CHAPTER ONE

INTRODUCTION

1.1GENERAL INTRODUCTION

Manufacturing processes are sometime imperfect; for that reason their output may contain defective items. These defective items can be reworked, scrapped, subjected to other corrective processes or sold at reduced prices, but the result is increased extensive costs in every case. In recent decades, researchers tried to determine the optimal batch quantity of imperfect production system considering different operating conditions. Research is focused on the practical situations involved in a single or multi-stage production system.

In the market situation today with high competition, different companies have started to look for different approaches and practices to improve the quality level of the product at a reduced cost, create a safe and rewarding workplace and eventually achieve higher customer satisfaction. During the early ages of manufacturing, US manufacturers mainly relied on mass production and final stage inspection. The product would be inspected only at the final stages. These practices resulted in increased inventory level, increase in rework and the consequence was loss of time and money. The Japanese counterparts started introducing low cost products with higher quality. Faced with a global competition, the US manufacturers had to change their manufacturing strategies to maintain market share. In the 1980’s Motorola launched a process improvement methodology and named it six-sigma. After launching six-sigma initiatives Motorola enjoyed increased customer experience, increased sales, increased stock rate and more profit. Later General Electrics and Allied Signals followed the footsteps of Motorola and they also improved their business . On the other hand, the Japanese were practicing Lean Manufacturing, which has been in use for more than 30 years. They were concentrating on delivering a high quality product in a reduced lead-time. They believed that this would directly affect and improve customer satisfaction. Though General Electrics enjoyed higher Quality product at reduced cost, they were not able to meet their target delivery dates. Their lead-time in delivering the finished goods was much higher. So, General Electrics started using lean manufacturing concepts to overcome lead-time related problems. The approach of lean and six-sigma explains the connection between shareholder value establishment and precise advancement in the business. Lean six-sigma gives more edge than that could have been attained individually by Lean or Six-Sigma . The following chapter contains a review of literature pertinent to the evolution of lean and six-sigma concepts, their individual approaches towards process improvement and their integration [1].

1.2 PROBLEM STATEMENET

The research problem is the emergence of some problem after the product is delivered to the assembly (filling) department and the abatement problem :

- Existence of some chips in the back of the product , that lead to equipment damage and disrupt production .
- As well as Existence of vacuum in the back of the product as result of small size of bullet and this problem lead to disruption of production.

And one of the most problem for the arrival of reject ratio of 5.1% and this ratio is consider high when compared with six-sigma .

1.3 OBJECTIVES OF PROJECT

In this research focus on the reasons that generates defect and rework .and looking for the solutions that help to avoid variations .

The main objective of the research are :

I. Reduce ratio of defect and re-work.

II. Reduce down time of machines.

1.4 SCOPE OF PROJECT

The scope of the project is to use lean six sigma concepts to improve Production of the caliber projectile 39 x7.62 mm . Using cups as raw material and the process includes forming a lead wire and assembled with cups in specific stages of the production .

Help the existing employees and value stream leaders to better understand the improvement opportunities and will document the progress where they will be responsible for carrying out and sustaining the change. The improvement opportunities like improving business models with customers or improving the supplier's purchasing contracts will be out of scope of this project.

The research presents a number of excellence tool that use to reduce reject and re-work , study has been conducting form (January to September) 2014 to calculate the total cost of production and cost of poor quality .

The information of these research depend on the voice of customer (filling management) that represent main customer .

The research will address both factor internal and external affect the rate of rejects and re-work , also research is interested in studying the current process in manufacturing and discuss the possibility of the development of performance for existing process without increasing in expenditure .

1.5 RESEARCH METHDOLOGY:

Six Sigma methods, include many of the statistical tools that were employed in other quality processes, employed in a systematic project-orientated fashion through the Define, Measure, Analyse, Improve, and Control (DMAIC) cycle .

This DMAIC cycle contained the following steps:

a. Define

Identify customers and their priorities; Identifies a project suitable for Six Sigma efforts based on business objectives as well as customer needs and feedback; Identify CTQs (Critical to quality characteristics) which the customer considers to have the most impact on quality

b. Measure

Determine how to measure the process and how it is performing; Identifies the key internal process that influences CTQs and measure the defects currently generated relative to those processes.

C. Analyse

Determine the most likely causes of defects; Understand why defects are generated, by identifying the key variables that are most likely to create process variation.

d. Improve

Identify means of removing the causes of defects; Confirm the key variables and quality of their effects on the CTQs; Identify the maximum acceptance ranges of the key variables and a system for measuring deviations of the variables; Modify the process - keeping it within an acceptable range.

e. Control

Determines how to maintain the improvements; Put tools in place to ensure that key variables remain within the maximum acceptance ranges under the modified process.

CHAPTER TWO LITURE REVIEW

2. LITERATURE REVIEW

This Literature review will give a basic idea about the evolution of Six-Sigma, what it is about and its methodology. Some case studies to highlight its importance are also discussed in this literature review. While explaining the concept of Lean, case studies of successful Lean implementation are also elucidated. It will also brief about Lean manufacturing’s integration with Six-Sigma and how it has helped in process improvement.

2.1 SIX-SIGMA EVALUATION

2.1.1 WHAT’S SIX-SIGMA ?:

Six-Sigma in general is a fact-driven, disciplined and statistical approach that is followed to eliminate defects and guide processes to reach perfection. Being a versatile system in making business leadership perform better, Six-Sigma doesn’t work based on any single theory/strategy. It is based on result driven strategies used in the past century and many important management ideas, which lead the way in today’s competitive money making world. There is no one single definition for Six-Sigma. It is a statistical measure of performance of processes/products; a goal that reaches perfection for performance improvement; a management system to achieve business leadership and enhanced performance in a long run . In simple words, Six-Sigma combines best techniques of the recent past with the best management breakthroughs and common sense. Three main areas of Six-Sigma focus are customer satisfaction, reducing defects and eventually reducing cycle time. Team leader's commitment, usage of common language throughout the organization, process reengineering enforced by aggressive engineering goals, fact based decision making, good communications to keep the interest on Six-Sigma and its continuity on track and maintaining metrics to evaluate past performance and assess future goals are some of the key success factors of Six-Sigma .

Six-Sigma is a management language that institutionalizes a precise, closely controlled, fact-based approach to deliver more money to the bottom line through process improvement and process design projects. These design projects are selected by top management and led by highly trained Six-Sigma Black Belts or Master Black Belts with the intention to create ideal processes, products, and services all aligned to delivering what the customers want . From the above discussion it is clear that the management's commitment, which acts as the driving force for both breakthrough and traditional improvements, is very essential in the journey towards successful implementation of Six-Sigma methodology. In general mathematical terms Six-Sigma is the relationship of manufacturing variability and product specifications. In statistical terms, it means that no more than 3.4 DPMO (defects per million opportunities) is possible when a process is at a Six-Sigma level of performance. A defect can be defined as a measurable attribute of the process or its output that is not within the standard acceptable limits, i.e., not conforming to specifications [2].

Customer focus, fact-driven management, process focus, down to business management, boundary-less group effort and drive for excellence are the six critical factors that are required for an organization to attain a quality level of Six-Sigma . The eventual purpose of Six-Sigma is to raise profits by getting rid of variability, discrepancies and wastes that weaken customer trustworthiness. Any organization like manufacturing, engineering, R&D, sales and marketing, health care and government agencies can utilize Six-Sigma for excellence in quality [3]

2.1.2 MOTOROLA'S JOURNEY IN SIX-SIGMA:

Six-Sigma Journey In the 1980s Motorola was the leader in the market of its kind. But during the mid-1980s Japanese high quality products made Motorola lose its feet in the market once conquered by them. Customer discontent was like a pandemic with Motorola. Making profit was out of reach for the reason that the operating costs were very high. Once the head of purchasing from one of the customers was quoted as saying that “Love, love, love the product; hate, hate, hate the company.”This ultimately demonstrates that the business was not customer driven. Agreement reviews, responses to demand for quotes, invoicing, response to customer grievances and other administrative areas were in a weak position because of the weary administration of management and disinterested workers. Response times were lengthy and not planned for customer satisfaction. Customers experienced a high level of early-life failures of the products. Inspired by the Japanese manufacturer's success, Motorola arranged visits to Japan to study the operating methods and product quality levels pursued by the Japanese. What Motorola found was that the quality level of the products should be quantified so as to improve the product's quality. Motorola's CEO Bob Galvin, considered the pioneer of Six-Sigma at Motorola, visited major company sites worldwide to instruct employees about Six-Sigma and encouraged them to integrate it into the day- to-day business activities. The concept of opportunities-for-errors was developed to account for differing complexities . He along with Bill Smith, Motorola's Vice-President dedicated Motorola to a plan that would decide quality goals for improving the corporation 10 times by 1989, 100 times by 1991. It was with his help that Motorola won its first Malcolm Baldrige National Quality Award in 1989 [3].

2.1.3 GENERAL ELECTRIC'S JOURNEY IN SIX-SIGMA:

Six-Sigma Journey Inspired by the success of Six-Sigma implementation in Allied Signals, Jack Welch, CEO of General Electric (GE), went on to use Six-Sigma as a business improvement strategy. Spending about $250 million GE educated and trained nearly 4,000 Black Belts and Master Belts and additional 60,000 Green Belts out of a total work force of 60,000 in the year 1997. These trainings added to a $3,000 million as an operating income for the year 1997. GE adopted Motorola's ʿ measure-analyze-improve- control ʿ(MAIC) and added 'define' to it to frame DMAIC approach. Also GE adopted many other concepts and disciplines from Motorola. The improvement measures varied from creating new design for a product from start to finish to saving billions of dollars in a span of three years. GE Medical System used six-sigma principles to manufacture a $1.25 million diagnostic scanner from start to finish, which ultimately reduced chest- scanning time from 180 seconds to 17 seconds. GE Plastics improved production of plastic by 1.1 billion pounds by implementing Six-Sigma technology. Inventory turns increased from 5.8 to 9.2. During the period from 1996 to 1998, GE incurred $1 billion in cost and the return on that investment was close to $1.75 billion . [2]

2.1.4 MISAPPREHENSIONS ABOUT SIX-SIGMA:

Though Six-Sigma has been proved to be successful there have always been some misconceptions about it. Many people look upon it as a catchphrase of the month. They fail to keep in mind that it is a strategy, which evolved through Deming's management philosophies and total quality management. It focuses on customer, maintains complete training structure and delineates value from customer's viewpoint considering quality, service, and delivery. Another misconception is that the goal of 3.4 defectives per million is absolute and should be functional to every opportunity, tolerance and specification. The idea is to use Pareto based analysis for selecting projects that are like low hanging fruits, which will provide instant outcomes. The last misconception is that Six-Sigma is only a quality program. From past literature it is evident that Six-Sigma relates quality and customer obligations, meaning that it involves all those who are accountable to deliver a final product to the customer . [3]

2.2 EVALUATION OF LEAN :

The concept of lean has been prevalent in the manufacturing sector for more than 30 years. It is commonly known as a measure to reduce inventory and the number of hands involved in any process. It is also associated with continuous improvement. The main theme in the lean concept is waste reduction. Lean can also be referred to as a production philosophy that foresees the supply chain that consists of receiving raw material to sending out finished goods and from designing a product to customer service. It is an idea of "hundred small improvements every day" than "one home run once a year”. It is a useful tool that helps in reducing waste of time, material, effort and resources in any industry. The core approach of lean manufacturing is to produce a product in the shortest possible cycle time and streamline the flow of processes. According to the Lean institute, the fundamental objective of Lean is to offer value to the customer through an ideal value added process that has zero waste. Based on a study by the Massachusetts Institute of Technology, lean requires half as much effort in design, development and time than a normal production process . [4]

Unlike older manufacturing strategies like mass production, Lean depends on many frequent deliveries of limited quantities with a fewer possible suppliers. The former philosophies resulted in large work in process inventory. Creating value throughout the process stream and therefore eliminating waste is known as ‘Lean management’. In mass production, the cost involved in fixing defects is less than the cost involved in producing defective parts in lots. Lean creates a standardized work environment and minimizes the cycle time and variability in production to meet the variability in demand. The other major variability in today’s industrial environment is supplier variability, which can be overcome by partnering with suppliers and creating a supplier - producer cooperation [5].

The introduction of lean manufacturing has changed the typical ways of measuring performance. Performance measures like cycle time tracking, sales per employee hour and worker participation have replaced measures like equipment utilization and labor variance. Higher quality products can be delivered at reduced rework and inspection. Eliminating excess inventory, excess floor space and unwanted movements result in achieving the shortest possible cycle time. Hence, lean concepts, when implemented successfully, can deliver a product with higher quality in a short period of time.

The main contributors that make designing, redesigning and parts manufacturing simple in a short span of time are factory workforce, suppliers and capacity. Among many, the common Lean practices include standardization, reduced cycle time, built in quality, continuous improvement, and product based streamlined layout . The concept of zero defects in lean manufacturing includes mistake proofing (Poka Yoke), source and automated inspection, production stoppage as soon as a defect is identified and enduring setup conformance. As an essence, Lean production aims at increasing the product flow velocity and throughput by eliminating all possible non-value added activities . The concept of Lean manufacturing relies mainly on manufacturing cells that are capable of producing a variety of products and keeping the production facility flexible enough to produce the exact mix and right quantity of products. Availability of a right product in right quantity at the right time is also one way of describing Lean manufacturing. [5]

Unlike traditional forecast based production, lean manufacturing utilizes a pull system where production is triggered by demand. The rate at which finished goods leave the facility is what determines the rate of supply from suppliers or from a preceding work center in the same facility . Generally the following are termed as the basic principles of lean, define value from customer’s standpoint, identify the value stream, eliminate seven deadly wastes, pull the work and not push and pursue the same to perfection . Value Stream Management is a process by which planning and lean inventiveness through methodical data collection and data analysis are linked. A value stream identifies all essential members and information of a process or supply chain. Some of the essential members/factors include suppliers, customers, process flow, mode of information flow (electronic or manual) and information about cycle time, lead-time, customer requirement, availability of resources, and net available time per operating period (day or shift). The principle of cost reduction, knowledge about the seven deadly wastes, just in time, autonomation, 5S and the stages of Lean implementation (demand, floe and leveling) are the key notions and tools used in lean initiatives. These tools actually help in developing an accurate value stream map.[4]

One way to be profitable is to reduce waste from the system by effectively utilizing the value stream and eventually by reducing the cost. This is how the cost reduction principle works. The eventual intention of implementing Lean is to eliminate wastes like overproduction, excessive waiting, excessive transport, unwanted processing, more than required inventory, unwanted movement, and rejections.

Autonomation, is not complete automation but automation with a human touch. It simply means using automated mistake proofing for preventing defects and free up workers to perform multiple tasks within a work cell. This strategy maintains a zero defect environment where a defective product is never allowed to flow down the production stream and hence reducing the risk of customers receiving defective parts. 5S (Sort – Set in order – Shine – Standardize - Sustain) is a process designed for planned organizing and standardizing the workplace. 5S is an important member of the lean implementation process by which the work area is maintained as a neat and safe work place. Generally 5S audits are conducted on a regular basis to maintain the standards of the work place. It promotes cleaning and maintaining the work area, which makes it easy to identify and spot the required tools at the right time .

2.3 LEAN SIX-SIGMA INTEGRATION:

Though both, six-sigma and Lean, have made improvements in organizations individually, together they complimented each other. As a means to having a scientific approach towards quality, lean organizations should make additional use of the data in decision-making process. Companies that have benefited from lean manufacturing lack six-sigma knowledge , which is important in training the management about the involvement of people and requirement of resources. Lean techniques like value stream mapping helps in identifying the various value added and non-value added activities involved within a process based on definitions. Identifying Customer Critical-to-Quality characteristics, a six-sigma tool, can further refine this list of value added and non-value added activities. Value stream mapping helps in calculating the actual cycle time, inventory levels and lead-time for any particular process. Six-Sigma, on the other hand, ensures that there is less variation in the process.

General Electrics has considered Six-Sigma as the best initiative they have ever come up with. But even now they accept that they have variance in their deliveries between four to twenty days. Having Six-Sigma alone has not reduced the lead-time for General Electrics. The point to be noted is that Lean and Six-Sigma should be integrated for a combined improvement. Six-sigma does not address the process speed and eventually looses site of customer due dates. On the other hand, Lean fails to develop cultural infrastructure, which is important for its successful implementation. Lean Six-Sigma is a methodology that maximizes shareholder value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed and invested cost. The synthesis of six-sigma and lean production is necessary because lean cannot bring a process under statistical control, 5S cannot reduce lead- time, and both enable the reduction of the cost of complexity. Some questions that seem to be difficult to answer by both lean and Six- Sigma are, which process to consider first? In what order should implementation be carried out? How to attain high quality, improved lead-time and high cost savings quickly? Lean Six-Sigma tends to increase profit by reducing quality costs and the overall invested capital reduces inventory by bringing down the process lead-time. Lean six-sigma relentless pursuit of high quality and speed lead to corporate success and personal success for those who become part of the lean six-sigma journey .

2.3.1 TOOLS USED IN LEAN SIX-SIGMA :

There are a variety of tools that can be used for lean six-sigma approach. It is not required to use all tools at all times. Based on the nature of the process the selection of tools may vary. Different tools can be used in different phases of the implementation process. The usage of some of the common tools is discussed in the following :

A. Flow Diagrams:

This is a graphic representation of the series of steps followed in the course of a process. These diagrams help examine the logic; or lack of logic, in the sequence of steps that are used to produce output. It often helps in identifying bottlenecks so that improvement teams working on projects can actually target these areas first. In general it gives a good perspective of the process as a whole. Flow diagrams can also be used to define the scope of a quality improvement project and the boundaries of the team's effort. [1]

B. Histograms:

A histogram is used to graphically summarize and display the distribution of data set. In a typical frequency histogram, the heights of the bars are determined by the class frequency. Given that the bars in a histogram are of equal width, the area of a particular bar is relative to the equivalent class relative frequency [7].

C. Value Stream Mapping (VSM):

Value stream management is a process of planning and linking lean initiatives through systematic data capture and analysis. Value stream mapping is a visual representation of material and information flow for a product family (value stream). It is vital as a tool for visually managing process improvement. Value stream mapping is a lean manufacturing tool, which is known as "material and information flow mapping." This mapping tool uses the techniques of lean manufacturing to analyze and evaluate certain work processes in a manufacturing operation. This tool is used primarily to identify, demonstrate and decrease waste, as well as create flow in the manufacturing process.

D. Brainstorming:

Alex Osborn developed brainstorming technique in 1950s . The success of this technique is based on the quantity of ideas. It is a group technique for generating new ideas and promoting creative thinking. According to Dr. Juran, there are four rules of brainstorming such as no idea can be criticized, self-criticism and self- judgment are suspended, team members are instructed to aim for large number of new ideas in the shortest possible time, and team members should expand ideas. This technique may be used to define a project, to develop theories for identifying symptoms of the problem, and for designing solutions after identification of the root causes[5].

Two main tools that are often used in define phase are

E. CTQ (Critical to Quality) tree :

F. Cause and Effect diagram (CE):

A CTQ tree is used to identify the factors that are critical to customers. SIPOC plays a major role in developing a CTQ tree so as to identify quality requirements of the customer. After the critical to quality factors are identified the cause and effect (CE) diagram is constructed. Though the CE diagram does not identify the potential causes it helps in understanding the possible causes that contribute to the effect. The most important aspect or characteristic of the CE diagram is that it will depict the relationship between all the factors that may be potential contributors to the targeted problem. [6]

G. KAIZEN:

KAIZEN means improvement. Moreover, KAIZEN means continuing improvement in personal life, home life, social life, and working life. When applied to the workplace KAIZEN means continuing improvement involving everyone - managers and workers alike.

KAIZEN is a Japanese word meaning gradual and orderly, continuous improvement. The KAIZEN business strategy involves everyone in an organization working together to make improvements 'without large capital investments'.

KAIZEN is a culture of sustained continuous improvement focusing on eliminating waste in all systems and processes of an organization. The KAIZEN strategy begins and ends with people. With KAIZEN, an involved leadership guides people to continuously improve their ability to meet expectations of high quality, low cost, and on-time delivery. KAIZEN transforms companies into 'Superior Global Competitors'.

There are two elements that construct KAIZEN, improvement/change for the better and ongoing/continuity. Lacking one of those elements would not be considered KAIZEN. For instance, the expression of "business as usual" contains the element of continuity without improvement. On the other hand, the expression of "breakthrough" contains the element of change or improvement without continuity. KAIZEN should contain both elements. [7]

H. PARETO CHART :

Pareto Analysis is used to record and analyze data relating to a problem in such a way as to highlight the most significant areas, inputs or issues. Pareto Analysis often reveals that a small number of failures are responsible for the bulk of quality costs, a phenomenon called the ‘Pareto Principle.’

This pattern is also called the ‘80/20 rule’ and shows itself in many ways. For example:

80% of sales are generated by 20% of customers.

80% of Quality costs are caused by 20% of the problems.

20% of stock lines will account for 80% of the value of the stock.

A Pareto diagram allows data to be displayed as a bar chart and enables the main contributors to a problem to be highlighted.

I. FAULT TREE ANALYSIS :

Fault tree analysis is a probabilistic deductive systems analysis tool that provides a pictorial system representation using Boolean logic gates in a vertically oriented tree formation.

Starting at a top-level event, fault tree analysis depicts the system operation graphically. Then, flowing backward through the system, it uses logic gates to depict events that must occur for proper system operation. It is typical during an analysis to create a function tree first that displays the proper operation of the system.

The analyst then takes each positive event and reverses the outcome, making it a fault or failure, and redraws the subordinate events that contribute to the upper-level event failure, until a Basic Events block is reached. At that point, the analysis for that leg is concluded. [8]

CHAPTER THREE CASE STUDY

3.CASE STUDY

3.1 HISTORICAL INFORMATION OF 7.62 x 39 MM

The 7.62 x 39 mm Russian cartridge (properly called the M43 but commonly referred to as the AK47 cartridge) was adopted by the Soviet Union shortly after the World War II. The first production rifle chambered for this new cartridge was the semi-automatic SKS45 carbine . This rifle was quickly superseded by the selective fire AK47. Other so-called East Block countries allied with- or armed by the Soviet Union adopted the same or similar rifles chambered for the M43 cartridge. China , Sudan and a number of Arabic countries also produced military guns in this caliber. The cartridge is now manufactured in a number of countries including the United States. Large numbers of obsolete, surplus SKS carbines were imported into the U.S. from China, Russia and a number of former block countries. Their low cost, robust nature, modest recoil and generally acceptable accuracy made them very popular with recreational shooters. [9]

3.1.1DESIGN FEATURES AND BALLISTIC PROPERTIES :

The standard bullet weight for the M43 cartridge was slightly less than 8 grams (122 gr). Muzzle velocities for this bullet fired from SKS carbines and AK47 assault rifles are typically 2300 f/s to 2400 f/s (~720 .m/s).

The overall length of the M43 bullet is about 1.045 in (26.5 mm). The center of gravity for the M43 Soviet ball round is about 9mmforward of its base.

In accordance with the military practices of virtually all countries in the 1940s and thereafter, the Soviet M43 bullet was of full metal jacketed design and possessed a connection point. A mild steel core (rather than a lead core) was employed in the M43 service round. This core is about 0.775 inches(19.7 mm) in length and 0.226 in (5.74 mm) in diameter with a flat point and is both centered and secured inside the mild steel bullet jacket by means of a lead sheath of about 0.020 in (0.5 mm) thickness. This core weighs about 55 gr (3.57 g).

This hard, non-deforming bullet is one of the most ballistically stable rifle bullets in existence and as a consequence, it often produces entrance and exit wounds in gunshot victims that look more like wounds from full metal jacketed pistol bullets than so-called high velocity wounds. This ballistic stability increases the likelihood of surviving a gunshot wound from one of these bullets as compared to a soft point . [9]

3.2 DEFINE PHASE :

The first step in DMAIC procedures is to define the problems so that possible, The goal of define phase is to define the project scope by understanding background information about the SIPOC ,the process (voice of process) , customers (voice of customer) and voice of business .

3.2.1 SIPOC

SIPOC is an acronym for ***S***uppliers, ***I***nput, ***P***rocess, ***O***utput, and ***C***ustomers, defined as:

a. The suppliers are those who provide the information, material, or other items that are worked on in the process.

b. The input is the information or material provided.

c. The process is the set of steps actually required to do the work.

d. The output is the product, service, or information sent to the customer.

e. The customer is either the external customer or the next step in the internal business.

SIPOC diagrams give a simple overview of a process and are useful for understanding and visualizing basic process elements. The figure (3.1) clarifying SIPOC Diagram of bullet factory

3.2.2 VOICE OF BUSINESS:

Every project must start by this step ,We can calculate the losses profit from production plan during last 9 month (from January to September 2014) as following :

Table (3.1) Difference between plan and actual

Plan(%)	Actual production (%)	Losses (%)
100	81.8	18.2

This amount of losses = <u>2,193,000 SDG</u>

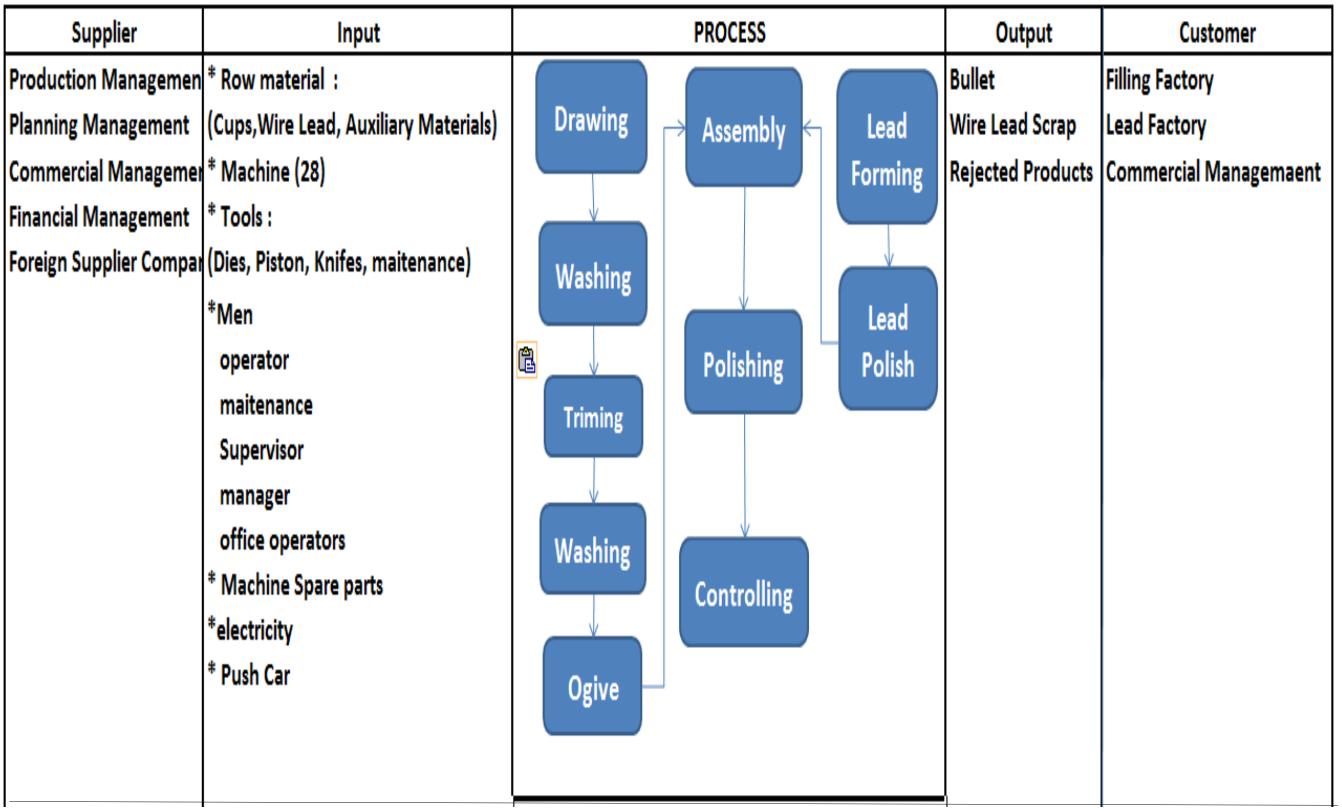

Figure (3.1) SIPOC Diagram of bullet factory

Companies suffer from huge hidden costs, which manifest as the cost of poor quality. By halving this cost, the companies can double their profits without making any capital investments.

Calculating the cost of poor quality allows an organization to determine the extent to which organizational resources are used for activities that exist only as the result of deficiencies that occur in its processes. Having such information allows an organization to determine the potential savings to be gained by implementing process improvements.

Important performance dimension that is not captured in defect measurement or Sigma measurement is dollar impact of defect, or so called "cost of poor quality" or CPQ.

Because of that reason, CPQ becomes an important key on starting point of quality measurement. For this, we should interpret problems and defect into cost of money per incident –including cost of operator and material for rework, or for the delivery delay- and also opportunity cost. CPQ measurement can be a very useful way to strengthen consensus, to improve, and also to help choosing problems with clearer benefit.

The sheer size of internal failure costs, external failure costs and appraisal costs indicate that cost of poor quality (or chronic waste) does not exist as a homogenous mass. Instead, they occur in specific segments, each traceable to a specific cause(s). These segments are unequal in size and a relative few account for a bulk of the costs. Ironically, these costs seldom show in traditional accounting reports. However, quality-related costs are much larger than are commonly understood. For most companies, these costs run in the range of 20 to 30% of sales or 25 to 40% of operating expenses.

Quality costs are not simply the result of factory operations. The support operations including maintenance, human resources and so on, are also major contributors. The bulk of these costs are the result of incapable support processes. Such costs are buried in the standards, but are in fact avoidable. The problem is that while these costs are avoidable, there has been no clear responsibility for action to reduce them. Fortunately, today there are structural approaches for doing so. From the production report found the reject equal 650,000 units , the cost of unit during process equal 0.43 SDG :

650,000 X 0.43 = 279,500 SDG

Also cost of rework approximately 700,000 unit

= 700,000 X 0.36 = 252,000 SDG

COPQ =549,500 SDG

3.2.3 VOICE OF PROCESS

In this step we must calculate Rolled Throughput Yield (RTY)

RTY is process performance that provide great insight in to the cumulative effects of an entire process. It measure the yield for each of several process steps and provides the probability that a unit will come through that process defect free .

First Time Yield = (Number of First Time Right products)/ Total Inputs to the process.

Rolled Throughput Yield = Multiplication of FTY of all the process. RTY will always be in percentage values.

Table (3.2) First time yield of process

S	Process	FTY
1	Draw	81.8%
2	Trimming	75.7%
3	Ogive	93.1%
4	Led forming	89.6%
5	Assembly	85.6%

RTY = 81.8 X 75.7 X 93.1 X 89.6 X 85.6 = 42.1%

3.2.4 VOICE OF CUSTOMER :

As mentioned in chapter tow can use Pareto chart to clarify the voice of customer. As a basic Quality Improvement tool, Pareto Analysis can define categories of defects which cause a particular output to be defective; count the frequency of occurrence of each defect; display graphically as a bar chart, sorted in descending order, by frequency of defect; use a second y axis to show the cumulative % of defects. the following table clarified the complaints from filling shop :

Table (3.3) Customer complaints

frequency	customer complaints	S
11	bad closing	1
7	Chips	2
3	empty projectile	3
2	big volume	4
1	non regular	5

From above table can drawn Pareto chart using minitab :

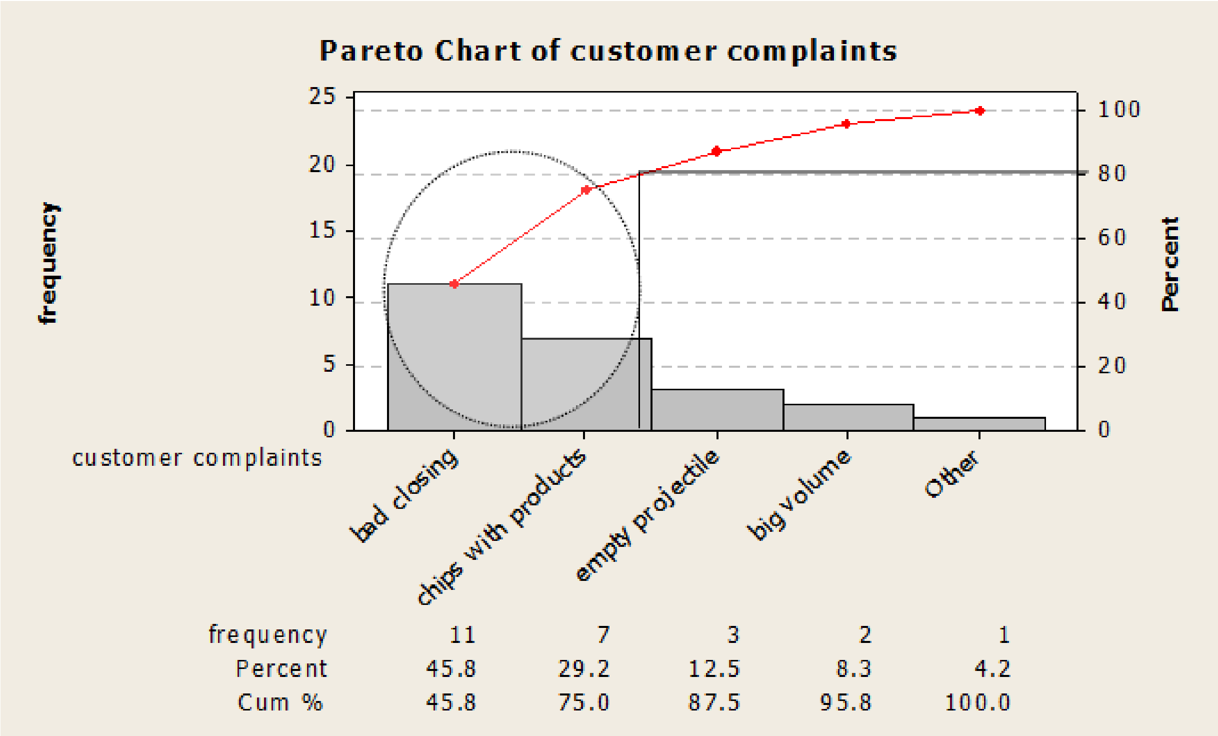

Figure (3.2)Pareto chart of costumer complaints

Approximately, 82% of our customer complaints are due to bad closing and chips with the products(CTQ). Thus, if we need to select a project, it should be on improving the quality of closing of the projectiles; and how to remove the chips before delivering filling shop .

3.3 MEASURE PHASE :

The purpose of the measure step is to evaluate and understand the current state of the process. This involves collecting data on measures of quality, cost, and throughput/cycle time. It is important to develop a list of all of the key process input variables (sometimes abbreviated KPIV) and the key process output variables (KPOV). The KPIV and KPOV have been identified at the define step, but they must be completely defined and measured during the measure step. Important factors are the time spent to perform various work activities and the time that work spends waiting for additional processing

In study Data collected by examining historical records, but this may not always be satisfactory, as the history may be incomplete, the methods of record keeping may have changed over time, and, in many cases, the desired information never may have been retained. Consequently, it is often necessary to collect current data through an observational study.

3.3.1 MEASYREMENT SYSTEM ANALYSIS :

a. Determining the measurement method

The product between process are measured by weight of total barrel then manias the weight of barrel from the total weight . after that divided the total weight over weight of unit .

b. Who Determining the rework

The operator accumulate the product that fall down out of the box then classified the scrap and return rework to the machine .

c. How measure weight of rework .

The operator are measure

d. Compute the machine productivity / minute

To find rail capacity of machine must to compute the productivity of machine per unit to compare capability of machine with a target .

Table (3.4) Capacity of machines

Process	Design Capacity (Unit/min)	Design Capacity (Unit/hour)

Drawing	86	5160
Trimming	100	6000
Ogive	75	4500
Assembly	60	3600
Controlling	100	6000
Lead Forming	128	7680

3.3.2 DETERMINING DIMENSIONAL AND TOLERANCE :

Dimensional variation is always a key parameter in product design. Variation among parts can come from any number of circumstances. Setting tolerances is challenging because of the need to be cost-competitive. Tight tolerances may be good for the quality– or the “feel”– of the product. But too-tight tolerancing may prove too costly in terms of the time and the extra machining it requires. Ideal tolerancing is a matter of finding the best compromise between product quality and economics, and it’s a critical consideration in terms of minimizing production scrap and rework. Accurate tolerance analysis is essential, and it’s important that the tolerance values assigned to the model by the designer remain with that model as the product moves through the entire development process.

Drawing stage :

Table (3.5) Drawing tolerances

Process NO	Weight(g)	Diameter (mm)	Length (mm)
1st drawing	2.43 ± 0.06	11	18
2nd drawing	2.43 ± 0.06	11	20 -3

Trimming stage :

Table (3.6) Trimming tolerances

Process NO	Weight (g)	Length (mm)
Trimming	1.93 ± 0.05	16.8 – 17.05

Ogive stage :

Table (3.7) Ogive tolerances

Process NO	Weight (g)	Diameter (mm)	Length (mm)
1st Ogive	1.93 ± 0.05	11	19.2 ± 0.5
2nd Ogive	1.93 ± 0.05	11	23.3 ± 0.3
3rd Ogive	1.93 ± 0.05	11	24.5 ± 0.5
4th Ogive	1.93 ± 0.05 g	11	25.5 ± 0.5

Lead forming stage :

Table (3.8) Lead forming tolerances

Process NO	Weight(g)	Diameter(mm)	Length (mm)
Lead forming	6.12 ± 0.05	6.73 -0.05	21 – 0.5

Assembly stage :

Table (3.9) Assembly tolerances

Process NO	Weight(g)	Diameter (mm)	Length (mm)
1st closing	7.95+ 0.1	7.8 – 0.02	19.2 ± 0.5
2nd closing	7.95+ 0.1	7.8 – 0.02	23.3 ± 0.3
3rd closing	7.95+ 0.1	7.8 – 0.02	24.5 ± 0.5
4th closing	7.95+ 0.1	7.83 – 0.03	24.5 ± 0.5

3.3.3 DRAW PROCESS MAP :

The purpose of the process map explain sequence of operations required to complete a task, the bellow figure clarified process map for bullet manufacturing

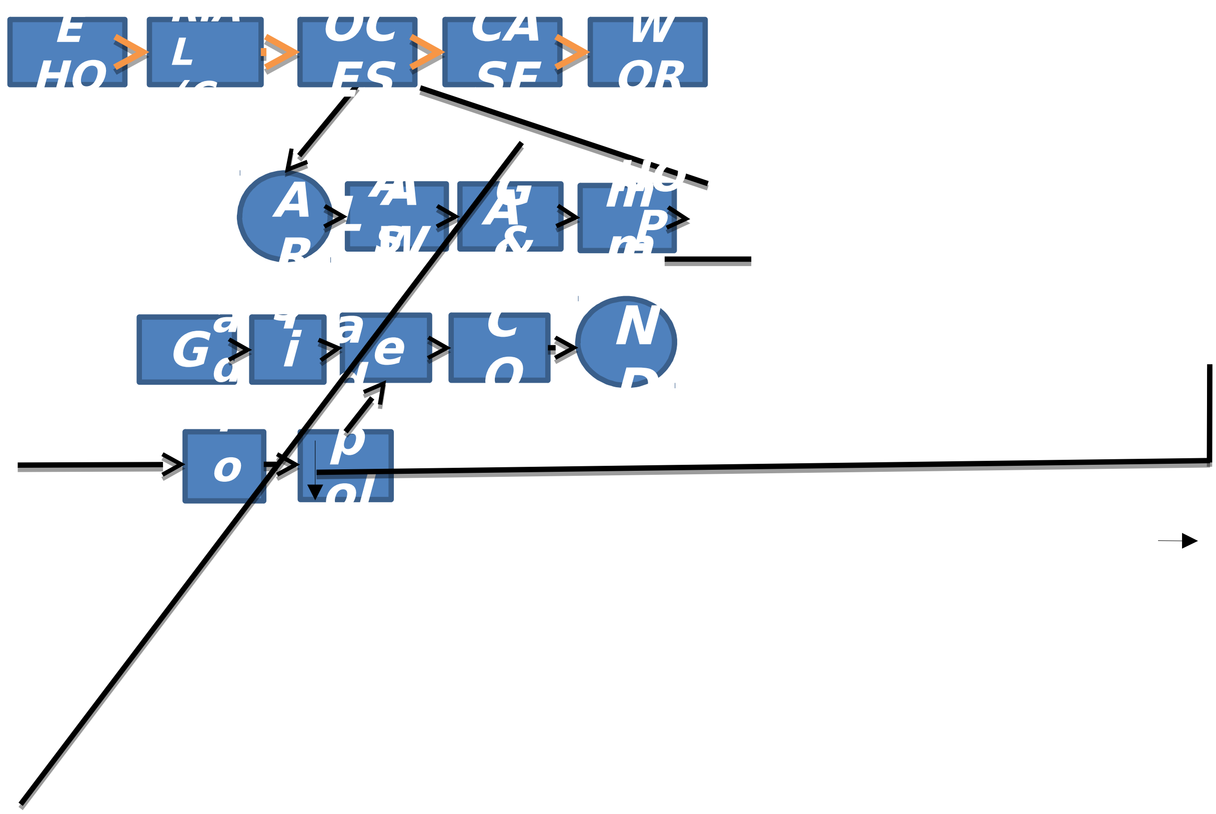

Figure (3.3) Process map of manufacturing bullet

3.3.4 CHECK FOR NORMALITY:

in this phase must inspection normality of data to insure there is no special cause of variations ,check for normality is important because when a data distribution is normally distributed, only random variation is present. There are two types of variation – Random or Common Cause of variation and Assignable or Special Cause of variation. When a data is not normally distributed, it is said to have special cause of variation.

The below table clarified the 35 sample of production

Table (3.10) 35 sample of Production during 2014

S	Production	S	Production	S	Production
1	400	13	450	25	350
2	350	14	250	26	250
3	450	15	450	27	200
4	450	16	400	28	200
5	450	17	450	29	250
6	400	18	400	30	200
7	550	19	400	31	150
8	550	20	450	32	250
9	450	21	450	33	200
10	350	22	550	34	75
11	450	23	550	35	325
12	300	24	500		

From the above table can be check the normality of data by using minitab, From the figure(3.4) must checking the p-value. If $p > 0.05$, data is normally distributed, If $p < 0.05$, data is not normally distributed.

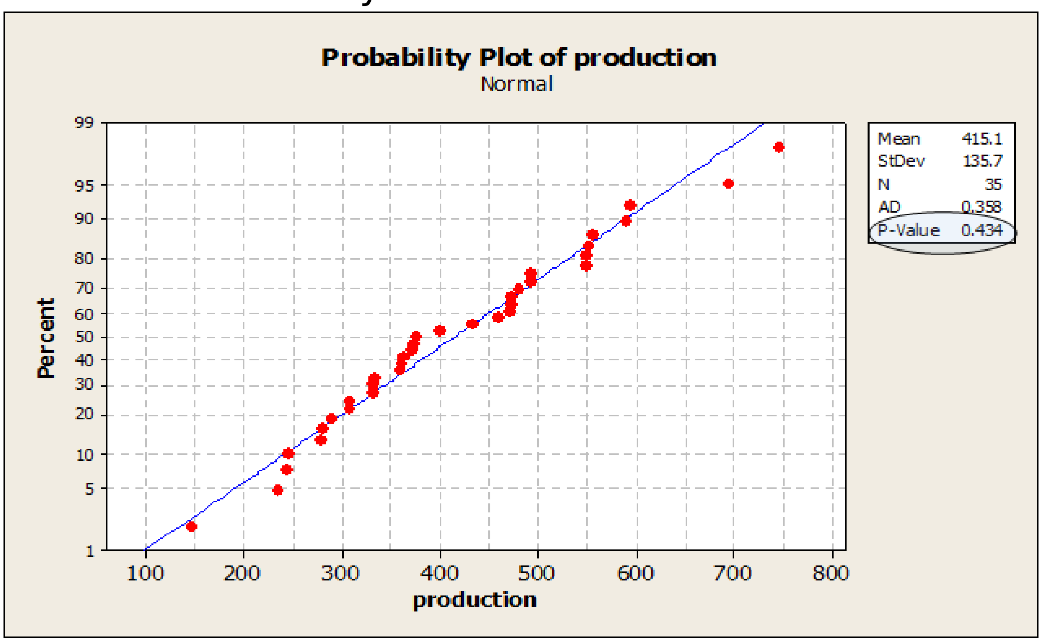

Figure (3.4)normality test for above table

A process should always have only common cause of variation. Also can used a tool called Anderson-Darling Normality Test. The second check for normality is Histogram.

From table (3.10) can be drawn Histogram to assure data normally distribution.

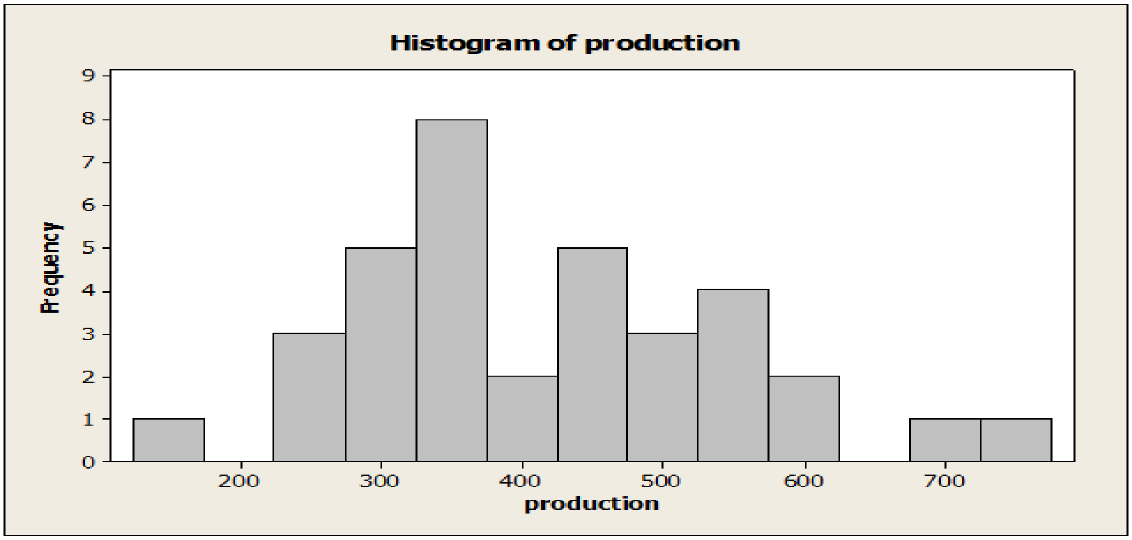

Figure (3.5)histogram for 35 sample

From the above figure data is not normally distributed, When Histogram and Anderson Darling test contradict, use another tool to confirm. That is Boxplot test

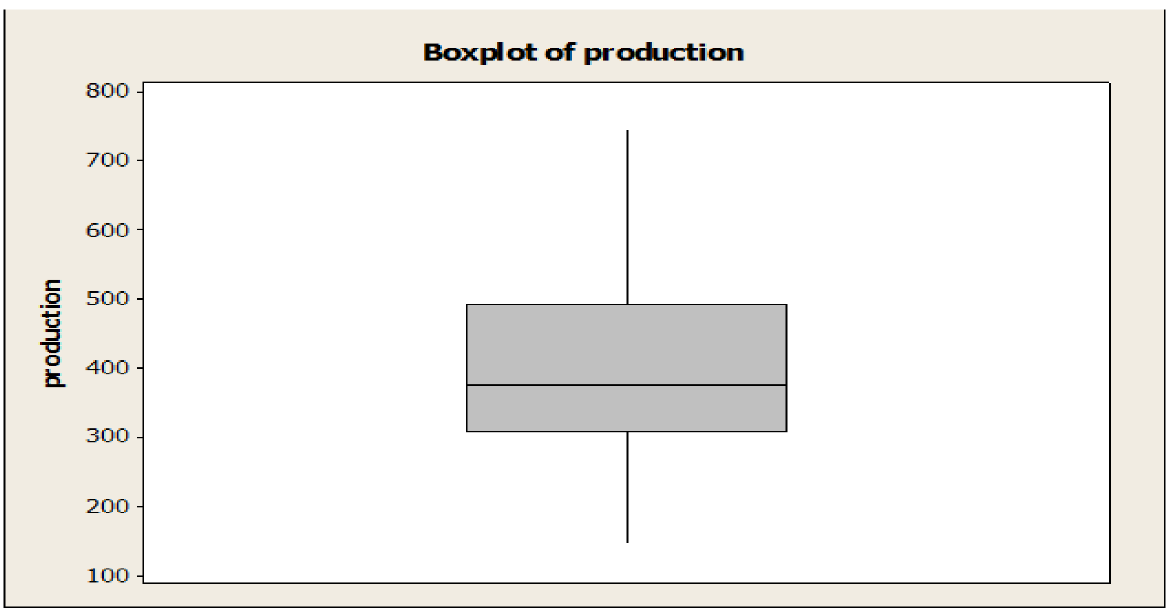

Figure (3.6) Box Plot to check normality 35 sample

In the Box Plot, need to check two things

i. If the Box is right in between the two lines.
ii. If there is no star mark in the Box Plot.
iii. If the box is right in between and no star mark.

From the Histogram and the Anderson Darling test, data is normally distributed.

If data is normally distributed, then use the Graphical Summary tool.

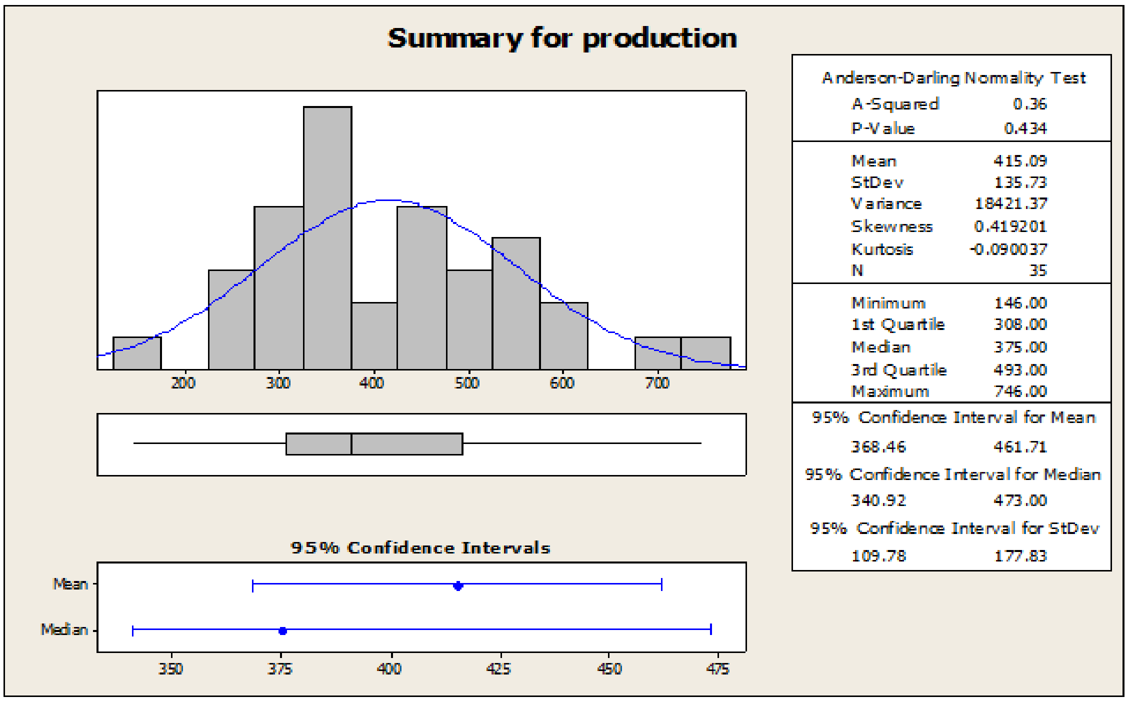

Figure (3.7)graphic summery for 35 sample of production

From the above figure (Graphical Summary tool):

i. P-value = 0.434 > 0.05 à Data is normally distributed
ii. Mean = 415.09, Median = 375 (If the difference in mean and median > 10%, data is not normally distributed).
iii. Standard Deviation = 135.73
iv. Skew = 0.419201 (This should be 0 for perfectly normally distributed data) But this skew is acceptable. Any skew > 1 or < -1 is unacceptable. Any skew value

of < -1 or > 1 will result in data to be normally distributed.

v. Maximum – Minimum = Range of the data = 746 – 146 = 600

3.3.5 CHECK FOR STABILITY :

Stability means consistency and predictability. The Stability checked with a tool called as Run Charts, from table (3.10) can draw run chart. From the figure (3.8)must Check the 4 p-values.

If all 4 p-values > 0.05, process data does not have special cause of variation. Only common cause of variation exist in the process.

If any p-value < 0.05, special cause of variation exists in the process. Clustering p-value = 0.005 < 0.05 à Process data has special cause of variation.

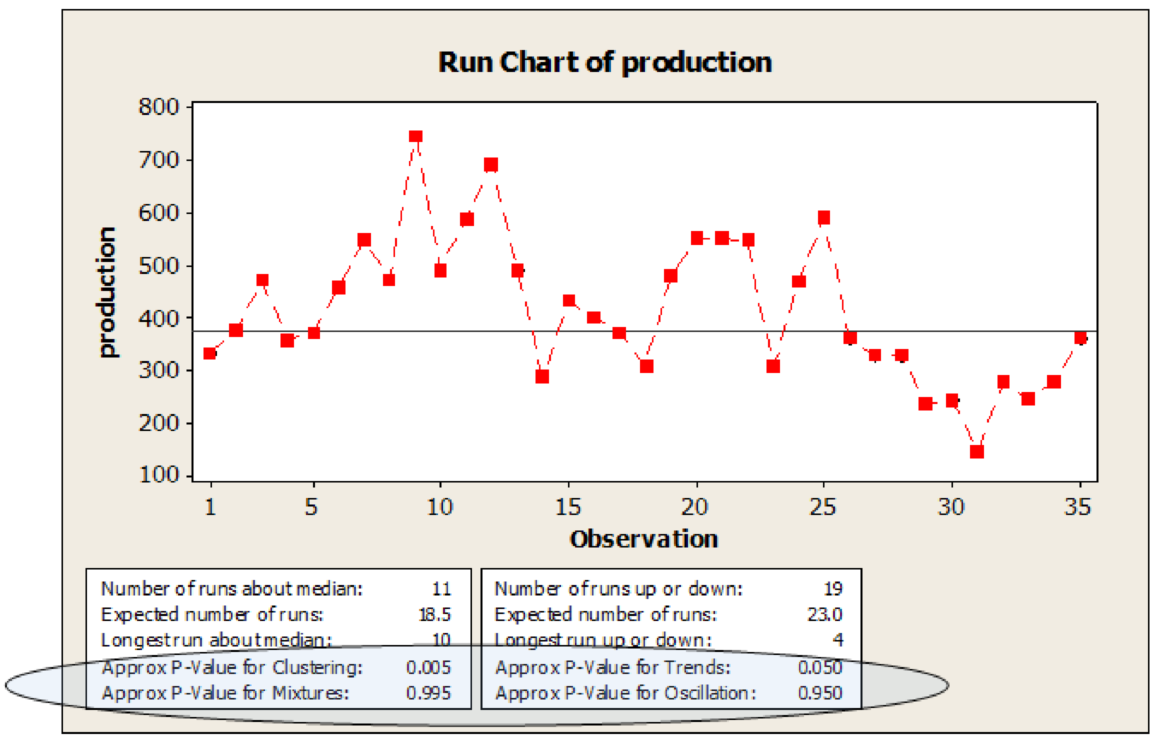

Figure (3.8) run chart for 35 sample of production

3.3.6 IDENTFING X VARIABLE AFFECT IN LOSSES .

There is many variable are effect in performance. This variable are different some variable effect in quality of product, or in dawn time of machine. This variable may from machine, spare part, tool, labour or environment .

After collecting all variable must determining which one controllable or not, then determining the availability of data for the variables . The next step flagging uncontrollable variable and collecting data for variable doesn't have data .

Table (3.11) The causes affect in target

#	Potential Failure Modes (process defects)	Note
1	Wearing in roller rod	
2	Mandrel 108	
3	Teflon guidance	
4	Mandrel 116	
5	capture spring	
6	BRKT	
7	Ejectors spring	
8	Feeding device Gear	
9	Feeding device regulator	
10	Mandrel OA176	
11	Mandrel OA174	
12	Loose in knife holder	
13	Knife	

3.3.7 DOWNTIME OF MACHINE :

As known the downtime is leading to a significant reduction in the ability of a company to generate revenue. to avoid these losses data must be collected to determine the reason of dawn time. The following table clarified downtime during period of study .

Table (3.12) Down time of machine with the general reason

Row Labels	Sum of Time taken to solve	%	Frequency
Electrical fault	367	1%	5
Lack of operator	2580	10 %	14
Lack of Tools	1480	6%	7
Mechanical fault	9919	37	30

		%	
Other	285	1%	3
Social (Eid) +Cleaning	330	1%	1
Tool change	8799	33 %	63
Waiting (raw material)	2855	11 %	27
Grand Total	26713	100 %	153

Thesis time need more details. These mean must compute down time for every stage alone then use pareto chart (as mentioned in define phase) to determine which stage has more down time .

The below table clarified down time for every stage :

Table (3.13) Down time between process

Time	Process	#
11605	Drawing	1
7040	Assembly	2
5489	Ogive	3
1444	Trimming	4
595	Lead	5
540	Controlling	6

Pareto chart can be drawn from above table to determine which machines cause in 80% of total down time :

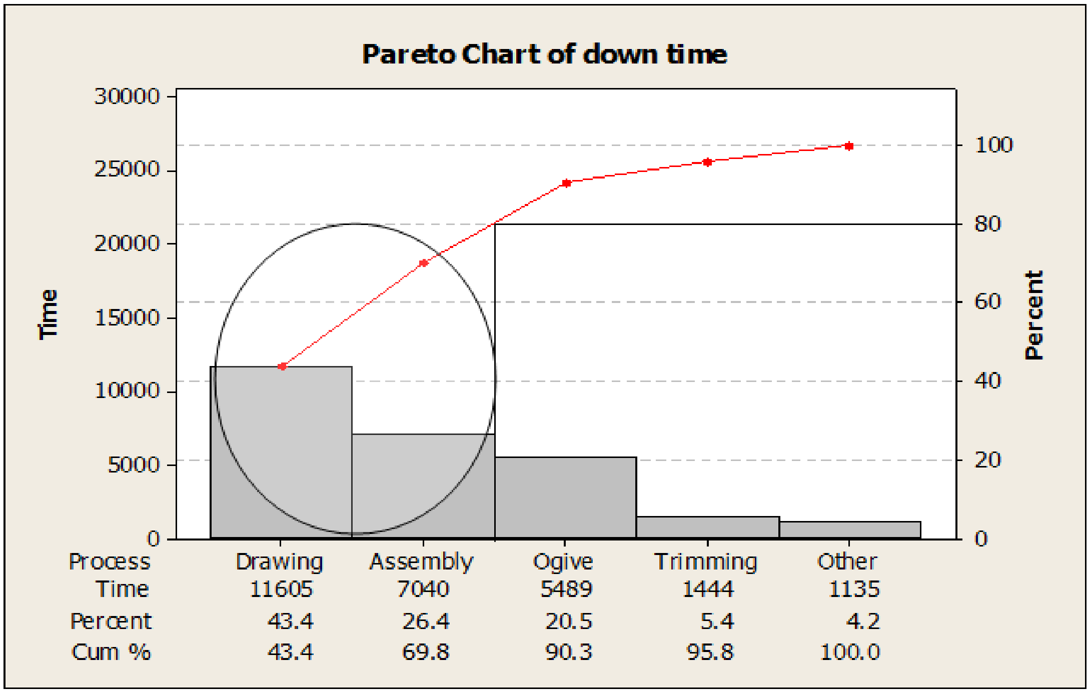

Figure (3.9) Pareto chart for down time machine

Approximately, 82% of our down time from drawing and assembly machines. In the next phase will analyze above figure

3.4 ANALYZE PHASE :

In the analyze step, the objective is to use the data from the measure step to begin to determine the cause-and-effect relationships in the process and to understand the different sources of variability. In other words, in the analyze step we want to determine the potential causes of the defects, quality problems, customer issues, cycle time and throughput problems, or waste and inefficiency that motivated the project. It is important to separate the sources of variability into common causes and assignable causes. generally speaking, common causes are sources of variability that are embedded in the system or process itself, while assignable causes usually arise from an external source. Removing a common cause of variability usually means changing the process, while removing an assignable cause usually involves eliminating that specific problem. A common cause of variability might be inadequate training of personnel processing insurance claims, while an assignable cause might be a tool failure on a machine.

3.4.1 CAUSE – AND- EFFECT DIAGRAM :

In situations where causes are not obvious, the cause-and-effect diagram is a formal tool frequently useful in unlayering potential causes. The cause-and effect diagram is very useful in the analyze step of DMAIC. The cause-and effect diagram constructed by a quality improvement team assigned to identify potential in analyzing the tank defect problem, then elected to lay out the major categories of tank defects as machines, materials, methods, personnel, measurement, and environment.

A brainstorming session ensued to identify the various subcauses in each of these major categories and to prepare the diagram in Fig. (3.10). Then through discussion and the process of elimination, finally decided that tools and spare parts contained the most likely cause categories.

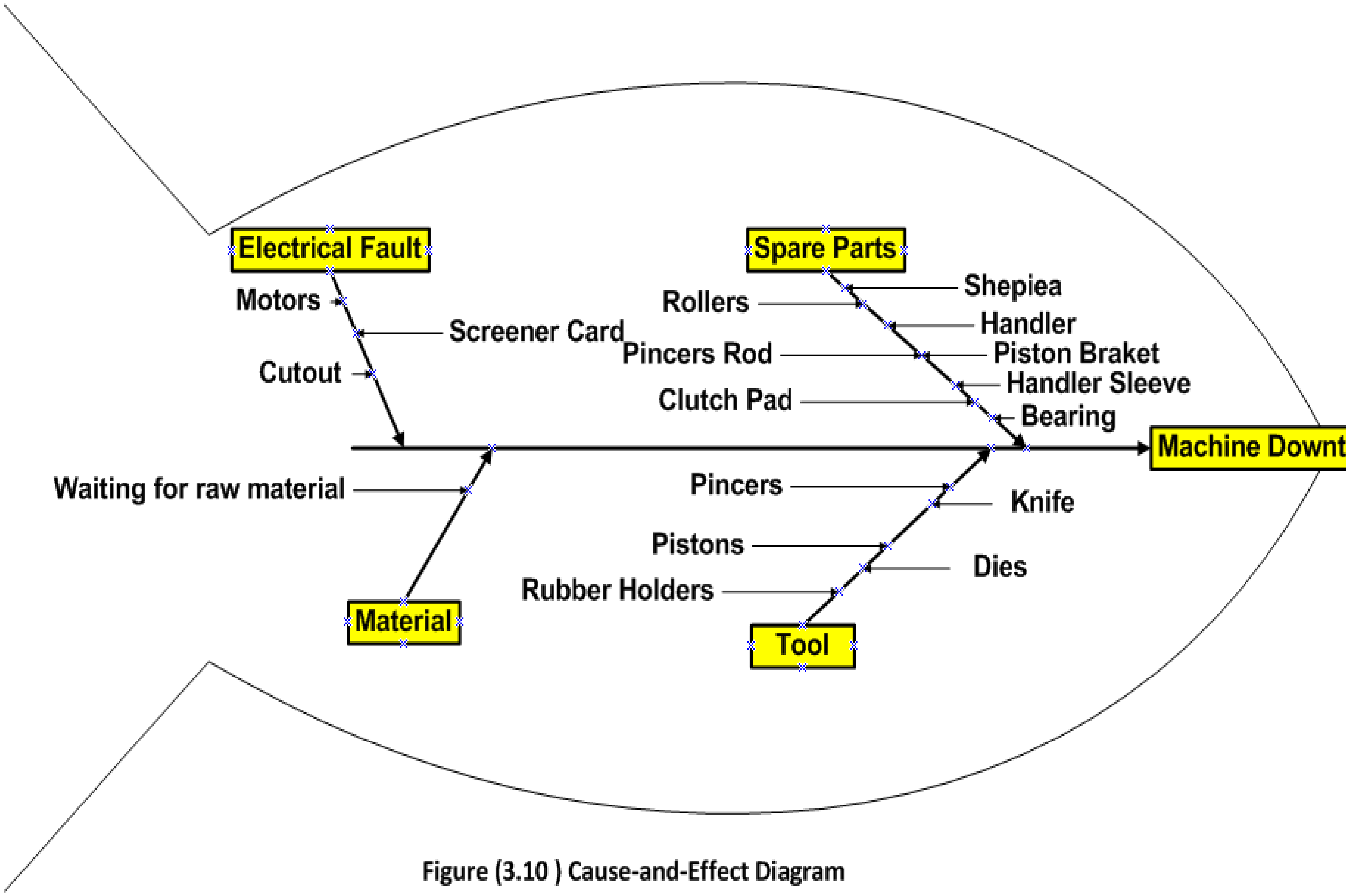

Figure (3.10) Cause-and-Effect Diagram

3.4.2 FAULT TREE ANALYSIS

There will be many legs to be analyzed, spreading from the top-level event, resembling a triangle or a "tree"—hence the name fault "tree" analysis. The method of Construction FTA as following :

A .Define the bounds of the system (Bullet of standard 39 X 7.62)to be analyzed to which failures will be resolved.

B. Identify the TOP-level event of the system to be analyzed. The TOP-level events of the system represent those events for which reliability and availability predictions are required. In our project The TOP-level is downtime and defects.

C. Using a top-down deductive-reasoning approach, identify all the immediate causes of the TOP-level events. In figure (3.11) can be observe the general shape, empty bullet and weight of lead those cause the defect and downtime.

D. Now define the immediate causes of the new system events. It is important that intermediate system events are not missed out when defining the immediate causes. In this way, the levels of the fault tree progress systematically from major system events, through intermediate levels of complexity, to the basic events representing component failures at the roots of the fault tree. Also in figure (3.11) can be observed dimension of bullet is different this reason from trimming or ogive, lead doesn’t fit into jacket and less specification in raw material of lead.

E. Continue this process of defining the immediate causes of system events until all the roots of the fault tree determined . from the below figure can be observe the root cause of defect and downtime. The reason can be summarized in knife and holder of trimming stage, die of ogive stage and raw material of lead.

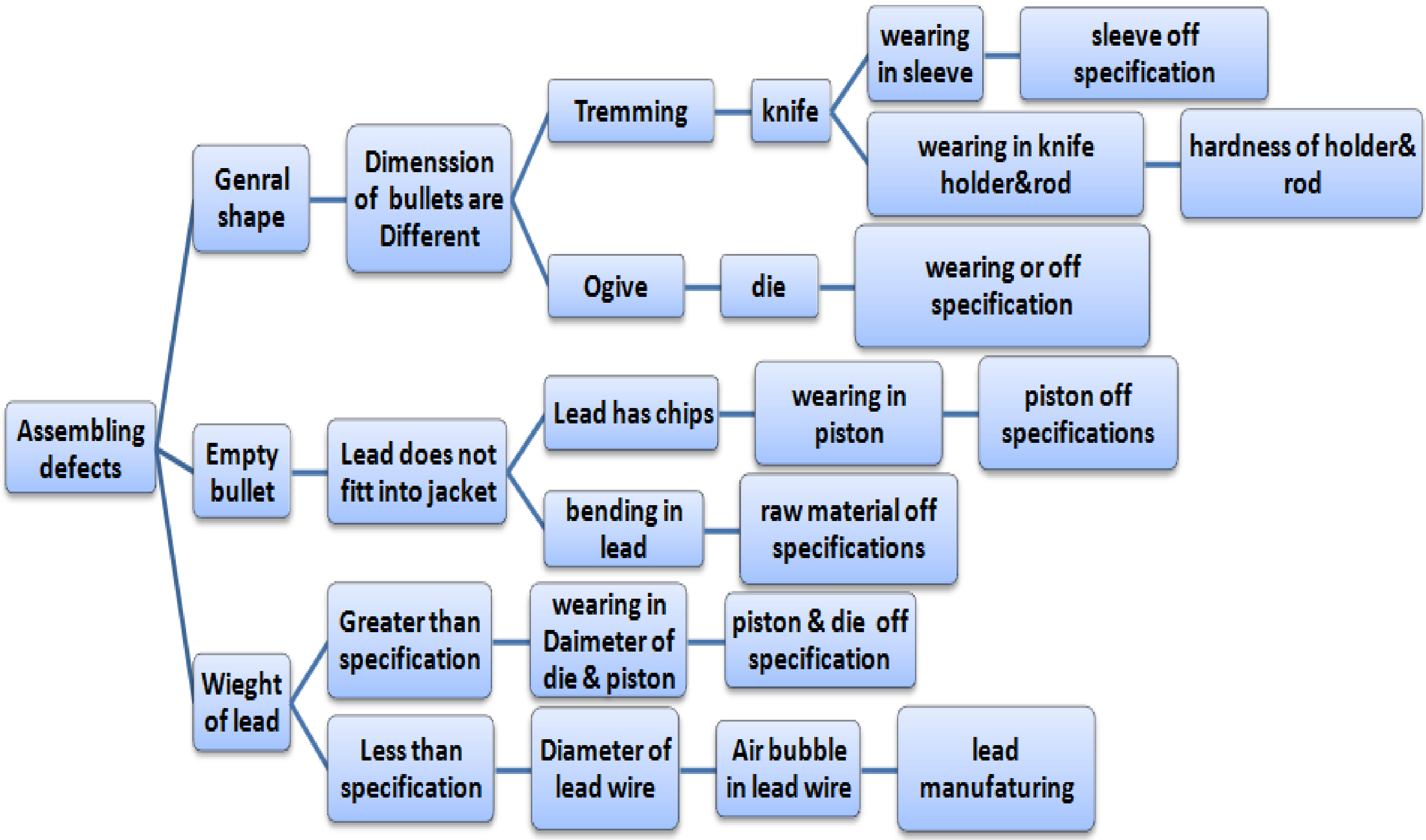

Figure (3.11) Fault tree analysis

3.4.3 FAILURE MODES AND EFFECT ANALYSIS (FMEA)

(FMEA) is another useful tool during the analyze stage. FMEA is used to prioritize the different potential sources of variability, failures, errors, or defects in a product or process relative to three criteria:

A. Occurrence

In general, the probability of occurrence evaluates the frequency that potential risk(s) will occur for a given system or situation. The probability score is rated against the probability that the effect occurs as a result of a failure mode. The example below applies a linear scoring scale to the probability of occurrence of failure modes associated with the manufacturing process of a bullet .

Table (3.14)Occurrence Rating

Occurrence Rating		Occurrence Rating	
1- 3 days	10	21-30 days	5
4-5 days	9	31-40 days	4
6-10 days	8	41-50 days	3
11-15 days	7	51-60 days	2
16-20 days	6	> 60 days	1

B. Detectability

In general, detectability is the probability of the failure being detected before the impact of the failure to the system or process being evaluated is detected. The detectability score is rated against the ability to detect the effect of the failure mode or the ability to detect the failure mode it self.

The ability to detect a failure, defect or error (ranked on a 1 to 10 scale with 1 = very likely to detect and 10 = very unlikely to detect).

C. severity

In general, severity assesses how serious the effects would be should the potential risk occur. In Our case of a manufacturing process for a bullet, the severity score is rated against the impact of the effect caused by the failure mode on the batch quality. A non-linear scoring scale can be applied to augment the effect of the severity criteria as shown in the table (3.14) .

Table (3.15)Severity Rating

Severity Rating		Severity Rating	
5 - 15 minutes	1	61-120 minutes	7
16 - 30 minutes	3	121-240 minutes	9
31-60	5	>= 1 shift	1

minutes			0

The severity of a failure, defect or error (ranked on a 1 to 10 scale with 1 = little impact and 10 = extreme impact, including extreme financial loss, injury, or loss of life).

The three scores for each potential source of variability, failure, error or defect are multiplied together to obtain a risk priority number (RPN). Sources of variability or failures with the highest RPNs are the focus for further process improvement or redesign efforts.

The analyze tools are used with historical data or data that was collected in the measure step. This data is often very useful in providing clues about potential causes of the problems that the process is experiencing. Sometimes these clues can lead to breakthroughs and actually identify specific improvements. In most cases, however, the purpose of this phase is to explore and understand tentative relationships between and among process variables and to develop insight about potential process improvements. A list of specific opportunities and root causes that mentioned in table (3.16) are targeted for action in the improve step should be developed. Improvement strategies will be further developed and actually tested in the improve step.

From the table (3.16) the knife holder has highest RPN, Its mean must taken firstly in improve phase .

Table (3.16) FMEA analysis phase

#	Process Function	Potential Failure Modes	Potential Effect(s) of Failure (Impact to	SEV	Potential Cause(s) of Failure	OCC	DET	DE	RPN

	(Step)	(process defects)	Operations)					T	
1	Drawing machine	wearing in roller rod	Timely delivery of the product to the next step get impacted by 180 minutes.	9	Off-center of bearing motion because of corrosion in Rollers Die (New Dies not available)	6	No	10	540
		Mandrel 108	Timely delivery of the product to the next step get impacted	5	The spec. of Mandrel	9	No	10	450
		Mandrel 116	Timely delivery of the product to the next step get impacted.	3	The spec. of Mandrel	10	No	10	300
		BRKT	Timely delivery of the product to the next step get impacted.	10	Because of Rollers offcentered/ and the material of the Part	2	No	10	200
		Feeding device Gear	Timely delivery of the product to the next step get impacted.	9	Raw material QLY, which impact on the gear by copper chips	2	No	10	180
2	Assembly Machine	Mandrel OA176	Because of the operator spend 20 minutes in adjusting and change the Mandrel face Edge	3	Because of Teflon damage which is relay on the spec. of Teflon/Mandrel	6	No	10	180
		Mandrel OA174	Because of the operator spend 10 minutes in adjusting and change the Mandrel face Edge	1	Spec. of the Mandrel, cause to Bad Performance	5	No	10	50
3	Trimming Machine	pins of Knife holder	non-tightly clamping of knife holder impact on the variation of the cutting length	9	non-alignment resulted from the wrong direction of the case, which impact on the Knife alignment	4	No	10	360
		Knife holder	non-alignment knife impact on the variation of the cutting length	9	non-alignment resulted from the wrong direction of the case, which impact on the Knife alignment	7	No	10	630
4	Lead Forming	Mandrel 143	Because of the operator spend 10 minutes in adjusting and change the Mandrel face Edge	7	Spec. of the Mandrel, cause to Bad Performance	5	No	10	350
		Material specification	impact on the strength of the lead which defect the output	4	Raw material	10	No	10	400

3.5 IMPROVE PHASE :

In the measure and analyze steps, we focused on deciding which KPIVs and KPOVs to study, what data to collect, how to analyze and display the data, identified potential sources of variability, and determined how to

interpret the data they obtained. In the improve step, they turn to creative thinking about the specific changes that can be made in the process and other things that can be done to have the desired impact on process performance.

A broad range of tools can be used in the improve step. Redesigning the process to improve work flow and reduce bottlenecks and work-in-process will make extensive use of flow charts and/or value stream maps. Sometimes mistake-proofing (designing an operation so that it can be done only one way—the right way) an operation will be useful. Designed experiments are probably the most important statistical tool in the improve step. Designed experiments can be applied either to an actual physical process or to a computer simulation model of that process, and can be used both for determining which factors influence the outcome of a process and for determining the optimal combination of factor settings.

The objectives of the improve step are to develop a solution to the problem and to pilot test the solution. The pilot test is a form of confirmation experiment: it evaluates and documents the solution and confirms the solution attains the project goals. This may be an iterative activity, with the original solution being refined, revised, and improved several times as a result of the pilot test's outcome.

3.5.1 CHECK SHEET

A Check Sheet is an organized way of collecting and structuring data, its purpose is to collect the facts in the most efficient way. It ensures that the information that is collected is what was asked for and that everyone is doing it the same way. Data is collected and ordered by adding tally or check marks against predetermined categories of items or measurements. It simplifies the task of analysis. From the Analyze investigations, there is no preventive maintenance, its mean must make work instruction for critical fault detection and make check list for inspection for the output quality every 10 minutes for each machine. The form of this sheet are attached In appendixes .

3.5.2 MODIFICATIONS :

From table (3.16) the trimming machine has highest number of RPN ,there are Tow modifications are suggested and practically tested in the machine , the modification is :

a. Add cover to prevent chips

Figure (3.12) Protection cover in trimming machine

a. Add cover to prevent chips from filling in box of products, this cover will protect the belt of motor and prevent injury of operators. The above.03 figure clarified the cover .

b. Add bearing between the rod and knife holder , this bearing will protect wearing that’s resulted from friction between rod and holder. The below figures clarified difference between old and new design .

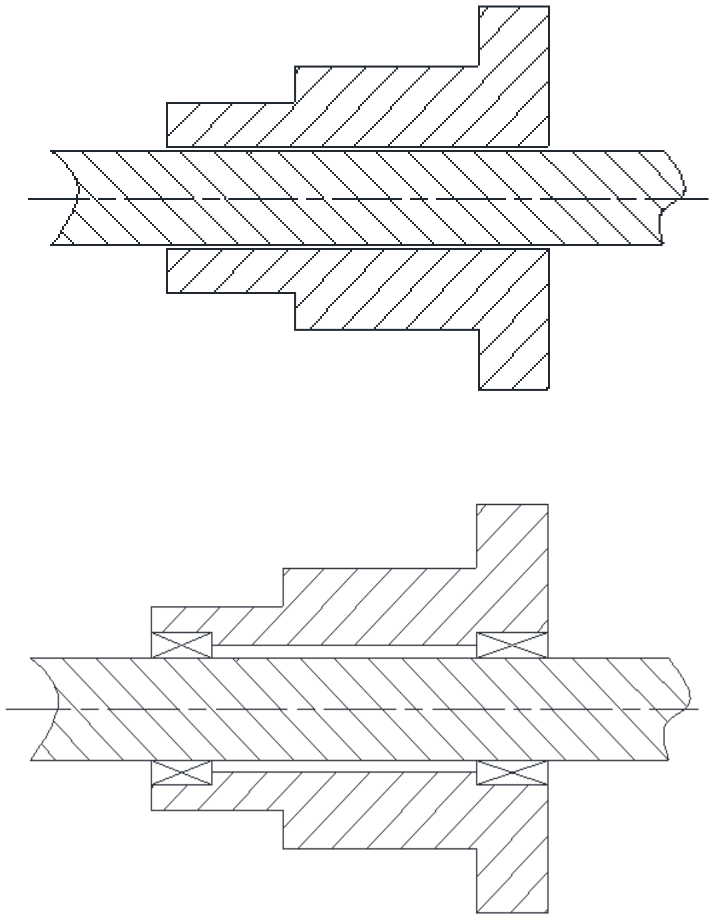

Figure (3.13) difference between pre & post knife holder

3.5.3 UPDATE FMEA .

After implementing the recommendations and taken action, the production will improved and the improvements can be observed in table (3.17) also the other improvements can be observed from FMEM after updates .

table (3.17) FMEA after improve actions.

S	Process function (step)	Potential Failure Modes (process defects)	Recommend Actions	Taken Actions	SEV	OCC	DET	RPN
1	Drawing machine	wearing in roller rod	change type of bearing and revision drawing of roller	they have started the greasing process on Wednesday	8	6	1	48
		Mandrel 108	All drawings finished and to be provided to Tools department after QC check. Tools heat treatment	workshop manager accept the old drawing without any change,& reject any tools off	5	8	1	40

			process to be improved.	specification				
		Mandrel 116	All drawings finished and to be provided to Tools department after QC check. Tools heat treatment process to be improved.	workshop manager accept the old drawing without any change,& reject any tools off specification	3	10	1	30
		BRKT	Check the adjustment of the BRKT every week (Sunday) and if problems detected, adjustment should be fixed.	they have started the adjusting process on Wednesday	10	2	1	20
		Feeding device Gear	Clean feeding device every 5 days (Sunday)	They will start cleaning process on Tuesday	9	2	1	18
	Assembly	Mandrel OA176	All drawings finished and to be provided to Tools department after QC check. Tools heat treatment process to be improved.	workshop manager accept the old drawing without any change,& reject any tools off specification	3	6	1	18
		Mandrel OA174	All drawings finished and to be provided to Tools department after QC check. Tools heat treatment process to be improved.	workshop manager accept the old drawing without any change,& reject any tools off specification	1	5	1	5
4	Trimming Machine	pins of Knife holder	Daily check for knife pins	check for knife pins Daily	7	2	1	14
		Knife holder	Daily check for knife variation - weekly (Sunday)check for sleeves & add bearing between holder and rod	they have started checking knife variation every 2 hour from Sunday and bearing were added	7	1	1	7
5	Lead Forming	Mandrel 143	All drawings finished and to be provided to Tools department after QC check. Tools heat treatment process to be improved.	workshop manager accept the old drawing without any change,& reject any tools off specification	1	5	1	5

After implement the improvement the performance was enhanced ,that can observed in the following table

Table (3.18) Defect %(Pre improve) and Defect %(post)

Process	Defect %(Pre improve)	Defect %(post)
Assembly	5.1	2.6

3.5.4 VALUE STREAM MAPPING

The first step, identifying the product, the bullet is product was chosen for this study, an initial VSM of the current process is created. Following the completion of the current map. All this information is then compiled on a map and analysis is performed. VSM was included every step of the process . For each step, parameters included cycle time, work in progress (WIP), set up time, down time, number of workers, and scrap rate. In this study VSM identified where value is added in the manufacturing process. It also show all other steps where there is non added value. After analyzing and evaluating the current process of the product, the problem areas were identified. Once was changed the current process to minimize problem areas completely, it can create a final state VSM. The last step of the value stream mapping process is to implement the new ideas, which will in turn create a more efficient lean manufacturing process .

Figure (3.12) clarifying the total time for Ogive stage after improvement, the time was reduced from 728 min to 693 min , this time foe sorting and machining .Improve phase not only generates the solutions but also give feedback mechanism check the effectiveness of improvements.

Table (3.19) Benefits after implement improve actions

Improvement action	***Attacked Cause***	***Impact***	***Cost of Improvement***	***Saving***	***Benefits***
Design and implement protection cover for the trimming machine	time waste in Ogive stage	1- Reduce the time in sorting out the chips by (162min/patch) which is coming from trimming stage.(also reduce time of oppsite chemcal soap in sorting chips). 2- Protect motor belt 3- Protect the operator from getting injured .	114.95	6,052.00	5,937.05
Add bearing between the knife an	Knife misalignment in trimming stage	Reduce the bullet defect (length variation)	500.00	268,750.00	268,250.00
SUM			614.95	274,802.00	**274,187.05**

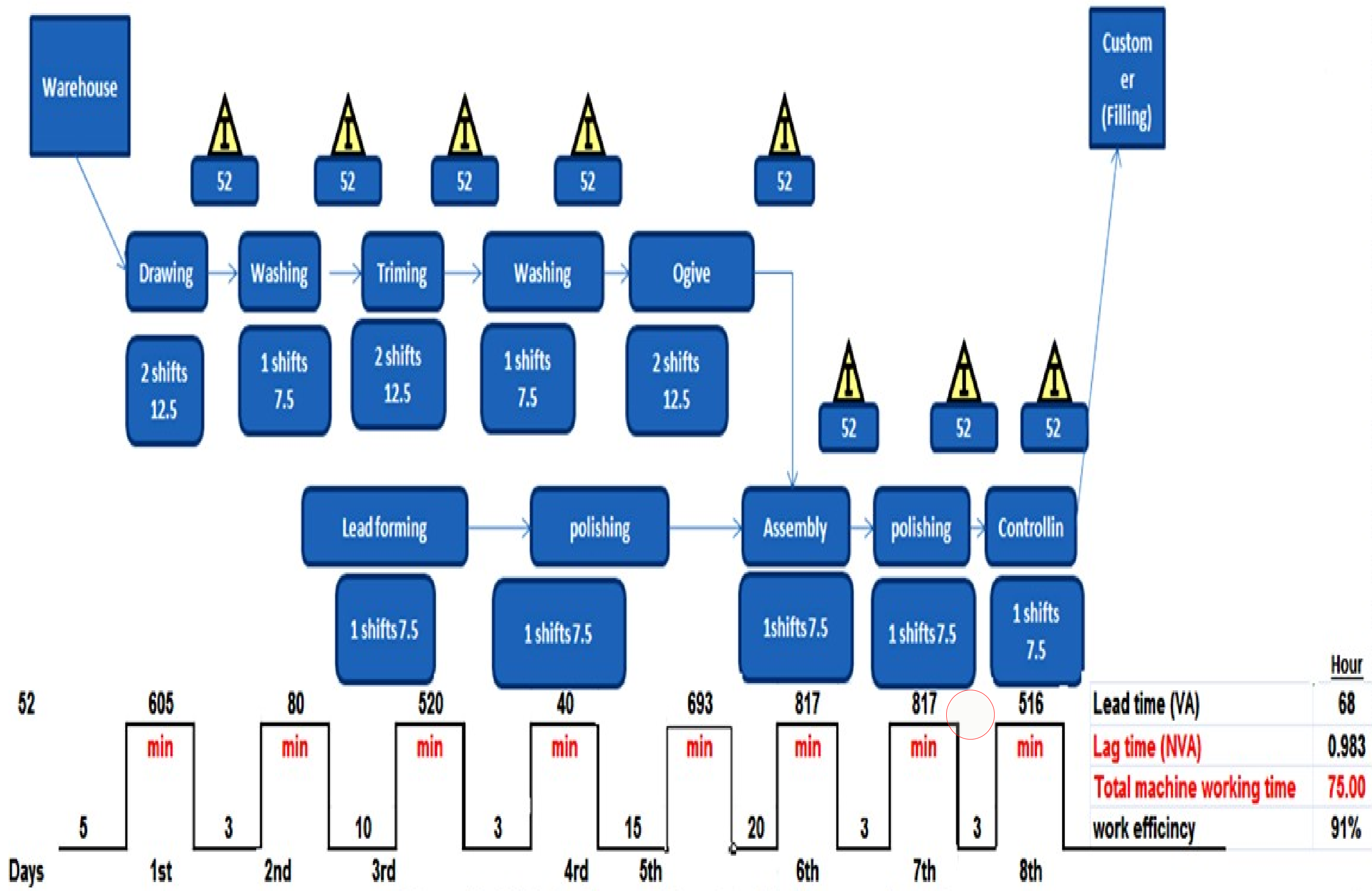

Figure (3.12) Value Stream Mapping of bullet manufacturing

3.6 CONTROL PHASE :

The objectives of the control step are to complete all remaining work on the project and to hand off the improved process to the process owner along with a process control plan and other necessary procedures to ensure that the gains from the project will be institutionalized. That is, the goal is to ensure that the gains are of help in the process and, if possible, the improvements will be implemented in other similar processes in the business. The process owner should be provided with before and after data on key process metrics, operations and training documents, and updated current process maps. The process control plan will be a system for monitoring the solution that has been implemented, including methods and metrics for periodic auditing. Control charts are an important statistical tool used in the control step of DMAIC; many process control plans involve control charts on critical process metrics.

The transition plan for the process owner will check several months after project completion. It is important to ensure that the original results are still in place and stable so that the positive financial impact will be sustained. It is not unusual to find that something has gone wrong in the transition to the improved process. The ability to respond rapidly to unanticipated failures was factored into the plan. The table (3.21) clarified control plan.

The plan contains check defect and rework every 10min for all stage, daily instruction as in appendix, weekly instruction for drawing stage that include check the bracket, feeding device gear and roller. Also the plan include daily instruction for check sharpness of knife and weekly for sleeves and bearing of knife holder.

Table (3.21) Control plan

Sub Process	Sub Process Step	CTQ		Specification/ Requirement	Measurement Method	Sample Size	Frequency	Who Measures	Where Recorded	Decision Rul Corrective Act
		KPOV	KPIV	USL LSL						
Machine production	All Stages	Defect %	Check defect every 15 minute	4% , 10 %	Defect and rework sheet	10 sample / 15 minute	every 15 minute	Operator	Daily work instruction	check ,clean at start and end of work, Lubricate hourly
Machine production	All Stages	Downtime	Daily work instruction	15 minutes daily	Downtime sheet	-	Daily	Operator	Daily work instruction	check ,clean at start and end of work, Lubricate hourly
Machine production	Drawing	BRKT downtime	weekly check for BRKT	20 Minutes in week	Downtime sheet	-	Weekly	Operator	weekly check list sheet	check, clean an adjust the BRK every week
Machine production	Drawing	Rollers downtime	weekly check for roller	20 Minutes in week	Downtime sheet	-	Weekly	Operator	weekly check list sheet	check ,clean, Lubricate and adjust the roller every week
Machine production	Drawing	Feeding device Gear downtime	weekly check for feeding device gear	20 Minutes in week	Downtime sheet	-	Weekly	Operator	weekly check list sheet	check ,clean ge Lubricate the feeding gear ro every week
Machine production	Trimming	Defect %	Daily & weekly check for knife	2% , 4%	Defect and rework sheet	10	Daily, weekly	Operator	Daily weekly check list sheet	Check knife variation , sharpness & bearing daily & weekly

CHAPTER FOUR CONCLUSIONS AND RECOMMENDATIONS

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The effectiveness of six sigma integration approach has been tested in many stages. Success mainly in trimming stage is evident from case studies.

This integrated approach of using lean and six-sigma tools was proposed and evaluated through a case study. Using a FMEA ,fish bone diagram and value stream map the opportunity for improvement was identified, namely lead-time reduction before Ogive stage. The first step of the improvement, lead-time reduction, was actually a lean goal where a detailed current state value stream map was utilized to calculate lead-time. After fixed the cover in the trimming machine the lead-time was reduced in cleaning(sorting) before ogive stage from 50 min to 15 min. After adding bearing between rod and holder the ratio of defect was reduced by 2.5%. The total cost of modifications is 614.95 SDG, As mentioned in table (3.19) Modifications can saved 274,187 annually.

The tools to be used in the approach is not limited to what was used in this case study. Depending on the nature and type of the application a suitable lean and, or six-sigma tool can be utilized. As in this case study, failure mode and effect analysis , fault tree analysis and cause effect diagram but engineering knowledge is essential in identifying the root causes for defects. Without engineering knowledge the actual cause of the defect might be either missed or misinterpreted. While working on defects from assembly lines the actual cause of the defect might be from another department mostly from trimming

4.2 RECOMMENDATIONS

The author of this work recommends the following :

1. Commitment in registering downtime .
2. Commitment in implementing preventive maintenance .
3. Train operator as TQM concepts.
4. Put system for motivations to encourage operator .
5. Re-operating visual control machine .
6. Provide tool and spare part to avoid down time .
7. Don’t accept any tool off specification.
8. Implement FMEA in other workshop.

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APPENDIXE

a. **Daily instructions**

Date :…………………… …….   Shift : ………………………

Machine NO:………………………   Stage : …………………………

Table (3.22) Daily instructions

	Task	7:45 AM	9:00 AM	10:00 AM	12:00 PM	1:00 PM	3:00 PM	4:00 PM
1	Oiling machine each hour							
2	Supervisor visit each hour							
3	Accumulate fill down products							
4	Clean floor in start and end of shift							

Supervisor :……………………………………………….. signature : ……………………………

Engineer :……………………………………………….. signature : ……………………………

b. **Weekly instructions for drawing stage**

Date : ………………………………. shift : ……………………………… Machine NO:…………………

Table (3.23) Weekly instructions for drawing stage

#	**TASK**	Sun	mon	Tus	wed	thur
1	Greasing roller and BRKT					
2	Check the adjustment of roller and BRKT					
3	Clean gear handler					

Supervisor :……………………………………………….. signature : ……………………………

Engineer :……………………………………………….. signature : ……………………………

C. Weekly instructions for Trimming stage

Date : ……………………………… shift : ……………………………… Machine NO:………………….

Table (3.24) Weekly instructions for Trimming stage

#	TASK	sun	Mon	Tus	wed	thur
1	Check the sharpness of knife					
2	Check the alignment of knife before starting					
3	Check the bins of knife before starting					
4	Check the sleeve of knife before starting					

Supervisor :………………………………………………. signature : ……………………………

Engineer :………………………………………………. signature : ……………………………

D. **Weekly instructions for Ogive stage**

Date : ……………………………… shift : ……………………………… Machine NO:………………….

Table (3.25) Weekly instructions for Ogive stage

#	Task	Sun	mon	Tus	Wed	thur
1	Check corrosion of BRKT separator					

Supervisor :………………………………………………. signature : ……………………………

Engineer :………………………………………………. signature : ……………………………