. Defect cost is 1.90$. After improvement Defect rates reduced as 53% and Defect rate become %2 with 9.000 planned daily production and 2.565.000 yearly production; if we add expenditures as; tonnage monitor 13.000$ and springy puntas 1.477$ that used to improve process. EBT ($) is calculated as 112.785 and EAT ($) become 90.228.

In conclusion; this paper is about reduction of defects in SUPSAN by applying Six Sigma principles with the help of DMAIC methodology. So results obtained proved to be worthy that enhances defect rate from 4.34% to 2%. This demonstrates that as long as the organisation continues embracing Six Sigma, it solves quality problems, saves cost, increases product quality and ensures customer satisfaction.

# 7.REFERENCES

-[1] Dr.Rajeshkumar U. Sambhe, (2012), “Six Sigma Practice for Quality Improvement- ACase Study of Indian Auto Ancillary Unit”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN:2278-1684 vol 4,Issue 4(Nov-Dec.2012), pp 26-42.

-[2] J.Anthony, M Kumar and M K Tiwari,(2005), “ An Application of Six Sigma Methodology of Reduce the Engine-Overheating Problem in an Automative Company” Proceedings of the Institution of Mechanical Engineers, Part B. Journal of Engineering Manufacture vol.219 2005 pp 633-646.

-[3] Rajeshkumar u. Samble, Dr.Rajendra S.Dalu, (2011), “ Evaluating Six Sigma Implementation in Medium Scale Indian Automative Enterprises” International Journal of Engineering Science and Technology (IJEST), vol.3 no.3 Mar 2011, pp 1790-1796.

-[4] S.N.Teli, Dr.V.S.Majali, Dr.U.M.Bhushi, Sanjay Patil (2012), “ Automobile Product Development Process (APDP) Strategy by Integrating Six Sigma to Reduce the Cost of Quality”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN:2278-1684 vol 4, Issue 3 (Nov.-Dec. 2012), pp 40-48.

-[5] Kunal Ganguly (2012) “Improvement process for Rolling mill through the DMAIC Six Sigma Quality Management Technique- An Overview” Journal of Engineering Research and Studies JERS/Vol.II/Issue III pp.64-72.

-[6] Sunil Dambhare and Siddhart Aphale (2013) “ Productivity Improvement of a special purpose Machine Using DMAIC principles: A Case Study: Journal of Quality and Reliability Engineering volume 2013, Article ID 752164, 13 pages.

-[7] Snee, R., “Impact of Six Sigma on Quality Technology”, Journal of Quality Technology, vol.12,no.1,2000,pp.2-5.

-[8] Horel, H., “Putting Six Sigma in Prospective”, Quality Engineering Magazine”, vol.40, No.10,2001,pp.58-62.

-[9] Anthony, R. And Banualas, W. (2002) “Design for Six Sigma”, Journal of Research Technology and Management, Vol. 65,1,2002, pp.23-25.

-[10] Tony, B., “Six Sigma and the Future of Quality Profession”, Quality progress Magazine,vol.3,no.32,2004,pp.46-52.

-[11] Zbaracki, M., “The Rhetoric and Reality of Total Quality Management”, Journal of Management System,vol.43 no.2,pp.60-62.

-[12] Breyfogle, F., “Featured Company Bechtel”,ASQ Six Sigma Discussion Magazine, vol.3, No.1,2004,pp.4-6.

-[13] Joseph., “Key Ingredients for Effective Implementation of Six Sigma Program”, Business Excellence Magazine, vol.6, no.4,2004,pp.20-27.

-[14] Bendall, F. and Marra, T., “Six Sigma Black Belts: What Do They Need to Know”, Journal of Quality Technology, Vol.33, No.4,2005,pp.391-406.

-[15] Kumar et al., “Winning Customer Loyalty in an Automative Company through Six Sigma: A Case Study”, Journal of Quality Reliability Engineering, 2006 (in press).

-[16] Sanders, D and Hilolo, Q., “Six Sigma on Business Processes: Common Organizational Issue”, Journal of Quality Engineering, vol.12,no.2,2007,pp.5-8.

-[17] Kim Yong, Kim Jeong, Chung Min Gyo. (2010) A Six Sigma based method to renovate information services: Focusing on information acquisition process. Library Hi Tech, 28 (4),632-647.

-[18] Abbas Al-Refaie, Ming-Hsien Li, Issam Jalham, Nour Bata and Kawther Al-Hmaideen, Improving Performance of Tableting Process Using DMAIC and Grey Relation Analysis, Proceedings of the International MultiConference of Engineers and Computer Scientists 2013 vol II, IMECS 2013, March 13-15, 2013, Hong Kong.

-[19] Hemendra Nath Roy, Sudipta Saha, Tarapada Bhowmick and Sufal Chandra Goldar (2013), Productivity Improvement of a Fan Mnufacturing Company by using DMAIC Approach: A Six Sigma Practice, Global Journal of Researches in Engineering Industrial Engineering , vol 13,(4),2013,pp.1-6.

-[20],[21] A Case Study of Defects Reduction in a Rubber Gloves Manufacturing Process by Applying Six Sigma Principles and DMAIC Problem Solving Methodology. (Ploytip Jirasukprasert, Jose Arturo Garza-Reyes, Horacio Soriano-Meier, Luis Rocha-Lona)

-[22],[23],[24] Reduction of Welding Defects using Six Sigma Techniques (Shashank Soni, Ravindra Mohan, Lokesh Bajpai and S.K.Katare)

-[25],[26],[27],[28] Reduction of Defects in Latex Dipping Production: A Case Study in a Maleysion Company for Process Improvement (M.C.Ng, Hasnida Ab-Samat, Shahrul Kamaruddin)

-[29],[30],[31] Applying Lean Six Sigma for Waste Reduction in a Manufacturing Environment (Mohamed K.Hassan)
-[32],[33],[34],[35] Reduction in defects rate using DMAIC approach- A Case Study (Jitender Kumar, Mukesh Verma, K.S.Dhillon)
-[36],[37] Reduction of Paint Line defects in shock absorber through Six Sigma DMAIC phases. (K.Srinivarsan, S.Mutlu,N.K.Prasad, G.Satheesh)
-[38],[39],[40] Applying Six Sigma Methodology based on "DMAIC" Tools to Reduce Production Defects in Textile Manufacturing. (Mohammed T.Hayajneh, Omar Bataineh, Rami Al-Tawil)
-[41] Manufacturing waste reduction using Six Sigma Methodology (Ricardo Banuelas, Jiju Anthony and Martin Brace)
-Yalın Altı Sigma ve Bir Uygulama (Doç.Dr.Onur Özveri, Arş. Gör. Engin Çakır)
-Bir çelik Boru Üretim işletmesinde Çekme Tipi Borulardaki Fire Oranının azaltılması amaçlı Altı Sigma Proje Analizi (Zeynep Gergin, Elif Naz Acar, Dilara Terzi)
-Combining Lean Concepts&Tools with the DMAIC Framework to Improve Processes and Reduce Waste. (Nazen Arafeh)
-Improvement in Production rate by Reducing the defects of Injection Moulding (Vikas Tayal, Jitender Kumar)
-Implementing Six Sigma and Lean, A practical guide to tool and techniques (Ron Basu)
-Lean Six Sigma that Works (Bill Carreira and Bill Trudell)
-Scrap Reduction at EFD (David J. Byler, Nathan W-Griggs, and Caitlin E. Macleo)
-Essentials of Lean Six Sigma (Salman Taghizadegan)
-World Class Applications of Six Sigma Real World examples of success edited by Jiju Antony, Ricardo Banuelas and Ashok Kumar.
-An analysis of the Six Sigma DMAIC method from the perspective of problem solving (J. De Mast, J.Lokkerbol- International Journal of Production Economics 2012-Elsevier)
-Six Sigma in Lean Construction Systems: Opportunities and Challenges (Toriq S.Abdelhamid)
-Obaidullah Hakeem Khan Kundi (2005) " A Study of Six Sigma Implementation and Critical Success Factors" Pakistan's 9th International Convention an Quality Improvement vol.27 pp.268-317

-Roger W.Hoert (2001) “ Six Sigma Black Belts :What Do They Need To Know?” Journal of Quality Technology vol.33.No:4

-Silvia Ponce and Sid.Ali Zahaf (2004) “ Knowledge Communities, a key element in Six Sigma Implementation Strategies and Deployment” Hec Montreal pp 4-6

-Hackman, F. and Wageman, G., “Why Should Statisticians Pay Attention to Six Sigma”, Journal of Productivity, vol.14, No.2,2003,pp.100-103.

-Kunal Ganguly, (2012) “Improvement Process for Rolling Mill through the DMAIC Six Sigma Approach”, International Journal for Quality Research vol6,no.3 pp 221-231.

-Hsiang-Chin Hung and Ming-Hsien Sung, (2011), “Applying Six Sigma to Manufacturing Processes in the Food Industry to Reduce Quality” Scientific Research and Essays vol.6(3), pp.580-591.

-Prof.Dr.Vidosav Majstorovic 1, M.Sc. Tatjana Sibalija 1, “Application of Six Sigma Methodology in Serbian Industry”.

-S.Pimsakul, N.Somsuk, W.Junboon, and T.Laosirihongthong, (2013), “Production Process Improvement Using the Six Sigma DMAIC Methodology. A Case Study of a Laser Computer Mouse Production Process” The 19th International Conference on Industrial Engineering and Engineering Management, DOI 10.1007/978-3-642-37270-4 13, Springer-Verlag Berlin Heidelberg, pp 133-146

-Mohit Tanejal, Arpan Manchanda, (2013), “Six Sigma an Approach to Improve Productivity in Manufacturing Industry” International Journal of Engineering Trends and Technology (IJETT)-vol 5 no:6 Nov 2013, pp 281-286

-Tushar N. Desai and Dr. R.L. Shrivastava, (2008), “ Six Sigma-A New Direction to Quality and Productivity Management” Proceedings of the World Congress on Engineering and Computer Science 2008 WCECS 2008, October 22-24, 2008, San Francisco, USA

-E.V. Gijoa, Johny Scariab and Jiju Antonyc, (2011), “Application of Six Sigma Methodology to Reduce Defects of a Grinding Process” doi:10.1002/qre.1212 qual.Reliab.Engng. Int.2011,27,pp 1221-1234

-R.Gonzalez Falcon et. al (2012), “ Improving Energy Efficiency in a Naphtha Reforming Plant Using Six Sigma Methodology”, Fuel Processing Technology 103 (2012), pp 110-116

-Jeroen Demast, Joranlokkerbol (2011), “ An Analysis of the Six Sigma DMAIC Method from the Perspective of Problem Solving”, International Journal of Production Economics 139 (2012),pp 604-614

-Ploytip Jirasukprasert et. Al (2012), “ A Case Study of Defects Reduction in a Rubber Gloves Manufacturing Process by Applying Six Sigma Principles and DMAIC problem Solving Methodology”, Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management Istanbul, Turkey, July 3-6, 2012 ,pp 472-481

-Adan Valles et. Al (2009), “ Implementation of Six Sigma in a Manufacturing Process: A case study”, International Journal of Industrial Engineering, 16(3), pp 171-181

-S.Suresh, a. L. Moe and a.B.Abu (2015), “ Defects Reduction in Manufacturing of Automobile Piston Ring Using Six Sigma”, Journal of Industrial And Intelligent Information vol.3,no.1,March 2015,pp 32-38

-Lateef Ur Rehman, Ateekh-Ur-Rehman (2012), “Safety Management in a Manufacturing Company: Six Sigma Approach” Engineering, 2012

-Md. Enamul Kabir, S.M. Mhbubul Islam Boby, Mostafa Lutfi, (2013), “Productivity Improvement by Using Six Sigma”, International Journal of Engineering and Technology vol 3no.12, December,2013,pp 1056-1084.